INFRASTRUCTURE

Guidelines for THE TRANSITION FROM ANALOGUE TO DIGITAL BROADCASTING

Report



J A N U A R Y 2 0 1 4 Telecommunication Development Sector



Guidelines for the transition from analogue to digital broadcasting

January 2014



These Guidelines were co-written by ITU experts Mr Jan Doeven, Mr Gu-Yean Hwang, Mr Colin Knowles, Mr Junji Kumada, Mr Yukihiro Nishida, Mr Sharad Sadhu, Dr Kazuyoshi Shogen and Mr Peter Walop, with contributions from Mr Roger Bunch, vice-chairman of ITU-R Study Group 6, under the supervision of the ITU Telecommunication Development Bureau (BDT) Spectrum Management and Broadcasting Division and the ITU Regional Office for Asia and the Pacific and with the co-operation of the ITU Radiocommunication Bureau (BR). Special thanks are also extended to the Korean Communications Commission (KCC), Republic of Korea and the Ministry of Internal Affairs and Communications (MIC) in Japan, for their contribution to the development of the Guidelines.



Please consider the environment before printing this report.

© ITU 2014

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

Foreword

The broadcasting revolution is well-underway, and the transition from analogue to digital broadcasting is not only creating opportunities for the provision of ICT applications and multimedia services but is also contributing to the efficient use of spectrum through the digital dividend and the release of spectrum for other uses such as wireless broadband communications.

The transition to digital terrestrial television broadcasting (DTTB) and the introduction of mobile television broadcasting (MTV) services is benefiting regulators, service providers, network operators and consumer electronics manufacturers but it is a complex process that differs from country to country. This is in part due to different national regulatory frameworks, service offerings and network configurations but is also due to national priorities, market circumstances, geography, and population distribution.

Independent of national variations, I believe that this publication can lead to well-motivated decisions on digital migration process, close cooperation between the regulator and market players, clear and timely regulatory frameworks, including decisions on the digital dividend, and adequate information and assistance to viewers.

The Guidelines for the transition from analogue to digital broadcasting is intended for a global audience to provide information and recommendations on policy, regulation, technologies, network planning, customer awareness and business planning for the smooth transition to DTTB and introduction of MTV.

This updated version of the Guidelines is a complete review of the previous editions and is applicable to all regions. Furthermore, annexes have been added with information on satellite TV, cable TV and IPTV. These delivery means could be supportive to DTTB services, for example in providing interactive services.

ITU is assisting the Membership in the DTTB transition and has developed frequency plans for digital terrestrial broadcasting (GE 06 plans) for Region 1 and Iran, which should be implemented by 17 June 2015, with the exception of some developing countries for which the transition period will end on 17 June 2020. We are also in the process of assisting developing countries and least developed countries (LDCs) in the smooth transition from analogue to digital broadcasting through the development of several projects and I hope that this updated version of the Guidelines will help continue to support the work on defining country specific roadmaps for the transition that will benefit consumers, and both the public and private sectors.

I would like to thank the experts who have developed these Guidelines for their expertise and experience, and for their continued support throughout the transition phase. I would also like to extend special thanks to the Korean Communications Commission (KCC), Republic of Korea and the Ministry of Internal Affairs and Communications (MIC) in Japan, for their contribution with financial and human resources to the development of these Guidelines.

Brahima Sanou Director

Telecommunication Development Bureau

Executive summary

Introduction to the Guidelines

The broadcasting industry and the national regulators face both opportunities and challenges in dealing with the transition from analogue to digital broadcasting. The transition requires decisions to be made on a large number of political, social, economic and technological issues. Therefore, it is necessary to develop a well-defined roadmap covering national strategies and key decisions.

The Guidelines on transition to digital terrestrial television broadcasting (DTTB) and introduction of mobile television (MTV) are intended to provide information and recommendations on policy, regulation, technologies, network planning, customer awareness and business planning for the smooth introduction of DTTB and MTV. Included in the Guidelines are:

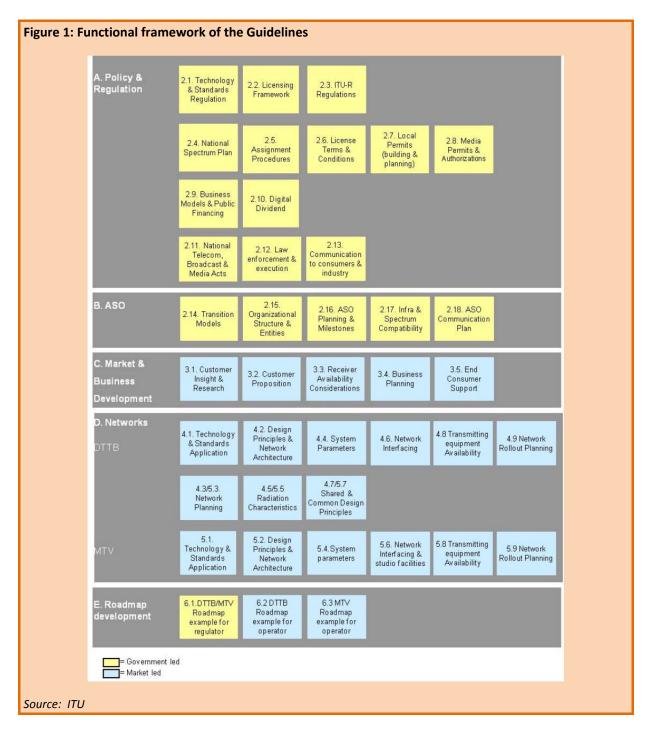
- options for policy and technology choices;
- context and introduction to the policy and technology choices;
- relevancy and impact of choices;
- cost/benefit analysis;
- implementation guidelines;
- generic roadmaps and main activities;
- documentation references.

The Guidelines have been developed on the basis of the World Telecommunication Development Conference (WTDC-06 and WDTC-10) instructions and with the support of ITU, the Korea Communications Commission (KCC), Republic of Korea and the Ministry of Internal Affairs and Communications (MIC) in Japan.

The first edition of the Guidelines was published in 2010 and was the result of an ITU project on the transition from analogue to digital broadcasting in Africa as a part of ITU/BDT activities on the implementation of regional initiatives projects approved by WTDC-06. All African countries are situated in the planning area of the Geneva 2006 Agreement (GE06); therefore the provisions of the GE06 Agreement were an integral part of the Guidelines. However, most sections of the first edition of the Guidelines were applicable in all regions.

The second edition of the Guidelines was published in 2012 and contained a number of additions particularly relevant to the Asia-Pacific region, following the initiatives approved by WTDC-10. In the Asia-Pacific region the need arose for Guidelines that not only deal with DTTB delivery but also programme production and more; in particular, digital archiving. For that reason an annex was added containing Guidelines for migration of broadcast archives from analogue to digital.

The current edition of the Guidelines is a complete review of the previous editions and is applicable to all regions. This edition has been updated with the latest ITU-R Recommendations and reports, including Recommendations regarding the five DTTB systems that are in use worldwide, the decisions taken at WRC-12 and the experience gained in the applications of the Guidelines in the ITU/BDT analogue to digital roadmap projects. Furthermore annexes have been added with information on satellite TV, cable TV and IPTV. These delivery means are competing with DTTB in many countries, but could be also supportive to DTTB services e.g. in providing interactive services.



Functional framework of the Guidelines

The Guidelines follow a comprehensive functional framework indicating the decisions to be considered for the introduction of DTTB and MTV. It consists of five functional layers:

Α	Policy and regulation
В	Analogue switch-off (ASO)
С	Market and business development
D	Networks (DTTB and MTV)
Е	Roadmap development

In each layer a number of functional building blocks have been identified (see Figure 1).

In general, layers A to E are either government led or market led. However in some countries different roles and tasks can be assumed by the different players.

For each of the functional building blocks shown in Figure 1, guidelines on key topics and choices are provided. These guidelines are described in sections with corresponding numbers. Each section includes implementation guidelines assisting in making the right trade-offs, applicable to the local situation.

Many of the key topics and choices identified for each of the functional building blocks are interrelated to other functional building blocks in the functional framework. In a number of cases a trade-off should be made between several key topics or choices. The final choice can often only be made after several iterations.

Brief description of each part and annex

The report has been structured in six parts and seven annexes. The relation between the parts and annexes of the Guidelines and the functional framework is shown in Table 1.

Part	Subject	Related layer of functional framework
Part 1	Introduction	_
Part 2	Policy and regulation	Layer A and B
Part 3	Market and business development	Layer C
Part 4	DTTB networks	Layer D regarding DTTB
Part 5	MTV networks	Layer D regarding MTV
Part 6	Roadmap development	Layer E
Annex A	Implementation of the GE06 Agreement	Layer D
Annex B	More detailed information on some regulatory topics	Layer A and B
Annex C	More detailed information on some DTTB network topics	Layer D regarding DTTB
Annex D	More detailed information on some MTV network topics	Layer D regarding MTV
Annex E	Guidelines for migration of broadcast archives from analogue to digital	-
Annex F	Television broadcasting via satellite	Layer B and C
Annex G	Television broadcasting via cable TV networks and IPTV	Layer B and C

Table 1: Structure of the report

Part 1 (Introduction) provides general information on the functional framework of the Guidelines, guidance to readers, advantages of digital switch-over and references to the status of digital switch-over.

Part 2 (Policy and regulation) provides an overview of the key issues and choices the regulator faces when formulating DTTB, MTV or ASO policy objectives. In striving for a rapid service up-take and development of the DTTB and MTV markets, the regulator will implement such policies by issuing information, funds, rights, licences and permits to (qualified) market parties in compliance with the relevant legislation. Because of the specific nature and the one-off character of the ASO, this process is dealt with in five separate and consecutive sections (relating to functional building blocks 2.14 to 2.18), which can be read independently from the other sections in Part 2.

Part 3 (Market and business development) provides an overview of the key business issues and choices DTTB and MTV service providers/broadcast network operators face when planning the commercial launch of these services. Part 3 includes a set of business activities and tools for defining the DTTB/MTV service proposition and associated business case and plan, taking into account identified demand drivers, service barriers, financial feasibility and more specifically receiver availability and customer support issues.

This part is not only intended for commercial market parties seeking an acceptable return on their investments, such as DTTB/MTV service providers and broadcast network operators. The national regulators should also acquire an understanding of the key business issues and choices at hand as to define realistic DTTB/MTV policies and licence conditions.

Commercial parties will seek a DTTB or MTV service proposition which fulfils a consumer demand, generating sufficient revenues (either advertising of subscription based). In contrast, public service broadcasters (PSB) normally meet the objectives of public interest in the field of information and culture.

That is why they are interested in viewing ratings, high population coverage and mainly prefer unencrypted broadcasting. Market and business development works differently as they have to fulfil primarily these 'information and culture' objectives. However, PSBs can also have advertising-based income and some of the topics addressed in this Part might also be relevant for PSBs.

Parts 4 and 5 (DTTB networks and MTV networks respectively) cover functional building blocks 4.1 to 4.9 and 5.1 to 5.9 (see Figure 1) and contain guidelines on key issues and choices operators face when planning transmitter networks for broadcasting DTTB and MTV services. Choices in network architecture, frequency planning, network planning, roll out planning and network operation should be made in such a way that the licence conditions are fulfilled and that the business objectives are met. In doing so, optimum solutions should be found between, often conflicting, requirements regarding picture and sound quality, coverage quality and transmission costs.

Many of the issues regarding technology choices, frequency planning and network planning may also be relevant to regulators, depending on the roles and responsibilities of regulator and network operator in a country.

DTTB and MTV networks are described in separate parts because in general there are different key topics and choices involved regarding technology, regulation and business aspects. However, because of the similarity of the issues, guidelines regarding functional building blocks 5.3, 5.5 and 5.7 (see Figure 1) relating to MTV networks, are described in the corresponding sections in Part 4 (DTTB networks).

Part 6 (Roadmap development) deals with the development a set of generic roadmaps regarding the whole process of transition to DTTB and introduction of MTV by the regulator and DTTB and MTV network operator and service provider. This part covers functional building blocks 6.1 to 6.3 (see Figure 1). In addition, information is given on the development of a national roadmap, illustrated with examples from national roadmaps that have been prepared with ITU assistance.

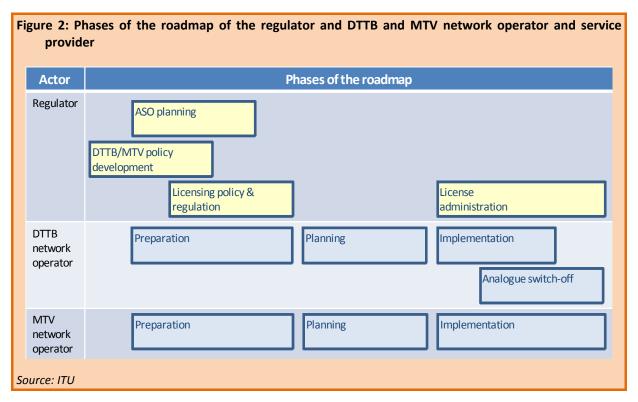
A roadmap is a plan that matches short-term and long-term goals and indicates the main activities needed to meet these goals. Developing a roadmap has three major uses:

- 1 It helps to reach consensus about the requirements and solutions for transition to DTTB and introduction of MTV.
- 2 It provides a mechanism to help forecast the key milestones for the transition to DTTB and introduction of MTV.
- It provides a framework to help plan and coordinate the steps needed for transition to DTTB and introduction of MTV.

The roadmap for regulator, DTTB and MTV operator consists of a number of phases. Figure 2 shows these phases and the order of the phases. The roadmap is constructed by placing the relevant functional building blocks in each phase in a logical order and in a time frame. In practice the selection of functional building blocks may differ from country to country, depending on the roles of the regulator, network operator and service provider, in particular regarding the responsibility for technology choices and network planning.

It is important to adopt realistic time schedules, noting that in DTTB deployed countries the period between DTTB launch and completion of analogue TV switch-off ranges from 3 to 14 years.

There is no clear marker that will indicate the start of the process. The start could be triggered by the wish of broadcasters to introduce DTTB or MTV services, or by mobile operators wishing to use part of the "Digital Dividend" for mobile services. Sometimes governments initiate the process, taking into account that the GE06 Agreement stipulates that the transition period ends on 17 June 2015 and for a number of countries¹ on 17 June 2020 with regard to Band III. The process ends when all analogue television services are switched-off and all DTTB and MTV stations are in operation without any restrictions that were necessary to protect analogue television services. However, further evolution of DTTB and MTV networks is likely to take place resulting from the introduction of new services, regulatory obligations or technology changes.



Annex A (Implementation of the GE06 Agreement) gives information and additional guidelines in relation to GE06 implementation. In countries situated in the GE06 planning area, the provisions of GE06 are of great importance in applying the Guidelines described in Parts 4 and 5. The entries in the digital TV plan annexed to the GE06 Agreement are the basis for the national DTTB frequency plan (as well as the MTV frequency plan) in countries situated in the GE06 planning area. However the digital plan is not necessarily compatible with the analogue TV plan annexed to the GE06 Agreement. Annex A indicates that during transition the operation of DTTB stations is possibly restricted or totally blocked because analogue TV services in the same country and in neighbouring countries need to be protected.

The GE06 Agreement is very flexible in its implementation. In order to achieve this flexibility, a set of rather complex procedures for implementation (Article 5 of the GE06 Agreement) and modification of the plan (Article 4 of the GE06 Agreement) were agreed. Annex A also describes these procedures and the impact it may have on the station characteristics and coverage.

ix

The countries with a prolonged transition period in Band III are listed in footnote 7 related to Article 12 of the Geneva 2006 Agreement.

Annex B (More detailed information on some regulatory topics) gives more detailed information regarding spectrum regulation and describes:

- 1. overview of spectrum management approaches;
- 2. economic aspects of assigning licences;
- 3. assignment procedure steps;
- 4. overview of different auction designs.

Annex C (More detailed information on some DTTB Network topics) gives more detailed information regarding DTTB networks and describes:

- 1. considerations on satellite links used for DTTB signal distribution;
- 2. planning principles, criteria and tools;
- 3. practical considerations on timing of signals in SFN;
- 4. consideration on signal-to-noise ratio of transmitters.

Annex D (More detailed information on some MTV Network topics) gives more detailed information regarding MTV networks and describes:

- 1. testing of transmission equipment;
- 2. measurement system for MTV and field measurement case examples.
- 3. MTV status in some countries

Annex E (Guidelines for migration of broadcast archives from analogue to digital) is intended as a basis upon which users can develop a roadmap for the migration of their archives from analogue to digital. Much of the material contained in these archives may be of significant historical and cultural significance to the countries in which it was created. ITU and other UN agencies have long recognized the importance of preservation of this material, and the World Telecommunications Development Conference (WTDC-10) identified assistance to broadcasters in the migration of archives from analogue to digital as a broadcasting development priority.

These guidelines focus on the broader strategic and operational questions of archives migration, including the benefits that can flow from migration in addition to the basic proposition of preservation of historical programme content. These guidelines do not attempt to provide the technical solutions to archives migration because those solutions will depend very much on local needs, resources, and available funds.

Annex F (Television broadcasting via satellite) focuses on the broader strategic and operational questions of satellite TV and is intended to obtain insight in the prospects of an alternative means of television delivery. Satellite broadcasting may have an impact on DTTB and ASO (analogue switch-off) regulation and on market and business development regarding the DSO (digital switch-over) process.

Annex G (Television broadcasting via cable TV networks and IPTV) provides information on IPTV, cable TV and broadcasting via telecommunication networks to give insight in the prospects of alternative means of television delivery. These alternative delivery means may have an impact on DTTB and ASO (analogue switch-off) regulation and on market and business development regarding the DSO (digital switch-over) process.

Conclusions

The transition to DTTB and the introduction of MTV services is a complex process, involving decisions on key topics and choices of 41 functional building blocks. In a practical situation, a number of decisions may have already been taken. Perhaps some decisions may need to be reviewed when applying the Guidelines.

When implementing the Guidelines it should be taken into account that:

- Transition to DTTB and introduction of MTV will benefit regulators, service providers, network
 operators and consumer electronics manufacturers. However, ultimately the market will
 determine the success of the services that are offered.
- DTTB and MTV networks may need to be modified in the future because of changing viewer needs, new technologies and services.
- Regulatory frameworks, service offerings and network configurations are likely to be different from country to country, taking into account national (political) priorities, market circumstances, geography, and population distribution.

Independent of national variations, experience has shown that it is essential to meet a number of conditions to achieve a successful transition to DTTB and the introduction of MTV services, including:

- strong leadership from government;
- firm decision that sets the analogue TV switch-off date;
- close cooperation between the regulator and market parties;
- clear and timely regulatory framework (including decisions on the "digital dividend");
- adequate information and assistance to viewers.

Table of contents

1.1	Functional framework
1.2	Guidance to readers
1.3	Advantage of digital broadcasting transition
1.4	Status of digital switch-over
2 – Po	licy and regulation
2.1	Technology and standards regulations
	2.1.1 Technology and standards policy trade-offs
	2.1.2 Technology and standards choices for DTTB and MTV
	2.1.3 Implementation guidelines
2.2	Licensing framework
	2.2.1 General licensing framework for television services
	2.2.2 Licensing framework for DTTB and MTV
	2.2.3 Licensing public broadcasters for DTTB and MTV
	2.2.4 Implementation guidelines
2.3	ITU-R regulations
	2.3.1 The international context of the ITU-R regulations
	2.3.2 Applicability and implications of the GE06 plan and ITU-RR
	2.3.3 Implementation guidelines
2.4	National spectrum plan
	2.4.1 The context of the national spectrum plan
	2.4.2 Planning current and future DTTB and MTV spectrum use
	2.4.3 National spectrum plan publication and DTTB/MTV introduction
	2.4.4 General approaches for pricing spectrum usage
	2.4.5 Implementation guidelines
2.5	Assignment procedures
	2.5.1 Basic assigned instruments and procedures
	2.5.2 Assignment procedures for DTTB and MTV services
	2.5.3 Implementation guidelines
2.6	License terms and conditions
	2.6.1 Licensing and fair competition rules
	2.6.2 Frequency licence terms and conditions
	2.6.3 Implementation guidelines
2.7	Local permits (building and planning)
	2.7.1 Economics of rolling out transmitter sites
	2.7.2 Instruments to facilitate transmitter site erection
	2.7.3 Implementation guidelines

		Page
2.8	Media permits and authorizations	63 63
	2.8.2 Broadcast licensing requirements	64
	2.8.3 Implementation guidelines	65
2.9	Business models and public financing	66
	2.9.1 General PSB financing models and sourcing	67
	2.9.2 DTTB specific financing issues	68
	2.9.3 Implementation guidelines	69
2.10	Digital dividend	69
	2.10.1 Definition of the digital dividend and its application	70
	2.10.2 Determining the size of the digital dividend	72
	2.10.3 Digital dividend options	73
	2.10.4 Implementation guidelines	75
2.11	National telecom, broadcast and media act	76
	2.11.1 Check compliancy with telecommunication, broadcast and media acts	76
	2.11.2 Checking compliancy with other legislation	77
2.11.3	3 Implementation guidelines	82
2.12	Law enforcement and execution	84
	2.12.1 Centralized and segmented models	84
	2.12.2 Impact of convergence	86
	2.12.3 Implementation guidelines	88
2.13	Communication to end-consumers and industry	89
	2.13.1 Scope of government led communications	89
	2.13.2 DTTB/MTV communication moments and topics	91
	2.13.3 Implementation guidelines	92
2.14	Transition models	93
	2.14.1 ASO objectives and hurdles	94
	2.14.2 ASO factors	95
	2.14.3 ASO transition models	98
	2.14.4 Implementation guidelines	100
2.15	Organizational structures and entities	101
	2.15.1 Key success factors for ASO	102
	2.15.2 Organizational ASO structures and entities	104
	2.15.3 ASO costs and support	106
	2.15.4 Implementation guidelines	109
2.16	ASO planning and milestones	110
	2.16.1 Outlining the ASO planning	110
	2.16.2 Overall ASO planning set-up	112
	2.16.3 ASO planning phases	113
	2.16.4 Implementation guidelines	114

	2.17	Infrastructure and spectrum compatibility
		2.17.1 Scoping incompatibility
		2.17.2 Implementation guidelines
	2.18	ASO communication plan
		2.18.1 Communication strategy and messages
		2.18.2 Communication tools
		2.18.3 Implementation guidelines
Part	3 – Ma	rket and business development
	3.1	Customer insight and research
		3.1.1 Overview of the DTTB and MTV markets
		3.1.2 Market research methods
		3.1.3 Implementation guidelines
	3.2	Customer proposition
		3.2.1 DTTB competitive advantage and related service proposition attributes
		3.2.2 MTV competitive advantage and related service proposition attributes
		3.2.3 Implementation guidelines
	3.3	Receiver availability considerations
	3.3	3.3.1 DTTB functional receiver requirements and availability
		3.3.2 MTV function receiver requirements and availability
		3.3.3 Implementation guidelines
	3.4	Business planning
		3.4.1 Business models for DTTB services
		3.4.2 Business models for MTV services
		3.4.3 Example business cases
		3.4.4 Implementation guidelines
	3.5	End-consumer support
		3.5.1 Customer call centre operations
		3.5.2 Retail shops and other channels
		3.5.3 Tools to check service availability
		3.5.4 Smart card and service activation
		3.5.5 Implementation guidelines
Part	4 – DT1	TB networks
	4.1	Technology and standards
		4.1.1 Technical tests to evaluate system performance
		4.1.2 SDTV and HDTV specifications
		4.1.3 Selection of DTTB transmission standard
		4.1.4 Compression system
		4.1.5 Encryption system
		4.1.6 Additional applications and features
	4.2	Design principles and network architecture
		4.2.1 Trade-off between network roll-out speed, network costs and network quality

		4.2.2	Main reception mode and defining receiving installations
		4.2.3	Services for national, regional, or local coverage
		4.2.4	Frequency plan and network topology
		4.2.5	Head- end configuration
		4.2.6	System redundancy requirements
		4.2.7	Type of distribution network
	4.3	Netwo	ork planning
		4.3.1	Service trade-off
		4.3.2	SFN or MFN
		4.3.3	Fill-in transmitters
		4.3.4	Feed back to business plan and service proposition
	4.4	Syster	m parameters
		•	Fast Fourier transform size
			Carrier modulation and code rate
			Guard interval
			Choices per DTTB system
	4.5		tion characteristics
	4.5		Transmitter power and antenna gain
			Polarisation
			Use of existing antennas or new antennas
			-
	4.6		ork interfacing
			Interfaces with head-end
			Interfaces in the network
			Radio interface between transmitting station and receiving installations
		4.6.4	Interfaces between transmitter sites and network monitoring system
	4.7	Share	d and common design principles
		4.7.1	Application of shared and common design principles
		4.7.2	Site and antenna sharing
	4.8	Transı	mission equipment availability
		4.8.1	Market research
		4.8.2	Technical specifications
	4.9	Netwo	ork roll-out planning
	1.5		Technical tests
			Implementation plan
			Information to end consumers
		1.5.5	
Part 5	5 – MT	V netw	orks
	5.1	Techn	ology and standards application
			Comparison of MTV Standards
		5.1.2	Selection of MTV standard
		5.1.3	Formation of services and channels
		5.1.4	Case studies of MTV services

		5.1.5 Encryption system
		5.1.6 Additional services
	5.2	Design principles and network architecture
		5.2.1 Trade-off between factors
		5.2.2 Network architecture: Head-end
		5.2.3 Network architecture: transmission
	5.3	Network planning
	5.4	System parameters
		5.4.1 FFT size
		5.4.2 Carrier modulation and code rate
		5.4.3 Guard interval
	5.5	Radiation characteristics
	5.6	Network interfacing and studio facilities of additional services
		5.6.1 Connection between studio and head end system
		5.6.2 Production facility for data services or additional services
	5.7	Shared and common design principles
	5.8	Transmission equipment availability
		5.8.1 Transmission equipment specification
		5.8.2 Market research of transmission equipment
		5.8.3 Testing of transmission equipment
	5.9	Network rollout and planning
		5.9.1 Setting up a pilot system
		5.9.2 Field test and analysis
		5.9.3 Audience research and analysis
		5.9.4 Developing the master plan
	5.10	Additional Information on MTV
Part 6	– Road	lmap development
	6.1	Roadmap for the regulator
		6.1.1 Construction of a roadmap
		6.1.2 Generic roadmap for transition to DTTB and introduction of MTV by a regulator 31
		6.1.3 Implementation guidelines
	6.2	Roadmap for transition to DTTB by a network operator
		6.2.1 Construction of a roadmap
		6.2.2 Generic roadmap for transition to DTTB by a network operator
		6.2.3 Implementation guideline
	6.3	Roadmap for introduction MTV by a network operator
		6.3.1 Construction of a roadmap
		6.3.2 Generic roadmap for introduction of MTV by a network operator
		6.3.3 Implementation guidelines

	6.4	National roadmap development
		6.4.1 Analysis of national TV market
		6.4.2 Formulation of DSO objectives
		6.4.3 Construction of the national roadmap
		6.4.4 Implementation guidelines
Bibli	ograph	y
Usef	ul web	sites
Anne	ex A – (GE06 implementation
	A.1	GE06 plans
	A.2	GE06 compliance of stations in the national frequency plan
		A.2.1 Implementation conditions
		A.2.2 Use of different characteristics of a digital plan entry
		A.2.3 Application of other transmission systems
		A.2.4 Modifications of the GE06 plans
Anne	ex B – I	More information on some regulatory topics
	1.	Overview of spectrum management approaches (section 2.4)
	2.	Economic effects of assigning licences
	3.	Assignment procedure steps
	4.	Overview of different auction designs
Anne	ex C – I	More detailed information on some DTTB network topics
	C.1	Considerations on satellite links used for DTTB signal distribution
	C.2	Planning principles, criteria and tools
	C.3	Practical considerations on timing of signals in SFN
	C.4	Consideration on signal-to-noise ratio of transmitters
Anne	ex D – 1	More information on some MTV network topics
	D.1	Testing of transmission equipment in details
	D.2	Measurement system for MTV and field measurement case examples
	D.3	MTV in Chile: Status of OneSeg services
	D.4	How ATSC mobile TV works
	D.5	Overview of NOTTV mobile TV service in Japan
	D.6	Examples of system parameters data for DVB-H
Anne	ex E – G	Guidelines for migration of broadcast archives from analogue to digital
	E.1	Introduction
	E.2	The concept of digital work flow and archives
	F 3	What material is a candidate for conversion

	E.4	Archives and content strategies
		E.4.1 Access and repurposing content
		E.4.2 Content metadata
	E.5	Storage and preservation of content
		E.5.1 Need for and benefits of migration
		E.5.2 Machine availability
		E.5.3 Digital archives options
		E.5.4 Analogue-Digital
		E.5.5 Digital-Digital
		E.5.6 Preservation of quality, a critical decision
	E.6	Establishing priorities for migration
		E.6.1 Estimating workload
		E.6.2 Managing new content
	E.7	The migration roadmap
		E.7.1 Compile an inventory of content assets
		E.7.2 Assess risk and classify items
		E.7.3 Estimate conversion workload for each group
		E.7.4 Estimation of work hours
		E.7.5 Ingest of new material
		E.7.6 Definition of desired production and archives workflow
		E.7.7 Metadata definition
		E.7.8 Physical storage
		Attachment 1 to Annex E – Example of a digital television archiving project
		Attachment 2 to Annex E – Archiving showcase project Attachment 3 to Annex E – Archiving in Vietnam
		Attachment 4 to Annex E – UNESCO facilitates archiving activity
Ann		elevision broadcasting via satellite
	F.1	Introduction
	F.2	ITU Radio Regulations, Procedures
	F.3	Satellite network design principles and roll-out planning
		F.3.1 System parameters
		F.3.2 Network architecture and planning
		F.3.3 Satellite interference
		F.3.4 Feed for terrestrial television stations via satellites
	F.4	Facilities in broadcasting stations
	F.5	Satellite TV policies and framework
	F.6	Consumer Side, Receivers, Technical Issues
	F.7	Equipment Availability
	F.8	Cease of analogue television broadcasting via satellite
	F.9	Future issues
	F.10	Conclusions

			Page
Ann	ex G – 1	Television delivery via cable TV networks and IPTV	465
	G.1	Introduction	465
	G.2	IPTV domains	465
	G.3	Cable TV	466
		G.3.1 Hybrid fibre coaxial systems	466
		G.3.2 Other cable-based services	467
	G.4	IPTV and cable TV services	467
		G.4.1 Broadcast services	467
		G.4.2 On-demand services	469
		G4.3 Public services	469
	G.5	Quality of Experience (QoE) and Quality of Service (QoS)	470
		G.5.1 Introduction to QoE and QoS	470
		G.5.2 QoE for video and audio	471
		G.5.3 Network OoS parameters affecting OoF	471

Part 1 - Introduction

This report contains guidelines on migration from analogue television to digital terrestrial television broadcasting (DTTB) and introduction of mobile television broadcasting (MTV). The guidelines identify the policy, economic and technology choices to be made and their potential impact on the transition to DTTB and introduction of MTV. Included in the guidelines are the elements related to the choices and information regarding the cost benefit analysis of policy decisions and best practices.

The importance of these topics is stressed by the World Telecommunication Development Conference (WTDC-10). In the Final Acts of WDTC-10 it is stated: "Given the increasing demand for limited radio-frequency resources, efficient spectrum management and the transition from analogue to digital broadcasting are critical issues for policy makers, regulators, broadcasters and other stakeholders."²

"Countries will continue to implement the transition from analogue to digital broadcasting with different time-scales according to their national priorities as well as, where applicable, the deadlines set by the ITU Regional Radiocommunication Conference (RRC-06) and its associated plan and agreement. During the period of this strategic plan, there will be a continuing need, as a high priority, to assist administrators, regulators, broadcasters and other stakeholders in developing countries in researching and supporting the introduction of digital broadcasting. Continued assistance to developing countries on spectrum management will also be a necessity." 3

The first edition of the Guidelines was published in 2010 and was the result of an ITU project on the transition from analogue to digital broadcasting in Africa as a part of ITU/BDT activities on the implementation of regional initiatives projects approved by WTDC-06. All African countries are situated in the planning area of the Geneva 2006 Agreement (GE06); therefore the provisions of the GE06 Agreement were an integral part of the Guidelines. However, most sections of the first edition of the Guidelines were applicable in all regions.

The second edition of the Guidelines was published in 2012 and contained a number of additions particularly relevant to the Asia-Pacific region, following the initiatives approved by WTDC-10. In the Asia-Pacific region the need arose for Guidelines that not only deal with DTTB delivery but also programme production and more in particular digital archiving. For that reason an Annex was added containing Guidelines for migration of broadcast archives from analogue to digital.

The current edition of the Guidelines is a complete review of the previous editions and is applicable to all regions. This edition has been updated with the latest ITU-R Recommendations and reports, including the Recommendations regarding the five DTTB systems that are in use worldwide, the decisions taken at WRC-12 and the experience gained in the applications of the Guidelines in the ITU/BDT roadmap projects. Furthermore Annexes have been added with information on satellite TV, cable TV and IPTV. These delivery means are competing with DTTB in many countries, but could also be supportive to DTTB services e.g. in providing interactive services.

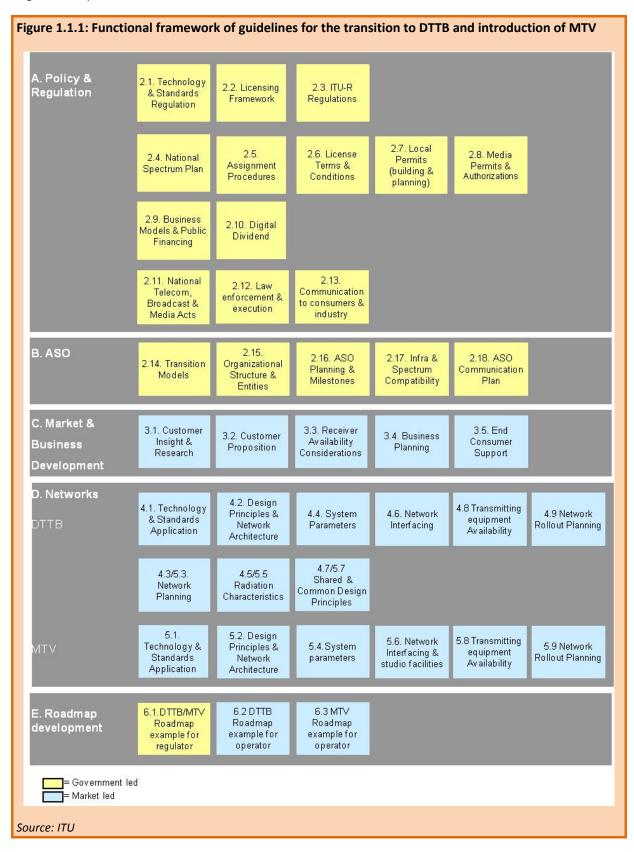
1.1 Functional framework

The guidelines on migration from analogue television to DTTB and introduction of MTV were developed on the basis of a functional framework indicating the functional building blocks to be considered for the transition to DTTB and introduction of MTV.

WTDC Final Acts Annex B, Hyderabad Declaration, declares 12.

WTDC Draft Final Annex A, ITU-D contributions to the ITU strategic plan, Section 6.1.5.

Figure 1.1.1 provides an overview of the functional framework.



This functional framework consists of five layers:

- A. Policy and regulation
- B. Analogue switch-off (ASO)
- C. Market and business development
- D. Networks (DTTB and MTV)
- E. Roadmap development

In each layer a number of functional building blocks have been identified (see Figure 1.1.1). For each of the functional building blocks guidelines on key topics and choices are given in Part 2 to 6.

In general, layers A to E are either government led or market led. However, in some countries government departments or agencies have a broader role than in others. The functions in each layer are described for the situation that exists in most countries that have introduced digital television services. If government departments or agencies have responsibilities for one or more of the functions in layer C or D, the relevant guidelines in these layers should be followed.

Government departments or agencies not having direct responsibility for functions described in layer C or D should nevertheless be aware of the complexity of these functions and the impact government decisions may have on it.

Layer E (Roadmap development) relates to government as well as market led functions.

The objectives of each of the five layers of the functional framework are described in the following:

Layer A: Policy and regulation

Layer A deals with the key issues and choices the regulator faces when either formulating DTTB, MTV or ASO policy objectives. In striving for a rapid service up-take and development of the DTTB and MTV markets, the regulator will implement such policies by issuing information, funds, rights, licences and permits to (qualified) market parties in compliance with the relevant legislation.

Layer B: Analogue switch-off (ASO)

Analogue switch-off (ASO) is the process of turning off the analogue terrestrial television signal and replacing it with a digital signal. It will basically require changing existing television broadcast networks and changing end-consumer television receiver equipment (either connecting a digital converter to the existing television set/recorder or replacing the existing television set for an integrated digital television set and/or digital recorder).

The ASO is a government initiated policy, aiming at gaining spectrum efficiency which will bring consumer benefits (more choice in television channels and services) and industry benefits (new revenue streams and business models). The key objective in the ASO process is reducing the risks of disenfranchising viewers.

Layer C: Market and business development

Layer C deals with key business issues and choices that service providers and broadcast network operators face when planning the commercial launch of DTTB and MTV services.

It includes a set of business activities and tools for defining the DTTB/MTV service proposition and associated business case and plan, taking into account identified demand drivers, service barriers, financial feasibility and more specifically receiver availability and customer support issues.

This layer is not only intended for *commercial* market parties seeking an acceptable return on their investments, such as DTTB or MTV service providers and broadcast network operators. The regulators should also acquire an understanding of the key business issues and choices at hand to enable them to define realistic DTTB/MTV policies and licence conditions.

Commercial parties will seek a DTTB or MTV service proposition which fulfils a consumer demand that generates sufficient revenues (either advertising of subscription based). In contrast, public service broadcasters (PSB) normally meet the objectives of public interest in the field of information and culture. That is why they are interested in viewing ratings, high population coverage and mainly prefer unencrypted broadcasting. Market and business development works differently as it has to fulfil primarily 'information and culture' objectives. However, PSBs can also have advertisement-based income so some of the topics addressed in this section might also be relevant for PSBs.

Layer D: Networks

Layer D deals with key issues and choices operators face when planning transmitter networks for broadcasting DTTB and MTV services. Choices in network architecture, frequency planning, network planning, roll out planning and network operation should be made in such a way that the licence conditions are fulfilled and that the business objectives are met. Optimum solutions should be found between, often conflicting, requirements regarding picture and sound quality, coverage quality and transmission costs. Many of the issues regarding technology choices, frequency planning and network planning may also be relevant to regulators, depending on the roles and responsibilities of the regulator and network operator in a country.

A DTTB network consists basically of one or more head-ends, a distribution network and transmitter sites. The coverage area of a DTTB network is often achieved by one or more high or medium power transmitters and a number of additional low power transmitters. The transmitters may operate in single frequency networks (SFN) or multi frequency networks (MFN) or combinations of SFN and MFN. Normally high and medium power transmitters are fed by satellite, radio relay link or optical fibre. The additional low power transmitters could also be fed by satellite, radio relay link or optical fibre or by off-air reception from a high or medium power transmitter. In practice low power stations are referred to by a variety of terms often related to the way the station is fed or the frequency relation to a high or medium power station (see the Table 1.1). These terms may have different meanings from country to country. In these Guidelines the term "fill-in transmitter" (or in short "fill-in") is used as the general term for a low power station used to supplement the coverage achieved by a high or medium power station, except in cases where one of terms shown in Table 1.1 appears in a quote, table or figure taken from another publication.

Table 1.1: Often used terms for lower transmitters

Input signal	Transmission frequency	Often used terms	
Baseband signal (either fed by fixed link or satellite, or by off-air reception and demodulation)	Different receive and transmit frequency	Fill-in transmitter Re-transmitter	
RF signal (off-air reception)	Different receive and transmit frequency	Fill-in transmitter Transposer Translator Transponder Repeater	
RF signal (off-air reception)	Same receive and transmit frequency	Fill-in transmitter Active reflector On-channel repeater Gap-filler	

Layer E: Roadmap development

Layer E deals with the development a set of generic roadmaps regarding the whole process of transition to DTTB and introduction of MTV. In addition, information is given on the development of a national roadmap, illustrated with examples from national roadmaps that have been prepared with ITU assistance.

A roadmap is a plan that matches short-term and long-term goals and indicates the main activities needed to meet these goals. Developing a roadmap has three major uses:

- 1. It helps to reach consensus about the requirements and solutions for transition to DTTB and introduction of MTV.
- 2. It provides a mechanism to help forecast the key miles stones for the transition to DTTB and introduction of MTV.
- 3. It provides a framework to help plan and coordinate the steps needed for transition to DTTB and introduction of MTV.

In the description of the guidelines, a common set of definitions is used with regards to different involved players. Figure 1.1.2 shows the players and related key activities of the government led layers.

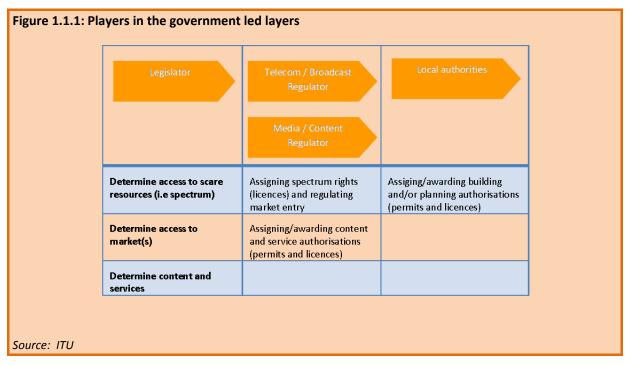


Figure 1.1.3 shows the value chain of the market players and their related key activities.

Content Creation	Content Aggregation	Multiplex Operations	Service Provisioning	Content Distribution	Reception
Create content and services	Aggregate content and service into customer oriented packages and service streams	Divide available spectrum in capacity units and allocate to (type of) services	Support or enhance the operations and marketing of content and services	Provide infrastructure or manage access to or delivery of the content	Provide decoding, navigation and interfacing equipment or software
	Manage advertisers, agencies and advertising space		Manage client relationship and invoice services		
e: ITU					

It is important to note that in practice one organization may encompass more than one role. For example a broadcaster could carry out all activities of a content creator, content aggregator, multiplex operator, service provider and content distributor. Alternatively, a network operator could have for instance the role of multiplex operator, service provider and content distributor.

1.2 Guidance to readers

Structure of the Guidelines

The ITU Guidelines for the transition to DTTB and introduction of MTV are based on a functional framework consisting of five functional layers and for each layer a number of functional building blocks have been identified (Figure 1.1.1). For each block, guidelines are described in Part 2 to Part 6. Sections in Part 2 to Part 6 and the related functional blocks have corresponding numbers.

The Guidelines consists of six parts, seven annexes, a glossary of abbreviations used in the Guidelines and a bibliography. The relation between the parts and annexes of the Guidelines and the functional framework is shown in Table 1.2.

Table 1.2: Structure of the report

Part	Subject	Related layer of functional framework
Part 1	Introduction	_
Part 2	Policy and regulation	Layer A and B
Part 3	Market and business development	Layer C
Part 4	DTTB networks	Layer D regarding DTTB
Part 5	MTV networks	Layer D regarding MTV
Part 6	Roadmap development	Layer E
Annex A	Implementation of the GE06 Agreement	Layer D
Annex B	More detailed information on some regulatory topics	Layer A and B
Annex C	More detailed information on some DTTB network topics	Layer D regarding DTTB
Annex D	More detailed information on some MTV network topics	Layer D regarding MTV
Annex E	Guidelines for migration of broadcast archives from analogue to digital	_
Annex F	Television broadcasting via satellite	Layer B and C
Annex G	Television broadcasting via cable TV networks and IPTV	Layer B and C

The sections in Part 2 to Part 6 are structured as follows:

- an introduction of the functional block;
- sections addressing:
 - key topics and choices identified for the functional block;
 - implementation guidelines.

In Part 2, 3 and 6 the implementation guidelines have been placed at the end of each section. Part 4 and 5 contain a multitude of choices, therefore the implementation guidelines have been placed at the end of each subsection. In the sections many examples are given and the provided footnotes give references to sections or paragraph of documents for additional or more detailed information. These documents are also listed in the Bibliography of this report.

Each section identifies the policy, economic, and technology choices to be made and their potential impact on the transition to DTTB and introduction of MTV., and also include practical guidance on the choices to be made. These Guidelines are of a general nature and cannot be applied without considering local circumstances and the status of DTTB or MTV implementation in each individual country. Nevertheless, in a number of cases a generic choice is given that suits best in most practical circumstances, or alternatively, the best model is provided for some practical circumstances.

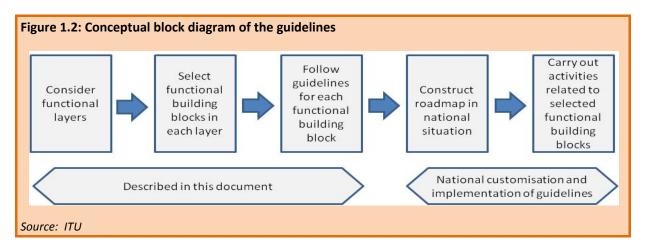
Use of the Guidelines

The development of a national roadmap for transition to digital terrestrial television starts with an analysis of the current TV market structure, analogue TV networks and regulatory framework. The aim or end milestones of the roadmap are identified by formulating the digital switch-over (DSO) objectives. The next step in developing the national roadmap is the selection of the functional building blocks, taking into account the local situation, the responsibility of the players involved and the status of DTTB and MTV implementation, followed by the construction of the roadmap.

Sections 6.1, 6.2 and 6.3 provide generic roadmaps for transition to DTTB and introduction of MTV by a regulator and an operator. Sections 6.4 describes the development of a national roadmap and gives references to the national roadmaps that were developed with ITU assistance in a number of countries in Africa and the Asia and Pacific region.

Finally the choices identified in the relevant guidelines should be considered and the associated activities carried out. In the description of the roadmaps in sections 6.1, 6.2 and 6.3, and in the national roadmaps referred to in section 6.4, the main activities related to the selected functional blocks are indicated.

Figure 1.2 shows a conceptual block diagram on the use of the Guidelines in a national situation after the TV market, current TV networks and regulatory framework have been analysed and the DSO objectives have been formulated.



There is no need to read the guidelines in sequential order in Part 2 to Part 6 and the annexes. The reader can take the sections or functional blocks of his or her interest. Relationships with other sections are indicated in the text. Furthermore, the example roadmaps in Part 6 show how the various functional building blocks interrelate.

1.3 Advantage of digital broadcasting transition

Transition to digital TV is a government initiated policy, aiming at gaining *spectrum efficiency*⁴ which will bring *consumer benefits* (more choice in television channels and services) and *industry benefits* (new revenue streams and business models):

1. Spectrum efficiency: By converting the terrestrial television platform from analogue to digital technology, countries can benefit from the increased spectrum efficiency offered by digital technology. In a given frequency channel, it is possible to broadcast several programme channels (as compared to one in an analogue network)⁵. The more efficient use of spectrum means that some capacity is freed up, the so-called digital dividend⁶, and is available for new services (e.g. new broadcast services or fixed and/mobile services). To ensure the maximum benefits of digital switch-over, countries in a given region should agree to convert to digital broadcasting, if possible through a coordinated frequency plan. Europe, Africa and parts of Asia have agreed to such a plan: the GE06 Agreement⁷.

⁴ ASO spectrum efficiency may result in freeing up spectrum, the so-called digital dividend (see section 2.10).

The exact number of channels depends mainly on the desired picture quality, robustness of the signal, compression technology and type of multiplexing (constant bit rate or statistical multiplexing). For more details see sections 4.1 and 4.4.

⁶ See section 2.10 Digital dividend.

See section 2.3 ITU-R Regulations.

- 2. Customer benefits: The customer benefits derive primarily from the possibility of digital processing and compression, making much more efficient use of the network's capacity. The key benefits include (as compared to analogue television broadcasts):
 - wider choice in TV and radio channels;
 - improved picture and sound quality (depending on the system settings);
 - greater flexibility due to portable and mobile reception;
 - enhanced information services including the electronic programming guide (EPG), enhanced 'teletext' services (with enhanced graphics)⁸ and, where a return path is available, a wide range of interactive services like video-on-demand, e-learning, etc.⁹;
 - future innovative services and lower prices: increasing market competition and innovation thanks to the potential arrival of new entrants at different levels in the value-chain, for instance new service providers, broadcasters, network operators or developers of interactive applications. In addition, switch-over implies specific benefits for some categories of market players: easier storage/processing of content and reduction of transmission costs. Lower prices (per channel) for the end-consumer are possible. International studies have shown that DTTB networks are inherently cheaper than the other two major competing platforms satellite and cable, depending on:
 - i. the required geographical coverage: near 100 per cent coverage will exorbitantly drive-up the DTTB network costs in most cases;
 - ii. market structure: i.e. will the DTTB provider pass on the improved margin to the endconsumer, and;
 - iii. type of network roll-out: a network designed for rooftop is cheaper than an indoornetwork 10.
- 3. *Industry benefits*: With the introduction of DTTB networks a new industry has arisen. A new industry producing:
 - pay-tv services: DTTB networks can easily facilitate a full bouquet of services and incorporate
 a paying/billing system (i.e. conditional access (CA) system);
 - new transmitter networks: including new transmitters, antennas and transport networks;
 - new receiver devices: several devices are being produced in the current market, including set-top-boxes, PC-card integrated receivers, USB-based receivers and integrated digital television sets (IDTVs);
 - conditional access systems: the market comprises already ten global players delivering integrated systems (head-end encryption and smart-card decryption).

See for more details section 4.1 Technology and standards application.

Several set-top-boxes are available on the market with a combined DTTB tuner (e.g. DVB-T) and xDSL modem. The return traffic is handled through the xDSL modem. Especially triple-play providers, like telecom providers, are looking into the possibilities of such an integrated approach. For example, the most popular television channels are delivered through the DTTB network and more individual service, like video-on-demand or theme channels, are delivered through the xDSL network. Many mobile phones equipped with DTTB receiver (e.g. One-Seg services in ISDB-T) are available on the market for bi-directional service in which mobile phone networks are used as return channel.

¹⁰ CDG Eurostudy, "Digital Terrestrial Television in Europe, the Dynamics of Transition", 1998.

1.4 Status of digital switch-over

Digital terrestrial television has been introduced in many countries in all regions and several countries have started switching off analogue TV services. In a number of countries switch-off of analogue terrestrial TV services has been completed.

The digital terrestrial television market is growing fast and information on the status of digital switch-over needs regular updates. For up to date and detailed information on DTTB and MTV implementation in a large number of countries the following websites can be consulted:

- DVB ¹¹, information on adoption and deployment of DVB-T and DVB-T2, in some cases information regarding other DVB standards is also provided;
- DTMB¹²:
- ISDB-T¹³:
- DigiTAG¹⁴, information on DTTB and MTV implementation;
- WorldDMB¹⁵, Information on implementation of DAB, DAB+ and DMB.

Detailed technical information on DTTB implementation in a number of countries in Regions 1, 2 and 3 is also given in Report ITU-R BT. 2140¹⁶.

The implementation differs from country to country. In most countries a large package of television services, sometimes extended with digital radio services, is offered with fixed antennas on the roof. In other countries, the emphasis is on portable indoor reception. Some countries have started HDTV services on the terrestrial platform and many countries plan to do so in the coming years.

Digital terrestrial television has proven its success. Those countries that have not started yet to prepare DTTB and MTV introduction are advised to do so, sooner rather than later, taking into account the end of transition stipulated in the GE06 Agreement (for those countries covered by this agreement).

Noting the priority given by WTDC-10 for the development of migration plans countries need to formulate their plans around economic, service, and spectrum considerations discussed later in these Guidelines. With the rapid transition of many countries to digital, the pace of migration of professional and consumer equipment to digital will accelerate, and analogue equipment will become progressively more expensive and less readily available. Already, rapid fall in the price of digital equipment has taken place as more countries move to digital technology.

See www.dvb.org/about dvb/dvb worldwide/index.xml

See www.dvb.org country updates

See http://dibeg.org.jp for deployment and other information about ISDB-T and One Seg (the MTV implementation of ISDB-T) and see also www.forumsbtvd.or.br

¹⁴ See www.digitag.org/

See www.worlddab.org/country information

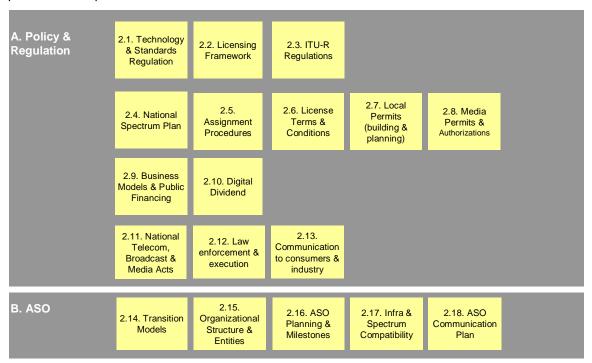
Report ITU-R BT.2140, Transition from analogue to digital terrestrial broadcasting; appendix 1 to part 1 and appendix 1 to part 2.

Part 2 - Policy and regulation

Introduction

This part of the Guidelines will provide an overview of the key issues and choices the regulator faces when either formulating digital terrestrial television broadcasting (DTTB), mobile television (MTV) or analogue switch-off (ASO) policy objectives. In striving for a rapid service up-take and development of the DTTB and MTV markets, the regulator will implement such policies by issuing information, funds, rights, licences and permits to (qualified) market parties in compliance with the relevant legislation.

Part 2 comprises 18 sections and each section corresponds to the detailed functional framework, as depicted in the representation below.



Each section is concluded with implementation guidelines assisting the regulator in making the right trade-offs, applicable to the local situation.

Because of the specific nature and the one-off character of the ASO, this process is dealt with in five separate and consecutive sections (sections 2.14 - 2.18), which can be read independently from the other sections in this part.

2.1 Technology and standards regulations

In this section the key *policy* decisions are outlined on adopting or promoting DTTB/MTV technology and associated standards.

Regulators setting standards for DTTB/MTV services aim to achieve interoperability, economies of scale or safeguarding *Universal Services* (for example if High Definition Television – HDTV has to be provided)¹⁷.

¹⁷ For more details on Universal Service and Universal Access see www.ictregulationtoolkit.org, module 4, infoDev/ITU.

However, setting standards can have a downside too. Careful consideration is required, taking into account local market dynamics and balancing the different pros and cons.

In any policy decision on setting standards, a technical evaluation of the different options available should be included. For this technical evaluation, see section 4.1 for DTTB networks and 5.1 for MTV networks. This section deals with the question of whether a standard should be prescribed/promoted and for what system/network elements.

This section considers:

- 2.1.1 Technology and standards policy trade-offs: policy considerations on DTTB and MTV standards.
- 2.1.2 Technology and standards choices for DTTB and MTV: specific technology choices to be made in regulating the DTTB and MTV markets.
- 2.1.3 Implementation guidelines.

2.1.1 Technology and standards policy trade-offs

Although choosing one single model for setting standards has the benefit of clarity, regulators must very often strike a balance between two basic models:

- mandating single technologies and standards: this model will deliver full harmonization and hence the largest possibilities for reaping the benefits of economies of scale and interoperability; or
- leaving service development entirely to the market: this model will deliver maximum consumer choice

Traditionally there is strong pressure on regulators for both models, from different sides of the industry. However, between the advocates of both strands there is also a common recognition of the downside of both options:

- 1. The mandating of technologies and standards picking a winner by regulation presents high risks of selecting the wrong standard and hence hampering innovation as well as service roll out and take up.
- 2. Complete absence of harmonization can increase the risks of unduly favouring first-movers (e.g. those acquiring a licence first) and technology-led market power. Once such market power is established, regulation can be imposed only by bearing high costs (e.g. for expropriating investors). Moreover, absence of harmonization can lead to (too) fragmented markets, especially for small home markets (and this applies to almost any country considering the global scale of broadcast and telecoms markets for receiver equipment).

As a DTTB or MTV network comprises several elements, it is important to distinguish the key system elements (see also section 4.1). The following key network elements can be distinguished:

- 1. television presentation formats: for DTTB platforms either Standard Definition Television (SDTV) and/or High Definition Television (HDTV) and for MTV platforms a minimum bit rate per service;
- transmission standard: for DTTB platforms e.g. ATSC, DVB-T(2), ISDB-T or DTMB and for MTV platforms T-DMB or OneSeg/ISDB-T;
- 3. compression technology: for DTTB platforms MPEG2 or MPEG4 and for MTV platforms e.g. H264/MPEG-4 AVC or open;
- 4. *conditional access* (CA) system and *digital rights management* (DRM): interoperability between deployed systems for respectively DTTB and MTV platforms;
- 5. application programming interface (API) for additional and interactive services: for DTTB platforms e.g. MHP or proprietary and for MTV platforms specific technical requirements to support integration between DTTB and non-broadcast networks (such as 3/4G mobile).

Observing the different DTTB and MTV markets, it can be concluded that, in most cases, the regulator strikes a balance by not prescribing or recommending technologies/standards for all system/network elements but only for selected elements. For example, the regulator only prescribes the transmission standard but leaves the television presentation format (either SDTV or HDTV) to the market to decide. The regulator tends to prescribe a minimum set of standards so as to leave room for entrepreneurship in developing new services.

In addition, the regulator may not lay down standards for all multiplexes but only for a selected number of multiplexes. For example, the regulator prescribes one multiplex to be operated on the basis of an MTV transmission standard (for the provision of an MTV service) and leaves the rest of the available multiplexes technology neutral. In such a case the licence holder is free to allocate the remaining multiplexes either to a DTTB service or to the MTV services for additional capacity (e.g. more services/channels, better picture quality, etc). Although unlikely, the licence holder could possibly decide to allocate the remaining capacity for MTV services on the basis of a different standard.

Observing the licensing of DTTB and MTV services, the intervention of regulators is still justified if:

- 1. There is a serious risk of *market failure*. The risk of market failure can be higher in situations when:
 - a. Market fragmentation results in too small *local* markets, the following examples can be given:
 - i. Early market launches without set standards could result in a market with multiple standards with high consumer switching costs.
 - ii. Lack of co-ordination between operator bids for example each bidder will not know the technology choice of others and this could lead to an outcome where there are two different technologies used in the market. This could reduce competition between service providers by increasing end-user switching costs. Customers would need to buy a terminal which uses a rival standard when switching service provider.
 - b. Lack of competition¹⁸, the following examples can be given:
 - i. No open wholesale model and/or lack of several licences for example if there is only spectrum available for one licence holder and no specific rules are in place for open and fair access to the DTTB/MTV platform (i.e. wholesale model). Such a situation could limit competition between DTTB/MTV service providers as they do not have equal or fair access to the DTTB/MTV platform.
 - ii. Manufacturers of a technology are heavily subsidizing network equipment prices as to change technology choices. While there may be short term benefits, this may not be, in the longer term, in the interests of consumers if the technology is not open or well supported.
- 2. There are significant *public interest* considerations. Protecting the public interest can play an important role if:
 - a. DTTB or MTV services are defined or considered as a Universal Service and there is a risk of consumer confusion. In general DTTB services are considered to be a Universal Service. In contrast, in most cases, MTV is not considered to be Universal Service at this moment, even

It is important to define the relevant market. This could be different between the DTTB and MTV markets. In general, the DTTB services operate in a market with several other players/platforms offering similar services. In the MTV market the relevant market is considered to be smaller.

in countries like Japan and Korea where MTV services are provided free-to-air¹⁹. The risk of consumer confusion is especially high if:

- i. DTTB licensing is linked to the Analogue switch-off (ASO), the process of turning off the analogue terrestrial television signal and replacing it with a digital signal. In these circumstances, the viewers have to choose a new digital television service and consumer choice should be limited.
- ii. Other digital services are already operational for example, the public broadcaster already broadcasts a DTTB service and has adopted a transmission standard. Launching commercial DTTB service on a different standard could seriously confuse the viewer as they expect a comprehensive television offering including both public and commercial channels.
- b. DTTB (or MTV) services are defined or considered as a Universal Service and the service should be affordable for the largest population possible (hence the lowest prices). Especially in small local markets this could be an important consideration. Setting a standard could help to avoid local market fragmentation and to reap the benefits of a worldwide adopted standard (i.e. economies of scale).
- c. Spectrum efficiency is required. Although regulators always strive for spectrum efficiency, setting a standard might be considered if:
 - i. An inappropriate standard would result in significant spectrum loss for example adopting a certain standard in Region 1 (especially in Europe) leads to spectrum inefficiencies if the standard uses a different channel raster and carrier type (see for more details section 4.1).
 - ii. Multiple standards would result in significant spectrum inefficiencies. For example, in the case no wholesale model is in place and content is duplicated on different DTTB/MTV multiplexes. Especially when available spectrum is very limited, given the demand of broadcasters, setting a single standard could be considered.

2.1.2 Technology and standards choices for DTTB and MTV

Table 2.1.1 provides an overview of the different technology/standards choices regulators made when licensing *DTTB* services. The following key network elements have been distinguished (see also section 4.1):

- 1. television presentation formats (i.e. SDTV and/or HDTV or neutral);
- 2. transmission standard (i.e. stipulated, recommended, or neutral);
- compression technology (i.e. MPEG2 and/or MPEG4 or neutral);
- 4. digital rights management (DRM) or conditional access (CA) system (i.e. interoperability between deployed systems);
- 5. application programming interface (API) for additional and interactive services.

-

¹⁹ For guidelines on defining DTTB and MTV as Universal Services see section 2.1 and 2.2.3.

Table 2.1.1: Technology regulation for DTTB networks

Country	TV presentation format	Transmission standard	Compression technology	DRM/CAS	Additional services
Angola ²⁰	S	S	S	-	S
Belgium ²¹	Neutral	S	Neutral	Neutral	Neutral
Brazil	S	S	S	Neutral	Neutral
Denmark ²²	R	S	Neutral	Neutral	Neutral
Finland ⁶	Neutral	S	Neutral	Neutral	Neutral
France ⁶	S	S	S	Neutral	Neutral
Germany ⁶	Neutral	S	Neutral	Neutral	Neutral
Japan	S	S	S	Neutral	Neutral
Korea	S	S	S	Neutral	Neutral
Netherlands ²³	Neutral	S	Neutral	Neutral	Neutral
Spain ⁶	Neutral	S	Neutral	Neutral	R
Sweden ⁶	Neutral	S	Neutral	Neutral	S
UK ²⁴	Neutral	S	Neutral	Neutral	Neutral
USA ²⁵	S	S	Neutral	Neutral	Neutral

S = Stipulated

R = Recommended

Table 2.1.1 shows, regulators only tend to set standards for television presentation formats and transmission standards. Please note that the introduction dates of the DTTB services in the various countries vary significantly. Countries like Sweden, UK, Spain and the Netherlands were countries to introduce DTTB early. In these countries discussions on television presentation formats and compression technologies were not contemporary topics at that time.

Table 2.1.2 provides an overview of the different technology/standards regulations for *MTV* services in the various countries. Please note that in most European countries as included in the table the MTV service has been discontinued (due to a limited market uptake of the service). The following key network elements have been distinguished (see also section 5.1):

 television presentation format (e.g. QVGA, VGA, HDTV etc. or minimum required bit rate per service);

See ITU assessment report 'Roadmap for the transition from analogue to digital terrestrial television in Angola', April 2012: www.itu.int/ITU-D/tech/digital broadcasting/project-dbafrica/Roadmaps/db afr roadmap Angola.pdf.

See State publications in 'Belgisch Staatsblad' no 2008-3603 (Decision of 18 July 2008) and no. 2008-4155 (Decision of 17 October 2008), respectively the licensing procedure and licence terms and conditions.

See country reports on these countries on www.digitag.org and www.dvb.org.

See State publications in 'Staatscourant' of 4 juli 2001(no. MLB/JZ/2001/28.179) and 31 januari (no. 2002/IVWT/691808), respectively the licensing procedure and licence terms and conditions.

See multiplex licences on www.ofcom.org.uk/tv/ifi/tvlicensing/muxlicensees/.

See FCC Third Periodic Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television, December 31, 2007 on www.fcc.gov.

- 2. transmission standard (stipulated, recommended, or neutral);
- compression technology (e.g. H264/MPEG-4 AVC or neutral);
- digital rights management (DRM) or conditional access (CA) system (i.e. interoperability between deployed systems);
- 5. service integration and additional services (i.e. technical requirements to support integration between DTTB and non-broadcast networks (such as 3/4G mobile).

Table 2.1.2: Technology regulation for MTV networks

Country	TV presentation (min. bit rate)	Transmission standard	Compression technology	DRM/CAS	Service Integration
Angola ²⁶	-	S	S	-	S
Austria	S ²⁷	R	Neutral	Neutral	Neutral
Belgium ²⁸	Neutral	S	Neutral	Neutral	Neutral
Denmark	Neutral	S	Neutral	Neutral	Neutral
Finland	Neutral	S	Neutral	Neutral	Neutral
France	S ²⁹	S	Neutral	Neutral	Neutral
Germany	Neutral	S ³⁰	Neutral	Neutral	Neutral
Italy ³¹	Neutral	S	Neutral	Neutral	Neutral
Japan	Neutral	S	S	Neutral	Neutral
Korea	S	S	S	R	Neutral
Netherlands	Neutral	S ³²	Neutral	Neutral	Neutral
Switzerland	Neutral	R	Neutral	Neutral	Neutral
USA	Neutral	Neutral	Neutral	Neutral	Neutral

S = Stipulated

R = Recommended

Please note that in Angola the MTV service is an Oneseg/ISDB-T service which is an integrated part of the DTTB network. See also ITU assessment report 'Roadmap for the transition from analogue to digital terrestrial television in Angola': www.itu.int/ITU-D/tech/digital_broadcasting/project-dbafrica/Roadmaps/db_afr_roadmap_Angola.pd.

²⁷ In Austria, the regulator required a description of minimum bit rate per service in the tender. Any change of the system parameters has to be announced to the regulator

See State publications in 'Belgisch Staatsblad' no 2008-3603 (Decision of 18th of July 2008) and no. 2008-4155 (Decision of 17th of October 2008), respectively the licensing procedure and licence terms and conditions

In France, the regulator specified the modulation profile and the number of TV programs (16) assuming an average of 250 kbit/s for each. But this has been the result of a consensus among interested parties resulting from the consultation phase prior to the tender.

In Germany, two technology-specific licences were granted, one for T-DMB and the other for DVB-H.

In both Italy and the Netherlands, no special MTV licences were assigned as the current DTTB licences could be used to deploy MTV services.

³² In such a way that the DTTB licence was a licence to operate a DVB system and hence the DVB-H standard had to be adopted.

Table 2.1.2 shows that regulators tend to stipulate only the transmission standard for MTV services. Also, in some cases, the minimal bit rate per service is regulated (as in Austria, France and Korea).

2.1.3 Implementation guidelines

The following *general* guidance can be provided for regulating technologies and standards for DTTB and MTV services:

- 1. In general, when licensing DTTB and MTV services only set standards, if:
 - a. a significant risk of market failure is expected (see above text), and/or;
 - b. safeguarding public interests/Universal Services is required (see above text).
- 2. If deemed necessary to stipulate standards, only set a minimum of standards closely related to the policy objectives and only for those system elements that support the set objectives. Setting standards is aimed at achieving interoperability, economies of scale, and safeguarding Universal Services. Consequently, regulate only the system elements that contribute to those objectives. Such an approach implies for example:
 - a. Regulating only the transmission standard and not the television presentation format, if HDTV is deemed not to be part of the Universal Service. For example, in several countries, the licence holder is free to determine whether HDTV services are going to be included in the service bouquet. In contrast, in France one of the DTTB multiplex (for pay television services) is required to carry HDTV services.
 - b. Regulating only the Application Programming Interface, if additional services (like interactive applications such games, enhanced EPGs and e-learning services) are required to operate across DTTB multiplexes and even across platforms. In Spain and Sweden such requirements are respectively recommended or stipulated³³.
- 3. Check the necessity of (additional) standard setting. Check the applicable (international) regulatory framework on interoperability and open access to platforms. For example, in Europe the Regulatory Framework for Electronic Communications provides already a good basis for regulating interoperability and open access, limiting the necessity for local regulators to set standards for achieving these objectives.
- 4. Consider other regulatory instruments as well. For example, it might be uncertain whether market distortions will occur (fragmented markets and high switching costs). One way of addressing these problems without prescribing operators' choices would be to evaluate multiplex licence bids with reference to criteria such as:
 - a. the promotion of service competition;
 - b. low end user switching costs and;
 - c. the existence of competitive, low cost, handsets.

17

The current trend on setting API standards is that they are considered less urgent for DTTB services as the uptake and possibility of additional services is limited. Also when the available DTTB multiplexes are operated by a single operator stipulating a common API across the multiplexes is unnecessary.

- 5. Either set a standard or do nothing. Avoid actively *promoting* standards as industry pressure will unavoidably force the regulator in the situation to promote all standards and this will increase³⁴:
 - a. confusion in end-consumer markets and;
 - confusion in the market for network equipment and content/service providers.

The following *specific* guidance can be provided for regulating technologies/standards for *DTTB* services:

- 1. In the area covered by the GE06 Agreement, stipulate the DVB-T(2) transmission standard or another standard that provides spectrum compatibility with the GE06 specifications³⁵ when safeguarding the public interest (Universal Service) will be required *and* there is only a small down side risk of setting the wrong DTTB transmission standard:
 - a. Setting a single standard will provide clarity in the (national) market and will reduce consumer confusion in countries which still have to realize the ASO. For a successful ASO consumer choice should be limited and the ASO process itself manageable (not two or more DTTB transmission standards in a country).
 - b. Stipulating the DVB-T(2) standard (or another standard that provides spectrum compatibility) is in line with the GE06 Agreement. Standards that are not compatible with the GE06 specifications will require extra spectrum coordination efforts (which will be lengthy and require cooperation of neighbouring countries) and may result in spectrum inefficiencies. Consequently, setting a different spectrum incompatible standard may result in DTTB service delays and hamper the continuation of the Universal Service for television.
 - c. The country's bordering neighbours that are not covered by the GE06 Agreement may need extra spectrum coordination efforts through bi-lateral or multi-lateral negotiation with these neighbouring countries.
- 2. In regions not covered by the GE06 Agreement, all five DTTB transmission standards recommended by ITU-R, in Recommendations BT.1306 and 1877, have already been deployed in several countries, e.g. ATSC in Korea and the US, DVB-T in Singapore, Australia and New Zealand, ISDB-T in Japan and Maldives, DTMB in China. Each of these transmission standards has substantial consumer equipment markets that make these choices effective. Countries in these regions are not necessarily guided by the principles stated in paragraph 1 above, because the spectrum conditions are different from those specified by the GE06 Agreement. However, smaller countries may need to consider decisions made by larger neighbouring countries as to secure the availability of professional and consumer supplies, maintenance and spares support in their country.

_

See the EC Commission statements around the introduction of mobile television in Europe. Initially the statement was "Member States will be required to encourage the use of DVB-H". Under industry pressure, this statement was changed into "The objective of full interoperability across networks and devices remains important. Developments in the market have shown that interoperability can be achieved when stakeholders act together with a common aim of implementing a technical standard such as DVB-H".

See also Annex A titled GE06 on the implementation of the GE06 Agreement.

- In markets where only one DTTB multiplex operator will be operational (as for example in Finland and Belgium), the risk of having a fragmented local market is less likely and from this point of view setting a transmission standard might not be necessary (not considering avoiding consumer confusion). In such circumstances, the regulator could consider a more technology neutral stance. However, regulators should in general adopt a single consumer standard for DTTB for free-to-air services so that consumers can gain access to these services at lowest cost and inconvenience.
- 4. Only set additional standards for the television presentation format (i.e. HDTV) and compression technology when these are deemed to be necessary because:
 - a. the regulator considers HDTV formats an essential part of a Universal Service and does not believe market players will introduce these services autonomously (given the local market structure), and;
 - b. the regulator believes that having different incompatible compression technologies (like MPEG 2 and 4)³⁶ in the market will result in consumer confusion³⁷.
- 4. Prescribing API standard needs careful investigation on the requirements of a country because:
 - a. the DTTB platform in Europe has proven not to be very attractive for developing interactive services (especially with the increasing number of broadband connections and services in the world, application developers do not tend to develop interactive services for the DTTB platform);
 - b. laying down such standard requirements may or may not increase receiver prices depending on the API standard applied;
 - c. special market or regulatory requirements may apply. For example in Japan requirements such as content protection (digital rights management) and interactive services (quiz programmes, etc.) have been standardized and applied. As well as in Brazil where an API called GINGA has been standardized and applied.

The following *specific* guidance can be provided for regulating technologies/standards for most MTV services that are introduced independently from the DTTB services³⁸:

- 1. Setting a MTV transmission standard might be justified if:
 - a. In the market several service providers will be or are operational and the risk of local market fragmentation is high because:
 - i. MTV licences are assigned to multiple mobile operators or other service providers, and not to a single multiplex operator having one transmission standard, and;
 - ii. cooperation between providers is expected to be low and will not be stipulated in the licensing procedure (e.g. in the public tender).

In France, the regulator assigned licences with the requirement to provide television channels in HDTV quality and laid down mandatory standards for integrated digital television sets to include a DVB-T receiver (1st phase) and MPEG4 compression technology (2nd phase). For more detailed information see the website of the regulator CSA www.csa.fr.

MPEG 2 receivers cannot handle DTTB services compressed in MPEG4 format.

Please note that ISDB-T and DVB-T2 Lite support both DTTB and MTV simultaneously and they should be distinguished from other stand alone MTV systems.

- b. Interoperability is at risk (i.e. if consumers cannot 'roam' their MTV enabled mobile phone between service providers). Interoperability is important in situations where the market is predominantly a pre-paid market (as opposed to post-paid markets where mobile operators can subsidize handsets to an acceptable retail price level).
- 2. Provide room for the MTV licence holder to change/alter transmission technology during the course of the licence period because:
 - a. currently there are several competing transmission standards (like T-DMB, ISDB-T/OneSeg and DVB-T2 Lite) and there is no clear technology 'champion' (yet), and;
 - b. most of the standards don't have production numbers in place to bring consumer prices down for mass market consumption (although there are some exceptions like T-DMB and OneSeg terminals which have reached mass numbers in, respectively, Korea and Japan and Brazil³⁹).
- 3. Although there are some exceptions, in markets with only one MTV service provider or one MTV multiplex operator (with several service providers), the need for setting a MTV standard so as to avoid *consumer confusion*, increase *interoperability* and *economies of scale* is limited because:
 - a. Almost without exception most MTV services are launched on the 'back' of a mobile phone offer and hence are launched by mobile operators. Mobile users tend to select a mobile operator/phone (as opposed to consumers purchasing a television set for DTTB service without considering the provider).
 - b. In post-paid/subscription based MTV markets, the phone is supplied by the mobile operator and interoperability with the MTV network is guaranteed. Mobile users switching between providers will be provided with a new mobile handset. This situation might be different in predominantly pre-paid/'SIM-only' markets (see guidelines below).
 - c. At this stage of the MTV market development without a clear MTV 'winner' and the introduction of competing non-broadcast systems like LTE/4G networks, economies of scale cannot be promoted by setting a standard. The worldwide handset production volumes are still limited (in absolute numbers and in terms of the different handset models). In such a situation, the risk of picking the wrong standard can be high. Moreover, avoiding local market fragmentation could also be avoided by licensing only a single multiplex operator (especially when there is only limited spectrum available).
- 4. When setting a standard for the bearer level (i.e. transmission standard), the regulator could consider combining this with a wholesale model⁴⁰, as this will reap the most economies of scale and spectrum efficiency due to⁴¹:
 - a. one single infrastructure;
 - b. sharing broadcast content, common between the various MTV service providers (while at the same time tailoring the service offering/content to the conditions of the individual provider, thereby leaving room for service differentiation).

3

Some of the largest MTV markets are reported to be in Korea, Japan and Brazil with, respectively, 21.6 million T-DMB terminals in 2009 (Korea), more than 110 million OneSeg terminals in 2011 (Japan). Please note that the viewers have access to the MTV service free of charge.

A model in which only one MTV multiplex operator will be allowed to operate MTV networks, offering all available MTV capacity to any interested MTV service provider.

See TNO study for the European Parliament, "Mobile TV (IP/A/ITRE/FWC/2006-087/LOT 2/C1/SC2)", October 2007.

- 5. In case an operational DTTB licence holder is also allowed to offer MTV services on the basis of his assigned licences (as Japan and Brazil), then depending on the DTTB licence terms and conditions, the MTV standard might be set automatically.
- 6. If standard setting is deemed necessary, only set a standard for the bearer level (transmission standard) and not for other network elements because:
 - a. To resolve interoperability issues between service providers due to the application of proprietary DRM solutions, setting a DRM standard is not necessarily required. For the regulator, it is better to stipulate the application of open standards for DRM (either in the licence terms or the assignment procedure), i.e. the selected DRM solution is not allowed to be embedded in the handset⁴².
 - b. To resolve interoperability issues between service providers for the operations of additional/interactive services, setting an 'API' standard is also not necessarily required. It will suffice for the regulator to stipulate open standards (not handset embedded).
- 7. Do not propose to mandate inputs to picture quality such as frames per second and picture resolution (which is not uncommon in DTTB markets). Different picture formats are appropriate for different services. For example, sports channels may require high resolution and a high number of frames per second while low resolution and low frame rates may be acceptable for news broadcasts. These trade-offs are best to be left to the operator's judgment. It is in the operators' interest to provide good picture quality. Any mandate on picture quality in this instance would limit the flexibility of the mobile TV operator to develop the optimal mix of formats.
- 8. However, the MTV service that aims mainly at mobile reception of the DTTB services (e.g. by having an OneSeg or DVB-T2 Lite service deployed on the back of the DTTB network) mandating inputs to picture quality may be required as regulators should take into consideration the interoperability/interrelationship between both type of services (MTV and DTTB).

2.2 Licensing framework

The licensing framework is the comprehensive set of required licences, authorizations and permits for a market and public introduction of DTTB and MTV services. The objective of any licensing framework should be to actually implement the defined policy objectives for the introduction of DTTB and MTV services, including the analogue switch-off (ASO).

This section is split in four parts:

- 2.2.1 General licensing framework for television services: the three types of rights and associated obligations to assign to market parties. Followed by the key differences between assigning rights for analogue and digital television services (i.e. DTTB and MTV services) and the two basic assignment models.
- 2.2.2 Licensing framework for DTTB and MTV: the various applied assignment models for DTTB and MTV services in the commercial market (as opposed to assigning rights to public broadcasters). Followed by the key drivers behind the framework/model choices.

Please note that CAS based solutions tend to be handset embedded, making the handset provider specific. For example the DRM OMA B-cast solution is SIM card based and does allow handset roaming between service providers.

- 2.2.3 Licensing public broadcasters for DTTB and MTV: issuing licences to public broadcasters is very often based on a separate licensing framework as these rights are assigned by priority (embedded in a separate legal framework/act).
- 2.2.4 Implementation guidelines.

After determining the licensing framework (which rights will be assigned to which entity), the regulator has to design an assignment procedure and execute this procedure. In Annex B a general assignment procedure with detailed steps for either a public tender or auction is included.

2.2.1 General licensing framework for television services

A licensing framework for *any* television services comprises the assignment of three sets of rights (and obligations). These three types of rights apply to analogue and digital television services. However the distribution of those rights over the various market players might be different for digital platforms. The following types of rights can be distinguished:

- 1. Spectrum rights: the right to have access and use a defined part of the radio spectrum in a designated geographical area for a specified time period, which may include obligations such as:
 - a. the obligation to provide television services within a certain time frame (roll-out obligations);
 - b. the obligation to provide a defined portfolio of television services;
 - c. service level obligations, including aspects like broadcast standards, geographical/population coverage, service/network availability, allocated bandwidth/multiplexes per service, etc.
- 2. Broadcast rights: the right or permission to broadcast television content⁴³ on a defined broadcast DTTB/MTV platform in a designated geographical area and for a specified time period, very often both at a programme level (for specific programmes or services often referred to as media/broadcast permit or authorization) and a platform level (i.e. for a bouquet of channels and services often referred to as a broadcast licence). These rights may also have associated obligations such as:
 - a. the obligation to provide a defined portfolio of television services (including 'must carry/provide' and 'price cap' rules);
 - b. the obligation to provide public service broadcasting (PSB)⁴⁴ services (such as a certain level of local news coverage, arts, religious programming, maximum limits on the number of repeats and to be viewed freely);
 - c. service level obligations, including aspects like broadcast standards, geographical/population coverage, service/network availability, allocated bandwidth/multiplexes per service.
- 3. Operating rights: the right to erect and operate a broadcasting infrastructure in a defined geographical area for a specified time period, including aspects such as horizon pollution, environmental and health hazards. These rights can be accompanied by:

-

¹³ Including linear broadcasting of television programs and associated services such as the EPG, subtitling.

Refers to broadcasting intended for the public benefit rather than for purely commercial concerns. The regulator requires that certain television broadcasters fulfil PSB requirements as part of their licence to broadcast.

- a. site sharing obligations: network operators or infrastructure holders (e.g. tower companies) have to provide antenna space (under certain conditions⁴⁵);
- b. antenna sharing obligations: network operators have to provide access to broadcast antennas (provided this is technically possible⁴⁶).

It is important to note that these rights can have different licence forms and definitions. Table 2.2.1 provides an overview of terminology used for the DTTB and MTV licences across the world.

Table 2.2.1: DTTB and MTV licensing terminology

Type of right	License/permit reference	Reference used in this report
Spectrum rights	Frequency/Spectrum licence	X
	Multiplex licence	
	Platform licence	
	Broadcast licence	
	Network operator licence	
Broadcast rights	Media/broadcast authorization/ permit (programme level)	Х
	Broadcast licence (platform level)	Х
Operating rights	Building/Planning permit	X
	Transmitter/EMC licence/permit	X
	Broadcast licence	
	Platform licence	

As described in the introduction (Part 1) of these Guidelines, the value chain for DTTB/MTV services comprises six basic functions, which are the responsibility of associated "players" (as depicted in Figure 2.2.1)⁴⁷. Compared to an analogue television service the digital value chain has an extra function/player: the multiplex operator. By nature of the digital broadcast technology, where multiple programmes or services can be carried on one frequency (i.e. multiplex), assigning the multiplex capacity to the various services is an extra function compared to the analogue broadcast value chain⁴⁸. This extra function is also referred to as managing the functional bandwidth of the multiplex, i.e. assigning access and available capacity to each service. The technical operation of the multiplex can be outsourced to a

In defined cases the network operators are exempt from providing access. For example, in the case where there is no capacity left and/or intended space is reserved/planned for own future operations. For more details on site sharing rules see, for example, the EU Directive 2002/19/EC of the European Parliament and of the Council of 7 March 2002 on access to, and interconnection of, electronic communications networks and associated facilities (Access Directive).

In general, such antenna sharing rules are unknown in the telecommunication market. However, such rules do exist in some broadcast markets (for example in the UK, the Netherlands and Thailand).

Please note that some functions/players in the value chain can be combined in one company or entity. For example cable companies and mobile operators combine service provisioning and content distribution. But also for DTTB/MTV platforms, the multiplex operator function can be combined with content distribution function or the service provisioning function with multiplex operator function.

In the analogue value chain, each frequency can carry only one service (1-to-1 relationship) and the frequency licence holder is very often the broadcaster. In the digital value chain the relationship is 1-to-N and the broadcaster is not necessarily the frequency licence holder.

content distributor (i.e. the broadcast network operator). In Figure 2.2.1 an overview of the value chain is provided.

igure 2.2.1: Function/players in the digital value chain						
Content Creation	Content Aggregation	Multiplex Operations	Service Provisioning	Content Distribution	Reception	
Create content and services	Aggregate content and service into customer oriented packages and service streams	Divide available spectrum in capacity units and allocate to (type of) services	Support or enhance the operations and marketing of content and services	Provide infrastructure or manage access to or delivery of the content	Provide decoding, navigation and interfacing equipment or software	
Gource: ITU	Manage advertisers, agencies and advertising space		Manage client relationship and invoice services			

By having this extra function of the multiplex operator in the value chain, two basic licensing models can be distinguished for DTTB and MTV services:

- 1. Model A: the spectrum rights are assigned to the multiplex operator and this entity can decide the allocation of the available capacity to the various services. In this model the frequency licence holder is allowed to use the defined spectrum and can decide the loading of the multiplex(es), e.g. which broadcasters can get access to the platform. The function of multiplex operator and service provider can be aggregated into one entity/organization. In turn, this organization can outsource the technical operations to a specialized content distributor (i.e. a broadcast network operator). In this model, it can still be required for the individual broadcaster or service provider to get a general broadcast authorization (e.g. by a media authority) for broadcasting television content (very often not defined for a specific platform). This model was applied in countries like the Netherlands (for DTTB and MTV), Belgium (for DTTB and MTV) and the UK (for DTTB and MTV);
- 2. Model B: the spectrum rights are assigned to the content distributor and this entity cannot decide the allocation of the available capacity. In this model the frequency licence holder is only allowed to use the defined spectrum. The regulator decides the loading of the multiplexes by assigning broadcast licences/rights for the DTTB/MTV platform to individual broadcasters and/or service providers (bundling the various broadcast channels into one or several packages, in a separate assignment procedure (very often a public tender). In this model the regulator is the actual multiplex operator, or in other words the functional bandwidth manager. In this model the service provider can be a separate entity from the content distributor (i.e. broadcast network operator). This model was applied in countries like Angola (for DTTB), Germany (for MTV) and Sweden (for DTTB).

Most DTTB/MTV assignment models are derived from these two basic models and vary in the degree to which the frequency licence holder can also manage the capacity of the multiplex. Deciding this degree of freedom is mainly a policy decision and depends on the policy objectives. For example in Model B, a stricter regime could be applied by excluding the spectrum licence holder also from offering DTTB/MTV services himself. Or in model A, the frequency licence holder has to offer some specific content ('must carry') and is just free in allocating the remaining capacity.

Please note that in the case of free-to-air television the service provisioning function is very limited and basically comprises the promotion of the digital platform and providing information about the platform. This service provisioning function is then carried out either by the content aggregator or the content distributor.

Table 2.2.2 provides a schematic overview of possible licensing frameworks.

	DTTB and MTV Value Chain							
Type of right	Content Creator	Content Aggregator	Multiplex Operator	Service Provider	Content Distributor	Device Creator		
Spectrum rights			Х	Х	Х			
Broadcast rights		Х	Х	Х				
Operating rights				Х	Х			

Table 2.2.2: Possible licensing frameworks

2.2.2 Licensing framework for DTTB and MTV

Licensing DTTB and MTV services will involve assigning *all* three types of rights (see section 2.2.1). The regulator will basically check compliancy with the applicable legislation and in turn this will:

- 1. Ensure uninterrupted DTTB and MTV broadcasts with minimum service levels (e.g. availability and coverage). Considering the relatively high level of required investments, such assurance should be provided.
- 2. Ensure that DTTB and MTV broadcasts comply with media legislation. Television broadcasts do have political attention and varying degrees of control are exercised over broadcast content.
- 3. Ensure that DTTB and MTV comply with environmental and health legislation. As DTTB services require relatively large transmitter sites (in some cases to a lesser extent for MTV services)⁴⁹, environmental and health issues will become publicly apparent and have to be dealt with carefully.

Regulators can balance the importance of these rights in different ways, depending on the local situation and objectives. Hence, the applied licensing framework for DTTB and MTV varies from country to country and comes in many different forms and definitions. Table 2.2.3 includes some examples of DTTB and MTV licensing in Europe (initial licensing)⁵⁰.

Broadcast sites will require antenna heights of over 80-100 meters and relatively large transmitter powers (as compared to mobile networks like GSM/UMTS/LTE). However, MTV networks can be rolled out over typical mobile infrastructure as well.

For a more comprehensive overview for DTTB see the website of Digitag (www.digitag.org). Please note that all MTV services have stopped in Europe. However, mobile television services do exist on mobile networks like UMTS/LTE.

Table 2.2.3: Example DTTB and MTV licensing

Country	DTTB/MTV	Type of right	Content Creator	Content Aggregator	Multiplex Operator	Service Provider	Content Distributor	Device Creator
Finland	DTTB	Spectrum			Х		Х	
	(model A) ⁵¹	Broadcast		Х				
		Operating					Х	
Sweden	DTTB	Spectrum			Х			
	(model B) ⁵²	Broadcast		Х				
		Operating					Х	
The UK	DTTB	Spectrum			Х	Х		
	(model A) ⁵³	Broadcast		Х				
		Operating					Х	
Germany	MTV	Spectrum					Х	
	(Model B) ⁵⁴	Broadcast			Х			
		Operating					Х	
Italy	MTV	Spectrum				Х		
	(Model A) ⁵⁵	Broadcast		Х				
		Operating				Х	Х	

The following underlying factors can be identified for having different licensing frameworks, including:

1. Spectrum management objectives: In order to increase spectrum efficiency the regulator would like to avoid content duplication. This would argue for a licensing framework in which either:

In Finland (initial licensing), the spectrum rights were assigned to a multiplex operator who was also the content distributor (the national broadcast network operator Digita), hence the two crosses at the same line. However, strict rules applied to Digita for providing non-discriminatory access and fair pricing.

In Sweden (initial licensing), the spectrum rights were assigned to a multiplex operator (Senda, later Boxer) and the regulator determined the assignment of the broadcast rights for the DTTB platform. Senda outsourced the content distribution to Teracom (the national broadcast network operator). Senda had a difficult start as the broadcast rights were assigned to parties with vested interests in other platforms and consequently a large portion of the platform capacity remained unused. The regulator had to intervene to resolve the problems.

In the UK (initial licensing), the spectrum rights were assigned to a multiplex operator who was also the service provider (Ondigital, later ITV Digital), hence the two crosses at the same line. The content distribution and technical multiplex operations was outsourced to a specialized broadcast network operator NTL Broadcast (later Arqiva).

In Germany (initial licensing), first the broadcast rights for the MTV service were assigned to a multiplex operator, a consortium of investors called Mobile 3.0. Who outsourced its service provisioning to a virtual mobile network operator (Debitel). The spectrum rights were assigned to Media Broadcast (TDF group). Because the consortium did not have the support of the mobile operators nor content providers the launch failed and the broadcast licence was returned to the government.

In Italy, the spectrum rights were assigned to the multiplex operator, who also carried out the service provisioning. In the case of the multiplex operator 3i, the content distribution was carried out by the same company. In the case of TIM and Vodafone, the broadcast network operations were outsourced to Mediaset (a national broadcast network operator).

- the spectrum rights are awarded in combination with an obligation to provide a defined bouquet of channels, for example as proposed in the bid book in a public tender (variant of model A); or
- b. the spectrum rights are award to an independent multiplex operator (functional bandwidth manager) who grants capacity to individual content aggregators in a transparent and non-discriminatory way. Depending on the stipulated capacity assignment rules, control over content could be less (variant of model A or towards model B).
- 2. Competition rules and objectives: the regulator would like to see the introduction of a new competing platform next to a dominant (e.g. satellite or cable) platform. This would argue for a licensing framework in which either:
 - a. the spectrum rights are assigned to an independent multiplex operator and/or service provider (by excluding market parties which already offer television and/or telecommunication service in the end market) and with enough capacity to provide a competitive offering, by aggregating several multiplexes (variant of model A); or
 - b. the broadcast rights and obligations for the DTTB platform are relaxed as compared to the dominant platform. For example, the DTTB service provider is exempt from 'must carry' or 'price cap' rules⁵⁶ (variant of model A).
- 3. *Market structure and environmental objectives*: in order to avoid duplication of infrastructure, the regulator can decide to structure the licensing framework in which either:
 - a. the broadcast rights (for distributing television content on the DTTB or MTV platform) and frequency rights are awarded to separate entities (by assigning only one licence for the frequency and operating rights, the regulator ensures that only one network will be rolledout - variant of model B); or
 - b. the operating rights are put into operation by laying down site and, possibly, antenna sharing obligations. Such an arrangement only 'loosely' avoids infrastructure duplication as, in most cases, it creates only a possibility and not an obligation to share infrastructure (in a variant of model A).
- 4. Media rules and objectives: several objectives are possible. First, the regulator could strive to maintain a 'level playing field' in a defined television market (this may run across the different broadcast platforms, including cable, satellite and terrestrial platforms) and would like to see the same rules applied to each market entrant. Secondly, the regulator would like to see the analogue television services continued onto the digital platform(s). The two different objectives would result in respectively:
 - a. general broadcast authorizations are assigned to content aggregators/broadcasters with the same terms and conditions applicable to the each platform (variant of model A); or
 - b. the frequency rights are assigned to the same entities as the holders of the analogue frequency rights. This may not be uncommon for assigning digital frequency rights, for example, the DTTB spectrum rights in Brazil, Japan, USA and the digital spectrum rights to existing analogue FM licence holders in the UK. Please note that this licensing practice can be a legal pitfall (as new entrants are excluded) and might result in frequency inefficiencies (a variant of model B or a form of assigning by priority), while this licensing practice can contribute to smooth introduction of digital services and avoid confusions to the end-consumers.

-

For details on 'must carry rules' or 'signal carriage obligations' see for example the United States' Telecommunications
Act on www.fcc.gov and for 'price cap' rules see for example European roaming price caps for mobile operators on http://ec.europa.eu

Convergence trends (i.e. industry convergence, referring to the process by which boundaries become blurred between the media, communications and device industries) do have an impact on the current licensing frameworks. Especially in the case of MTV (as it is a form of industry convergence between all three industries), the licensing framework changes towards:

- 1. Broader market definitions: the definition of the *relevant* television market needs to be redefined and hence the applicability of the spectrum and broadcast rights/obligations changes. Also the licensing procedures need to be aligned.
- Less strict rules on the standards and technologies: the spectrum licence holder will have more
 freedom in the choice of service (for example between DTTB and MTV service), the allocated
 capacity per service and the applied standards (although the latter is more related to shortening
 technology life cycle as compared to the spectrum licence duration⁵⁷).

2.2.3 Licensing public broadcasters for DTTB and MTV

In general, public service broadcasting (PSB) refers to broadcasting intended for the public benefit rather than for purely commercial objectives. In most cases the broadcast content is specified in a media or broadcast act and includes aspects such as:

- 1. number of channels and programming hours;
- 2. composition of programming (for example, level of local news coverage, arts and religious programming, maximum limits on the number of repeats, languages, etc.);
- coverage in terms of population and/or geographical areas (very often platform dependent or non-specified);
- 4. access to the PSB content (including cost of reception, may include 'free-to-air' concepts).

The regulator can organize PSB in different ways, depending on the way (a part of) the PSB is funded⁵⁸. In practice two basic forms can be found, which can change or be combined over time:

- 1. a PSB entity is established by government, with defined PSB services, fully or partly funded by public sources (either licensing fees and/or general taxes);
- 2. a commercial/private broadcaster was established, (fully) funded by commercial income (either advertising based and/or subscription based) and has a PSB obligation assigned (either when the broadcast or spectrum rights were granted) which can be funded by the government.

Observing the licensing of DTTB and MTV services across the world, PSB on these new platforms is arranged in the following way:

1. The PSB entity (i.e. the national public broadcaster) is assigned one or two DTTB multiplexes by *priority* (i.e. without any duty to apply for a licence in a competitive bidding procedure like an auction or public tender). Please note that this does not include commercial/private broadcasters with a PSB obligation⁵⁹.

See also sections 2.1 and 2.4.

See also section 2.9 for more details on financing PBS.

Assigning priority rights to commercial entities can lead to serious market distortions. Moreover, it is argued that any PSB entity with advertising income distorts the market and hence should not acquire any priority rights.

- 2. The PSB DTTB multiplexes are assigned at the same time as the time of assigning (a part of) the remaining commercial multiplexes, so as to ensure a complete bouquet of channels (depending on the competitive environment) and to facilitate a joined-up network roll-out and possibility to increase frequency efficiency, or alternatively.
- 3. The PSB DTTB multiplexes are assigned first so as to ensure PSB on the new DTTB platform and to determine the actual roll-out of this platform, independently from any commercial initiatives.
- 4. The PSB channels on the DTTB platform are in most cases free-to-air, although this does not necessarily imply that no conditional access system is applied ⁶⁰.
- 5. For commercial content aggregators (i.e. individual commercial broadcasters) on the DTTB platform no PSB or any other broadcast obligations are levied (as, in most cases, the existing broadcast licence for the analogue service suffices)⁶¹.
- 6. No PSB obligations are assigned to any MTV service provider, nor are MTV multiplexes assigned by priority to the PBS entity as these new MTV services are often considered to be either:
 - a. not a part of a Universal Service, and/or;
 - b. still to be in the early stages of development.

It goes almost without saying, that defining PSB on a DTTB (or MTV if desirable) platform will cost money, especially when coverage obligations are included and the PSB entity rolls out its network first and independently from any commercial initiative.

In the case of DTTB and MTV platforms cost efficiencies can, however, be gained by shared roll-out plans, including:

- 1. sharing multiplex capacity between the PSB entity and the commercial channels. Depending on the defined PSB content the public broadcaster might not utilize the complete PSB multiplex and remaining capacity can be assigned to commercial channels⁶²;
- 2. sharing sites and other common infrastructure like antennas and back-up transmitters;
- 3. applying jointly for building and other local permits.

A conditional access system is applied and the end-consumer needs a smart card although the PSB content can be viewed without paying an access fee for this content. Especially for satellite distribution this is not uncommon (for the purpose of respecting content rights arrangements).

This may cause market distortions in case of DTTB only broadcasters. After ASO, these channels may have the same coverage as the analogue commercial broadcasters with possibly expensive PSB obligations. This will raise the question of how these analogue commercial broadcasters will compete on a level playing field with such DTTB only channels. For more details see the Ofcom review of public service television broadcasting (www.ofcom.org.uk).

Including the PSB multiplex in a statistical multiplexing scheme with commercial multiplexes can further increase operating efficiencies, while detailed arrangements need to be agreed on technical items such as the minimum guaranteed bit rate for each service.

2.2.4 Implementation guidelines

The following guidance can be provided for licensing *DTTB* services:

- 1. Provide a coherent licensing framework in which all three types of rights and obligations are addressed (see section 2.2.1).
- 2. Deciding for either model A or B (see above), depends heavily on the policy objectives:
 - a. Model A provides more room for the spectrum licence holder to leverage its investments as he can change the service bouquet quickly to meet changing market conditions. Please bear in mind that in this model the regulator can still exercise control over the content on the DTTB platform by:
 - i. reserving capacity for the public broadcaster (see section 2.3.2);
 - ii. selecting the 'best' content offering in case of public tender (when assigning the spectrum rights);
 - iii. setting 'must carry' rules for a minimum package of channels;
 - iv. providing general broadcast authorizations to individual broadcasters.
 - b. Model B provides the most control over the content and the regulator has a direct say in the DTTB service. Past experiences have shown that some risks can be attached to this approach. Especially the risk of selecting the 'wrong' content which can result in failing to have the full capacity utilized (by strategic blocking or no agreement on pricing or service levels of the content distribution) or not be able to change the content quickly (this will require a new assignment procedure). Applying this model requires:
 - i. reciprocal assignment procedures for the spectrum and broadcast rights: assign the broadcast rights with the obligation to outsource the roll-out of the network to the 'winner' of the spectrum rights, and the assignment of the spectrum rights with the obligation to roll-out the network;
 - ii. a broadcast assignment procedure in which the applicants include in their bid, 'Letters of Intent' with content providers that they will provide the content when the applicant wins the licence;
 - iii. a rapid procedure for reassigning multiplex capacity.
- 3. Assign, if (legally) possible, the spectrum rights to the entity which bears the network infrastructure investment risks⁶⁴. For investors this will lower the investment risk as they will get control over vital assets and, depending on the licence terms and conditions, could use the rights for alternative purposes.
- 4. Promote a level playing field across the defined television market by requiring the same media authorizations (broadcast rights) for each content aggregator/broadcaster either⁶⁵:

-

For example, in several European countries the DTTB spectrum licence holder has a roll-out obligation without any provisions for acquiring (local) operating rights, resulting in severe roll-out delays as local building permits may not be granted.

This is not necessarily the provider of the transmitter network infrastructure. This may also be the service provider with a long-term distribution contract.

Please note that competition considerations could create exemptions for market parties with significant market power. Especially for parties with significant market power (and with a credible risk of market power abuse) asymmetric rules can be applied such as 'must carry' and 'price cap' rules.

- a. independently of the applied broadcast platform or distribution technology; or
- b. for each platform.
- 5. Avoid a 'deadlock' situation, by assigning spectrum rights for only parts (or slots) of a single multiplex to content aggregators (i.e. television broadcasters). Especially if these spectrum licence holders are then free to select their network provider⁶⁶.

The following guidance can be provided for licensing *MTV* services that are introduced independently of the DTTB services⁶⁷:

- 1. As above for licensing DTTB service.
- 2. Ensure the involvement of the mobile operators in the case of pay or subscription based services⁶⁸, by either:
 - a. assigning the spectrum rights directly to mobile operators, provided there is enough spectrum available and such a policy is in compliance with competition rules; or
 - b. requiring that the bidder for the spectrum rights and/or broadcast rights provides in its bid a contract or letter of intent with one or more mobile operators who will provide the MTV service in the end-market⁶⁹.
- 3. Ensure the involvement of content aggregators or providers by stipulating enclosure of a contract or letter of intent with content aggregators in the bid documents⁷⁰.
- 4. Promote shared multiplex capacity for common broadcast channels in case of frequency scarcity. This will require an independent spectrum licence holder (and network provider) who will assign MTV capacity for at least one multiplex (i.e. the functional bandwidth manager or multiplex operator). In this multiplex the common channels across the different MTV service providers can be facilitated. Any additional capacity should be created to offer the different mobile operators exclusive capacity on the MTV platform for offering their specific or exclusive content.
- 5. In markets with more than one mobile operator avoid assigning all MTV spectrum rights to only one mobile operator. This may create a major barrier for any other mobile operator in the market or entering the market (at a later date). These other operators may be very reluctant to join the MTV platform of their competitor. Regulatory counter measures such as stipulating transparent/non-discriminatory access and fair pricing may not overcome this obstacle⁷¹.

For example, in Spain a deadlock situation arose when partial spectrum rights (i.e. slots on a DAB multiplex) were assigned to various broadcasters, selecting different network operators. An extra intervention was needed to resolve the situation.

MTV service can also be introduced on the back of DTTB networks. For example in the case of ISDB-T and DVB-T2 Lite networks.

Involvement of the mobile operators is crucial as they have control over the client base and arrange the introduction and supply of MTV enabled mobile handsets. Also in the case of pay-tv models and the MTV service is provided through a conditional access system (SIM card based) the involvement of the mobile operator is needed.

Such a requirement was included in the Austrian MTV assignment procedure. Please note that such a requirement did not entail excluding the mobile operators from putting in a bid themselves.

Such a requirement was included for example in the Belgium MTV assignment procedure.

For example, in the Netherlands a vertical market arose when KPN, the incumbent mobile operator, took over Nozema/Digitenne, the DVB licence holder.

The following guidance can be provided for assigning PSB obligations for *DTTB* services:

- 1. Assign by priority at least one DTTB multiplex (or enough multiplex capacity) to the PSB entity so as to safeguard the PSB after ASO. Special attention should be paid to:
 - a. number of services and the DTTB network coverage percentage, as this might vary compared to the coverage percentages of the analogue services;
 - b. any requirements for HDTV content and/or compression schemes (like MPEG4), as this will determine either the picture quality per service or the required multiplex capacity for the PSB services (see also section 4.1);
 - c. receiver installation implications as PSB viewers might have to change their antenna installations. If possible, assign the PSB multiplex to an adjacent channel close to the analogue channels.
- Check the media and/or broadcast legislation for whether this PSB multiplex assignment is compliant with current PSB definitions. Very often the PSB obligation is defined for the analogue terrestrial platform and hence it is legally unclear to what extent such PSB obligations are applicable to DTTB platform.
- 3. Promote joint network roll-outs by assigning the commercial multiplexes at the same time (or closely after) as the time of assigning the PSB multiplexes.
- 4. Carefully define the picture quality of the PSB channels when multiplex capacity is shared with commercial parties (for example by stipulating a minimum constant bit-rate/bandwidth per channel). Because commercial parties generally tend to sacrifice picture quality for an extra number of channels⁷².
- 5. Consider the 'level-playing-field' after ASO for commercial broadcasters with and without PSB obligations.
- 6. Consider the impact of having 'free-to-air' PSB multiplex/channels on the commercial multiplexes. Especially in the case of having a commercial pay DTTB service, a 'free-to-air' PSB package can result in:
 - a. a lower uptake for the commercial DTTB operator, as consumers only view the PSB channels;
 - b. commercial broadcasters (on an advertising business model) in the commercial pay package may claim also a position before the conditional access (i.e. 'free-to-air).
- 7. Check any 'free-to-air' definition in current media or broadcast legislation as this definition might be reconsidered. In the analogue situation 'free-to-air' is often explained as the case where viewers just have to purchase an analogue television set with an antenna in order to receive the PSB services freely without any extra charge. For a DTTB platform this will change as people will have to purchase a decoder and possibly a smart card. Without any adjustments this situation could inflict extra obligations for the government.

The following guidance can be provided for assigning PSB obligations for MTV services:

 Apply or keep the option open for imposing 'must carry rules'. This might become relevant for countries where the mobile platform is or will be the single platform to reach significant portions of the populations.

This might require changing the settings of the entire multiplex from statistical multiplexing to constant bit rate with loss of transport efficiency.

2.3 ITU-R regulations

ITU-R regulations entail the Radio Regulations (RR) and in particular the Table of Frequency Allocations and the relevant provisions of the World Radiocommunication Conference 2012 (WRC-12), as well as the GE06 Agreement and the entries in the associated plans.

With these regulations ITU strives to avoid harmful interference, achieve equipment compatibility and to ensure future spectrum availability for DTTB and MTV. The regulator should formulate its DTTB/MTV policy and regulations to be compliant with these ITU regulations.

While GE06 only applies in Region 1, the normal provisions of the Radio Regulations do apply to coordination of frequency allocations with neighbouring countries etc. This international coordination is somewhat more complex where there is no regional plan (like GE06) for DTTB services against which to plan assignments. This becomes increasingly important where the potential for trans-border interference exists.

The coordination of such plans is further complicated by the co-existence of different transmission standards like ATSC, DTMB, ISDB-T and DVB where there may be different protection criteria compared with a situation with only one transmission standard. However oceans, mountains, and sparsely populated areas (using low power local transmitters) can separate one country from another and provide natural protection for trans-border interference.

Although GE06 only applies in Region 1, some more details are provided in this section because the underlying principles can also be applied at a national regulatory level or for international spectrum coordination between countries (in Regions 2 and 3). Hence, this section includes⁷³:

- 2.3.1 The international context of the ITU-R regulations.
- 2.3.2 Applicability and implications of the GE06 plan and ITU-RR.
- 2.3.3 Implementation guidelines.

2.3.1 The international context of the ITU-R regulations

The ITU regulations, comprising the Constitution and Convention, Radio Regulations, Regional Agreements, provide the framework for the global coordination and management of the radio-frequency spectrum.

The ITU Radio Regulations (RR) constitutes the principle regulatory framework for spectrum management⁷⁴. In compliance with these RR, the Member States undertake to operate and manage radio services in their country. The Radio Regulations have international treaty status and are periodically reviewed (about every three to four years) by World Radiocommunication Conferences (WRC) and Regional Radiocommunication Conferences (RRC).

Relevant for the introduction of DTTB and MTV services, the RR specifies, among other regulations:

1. the Table of Frequency Allocations for the different radio services and their relative status (Article 5);

⁷³ For a comprehensive overview of the GE06 Agreement and its application see annex A "GE06 Implementation".

In addition to the RR, the ITU framework for spectrum management also comprises the Constitution and Convention, stipulating the organizational and administrative procedures and rules between member States. For more detailed information see Report ITU-R SM.2093, "Guidance on the regulatory framework for national spectrum management.

- 2. the maximum values of the power radiated by the radio stations (Articles 21 and 22) and the regulatory procedures (Articles 9, 11, 12) for ensuring compatibility through coordination and notifications;
- 3. the plans giving each country guaranteed access to the spectrum for the operation of certain services. In particular for DTTB and MTV services, the GE06 Agreement adopted at Regional Radiocommunication Conference 2006 (RRC-06)⁷⁵, contains:
 - a. provisions for the terrestrial broadcasting service and other terrestrial services;
 - b. a plan for digital TV and the List of other primary terrestrial services;
- 4. the various administrative provisions, including Article 18 which requires each Member State to grant a licence to any transmitting station to be operated by any private person or any enterprise.

The ITU RR provides national spectrum managers detailed insights into which frequency bands are internationally allocated for broadcasting services in each Region. Special attention should be given to the footnotes in the ITU RR as the provide details on alternative allocations for individual or group of countries. For Region 1 the European Broadcast Union (EBU) regularly publishes a comprehensive report that provides an updated overview of the different frequency bands allocated to broadcasting services, including the application of the ITU RR⁷⁶. Although the report is only focussed on Region 1, it provides an interesting overview of the bands allocated to broadcasting services, including television services.

At a national or regional level the DTTB/MTV spectrum plan could comprise either assignments or allotments:

- 1. Assignments: in assignment planning, a specified channel is assigned to an individual transmitter location with defined transmission characteristics (for example, Effective Radiated Power ERP, antenna height, etc.).
- 2. Allotments: in allotment planning, a specific channel is "given" to an administration to provide coverage over a defined area within its service area, called the allotment area. Transmitter sites and their characteristics are unknown at the planning stage and should be defined at the time of the conversion of the allotment into one or more assignments (e.g. when the regulator provides a licence with the actual assignments or when the licence holder, with assigned allotments, is intended to take a transmitter location into operation).
- 3. Combinations of both.

It is important to note that an allotment will have to result in the actual allowed Effective Radiated Power (ERP) and consequently the density of the network, given the type of service desired (e.g. either rooftop or indoor coverage). An allotment entry may not always constitute a spectrum right that can be deployed into an economical feasible service.

For example, very low powers might result in a required network implementation of many transmitter sites. Depending on several operational factors, such as earning capacity of the intended service, cost sharing with other revenue streams/business, re-use of existing infrastructure, an allotment may not be put into operation in an economically feasible way.

On the 16th of June 2006, the GE06 plan was signed by more than 100 countries.

⁷⁶ See EBU technical report TR 018 titled 'Frequency bands allocated to broadcasting' available on http://tech.ebu.ch/

Regulators should determine what spectrum is going to be assigned for DTTB and MTV, by answering the following three key questions:

- 1. What frequencies or allotments will be assigned for what type of service (for example two allotments/multiplexes for DTTB services and one for MTV services)?
- 2. In what combinations these frequencies or allotments will be assigned (for example two separate allotments/multiplexes to be licensed to two different licence holders or two allotments to one single licence holder)?
- 3. When these frequencies or allotments will be licensed or can be taken into operation?

2.3.2 Applicability and implications of the GE06 plan and ITU-RR

As the GE06 plan only applies in Region 1, spectrum planners in the other Regions need to consider international coordination and their own national plans when conducting the following analysis, as well as any future coordination plans that may emerge as more countries in the region make decisions about digital migration. This section should be read accordingly noting that GE06 does not in Regions 2 and 3.

In determining the application and implications of the GE06 plan and the ITU-RR, the regulator should define the spectrum available for DTTB and MTV services. In defining this available spectrum three basic steps are being carried out:

- analysing and making an inventory of the acquired administrative rights (assessing usability);
- 2. determining the application of these acquired rights in terms of:
 - a. what frequencies or allotments will be assigned for what type of service;
 - b. in what combinations these frequencies or allotments will be assigned;
 - c. when these frequencies or allotments will be assigned or can be taken into operation;
- 3. assessing the service coverage of the frequencies to be assigned⁷⁷.

Step 1

It is important to realize that the included spectrum rights in any plan are of administrative nature and they may be the result of international negotiations. Hence a proper analysis is necessary to determine the applicability of these rights, i.e. whether it is technically and financially feasible to roll-out DTTB and/or MTV networks on the basis of these rights.

Four main sources provide input for making a comprehensive inventory of the included spectrum rights:

- 1. The GE06 plan (if applicable). The plan includes important restrictions and conditions. For example, spectrum rights that can only be assigned or taken into operation after bi-lateral negotiations or discussions with neighbouring Member States⁷⁸.
- 2. Bi-lateral or multi-lateral agreements. (Next to the GE06 plan) various bi-lateral agreements between Member States can be present. These bi-lateral agreements are not known to ITU and hence not included in the GE06 plan. In Europe, for example, some countries agreed bi-laterally the usage of digital broadcast spectrum before the GE06 plan was agreed. Very often these

In the case the regulator would like to stipulate upfront service coverage requirements in the License Terms and Conditions.

For guidelines and help on the interpretation of the GE06 plans, please refer to EBU report, EBU Technical Department, "GE06 – Overview of the second session (RRC-06) and the main features for broadcasters" or EBU report, EBU BPN 083, "Broadcasting aspects relating to the procedures for coordination and plan conformity agreement in the GE06 agreement", November 2007.

- intermediate bi-lateral plans were introduced to make a rapid introduction of DTTB and/or MTV services possible⁷⁹.
- 3. Provisions in the RR for other services (i.e. other than broadcasting services). Very often special provisions apply, protecting defined services in the broadcast bands. For example, radio astronomy might have the status of primary use and is protected from interference from broadcast services (frequencies 608 614 MHz or Band V channel 38 in 8 MHz raster). This protection could apply in the country itself as well as abroad. It is important to determine in which geographical area this protection applies, this could be a limited area. Outside this area a broadcast service can operate, possibly without restrictions.
- 4. An assessment of future WRC or RRCs. For DTTB and MTV services the WRC of 2015 should especially be considered, as it will provide a confirmation of a worldwide mobile allocation and identification for IMT in all three Regions in the band 698-862 MHz⁸⁰.

Step 2

In this step the regulator "translates" the administrative rights into assignable packages of spectrum rights (e.g. several multiplexes per package or specific assignments for each transmitter location). The main factor determining this assembly of packages is the regulator objectives. These objectives can be categorized as follows:

- 1. The realization of a (DTTB) Universal Service. For example, the regulator has the objective to provide a licence for the realization of a (near) nationwide multiplex for the public broadcaster. This would result in selecting lower frequencies (in Band III or IV) for a spectrum package reserved for PSB⁸¹.
- Introduction speed: The regulator might strive for a rapid service roll-out and is intended to include strict roll-out obligations in the spectrum licence. Such an objective would result in including frequencies in a single package without any current restrictions (For example, excluding frequencies that are still in use by other users and the termination of use is dependent on negotiations).
- 3. Service package composition: The regulator aims to provide a spectrum licence on the basis of which the licence holder can compete with other television providers (like cable companies or satellite operators). Such an objective would bring several multiplexes together in one spectrum package so as to have for each transmitter site the same number of frequencies available (and hence to be able to broadcast the same channels across the service area).
- 4. Type of service: For example in the case of MTV in the UHF band⁸², the objective to launch an MTV service would argue for assembling a package comprising only of frequencies below 758 MHz (channel 57 in 8 MHz raster) because this would avoid interference on the handset with the GSM/UMTS receiver and would avoid a future spectrum management conflict related to the Digital Dividend discussion. Alternatively, the objective to launch a DTTB on the basis of

⁷⁹ See for example the multi-lateral Chester Agreement of 1997 which was preceding the GE06 Agreement for 32 countries.

The allocation of these frequencies to IMT is a direct result of the current debate on the digital dividend. For more detail see section 2.10.

Depending on the local (spectrum) situation, this package could comprise a single frequency network – SFN – (i.e. assignment of one frequency in a single geographical area) or a multi frequency network – MFN – or a combination of both. For more details on SFN/MFN planning see section 4.2 and 4.3.

Frequency bands for MTV are different according to standards. For example T-DMB is implemented in the VHF band.

(existing) rooftop antennas, would require packaging frequencies close to the analogue television channels. Having the digital frequencies close to the analogue frequencies on each transmitter station, would avoid viewers to retune or redirect their receiver/antenna installation.

Step 3

This step is optional and depends mainly on whether the regulator would like to award precisely defined assignments. It is not uncommon that the regulator only carries out an initial network planning and leaves the detailed network planning to the licence holder⁸³.

A detailed network planning to predict the network coverage requires considerable resources and knowledge. The calculation should be as accurate as possible otherwise the regulator has to allow a large safety margin in order to avoid unachievable requirements. In this way, drafting a detailed network planning seems only justified for the situation where the regulator would like to award exact assignments rather than allotments. For a detailed network planning some minimal resources are required:

- an accurate and up-to-date population database (i.e. with sufficient accuracy that it can be used to inform the public/viewers whether they will have DTTB/MTV reception, hence the database should be as detailed as possible such as at the level of individual addresses or postcodes);
- planning software and expertise (capable of carry out calculations for either SFN and/or MFN topologies);
- 3. detailed information on existing sites in operation either currently or in the future (not only in the country but also abroad and also including other services in the broadcast bands).

2.3.3 Implementation guidelines

The following guidance can be provided for determining the applicability and implications of the ITU RR and if applicable any regional plans (like the GE06 plan):

- 1. Carry out a step-by-step approach as described in section 2.3.2.
- 2. As a regulator, determine and define your objectives clearly before you start to assemble frequency packages. Otherwise such an assembly exercise will become a pure technical exercise which will not service the public interests.
- 3. Consider carefully the permitted powers and planning/reception conditions. The regulator should clearly define its planning conditions⁸⁴.
- 4. Check assignment or allotment plans with potential network operators or service providers (by consultation). In this way the regulator assures that no licence will be awarded for which the licence holder might claim that it is not executable.

No exact definitions exist for a detailed network planning. However as a working definition one could say that a detailed network planning, is the planning on which basis the licence holder will order its transmitter equipment (i.e. the exact transmitter configuration in terms of antenna diagram and ERP is known).

In the case of GE06, the plan includes detailed planning conditions. However, the regulator is free to draft its own planning conditions. Such situations could arise for specific required services not accurately covered by the GE06 standardized planning conditions or countries not governed by GE06 (Regions 2 and 3).

- 5. As an alternative for conducting a detailed network planning, the regulator could invite potential applicants to determine the maximum service coverage in a public tender procedure (under the condition that the detailed calculations are provided). Successively, the regulator can then select the best planning (either that is highest or closest to a set target) and then attach the predicted network coverage to the licence terms and conditions.
- 6. Only in the case of an assignment planning by the regulator and where the regulator would like to stipulate the coverage clearly upfront, the calculation of a detailed service coverage prediction seems to be justified.

2.4 National spectrum plan

The national spectrum plan reflects the long, medium and short-term planning of the available national spectrum resources for DTTB and MTV services in a particular country. It may also include the stipulated assignment procedures for the various services and a national frequency register, including all the assigned licensees and licensees.

With a national spectrum plan the regulator strives to ensure effective and efficient spectrum usage and compliance with international standards. As well as informing market parties on the current and future (intended) use of spectrum.

This section focus on the planning process and inclusion of the *commercial* DTTB and MTV services in the national spectrum plan. The planning process for licensing of PSB services is often separated and is included in section 2.2.3.

This section includes subsections on:

- 2.4.1 The context of the national spectrum plan.
- 2.4.2 Planning current and future DTTB and MTV spectrum use.
- 2.4.3 General approaches for spectrum usage.
- 2.4.4 Implementation guidelines.

2.4.1 The context of the national spectrum plan

At a national level, the radio-frequency spectrum is considered the state's public domain. As such, it is subject to the state authority and must be managed efficiently so as to be of the greatest benefit to the entire population. As the result of the state's right to manage the spectrum, authorized spectrum users derive the benefits of the right and associated obligations to access and use the spectrum.

The national spectrum plan is the result of the national (long term) planning process for spectrum usages and basically matches *supply* with future market *demand*. The associated planning process spans across all categories of use. Typical usage categories are:

- 1. Federal, including spectrum for the following services:
 - a. military and emergency services;
 - b. public service broadcasting PSB (see section 2.2.3. on licensing PSB).
- 2. Non-Federal (or commercial use), including sub-categories such as:
 - a. mobile (voice and data, including GSM, DCS1800, UMTS, LTE, WiMAX, etc.);
 - b. fixed links (relay services);
 - c. private mobile radio/paging services;
 - d. broadcasting (including terrestrial radio and television services, such as DTTB and MTV, and electronic news gathering services);
 - e. wireless (including wireless telephony, Wifi, cordless microphones, etc.);
 - f. satellite services.
- 3. 'Other', including services such as radio astronomy.

The national spectrum plan (or sometimes also referred to as national frequency plan) is the key instrument for efficient national spectrum management and comprises in most cases (also for DTTB and MTV services):

- 1. The current use of the available spectrum for radio communication (including the spectrum for broadcasting), registered in a National Frequency Register 85. Such a register includes information (per frequency range) on:
 - radio service (i.e. assignments); a.
 - prescribed system (e.g. a DTTB or MTV transmission standard)⁸⁶; b.
 - licensing regime (licence needed or licence free); c.
 - d. license holder (may not be public information);
 - license duration; e.
 - f. required/allowed radio interfaces (e.g. maximum power, channel spacing, etc.);
 - user rights and obligations (such as exclusive use, sharing with equal rights or with priority,
- The planned or intended use of the available spectrum (including the spectrum for DTTB and MTV services), including information (per frequency range) on:
 - see above, except for licence holder;
 - planned assignment procedure;
 - license fees to be paid (i.e. spectrum pricing instruments).

The national spectrum plan may also include the state's spectrum management approach by incorporating:

- 1. the spectrum management objectives, including objectives such as:
 - balanced spectrum usage between the various categories of use (for example between broadcasting and telecommunications)⁸⁷;
 - efficient spectrum usage;
 - harmonization (International) of spectrum assignment and associated consumer equipment;
- the preferred assignment procedure (per type of service or frequency range)⁸⁸; 2.
- the preferred licensing regime (e.g. technology independent licences). 3.

It is advised to update the National Frequency Register in a separate cycle from the national spectrum plan. The planning cycle is much longer for the national spectrum plan (i.e. spectrum management policies and objectives do not change every one or two years). The National Frequency Register should be updated instantaneously when new frequencies are being used or terminated.

If prescribed. In Europe, the USA and elsewhere, technology-free spectrum management approaches are promoted. See for example ECC report 80, Enhancing harmonization and introducing flexibility in the spectrum regulatory framework, March 2006.

See also section 2.10 'Digital dividend'

Preferred assignment procedures per frequency range are often based on an assessment of 'technical' scarcity. Three basic assignment procedures can be distinguished and are commonly applied; First-Come-First-Served (FCFS), public tender and auction (see also section 2.5 'Assignment Procedures').

For more background on general spectrum management approaches (like 'command and control' versus flexible approaches or 'technical driven' versus market based approaches), please refer to the Annex B of these Guidelines.

2.4.2 Planning current and future DTTB and MTV spectrum use

The national (long term) planning process for spectrum management is basically matching *supply* with future market *demand*. Typically the associated planning process spans across all categories of use. For example, the planning can run across the categories *Governmental*⁸⁹, *Non-governmental* and *Other*. This planning process is no different than any other strategic planning process with the following steps in an iterative process⁹⁰:

- 1. determine spectrum requirements for the future use (e.g. by consultation of the market or extensive market analysis);
- 2. assess spectrum availability (e.g. by analysing the National Frequency Register and/or ITU International Frequency List);
- 3. draft planning options (e.g. by apply scenario analysis) and public hearing;
- 4. finalize spectrum plan;
- 5. implement spectrum plan (i.e. apply spectrum management instruments to re-allocate spectrum use).

This planning process can also be applied per category of use or frequency band. The planning steps remain the same. For planning the DTTB and MTV spectrum the same planning steps can be followed.

With an accurate National Frequency Register the current frequency use will be easily identified (see the above step 'Assessing spectrum availability'). In such a case the planning process will focus on assessing future demand. Two basic options exist for assessing this future demand:

- market consultation, and/or;
- 2. market analysis (including for example international studies on DTTB and MTV services and analysing TV viewing reports).

A powerful instrument in any strategic planning process is scenario analysis (applicable for both steps of determining spectrum requirements and drafting planning options). In a scenario analysis external and internal factors are being identified and analysed so as to arrive to the key factors determining future scenarios (ideally having two or three base scenarios by varying a limited set of key factors). ITU-R report SM2015 includes a comprehensive list of factors to be considered. Scenario analysis will help to improve the national frequency planning process by providing insight into:

- 1. key external factors (e.g. number of television households, television advertising spend, deployment of other television platforms such as IPTV/WiMAX, etc.);
- risk factors (which factors can vary the most, or are most unpredictable and have potentially the largest impact – such as early DTTB/MTV licence termination, the licence holder returns licence or goes bankrupt, or the introduction of an unforeseen disruptive technology);
- 3. planning re-tuning opportunities (under which conditions is the planning out-dated results of international frequency planning conference not adopted yet in the national planning, clarity on the 'digital dividend' discussion);

For example, falling into this category is the spectrum for the police forces or military services.

For a more detailed description of the planning process see Report ITU-R SM.2015.

4. mitigation strategies (how can undesired effects/developments be counterbalanced – such as re-farming of current DTTB spectrum usage due to 'Digital Dividend' results⁹¹, ASO).

2.4.3 National spectrum plan publication and DTTB/MTV introduction

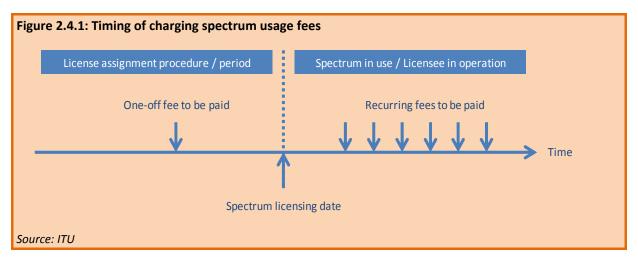
Nowadays, most regulators publish their national spectrum plan (including the spectrum management approach and objectives) and the associated National Frequency Register on the internet and the general public and market players have free access.

As described in the previous section, the plan basically describes the current and future use of the national spectrum⁹². As said, it is important that the provided information is accurate and up-to-date as potential investors will base their market assessments on this information.

For the transition to DTTB it should be noted that the information should be aligned with any publications on the ASO (see sections 2.14 till 2.18).

2.4.4 General approaches for pricing spectrum usage

Before going into any details of pricing spectrum usage it is important to note that the regulator can charge money for spectrum usage at different moments in time. Figure 2.4.1 schematically illustrates this point.



The most common form of paying for spectrum licences (i.e. spectrum usage, on the right side of the above figure) is a cost based system. Spectrum management costs money and these costs are charged to spectrum users or, to be more precise, to spectrum licence holders (as opposed to licence free spectrum usage). By aggregating all spectrum management costs (including overhead costs) and subsequently dividing it between all licence holders, the licence fee is determined.

For example, a DTTB service provider uses frequencies above 790 MHz (channel 60 in 8 MHz raster) and those channels have been allocated to a different category/mobile services.

⁹² In federal states spectrum management tasks and duties can be split and assigned to different (language) regions. This is not unusual for managing broadcast spectrum. For example, in Belgium the broadcast spectrum is managed at a regional level and telecommunication spectrum at a national level. However, as broadcast and telecommunication industries converge, such an approach can be more and more challenging (for example when assigning MTV licences which tend to be more useful when they have nationwide coverage).

In recent years new ways of charging for spectrum usage/licences were introduced. In countries such as the UK, Australia and New Zealand, so called 'administrative incentive pricing' regimes have been introduced.

These pricing regimes are not based on costs but on economic value so as to make spectrum allocation more flexible and return this economic value to society at large. For determining the economic value of licences (i.e. the licence fee to be paid each period) complex models are used based on principles of 'next-best-alternative' or opportunity pricing. As these pricing considerations go beyond the scope of these Guidelines, more details may be obtained from the websites of Ofcom in the UK (www.ofcom.org.uk), Commerce Commission of New Zealand (www.comcom.govt.nz) or ACMA of Australia (www.acma.gov.au).

Next to 'administrative incentive pricing' regimes, which are based on economic value, regulators also introduced the assignment instrument of auctions (left hand side of the above figure). Especially for licensing/assigning mobile service licences, auctions were introduced. In an auction, the bidder assigning the highest economic value to the licence and consequently offering the highest price will acquire the licence.

Auctions are used primarily as an instrument to allocate scarce resources (i.e. spectrum) in a transparent manner and are different from the above mentioned 'administrative incentive pricing' regimes. However, licensees having acquired their licence through an auction and hence having paid the economic value of the licence already should not be charged twice by applying also an administrative pricing regime for that licence. For more details on auctions please refer to section 2.5 of these Guidelines.

License fees based on cost recovery have the following advantages and disadvantages:

Advantages:

- a. transparent and accountable;
- b. relatively easy to determine price levels (as opposed to value based pricing);
- c. in line with 'command and control' spectrum management approach.

Disadvantages:

- a. does not reflect economic value of spectrum and can result in allocating spectrum to users/applications not generating most value for society;
- b. pricing can vary from year to year as the number of licence holders and/or users change of the years (given a certain cost level), generating market resistance/court cases;
- c. needs regular updating as cost levels can change over time;
- d. ignores earning capacity of licence holders (especially the spectrum levies for broadcasters can be relatively high and this can be perceived as unfair).

2.4.5 Implementation guidelines

The following guidance on *spectrum planning* can be provided:

- 1. Execute the DTTB and MTV planning process like a strategic planning exercise.
- 2. The DTTB and MTV planning process should address at least the following key decisions:

- a. The number of multiplexes to assign and in what order: e.g. the regulator can decide to issue the multiplexes in two stages; a first set of multiplexes to test the market and a second set of multiplex to further grow the market⁹³.
- b. Application of the multiplex: in case the regulator would like to set aside multiplexes earmarked for MTV and/or DTTB⁹⁴. Also for the frequencies in Band III, the regulator has to decide whether these frequencies are going to be assigned to MTV, DTTB and/or other services.
- c. Aggregation of multiplexes: the regulator has to decide either how many multiplexes can be aggregated by any single licence holder or issue a fixed set of multiplexes⁹⁵.
- 3. In addition to the listed factors in Report ITU-R SM.2015, consider also the following factors in the DTTB and MTV planning process:
 - a. International frequency allocation: ITU-R, regional plans (like GE06) and any bi-/multi-lateral agreements.
 - b. Digital dividend: i.e. frequency channels in band V between 698-862 MHz are in the process of being allocated to IMT worldwide on co primary basis with broadcasting (see also section 2.10) and allocating spectrum to DTTB/MTV might be risky⁹⁶. Reassigning DTTB/MTV frequencies later to other applications (i.e. IMT) will require spectrum re-farming and this may prove to be costly and lengthy⁹⁷.
 - c. For MTV service, the number of mobile telecom providers: with several MTV service providers in the market, channels offered by all providers might be shared or, in other words, transmitted only once. The planning process should therefore address the interest in mutually exclusive channels and common channels⁹⁸.

Alternatively, the regulator can decide to leave the launching schedule of multiplexes to the licence holder (of a set of multiplexes). In cases where market demand is yet unclear, the licence holder can regulate the demand and supply accordingly to the market developments. For example, in the UK this type of licence was issued to the commercial DAB operator Digital One (see www.ukdigitalradio.com).

For example, the regulator can decide to have a minimum number of multiplexes to be operated for MTV (out of a set of multiplexes and the licence holder is free to decide which multiplex). Alternatively, the regulator can leave it to the licence holder to decide what application will be taken into operation.

⁹⁵ For more details on aggregation rules see section 2.5.

WRC-07 decided to allocate (on co primary basis) the upper part of the UHF band, 790-862 MHz, to the mobile service and to identify it for IMT worldwide. In ITU Region 2 (Americas) and in several countries of Region 3 (Asia- Pacific), the band 698-790 MHz, which was already allocated to the mobile service in these regions, was also identified for IMT. The international harmonization of the digital dividend was further refined by WRC-12. The misalignment in the mobile allocations of the digital dividend spectrum between the three ITU Regions has been corrected, by allocating the band 694-790 MHz to the mobile, except aeronautical mobile, service in Region 1 and identifying it for IMT. Subject to confirmation by WRC-15, this provides a worldwide mobile allocation and identification for IMT in all three Regions in the band 698-862 MHz, notwithstanding that individual member States have to decide the allocation of the digital dividend. For further details see section 2.10.

Assigning the 'digital dividend' later to other applications (IMT) could result in significant costs for the incumbent broadcast network operators as the network might have to be retuned and service quality might degrade. For regulators to avoid picking up the bill for these retuning costs (including costs for extra communication to the public), this specific risk should be included in the DTTB/MTV licence terms and conditions (if the regulator decided to initially assign to DTTB/MTV).

Mobile operators offering MTV would like to differentiate their offers and hence require their own capacity. However, common (popular) channels can be shared between them. This will require an independent multiplex operator.

- d. Joint or shared roll-out of DTTB and MTV: a joint or shared roll-out (between licence holders) can contribute to frequency efficiency, site sharing and content efficiency (harmonized content offering across MTV and DTTB platforms)⁹⁹.
- e. ASO: switching off analogue television services will free-up spectrum (at a later date) and will determine the available multiplexes in the future and hence the future market conditions¹⁰⁰.
- 4. Consult market parties as successful launches of DTTB and MTV service will require active participation of commercial parties and investors, most notably the public broadcaster, commercial broadcasters, content distributors (especially national broadcast network operators) and mobile operators.

The following guidance can be provided for *including DTTB and MTV service introductions* in the national spectrum plan:

- If possible, provide clarity on the digital dividend allocation (especially frequency channels in band V between 698-862 MHz), preferably before assigning any new DTTB and/or MTV frequency licences as it will provide bidding entities insight into the future competitive landscape;
- 2. Be in line with legislation, policy and regulations and the ASO plan as the national spectrum plan is considered to be a key spectrum management instrument, most notably:
 - a. license terms and conditions of assigned spectrum rights for DTTB (and possibly MTV) and future assignments;
 - b. assignment procedures for assigned spectrum rights for DTTB (and possibly MTV) and future assignments;
 - c. policy decisions or intended decisions on the digital dividend;
 - d. licensing framework, especially for acquiring authorizations to broadcast content (see section 2.8 Media permits and authorizations) and to roll-out infrastructure (see section 2.7 Local permits);
 - e. switch over date(s)¹⁰¹.
- 3. Published and/or be updated in the following cases:
 - a. completion of WRCs or any other regional agreements on spectrum planning;
 - decisions on spectrum re-farming operations, especially in relationship to the international digital dividend decisions;
 - c. publication of ASO policies and plans;
 - d. decisions on assigning DTTB and MTV spectrum, either planned (e.g. auctions or public tender) or in case of a 'first-come-first-served' application.

⁹⁹ For more technical details see section 4.7.

 $^{^{100}}$ The ASO process is described in more detail in sections 2.14 and 2.16.

⁽Parts of the) assigned spectrum rights in a licence can be conditional, i.e. can be taken into operation when the analogue frequencies are freed up. Especially in the case of assigning DTTB and/or MTV allotments, the timing of available spectrum can become complex.

The following guidance can be provided on *pricing spectrum* (for recurring fees only):

- 1. It is recommended to apply a relatively 'simple' cost recovery model (over a market based approach such as administrative incentive pricing) when introducing DTTB and MTV services because (unless such a system is already in place):
 - a. of the advantages as mentioned in the previous section;
 - b. determining upfront the market value of any service is very difficult (as experience in the UK, Australia and New Zealand has shown) if such a regime is applied, it really has to be applied to all commercial categories (see also section 2.4.1) because it will be difficult to (legally) separate markets;
 - c. DTTB and MTV services are still in their early phases and vary significantly between countries and consequently 'comparables' are difficult to apply. Determining upfront the market value for this type of service categories will be very challenging (see also the implementation guidelines in section 2.5.3).
- Consider the consequences of setting an administrative charge 'per frequency in operation'.
 Such a pricing regime is very often applied for analogue applications (like FM or TV), but can result in disproportionate charges for a DTTB licence holder¹⁰².
- 3. Avoid mixing different pricing regimes. For example, assigning the spectrum licence through an auction and also charging value based licence fees. This combination will be considered as paying twice for the same value (for society).

2.5 Assignment procedures

This section is primarily focused on assigning spectrum rights for DTTB and MTV services and the common instruments and procedures applied. The different included instruments and procedures can be applied to assigning any right or good. Hence the different instruments and procedures can also be applied for assigning broadcast and operating rights (see section 2.2). Assigning licences will have economic effects and some more detail information on these effects can be found in the Annex B of the Guidelines.

This section comprises:

- 2.5.1 Basic assigned instruments and procedures.
- 2.5.2 Assignment procedures for DTTB and MTV services.
- 2.5.3 Implementation guidelines.

2.5.1 Basic assigned instruments and procedures

In terms of assigning spectrum rights, the following three basic instruments are applied 103:

1. First come first served (FCFS): This means that the applications are appraised individually in the order in which they are submitted (no comparison one with the other). A licence is granted depending on the appraisal. The applications are first of all evaluated in terms of admissibility and then minimum requirements, whereby checks are made to ensure that:

For example a single licence holder operating five multiplexes will bring five frequencies per site on air. A charge per frequency in operation does not reflect the monitoring effort of the regulator and hence this operator can argue that the fee is disproportionably as compared to for example a FM broadcaster.

Sometimes Lottery is also included as an assignment instrument. Licenses were allocated in the United States through lotteries at the beginning of the nineties. After paying an entry fee, interested organizations could acquire a licence through a lottery. However, the entry fee was far less than the value of the spectrum. This resulted in organizations with speculative objectives taking part in the lotteries. In view of this experience, lotteries are not being considered.

- a. the application is consistent with allocation and allotment agreements;
- b. there is sufficient frequency capacity;
- c. the application cannot be 'inserted' into another application (sharing);
- d. The application will not cause (or be affected by) interference;
- e. the applicant has the required expertise and financial resources to offer/execute the proposed service/usage.
- Public tender: In such cases the regulator makes known in advance which requirements it sets for a service/infrastructure and which aspects will be involved in the appraisal of the tenders. The proposals can be submitted either in writing (bid book) or verbally (for example, in the United States verbal procedures are also used: `comparative hearings'). The selection criteria can be divided into three categories:
 - a. the applicant (for example solvency, technical qualifications) and the application (for instance form and layout requirements, fee obligations, timing of submittal);
 - b. the service being offered (for example proposed rates, quality and degree of coverage);
 - c. the technical quality of the system (for instance the frequency usage required and the quality of the proposed infrastructure).
- 3. Auctions: In the case of auctions, frequencies are allocated on the basis of a financial bid for a licence. The regulator lays down a limited number of admissibility criteria (which work as a threshold), but does not get involved in the actual details of the services offered. The bidder who assigns the highest economic value to the licence will bid the highest price¹⁰⁴. Various forms of auctions are possible and have been applied in spectrum management¹⁰⁵:
 - a. Dutch auction (with a descending bidding price);
 - b. the conventional auction, including:
 - i. single round, often sealed or closed bid (first price or second price/Vickery auction);
 - ii. multi-round, open bid (including sequential, standard simultaneous and combination auction)¹⁰⁶.

-

Auctions were introduced to include market based instruments into spectrum management, next to so called administrative incentive pricing of licences (see section 2.4.4).

For more detail on auction design see Handbook of Telecommunications Economics, Martin Cave, Sumit Majumdar and Ingo Vogelsang, Peter Cramton on Spectrum Auctions, Elsevier Science, 2001 and FCC's, Second/Fifth Report and Order on auction design, 1994.

 $^{^{106}\,}$ For the different auction types an overview is included in Annex B of these Guidelines.

In table 2.5.1 an overview is provided of the strength, weaknesses, risks and general applicability of each assignment instrument.

Table 2.5.1: Overview of assignment instruments

Instrument	Strength	Weakness	Risk	Application
FCFS	Fast Simple	Does not promote spectrum efficiency	A more efficient application does not get licence because it is submitted too late/ later	Economic value of the licence is limited Number of licences per year is large and no scarcity is expected in the near future Permits/licences are similar in their application There is no (foreseeable) shortage of spectrum/ frequencies
Public tender	Focus on quality Thorough procedure Regulator retains (most) control over the assignment	Time consuming Not transparent	Risk of appeal procedures Can result in excessive profits for licence holder	The number of licences per year is limited There is a new service or system where several different solutions are (still) possible Grip on the assignment process is necessary (for example in the case of distorted markets) Supplementary requirements are needed on the basis of social and cultural factors (and need to be compared)
Auction	Results in allocation efficiency (in economic terms) Simple Transparent Returns economic value to the government/society	Regulator has less control over end result (depending on the set quality requirements) Auction is an upfront investment and may slow down service investments due to capital market constraints	Collusion between bidders could result in lower proceeds Errors in the auction design and execution could result in the wrong assignment Winner's Curse, bid was too high and service has to be terminated	The number of frequencies to be assigned is less than the available spectrum/licences Quality requirements can be formulated upfront No market distortions that could be jeopardized long term interest of endusers

2.5.2 Assignment procedures for DTTB and MTV services

Observing the DTTB licensing assignment procedures across the world, in almost all countries, the DTTB licences for public service broadcasting (e.g. assigned to a public broadcaster) are assigned by priority and that the DTTB spectrum rights are assigned by means of a public tender or by renewal to commercial parties¹⁰⁷.

In some cases the public tender was accompanied with additional instruments to return (parts of) the economic value to society. The table 2.5.2 an overview is provided:

Table 2.5.2: Applied assignment instruments for commercial DTTB services

Country	Applied policy for existing analogue television licence holders	Applied assignment instrument for other DTTB spectrum rights	Remarks
Australia	Renewal	Public tender	In Australia, most of the digital television spectrum licences were renewals of existing analogue licences ¹⁰⁸
Belgium ¹⁰⁹	By priority	Public tender	Only the public broadcaster had an analogue television licence Additional digital licence fees to be paid on the basis of a percentage of the gross revenues
Brazil	By priority / renewal	Public tender	Most of the DTTB spectrum licences were renewal of existing analogue licences. Currently, new DTTB spectrum licences are assigned by public tender. For Public Broadcasting, however, it is possible to acquire new licences for digital only transmissions.
Denmark ¹¹⁰	By priority	Public tender	Only the public broadcaster had an analogue television licence
Finland	By priority	By priority ¹¹¹	National network operator was assigned the licence with roll-out obligations. The public broadcaster had an analogue television licence and got automatically facilitated on the DTTB platform.

^{&#}x27;By priority' refers to (Public) broadcasters getting their digital licence first, without any competition, to carry-out their digital public service broadcast obligation. This might entail that they can offer more services as compared to the analogue situation. The remaining digital spectrum is then assigned to other commercial interested parties/bidders. 'Renewal' refers to (commercial) analogue television licence holders getting their licence/analogue rights 'converted' to a digital licence enabling them to at least continue broadcasting their current program(s) after ASO. This might result in spectrum efficiencies if the digital licence holder only facilitates a limited number of channels.

¹⁰⁸ For more details see <u>www.acma.gov.au</u>.

See State publications in 'Belgisch Staatsblad' no 2008-3603 (Decision of 18th of July 2008) and no. 2008-4155 (Decision of 17th of October 2008), respectively the licensing procedure and licence terms and conditions.

¹¹⁰ See country reports on <u>www.digitag.org</u> and <u>www.dvb.org</u>

The initial licence was assigned by priority to the national broadcast network operator (Digita, fully government owned), before this operator was acquired by the commercial TDF group. In this way, TDF acquired the DTTB frequency licence. To date there is only one DTTB network operator in Finland.

Country	Applied policy for existing analogue television licence holders	Applied assignment instrument for other DTTB spectrum rights	Remarks
France ¹¹⁰	By priority	Public tender	The public broadcaster and other existing analogue broadcasters got facilitated on the DTTB platform. Please note that this right to be facilitated will expire at the time of the ASO. This does not apply to the public broadcaster.
Germany	By priority	By priority ¹¹²	National network operator was assigned the licence with roll-out obligations. The public broadcaster and other existing analogue broadcasters got facilitated on the DTTB platform. Please note that the public broadcasters (ARD/ZDF) got a full multiplex assigned. Others have to share a multiplex.
Japan	By priority	N.A. (see remarks)	DTTB spectrum licences were issued only to the existing analogue television licence holders
Korea	By priority	Public tender	The public broadcaster and other existing analogue broadcasters got facilitated on the DTTB platform. DTTB license holders have spectrum rights, broadcast rights and Operating rights.
Netherlands	By priority	Public tender	Only the public broadcaster had an analogue television licence Additional licence fees based on percentage of gross revenues ¹¹³
New Zealand ¹¹⁰		By priority, FCFS	The public broadcaster, in cooperation with commercial broadcasters developed a proposal for DTV
Spain ¹¹⁰	By priority	Public tender	The public broadcaster and some other commercial broadcasters had an analogue television licence. They are facilitated on the first multiplexes
Sweden ¹¹⁰	By priority	Public tender	Only the public broadcaster had an analogue television licence
Thailand	By priority	Auction	Existing analogue license holders by priority if they are a public broadcaster. Commercial DTTB licenses are assigned by auction. The current legislation requires the regulator to assigned broadcast spectrum rights by auction.
United Kingdom	By priority	Public tender	The public broadcaster and three other commercial broadcasters had an analogue television licence. They were facilitated in the first two digital multiplexes
United States	Renewal ¹¹⁴	Public tender	Additional licence fees based on percentage of gross revenues

-

The initial licence was assigned by priority to the national broadcast network operator (T-Systems, part of Deutsche Telecom, fully government owned), before this operator was (partly) privatized and acquired by the commercial TDF group. In this way, TDF acquired the DTTB frequency licence too.

Next to paying the monthly licence fee to the spectrum manager, the licence holder has the obligation to pay an additional annual charge of 15 per cent over that part of its annual revenues above € 45 m, commencing in the 8th year of operation (licence duration is 15 years).

¹¹⁴ In the US most of the DTV spectrum licences were renewals of existing analogue licences (as most broadcasters/stations operate their own transmitter network). For more details see www.fcc.gov.

A similar picture can be observed for the applied assignment instruments for the MTV licences. Table 2.5.3 provides an overview¹¹⁵:

Table 2.5.3: Applied assignment instruments for MTV services

Country	Applied assignment instrument for MTV spectrum rights	Remarks
Australia	Not assigned or planned yet	
Belgium	Public tender	Additional licence fees based on profitability
Brazil	Not assigned or planned yet	MTV (OneSeg) service is part of DTTB
Denmark	Public tender	
Finland	Public tender	
France	Public tender	
Germany	Public tender	Media licence (broadcast rights to be re-assigned)
Japan	Public tender for MTV independent of DTTB	Two kinds of MTV service are introduced: one is a part of DTTB and the other is independent of DTTB services.
Korea	Public tender	
Netherlands	Public tender ¹¹⁶	Additional licence fees based on percentage of gross revenues
New Zealand	Not assigned or planned yet	Digital dividend is delaying (political) decisions
Spain	Not assigned or planned yet	
Sweden	Not assigned or planned yet	Digital dividend and HDTV is delaying (political) decisions
Thailand	Auction, not planned yet	The current legislation requires the regulator to assigned broadcast spectrum rights by auction.
United Kingdom	Not assigned or planned yet ¹¹⁷	Digital dividend debate is delaying process
United States	Not assigned or planned yet	In Trial phase

The above discussed assignment instruments should be embedded in a carefully prepared assignment procedure. A general overview of the steps in a typical assignment procedure is described in Annex B.

¹¹⁵ For more details see BMCOforum, Best practice regulatory frameworks for mobile TV, June 2008.

In the Netherlands (like in Italy and Japan) the MTV licensing was related to the DTTB licence by allowing the licence holder to offer MTV service as well. The initial DTTB licence was assigned through public tender.

The UK had a commercial launch based on the radio standard DAB (-IP) but not on television designated bands. BT Movio launched its mobile broadcast entertainment service based on DAB-IP technology and a wholesale business model. BT discontinued its mobile service in 2007. Virgin Mobile started retailing the service to customers, but discontinued services in 2007 too.

2.5.3 Implementation guidelines

In addition to the above tables, the following guidance can be provided for DTTB and MTV assignment procedures:

- 1. Although additional requirements (like service roll-out and channel line-up/bouquet, must carry obligations, etc.) can be stipulated in an auction procedure (see step 6, but only as a threshold), in most cases a public tender should be preferred because of the following considerations:
 - a. The regulator strives to achieve media objectives and would like to compare service offering as to select the 'best' service (and not just check whether the offer passes the threshold). Comparison of offerings is very often necessary as the regulator is not familiar with what commercially is possible.
 - b. In most cases, the DTTB/MTV market is not a 'proven' market (in the sense that the revenues are still hard to predict with high levels of uncertainty¹¹⁸) and the risks of a Winner's Curse is relatively high in the case of an auction¹¹⁹.
- Avoid combining a public tender and an auction instrument to assign DTTB/MTV licences. In such an approach the regulator first selects the 'best' bidders and then assigns the spectrum licence to the highest bidder between the selected bidders. Or alternatively, the regulator request bids with a qualitative offer (e.g. channel bouquet/line-up and service roll-out) and a bidding price. Practice has demonstrated that such an assignment procedure results in bizarre outcomes (e.g. bidders compensate a perceived relatively weak qualitative offer with extraordinary high bidding prices or, conversely, bidders believed to have an excellent qualitative offer do not offer a reasonable price). Also such an approach is prone to legal procedures as the balancing between the qualitative offer and price is disputable and may be perceived to be unfair or biased.
- 3. Avoid combining auctioning spectrum licences and forms of administrative incentive pricing (i.e. levying licence fees based on market or economic value)¹²⁰. In general the licence holders or market players perceive such a combination as paying twice for the same licence. This should not be confused with paying the auction price in various instalments during the licence duration (so as to lower the need for attracting capital and consequently increasing the financial resources for service roll-out).
- 4. If the regulator would like to exclude possible bidders, prepare these exclusions of possible bidders thoroughly as these rules can be legally contested. The regulator might like to exclude parties with significant market power (and a potential risk that they will abuse this power). The regulator publishes these qualification rules upfront. National or international legislation might limit the possibilities of excluding parties upfront.

In contrast, in a proven market the revenue side is relatively easy to predict, especially through comparing similar business in other markets/countries (i.e. benchmarking) because the service is homogenous and the uptake curves 'look' similar across the various markets.

The 'winner's curse' is the problem of assessing the revenue side as in most case the cost side is relatively easy to estimate. In auction design the problem of the winner's curse can be reduced by having multi-round open bid auctions. It is a misunderstanding that auctions would result in higher end-consumer prices. In competitive markets, auctions do not lead to higher end-consumer prices, they only reduce operating margins. Hence this is not a reason not to select auction as an assignment instrument.

¹²⁰ See also section 2.4.

- 5. Stipulate aggregation rules in cases where more than one DTTB and/or MTV licences/multiplexes can be applied for in the assignment procedure. Without aggregation rules, there is risk of 'deep pockets' acquiring all available licences which can limit the quality and/or diversity of the service offering (especially in the case of auctions without any 'must carry' type of rules).
- 6. If possible/known, determine and publish other future DTTB/MTV assignments, when the first DTTB/MTV assignment procedure is announced (in the case of assigning available multiplexes/frequencies in stages). Bidders need to know their competitive environment during the licence duration. Special caution is required in the case where bidders are allowed to ask for clarification during the bidding procedure. The regulator answers might be used in legal appeal procedures.
- 7. Start preparing the assigning procedure for DTTB licences when:
 - a. There is a market initiative requesting a licence. The application and applicant should satisfy admissibility and minimum requirements, before starting any preparations. Such a request does not necessarily result in a FCFS procedure.
 - b. The government would like to take the lead in the introduction of DTTB services as it sees the availability of such services crucial in the further economic, social and human development of the country.
 - c. Analogue television licences (are about to) expire, because assigning DTTB licences will provide an opportunity to terminate analogue television licences (for example, by stipulating 'must carry' rules for analogue channels in the DTTB licence).
 - d. ASO plans have been formulated and decided, because DTTB licences are required to facilitate the continuation of existing (analogue) television services and to free-up spectrum (for ASO planning and timing see section 2.16).
- 8. If possible, combine the licensing procedure for MTV and DTTB licences as this will allow bidders to reap infrastructure and operating synergies (e.g. combined network roll-out and service provisioning). In cases where the DTTB business case seems to be weak, such a combination could be critical for market parties to be interested. In practice such combined licensing is carried out by either¹²¹:
 - a. stipulating that at least one of the multiplexes should be used for MTV; or
 - b. organizing separate DTTB and MTV assignment procedures closely after each other; or
 - c. assigning the national DTTB network operator the MTV licence as well by priority (in combination with strict access and pricing rules for the MTV platform, to avoid anticompetitive behaviour).

2.6 License terms and conditions

The regulator has to set licence terms and conditions for any of the three types of licence categories, as mentioned in section 2.2 Licensing framework. This section will focus on the licence terms and conditions of the DTTB and MTV frequency or spectrum licences.

Assigning DTTB/MTV frequency rights is carried out in conjunction with assigning the other two types of rights as well. However, broadcast or operating rights could also be included in the spectrum licence, depending on the existing regulatory and legal framework. In some situations changing the legal

-

 $^{^{\}rm 121}$ See respectively the licensing procedures in Belgium/Denmark, France and Finland.

framework might take too long (or is not desired) for the planned DTTB/MTV spectrum licensing and the regulator might decide to include broadcast or operating rights in the spectrum licence. But in the framework of these Guidelines and in this section, it is assumed that the frequency licences serve the sole purpose of safeguarding efficient and proper spectrum usage.

This section comprises the following sections:

- 2.6.1 Licensing and fair competition rules: assigning DTTB/MTV spectrum licences will create exclusivity and the regulator has to ensure fair competition.
- 2.6.2 Frequency licence terms and conditions: the standard licence terms and conditions to be included in a DTTB/MTV spectrum licence.
- 2.6.3 Implementation guidelines.

2.6.1 Licensing and fair competition rules

At a national level the radio-frequency spectrum is considered the State's public domain and is a scarce resource. Moreover, for most wireless applications it is the only or unique resource. As the result of the State's right to manage the spectrum, authorized spectrum users acquire very often the exclusive rights to access and use the spectrum. In this way, by assigning licences, the regulator interferes in markets. Consequently, the regulator should also ensure fair competition at the same time.

Assigning frequency rights is normally carried out on the basis of exclusivity. Frequency sharing does occur for some applications, like wireless telephony (DECT), Internet (Wifi) and wireless microphones. However, for DTTB and MTV applications, assignment of spectrum rights is carried out on the basis of exclusivity for the main reason that no technology is available to allow frequency sharing. Other reasons for assigning on the basis of exclusivity are:

- safeguarding un-interrupted broadcasts; 1.
- 2. safeguarding DTTB/MTV investments;
- exercising control over media/television platforms (and their content).

The root of the fair competition issue is that assigning exclusive frequency rights to one market player will impose, at the same time, a limit on market access for other parties. The regulator has to avoid creating unfair competition and possibly to guarantee access to the platform. Whether additional regulation is needed to guarantee fair and open competition for the DTTB/MTV markets depends on the local circumstances:

- The existing legal framework: for example in Europe, the various Directives already safeguard to a great extent fair competition. National governments have to adopt these competition rules in their national legal framework, including aspects such as:
 - transparent and non-discriminatory licensing criteria for spectrum licences: limiting selection criteria either to:
 - i. 'essential criteria' addressing the bidder: bidder should be technically and financially capable of offering the DTTB/MTV services, should be registered in the trade registers, etc;
 - ii. other criteria addressing the bid: the number, the roll-out speed, the variety, the quality and the pricing of the offered DTTB/MTV services¹²²;

 $^{^{122}}$ In case of an auction the selection criteria will mostly only include 'the essential criteria'.

- b. limited grounds for excluding bidding parties for the DTTB/MTV licence, either:
 - i. bidder does not meet the 'essential criteria'; or
 - ii. probable risk of market power abuse: potential bidders owns or has control over competing platforms (with a significant market share, e.g. above 25 per cent of the relevant market) and is likely to acquire the licence just for strategic blocking or limiting competition;
- c. access to and fair pricing of 'essential facilities', including either:
 - i. site/antenna sharing rules imposed on parties owning or controlling high towers which cannot be duplicated in an economic feasible way¹²³;
 - ii. access to networks when these cannot be duplicated too (i.e. rules for open network provisioning). When only one DTTB/MTV network operator/provider is licensed this might be the case.
- 2. The selected DTTB/MTV assignment procedure: when the assignment procedure is open to all interested market parties, the selection criteria are transparent and non-discriminatory and published up-front, most competition issues are resolved. In contrast, assigning by priority frequency rights (without a tender procedure or auction) to commercial parties might raise the need for additional legislation¹²⁴.
- 3. The market structure for television services: the more distribution/platform alternatives that are available for end-consumers, the less likely is that markets are being disturbed by assigning exclusive rights. The licence holder will not be in the position to abuse its 'power'. However, the regulator might have to consider platform ownership carefully. Cross-ownership might be grounds to limit access to the assignment procedure for DTTB and MTV licences¹²⁵.

In principle the regulator has two key regulatory instruments to ensure fair competition when licensing exclusive DTTB/MTV rights:

- 1. Assigning the DTTB/MTV spectrum licences in open and transparent assignment procedure, including:
 - a. publishing the 'essential' and other criteria upfront, transparent and not favouring one or other specific party (e.g. requiring specific content that only one party can delivery because it holds the exclusive rights to this content);
 - b. limiting the grounds for the exclusion of potential bidders: either bidders do not meet the 'essential criteria' or there is a probable risk of market power abuse.
- 2. Imposing 'open network provisioning' rules on DTTB/MTV network providers in case these networks have been rolled out exclusively by one/few parties (and/or parties with interest across the DTTB value chain), including 126:
 - a. the grounds for refusing capacity;

Although the Essential Facilities theory can provide a theoretical framework, in practice it will come down to listing these high towers and defining economic feasibility (i.e. defining a reasonable return for investments). Alternatively, the regulator could set site sharing rules on the basis of preventing 'horizon' pollution.

To distinguish from assigning frequency rights to public broadcasters, as these bodies operate often under a special act or under special provisions in either the broadcast or telecommunication act.

For more details on cross-ownership regulation see for example the FCC 2010 review of the Media Ownership Rules on www.fcc.gov/ownership/.

¹²⁶ For more details on open network provisioning rules see also <u>www.ictregulationtoolkit.org</u>, *Info*Dev/ITU.

- b. the maximum (multiplex) capacity to be allocated to one single broadcaster or service provider;
- c. the fair pricing of capacity¹²⁷;
- d. the rules for capacity reservations¹²⁸;
- e. the requirement to publish an approved reference offer 129.

2.6.2 Frequency licence terms and conditions

The list below provides an overview of the licence terms and conditions which, in most cases, are included in a DTTB/MTV licence. These terms and conditions apply to DTTB/MTV licences issued to commercial parties and public service broadcasters. However, the latter group acquires its licence under a different legal framework and might include specific rights and obligations (see section 2.2.3):

- 1. *Granting of licence*, including:
 - a. the definition of the legal basis of the licence (referring to the broadcast, media or telecommunication act);
 - b. the licensing starting and termination dates (these dates can either be fixed dates or dates related to other events such as the acquisition of an operating or broadcast licence);
 - c. definitions (of terms used in the license).
- 2. Spectrum rights: depending on whether the DTTB/MTV licence is based on allotments or assignments (see also 2.3.1), the rights are defined in frequency tables stipulating the maximum allowed transmitting powers (ERPs), transmitter locations/sites and geographical area in which a specified frequency can be used. In addition, the following duties are include too:
 - a. avoiding interference;
 - b. applying proper (and possibly certified) transmitter equipment;
 - c. complying with health and safety measures (for own personnel and the public);
 - d. reporting transmitter activation and cooperating with inspection;
 - e. providing information to the regulator.
- 3. License obligations including:
 - a. the obligation to provide television services within a certain time frame (roll-out obligations);
 - b. the obligation to provide a defined portfolio of television services (this may come in the form of including the licence holder's bid book in which the services were defined and proposed);
 - c. service level obligations, including aspects like broadcast standards, geographical/population coverage, service/network availability, allocated bandwidth/multiplexes per service, etc;

The regulator will have to establish a fair return on investments for the investments (Capex) and margin on the operational costs (Opex). This might also entail setting rules for which part of shared and overhead costs may be included in the regulated prices.

Any reservation system is prone to strategic blocking and the regulator might have to set rules for maximum reservation periods and capacity.

A reference offers typical include (a) service description and levels, (b) technical interfaces and operations (c) tariff structure, prices and billing procedures and (d) reference contract(s). The regulator should approve this reference offer before the service or network provider publishes its offer. For example reference offers see www.arqiva.com under Reference Offers.

- d. the obligation to provide site and antenna sharing (this provision might be incorporated in national legislation and this licence term just confirms its applicability).
- 4. Exercise of spectrum rights: the licence may include the possibility that entities other than wholly owned affiliates can use (parts of) the defined spectrum rights. This might be relevant in situations where another company, other than the licence holder, will actually roll-out and operate the broadcast network.
- 5. Spectrum trading and sharing: the regulator may or may not allow trading or sharing of the defined spectrum. Or alternatively, the regulator could include the following: the licensee shall not, except with the prior written approval of the regulator, assign, transfer, trade, sell or otherwise dispose of the whole or any part of the rights, privileges, duties and/or obligations under this frequency licence to any person or persons.
- 6. Interoperability and technical standards: the licence may stipulate any requirements on interoperability and technical standards to be applied. For details on these stipulations, please refer to section 2.1.
- 7. License fees (see also section 2.4.4 and 2.5.3): including fees for:
 - a. covering (a part of) the costs for spectrum management and monitoring;
 - b. recouping market value, i.e. additional fees based on the market value of the licence, for example a percentage of the revenues realized in certain years of operations.
- 8. License duration and renewal: for DTTB and MTV licences the licence duration often ranges from 10 to 20 years, as the DTTB/MTV business is very capital intensive. Very often, renewal is included in the licence as well. Please note that without stipulating the grounds for renewal or termination (i.e. refusal of renewing the licence), such a clause is in effect just a licence extension.
- 9. *Modification, revocation and termination*: including the right for the regulator to either terminate or change the licence (terms and conditions) when deemed necessary (very often based on major spectrum efficiency considerations). In additions, items are included on dispute resolution, sanctions, and "force majeure".
- 10. Complaints received from the public, about programming (depends on the framework and bidding procedure). This could also include complaints from the public about interference. The licence terms stipulate that the licence holder should handle these complaints and resolve them in an adequate time frame.
- 11. Content and copyrights: to exclude the regulator for being responsible for paying any content or copy rights to be paid. The licence holder remains responsible for paying any of these levies. This might also be incorporated in the broadcast licence. It may also be possible that payment for these rights is arranged between the licence holder (i.e. the service provider) and the individual broadcasters, by having mutual agreements¹³⁰.

-

Content rights arrangements and legislation vary from country to country. However, very often, national collecting societies are present and will collect any duties. Collecting societies tend to collect fees from all parties that generate revenues from using the content (e.g. service providers and content distributors). Studios and Majors will generally only collect fees directly from broadcasters (very often on the basis of the number of 'runs'. 'Simulcasts' on the DTTB platform might be exempt from paying as programs are also broadcast on other platforms at the same time).

2.6.3 Implementation guidelines

The following guidance can be provided for setting DTTB and MTV licence terms and conditions:

- Include the spectrum rights:
 - a. In countries where the GE06 plan is applicable and the plan includes assignments: stipulate frequency assignments (i.e. with the exact transmitter locations and powers) in the licence.
 - b. In countries where the GE06 plan is applicable and the plan includes allotments: the regulator has two options either include assignments or allotments. Including assignments in this situation will require detailed network planning. However, it is recommended to include allotments in the licence as the licence holder will be in the best position (and will probably have better means) to detail the network planning that best fits its business plan requirements. When including allotments, the regulator should be aware that the licence holder has the possibility of selecting the transmitter location and the individual powers of each station. Consequently, the regulator will have to include the 'Reporting transmitter activation' clause in order to monitor proper spectrum usage.
 - c. In countries where the GE06 plan is not applicable: the regulator can choose either of the above cases.
- 2. For including technical standards in the licence terms and conditions, please refer to section 2.1.2.
- 3. When including a roll-out obligation, make sure the licence holder can actually roll-out the services, especially with regards to any required local permits (see also section 2.7). It would be better if some 'checks' by local governments on, for example, EMC matters will be waived or relaxed with granting the national frequency licence. This will speed up the licensing of building permits. Such a policy will not hamper the local council to determine the best location for the DTTB/MTV transmitter sites. Also, monitoring to ensure transmitter emissions are correct (i.e. whether the transmitting station transmits within the set interference limits) will still be required.
- 4. Include the assignment instrument in the renewal clause. The possibility of renewal can make investing in DTTB/MTV services more attractive. In this light, any renewal clause should state the (re)assignment instrument which could be an automatic renewal after the regulator has verified that the license holder has performed its duties in accordance with the license terms and conditions or by a (form of) public tender.
- 5. When the licence is assigned through a public tender, include the services (etc.) proposed in the licence holder's bid book in the licence terms and conditions. This recommendation applies to both types of public tender whereby:
 - a. the bidder with the best offer acquires the licence (best bid);
 - b. the bidder who surpasses a set threshold (e.g. certain service level requirements) will get the licence (qualifying bid). Although not recommended in these guidelines this type of public tender, is very often applied in combination with a monetary bid.
- 6. Check consistency between the licence terms and conditions of any commercial licence holder and the public broadcaster (if applicable), including:
 - a. service or network roll-out obligations: the public broadcaster might have an obligation for (near) national coverage for rooftop reception, whereas the commercial licence holder might like to roll-out an indoor network or perhaps a rooftop network in a smaller coverage area. A shared network roll-out might become more complex and fragmented;
 - b. *sharing of multiplex capacity*: sharing multiplex capacity might be desired or necessary and any legal limitation should not block this collaboration between commercial and public broadcasters;

- c. sharing EPG, programming information and possibly system software updates ¹³¹: broadcasters (public and/or commercial) have to share/provide EPG data between services (including an agreed format) and have to agree system software updates in order to have a uniform bouquet of DTTB services;
- d. conditional access and free-to-air broadcasting: a joint network roll-out between the public broadcaster and the commercial licence holders might require an agreement for the common use of a conditional access system and/or the exemption of applying such a system.
- 7. Check ASO compliancy: make sure the licence terms and conditions are in line with any ASO plans, including:
 - a. the possibility to (temporarily) change defined frequencies for resolving any spectrum incompatibilities (see section 2.17);
 - b. site sharing obligations and the requirement to remove old analogue antennas in order to resolve any infrastructure incompatibilities (see section 2.17);
 - c. the obligation to carry and provide PSB free-to-air channel(s): i.e. if the licence holder applies a conditional access system, this system should be able to offer free-to-air channels. Also, perhaps more importantly, the licence holder has to provide the retail logistics for getting a 'free-to-air-only' smart card.

2.7 Local permits (building and planning)

For rolling out terrestrial communications networks, including DTTB and MTV networks, transmitter sites are required. This section addresses the necessary permits and authorizations from local authorities required to establish and operate broadcast transmitter stations. This section includes:

- 2.7.1 Economics of rolling out transmitter sites.
- 2.7.2 Instruments to facilitate transmitter site erection.
- 2.7.3 Implementation guidelines.

2.7.1 Economics of rolling out transmitter sites

In any DTTB/MTV network the number of sites is the key cost driver. The broadcast network operator aims to reduce the number of sites in its network design, whilst maintaining the required service levels of service coverage, reception quality and network availability (see also section 4.2 and 4.3).

In turn, considering the cost structure of a transmitter site, the second cost driver is having the availability of a mast, tower or any other tall construction. Erecting new transmitter towers tend to be expensive. Not only for the purchase of a tower, but also the possibly (long) procedure to acquire permission to erect such a tower (i.e. a building permit). The associated costs do not only include the cost of a site acquisition organization but also any delays in service launch and hence cost of capital.

System software update (SSU) is required in order to guarantee the functionality of a receiver once deployed in the field a software update service is required. SSUs are delivered to the receivers over the DTTB network. For implementation guidelines of SSU on DVB systems see ETSI TS 102 006, Specification for System Software Update in DVB systems.

Consequently, the broadcast network operator objective is to re-use as many existing sites as possible ¹³². These existing sites can either be own property or third party property. In case of third party property, the network operator will bear operational expenses for site rental fees.

From a network operator point of view, having access to and fair pricing of sites is important to keep investment and cost levels down (and ultimately provide a profitable service). However, these third party site owners could be a direct competitor (e.g. the incumbent broadcast network operator or the public broadcaster) or a commercial tower company (i.e. tower facility providers)¹³³ and they may abuse their position in not granting access or charging unfair prices.

Hence, the regulator and local authorities do have an important role here to facilitate transmitter site build-up and site sharing arrangements.

2.7.2 Instruments to facilitate transmitter site erection

Regulators tend to intervene in this tower market for the following reasons:

- 1. facilitating site sharing and fair pricing;
- 2. 'horizon pollution': Regulators may like to control the number of transmitter sites and plan the locations of these transmitter sites;
- 3. *health hazard control*: Regulators have a duty to control health hazards for EMC, noise, dangerous goods and mast construction strength.

In pursuing the above objectives the regulator normally applies he following instruments:

- 1. requiring and issuing *building permits* (very often at a local or regional level): granting of rights to erect new sites to the DTTB and/or MTV network operator;
- mandating site sharing rules (at a national level): imposing obligations for network operators or tower facility providers (including telecommunication providers and other broadcast network operators) to provide antenna space on their sites;
- providing guidelines for and determining site sharing pricing (at a national level): imposing obligations for network operators or tower facility providers to charge fair prices for antenna space.

Depending on the relative importance of the regulator objectives a mix of the above instruments is applied. However, an important interaction does exist between applying the regulatory instruments of building permits and site sharing rules. Having very strict rules and long procedures for acquiring building permits can turn sites into 'essential facilities' (see also 2.6.1) and consequently the need for site sharing rules will increase. Also, strict building permit procedures can hamper, or even make it impossible, for the (spectrum) licence holder to comply with stipulated service/network roll-out obligations.

Tower companies are either dedicated companies owning transmitter locations (masts or other tall constructions) or a subsidiary of a broadcast network operator, telecom operator or utilities company. They rent-out antenna and transmitter space. They tend not to own any transmitter equipment and are considered real estate owners, although special real estate. Some typical examples are Crown Castle International and American Tower.

Availability of antenna space on a mast is not only determined by the physical meters of free space but also the wind load of the mast, i.e. the mechanical strength of the mast to carry additional wind load.

Building permits

Before allowing the transmitter site to be erected and taken into operation, the (local) regulatory authority can check compliancy in the following areas¹³⁴:

- 1. Field strength and EMC, addressing:
 - a. Field strength calculations: A check on whether the maximum permitted levels of radio emissions are not exceeded by the introduction of (additional) DTTB /MTV equipment¹³⁵. This check is carried out for the purpose of protecting the health or safety of people who operate, work on or use the services supplied by DTTB/MTV transmitters, as well of residents near high power DTTB/MTV transmitter sites.
 - b. *Electromagnetic compatibility (EMC):* A check to ensure EMC levels are not exceeded. Most industrialized nations have established agencies or other regulatory bodies responsible for defining and enforcing EMC standards¹³⁶. If EMC regulations exist in a country, equipment manufacturers cannot legally ship their product into that country until compliance with those regulations is met. The purpose of the regulation is to minimize electromagnetic interference between electronic products which may diminish the performance of other electrical products or disrupt essential communications. All products that fall within the scope of the regulation are subject to compliance with the arrangements and must be labelled appropriately with the compliance mark.
- Mechanical: check on whether the mechanical construction can carry the additional (wind) load of the (additional) DTTB/MTV equipment (this might also include dishes for fixed wireless links to transport the multiplex streams to the transmitter tower). Local regulators might stipulate an independent and certified engineering bureau to carry out the calculations. Standards for mechanical strength calculations are numerous and vary from country to country (and even between local authorities).
- 3. Noise: check to ensure that the DTTB/MTV transmitters, their cooling equipment and power supply do not exceed set standards for maximum noise levels. Especially in urban areas such standards might be applicable. Standards for noise limits are numerous and are specific for each environment. For example, a DTTB/MTV transmitter installed on the top of an office building might have to comply with different standards than a dedicated transmitter tower in a rural area.
- 4. Dangerous goods: check whether or not too many dangerous goods are accumulated in one single location. For example, there may be regulatory limits for the storage quantities of diesel for the transmitters' power supply or back-up generator. Additionally, some fire prevention measures have to be considered.

In some countries, the permission to build and to transmit (take the transmitter into operation) are split in two separate licensing procedures: the building permit and the environmental permit. In addition, they might be related. For example, the building permit procedure is not started before the environmental permit is assigned.

Sites carrying several services (like FM radio or Analogue television) next to the planned DTTB/MTV services might require specialized software and knowledge for calculating the cumulative field strength. Several international bodies exist for setting radio frequency or field strength safety standards and guidelines. Globally, the two leading organizations are the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE).

See for example the Federal Communications Commission (FCC) in the United States and The British Standards Institution (BSI). Institutes providing standards include International Electrotechnical Commission (IEC), Comité Européen de Normalisation (CEN) and European Telecommunications Standards Institute (ETSI).

5. Horizon pollution: Local governments check whether the planned DTTB/MTV transmitter sites fits in the local building plans (in the case of erecting a new tower). This might be a hard requirement to meet, requiring intensive lobbying and additional investments. Because DTTB towers tend to be very tall (over 100 meters) the horizon pollution might be perceived as large. Especially in urban areas acquiring a building permit might be challenging. Special commissions might be in place to assess the aesthetics of the building request. It is not unusual that specially designed towers are requested, pushing up the DTTB investment levels considerably.

Normally, most of the above checks are carried out at a local level and very often with different standards and calculation methods applied. However, it could be argued that the test on field strength and EMC could be simplified and carried out at national level. For example, by the national radio agency or communication commission that issue the frequency licence and check spectrum compliancy (see previous section). In addition, the national regulator could also inform the local governments what standards are applicable for these DTTB/MTV building requests. In some countries, centralized approaches have been applied for the roll-out of telecommunication or broadcast networks.

Site sharing rules

Generally, site sharing rules are applicable to certain entities such as telecom operators and broadcast network operators as defined in the relevant telecommunication act. Very often these entities are defined as parties that provide a network/service for electronic communications, including broadcast communications. Real estate property owners (and possibly tower companies) might not fall under the defined entities. Alternatively, in some countries offering tower facilities and/or services will require a special license (i.e. a facility license) from the national regulator regardless the entity offering those facilities or services.

In essence, site sharing rules provide arrangements to acquire access to transmitter sites and (possibly) pricing methods and limits. The ground rule is that parties that fall under the defined entities should provide access to any reasonable request. The site sharing rules might provide grounds for refusing access, including:

- 1. the site sharing request is not deemed reasonable: for example the requesting party does not provide (enough or relevant) technical data to assess the capacity claim on the tower or claims a reservation without a clear date for actual operations¹³⁷;
- 2. the requested capacity is not available: either the maximum (wind) load is exceeded with the additional antenna system or there are no physical meters left on the mast¹³⁸;
- 3. the site owner has reserved the capacity for its own services or operations: this ground for refusal will require the adoption of a reservation system in the site sharing rules.

Site access rules might not necessarily come with rules for fair pricing. As mentioned before, site sharing rules might be imposed on the basis of 'essential facilities' and/or 'horizon pollution'. In any case, the applied pricing regimes are very often based on the theory of essential facilities¹³⁹. The regulator can basically impose two types of pricing regimes:

As indicated in section 2.6, capacity reservations need special attention as they might be prone to strategic blocking.

¹³⁸ It is not always evident whether maximum load capacity is reached, when the requesting party is proposing mast rearrangement (i.e. moving antenna systems). Also disputes might arise around the payment of these rearrangement costs.

For more details and background on the Theory of Essential Facilities please refer to www.ftc.gov or www.ictregulationtoolkit.org for a brief overview.

- 1. *Price cap*: this form of price regulation is the most strict form (and it can be debated whether this should be applied) as price cap regulation will dictate the maximum price the site owner is allowed to charge for site sharing or facility services.
- Cost plus: under this regime site sharing pricing is based on a defined list of permitted costs plus a maximum margin or yield on top of these costs. Many costing models exist and even after having adopted a refined model many debates/conflicts may still occur, more specifically about 140:
 - a. what cost to include and for what portion: especially R&D and overhead costs are debatable;
 - b. what deprecation scheme: historical or replacement costs;
 - c. what percentage for the Weighted Average Cost of Capital (WACC).

2.7.3 Implementation guidelines

The following guidance can be provided in regulating building permits and site sharing:

- 1. Determine (local) policy objectives first and apply the regulatory instruments accordingly. For example, if the key objective is to avoid horizon pollution do not use essential facility arguments, because this leaves the regulator open for legal scrutiny. 'Essential facilities' might be difficult to prove and the objective to prevent horizon pollution might be lost.
- Check consistency between applied regulatory instruments and the existing legal framework, especially:
 - a. Check applicability of the existing site sharing framework: very often defined for mobile operators, and not for any other operators or tower companies. Consequently the DTTB/MTV introduction might require a re-definition of the telecommunication act (which may be a lengthily process).
 - b. Check building permit and site sharing regimes with any included service roll-out obligations in the spectrum licence (and/or broadcast licence).
 - c. Check consistency in applied building and environmental standards across the country and consider centralizing checks and informing local authorities about the standards to be applied.
- 3. Consider addressing access to transmitter equipment space. Site sharing rules are very often limited to providing access for antennas, but transmitter space might be as difficult, or if not more difficult, to get access to. Transmitter space could be the limiting factor rather than the mast capacity and floor space pricing might not be regulated and market parties might charge excessive prices.
- 4. When site sharing rules are desirable for the purpose of avoiding strategic blocking, also provide rules on pricing. Site sharing rules without pricing rules tend not to work as excessive pricing will, in effect, stop access.
- 5. Generally for MTV networks many more sites will be required, compared to rolling out a DTTB network for rooftop¹⁴¹. These additional MTV sites might be similar in height than mobile network sites. Hence for MTV networks the presence of site sharing rules for mobile operators might be especially relevant.

_

Many different cost models exist under this regime, most notably (in the telecoms industries) Long Run Incremental Costs (LRIC) models. Regulators in many countries apply this model, such as New Zealand, Australia, the United Kingdom, the European Community, and the United States. These models are also applied for site sharing. For more details see www.ictregulationtoolkit.org, section 3.3.2.

 $^{^{141}\,}$ Depending on required coverage, transmission mode, etc. (see networks sections).

6. Make information on existing sites available for licence holders. In some countries special agencies exist for administrating transmitter sites and their use¹⁴². Such agencies could help in making information on sites available, harmonize site sharing policies and speed up licensing procedures by provide expert knowledge to local authorities or evaluate site share applications. The latter can be especially relevant for DTTB roll-out as often the digital transmitters will be installed on the analogue television sites.

2.8 Media permits and authorizations

As described in section 2.2.2, licensing DTTB and MTV services will involve three types of rights, including broadcast rights. Broadcast licences, as defined in these Guidelines, grant the right or permission to broadcast television content on a defined broadcast DTTB/MTV platform in a designated geographical area and for a specified period.

In regulating access to the DTTB and MTV platforms and/or to determine content composition on the DTTB and MTV platforms, the regulator can avoid unwanted broadcasts, promote defined broadcasts or avoid duplication of content.

In most countries, the regulator granting broadcast rights will differentiate between:

- 1. Public service broadcasting (PSB)¹⁴³: Public service broadcasters are normally authorized in a different way. In most cases the broadcast content is specified in a (separate) media or broadcast act. For more details on licensing public broadcasters please refer to section 2.2.3.
- Non-public service broadcasting or commercial broadcasting: this group of broadcasters
 includes pay-tv operators (i.e. they offer a service package/television content on the basis of
 subscription fees or pay-per-event basis) and free-to-air broadcasters (they offer television
 content on the basis of advertising income).

This section focuses is on granting media/broadcast permits/authorizations for non-PSB/commercial broadcasters and is organized into:

- 2.8.1 Broadcast licensing framework: The different levels of granting broadcast rights.
- 2.8.2 Broadcast licensing requirements: The broadcast requirements to be met for granting the licence (may be split in different service/content categories).
- 2.8.3 Implementation guidelines.

2.8.1 Broadcast licensing framework

By the nature of digital broadcast technology, where multiple programmes or services can be carried on one frequency (i.e. multiplex), the broadcast rights for DTTB/MTV services are very often organized at two levels¹⁴⁴:

 Programme level/linear broadcast stream: the right to broadcast a specific television programme/service (or sequence of programmes/services), either through a general broadcast authorization or for a specified platform only, like the DTTB/MTV platform (referred to as

¹⁴² For an example of an antenna bureau and its register see www.antennebureau.nl/english

Refers to broadcasting intended for the public benefit rather than for purely commercial concerns. PSB requirements can be imposed on the national/regional public broadcasters as well as on commercially funded broadcasters as part of their licence to broadcast.

¹⁴⁴ See also the difference between the licensing framework for analogue and digital television services in section 2.2.1.

media/broadcast permit/authorization). These rights will come with the obligation to adhere to a defined set of content criteria such as:

- a certain level of local news coverage, arts, religious programming;
- a maximum number of repeated programmes;
- a percentage of locally produced content (content production quotas);
- a maximum number of advertising hours, etc. d.
- Platform level/multiplex level: the right to broadcast a bouquet of television services with associated obligations (either laid down in the frequency licence as specific terms or in a separate broadcast licence) such as:
 - the obligation to provide a defined portfolio of television services (including 'must carry' and pricing regulation rules);
 - the obligation to carry public service broadcasting (PSB) programming or services;
 - service level obligations, including aspects like broadcast standards, geographical/population coverage, service/network availability, allocated bandwidth per service or number of multiplexes.

2.8.2 **Broadcast licensing requirements**

When granting DTTB/MTV broadcast permits for commercial broadcasters at the programme level, regulators tend to differentiate three categories of requirements/conditions to be met for granting a broadcast licence:

- 1. Applicant: the applicant has to comply with a set of 'essential criteria' to be eligible for granting a licence, including¹⁴⁵:
 - legal status: the regulator might require the applicant to be a legal entity registered in the trade registers or may also allow individuals to apply;
 - ownership restrictions: in many countries cross-ownership rules exist, avoiding concentration of power in the media industry 146. The applicant may have to fulfil these cross-ownership requirements;
 - jurisdiction: this aspect is especially relevant for broadcast companies with multi country broadcasts or headquarters outside the country of the regulator, which is very often the case for DTTB/MTV multi-channel international broadcasts. For example, the European 'Television without Frontiers Directive' arranges this aspect 147. Dual licensing is not permitted. A service which is licensed (or otherwise appropriately authorized) in one Member State does not need separate licensing in any other Member State. In countries outside the European Union dual licensing might be permitted in the absence of such international or inter-regional directives.
- Television programme services: this is the core of the broadcast requirements and is very often based on a linear broadcasting model, comprising a stream of programmes. Normally for each programme an authorization has to be granted, although such individual applications might be

¹⁴⁵ See also section 2.6.1 on 'essential criteria'.

See also section 2.11.2.

¹⁴⁷ See 89/552/EEC, as amended by European Directive 97/36/EC.

combined in one overall application. The regulator may apply a set of defined *content* criteria (see section 2.8.1) *and/or* can refer to separate entities/organizations; monitoring whether the broadcasted content/advertising complies with the broadcast standards or 'codes of (proper) conduct' ¹⁴⁸. In order to regulate the number of commercials/advertising, the television programme services may be split into four categories and for each category a maximum number of broadcast hours is applicable:

- a. editorial content: is a 'normal' television programme service, conventional programme material. The majority of television content falls within this category;
- b. *advertising*: advertising for third party products or services in scheduled advertising breaks or slots;
- c. teleshopping: teleshopping is a special form of advertising and involves the broadcast of direct offers to the public with a view to the supply of goods or services in return for direct payment;
- d. *self-promotional service*: self-promotional material is a particular kind of advertising in which the broadcaster promotes its own programmes, services or associated products.
- 3. Additional services: on a DTTB/MTV platform two additional service categories need to be addressed specifically:
 - a. electronic programming guide (EPG): because the EPG is the 'window' on all available services on DTTB/MTV platform, regulators may wish EPG providers to comply with an EPG code of conduct, including provisions to ensure:
 - i. that information on the available services is not biased/not unfairly distributed and access to the EPG service is made on fair, reasonable and non-discriminatory terms;
 - ii. the inclusion of information on how to use the EPG or Access services (see below) in order to provide aid to people with disabilities;
 - iii. the inclusion of the PBS channels.
 - b. access services: access services include service like subtitling, sign language and audio description. The regulator can include targets for access services (in either percentage of programming or for specific programmes/events) and require promotion of awareness for these services.

2.8.3 Implementation guidelines

The following guidance can be provided on assigning broadcast rights (i.e. media permits and authorizations):

1. Keep PSB separate from commercial broadcasting and limit the set of defined content criteria in terms of the type of programming, including percentages for local news coverage, arts, religious content and the maximum number of repeats. Such content requirements are very difficult to monitor and are best facilitated by the public broadcaster as they are the key vehicle for the regulator to arrange and have direct control over the (DTTB) television content. In addition, allowing public broadcasters to have advertising income will make setting content requirements

For programming and advertising content, separate 'codes of conduct' may exist with separate entities monitoring proper conduct. For example in the UK: Ofcom and Advertising Standards Authority. For example codes please refer to www.cbaa.org.au/ in Australia, www.asasa.org.za in South Africa or www.ofcom.org.uk/tv/ifi/codes/ in the UK.

- more complex. The content requirements should be in line with each other between the PSB and commercial domain, in order to prevent level-playing-field/competition issues.
- 2. Have a dedicated or additional code of conduct for DTTB and MTV platforms as the existing regime may be based on analogue television services only, by including a code of conduct for the EPG and access services¹⁴⁹.
- 3. Exclude clearing content rights by having a content (and copy) right clause in the broadcast licence/authorization. When granting broadcasting rights the regulator should explicitly mention that these rights do not waive any content fees. The licence holder will still have the duty to clear the content rights with the relevant rights holders (e.g. collecting societies, film studios).
- 4. Exclude platform access rights by including an additional clause stipulating that issuing the broadcast licence will not grant the right to have access to any DTTB/MTV multiplex. To avoid unnecessary work, it might be even better to first check whether the applicant has come to an agreement with the multiplex operator, before taking the application into consideration.
- 5. Consider inclusion of 'listed events'. Although not specific for the introduction of DTTB and MTV, 'listed events' may be a relevant topic in countries where these platforms will be the first platforms to facilitate conditional access. With conditional access systems, specific events can be easily 'shielded' from the general public. Regulators may restrict the acquisition by broadcasters of exclusive rights to the whole or any part of live television coverage of listed events such a major sports events.
- 6. Arrange a conditional access provision (in the relevant media/broadcasting act) if not present at the date of the DTTB/MTV introduction. A conditional access provision/directive will guarantee:
 - a. legal protection of encrypted services: such a provision might be required by suppliers of content;
 - b. access to and interoperability of conditional access systems, to be provided on fair, reasonable and non-discriminatory terms. Especially relevant in situations where multiple pay-tv operators/providers are present on the DTTB/MTV platform and viewers should not be confronted with two conditional access systems and consequently two smart cards.

2.9 Business models and public financing

This section addresses the financing of public service broadcasting (PSB). Financing of non-PSB or commercial broadcasters is by definition a matter for the commercial or private parties to resolve. For the business planning and financing of commercial DTTB/MTV services please refer to section 3.4 of these Guidelines.

This section is split into:

- 2.9.1 General PSB financing models and sourcing.
- 2.9.2 DTTB specific financing issues.
- 2.9.3 Implementation guidelines.

66

For example codes see Ofcom's 'Code of Practice on Electronic Programme Guides' and 'Code on Television Access Service', 17 April 2008.

2.9.1 General PSB financing models and sourcing

As discussed in section 2.2 of these Guidelines, public service broadcasting (PSB) refers to broadcasting intended for the public benefit rather than for purely commercial objectives. In most cases the PSB content is specified in a media or broadcast act or separate contract/charter. Prescribing television services to be provided by the public broadcaster will also imply making resources available for the specified content.

The funding of defined PSB services can be organized in three basic forms, which can change or be combined (over time):

- 1. A PSB entity is established by government, with defined PSB services, fully funded by public sources (either through licensing fees and/or general taxes)¹⁵⁰. For example the BBC in the UK, the VRT in Belgium, or the NHK in Japan operate their services under this model.
- 2. A PSB entity is established by government, with defined PSB services, funded by public sources and (later) partly by commercial income (mostly advertising based). Examples include France Television, NBT in Thailand and the NPO in the Netherlands.
- 3. A commercial/private broadcaster was established, fully funded by commercial income (either advertising based and/or subscription based) and has a PSB obligation assigned (very often when the broadcast or spectrum rights was granted). Examples include TV2 in Sweden, ITV in the UK and TF1 in France.

A mixed system, whereby the defined PSB service is operated by commercial party or the public broadcaster deploys also commercial activities, will require rules for accounting separation. Such a system of having separate accounts for the PSB activities is the same as applied in the telecoms industry (for example for wholesales services provided by dominant market parties or for terminating (mobile) telephony traffic in local access networks).

This issue of accounting separation is closely related to (forbidden) cross subsidizing between the publically and commercially funded (television) services. This situation is frequently quoted in the broadcast industry when public broadcasters are competing with commercial broadcasters in the same advertising market¹⁵¹.

The introduction of DTTB will, initially, not lower the required PSB resources as often a simulcast period is required in which two networks are operated in parallel (see also section 2.15.3) and the volume of television programming to be produced will normally increase. There are different sources for funding the PSB services. The collected resources are either made available to a PSB entity (option 1 and 2 below) or to a commercial entity (option 3 below) ¹⁵²:

- 1. General taxes: financial resources for PSB are made available as a certain proportion of the national government's total budget.
- 2. TV licence fees: financial resources are collected on the basis of ownership of a television set/device. Every citizen in possession/or owning a television set will have to pay a TV licence fee. Variations exist. For example, in some countries (with nearly 100 per cent of the population

_

Please note that the public broadcaster might be allowed to deploy commercial/market activities next to its PSB duties/defined tasks. For example, by selling television programme formats, publications and merchandising. The key point is however how the defined PSB services are being financed.

For more detail on accounting separation and cross subsidizing services, please refer to www.ictregulationtoolkit.org chapter 2.6.1 and www.ofcom.org.uk, review of the wholesale broadband access markets.

¹⁵² See also <u>www.ictregulationtoolkit.org</u>, chapter 5.2.1.

- watching television), it is by default assumed that everybody watches the PSB channels and hence every citizen has to pay TV licence fees.
- 3. Industry levies: fees as a percentage of annual revenue, on certain classes of licensed operators.
- 4. Various other regulatory sources such as the proceeds of licence competitions, spectrum auctions and fees.
- 5. Alternative resources from third parties: including the World Bank, IMF, ITU/Broadcaster Unions sponsored project and NGOs.
- 6. Public private partnerships (PPPs): in such partnerships the public broadcaster and a commercial DTTB licence holder will jointly roll-out a combined DTTB services. Different forms of PPPs can be applied:
 - a. A commercial party rolls-out the network/service and the PSB is carried in the service bouquet. In return for its investment efforts the commercial party is allowed to use the remaining multiplex capacity of the PSB multiplex, does not have to pay any content rights for the PSB content and gets access to EPG data.
 - b. A public broadcaster rolls-out the network/services with multiple multiplexes and a conditional access platform allowing pay-tv services to be charged. The public broadcaster rents out the remaining capacity to any commercial broadcaster interested in DTTB distribution.
 - c. The public broadcaster and a commercial network operator jointly finance the DTTB network, providing a free-to-air DTTB services¹⁵³. Remaining capacity will be rented out to any other commercial broadcasters.

2.9.2 DTTB specific financing issues

The introduction of DTTB services will pose some specific financing issues, including:

- 1. Financing of digital receivers: especially relevant in the case of a mandatory switch-off date set by the national government. Such a date will raise the issue of compensating affected viewers who have to purchase a digital alternative. An approach for resolving this issue might be through a joint network roll-out with a commercial pay-tv operator (PPP). For more details on financing receivers see also section 2.15.
- Financing the impact of free-to-air stipulations: national legislation might stipulate free-to-air reception. However a joint or combined roll-out with a commercial pay-tv operator might complicate this issue as this might jeopardize the commercial party's business model; the other broadcasters might request free-to-air reception too. Generally this issue is resolved by providing viewers with a smart card on which the PSB services are not encrypted.
- 3. In the case where the PSB service is encrypted (by having a conditional access system), either as a pay or free-to-air service, it might provide the PSB entity with an opportunity to lower content right duties as the number of viewers is controlled 154. On the other hand, cost may increase

¹⁵³ In this model the public broadcaster forms the launching client for the commercial broadcast network operator, in the form of having a long term distribution contract agreed. This will facilitate access for the network operator to other financial resources to further fund the DTTB investments. In addition, a variation on this model is that the broadcast network operator shares in the advertising income as a form of payment.

The content right duties are based on the number of activated smart cards, rather than on the potential number of viewers. Although generally the case, it might be very dependent on the local legislation and the policy of the collecting society.

because of the costs of providing smart cards. But these costs could be shared with a commercial party offering pay DTTB services. Some regulatory monitoring might be required as the provisioning of smart cards should allow a PSB option only (without the commercial services) and smart card provisioning might be misused to lure viewers into more expensive pay-tv options.

- 4. Financing the simulcast period: see section 2.15.3.
- 5. TV licensing fee systems might need revision: the existing system might be based on free television reception for every viewer with an analogue television set, assuming a near nationwide coverage of the terrestrial network for PSB. The DTTB service introduction can increase the number of PSB services and consequently the public broadcaster might request an increase of the existing TV-licence charge. However, this might be deemed to be (legally) unfair because the additional DTTB services might not be accessible to the entire population until (near-) nationwide coverage will be achieved. In this way the introduction of DTTB services may lead to a public debate on the revision of the TV licensing system.

2.9.3 Implementation guidelines

The following guidance can be provided for funding PSB:

- Do not count on cost reductions in the short run due to the introduction of DTTB services.
 Although DTTB platforms are more efficient (than analogue terrestrial platforms) and can lower the distribution costs per service (in the long run, with more services utilizing the multiplex capacity), in the short run costs will increase, mainly due to:
 - a. simulcast period;
 - b. possibly (partly) financing of receivers.
- 2. When financial funds are limited, apply a PPP model¹⁵⁵. Which exact model to apply depends on the specific local circumstances, like the current legislation, the market structure and the position/financial means of the public broadcaster.
- 3. Check the legal framework on 'DTTB compliancy', especially in the areas of:
 - the definition of 'free-to-air' PSB: a strict definition might limit the possibilities of PPPs;
 - b. TV-licence fees: current definitions might limit the possibilities for increasing the PBS budget.

2.10 Digital dividend

The digital dividend is the amount of spectrum in Band III, IV and V that is made available by the transition of terrestrial television broadcasting from analogue to digital. Any spectrum available after digital television services have been facilitated may be reallocated. Typically such a spectrum reallocation will involve a policy decision. As a first step the digital dividend should be defined (i.e. what is under consideration) and all possible allocations should be identified.

This section includes a general overview of the key decisions spectrum managers or regulators have to take on the allocation and management of the digital dividend in the process of migrating from analogue to digital terrestrial television services. For a detailed insight into what the digital dividend process entails

Do not resort to an auction instrument as an additional source for finance. For further motivation see the Implementation guidelines of section 2.5.

and to help spectrum managers managing the digital dividend process, please also see the ITU report *Digital dividend: insights for spectrum decisions*¹⁵⁶.

This section includes:

- 2.10.1 Definition of the digital dividend and its application.
- 2.10.2 Determining the size of the digital dividend.
- 2.10.3 Digital dividend options.
- 2.10.4 Implementation guidelines.

2.10.1 Definition of the digital dividend and its application

The digital dividend can best be defined as the spectrum (in the VHF Band III ranging from 174 - 230 MHz and the UHF Bands IV and V ranging from 470 - 862 MHz) that is made available by the transition of terrestrial television broadcasting from analogue to digital.

This definition of the digital dividend considers that, in order to obtain any dividend, analogue transmissions need to be switched-off, which requires that a successful transition to digital TV has to take place. For that in turn digital terrestrial broadcasting has to be able to attract viewers in sufficiently large numbers to make this possible. This can only happen if the digital service offering is attractive enough to the viewers to justify the purchase of digital receivers, requiring in general a significant increase in the number of programmes and perceived quality (e.g. HDTV). Hence the introduction of digital terrestrial television services, although more spectrum efficient, may not only result in a decrease of spectrum consumption. The recent developments in the area of HDTV (i.e. the introduction of 4k and 8k HDTV versions) may change the allocation of the digital dividend.

The digital dividend for *broadcasting* services (e.g. HDTV) may be made available as frequency channels in the UHF band become available through analogue switch-off. This is essentially an issue that can be integrated at the time of frequency planning of digital television, which may also involve negotiations with neighbouring countries.

In order to avoid interference with broadcasting services, the digital dividend for the *mobile* service (IMT) can only be made available after analogue switch-off. In addition, this also requires that the corresponding frequency band be freed from digital broadcasting and from other services to which it may be allocated and that the constraints arising from cross-border interference be waived. This generally requires regional harmonization decisions and the conclusion of regional and/or bilateral agreements.

There are also many countries with a limited number of analogue television services in operation which mainly broadcast in the VHF band. In these countries parts of the digital dividend in UHF could be made available more easily as soon as the national digital switchover policies have been adopted, subject to cross-border coordination constraints.

Although the above definition is commonly used, it is important to note the following:

in some countries existing analogue television services may also make use of Band I (47 – 68 MHz) and, after digital switchover, Band I spectrum could be considered as digital dividend, too¹⁵⁷;

www.itu.int/ITU-D/tech/digital broadcasting/Reports/DigitalDividend.pdf.

Band I is less attractive than Bands III, IV or V for many services due to (a) its long wavelength, and therefore large antenna dimensions, (b) its susceptibility to ionospheric interference and (c) the high levels of man-made noise at these frequencies. In general, not much interest has been expressed for Band I.

- 2. Band III is also planned for MTV services (e.g. T-DAB, ISDB-T_{mm}) and many existing T-DAB services already make use of Band III; and
- 3. non-broadcasting services make use of Bands III, IV and V, in a number of countries.

In summary, it can be concluded that the size and the availability of the digital dividend varies from country to country, is dependent on local circumstances and requires decision making of the national regulator. In support of that decision making process the ITU however coordinates the allocation and the availability of the digital dividend at a global level by conducting WRCs. In the WRC-07 and WRC-12 some important decisions were made for national regulators to consider. The following sections will address these key decisions.

After having transferred existing analogue terrestrial services to the digital terrestrial platform, spectrum will be 'left over' and the key question is how this remaining spectrum should be allocated. Following our definition of the digital dividend many possible applications of the digital dividend can be considered. Three categories can be identified¹⁵⁸:

- 1) Broadcasting: spectrum needed for the improvement of terrestrial broadcasting services, including:
 - a. services with higher picture quality (notably HDTV and its successors);
 - b. increased number of services;
 - c. enhancement of TV experience (e.g. multi-camera angles for sports, individual news streams and other quasi-interactive options); and
 - d. digital radio services (i.e. T-DAB, T-DAB+ or DMB).
- 2) Mobile multimedia broadcasting: Radio resources needed for "converged" broadcasting services which are expected to be primarily "hybrids" of traditional broadcast and mobile communication services (like T-DMB or ISDB-T_{mm} network in combination with a UMTS/HSDPA/LTE network).
- 3) Fixed/Mobile services: Frequencies to be allocated to new "uses" which do not belong to the broadcasting family of applications. The most commonly considered application in this category is LTE or IMT. In various countries these LTE/IMT services have already been introduced in spectrum made available through the process of digital migration. The services that fall into this category are not limited to LTE/IMT. In summary the following example applications can be listed:
 - a. mobile telephony/broadband internet (LTE/IMT);
 - b. broadband access to scarcely populated areas;
 - c. services Ancillary to broadcasting, which already coexist with broadcasting;
 - d. low power devices (licence exempt or not);
 - e. private mobile radio;
 - f. military communications;
 - g. public protection and disaster relief (PPDR).

Already identified by the EU in its Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions; "EU spectrum policy priorities for the digital switchover in the context of the upcoming ITU Regional Radiocommunication Conference 2006 (RRC-06)", COM(2005) 461, Brussels 29.9.2005.

2.10.2 Determining the size of the digital dividend

As indicated in the previous section the size of the digital dividend is a matter of definition and is basically determined by:

- the base spectrum under consideration: VHF (Band III: 174 230 MHz) and UHF (Bands IV and V: 470 862 MHz)¹⁵⁹, often expressed in number of 'layers'¹⁶⁰;
- 2. minus the applications or services reserved for broadcasting (categories *broadcasting* and *mobile multimedia broadcasting*).

Hence the actual size of digital dividend can vary from country to country and depends on the regulator objectives. However, in the current debate on the digital dividend there seems to be consensus on the scope of the digital dividend as indicated above. In other words, first the broadcasting applications or services should be facilitated. Consequently, in Band III, IV and V, regulators first have to allocate spectrum to facilitate broadcasting applications ¹⁶¹:

- 1. existing analogue television services (and possibly in some country some other non-broadcasting services in Band III, IV and V);
- 2. additional DTTB for the improvement of terrestrial broadcasting services;
- 3. MTV services (in the case of T-DMB/ISDB-T_{mm} in Band III);
- 4. digital radio services (i.e. T-DAB, T-DAB+ or DMB) in Band III.

Quantifying the above four categories the following indication can be provided:

- 1. Existing analogue television services: In most countries where there are a few analogue TV services these can in general be accommodated into one DTTB multiplex. However, countries with more analogue TV services, using DTTB with a robust modulation or introducing HDTV services, may need multiple DTTB multiplexes.
- Additional DTTB/MTV services: The general consensus is that for a successful introduction of DTTB, more multiplexes are needed than the number of channels containing the current analogue TV programmes. In most countries, four to five multiplexes (and thus layers) are assigned in addition to facilitating the current analogue television service.
- 3. Digital radio services: During the RRC-06 it was recommended that each administration would limit the number of layers for digital radio to 3. This applies for Region 1 only. For the other Regions the spectrum trade-offs can be differently.

How much spectrum is precisely used for these broadcast categories depends on many local factors but most notably:

1. the type of digital TV reception (fixed rooftop, fixed indoor, portable or mobile and for which services respectively);

A layer is not defined in the GE06 Agreement, nor was it defined at RRC-06, but for most European countries it may be described as a set of channels which can be used to provide full or partial nationwide coverage. The number of layers

¹⁵⁹ With possibly Band I, see also footnote 157.

described as a set of channels which can be used to provide full or partial nationwide coverage. The number of layers depends, among others, on the geographical situation, the level of accepted interference, transmission and reception characteristics.

The supporting arguments to allocate the digital dividend for broadcasting applications can be found in EBU view "How should the digital dividend be used?", February 2008 and a common view published by Association of Commercial Broadcasters and Audiovisual Services in Germany and the EBU "European broadcaster's view on spectrum policy", February 2008.

- 2. the percentage of population or geographical area to be covered by the digital network;
- the required picture quality;
- 4. the applied transmission and compression technology;
- 5. the use of single or multi frequency networks (SFN or MFN);
- 6. the applied modulation/required robustness of the signal.

Consequently the remaining spectrum (if any), is generally considered to be that part of the digital dividend that can be allocated to services other than broadcasting (category Fixed/Mobile services).

Many countries licensed up to five or six multiplexes for DTTB services. In general after having licensed five or six multiplexes for DTTB services one or two layers remain in Band IV and V. However spectrum trade-offs seem to change with on the one hand the introduction of second generation transmission standards (e.g. DVB-T2), reducing the spectrum demand for DTTB, and the other hand the introduction of 4k and 8k versions of HDTV, increasing the DTTB spectrum demand. Also the rapidly developing mobile broadband market forces spectrum manager to constantly monitor and (re) consider spectrum trade-offs.

2.10.3 Digital dividend options

From a technical point of view it does not matter what applications an entry in a frequency plan represents (this includes also an entry in the GE06 plan), either *Broadcasting* or *Fixed/Mobile services* as long as the frequency 'contour' of the applications is the same (i.e. the same interference levels)¹⁶².

As most *Fixed/Mobile services* use a system based on a different bandwidth from that of broadcasting services (mostly 5 MHz), and have a return path (and hence have millions of receiving/transmitting handsets roaming throughout the country) these applications will need extra consideration in how these services may fit in an existing frequency plan for *Broadcasting* services.

It is efforts to harmonise global spectrum usage and to avoid interference, especially between *Broadcasting* and *Mobile services*, the ITU member states took some key decisions in respectively the WRCs of 2007 and 2012. The WRC-07 decided to allocate (on co primary basis) the upper part of the UHF band, 790-862 MHz, to the *Mobile service* and to identify it for IMT worldwide. In ITU Region 2 (Americas) and in several countries of Region 3 (Asia- Pacific), the band 698-790 MHz, which was already allocated to the *Mobile* service in these regions, was also identified for IMT.

The international harmonization of the digital dividend was further refined by WRC-12. The misalignment in the *Mobile* allocations of the digital dividend spectrum between the three ITU Regions has been corrected, by allocating the band 694-790 MHz to the mobile, except aeronautical mobile, service in Region 1 and identifying it for IMT. Subject to confirmation by WRC-15, this provides a worldwide mobile allocation and identification for IMT in all three Regions in the band 698-862 MHz, notwithstanding that individual member States have to decide the allocation of the digital dividend.

As said, it is important to note that it is up to the individual countries to decide the allocation of the digital dividend, more specifically about the allocation of services in the 698-862 MHz band. However, pressure from the mobile industry is great to allocate digital dividend spectrum uniquely to *Fixed/Mobile services* and regulators should be cautious in allocating and assigning this spectrum to *Broadcasting* services.

For more technical details on the technical constraints of applications based on GE06 Plan entries and sub-band allocations, see "Implementation of the Digital Dividend – technical constraints to be taken into account, Jan Doeven, EBU Technical Review, January 2007.

This mobile industry pressure is also reflected in recent technical and regulatory reports on the use of so-called 'White Spaces' for *Mobile* services¹⁶³. These white spaces have limited geographical extension and time duration, and any utilization must take into account the protection of nearby Primary services (including *Broadcasting* services). This white space operation can only be on a non-interference and non-protection basis and applying special technology that will 'search dynamically' for these white spaces (like ultra wide spectrum systems operating in a limited geographical range). Such systems would theoretically only require a general or type approval (i.e. no frequency licence assignment).

Table 2.10.1 provides an overview of a number of selected countries regarding the allocation of the digital dividend to *Mobile* services and the corresponding decision timeframe. What can be observed from the table is that countries already allocated and assigned digital dividend spectrum to *Mobile* services prior to the confirmation of such an allocation by WRC-15.

Table 2.10.1: Overview of the allocation to Mobile services in a number of countries 164

Country	National situation
Australia	 Analogue TV switch-off in 2013 694 – 820 MHz allocated to mobile broadband services Licenses auctioned in May 2013
Finland	 Analogue TV switch-off in 2007 790 – 862 MHz allocated to mobile broadband services Agreement with Russia on protection of Aeronautical Radionavigation services from mobile services in the band 790 – 862 MHz in December 2010 Re-allocation of PMSE services to 700 MHz band
France	 Analogue TV switch-off finalized on 30 November 2011 in Metropolitan France and overseas territories 790 – 862 MHz allocated to mobile broadband services Migration of broadcasting and military from 790 – 862 MHz Licenses auctioned in December 2011
Germany	 Analogue TV switch-off in 2008 790 – 862 MHz allocated to mobile broadband services Migration of broadcasting from 790 – 862 MHz Licenses auctioned in May 2010
India	 Analogue TV switch-off in 2015 698 – 806 MHz allocated to mobile broadband services
Japan	 Analogue TV switch-off in 2011 710 – 780 MHz allocated to mobile broadband services
Korea	 Analogue TV switch-off in 2012 698 – 806 MHz allocated to mobile broadband services Frequency plan for 698 – 806 MHz to be developed

The wording of "White Spots" or "White Spaces" or "Interleaved Spectrum" has been used to introduce a concept of frequency spectrum which is potentially available at a given time for further utilisation within frequency spectrum originally planned for broadcasting. See for more details for example CEPT report 24 or www.fcc.gov on the topic white space.

 $^{^{164}\,}$ Table taken from ITU report "Digital dividend: insights for spectrum decisions" and updated.

Country	National situation
Spain	Analogue TV switch-off in 2010
	790 – 862 MHz allocated to mobile broadband services
	Migration of broadcasting from 790 – 862 MHz
	Licenses auctioned in July 2011
Sweden	Analogue TV switch-off in 2007
	790 – 862 MHz allocated to mobile broadband services
	Migration of broadcasting from 790 – 862 MHz
	Licences auctioned in March 2011
UK	Analogue TV switch-off in 2012
	790 – 862 MHz allocated to mobile broadband services
	Migration of broadcasting from 790 – 862 MHz
	Licences auctioned in February 2013
USA	Analogue TV switch-off in 2009
	698 – 806 MHz allocated to mobile broadband services, mobile TV and public safety services
	Licences auctioned in 2008 and before

This timeframe of assigning digital dividend licenses ahead of WRC-15 means that incompatibility issues may still exist. Although resolving incompatibility issues is not new for spectrum managers, having different 'unknown' systems being deployed in adjacent channels complicate matters.

However due to great economic and industry pressure, spectrum is released before all incompatibility issues are fully understood and practical solutions are devised by regulators. In this light, the practical solution of the Swedish regulator (PTS) may prove an effective way for resolving these issues. In the licence conditions it is stipulated that the new licence holders are responsible for resolving interference and have to establish a common entity in which they cooperate to resolve any problems that may occur.

A similar approach was followed in the Netherlands when DVB-T was introduced and interference on cable networks was expected. At the time of launching the service the magnitude of this problem could not be accurately estimated and also here an entity was established to resolve any interference problems. A similar discussion is now taking place in Europe on the interference of 800 MHz broadband wireless networks on cable networks.

2.10.4 Implementation guidelines

The following guidance can be provided on managing the digital dividend choices in relationship with assigning DTTB and MTV licences:

- 1. Determine the size of the digital dividend for non-broadcast applications in a step-by-step approach by:
 - a. Determining the spectrum base (Band III, IV and V) and checking if also Band I should be included too. Including Band I seems only to be relevant in countries where there is already (analogue) television service in operation. If there is no television service in operation in Band I, and hence no associated installed receiver base in place, this band should not be included in the spectrum base.
 - b. Investigate and determine the number of Analogue/existing television services in operation. Careful consideration should be given to the exact broadcast locations and areas as services may only be made available in limited geographical areas.
 - c. Determine the required digital bandwidth for each analogue service and determine the number of layers/multiplexes (see also sections 4.1 and 4.2).

- d. Determine the number of digital radio services and MTV services in Band III in terms of number of layers/multiplexes.
- e. Determine the number of additional DTTB multiplexes/layers for the next 10-15 years and avoid (if possible) allocating services in the 698-862 MHz range (see also sections 4.1 and 4.2).
- f. 'Calculate' (i.e. the base minus the spectrum for broadcast applications) and determine the 'left over' (if any) for non-broadcast applications and report to the government.
- 2. Be aware that it is not necessary to assign all DTTB/MTV licences in one round (i.e. one single assignment procedure). However, assigning DTTB/MTV in multiple rounds will require sound arguments as spectrum will be temporarily left 'on the shelf'. Industry pressure will be great to allocate this spectrum for other services. Special care should be given to the argument for both the total number of layers and for the phased approach. The latter could include arguments such as the first round is to test the market and the licences should be assigned in a controlled manner so that the policies can be fine-tuned to market developments.

2.11 National telecom, broadcast and media act

In the previous sections 2.1 - 2.10 all the policy and regulatory choices/decisions directly related to the introduction of DTTB/MTV services have been addressed in detail. This section addresses the compliancy of the intended policy decisions with the existing and relevant regulatory framework. Very often this regulatory framework comprises national telecommunication, broadcast and media acts. The relevant regulatory framework varies from country to country and other Acts may have to be considered as well in the compliancy review, especially in the area of cross and foreign ownership and state aid.

This section is structured as follows:

- 2.11.1 Checking compliancy with telecommunication, broadcast and media acts.
- 2.11.2 Checking compliancy with other legislation especially related to cross and foreign ownership, and state aid.

2.11.1 Check compliancy with telecommunication, broadcast and media acts

For all the DTTB and MTV policy decisions the regulator will have to check compliancy with the existing (national) legislation laid down in the various Acts. Very often three Acts are directly related to policy and regulatory choices as addressed in Part 2 of these Guidelines:

- 1. *telecommunication act*: Especially those parts concerning the management and the assignment of spectrum are relevant;
- 2. broadcast and/or media act: especially those parts concerning acquiring the right or permission to broadcast television and radio (and associated) content.

From country to country, the exact content and titles of the various acts can vary. In some countries there is no specific broadcast act as those regulatory aspects are integrated into the telecommunication act or alternatively into the media act.

DTTB/MTV introduction practice has shown that there are some areas that are likely to have some discrepancy with existing legislation. Table 2.11.1 provides an overview.

Table 2.11.1: Typical areas of attention for intended DTTB/MTV policy decisions

Intended policy decision	Area of attention for compliancy
Exclude market parties up-front in a licence bidding procedure	Telecommunication and broadcast acts might not allow this as it stipulates only 'essential criteria' for excluding market parties. Also the competition legislation might stop such policy intentions.
Increase TV licence fee for digital viewers to finance the introduction of DTTB/MTV	Broadcast act might not allow this as the TV licence fee is levied on every citizen in the country. Also competition law might resist such intention (see also section 2.11.2).
Have public broadcast services behind conditional access	Media act might not allow this, even when the public broadcast services are free of charge. The notion of free-to-air might not be defined accurately enough.
Applying 'must carry rules' for the DTTB platform	In the absence of such rules for other competing television platforms, such an intended policy might raise the issue of not creating a level-playing-field. Conversely, not applying similar rules for DTTB, whilst applying them to other platforms, might also cause conflict.
Allowing the "State-assigned" or single DTTB/MTV operator (wholesale model) to offer DTTB services on his own platform	Competition law might limit such possibilities. Alternatively, such intended policy decision might ask for special measures such as having the State assigned operator to publish its wholesale tariffs (in a reference offer) and to have accounting separation.

Whilst checking regulatory compliancy, the regulator might need to change the legislation in order to be able to execute its DTTB and MTV objectives. This might delay the introduction of DTTB/MTV services. Hence the regulator should check compliancy as a continuous process when defining its DTTB/MTV policies. Also the Roadmap should cater for any necessary legislation changes. Alternatively, if introduction speed is critical in the DTTB/MTV policies, the regulator might consider altering the conflicting policy decision so as to make it fit into the existing regulatory framework.

2.11.2 Checking compliancy with other legislation

In some countries, licensing DTTB and MTV services might raise some specific issues that are not directly related to DTTB and MTV, including:

- 1. Cross-ownership: possibly in separate legislation, the ownership of media related activities might be limited. For example, publishers of papers/magazines/books (with a certain market share) are not allowed to own or control any other activities/companies in, for example, the television or radio industry. Such restrictions are often referred to as cross-ownership or media concentration rules. This may provide grounds to exclude or reduce the participation of media companies in DTTB/MTV assignment procedures.
- 2. Foreign ownership: possibly in separate legislation, existing legislation might limit the ownership of foreign shareholders in any company or bidding entity. This limitation might be confined to more specifically media companies. This may also provide grounds to exclude or reduce the participation of any foreign bidders for DTTB/MTV licences.
- 3. State aid: possibly in separate legislation or in the broadcast act, the commercial activities of the public service broadcaster (PSB) might be limited as they may be considered as forbidden state aid in commercial DTTB/MTV markets. PSB commercial activities are in principle defined by what is not stipulated as their public broadcasting task. However, the introduction of DTTB/MTV might blur that definition. For example, the PSB operating a shared multiplex or tower facilities together with commercial broadcasters.

4. Digital rights management (DRM): possibly in separate legislation, copy and privacy rights legislation might restrict or lay down requirements for the introduction of DTTB/MTV services. DRM is a generic term that refers to access control technologies (such as conditional access systems) that can be used by hardware manufacturers, publishers, copyright holders and individuals to try to impose limitations on the usage of digital content and devices.

Cross-ownership rules

Cross-ownership rules may not only limit the ownership across media platforms (like publishing and television) but also within a single platform. For example, the ownership of multiple radio/television entities (e.g. broadcasters) in a single local market may be restricted. In the table 2.11.2 an example overview is provided of ownership or concentration limits in the different countries.

Country	Concentration limits (simplified)
US ¹⁶⁵	 No entity can hold more than 39 per cent (reach) of the national TV market. No combinations among the four major national TV networks. Newspaper-broadcasting cross ownership not permitted. An entity may hold a TV station and a radio station in a single market (and more radio stations in larger markets).
UK ¹⁶⁶	A person may not acquire a TV licence if he/she holds a 20 per cent market share in the newspaper market.
France	No person may hold a television licence and 20 per cent of the newspaper market in a local area.
Sweden ¹⁵⁶	No ownership restrictions beyond normal competition law.
Japan	No entity can hold more than 10 per cent of shareholding in two or more TV broadcast companies in the same service area. No entity can hold more than 33.3333 per cent of two or more TV broadcast companies in different service areas.

Table 2.11.2: Concentration limits in a number of countries

In the following, an example set of cross-ownership rules is provided (taken and adopted from the FCC Media Ownership Rules¹⁶⁷).

- 1. Newspaper/Broadcast Cross-Ownership Rule to limit the ownership between newspaper and broadcast entities. Next to specific prohibitions and limits (e.g. the shareholding limits), the following aspects are also included:
 - a. A set of factors to evaluate a proposed combination, including (1) the extent to which crossownership will serve to increase the amount of local news disseminated through the affected media outlets in the combination; (2) whether each affected media outlet in the combination will exercise its own independent news judgment; (3) the level of concentration

See <u>www.fcc.gov</u>

See <u>www.ofcom.org.uk</u>

See the FCC 2006 review of the Media Ownership Rules on www.fcc.gov

- in the designated market area (DMA¹⁶⁸); and (4) the financial condition of the newspaper or broadcast station, and if the newspaper or broadcast station is in financial distress, the owner's commitment to invest significantly in newsroom operations.
- b. Waivers and when waivers are unlikely. For example for smaller markets (smaller than the top 20 DMAs), the Commission adopted a presumption that it is inconsistent with the public interest for an entity to own newspaper/broadcast combinations and emphasized that it therefore is unlikely to approve such transactions. The Commission will reverse the negative presumption in two limited circumstances: when the proposed combination involves a failed or failing station or newspaper, or when the combination results in a new source of a significant amount of local news in a market.
- 2. Local Television Ownership Limit under this rule, a single entity may own two television stations in the same local market if (1) the so-called 'Grade B' contours of the stations ¹⁶⁹ do not overlap; or (2) at least one of the stations in the combination is not ranked among the top four stations in terms of audience share and at least eight independently owned and operating commercial or non-commercial full-power broadcast television stations would remain in the market after the combination.
- 3. Local Radio Ownership Limit as a general rule, one entity may own (a) up to five commercial radio stations, not more than three of which are in the same service (i.e., AM or FM), in a market with 14 or fewer radio stations; (b) up to six commercial radio stations, not more than four of which are in the same service, in a market with between 15 and 29 radio stations; (c) up to seven commercial radio stations, not more than four of which are in the same service, in a radio market with between 30 and 44 radio stations; and (d) up to eight commercial radio stations, not more than five of which are in the same service, in a radio market with 45 or more radio stations.
- 4. The National Television Ownership Limit this type of rules permits a single entity to own any number of television stations on a nationwide basis as long as the station group collectively reaches no more than 39 per cent of the national TV audience.
- 5. Radio/Television Cross-Ownership Limit this limit cross-ownership between radio and television companies. Under that rule, one company may own in a single market: one TV station (two TV stations if permitted by the local TV ownership rule) and one radio station regardless of total market size; or if at least 10 independent media voices (i.e., broadcast facilities owned by different entities) would remain after the merger, up to two TV stations and up to four radio stations; or if at least 20 independently owned media voices would remain post-merger, up to two TV stations and up to six radio stations or one TV station and up to seven radio stations. Parties must also comply with the local radio ownership rule and the local TV ownership rule.

As the above example demonstrates, (cross-) ownership rules tend to be complex, especially in the area of broadcasting as it serves additional objectives of independent news judgment and diversification of news resources.

A contour may be visualized by imagining a rough circle surrounding a transmitter site at some distance, where the circle represents a certain field strength value, with greater radio field strengths inside, and lesser radio field strengths outside. The distances to the contours herein were derived using the maximum effective radiated power (ERP) and antenna height above average terrain (HAAT) combination permitted for each station class. For grade B the parameters are 50.0 kW ERP at 150 metres.

Designated Market Area is a term used by Nielsen Media Research to identify an exclusive geographic area of counties in which the home market television stations hold a dominance of total hours viewed. There are 210 DMA in the U.S.

Foreign ownership rules

Foreign ownership rules are intended to maintain a balance between encouraging investment in the broadcasting industry and meeting the government's sovereignty and security objectives. However, any foreign ownership restriction always comes together with concerns about whether these restrictions limit the ability of broadcast companies to gain access to capital. They may act as a barrier to innovation and growth in the sector.

Historically, governments have been concerned that foreign control of mass media facilities would confer control over the content of widely available broadcast material, which could lead to the possibility of foreign propaganda and misinformation. These fears are not unreasonable in situations where there are relatively few sources of information available to the public.

A global trend can be observed that governments tend to lift foreign investment restriction in the telecommunication industry first, followed by lifting or relaxing the limits in the broadcasting industry. The introduction of DTTB/MTV may accelerate this debate. Industry parties argue that the high cost of DTTB/MTV networks and the adoption of HDTV will increase the costs for broadcasters and foreign investments may be needed. Hence there might be pressure to relax foreign investment rules.

The following points outline the foreign ownership limits in Australia (taken and adapted from the independent Communications Law Centre in Australia¹⁷⁰):

- 1. the Treasurer has the power to stop substantial acquisitions of Australian assets which are contrary to the national interest;
- 2. it is allowed for single foreign shareholders to only hold up to 25 per cent of the shares in a mass circulation newspaper, with a maximum of 30 per cent for all foreign interests;
- 3. foreign proposals to establish ethnic newspapers in Australia will not generally be approved without substantial local ethnic community involvement and local control of editorial policy;
- 4. under the broadcasting services act, a foreign person cannot exercise control over commercial TV licences (foreign owners cannot have company interests in more than 25 per cent of a subscription TV licence and overall foreign interests cannot be more than 35 per cent);
- 5. there are no specific limits on foreign ownership or control of commercial radio in the broadcasting services act and acquisitions in this market fall under the foreign takeovers act and are considered on a case by case basis.

State aid

State aid can come in different forms and may lead to conflict with the competition regulations. To support and facilitate the uptake and development of DTTB/MTV services the government/state might decide to make some financial means available. Practice has shown that governments tend to provide financial support in the following DTTB/MTV areas, which may lead to competition law conflicts:

1. Providing aid for purchasing digital receiver equipment. Especially in the case of ASO (see sections 2.14 – 2.18 on the ASO) governments have provided support. For example in the United States, viewers could acquire up to two vouchers (of USD 40 subsidy each) for the purchase of a digital receiver. Also in other countries state aid was provided, for example Italy where viewers received a tax reduction if they purchased an integrated digital television set (IDTV) or in the UK where eligible viewers (e.g. over 75 years old or have lived in care home for six months or longer) can be provided with a digital receiver and/or installation aid under a special help scheme.

-

 $^{^{170}\,}$ See the website www.law.uts.edu.au/comslaw/

- 2. Imposing an additional television licence fee to fund the digital broadcasting activities of the public service broadcaster. For example in the UK and Sweden the government intended¹⁷¹ to increase the television licence fee to finance respectively the production of digital television content and the roll-out of the DTTB network.
- 3. Financial compensation to analogue television broadcasters which are required to discontinue analogue transmission before the expiry of their spectrum licences. Most notably this took place in countries like United States and some European countries.
- 4. Assigning one or more DTTB multiplexes by priority (i.e. without having to participate in a competitive bidding procedure) to public service broadcasters (see also section 2.2.3). Especially in markets where the PSB also has advertising income and where there are several other competing television platforms (e.g. satellite or IPTV) in the market, such an assignment may lead to a legal conflict.

All four above examples of state aid have led to competition law conflicts. Especially commercial broadcasters and other commercial television service providers may take such (intended) state aid decisions to court.

Some important European Commission/Court rulings have provided some guidance on when state aid is acceptable, including:

- 1. In the case of "Berlin-Brandenburg"¹⁷² the Commission gave specific indications of acceptable forms of public support for the digital switchover:
 - a. funding for the roll-out of a transmission network in areas where otherwise there would be insufficient TV coverage;
 - b. financial compensation to public service broadcasters for the cost of broadcasting via all transmission platforms in order to reach the entire population, provided this forms part of the public service mandate;
 - subsidies to consumers for the purchase of digital decoders as long as they are technologically neutral, especially if they encourage the use of open standards for interactivity;
 - d. financial compensation to broadcasters which are required to discontinue analogue transmission before the expiry of their licences provided this takes account of granted digital transmission capacity;
 - e. all measures must also respect the principles of transparency, necessity, proportionality and technological neutrality.
- 2. Also in the "Altmark" case, the European Court provided the following guidance on compensation for the costs incurred in the discharge of a public service obligation do *not* qualify as state aid if a number of conditions are cumulatively met:
 - a. clear public service obligations;
 - b. pre-established parameters for determining the compensation;
 - c. no overcompensation and;
 - d. either selection of (network) operator through tender procedure or determination of compensation with reference to costs of a typical, well-run undertaking.

-

In both cases the European Commission ruled that increasing the television licences fee for the intended purposes was in conflict with competition legislation. For the UK "Altmark" case ruling see press releases on http://europa.eu

¹⁷² See press releases on http://europa.eu

In many cases of directly compensating the public service broadcaster for digitalization costs the Commission concluded that the "Altmark" conditions were not fulfilled. In those cases, there were no objective pre-established parameters for determining the compensation. Furthermore, PSB network operators have not been selected by way of a tender procedure, and the compensation was not determined on the basis of an analysis of the costs of a typical well-run undertaking.

Finally granting one or more multiplexes by priority to public service broadcaster has shown fewer difficulties. In most countries it is common practice that the duties of the public broadcaster are defined in a separate broadcast or media act. Provided that the regulator will extend the defined duties to include digital broadcasting, little problems can be expected. It is a commonly accepted practice to assign one or two multiplexes by priority to the public service broadcaster.

Digital rights management (DRM)

Digital rights management has received international legal backing by the implementation of the 1996 WIPO Copyright Treaty (WCT). Article 11 of the Treaty requires participating nations to enact laws against DRM circumvention¹⁷³.

The WCT has been implemented in most member states of the World Intellectual Property Organization¹⁷⁴. The American implementation is the Digital Millennium Copyright Act (DMCA), while in Europe the treaty has been implemented by the 2001 European directive on copyright, requiring member states of the European Union to implement legal protections for technological prevention measures¹⁷⁵.

Basically, a national implementation will require that the legal framework (possibly in a dedicated act) will criminalize the production and dissemination of technology that allows users to circumvent technical copy-restriction methods. For example, under the national legislation, circumvention of a technological measure that effectively controls access to a work (including television broadcasts or films) is illegal if done with the primary intent of violating the rights of copyright holders.

DRM legislation is, as such, directed at the general public and not specifically addressed to DTTB/MTV licence holders, network operators, service providers or viewers.

However, in the DTTB/MTV licensing practice such national DRM legislation may require the regulator to:

- 1. include a reference to the DRM Act in the broadcast/spectrum licence terms and conditions (see also section 2.6.2 of these Guidelines);
- 2. check compliancy of any mandated conditional access system for either a DTTB or MTV platform (see section 2.1 of these Guidelines).

2.11.3 Implementation guidelines

The following guidance can be provided:

1. Check intended policy decisions continuously with existing legislations and allow time for changing existing legislation, if necessary. The roadmap planning should include time for this. In addition, carrying out market consultations (see Roadmaps in sections 6.1-6.3), covering the key policy decisions, during the policy making process will help to increase political acceptance.

For the text of the Treaty see www.wipo.int/treaties/en/ip/wct/trtdocs-wo033.html

¹⁷⁴ For participating members see www.wipo.int/treaties/en/ShowResults.jsp?lang=en&treaty id=16.

For the text of the European Copyright Directive, see http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0029:EN:HTML.

- 2. When introducing and licensing DTTB/MTV services the following should be checked in relationship to existing *cross-ownership* rules, whether:
 - a. DTTB/MTV multiplex control or ownership falls under the definition of media and/or broadcast entities as intended in the (cross-) ownership legislation;
 - b. a broadcast over the DTTB/MTV will add another television or radio entity in the local market;
 - c. broadcasting both radio and television channels over a DTTB/MTV platform will affect any radio/television cross-ownership limits;
 - d. any indented permission for DTTB/MTV licence trading 176 will obey the cross-ownership rules as well.
- 3. When introducing and licensing DTTB/MTV services the following should be checked in relationship to any existing *foreign ownership* rules, whether:
 - a. DTTB/MTV multiplex control or ownership falls under the definition of media and/or broadcast entities as intended in any foreign ownership legislation;
 - b. bidders for the DTTB/MTV licences (either for spectrum or broadcasting rights) will have to adhere to foreign ownership limits in:
 - i. either the radio markets; or
 - ii. television markets; and/or
 - iii. both markets.
 - c. any indented permission for DTTB/MTV licence trading will obey the foreign ownership rules as well:
 - d. any asymmetry in foreign ownership rules for the Telecommunication and Broadcasting industries exists. Such rules may be laid down in separate Acts. The further convergence between both industries may not contribute to clarity for foreign investors and hence limit the development of both industries;
 - e. the alignment between foreign ownership ruling and production quotas. Also consider rebalancing any lift of ownership rules with setting production quotas. With setting production quotas governments can limit risks of unwanted broadcasts (see section 2.8.2 of these Guidelines).
- 4. When introducing and licensing DTTB/MTV services the following should be checked in relationship to state aid law, whether:
 - a. the intended measures to support the introduction of DTTB/MTV are compliant with criteria such as provided by the:
 - i. "Berlin-Brandenburg" case;
 - ii. "Altmark" case.

When introducing and lice

5. When introducing and licensing DTTB/MTV check compliancy with any national digital rights management (DRM) legislation. Although primarily focused on criminalizing unauthorized copying or re-use of content and hence addressed to general public, DRM references could be included in the broadcast/spectrum licence terms and conditions. Such an inclusion protects the regulator from any liabilities.

Trading refers to the possibility to transfer and/or sell a spectrum licence to another company or entity. Very often the rules to grant such a permission are focused on whether the new entity is qualified (i.e. essential criteria) to operate the licence.

2.12 Law enforcement and execution

Any defined DTTB/MTV policy embedded in the relevant regulatory framework (see previous section 2.11) should have a form of law enforcement to have the set policy executed. For the introduction of DTTB/MTV services, and similarly for any service requiring spectrum, law enforcement focuses on the following policy aspects:

- 1. defining the national spectrum plan (see section 2.4);
- assigning spectrum and broadcast licences (see sections 2.2, 2.5, 2.6 and 2.8);
- 3. assigning local/building permits (see sections 2.2 and 2.7).

For maintaining the proper execution of the national spectrum plan and the assigned spectrum/ broadcast licences, often specific law enforcement entities exist. Varying from country to country, these entities are to include entities like the 'Radio Agency', the 'Communications/Broadcast Commission', the 'Electronic Media Regulatory Authority' or the 'independent Competition Authority for the communications industries'.

For maintaining the proper execution of assigned local/building permits, usually a non-DTTB/MTV specific regulatory framework exists. This section will not address this type of law enforcement because this falls outside the scope of these Guidelines. However, as discussed in section 2.7 it is important though that local councils/administrations are well informed about the specifics of DTTB/MTV broadcasting and are aligned with national spectrum policies (see section 2.7.3).

In this section the law enforcement organizational structure for the above first two policy aspects are discussed. This section deals with:

- 2.12.1 Centralized and segmented models.
- 2.12.2 Impact of convergence.
- 2.12.3 Implementation guidelines.

2.12.1 Centralized and segmented models

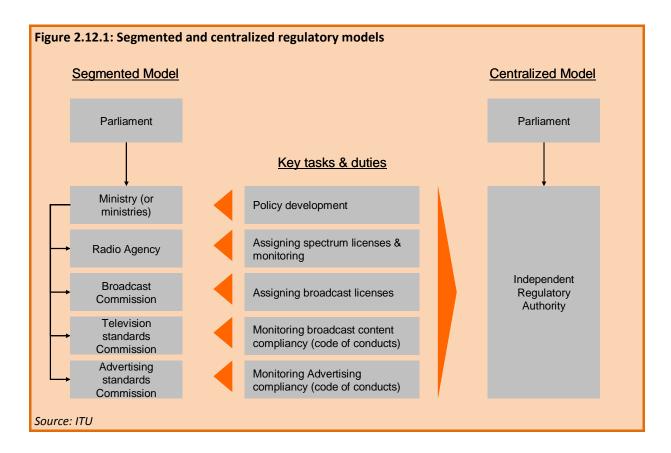
Regulators enforce DTTB/MTV policies by carrying out certain market interventions (like spectrum and broadcast licensing). In general regulators will intervene only where there is evidence that regulation is necessary, but then will do so firmly, effectively and decisively. However, using the least intrusive regulatory methods possible to achieve the public policy ends of which the regulators are the guardians. When regulation is necessary, regulators tend to promote and to facilitate effective co-regulation and self-regulation, placing greater reliance upon licensees and the industries to police their own affairs.

As said before, the organizational structure in which law enforcement is embedded varies from country to country. Basically two basic models can be distinguished; a segmented model in which the various regulatory duties are split between ministries and different specialized entities (very often organized per industry) or a centralized model in which all regulatory duties for one or more industries (e.g. the communications industries, including broadcasting and telecommunications) are centralized in one single entity. Good examples of the latter model are the Federal Communications Commission (FCC) in the USA and Ofcom in the UK¹⁷⁷.

Figure 2.12.1 illustrates the two different models and includes the key regulatory activities directly related to DTTB/MTV (and as addressed in the previous sections 2.1-2.10).

84

For example Ofcom was formed by bringing together five regulatory authorities – Oftel (telecoms), Radiocommunications Agency (spectrum), ITC (television), the Radio Authority (radio) and the Broadcasting Standards Commission (standards, fairness and privacy in relation to all broadcasters including the BBC).



Both models can have their own country specific implementations. For example in the segmented model it is possible that the Radio Agency does not directly report to any ministry but is directly governed by Parliament. Also, a centralized model can still operate in a non-coordinated way where different departments are working in their separate compartments. Both models do exist and little can be said about their relative effectiveness and efficiency. However, some countries are moving towards a more centralized or coordinated model.

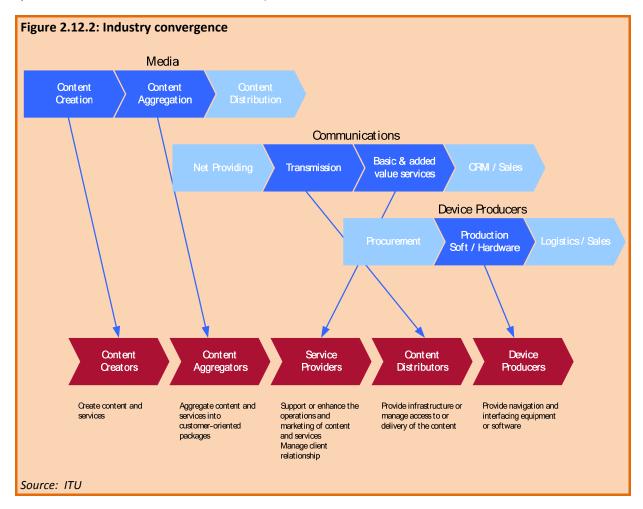
Before assigning any DTTB/MTV licence one should check whether the above mentioned tasks and duties are clearly assigned and coordinated between the existing regulatory entities. The trend towards a more centralized model is not directly related to the introduction of DTTB/MTV. However, the introduction of MTV is very often quoted as the example of the wider industry trend of convergence as it brings together the telecommunication and broadcasting industry¹⁷⁸. Also the allocation of the digital dividend between broadcasting and mobile services prompts the discussion on industry convergence (see 2.10). In other words the introduction of DTTB/MTV may result in a review of the organizational structure of the regulatory authorities.

It is the wider industry trend of the converging industries of broadcast and telecommunications that makes a more coordinated model necessary. As indicated in previous sections (see 2.2.2 and 2.11.2) asymmetry in legislation between the industries can occur and should be avoided. For example, asymmetry can occur when setting 'must carry', cross- and foreign- ownership rules or selecting assignment procedures (auction or public tender). In a segmented model with entities organized by industry and without close coordination between them, such asymmetry is more likely to happen.

Not only because of device convergence, integrating two receivers onto one device, but also that shared business models between broadcasters and telecom operators are necessary. For more details on business models see section 3.4 of these guidelines.

2.12.2 Impact of convergence

Apart from any efficiency considerations, regulatory convergence (i.e. towards a more centralized or coordinated model) is mainly driven by the widely observed market convergence trend. As illustrated in Figure 2.12.2, this market or industry convergence trend will result in a restructured value chain (see also part I and section 2.2.1 of these Guidelines).



Convergence takes place at basically three different levels, all having their specific impact on the regulatory framework:

- 1. network convergence;
- 2. device convergence;
- 3. industry/corporate convergence.

Network convergence

By the definition of network convergence, convergence will have taken place when all the different electronic communications networks (broadcasting, cable, satellite, telephony fixed and mobile) are each capable of providing all the different services (radio, television, voice, data) and with reasonable shares of consumer usage by each network ¹⁷⁹. From a consumer perspective, the various networks are interchangeable and service roaming should be seamless.

An important development in this network convergence trend is the adoption of the Internet Protocol (IP) for transporting any data, regardless whether this data represents information, voice, video or audio. Many telecom and broadcast companies follow a so-called "all IP" strategy facilitating efficient network operations, data exchange and seamless service roaming between networks.

Telecom networks are now able to deliver typical television services (e.g. by means of IPTV networks) and, conversely, broadcast networks are delivering typical telecom services like telephony and internet. More specifically, DTTB/MTV networks have become interactive by delivering, for example, services such as video-on-demand, gambling, shopping and voting.

With this *network* convergence an increased need for coordination arises between the telecommunication and broadcast regulations, especially for:

- Setting content requirements (see section 2.8). Traditionally the telecom regulator concentrates
 on regulating carriage but not content whereas the broadcast regulator very often has statutory
 content regulation powers.
- 2. Setting platform access requirements (see section 2.1.1, 2.2.2 and 2.6.1). Also here the telecom regulator has to liaise with the broadcast regulator as in the telecommunication industry platform access is not regulated in the same way. In the telecommunication industry a regulated 'wholesale' model is common, whereas in the broadcast industry access was regulated mainly at the level of site/antenna sharing. However, as previously discussed in these guidelines the introduction of DTTB/MTV may argue for the application of a wholesale model (see section 2.1.1).

Device convergence

Device convergence, however, is happening and at seemingly a faster rate than network convergence. A typical 3/4G mobile handset receives voice, data, still and (real-time) moving pictures – one-to-one and one-to-many communication. The PC screen routinely accesses movies, music, radio and television services. The MP4 players or Personal Media Players (PMP) have become a combined Internet access device, DVD player and television set.

Although device convergence may not lead to one single device accessing any platform or service, a small number of devices like the laptop computer/PC, the PDA, the TV set, the game console, the smart/mobile phone will be accessing, seamlessly, a much broader range of what were once separate, device-dependent services.

In a segmented regulatory model, this development will pose the question of why, for example, the (broadcast) regulator can regulate the content of one service (e.g. television programming displayed on a television set) but not of the other (e.g. the moving picture sequence downloaded from the Internet but also displayed on the same television set). From a consumer point of view, both services are perceived in the same way on their television set.

The ultimate form of network convergence would be one single unified network. However due to the specific characteristics of specific networks this is not even desirable. For example, broadcasting networks are very cost efficient in delivering large amounts of data to many. In fact the incremental costs are zero. The costs to transmit to one television set within the transmitter coverage area are exactly the same as to transmit to ten million television sets. This is in sharp contrast with, for example, an IPTV network delivering television services.

With this *device* convergence an increased need for coordination arises between the telecommunication and broadcast regulations, especially for:

- 1. Setting technology and standardization requirements (see section 2.1). As discussed access to a telecom service is differently organized than in the broadcasting industry. For example in the broadcasting industry it is common practice to lay down conditional access requirements (having a common interface) for the integrated digital television sets (IDTV), this is unknown in the telecoms industry. With the ever increasing number of different devices, a device specific regulation may well not be sustainable in the long run.
- 2. Setting limits for *subsidizing and bundling services*. In the telecoms industry some regulators restrict the possibilities of handset subsidizing whereas in the broadcast industry subsidizing receiver equipment is very often an accepted practice. Also dissimilarities may exist between the broadcast and telecom industry in the area of bundling services (e.g. only offering a single television, internet and telephony package may be prohibited in the telecoms industry).

Corporate convergence

Most eminently telecoms companies today, either fixed and/or mobile operators, offer television services and have built up know-how of the media content business, whether or not they choose to acquire content properties. Conversely, content or broadcast companies have started to deliver telephony and Internet services and their television programming over a widening range of networks, devices and to different audiences.

With this *corporate* convergence arises the regulatory issue of defining the legal entities/players like telecommunications, broadcast network operator and mobile network operator. For the different legal entities, different regulatory regimes might be applicable. For example, mobile operators might have obligations to share transmitter sites whereas broadcast network operators might not have. Review and revision of defined entities might be necessary. Again this will require coordination between the relevant regulatory entities.

2.12.3 Implementation guidelines

The following guidance can be provided:

- 1. Before assigning any DTTB/MTV licences, the involved ministries and regulatory authorities should check if the following tasks are clearly defined and no jurisdiction problems could occur:
 - a. policy formulation, including aspects such as defining the national spectrum plan, setting standards, setting licence terms and conditions etc;
 - b. assigning spectrum licences and monitoring proper use of the assigned spectrum;
 - assigning broadcast licences or permission to broadcast television and radio content;
 - d. monitoring broadcast and advertising compliancy (e.g. by applying codes of conduct for editorial content, EPG, access services and advertising).
- Continuously align and coordinate the DTTB/MTV policies between the involved regulatory entities, which seem especially relevant for licensing MTV services and allocating the digital dividend. These coordination efforts should focus and the areas as indicated in section 2.12.2 (including setting requirements for content, platform access, technology and standardization, subsidizing and bundling services).

3. Although not strictly related to the introduction of DTTB/MTV services, the government might consider a (phased) restructuring of the regulatory entities towards a more converged or centralized model. However, this should not hamper the realization of any set targets for the analogue switch-off (e.g. as communicated to the public by official publication)¹⁸⁰ or the planned assignments of DTTB/MTV licences (e.g. as indicated in the national spectrum plan).

2.13 Communication to end-consumers and industry

Informing the public at large¹⁸¹ and the television industry about the changes in the areas of legislation, policies and regulations (related to the introduction of DTTB and MTV) is a government led task.

Informing the end-consumers and the industry is an important element of policy execution. Providing adequate and timely information will ensure and support a rapid service take-up, a profound market development (i.e. content development and receiver supply/availability) and a smooth service transition.

With reference to the functional framework, it should be noted that this section addresses communications in the more general situation that new (DTTB/MTV) services are being licensed and introduced. For the more specific situation that DTTB/MTV services are licensed and introduced in the framework of switching-off analogue television services, refer to section 2.18 (i.e. functional building block 2.18 in layer B of the functional framework). In such a situation the communication is different and often special entities are established taking care of informing the public and industry.

This section is structured as follows:

- 2.13.1 Scope of government led communications: In what cases does a need arise for government led DTTB/MTV communications?
- 2.13.1 DTTB/MTV specific communications moments and topics.
- 2.13.1 Implementation guidelines.

2.13.1 Scope of government led communications

To limit the risk of distorting or confusing the market, regulators or legislators should only communicate about services and activities that directly fall within their responsibilities. A regulator should scope clearly where his communications duties lie. Related to DTTB/MTV licensing a need for public communication can arise in the case of:

- 1. government intervention restricting or changing free market competition (see section 2.6.1);
- 2. defined Universal Services and access to these services (see sections 2.1 and 2.2.3);
- 3. health and safety hazards (see sections 2.6.3 and 2.7.2).

Government intervention restricting free market competition

The first case is valid for both DTTB and MTV licensing as spectrum is a valuable and scarce resource which is assigned to a limited number of licence holders. As such the free market is restricted and hence the government has to explain and communicate its intentions and actions. Allocating parts of the spectrum for specific user categories, which is very often part of the national spectrum plan, is also a form

¹⁸⁰ For more details on the ASO see sections 2.14-2.18 of these Guidelines.

Please note that marketing and communication to specific user groups, such as carried out by commercial parties (e.g. network operators and service providers) and/or public broadcasters are separate and covered in section 3.5 of these Guidelines.

of restricting free competition. In addition, issuing broadcast licences and building permits could also potentially limited market entrance and competition. In fact, any form of licensing can be considered as market intervention¹⁸².

Defined Universal Services and access to these services

The second case can be different for DTTB and MTV licensing. A need arises for public communications when the legislator has defined for end-consumers a Universal Services (US) and access to these services (UAS). As a general guideline for determining these US and the UAS, a service has to satisfy two tests¹⁸³:

- 1. in the light of social, economic and technological developments, the ability to use the service has become essential for social inclusion; and
- 2. normal market conditions are unable to make the service available to all.

The outcomes of these two tests can be different from country to country, especially for developing countries. The main driver for inclusion may be economic before social factors. Special consideration might be given to the educational aspects of the widespread availability of (digital)¹⁸⁴ television content.

The services to be included in the scope of universal and service access (UAS) will change as technology and society changes. Especially convergence developments, where various delivery platforms (e.g. wireless/WiMAX, IPTV/Internet networks) can deliver television content in an efficient manner, the inclusion of Universal Services and UAS might change. Market consultation and evaluation might be necessary continuously, for example every three years.

With regard to DTTB services, most countries have defined US and UAS in various Acts (either telecommunication or broadcast/media acts) for these services and generally include:

- 1. free-to-air reception of the public broadcaster's radio and television content against acceptable costs for national viewers¹⁸⁵ (see section 2.2.3);
- 2. (near) nationwide population or geographical coverage of public broadcaster's radio and television services (see section 2.2.3);
- 3. 'must carry' rules for specified programming or services on specified delivery networks (see sections 2.2.1, 2.5.3 and 2.8.1).

For MTV services, as addressed in section 2.1, such US and UAS stipulations are rare. However, under certain market situations (e.g. the MTV platform is the only network to deliver television content in rural areas) the above tests can result in a different outcome.

Not only should the legislator earmark the DTTB/MTV service as a US, but should also define what capacity is reasonably and proportionally required for this US. Sections 2.2.3, 2.3.2 and 2.10.2 have provided guidance on assigning capacity to DTTB/MTV services.

-

¹⁸² It should be noted that in most countries spectrum licensing and management are allowed under the competition laws. For example, in the European competition laws, assigning spectrum licences are explicitly mentioned as lawful interventions. From a legal competition point of view, assigning broadcast licences might be reviewed more thoroughly. See also section 2.6.1 of these guidelines.

For more details on US/UAS and these tests and example test see www.ictregulationtoolkit.org, respectively module 4 and section 1.1.4, infoDev/ITU.

Especially digital television, because digital television can more easily facilitate thematic channels due to more distribution capacity and the possibility of interactive applications.

Very often only defined for the analogue terrestrial platform and it is unclear if such a provision also applies to the other/digital platforms. Also, acceptable costs are very often not defined. Especially when ASO is considered, these questions might arise and need to be resolved.

Health and safety hazards

As discussed previously in these Guidelines, before allowing the DTTB/MTV transmitter site to be erected and taken into operation, the (local) regulator checks for compliance with health and safety regulations, including field strength and EMC. The general public and industry should be informed about which standards and norms are applicable and should be adhered to. Very often governments will refer to and base their field strength and EMC regulations on standards of international bodies:

- 1. Field strength: the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE)
- 2. Electromagnetic Compatibility (EMC): International Electrotechnical Commission (IEC), Comité Européen de Normalisation (CEN) and European Telecommunications Standards Institute (ETSI).

For both DTTB/MTV such field strength and EMC standards should be known and published. Especially for the equipment producers (transmitter and receiver equipment) an alignment with international norms is advisable so as to reap the benefits of a global economy of scale.

2.13.2 DTTB/MTV communication moments and topics

Section 2.13.1 already provides general guidance when government led communications should take place. In this section, the specific communication moments and topics will be further specified.

Table 2.13.1 provides an overview of the DTTB/MTV related communications moments, topics and intended audiences. The table also refers to the relevant sections where detailed information and the policy considerations can be found.

When	Category	Topics	Primary Audience (Public/ Industry)	Sections
Continuously	Regulatory framework and organization	Legal framework and relevant acts	P/I	2.11
		Regulatory entities and their duties and tasks	P/I	2.12
		Public service broadcasting (role, tasks and duties)	P/I	2.2.3, 2.5.2
		Regulatory decisions on legal framework	P/I	2.11, 2.2
		Market consultations (general and industry wide) 186	I	_
	Inquiry, complaint and appeal procedures	Assignment procedures	I	2.5
		EMC and Safety (standards)	P/I	2.6.3, 2.7.2
		Spectrum interference (amongst users)	I	2.3
		Home equipment interference ¹⁸⁷	Р	_

Table 2.13.1: Communications moments and topics

⁻

Regulators might carry out market consultations on a review of complaint procedures or topics which may require additional regulation. For example asking for proposals on how to regulate access services (subtitling), video on demand services, etc.

In some countries it might be possible that the DTTB frequencies are in use by cable companies. The introduction of the DTTB service might cause interference and viewers need to be helped to resolve these problems (for example by sending the affected viewers other cable connectors).

When	Category	Topics	Primary Audience (Public/ Industry)	Sections
Recurring	National spectrum planning	Preparatory market consultations	I	2.4
		National spectrum plan	P/I	2.4
		International planning conferences (e.g. WRC-15)	I	2.3, 2.4
		Re-farming and revoking spectrum under existing users	P/I	2.4
		Appeal procedures for spectrum management decisions ¹⁸⁸	I	_
Case by case	Assigning DTTB/MTV licences	Preparatory market consultations on DTTB/MTV	I	2.4, 2.5
		Applicable licensing framework	I	2.2
		Applicable technology standards	I	2.1
		Applicable assignment procedure	I	2.5
		Spectrum licence terms and conditions	I	2.6
		Broadcast licence terms and conditions	I	2.8
		Required local/building permits	P/I	2.7
		DTTB/MTV regulatory decisions (including revoking) and appeal procedures	P/I	2.5
	Digital dividend	Market consultations on digital dividend	I	2.10
		International digital dividend decisions ¹⁸⁹	P/I	2.10
		Digital dividend regulatory decisions (including revoking) and appeal procedures	I	2.10
	ASO	See sections 2.18	P/I	2.18

2.13.3 Implementation guidelines

The following guidance can be provided on government led communications to end-consumers and the industry:

- 1. Limit the risk of distorting or confusing the market by communications based on the principles of:
 - impartiality and accountability: making sure that certain market parties or end-consumer groups are not favoured, that policy decisions are evidence supported and are based on a legal constitution;
 - o. responsibility: only communicate about topics where there is direct responsibility as indicated in section 2.13.1 (for example, informing the market about available transmitter or receiver equipment might be best left to the market);

92

Regulators might have on their website complaint procedures. See for example www.ofcom.org.uk/about/accoun/complaints/.

¹⁸⁹ A good source for information is the subscription based website service called Policy Tracker, see www.policytracker.com.

- c. *transparency*: keep the audiences continuously up-to-date on the regulatory process and decisions (even when there is no progress). Provide information in time and complete so that end-consumers and industry can have a reasonable preparation time.
- 2. Select appropriate communication tools for the target audiences. Communication tools should be tailored and a one-fits-all approach should be avoided. The following tools are generally applied for the two main audiences:
 - a. End-consumers/general public:
 - i. consumer associations and interest groups (and they inform their members);
 - ii. website (depends on the internet access and availability);
 - iii. printed media (official Gazette, newspapers and magazines);
 - iv. radio and television channels (for specific events like the ASO, see for more details section 2.18).

b. Industry:

- i. market consultation and information sessions;
- ii. (International) conferences and fairs;
- iii. direct mail (using the regulators' licence holder registers);
- iv. website (perhaps with a special login for licence holders);
- v. printed media (official Gazette, newspapers and professional magazines).

2.14 Transition models

The process of transitioning from analogue to digital terrestrial television broadcasting can be carried out in different ways depending on the local situation (e.g. the number of terrestrial viewers and services, spectrum availability, local demographics, infrastructure availability and ownership), international obligations and the government's policies and objectives.

This section and the following sections 2.15 to 2.18 all address the situation that analogue terrestrial television services will be discontinued and migrated to a DTTB platform in *one coordinated effort, led by the national regulatory authorities*. A key element in the Analogue switch-off (ASO) process is that the government sets a *mandatory* date for analogue switch-off.

This situation is fundamentally different from the situation where the national government decides to introduce a DTTB platform next to any existing analogue services; both the analogue and DTTB services can coexist next to each other and there is no (clear) objective to switch-off the analogue service in the near future.

This section comprises:

- 2.14.1 *ASO objectives and hurdles*: The key ASO objectives and what hurdles the regulator encounters when initiating an ASO process.
- 2.14.2 ASO factors: The key factors determining the ASO transition model.
- 2.14.3 ASO transition models: The basic transition models for realizing an ASO.
- 2.14.4 Implementation guidelines: What model to apply when.

2.14.1 ASO objectives and hurdles

Analogue switch-off is the *process* of turning off the analogue *terrestrial* television signal and replacing it with a digital signal. ¹⁹⁰ It will basically require changing existing television broadcast networks and changing end-consumer television receiver equipment (either connecting a digital converter to the existing television set/recorder or replacing the existing television set with an integrated digital television set and/or digital recorder). Very often with an ASO, not only the existing analogue services will be converted to digital, but also additional DTTB services will be introduced at the same time (as more than one/two multiplexes will be assigned).

ASO objectives

The ASO is a government initiated process, aiming at gaining *spectrum efficiency*¹⁹¹ which will bring *consumer benefits* (more choice in television services) and *industry benefits* (new revenue streams and business models). For more details on these consumer and industry benefits please refer to Part 1 of these Guidelines.

These above objectives are very valid reasons for governments to introduce DTTB services, however these objectives do not make it *necessary* to switch-off analogue and hence to carry out an ASO operation. The main reason for analogue switch-off is in the government's objectives to:

- 1. have a universal television service on the DTTB platform; and/or
- 2. securing the future of the terrestrial platform.

For countries where there is no frequency shortage that would prevent near-universal DTTB coverage, another reason to switch-off analogue transmissions exists. With the global objective to switch-off analogue transmissions, it is inevitable that analogue transmitter and receiver equipment will become obsolete. Consequently, network maintenance costs will go up and ultimately service levels will degrade as spare (analogue) components are no longer readily available.

ASO hurdles

With such clear benefits of having DTTB services, one could ask why ASO does not take place 'automatically' (i.e. without any government intervention). Any ASO, in the shorter run, involves significant costs and difficulties associated with the need to:

- Introduce technical upgrades in all segments of the value chain: requiring a (government led)
 coordinated effort across industries, otherwise the typical 'prisoner's dilemma' will occur:
 Studios or content creators will not produce digital content if no networks and viewers are
 available that can enjoy the full benefits of such digital content.
- 2. Review spectrum mechanisms and approaches: DTTB services will require the allocation of spectrum and assignment of licences, and possibly re-farming spectrum (moving incumbent users to different parts of the spectrum). All typical government tasks.
- 3. Financing the cost of 'simulcasting': to provide viewers a period of time to switch to another/digital platform, most ASOs will require a period of simulcasting, where both the existing analogue services and the new digital services are broadcast. Such a simulcast period will imply additional network costs with any or limited added value for the individual

This implies a transition from analogue terrestrial television to DTTB. Consequently in the functional framework the sections 4.1 – 4.9 on the technical implementation of DTTB networks are relevant too. Please note that an implementation of a DTTB network can also be carried out independently from any ASO, if there are enough frequencies available. The same applies to any implementation of a MTV network.

¹⁹¹ ASO spectrum efficiency may result in freeing up spectrum, the so-called digital dividend (see section 2.10).

broadcasters involved. In most cases, these individual broadcasters are either Public or commercial broadcasters. Consequently, governments must provide funds or compensation for these additional network costs. In addition, without a simulcast period, spectrum can sometimes not be freed-up and the ASO is, in effect, not possible.

2.14.2 ASO factors

A set of interdependent factors will largely determine the approach chosen for the ASO process, i.e. the ASO transition model. As these factors are related and very often controlled/influenced by different parties/entities, a collaborative and interactive approach for designing and managing the ASO process should be adopted (see section 2.15). These factors include ¹⁹²:

- required DTTB services;
- 2. the number of analogue terrestrial television viewers;
- 3. availability of spectrum;
- 4. DTTB service uptake.

Required DTTB services

First of all the government should determine which services are considered to be a Universal Service on the DTTB platform. These services then have to be facilitated on the DTTB platform after switching them off on the analogue platform. In many countries, these services are limited to the public service broadcasting (PSB) services. However in some countries, popular commercial analogue services are also considered to be essential to be present on the DTTB platform. Omitting these commercial services on the DTTB platform will hamper the update of the DTTB services. Consequently regulators include these services to have priority over new market entrants (for example by reserving capacity on the DTTB platform).

Next to the national PSB services, also regional and local PSB services should be taken into account. These regional and local PSB services should not necessarily (all) be facilitated on the DTTB platform (see also below).

Whether the DTTB platform can facilitate all US services depends heavily on:

- 1. spectrum availability (see below and also section 2.3);
- 2. network design and planning (see sections 4.2. and 4.3), and;
- 3. if a simulcast period is required: the government and/or the involved broadcasters might require a 'simulcast' period, allowing analogue viewers to switch to an alternative television platform. A simulcast period is however not necessarily required in each geographical area or for all US services¹⁹³, but if so, also;
- 4. duration of the simulcast period: the duration of the simulcast period will determine the possibilities of re-using frequencies and hence the available DTTB capacity (and total duration of the nationwide ASO).

 $^{^{192}}$ See also Digitag report "Analogue switch-off: Learning from experience in Europe", 2008.

For example in the Netherlands the analogue transmitters were switched-off nationwide, in one go, whilst only in half the country the PSB services were simulcast on the DTTB platform. Also regional PSB services did not have a simulcast period on the DTTB platform as they were facilitated on the satellite platform.

The number of analogue terrestrial television viewers

As an ASO process is a government led process, this risk of disenfranchising viewers is a sensitive topic and should be prepared carefully. Especially determining the various viewer groups ¹⁹⁴ and the number of affected viewers is critical.

In countries with a small number of television households relying on the terrestrial analogue television platform will be in the position to switch-off the analogue platform quickly as the logistics of providing digital receivers and informing the affect viewers is a relatively small operation. The perceived risk is also smaller because in the event of a failure in the migration process a relative small number of viewers are affected.

In determining the number of viewers of the different television platforms in a given country, very often the reception mode used for the primary television set can be the determinant. However the regulator should consider that in television households more than one 'receiver' can be present: multiple television-sets with different reception modes (e.g. the first set is cable connected and the second set relies on the terrestrial platform) and recording devices. For example in Europe many markets show an average of 2.2 television sets per household whereby secondary television sets rely upon the terrestrial platform, while in Japan most television households own an average of 2.4 television sets and many of them rely on the terrestrial platform. It should be noted that recent market studies show that the average number of television sets per household is decreasing due to viewers switching to consume television via smartphones and tables.

The following aspects should be taken into account when determining the various affected viewers (i.e. those relying on the analogue terrestrial platform):

- 1. Second (and third) television-sets and their reception mode.
- 2. Recording devices: (video/hard disk) recorders have an in-built analogue receiver enabling the recording of a different television programme than that being watched simultaneously on the connected television set. The standard set-top-box has only one tuner therefore to facilitate this 'split' functionality an advanced set-top-box will be equipped with a twin tuner¹⁹⁵.
- 3. Viewers in 'multi-dwelling units': viewers in this group share a common analogue receiver infrastructure, for example residential houses with several tenants (all watching television through a single analogue cable system), hotels, public building and places, prisons¹⁹⁶, etc.
- 4. Affected public service broadcasting (PSB) services and alternative reception modes: not only the national PSB services should be considered but also the regional and local PSB should be taken into account. Especially as these regional/local services might not be facilitated on the DTTB platform¹⁹⁷ or on the satellite platform (or any other alternative platform).

_

Television Household (TVHH) and Household (HH) are commonly used terms. However the term implies a 'family, ranging from single households to multi person households, watching television'. With this term very often other television usage is overlooked. For example, small groups of people watching television in clubs, bars and other public places.

This problem with second television sets and recorders is not DTTB specific but applies to all digital platforms. In most cases it is for the digital television service provider to manage this problem, i.e. to offer a twin tuner or a second tuner. A twin tuner is a set-top-box device incorporating two tuning units. Hence two different channels can be watched and recorded at the same time.

¹⁹⁶ In Germany, when switching off analogue television in Berlin, analogue television viewers in prisons were an unexpected group of viewers complaining of not be able to receive television anymore.

Facilitating regional services on a DTTB can be very spectrum in-efficient and relatively expensive. However, facilitating regional services depends on the country's requirement/decision. For more details see section 4.2 and 4.3.

Subsequently, per identified viewer group the actual numbers should be estimated and per group the number of affected PSB services. The government should then determine its responsibility in resolving the identified problems, ranging from just informing affected viewers to financially compensating viewers.

Availability of spectrum

It is evident that spectrum should be available for the introduction of DTTB services. In some countries the analogue terrestrial services should first be switched off before any DTTB service can be introduced. In other countries there is spectrum available for simultaneously broadcasting analogue and digital terrestrial services. These two situations may even occur in the same country depending on the region or geographical area. For example, in the Netherlands, in some parts there was simulcasting of terrestrial services whilst in others there was none. Also the simulcast period can vary throughout the country, like in Germany where this period ranged from 3-9 months.

Re-use of freed-up analogue frequencies for the launch of DTTB service elsewhere, in a phased approach may be the only possibility to complete an ASO nationwide¹⁹⁸. Such a phased approach implies a complex 'frequency puzzle' which has to be carefully designed and planned.

A good example of such a frequency puzzle can be found in Japan. Analogue frequencies in critical areas (approximately 2 000 out of 15 000 total channels in the country) were re-arranged to secure availability of spectrum for DTTB services. A variety of countermeasures to maintain analogue reception in those areas were taken under the regulator responsibility. These countermeasures were taken to recover services from interference that would otherwise take place and included measures such as use of high performance rooftop antenna, community antenna reception system, precise frequency-offset transmission, offset-beat canceller, and so on.

DTTB service uptake

In any ASO process, the actual attractiveness of the DTTB platform will for a large part determine the success of the ASO operation and the government should take this aspect into account. The attractiveness of the DTTB platform is directly related to:

- 1. The availability of the services (coverage): (a near) national coverage is easier to communicate to viewers and will make it easier for end-consumers to understand the DTTB offering.
- 2. The appeal of the service offering (content): the DTTB offering should have added value as compared to the analogue services (or any other competing platform). For example, in a typical terrestrial-TV country (i.e. where a large proportion of the population relies on the terrestrial platform) and without any cheap multi-channel offering on alternative platforms, DTTB's added value could be in the (limited) extra channels for a lower subscription fee (in the case of a pay-tv offering) or free-to-air (in the case of an advertising-/licensing fee-based offering).
- 3. The cost of the service: i.e. the price of receiver. High costs for the receiver will increase barriers either of the DTTB service operator (in the form of subsidies) or for the viewer (in the form of high purchase prices). However, DTTB receivers are continuously decreasing in price. The price of a simple set-top-box is considerably lower than that of analogue TV set. In addition, in many markets there is no longer any price difference between an analogue television set and integrated digital television set (IDTV) and only IDTVs are for sale.

Next to the other available digital alternatives, the assessed attractiveness of the DTTB platform will for a large part determine the speed of DTTB penetration and hence the required simulcast period.

For determining the available DTTB spectrum, see section 2.3. For the technical utilization of the available spectrum and network planning see section 4.2 and 4.3.

2.14.3 ASO transition models

Several different models to digital switch-over have been adopted, depending on the local circumstances (see previous section on ASO factors). However, two basic models can be identified (with combinations and in-between variants):

- 1. ASO with simulcast period, with two sub-categories:
 - a. Phased approach to analogue switch-off: region by region the analogue transmitters are switched-off. In principle, such a switch-off approach can be combined with a two basic rollout scenarios for the DTTB network:
 - i. the DTTB network is also rolled out in a phased approach, region by region; or
 - ii. the DTTB network is already available with (near) nationwide coverage before the first transmitters are switched-off.
 - b. National approach to analogue switch-off: on a nationwide scale, the analogue transmitters are switched-off at one moment in time whilst a (near) nationwide DTTB network is available.
- 2. ASO without simulcast period (in limited geographical areas or specific regions): the analogue transmitters are switched-off and at the same moment (i.e. one or several hours later) the digital transmitters are switched-on at the same transmitter site(s).

ASO with simulcast and a phased approach to analogue switch-off

In a phased approach the analogue terrestrial television services are switched-off region by region in a given country. This phased approached should be planned carefully and a detailed timetable should indicate exactly which analogue transmitters will be switched-off when in each region.

A phased approach provides several benefits:

- 1. lessons learned in one region can be used to improve the process in following regions. Failures in one region can be corrected and the impact of these failures is limited to a single region;
- 2. freed-up analogue frequencies in one region can be re-used in a following region in order to increase the DTTB coverage and/or expand the DTTB service offering;
- 3. cost and resource can be spread out over time and the migration process can be more manageable.

The phased approach has been used throughout Europe, for example in countries like Austria, France, Germany, Italy, Norway, Spain and Sweden.

In countries, such as Japan and the UK, that have opted to launch national DTT services before beginning analogue switch-off, it has provided the regulator the possibility to observe first how the DTT market develops before finally deciding how and when to cease analogue services. Such an approach will limit the risk of setting an ASO date too early as many viewers may still remain watching television services on the analogue platform at the date of ASO. However, the downside is that it lacks a clear marker for viewers to migrate to DTTB.

ASO with simulcast and a national approach to analogue switch-off

In a nationwide approach to analogue switch-off all analogue services are ended at the same date across the whole country. Clearly in such an approach all affected viewers can enjoy the DTTB services at the same time and are treated equally. However all these affected viewers will all need to acquire a digital receiver at the same time which may result in a large strain on logistic supply chains (not only for supplying DTTB receivers but also for any other competing platform such as satellite or cable).

In many countries a prerequisite to this approach is that the DTTB services have been launched and made available to all affected viewers. A nationwide ASO was carried out in countries like in Andorra, Denmark, Finland, Japan, Luxembourg and the Netherlands (in half of the country).

A nationwide approach will concentrate the efforts at one moment in time and might be difficult to manage (depending on the scale of the involved networks). However, a nationwide switch-off has the following benefits:

- 1. simple and concise communication possible to the affected viewers: no need for viewers to check when their region is going to be switched-off and no confusion possible for 'border cases';
- all viewers benefit from the advantages of digital switchover, as viewers are treated equally and given the same access to services but equally all suffer from the need to equip for digital (although depending on the roll-out of the DTTB network some viewers might have a longer simulcast period);
- depending on the spectrum availability, a nationwide approach could free-up spectrum more rapidly and make those frequencies available to DTTB network (for example, to increase the number of television channels/multiplexes).

ASO without simulcast

Although not applied very frequently, it is possible to switch-off the analogue transmitters without facilitating a simulcast period. In such an approach, where in a very short timeframe the analogue service is replaced by a digital service, the high simulcast costs are not incurred.

The key ASO factor determining such an approach is the political or regulatory willingness to adopt this model (see above "required PSB services"). The key (political) risks associated with this model are:

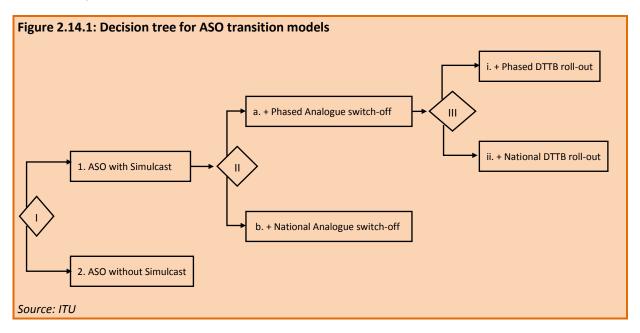
- 1. viewers cannot roll back to their analogue platform. Please note that in both models, with and without simulcast, viewers have to purchase a digital receiver for the DTTB platform (or any other alternative). In this aspect there is no difference;
- if something goes wrong after analogue switch-off, the damage is not confined to one region but is suffered on a nationwide scale (however, the number of affected viewers can still be limited).

Clearly the above risks will call for political or regulatory willingness to adopt this model. But when available budgets for simulcasting are low and the number of potentially affected viewers are low too, this model is certainly feasible (in at least limited geographical areas) as practice has proven.

2.14.4 Implementation guidelines

The following guidance can be given in determining which ASO transition model to apply:

1. Figure 2.14.1 illustrates the three basic decisions:



For each decision the relevant ASO factors are mentioned between square brackets:

a. Decision I:

- i. Model 1: when the politicians stipulate a simulcast period [required DTTB services]. This is when the risks of failure are assessed high. This is likely when the analogue terrestrial television platform is relatively large (as compared to the other available platforms) for the affected services [The number of analogue terrestrial television viewers] and/or added value of the DTTB platform is deemed to be low [DTTB service uptake].
- ii. Model 2: when the politicians don't stipulate a simulcast period and the down side risks are deemed to be low (possibly only in certain regions) [required DTTB services]. This is likely when the analogue platform is relatively very small [The number of analogue terrestrial television viewers]. This type of model was applied in the Netherlands (in half of the country).

b. Decision II:

- i. Model 1(a): when the [The number of analogue terrestrial television viewers] is relatively big and the sheer size of the switch over operations are relatively big (not enough resources to manage the ASO in one go).
- ii. Model 1(b): when the [The number of analogue terrestrial television viewers] is relatively small. This model was applied in countries such as Andorra, Finland, Luxembourg and the Netherlands (in half of the country). This is also applied to countries like Japan where the geometrical areas of analogue service are complicated (like labyrinth) and difficult to separate into phased regions.

c. Decision III:

- i. Model 1(a)(i): when the [The number of analogue terrestrial television viewers] is relatively big and available spectrum is limited [Availability of spectrum] and frequencies have to be re-used. This ASO transmission model was applied in Germany.
- ii. Model 1(a)(ii): when [The number of analogue terrestrial television viewers] is relatively big and available spectrum is not limited too much for a nationwide DTTB network with enough multiplex to have an attractive alternative [Availability of spectrum] + [DTTB service uptake]. This transmission model was applied in the UK.
- 2. A joint ASO process with a close cooperation with commercial parties is recommended as they have an interest to provide the viewers with a set-top-box. Commercial parties can generate revenue streams which can (partly) finance set-top-box subsidies. This obligation can be included in the DTTB frequency licence terms and conditions. Such an approach should be specifically considered in case the public funds are limited. It is then likely that the existing funding model will not be adequate to cover the investment needed to migrate to digital broadcasting transmitting network(s), let alone to (partly) finance set-top-box subsidies and the simulcast period (double network costs).
- 3. In case governments would like to compensate viewers for the costs of switching to digital (i.e. purchasing a set-top-box or IDTV) a voucher system such as that applied in the USA could be considered. In such a system responsibility of the government should be limited to the primary television set and inform the viewer about the other receivers (e.g. second sets and video recorders) in order to limited fraud.

2.15 Organizational structures and entities

The ASO process is a complex and time consuming operation and a special purpose entity (e.g. Task Force, Committee or separate company) may coordinate the overall process and planning. The ASO process is a joint effort between the legislator, regulator(s), content aggregators (i.e. public and commercial broadcasters), distributors (i.e. broadcast network operators for all platforms), device creators (i.e. receiver equipment producers and retailers) and end-consumer associations.

This section focuses on:

- 2.15.1 Key success factors for ASO: a successful ASO has its fundaments in its organization; four organizational success factors to be taken into account.
- 2.15.2 Organizational ASO structures and entities: example ASO organizations.
- 2.15.3 ASO costs and support: main categories of ASO associated costs and how government can provide (financial) support.
- 2.15.4 Implementation guidelines.

2.15.1 Key success factors for ASO

No single recipe exists for a successful ASO as the local circumstances are different in each country. However, some common key success factors have been identified in countries where the ASO have been completed or in those markets that have begun the process. The following success factors have been incorporated into the ASO organizations and plans of many countries¹⁹⁹:

- cooperation and coordination across the value chain;
- strong leadership;
- 3. effective communication strategy (see also section 2.18);
- 4. sufficient financial resources for the ASO organization.

Cooperation and coordination across the value chain

A successful ASO will require the active participation of, and coordination between the government, regulatory authorities and the television industry. Only by working together, the broadcast industry can ensure a minimum amount of disruption for viewers. With reference to the value chain as presented in section 1.2, the following functions/entities will need to support and participate in the ASO initiative:

- 1. Government/the regulator: key tasks and duties include:
 - a. administrations need to decide and politically agree the basic ASO transition model (see previous section 2.14);
 - b. administrations need to take political decisions, setting a firm analogue switch-off timetable (in line with the selected ASO model, either phased or national);
 - c. the regulator should manage and execute any additional frequency coordination efforts to free-up (temporarily) spectrum (very often with neighbouring countries)²⁰⁰;
 - d. the regulator needs to assign the required DTTB media and frequency licences (to the PSB and commercial parties, either a service provider or individual broadcasters);
 - e. the regulator might need to take away any obstacles in the acquisition of building permits (in case new sites or temporarily transmitter sites have to be erected quickly) or any other permits.
- Content creators: although not heavily involved they should:
 - a. be informed about the ASO timetable and the impact on the production chain;
 - b. come to agreement about the content rights for PSB services (or any other service transitioned from the analogue platform) to the DTTB platform.
- 3. Content aggregators (PSB and commercial broadcasters): key tasks and duties include:
 - a. broadcasters need to ensure that viewers are informed (by incorporating ASO items in their programming);
 - b. broadcasters need to ensure the continuation of receiving their television services (by delivering their television feeds to the DTTB head-end and, in case distribution is outsourced, agree distribution with the broadcast network operator).

¹⁹⁹ See also DigiTAG report "Analogue switch-off: Learning from experience in Europe", 2008.

²⁰⁰ See also section 2.3 "ITU-R Regulations".

- 4. Other (DTTB) Multiplex operator/Service providers: analogue terrestrial viewers do not necessarily have to migrate to the new DTTB platform; they can also switch to other platforms that also provide the affected programming (such as satellite, cable or IPTV). Also, it is possible that a commercial DTTB service provider is already operating a service in the market. Hence all service providers who offer an alternative for the affected viewer need to:
 - a. make sure that the marketing around analogue switch-off does not favour the terrestrial platform but instead informs viewers about opportunities for television reception across all platforms. They can supply useful information to viewers while also showcasing their support for analogue switch-off;
 - b. in case of a DTTB service provider already in operation, this provider should also cooperate in the coordination of the additional DTTB network(s) roll-out as site and other facilities might have to be shared. Possibly also some frequencies have to be exchanged or re-farmed.
- 5. Content distributors (DTTB network operator): key task and duties include:
 - a. network operators need to make necessary upgrades to their equipment to allow for digital broadcasting (including also erecting new sites or changing masts);
 - b. network operators may need to help in detailing the network planning and the associated roll-out planning (as the regulator very often has only got very rudimental network planning), serving as input for the government/regulator to set the switch-off timetable 201.
- 6. Device creators (equipment manufacturers): key task and duties include:
 - a. manufacturers need to supply sufficient quantities of DTTB receivers in regions (set-top-boxes, IDTVs and any other DTTB receivers);
 - b. in case of pay-tv services (either in collaboration with the PSB or not), the manufacturers might need to embed the right/required conditional access system in the set-top-box²⁰²;
 - c. manufacturers may be required to certify compliancy with any set standard (see section 2.1) and to provide proper or specific labelling on receiver devices to better inform the viewers.
- 7. Viewers: last but not least, the affected viewers should be involved in the planning and execution of the ASO process. An early commitment from consumer associations could help facilitating the ASO process and avoid unwanted negative publicity during or after the ASO. For most they need to:
 - a. be informed about the impact on viewers of the ASO changes;
 - b. help setting an acceptable ASO timetable;
 - c. help informing their members (i.e. the viewers) about those ASO changes and help them selecting the best digital alternative for them (in impartial way).

Strong leadership

Managing an ASO process will require strong leadership as it involves coordination of activities across many actors in the value chain who are mutually dependent and whose interests are very often not (directly) aligned. The decision to stop analogue television services needs strong leadership to affirm when and how analogue switch-off will proceed and define a clear roadmap. The government has to

²⁰¹ This might also include providing various ASO scenarios and timetables, for the government/regulator to select from or to decide their decisions upon.

Please note that embedding conditional access systems in IDTVs is very often not allowed. In this way pay-tv operators would be in the position to abuse their position by locking-in the viewer.

endorse this leadership to the regulatory authorities and it is best to establish a switchover commission or separate organizational entity to do so. Such an organization can bring together the above mentioned functions/entities of the broadcast industry.

Effective communications strategy

As identified by the European Commission's report "on accelerating the transition from analogue to digital broadcasting"²⁰³ next to the success factor of broadcaster cooperation (see previous section), an information strategy to inform the consumer was identified.

As discussed in section 2.14.2, the ASO duration is mainly driven by the uptake of the new DTTB service and the viewers need to know, first of all:

- 1. why an ASO process is planned and what the benefits will be;
- 2. the planning of the ASO: the date when analogue terrestrial television will end (in which area) and the availability of the DTTB platform/services;
- alternative platforms and programme availability on these other (digital) platform(s);
- 4. equipment needed, and associated costs, to receive digital television programs.

In order to prepare for analogue switch-off, viewers will need to have access to this information in a timely fashion²⁰⁴.

Sufficient financial resources for the ASO organization

Next to an endorsed ASO committee with a complete mandate, the ASO operation should be sufficiently funded. The funding requirements range from country to country and are depend on several factors but most notably the size of the operation (i.e. the number of affected viewers) and the scope of the government provided help and support. However as a minimum, sufficient resources must be available to support communication and marketing activities of the ASO organization in order to inform the affected viewers.

The range of provided help and support can be wide and next to making funds available for the ASO organization itself support can include other associated costs as well. Subsidies can be distributed to viewers to help offset the cost of DTTB receivers (very often by launching and managing a voucher system). Alternatively a loan system for acquiring the DTTB receiver can be provided. The repayment of the loan can be implemented by means of the conditional access system (if implemented)²⁰⁵. Also funds can be made available to help developing appealing content for the DTTB platform.

2.15.2 Organizational ASO structures and entities

In most countries a special organizational entity is established to manage the ASO process²⁰⁶. The entities can range from an 'ASO Task Force' or 'ASO Commission' (led by government and/or regulator representatives) to a separate organization with daily management (and supervised by the government and/or the regulator).

²⁰³ Commission of The European Communities' report no. SEC (2005)661, Brussels, 24 May 2005, p5.

For more detailed information on ASO communication, see section 2.18.

²⁰⁵ In countries with no sufficient funds for providing subsidies the government may provide a loan. The viewers can pay in cash (for example at the post office) or electronically their instalments. In case of (several) defaults the regulatory authorities have the possibility to switch-off the DTTB services by using functionality of the conditional access system.

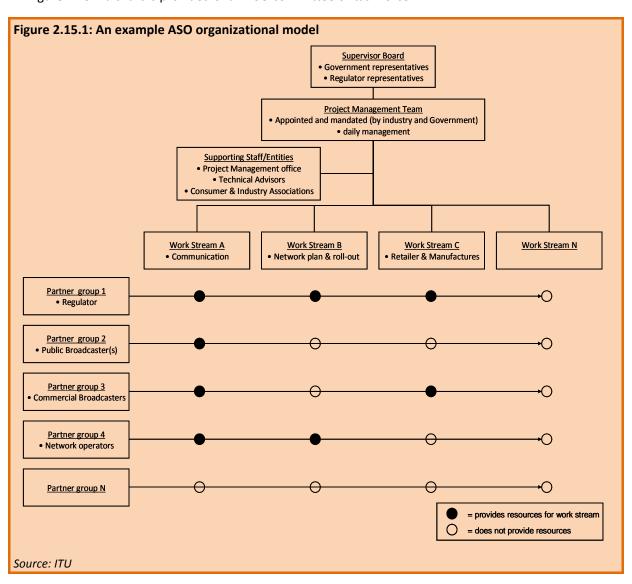
 $^{^{206}}$ For more detailed information on ASO associated costs, see section 2.15.3.

Key in all these organizational entities is that all involved parties in the value chain are represented in this organization and are mandated. Also, they are all organized as a project, with clearly defined objectives, planning and fixed termination date.

In the figure below an example organizational structure is provided. The scope of the organization is mainly driven by the government scope of assumed responsibilities. For example whether the government compensates viewers in their digital receiver equipment purchase costs or provides separate communication websites and channels, next to the any communication provided by the broadcasters (see also section 2.15.3)²⁰⁷.

The number of involved staff per included function is mainly driven by the size of the ASO operations and the selected ASO transmission model.

In Figure 2.15.1 a chart is provided of an ASO committee or task force.



For a full scope ASO organization see "The Digital Switchover Programme: Programme Structure, Ofcom and Digital UK, March 2009. Available on www.digitaluk.co.uk.

2.15.3 ASO costs and support

As mentioned before, the ASO process is a government/regulator led process because it sets a mandatory switch-off date. Consequently, the next question is what the government considers to be its responsibility in steering the process and resolving any (financial) hurdles. The following main categories of ASO associated costs/activities are listed (in decreasing magnitude, which may vary depending on the country's situation):

- 1. Costs for migrating viewers to digital, including (in increasing cost levels):
 - a. (financially) compensating consumer costs for purchasing a digital receiver;
 - b. helping to install new digital receiver equipment (possibly limited to a selected group of people with special needs, like elderly or disabled persons).
- 2. Transmitter network migration efforts (for changing the transmitter networks) ²⁰⁸.
- 3. Re-farming of spectrum efforts and compensations²⁰⁹.
- 4. Simulcast period for PSB or any other commercial analogue terrestrial services (the costs of running two networks in parallel during the simulcast period)²¹⁰.
- 5. Managing the ASO process and informing all relevant parties, including:
 - a. consumers/viewers;
 - b. regional/local governments/councils;
 - c. equipment manufacturers and retailers;
 - d. property managers (of multi dwelling units and shared aerials).
- 6. Setting mandatory certification and labelling of receiver equipment (to safeguard proper functioning and avoid scams/frauds)²¹¹.
- 7. Cost for resolving any interference: in some countries the introduction of DTTB services may cause interference when the DTTB frequencies are also in use by cable companies. Cable viewers may need help for resolving these problems (for example by providing affected viewers other cable connectors). Also inference may occur between mobile applications (i.e. LTE/IMT) and DTTB services²¹².

Table 2.15.2 provides an overview of the relative impact on the size of the ASO organization and budget (necessary financial resources) when the government takes on the responsibility of the above mentioned ASO associated costs/activities.

Migration costs are separate from simulcast costs as these are defined as running two (or more) networks in parallel (during the simulcast period). These migration costs are typically incurred by the broadcast network operator and include cost such as design and engineering costs and temporary facilities and sites.

²⁰⁹ The ASO may require existing spectrum users to change their frequencies. Very often retuning and migration costs are involved and these users will request compensation.

Explicitly excluding the costs of the running the DTTB network after the ASO. Depending on the ambitions of the (PSB) broadcaster (running many additional channels or only the analogue channels) this might be more (in the case where several multiplexes will be put into operations) or less (in the case where part of a multiplex will be utilized).

The increased proliferation of television sets with an integrated digital tuner (IDTVs) can ease the digital conversion task. However, consumer aid might be required to limit confusion. France and Italy have mandated digital tuners in television sets. The United States has made digital tuner mandating a cornerstone of its digital transition policy. Since March 2007, manufacturers have been obliged to include a digital tuner in all television sets.

²¹² For more details see section 2.10.

Table 2.15.2: ASO activities and impact on ASO organization and budget

No.	ASO Activity	ASO organization function (functions can mentioned multiple times)	Relative cost/ budget indication
1	Migrating viewers to digital	 Logistic function for administrating and handing-out vouchers Logistic function for aerial retuning and installation Contact centre function for (technical) assistance Consumer communication function Media and Public Affairs function 	++++
2	Transmitter network migration efforts	 Network planning function 	+
3	Re-farming of spectrum efforts and compensations	 Network planning function 	++
4	Simulcast period for PSB services	Broadcast network roll-out monitoring function	+++
5	Managing the ASO process	 Broadcast network roll-out monitoring function Market monitoring and research function Consumer communication function Industry communication functions 	+
6	Setting mandatory certification and labelling	Industry liaisons function	+
7	Cost for resolving any interference	 Logistic function for handing-out connectors Contact centre function Spectrum re-farming (see above) 	+

Table 2.15.2 shows that the largest cost will be the compensation of the viewers (depending on the number of television viewers). For example, in the USA, the government has set aside nearly USD 1 billion²¹³, and in the UK, the budget was estimated to be GBP 603 million for providing set-top-boxes and installation aid²¹⁴. However, as the cost of DTTB set-top boxes continues to drop and cheap IDTVs become widely available, financial aid might not be necessary.

In the paragraphs below, some key considerations on this financial support to viewers are included.

Under the 2005 Digital Transition and Public Safety Act, an initial budget was set aside of USD 890 million for set-top-boxes/converters (22 250 000 coupons of USD 40 each) and USD 100 million for administrative set-up. To assist consumers through the conversion, the National Telecommunications and Information Administration (NTIA) handled requests from households for up to two USD 40 coupons for digital-to-analogue converter boxes. By January 2009, the maximum budget of 33 500 000 coupons (i.e. USD 1.34 billion) was exceeded and the NTIA placed coupon requests on a waiting list. With the February 2009 "DTV Delay Act" the initial ASO date of February 2009 was postponed to the 16th of June 2009 allowing more households to apply for coupons. Under the American Recovery and Reinvestment Act of February 2009, an additional USD 650 million was inserted in the DTV transition assistance.

Under the Digital Switchover Help Scheme, the government ring fenced 3.5 per cent of the UK's television licence fee income, totalling to GBP 603 million. The Scheme has clear stipulations on the people eligible for aid. The scheme estimated in its central case that 4.7 million households would receive a set-top-box (with varying degrees of assistance) in the period 2007-2013. In the June 2009 "Digital Britain" report, it was expected however that the Scheme will under spend by GBP 200 million. For the "Digital Britain" report of June 2009 see www.culture.gov.uk.

How many households will need help with the digital transition should be assessed country by country. For some, financial assistance will be necessary to enable the purchase of equipment allowing for the reception of digital services. For others, only practical assistance will be necessary to help set-up new digital equipment²¹⁵. In general two models have been applied:

- help and assistance for selected groups;
- 2. universal help and assistance.

Selected groups

Deciding on defining selected groups can be a delicate and political sensitive process as it will often focus on inequality between groups that will receive aid and those who don't. In the United Kingdom, the Digital Switchover Help Scheme has been available for people of 75 years old or over and eligible disabled people²¹⁶. Such support included equipment to convert one television set, help with installation and an aerial replacement if deemed necessary.

In Japan, the government delivered coupons for set-top-boxes to lower income households only. These lower income households represented approximately 5 per cent of the nation's total households. Considering the Japan's total number of households of over 50 million this still implied a financial contribution for over 2.5 million households. In addition financial support has been made available to consumers purchasing IDTVs (reducing the IDTV prices up to 10 percent).

In some countries, financial aid has been handled through social services (e.g. Sweden and Germany) and in others (like in the USA) the postal service were used to distribute the TV converter box coupons to households.

Universal help

In some countries, financial support has been made available to all households regardless of income levels or need, like in the United States. Considering the high average number of television set per household, each household could apply for up to two coupons worth USD 40 each to use towards the purchase of a digital set-top box.

Congress in the USA, who decided on the funding and design of the support scheme, was clear that any household could request coupons. Congress did not specify any other eligibility requirement, such as income level. It was recognized that there was difficulty in trying to set a means test (based on economic or other need) as an eligibility requirement. It was also considered that efforts to confirm eligibility would likely delay reasonable and timely distribution of coupons and hence costs.

Therefore, the regulatory authority did not require that households had to prove a need for converter box coupons based on household income. However the help scheme was limited by stipulating that only one coupon could be used toward the purchase of each converter box, consumers could only request coupons in period of 15 months and all coupons expired three months after issuance²¹⁷.

This may be dependent on the state of the existing rooftop antenna (eroded/tilted or not) and the type of network. For example, an in-door network is not dependent on existing roof-top antennas. Also, nowadays set-top-boxes are more and more 'plug and play' devices.

Eligible disabled defined as people who (a) have lived in a care home for six months or more, or (b) get (or could get): (i) Disability Living Allowance (DLA), or (ii) Attendance or Constant Attendance Allowance, or (iii) Mobility supplement, or (c) are registered blind or partially sighted.

The regulatory authority, the National Telecommunications and Information Administration (NTIA) published an evaluation report on the digital TV converter box coupon program, available on www.ntia.doc.gov.

In Europe, very few countries have granted similar subsidies to households for acquiring a digital receiver 218.

2.15.4 Implementation guidelines

The following guidance can be given in setting up the ASO organization:

- 1. Include the identified ASO success factors in your organization design, by:
 - a. cooperation and coordination across the value chain: Involving all parties of the broadcast industry and organized in a project management structure;
 - b. *strong leadership:* Providing the project management leadership with a clear and strong mandate (the latter, by providing sufficient funds for the set tasks);
 - c. effective communication strategy: Having a communication function, as a bare minimum, in the project management organization;
 - d. *sufficient financial resources:* Having sufficient resources available to support the communication and marketing activities of the ASO organization and any other set tasks for the ASO organization.
- 2. Apply project management principles for the ASO organization, including:
 - a. appointing project management leadership;
 - b. defining the scope (set tasks, out-of-scope activities/tasks and project end-date) and project plan;
 - establishing a project management office (for managing the day-to-day planning);
 - d. defining clear Work Streams with defined milestones and deliverables;
 - e. defining task and responsibilities for all the involved organizations.
- 3. Apply a modest organization model (i.e. a temporarily 'ASO Commission' or 'ASO Task Force' who convene regularly under the supervision of government representatives) in countries where:
 - a. the terrestrial television platform is small²¹⁹ and/or the number of affected (PSB or commercial) services is limited (e.g. one or two national channels and no regional programming), and;
 - b. the selected ASO transition model is a nationwide switch off approach or an ASO without a simulcast period;
 - c. the assumed ASO tasks (i.e. the government's responsibilities) are limited and do not include financial or physical assistance for viewers migrating to digital.
- 4. In the case where financial resources are limited, limit the scope of the government's responsibilities to managing the ASO process, as a bare minimum (see activity 5 in Table 2.12.1). However, make sure this approach is legally backed-up (e.g. not compensating viewers or spectrum re-farming costs for existing broadcasters).

The European Commission has been vigilant in ensuring that its rules governing competition and platform neutrality have been observed. Only subsidies that can be used across all television platforms are permitted.

However, the impact of the ASO should not be underestimated. The number of terrestrial viewers may be limited in absolute numbers but the relative proportion might be very high. In addition, the alternative providers may be limited too. For example in some countries only one alternative is available; a pay-tv satellite service.

- 5. However a limited scope of ASO activities might hamper the DTTB uptake seriously as people might not be able to afford digital receivers. Alternatively, the government can make use of any commercial parties interested in rolling out DTTB services. Preferably such a party would roll-out the DTTB service in close collaboration with the public broadcaster so that infrastructure and other facilities can be shared. In this way, the government costs for ASO can be limited. Such a market driven approach should include as a minimum:
 - issuing a DTTB licence to a commercial party with defined obligations to roll-out a DTTB network;
 - b. prescribing collaboration with the PSB for a joint network roll-out (this could include also sharing multiplex capacity across all available multiplexes)²²⁰;
 - c. setting 'must carry' rules for the DTTB licence holder for carrying existing analogue television PSB channels;
 - d. stipulating the provision of relatively cheap DTTB receivers (to be best assessed in a public tender procedure);
 - e. providing assistance to the DTTB licence holder for rolling out the DTTB network, including help for getting access to sites and acquiring building permits (or any other permits).

2.16 ASO planning and milestones

In this section the national ASO planning is detailed and it includes:

- 2.16.1 Outlining the ASO planning: when and where to begin the process and how long the entire operation should last.
- 2.16.2 Overall ASO planning set-up: including the overall programme structure and the key result paths in an ASO plan.
- 2.16.3 ASO planning phases (in a phased approach, see section 2.14.3): the three phases and their key milestones.
- 2.16.4 Implementation guidelines on planning the ASO.

2.16.1 Outlining the ASO planning

When outlining the ASO planning three questions should be addressed:

- When should we start the ASO process?
- 2. Where should we start²²¹?
- 3. What duration should the ASO operation have?

When to begin the process

There is no clear marker that will indicate to governments or regulatory authorities when to start planning the ASO process. However, there are the following time constraints or pressure factors, forcing governments or regulatory authorities to act:

²²⁰ Preferably in a statistical multiplex mode as this would be most spectrum/capacity efficient.

Please note that this is only a relevant question in case the ASO transmission model has a phased approach to analogue switch-off (see section 2.14.3).

- 1. Market parties are interested in providing DTTB services and need to have clarity about the number of multiplexes available and the licensing regime. Hence, the regulator needs to provide or update the national spectrum plan to include the licensing of DTTB services and ASO plan. The latter will be necessary as the DTTB licence duration is likely to cover the analogue switch-off date. In countries applying the GE06 plan a general date of 2015 have been set and 2020 for some countries having analogue television services in Band III²²².
- 2. DTTB platform has only been partly launched (e.g. only to carry the PSB services) and market parties are interested in providing DTTB services and the introduction of such services are only possible when analogue spectrum is freed-up.
- 3. The 'digital dividend' discussion is putting increasing pressure on the government to act. Early planning will help to safeguard the future of terrestrial television and to prepare a profound plan to facilitate as many users as possible.
- 4. Neighbouring countries may launch DTTB already and might ask for spectrum changes (see also section 2.3). In such a situation the neighbouring countries will be the 'asking' parties and not being prepared may lead to inefficient spectrum usage in the own territory.
- 5. Analogue terrestrial equipment (transmitters and receivers), inevitably, will become obsolete and costs for maintaining the terrestrial networks will become unacceptably high. In addition, viewers/consumers will be deprived from the digital opportunities DTTB platforms provide.
- 6. The public or commercial broadcasters would either like to introduce more services or like to see its transmission costs lowered (especially in the case of one or two SDTV channels and when calculated per programme channel).

Where to begin the process

Determining where to begin the analogue switch-off process in a phased ASO approach varies between countries. Several considerations come into play when selecting the best area to start, including:

- 1. Assessed risk profile: Governments/regulators might adopt a risk-averse ASO approach that limits the impact of any failures in the ASO process.
- 2. Required speed of the ASO process: Governments/regulators like to see the introduction of the DTTB platform in high profile areas so as to provide an example for the rest of the country.
- 3. Technical considerations or spectrum availability: In some areas infrastructure might not be available to facilitate new DTTB equipment or in some areas of the DTTB spectrum is not available (e.g. because it will require bi-lateral negotiations with neighbouring countries or is in use by other national users).

However, based on the various considerations, three basic options can be identified with starting in:

Highly populated areas: Some countries have begun the process in large urban areas with high population densities but few transmitters. This option does not necessitate extensive planning to simultaneously switch off several transmitters and corresponding gap-fillers in a coordinated way. Such a start can imply a risk given that many people, often numbered in millions and including high ranked politicians, are affected by the ASO process. On the other hand a successful launch in these highly populated areas can accelerate the adoption of the DTTB services elsewhere in the country.

Please note that the GE06 Plan does not include switch-off dates but rather dates when the analogue is no longer protected.

- 2. Rural areas: Other countries have opted to begin the process in areas with low population densities. By doing so, the process can be tested times in low impact areas and experience built up before affecting large population centres.
- 3. Simulcast or test areas: In some countries, analogue switch-off has been tested in pilot areas. For example Spain and Italy have tested analogue switch-off in small isolated areas. After a successful test and thorough evaluation of the test results, the ASO process can then be extended to either highly populated or rural areas. Although this approach will limit the risk of failure, it will extend the ASO process (and hence costs) and will demand for a clear communication strategy (as to avoid consumer confusion about the actual start of the process).

How long should the process last?

In a phased approach the key questions is really how much time is the viewer allowed to benefit from the simulcast period (i.e. can have the opportunity to try the DTTB service and have the opportunity to fall back to the analogue platform). This period can range from a couple of months to several years²²³. Due to wide spread availability of digital receivers, their proven and plug-and-play functionality simulcast periods tend to be set nowadays for smaller periods. Deciding on the simulcast period will often imply a political decision (see section 2.14). However the frequency availability will to a large extent determine the range of technical possibilities. In practice the government will set minimum criteria and the network planner or regulatory authorities will provide the exact details.

2.16.2 Overall ASO planning set-up

The scope (i.e. the number of Work Streams or Result Paths) of the ASO planning is dependent on the assumed responsibilities by the government. Also the Work Streams of the planning are reflected in the ASO organization (see section 2.15.3).

The ASO planning is focused on the delivery of a series of regional switchover projects, in the case of a phased approach. However, there may be planning matters that cut across multiple Work Streams or multiple regional projects (for example, international co-ordination of frequencies). Work Streams may also have national projects (for example, a national communications campaign and contact centre management). In other words, activities and milestones from each Work Stream will be interdependent on the work carried out in other Work Streams, increasing the complexity of the overall planning.

In a full scale project planning the following Work Streams or Result Paths can be identified:

- Communications: To ensure that analogue television viewers are smoothly converted to digital TV by creating awareness, providing support and cultivating the right climate for switchover. Including sub-result paths for:
 - contact centre management: To provide timely, relevant and platform neutral advice about switchover to consumers and trade audiences, including technical advice, via websites and contact centre;
 - b. *multi dwelling units and shared aerials*: To ensure that owners, managers, tenants and residents of all properties, where there is a communal TV aerial system or those receiving television services outside of the home are able to continue to receive services after switchover;

²²³ For some country examples see Digitag report "Analogue switch-off: Learning from experience in Europe", 2008.

- c. media and Public Affairs: To manage relationships with key political and media stakeholders, nationally and regionally. To work with the voluntary sector and local government to reach out to potentially vulnerable groups. To secure a common approach to consumer protection across all relevant agencies.
- 2. Device producers and delivery: To supply the information and resources to the supply chain to enable them to supply the right product or service, in the right quantity at the right time, in the right place, to meet 100 per cent of the required consumer demand and satisfy the demand for related services as a result of digital switchover. This Work Stream may also include certification and labelling.
- 3. Network plan and roll-out: To plan and co-ordinate the conversion of the terrestrial transmitter network to digital within the timeframe agreed with the government. Including network planning and network roll-out monitoring activities. In a phased ASO approach this Work Stream might include several sub-Work Streams for each separate switch-off region.
- 4. Consumer and Market monitoring: To support the ASO programme by providing consumer and market information which can be used to monitor the progress of the ASO process, inform communications strategies, and assist the equipment supply chain's logistics planning.
- 5. Regulations and Licensing: To ensure that the programme is informed and engaged where appropriate in regulatory activities including licensing; spectrum management; international coordination, research and policy development in local areas relating to digital switchover (such as granting building and environmental permits).
- 6. Financial and aerial installation support: To manage the financial administration and the logistic chain for either providing compensation vouchers or physical assistance for installing or retuning receiver equipment.

2.16.3 ASO planning phases

The overall ASO planning in a phased approach can be a complex puzzle. Please note that although 'phased ASO' (see section 2.14.3) is taken as an example in the following paragraphs, the same consideration can be applied in the case of 'national ASO' (see section 2.14.3) by replacing the words 'in a region' with 'across the nation'. Three phases can be identified:

- 1. Phase 1: The introduction of DTTB services.
- 2. Phase 2: The simulcast period and the preparation of the ASO.
- 3. Phase 3: The analogue switch-off.

Phase 1: The introduction of DTTB services

In this phase of the planning the DTTB network will be rolled-out (in the region) and digital transmitters will be installed in either existing or new sites (for resolving any incompatibility issues see section 2.17). For the actual network planning, please refer to section 4.3.

It is important that in this phase of the planning:

- 1. the national spectrum plan should be updated and the DTTB licensing should be completed;
- no further analogue terrestrial television frequency licences should be issued and possibly existing analogue television licences should be revised (to make it possible to terminate the licence);
- 3. existing regulations have been reviewed to ensure that they reflect the implications of digital transmissions;
- 4. current analogue broadcasters are being informed that they will be allowed to continue with analogue transmissions up to analogue broadcasting switch-off date;

 the start-up phase of digital broadcasting will be closely monitored in terms of coverage, reception quality and interference for various types of reception including cable, indoor, community antenna reception, etc.

Phase 2: The simulcast period and the preparation of the ASO

In this phase of the planning the viewers in the affected region, are being actively informed about the switch-off date. It is important to note that Phase 2 might overlap with Phase 1, i.e. already before the DTTB network is being rolled-out or completed, the general public is being informed about the switch-off date.

It is important that in this phase of the planning:

- 1. receivers are available and distributed in the right amounts and locations;
- postcode or address 'checker' (for affected viewers to check if they are affected and possible what type of receiver is best – rooftop aerial or perhaps an indoor aerial might be sufficient) and websites are tested and operational;
- 3. contact centres are tested and ready to be operational;
- 4. in case of financial compensation and installation aid, the logistics chains for these services are tested and operational;
- 5. broadcasters will include in their programming ASO information and actively promote switch-over to digital.

Phase 3: Analogue switch-off

This stage will involve the switching off of all analogue terrestrial broadcasts in the region. Ideally before analogue switch-off all affected viewers have upgraded their TV sets to digital by using a set-top-box or IDTV. All current analogue terrestrial broadcasters will need to have migrated to a digital platform.

It is important that in this phase of the planning:

- the affected viewers are being monitored (by having call centres on stand-by) and research is carried out to identify any problems and learning points for the next switch-off region. Especially after the first region some time for reviewing the process should be allowed before switch-off starts in the next region in order to incorporate the lessons learned;
- 2. analogue equipment is dismantled, allowing re-use of transmitter infrastructure;
- 3. re-engineering of digital transmitters sites to remove any analogue restrictions that might have existed in order to protect analogue TV.

2.16.4 Implementation guidelines

The following guidance can be provided when planning the ASO process:

- 1. Although there are no clear markers for commencing any ASO process, it is best to begin ASO planning early because:
 - a. the benefits of analogue switch-off will be reaped early (see section 2.14.1)²²⁴;
 - b. early planning will put any country in the requesting (leading) role when bi-lateral coordination with neighbouring countries becomes necessary;

See section 2.14.2 and for example the Commission of The European Communities' report no. SEC (2005)661, Brussels, 24 May 2005.

- c. the longer the preparation time, the better the plan and the more spectrum will be available for broadcasting services (and any other services);
- d. early planning will allow time for testing migration scenarios, DTTB services and any other new broadcast service (e.g. mobile television).
- 2. Plan the ASO duration to be as short as possible: the shorter the process the less costs will be involved for the simulcast period and running the ASO organization. The minimum set simulcast duration will determine to a great extent the ASO duration.
- 3. The calendar for political and sporting events will need to be taken into consideration. Switch-off during nightly hours is normally the best hour.
- 4. Plan the ASO phases on the basis of the network planning (which is very often based on the spectrum availability) and technical possibilities, taken into account the specific weather conditions. For example, in most European countries, the technical possibilities for replacing antennas in the winter period are limited due to snow and/or low temperature.
- 5. As a next step, plan the communication 'around' the technical network roll-out planning. Communication can start as early as possible with providing the public with general information on the ASO process. The affected viewers are informed about the actual switch-off six months to one year at least before the analogue switch-off date.
- 6. Plan the communication process on the basis of the time necessary to ensure that viewers no longer depend on the analogue terrestrial platform.
- 7. Preferably, decide the allocation of the 'digital dividend' (see section 2.10) before any ASO plan is drafted because:
 - a. spectrum re-farming, due to alternative allocation of the 'digital dividend' might either interfere in the ASO planning or require re-planning after the ASO process and broadcasters might be very reluctant to cooperate (again);
 - b. for a solid network planning the frequency availability should be determined, otherwise this might increase the number of scenarios when planning the ASO (during the planning phase of the ASO);
 - c. a carefully drafted ASO plan may create some leverage for negotiating spectrum for broadcast services, rather than non-broadcasting applications.

2.17 Infrastructure and spectrum compatibility

Resolving infrastructure and spectrum compatibility or incompatibility happens in the case of having:

- 1. a simulcast period, having both a digital and analogue service in the same geographical areas (as mention in section 2.14.3 it is possible to have no simulcast period and to switch-over from one hour to the other); and
- 2. the analogue and digital plan are not compatible, i.e. there is a lack of digital spectrum in a certain area, not necessarily the entire country. In some countries there might only be analogue terrestrial television service in Band I/III and none in Band IV/V²²⁵.

This situation of infrastructure and spectrum incompatibility is likely to occur in the ASO process and should be addressed in the network planning prior to actual execution of the ASO process.

 $^{^{225}}$ Please note that in some countries non-broadcasting services might be operational in Band IV/V.

This section is organized in the following parts:

- 2.17.1. Scoping incompatibility: Where can incompatibility occur?
- 2.17.2 Implementation guidelines for resolving incompatibility issues.

2.17.1 Scoping incompatibility

Incompatibility can happen in both the transmitter infrastructure as well as in the available spectrum. The main incompatibility issues have been listed below:

- 1. Infrastructure or network facilities, including:
 - a. Lack of antenna capacity, either:
 - i. in the case of antenna sharing (two or more service or frequencies on one antenna ²²⁶): the antenna has reached its maximum electrical load (especially occurring at the antenna connectors);
 - ii. in the case of a new antenna: the new antenna exceeds the maximum weight or maximum wind load capacity or there is a lack of physical space to place the new antenna²²⁷;
 - b. Lack of floor space for placing extra transmitters: the additional floor space is technically limited by the maximum length of the feeder cables to the antennas. Longer cables may allow for the placing of the transmitters in containers outside the mast premises (depending also on local building regulations).
 - c. Lack of power/back-up/no-break facilities: the existing power supply facilities might have reached its maximum load. In addition, in rural areas, installing extra power units might be limited by fuel supply logistics.
 - d. Lack of cooling capacity: see above.
- Spectrum, i.e. in (a limited) geographical area the digital and analogue frequencies cannot coexist. In such a case the network planner or regulatory authorities have to trade off three considerations in its network design:
 - a. Continuation of the existing analogue services so as to avoid complaints due to degrading service and that consequently viewers will migrate to other available (competing) platforms.
 - b. The largest/best possible coverage for the digital service, ideally as close as possible to the analogue coverage, however 100 per cent is not possible otherwise there would not be an incompatibility problem (without a good digital signal people cannot switch to the new DTTB service).
 - c. Application of ASO without simulcast or allowing interference on analogue services caused by digital signals providing that sufficient support/subsidize for digital reception should be given to the viewers affected. In this case no spectrum incompatibility problem takes place.

Even frequencies/services with different antenna diagrams can technically be facilitated on one single antenna system, a so called 'multi-pattern' antenna, however those antennas are relatively complex and expensive and sharing prices will be more complicated (as it has to be combined with mast sharing and there is relatively little experience in the world about antenna sharing).

²²⁷ In some cases the physical mast space might be technically available but the location has been reserved for future services. However, the regulator should provide a site sharing regulatory framework and monitor any strategic blocking that may occur.

2.17.2 Implementation guidelines

For resolving the problems of infrastructure and spectrum incompatibility the following guidance can be provided:

- 1. For infrastructure incompatibility:
 - a. If there is a lack of antenna space: reduce the number of antenna layers and at the same time increase the transmitter power so as to compensate for the reduced antenna gain²²⁸. This option is becoming more and more (economically) feasible as transmitter prices continue to drop and the price differences between various power ranges are diminishing too. Conversely, a lack of floor space can be compensated by increasing antenna gain.
 - b. If there is a lack of transmitter space: place transmitters in prefabricated containers adjacent to the existing premises of the transmitter tower. However, this may be limited by the maximum length of the feeder cable. Prefabricated container production has got the added benefit and convenience of enabling construction off-site (e.g. at the manufacturers premises) and therefore increasing production output.
 - c. If there is a lack of both floor space and antenna space: reduce both the transmitter power and the antenna gain and consequently lower the ERP. In order to compensate for this reduced ERP, the planner can either:
 - i. increase the robustness of the signal. At the cost of having less services but having the same reception mode/system variant (in-door or rooftop reception) and associated coverage; or
 - ii. change the reception mode/system variant. At the cost of requiring a more sensitive receiver installation, possibly only achievable with a rooftop antenna, but having the same coverage and number of services;
 - iii. reduce coverage at the cost of having less viewers but having the same number of services and reception mode.
 - d. Lack of antenna space and capacity: split analogue antenna in two for respectively the analogue and digital services at the cost of accepting a reduced analogue service and having a larger digital transmitter²²⁹. In this way the analogue service can be gradually degraded (by further reducing power), providing an incentive to viewers to switch to digital. In the ultimate case, a temporary site should be considered. The cost of having a temporary site can be minimized by reusing these temporary sites by moving them from region to region after each regional switch-off, which will need careful planning.

2. For spectrum incompatibility:

a. Make a service trade-off between the number of affected analogue viewers and new digital viewers. This rationale could help the network planner in balancing service levels of both television services. This may be a complicated and delicate exercise when both services are not operated by the same service provider/operator. In some cases, this might be even a cross-border exercise when analogue services abroad are affected.

The gain of the antenna is directly related to number of layers of the antenna, hence the physical length of the antenna and perhaps more importantly the wind load.

Assuming the analogue antenna is made redundant by having a 'switch-able' top- and bottom-half.

- b. Assess the incompatibility problems first in the group of gap-fillers or small relay transmitters because:
 - i. the problems will be the largest in this group of transmitters (because there are so many of them); and
 - ii. in this group of transmitters, the largest degree of 'engineering'/planning freedom as they are small and very often in shielded areas. Also these frequencies can be moved around the country to free-up spectrum elsewhere.
- c. Assess site by site the possibilities for balancing the service levels of the digital and analogue service. The network planner can:
 - i. improve the digital service by lowering the ERP of the analogue transmitter, increasing the robustness of the digital signal or reducing coverage of digital services;
 - ii. allow more digital interference on analogue services. Check the level of interference which can be tolerated by the viewers. Planners should consider reducing analogue service levels, in order to provide an incentive for viewers to switch to digital.

2.18 ASO communication plan

This section focuses on communication to the *viewers* (identified as one the key success factors for ASO) and will address:

- 2.18.1 Communication strategy: including communication messages (related to the communication stage) and target groups.
- 2.18.2 Communication tools: the various communication means to reach the listed target groups.
- 2.18.3 Implementation guidelines.

2.18.1 Communication strategy and messages

Any communication strategy, informing the public at large, is based on several successive stages (i.e. creating awareness, understanding, etc.). Figure 2.18.1 presents the communication strategy for ASO transition and is based on these general communication stages. These stages span from creating ASO awareness through to measuring satisfaction after ASO completion²³⁰. The presented model can be used for:

- 1. designing communication messages in each stage of the ASO transition process;
- 2. determining key performance indicators (and formulating survey questions) to monitoring ASO progress.

As said in section 2.16, the speed of the ASO process is determined largely by the duration of the simulcast period which, in turn, is driven by the time viewers need to be informed and purchase a digital alternative. Also, setting a firm switch-off date is necessary as viewers tend to purchase a digital receiver just weeks prior to the deadline.

Hence, in a phased ASO approach, measuring 'readiness to convert' should be carefully planned, especially for the first region. The lessons learned from this first region could be used to set ASO dates for successive regions. However, it is not recommended to take a flexible approach and to convert to digital when viewers are 'ready'.

From the "Ofcom and Digital UK Switchover Tracker": Survey Switchover Progress Report – Q1 2008, available on the Digital UK website.



In the ASO communication strategy, the various target groups have to be identified. Depending on the scope set for the ASO organization (see section 2.15), the following target groups can be listed:

- 1. Viewers, including various sub-groups and cross sections:
 - a. national or by-region (especially for a phased approach);
 - b. rural/urban (might have an impact on the communication tools available);
 - c. social class, sex and age;
 - d. disabled, elderly people and people with special needs;
 - e. community centres and facilities (including town halls, libraries, prisons, hospitals, etc.);
 - f. landlords of multi dwelling units/shared aerials (including flats, student halls, hotels, etc.).
- 2. Industry, including:
 - a. manufacturers of digital receivers (and any related industry associations);
 - b. retailers of digital receivers and/or digital television subscriptions (might include next to DTTB, satellite, cable or IPTV pay-tv subscriptions);

- c. certification/labelling institutions (for providing uniform/trustworthy certificates and labels);
- d. local governments (after informing them about ASO and its timetable, they should also be informed about providing necessary local permits);
- e. consumer associations.

Because a digital television set-top-box/converter only outputs one analogue television channel at the time, the introduction of DTTB poses a special problem for premises using a shared/central antenna system. In the case of analogue reception, multi television sets could easily be connected to the central antenna system and be tuned to different programme channels independently from each other (because each television set already has got an in-build analogue tuner). With the introduction of DTTB, each analogue television set/screen will require a digital tuner and therefore each premise need to have digital alternatives (a simple solution of connecting only one set-top-box to a central antenna system will not work).

Some of shared/central antenna systems apply frequency conversion of UHF channels (if any) into VHF band in order to reduce the transmission cable loss. Although digital signals can also be converted into VHF, there exist restrictions in terms of number of channels (both analogue and digital during simulcast) in the capacity of VHF band, digital receiver capability of tuning VHF cannels, etc.

Reaching out to property managers (for multi dwelling units or shared antenna systems) needs therefore special attention²³¹.

2.18.2 Communication tools

The most critical communication tool is the affected television services broadcasted by public and commercial analogue terrestrial broadcasters. As mentioned in section 2.15, these broadcasters are a key member of the ASO team. The best way to reach the relevant viewers is through the television services that will be affected. Intensive communication on these services will be crucial for informing the viewers.

Figure 2.18.2 shows the sequence of ASO messages broadcasted by the Japanese public broadcaster (NHK) on the affected television service. As early as 3 years before the actual ASO date the communication to viewers started.

-

²³¹ See <u>www.digitaluk.co.uk</u>, "Business & Organisations".

Figure 2.18.2: ASO communications in Japan Step 1: Step 2: Step 3: 10 months before ASO a notice 3 years before ASO "Analog" logo 1 year before ASO screen was placed on the screen converted to letter box format was added in the letter box Step 4: Step 5: Step 6: 24 days before ASO countdown From 12:00 to 23:59 on ASO date **ASO** message superimposed se make arrangements Source: NHK

Although the analogue terrestrial broadcasters' cooperation might be critical, it is not evident that the broadcasters will cooperate on its own accord. The broadcasters might be reluctant to inform its viewers that the programming will be discontinued on the current platform because this could be perceived as a negative or unpleasant message, let alone the additional costs for the broadcasters to free-up television capacity for these ASO messages²³². Hence, an ASO planner might have to incorporate adequate time to get the broadcasters on board the ASO team.

National communication tools

At a national level, general information on what will happen when and how to prepare must be made available to viewers. In some countries, a mascot has been used to serve as a guide for viewers in the analogue switch-off process such as the robot Digit Al seen in many of the advertisements in the United Kingdom, or the deer shaped mascot "chi-deji-ka" in Japan (means digitalization of terrestrial TV and has similar pronunciation of deer in Japanese).

Sweden initiated the use of the eye-catching pink colour in its branding of analogue switch-off. The colour was omnipresent in each region prior to analogue switch-off and used in all communications by the government, broadcasters and network operator. Pink was also the colour of the bus that travelled

In the case that the public broadcaster is partly funded by advertising, this might even be a bigger hurdle as the ASO communication would eat-up valuable advertising space. Consequently, the public broadcaster might ask for additional funding.

around the country providing viewers with information on digital switchover. Advertising in this colour was also used, including on a Stockholm underground train.

Other tools used in national communication campaigns have included:

- websites;
- radio broadcasts;
- 3. advertisements in national (printed) media;
- 4. direct mail²³³, and;
- 5. call or contact centres.

Websites with information on digital switchover have been set up in most countries having completed ASO or being on the process. Generally these website have been set up by the group responsible for leading the process and in close cooperation with providers of information such as the broadcasters and network operators/planners. It is important that information between the websites of the ASO organization, network operators and broadcasters are synchronized.

Traffic can be large at these ASO websites and sufficient internet access capacity should be allocated. Also, depending on the 'media profile' of a specific country, reaching viewers through the (printed) media might prove to be important.

In general ASO projects generated positive media coverage. Good and intensive contact of the ASO committee with the media is therefore important to generate this positive image about the ASO. For example in the United Kingdom, Digital UK continually ensures that the media is informed of the analogue switch-off process by sending out press releases on a regular basis, generally based on research and studies on the status of the process.

Direct mail sent to households is a further means to inform viewers about the ASO. For example, letters and brochures were sent to all television households in Sweden by the government and the broadcast network operator. Similarly, letters and brochures were sent to television households in the United Kingdom and Switzerland.

Viewers have also sought out information from contact centres set up in for example Germany, Finland, Sweden, Switzerland, the United Kingdom and Japan. In Finland, the call centre responded to over 4 000 calls, especially in the weekend following switch-off. The government in Finland also set up an information desk in Helsinki which helped 3 000 visitors in the 3 day period that it was available. The call centres used in Andorra and the Netherlands did not report any increase in the number of calls received on the day or the days after switch-off. In Japan the number of calls peaked in the call centres at the day of ASO. In the ASO support and NHK call centres the number of calls reached to respectively 124 000 and 35 000 calls at the day of ASO. Please be aware that Japan applied a nationwide ASO (with simulcast). However the number of calls reduced to almost zero a week after the ASO date.

Regional communication tools

In a phased ASO approach and in the case of analogue regional services the ASO communications can also include regional messages. These analogue regional services differ per region and may not all be made available on the DTTB platform. Hence tailored information might be needed.

Please note that direct mail is very often not addressed as the individual viewer's address is not known. In countries with high levels of analogue terrestrial television penetration this might not pose a large 'overshot'. In other countries, some extra effort might be required to locate viewers.

For example in the Netherlands, in certain regions, viewers were used to receiving more than one analogue regional PSB service. However, on the DTTB platform the number of regional services was limited to one or two. In addition, viewers had to be informed that all regional PSB services were also available on satellite.

It is important to note that, should changes be made to the frequency channels used, following analogue switch-off (for example to free-up spectrum elsewhere, see also section 2.14.2), viewers will need to know how to re-scan their DTTB receivers. Most set-top-box receivers scan automatically, however this is either carried out when instructed manually or by rebooting the set-top-box. So it might be necessary to inform viewers to re-scan their digital receivers during the ASO process.

The same type of tools used for national communication can also be used for regional communication, including websites, radio broadcasts, advertising, direct mail and contact centres. However, using retailers to inform the public should typically be addressed regionally.

Sales personnel in retail outlets selling digital receivers should be properly trained to provide consumers with information on how to prepare for digital switchover. Retail shops have often made available brochures and other information on analogue switch-off. They have also often dedicated store space to digital switchover marketing material.

The use of logos is important for viewers to relate to the ASO process and build-up viewer's trust. For example, the Digital Tick logo used in the United Kingdom provided viewers with the guarantee that the digital receiver purchased would work in an all-digital environment. Another logo indicated equipment that was judged easy to install based on independent testing. In Japan, two kinds of logos were used in a different way. One logo indicating that the equipment provides digital reception capability, and the other indicating that the equipment provides only analogue reception and cannot be used any more after ASO.

Training of shop personnel costs money and retailers should have an incentive to do so. One should realize that this incentive stems from the fact of being able to sell new receiver equipment. Margins are really only high enough on IDTVs (or a set-top-box with a new television set). Margins on set-top-boxes tend to be very low. When actively using the retail channel to inform viewers, it is important to consider whether the introduction of DTTB services will lead to additional sales in television sets²³⁴.

2.18.3 Implementation guidelines

The following guidance can be provided for developing an ASO communication strategy:

- 1. Taking into account the local circumstance, draft the ASO communication strategy on the basis of:
 - a. a staged model, in which per stage the provided information or message varies;
 - b. targeted at different groups of the population; and
 - c. applying a mix of communication tools, differentiating the tools per target group and stage/message.

123

In addition, in case of a pay-tv offer on the DTTB platform, the sales commission for the subscription might provide incentive for retailers to invest in proper information.

- 2. Special communication care should be given to landlords, managing multiple dwelling units or shared aerials as they can be responsible for a large share of the affect viewers.
- 3. Although not on the top of the communication tool mix in developed countries, radio might be more important in some countries. This might especially be relevant in those countries where television penetration is still relatively low. ASO messages on the radio, could help to get people interested in DTTB television (with its additional services), which might boost the 'Information Society' objectives some governments might have.
- 4. From a communication's point of view, don't start the ASO process without the collaboration of the public (and commercial) broadcasters if there is a low penetration of other communication tools like the Internet and printed media. In such a situation the analogue terrestrial broadcast services might be the only way to reach the affected viewers.

Part 3 – Market and business development

This part of the Guidelines will provide an overview of the key business issues and choices digital terrestrial television broadcasting (DTTB) and mobile television (MTV) service providers/Broadcast network operators face when planning the commercial launch of these services. It includes a set of business activities and tools for defining the DTTB/MTV service proposition and associated business case and plan, taking into account identified demand drivers, service barriers, financial feasibility and more specifically receiver availability and customer support issues.

This part is not only intended for *commercial* market parties seeking an acceptable return on their investments, such as DTTB/MTV service providers and broadcast network operators. The regulators should also acquire an understanding of the key business issues and choices at hand so as to define realistic DTTB/MTV policies and licence conditions.

Commercial parties will seek a DTTB or MTV service proposition which fulfils a consumer demand, generating sufficient revenues (either advertising or subscription based). In contrast, public service broadcasters (PSB) normally meet objectives of public interest in the field of information and culture. That is why they are all interested in viewing ratings, high population coverage and mainly prefer unencrypted broadcasting. Market and business development works differently as they have to fulfil primarily these 'information and culture' objectives. However, PSBs can also have advertising-based income and some of the topics addressed in this section might also be relevant for PSBs.



3.1 Customer insight and research

Launching commercial DTTB and/or MTV services will require the identification of demand drivers (i.e. customer needs), competitive advantages, service uptake projections and possibly market entry barriers in the local market(s). Service providers and network operators will carry out some form of market research to identify these demand drivers, competitive advantages and service uptake projections.

This section is structured as follows:

- 3.1.1 Overview of the DTTB and MTV markets: market definition, key service and market characteristics.
- 3.1.2 Market research methods: basic market research approaches and embedding market research in the DTTB/MTV business planning process.
- 3.1.3 Implementation guidelines.

3.1.1 Overview of the DTTB and MTV markets

Most of DTTB and MTV based services generally deliver linear broadcasts (i.e. live broadcast streams) to end-consumers equipped with a digital receiver, whereby:

MTV services deliver the linear broadcasts onto a mobile device with, in most cases, return
channel capacity (allowing interactive services), including any mobile/smart phone or tablet-like
device; and

2. DTTB services deliver the linear broadcasts onto *stationary* or *portable* devices (with in most cases, no return channel), including to set-top-boxes (STB), digital recorders/personal video recorders (PVRs) or integrated digital television sets (IDTV).

With the difference between mobile and stationary/portable reception of linear broadcast content, two different end-consumer needs are addressed. Consequently, most regulators, service providers and network operators consider both services to operate in two distinct markets.

Table 3.1.1 provides an overview of the key differences between the DTTB and MTV markets, although differences/similarities depend on the actual services offered.

Table 3.1.1: Key difference between the DTTB and MTV markets

Market element	DTTB	MTV	
Content	 High resolution (including HDTV) Long form (e.g. films and live sport coverage) Semi interactive (e.g. EPG and programme associated data and information) 	 Low resolution (possibly 'tailor' made ²³⁵) Short form (e.g. news bulletins, soap highlights, music video clips) Fully interactive (e.g. programme associated Internet pages, video-ondemand services and direct service ordering) 	
Viewing time	 Prime time focused on the evening Average viewing duration: > 1 hr 	 Prime time scattered around office hours (travelling to and from work and at lunch break) Average viewing duration: < 1 hr 	
Target groups	 Television households (preferably without a multi-channel offering) Households²³⁶ Leisure sites (e.g. campsites, sport clubs, boats, etc.) Public places (e.g. bars, stations, libraries, etc.) 	Mobile phone users and users of other mobile devices (like navigation systems, smartphones and MP4 players)	
Receivers and service life cycle	Long (4-8 years or more)	Short (1-3 years or more)	
Window of opportunity	 ASO Roll-out speed of other digital platforms²³⁷ 	ASO Availability of alternative technologies (like LTE)	
Type of service offering	'stand-alone' multi-channel offering	 'stand-alone' multi-channel offering 'Piggy Back' offering (i.e. service is offered as an add-on to another existing service) 	

MTV content might be produced in a different format and screen lay-out. For example ticker information or screen overlays may need different letter size and fonts.

²³⁶ In some countries television service uptake is limited by the deployment and extension of the electricity network. A growing electricity network may imply an increasing potential market for DTTB services.

Once a set-top-box or any other digital receiver is delivered to the customer, a second set-top-box from a different service provider will not get in to the same household, at least for a long period (depending on the receiver and service life cycle).

Market element	DTTB	MTV
Revenue models	Advertising basedSubscription basedTV License fee based	Advertising basedSubscription basedRevenue sharing
Competing platforms	 Satellite multi-channel Cable multi-channel IPTV multi-channel Internet multi-channel and VoD Other DTTB licence holders 	 Mobile operators offering mobile television on the basis of G3/4 Other MTV licence holders DTTB licence holders offering free-to-air channels
Market maturity	MatureEstablished value chainElaborate channel offering	 Value chain/business model not established yet Limited dedicated channel offering Limited number of interactive service
Universal Service	 "Must carry" rules may apply "Price cap" rules may apply ASO related stipulations	No or limited "must carry" rulesNo or limited "price cap" rulesNo ASO stipulations

Although Table 3.1.1 suggests two distinct markets, over time the boundaries between the two markets will blur, because of:

- 1. Converged service concepts²³⁸: digital television service providers will introduce service offerings across several delivery platforms. Current examples, indicating this trend, are:
 - a. Broadcasters delivering popular linear programming over the DTTB platform (or Cable/Satellite/IPTV) and having "catch-up" or "high light" streams available on the mobile platform. This has already takes place in some countries where mobile/portable receivers have achieved widespread (e.g. OneSeg in Japan and Brazil). Also the introduction of the 'second screen' providing interactive services (like voting or ranking), background or more detailed programme information (often on a tablet like device) are examples of changing service concepts blurring market boundaries.
 - b. Service providers offering "TV anytime/everywhere" concepts enabling viewers to watch their favourite programmes anytime and anywhere they like. Most notably telecom and cable operators are offering these possibilities.
- 2. Receiver and network developments: improved receiver technology will make digital television streams available on an ever growing number of devices, due to:
 - a. integrated chip-set: many different receiver types are integrated onto one chipset/receiver, limiting the risk of standard/technology lock-in;
 - b. miniaturization: receivers are miniaturized onto smaller devices like USB/PCMCIA sticks and cards, increasing the number and type of 'screens' television content will be accessible.

in the train.

A future service scenario could look like this: in the train on your way home from work, you watch the live Music awards on your MTV- enabled mobile phone. You like the nominated songs, and so you order four MP3 music clips from your mobile, asking for them to be delivered both to your mobile and to your media centre at home. When you arrive at the railway station, you have to stop watching, even though they are about to announce the winner. When you get home, you switch on your television, and you continue to watch the Music awards from the point where you stopped watching

3. Regulation and licensing: progressively the regulators follow the international spectrum management trend of *technology neutrality*; enabling licence holders to offer a wider range of services (see also section 2.1 of these Guidelines).

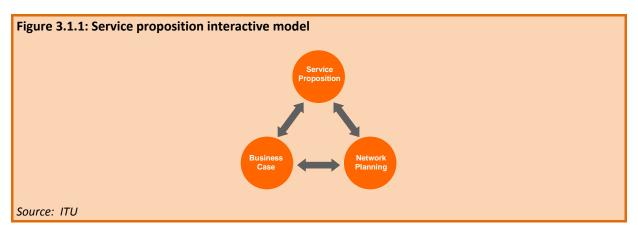
With blurring boundaries between digital television markets, new opportunities will arise but also new competition will be introduced. In researching the market and consumer needs these developments should be considered. The next section 3.1.2 will address incorporating these aspects into a market research design.

3.1.2 Market research methods

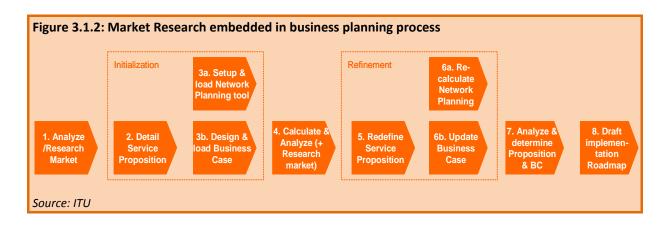
In the DTTB and MTV business development/planning process, market research and the resulting customer insights are used for the following key elements:

- service proposition: determining the demand drivers (i.e. customer needs) for the various customer target groups will help determining the willingness-to-pay and which attributes of the service proposition have to be included;
- business case: determining the relative value of the included service proposition attributes (as compared to the attributes of the competing service propositions) will help assessing the DTTB/MTV market share and up-take curve;
- 3. network planning: determining the customer target groups (e.g. where they are located, when and under what conditions they would like to receive the television content) will help planning the initial DTTB and MTV network (type of required network and roll-out order).

In the DTTB and MTV business development process, the above elements are interrelated. The simple example of network coverage (as part of the service proposition) illustrates the interrelationship between these elements. The network coverage determines the number of sites (through network planning) and this number will in turn drive one of the key costs in the Business Case. Ultimately, the balance between financial means and a marketable service proposition has to be found. Figure 3.1.1 depicts the interrelationship between the three elements.



Market research should therefore be embedded in an iterative business planning process. Preferably, in order to reduce costs and time-to-market lead times, field market research (i.e. interviewing or testing under end-consumers) should be conducted at the beginning of the planning process. This will require the market research to be set-up thoroughly and with enough scope (i.e. investigating several alternative service propositions and their attributes). Figure 3.1.2 depicts an example of such an iterative business planning process.



It should be noted that after initial calculation of the network planning and associated business case (see step 4 in Figure 3.1.2) a fundamental different approach might be required and additional market research will be necessary. In addition, as the business planning process is normally carried out over a longer period (half to one year as a minimum) changes in the market and regulatory environment might occur, having a significant impact on the business planning process. The latter also arguing that the process should be set up as an iterative process.

For carrying out market research, elaborate literature and specialized firms can be found. The different market research methodologies will not be individually addressed in these Guidelines. However, a general three-step approach will be presented for:

- Step 1. Determining the service proposition attributes and willingness-to-pay.
- Step 2. Estimating the DTTB/MTV market share.
- Step 3. Selecting the DTTB/MTV uptake-curve.

For each step, several research methodologies are suggested. The methodologies can be combined and are not necessary limited to one single step but can also cover all steps in one single market research effort.

Step 1. Determining the service proposition attributes and willingness-to-pay

For any service launch the Service provider has to determine which service attributes to include in its service proposition. These attributes can be categorized as:

- 1. 'must haves'/bare minimum: these attributes are necessary for the service to be accepted by the end-consumers/viewers, regardless of price;
- 'competitive advantage' or 'unique selling point': these attributes will set aside the DTTB/MTV
 service from other service propositions in the (future) market and preferably they are unique,
 that is to say that competitors cannot copy these attributes in the near future.

Table 3.1.2 provides some examples of service proposition attributes for DTTB and MTV services, split between 'must haves' and attributes that may provide a competitive advantage.

Table 3.1.2: Example service proposition attributes for DTTB and MTV

	'Must haves'	Competitive advantage
DTTB	 Number of channels above threshold level (dependent on the competing television offerings) Top-10 most viewed channels 'Must-carry' channels Pre-paid facilities²³⁹ 	 Exclusive content (for example English Premier League football rights) or local/regional content²⁴⁰ Portability Receiver price/one off price²⁴¹
MTV	 Integrated package with telephony subscription (implying one billing and content protection system) MTV receiver integrated in one handset (no separate receiver) and available in many different handset models Top-10 most viewed channels Pre-paid facilities 	 Exclusively produced content (for the MTV platform) Picture quality Service availability

The attributes included Table 3.1.2 do not necessarily apply to all DTTB/MTV markets and are dependent on the specific customer demands and competitive landscape. For a more elaborate overview of service proposition attributes see section 3.2 of these Guidelines.

To determine the DTTB/MTV service proposition attributes, four research methodologies can be applied:

- 1. Consumer trial: in a closed user group the DTTB or MTV services are tested, by providing potential customers a sample service. Such an approach, depending on the number of participants and number of DTTB/MTV sites, can be relatively expensive²⁴². Consumer trials are very often combined with a survey (see below) to collect additional information. Consumer trials can provide reliable information on:
 - a. *service attribute values*: for example which channels are appreciated most or what EPG features are best appreciated;
 - b. viewing/use patterns: for example when are the channels/services used, how often and for what duration?²⁴³

As opposed to subscription/post-paid paying schemes, pre-paid schemes are commonly available as well. Pre-paid schemes may be necessary as viewers may not have bank accounts.

Regional content is difficult to facilitate on Satellite platforms as the potential revenues are too low compared to the distribution/transponder costs. In a DTTB platform, with local insertion, these distribution costs are significantly lower.

In markets with only a multi-channel offering on the satellite platform, a DTTB offering could lower the barrier-to-entry for consumer by having a significant lower receiver installation cost (i.e. decoder and antenna/dish).

For more details on the technical set up and associated costs of a MTV trial, please see section 5.9 of these guidelines.

Because MTV handsets have an in-built return channel, very accurate real-time information can be collected about individual viewing patterns and use of other/interactive service. Please note that for respecting privacy regulations, the participants should be asked their explicit permission to collect this data.

- 2. *Market survey*: by interviewing a representative group of potential customers detailed information can be collected on the composition of the target groups and how attribute values change between the various groups. This information can be collected on:
 - media behaviour: information can be collected on media consumption patterns (e.g. use and appreciation of current television and radio services) of the potential target groups (e.g. differentiated between the standard demographics like income, social class, household size and composition);
 - b. switching factors: what attributes would make consumers switch to an alternative services (e.g. 25 per cent lower price, possibility to subscribe to a limited number of channels, better picture quality, portability, etc.);
 - c. price perception: an indication of the 'willingness-to-pay' can be obtained. However, the reliability could be low depending on the set-up of the questionnaire and the service references (i.e. are there alternative price markers for the interviewee like other digital television offers);
 - d. relative value of the presented service proposition attributes.
- 3. Benchmarking/market comparables: studying commercial DTTB and MTV launches in other markets/countries, could provide information on what attributes add value. However, careful consideration should be given to translating this information to the local DTTB/MTV market, especially for:
 - a. Type and number of channels: television content preferences vary greatly between countries due language and cultural differences. Only a very few channels have global appeal (like Discovery channel, National Geographic, BBC World and CNN).
 - b. Willingness-to-pay: the willingness-to-pay can vary greatly between countries due to market structure like free-to-air offers, exclusive content deals and government intervention (e.g. television licence fees, provision of cable distribution and price regulation).
- 4. Expert panel: bringing together a selected group of key customers and/or industry thought leaders in a structured but unhurried forum, so that a service provider can learn their opinions on various service proposition attributes and other marketing issues. Expert panels should be selected carefully, as the expert preferences might not represent the DTTB and MTV target groups. However, expert panels can provide information quickly and can be combined with additional market research for determining potential market share (see step 2 below).

Attribute Scores (n=607)

Electronic Programming Guide
Enhanced teletext
Mosaic channel
Picture in Picture display
Program associated information
Telebanking
MP-3 downloads
Computer games
Email notification in television screen
Ordering services and products with receiver

0% 10% 20% 30% 40% 50% 60% 70%

Score (% very interested)

Figure 3.1.3 provides an example of market research results on the relative value of the various service proposition attributes (including competition offerings).

Step 2. Estimating the DTTB/MTV market share

At this stage the DTTB/MTV service provider will have to consider the consumer's alternatives. Hence the provider will need to know the competition's current and possibly future offerings. By lining up the available (and future) service offerings and evaluating the value of the included attributes, the potential market share can be estimated. The market research results from step 1, forms the input for this step.

For estimating the DTTB/MTV market share the following research methodologies are available:

1. Conjoint or Rank Order and Acceptance (ROA) analysis: Conjoint analysis requires research participants to make a series of trade-offs, for example by presenting them a series of cards with possible DTTB/MTV service propositions (including the competition's attributes) and asking the participants to rank them in order of preference²⁴⁴. The mathematical analysis of these trade-offs will reveal the relative importance of the various attributes. To improve the predictive ability of this analysis, research participants should be grouped into similar target groups or client segments. Further improvement can be obtained by applying a Rank Order and Acceptance analysis, in this method the participants are also asked to indicate which card propositions are not acceptable. In this way, information is also collected on 'must have' attributes. Figure 3.1.4 below illustrates a simplified example of a series of cards.

132

The design of these cards should be carried out carefully to include all possible attributes and to make them distinguishable for the research participants. The cards do not necessarily include real service propositions.

Card 1	Card 2
A single television package	1. a-la-cart selection of channels
2. of 20 channels	2. of 10 channels
3. No Video-on-Demand	3. Video-on-Demand
4. Information channels	4. Information channels
5. Simultaneous viewing & recording	5. Simultaneous viewing & recording
6. Internet and email on screen	6. Internet and email on screen
7. Price: €45 per month	7. Price: €20 per month
Card 3	Card 4
A single television package	1. A single television package
2. of 50 channels	2. of 10 channels
3. Video-on-Demand	3. Video-on-Demand
4. Information channels	4. No Information channels
5. Simultaneous viewing & recording	5. No simultaneous viewing & recording
6. No Internet and email on screen	6. Internet and email on screen
7. Price: € 10 per month	7. Price: €40 per month
7. I floc. C to per month	7.1 floc. C40 per filonar

2. Market breakdown and market comparables: in this approach the potential market for DTTB and MTV services is broken down into smaller market segments and for each market segments the potential market share should be estimated. An expert panel could assess the relative strength of DTTB/MTV service attributes, as compared to the competition's service attributes, in each segment. Subsequently all the estimations are summed to a grand market total. Such a bottom-up approach could be further improved by checking the grand total with market comparables for the total market (see above). A common model to segment the market is Roger's diffusion of innovation or Product Life Cycle model with the categories of adopters: innovators, early adopters, early majority, late majority, and laggards.

Figure 3.1.5 provides an example of market research results on market shares of the various service propositions.

Figure 3.1.5: Example ROA results

	DTT	DTT	Analoge C	Analoge C	Satellite
	basic	basic	basic	standard	
	rental	purchase			
		•			
Age					
<30	25,7%		7,8%		
30-40	15,8%		12,3%		
40-50	0,2%		16,6%		
>50	0,3%		24,0%		
Gender					
Male	3,4%		21,3%		
Female	1,3%		23,2%		
Household size					
1	0,2%		21,4%		
2 3	3,0%		24,9%		
3	16,3%		1,5%		
4	4,4%		24,7%		
5+	10,5%		5,7%		
Education					
bo, Ibo			27,1%		
ha, vw	6,5%		12,4%		
un	2,6%		21,6%		
Income					
<2250	0,6%		19,6%		
2250-3500			18,9%		
3500-5500	1,1%		22,0%		
>5500	5,9%		16,3%		
Overall	5,5%		18,6%		

Source: ITU

Step 3. Selecting the DTTB/MTV uptake curve

In the previous step, the results show an estimate of the potential DTTB/MTV market share. This is the market share at market saturation level. But little information is known about how quickly this potential market share can be obtained and neither is the curve known at this stage.

Assessing the uptake curve is important because DTTB and MTV services are capital intensive, requiring relatively large up-front investments. Most uptake curves, especially for innovative products and services, are based on Roger's Product Life Cycle model. When plotted over a length of time the adoption of an innovation follows an S curve. Extensive academic literature can be found on estimating this S curve.

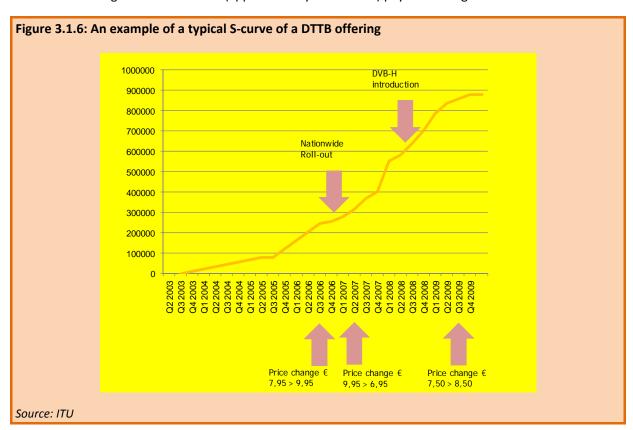


Figure 3.1.6 shows an example S curve of the DTTB service offering in the Netherlands. Please note that this DTTB offering is a multi-channel (approximately 35 services) pay-tv offering.

A pragmatic approach is in essence based on market comparables. What services are similar to the planned DTTB and MTV services and what adoption curve can be observed? In the case where good market comparisons are lacking, the remaining uncertainties (speed of adoption and exact curve) can be incorporated in the business case sensitivity analysis.

3.1.3 Implementation guidelines

The following guidance can be provided for customer insight and research:

- 1. Carry out profound market research, especially in the case where the required funding is largely to be provided by third parties (e.g. banks or private equity funds). In any business case for DTTB/MTV services the key value driver is the penetration level of the service. External financers will seek evidence for the presented penetration levels. Strategic investors might adopt a different stance (e.g. they might also consider the synergies with their current business lines).
- Consider market research as part of the business planning process and for planning DTTB/MTV
 services this process will be a highly iterative process. Service proposition design, network
 planning and business case development are strongly interrelated and need to be set-up in a
 flexible way so that changes can be executed easily.

- 3. Consider DTTB and MTV as different markets, having different demand drivers and competitive environment. Hence the service proposition is different. Just 'copying' the DTTB offering (e.g. 20 linear services) onto a MTV platform will in many cases not be enough. Especially (free-to-air) broadcasters will see little added value in doing so as they will question whether new target groups will be reached or additional viewing hours will obtained 245. However, DTTB system which provides both fixed and mobile reception services simultaneously (e.g. ISDB-T, DVB-T2 Lite) can share the same market. Mobile reception service is regarded as one of value-added services of DTTB.
- Include competition in any market research. In the long run, competition will be present (even when markets are limited by the number of issued spectrum licences). Also consider regulatory limitations for example:
 - limitations to provide hand-set subsidies (e.g. like in the Belgium mobile market);
 - limitation to freely assemble the channel line up (e.g. due to 'must-carry' obligations);
 - limitation to conclude exclusive content deals (e.g. in Europe and Thailand the regulatory authorities issued a list of sport and national events not to be included in pay-ty packages).

3.2 **Customer proposition**

In section 3.1 an outline of the applied market research methods are provided for determining the DTTB/MTV service proposition attributes. This section focuses on determining the competitive advantage and what the related service attributes could look like, based on previous DTTB/MTV service launches around the world.

This section is structured as follows:

- 3.2.1 DTTB competitive advantage and related service proposition attributes.
- 3.2.2 MTV competitive advantage and related service proposition attributes.
- 3.2.3 Implementation guidelines.

3.2.1 DTTB competitive advantage and related service proposition attributes

From a commercial perspective, the competitive advantage of a DTTB offering is solely dependent on the competitive landscape of the television market. Hence DTTB launches differ from country to country and are marketed in different ways, emphasizing different competitive advantages.

However, from observations of the various DTTB launches, six competitive advantage categories (or marketed reasons for DTTB launch) can be identified:

Interactivity/enhanced television services: in markets with only analogue television platforms, DTTB could offer interactive services as a competitive edge (however for a limited duration as all platforms will migrate to digital in the long run). Without any return path, these interactive services are limited to services like the Electronic Programme Guide (EPG), additional programme information and enhanced teletext. Market developments show that (mass produced) receivers come available with return path capabilities, such integrated IPTV/DTTB set-top-boxes. Also television set producers launch Internet enabled television sets for browsing

In markets with little television platforms available and/or with platforms with only a limited reach, the consideration of broadcasters might be different.

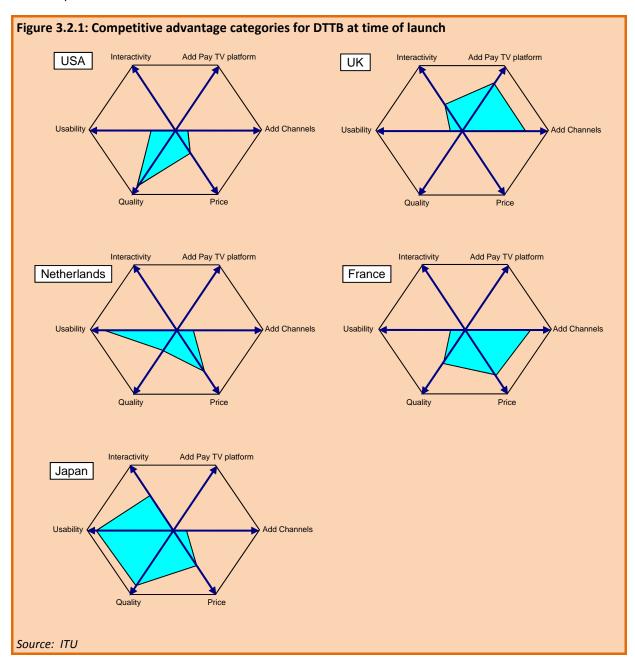
- and accessing Internet content on the television screen with a normal remote control. This development comes under the phrase Hybrid Broadband Broadcast (HBB)²⁴⁶.
- 2. Additional pay-tv platform/conditional access and billing facilities: as DTTB platforms can easily be equipped with conditional access and billing facilities, it could provide service providers a platform to launch pay-tv services, such as tiered television packages, pay-per-view offerings and pre-paid facilities. Pay-tv services are often launched on the basis of a multi-channel offering and hence this competitive edge comes very often in combination with an 'additional services' augment (see below).
- 3. Addition services/multi-channel offering: in markets with the analogue terrestrial television platform being the main platform and offering only a limited set of services the introduction of a multi-channel DTTB offering could be a key demand driver. It should be noted however that in most countries a multi-channel (pay-tv) satellite offer is available too and the DTTB platform is faced with limited capacity. A long(er) lasting competitive advantage should really be added to the DTTB platform.
- 4. Lower costs (one-off and/or recurring): A DTTB platform could have the advantage of having lower network costs²⁴⁷ and receiver costs. Especially these one-off costs could form a major barrier for consumers to adopt digital television. However, following a low cost strategy should be carefully considered as the competitor could have 'deeper pockets'.
- 5. Picture and reception quality: the introduction of DTTB could entail for viewers a significantly better reception and/or picture quality. A DTTB offer could include HDTV services. As addressed in section 4.4 of these Guidelines, trade-offs have to be considered between picture quality and reception quality (i.e. robustness of the signal)
- 6. Usability/Portability: DTTB services are wireless and can be received on very compact receivers. Hence DTTB services have the competitive advantage of portability, especially when the receiver comes with a small antenna or an integrated antenna. The latter even allows mobile reception as shown in the markets of Germany, Japan etc. with the launch of mobile phones with integrated DTTB receivers. None of the regular competing television platforms can offer such functionality²⁴⁸. Whether portability forms a demand driver, depends on the local market and should be investigated (like all the other above mentioned categories).

HBB defines the convergence between broadcast and Internet content for a coherent experience, it makes possible accessing Internet content on a television display. Manufacturers have demonstrated confidence in the emergence of this new market that allows viewers to watch Internet video content directly on their television sets by making many products available. For more details see www.digitag.org

Benchmark studies have shown that terrestrial networks are in most cases inherently cheaper than cable or satellite networks (except in cases where coverage has to approach 100 per cent of the population). A DTTB roll-out can be rolled out quicker and be localized to where the target population is situated. In addition, in the case of re-use of the analogue terrestrial infrastructure (sites and antennas) the cost difference could be even larger.

It should be noted that recent developments of LTE/IMT and Wi-MAX technologies could change the competitive landscape and should be considered as well.

These six main competitive advantages (or marketed reasons for adopting DTTB) can be depicted in a diagram. Figure 3.2.1 depicts the DTTB launches in five different countries, illustrating the wide range in market 'profiles'.



In the above figure it should be noted that the initial launch in the UK was followed by a market failure as the service provider ONdigital/ITV Digital went bankrupt. The platform was re-launched on the basis of an advertising model (rather than a pay-tv offering), building on an ITV Digital customer base of 1.25 million subscribers with a set-top-box. The service was re-named FreeView. Clearly this appeals on the competitive advantage of price.

It seems that the recent DTTB launch in France incorporated these 'lessons learned' into their service offering, as the DTTB platforms offer a free-to-air multi-channel television package with HDTV services included. Whether a DTTB free-to-air model can work, depends largely on whether (existing) broadcasters on the DTTB platform can reach additional viewers (or increase viewing hours).

In addition to the above mentioned six categories, any DTTB service proposition should always be complemented with the attributes for:

- 1. Installation and service activation: how viewers can get access to the services and how (individual) services can be activated, including the following aspects to consider:
 - a. retail logistics and channel management: which outlets (shops/internet) provide receivers and smart cards and what are the commission schemes?
 - b. smart card handling: provision of pre-activated smart cards, pre-paid cards, 2nd smart cards (for second screen in the home) and try-out periods;
 - c. installation aid: coverage and reception check (on the internet or via SMS, could include advise on best receiver installation), antenna direction guidance, 'plug and play' instructions and at-home installation aid.
- 2. Billing and customer care: how to bill the customer and handle service change requests and, in the case of a free-to-air DTTB offering, how to promote the platform. The following aspects should be considered, including:
 - a. television package tiers, service change requests (e.g. service up-grade notices over the phone or via SMS) and discount schemes;
 - b. moving house and address changes (might require coverage check/other receiver);
 - c. sending invoices (e.g. only over the internet or broadcasting billing information), and invoice intervals;
 - d. collection and bad debt handling.
- 3. Service deactivation/subscription cancellation and receiver returns: this service attribute is mainly relevant for subscription based DTTB services and deals with the way viewers can discontinue their service and return the rental digital receiver (the latter not applicable for a purchased receiver).

Table 3.2.1 provides an overview of example DTTB attributes, grouped in the six competitive advantage categories.

Table 3.2.1: Overview of example DTTB attributes

Category	Attribute	Example (country)
Interactivity/ enhanced television services	Programme information/ information channel	Red button service of the BBC, see <u>www.bbc.co.uk</u>
	Enhanced teletext, with full colour graphics	 For an example see www.channel4.com News, weather/traffic information, captioning, etc. are commonplace on most of DTTB platform in Japan
	Enhanced EPG	 Programme guide 7 day ahead and/or automatic recoding in Japan and many European countries
	Interactive service (DTTB platform only), including push VoD ²⁴⁹	 For example offering see www.topuptv.com on the basis of the DTTB free-to-air service Freeview in the UK For other example services see www.mirada.tv
	Hybrid broadband broadcast, requiring return path/Internet connection, including push and full VoD.	 For an example of Internet/DTTB set-top-boxes see www.hbbtv.org/ For Internet enabled integrated digital television sets see www.nettv.philips.com/
Additional pay-tv platform/ conditional	 Tiered service packages 	 DTTB pay-tv services in Sweden: Boxer, see www.boxer.se/ DTTB pay-tv service in Italy, DGTV, see www.dgtvi.it
access and billing facilities	Pay-per-view/event	DTTB pay-per-view services in Italy: DGTV, see <u>www.dgtvi.it</u>
Juennes	Pre-paid services	Multichoice scratch card payment service for example in Ghana and Kenya see www.dstvafrica.com
Addition channels/multi- channel offering:	Multi/premium channel offering	 DTTB pay-tv services in Sweden: Boxer, see www.boxer.se/ DTTB pay-tv service in the Netherlands: see www.kpn.com
	Multi-channel free-to- air offerings	 Free-to-air DTTB service in the UK, Freeview, see www.freeview.co.uk Free-to-air DTTB service in France, TNT, see www.tdf.fr Dynamic programming, e.g. one HD programme on prime hours and multiple SD programmes on the other hours
Lower costs/one-off and recurring	low cost offering	compare DTTB set-top-box prices, especially free-to-air boxes/receivers come as cheap as USD 20-40 retail price
Picture and reception quality	HDTV offering	 Free-to-air DTTB service in France, TNT, see www.tdf.fr In Japan most services are broadcasted in HDTV on the DTTB platform
Usability/Portability	Portable offering	Digitenne service from KPN in the Netherlands, see <u>www.kpn.com</u>
	Mobile offering (in-car and mobile)	 Free-to-air DTTB in Germany, see www.ueberall-tv.de 'One Seg' services offer either the same as or different from main programmes in Japan

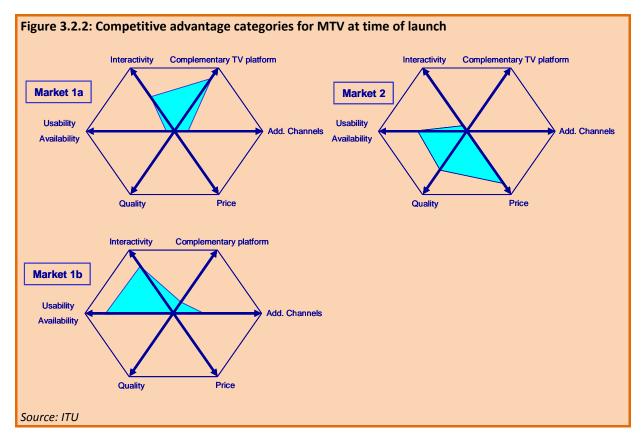
Push video on demand is a technique used on systems that lack the interactivity to provide real-time streaming video on demand. A push VoD system uses a personal video recorder (PVR) to automatically record a selection of programming, transmitted over DTTB platform (or the Internet connection). Users can then watch the downloaded programming at times of their choosing.

3.2.2 MTV competitive advantage and related service proposition attributes

As for DTTB, the competitive advantage of a MTV offering is solely dependent on the competitive landscape of the television market. Compared to DTTB markets, MTV markets are however relatively new and basically still two market situations can be distinguished²⁵⁰:

- 1. No mobile television services are commercially available in the market yet. Within this market situation two sub-situations can be distinguished:
 - a. no mobile television services in the market yet and no/limited nationwide or near nationwide television platforms available;
 - b. no mobile television services in the market yet and nationwide or near nationwide television platforms available.
- 2. Mobile television services are present in the market, delivered over a switched mobile network (e.g. UMTS/LTE/IMT). This is the case for example in Korea, Japan, USA and most European countries.

Competitive advantage for both market situations differs fundamentally. Using the competitive advantage framework, the two situations are depicted in Figure 3.2.2.



For any DTTB service introduction, the DTTB service provider is facing competition from one or more television offerings already present in the market.

Addressing the different market situations in Figure 3.2.2, the following can be observed:

- 1. Interactivity/enhanced television services: Only in markets without a mobile television service in the market (market 1a and 1b), MTV could add interactivity in the television market as a competitive advantage. In markets with already a mobile television offering on switched mobile networks, interactivity is (technically) already well developed. However, the launch of MTV services could help the development of truly interactive and broadcast related content, as broadcasters tend to get involved closer²⁵¹. Specially developed interactive content could create a competitive edge. But this is not necessarily uniquely related to the introduction of a MTV platform, platforms like LTE/IMT can provide nowadays similar services.
- 2. Complementary TV platform: in some markets (market 1a) the introduction of an MTV services could be driven by the lack of any other primary television platform. Provided that the mobile network is extended beyond the television network coverage, MTV could form a complementary TV platform. In some markets with already a mobile television offering (market 2), some mobile operators have considered launching a MTV service for extending the UMTS based mobile offering in under-served areas (sometimes referred to as mobile television roaming)²⁵². However, many mobile operators have acquired spectrum rights for LTE/IMT services and are deploying these new mobile networks, also for the purpose of offering video and television services.
- 3. Addition channels: In none of the markets a competitive advantage is expected from offering real time scheduled multi-channel offerings. These offerings are suitable for big(ger) screens. Only MTV exclusive or dedicated services could create a competitive advantage. To date, more and more content becomes available for the mobile platform. However, this content is not necessarily restricted to the MTV platform. In markets already with a mobile television offering (market 2), the competitive advantage of MTV could be in a combined service scenario of delivering popular services over MTV and VoD/less viewed channels over UMTS/LTE.
- 4. *Price/lower costs*: Especially in market 2 lower costs is a strong point for introducing MTV based services. Compared to UMTS based solutions (not considering any sunk costs for mobile operators²⁵³) MTV platforms can deliver broadcast content much cheaper. In any transmitter network the key costs driver is the number of sites. Due to the better propagation and the larger transmitter heights of MTV platforms, the number of sites in a MTV network is significant lower. However, LTE networks do operate in bands previously allocated to television broadcast services (see section 2.10 on the digital dividend) and can also deploy efficiently television broadcast functionality.

²⁵¹ See for example the National Football League (NFL) television service, especially developed for mobile reception. For more details see www.nfl.com/mobile.

²⁵² Such a combined service scenario will require a considerable amount of work in the areas of network/handset integration for seamless service roaming and marketing communication and support when both offerings (on UMTS and MTV platform) are not the same.

Mobile operators could have already invested heavily in UMTS/HSDPA networks and these costs might be considered as sunk costs, reducing the competitive advantage of lower costs. The same applies, although to a lesser extent to mobile operators investing in LTE/IMT spectrum and technology.

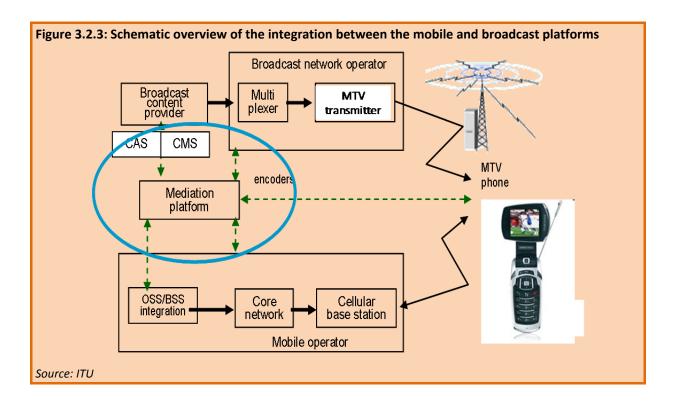
- 5. Picture and reception quality: In markets with already a mobile television offering (market 2), MTV platforms could add value by offering a better picture quality (by locating a higher constant, non-shared, bit rate) and possibly better reception quality (by having a more robust signal). This competitive advantage will become more evident when traffic levels (more viewing hours and more concentrated) become higher. In some markets, traffic congestion problems with UMTS/HSDPA solutions have been reported when active subscriber numbers exceed 10,000. For the relatively new LTE/IMT platforms not enough practical data is available yet to conclude how these networks perform under large groups simultaneously accessing a television service on these platforms.
- 6. Usability/availability: In markets without a mobile television offering (market 1), usability is a key competitive advantage. In addition, in countries with a limited electricity network roll-out, the MTV platform might prove to be the only platform to provide television services in rural areas. In markets with mobile television (market 2), MTV's competitive advantage could be network availability. The network availability with HSDPA solutions has been reported to be problematic (access blocking and interrupted broadcast streams). In addition, broadcasters have reported that MTV solutions are handset independent and 'porting' the television application to various handset devices is not necessary. It should be noted that this competitive edge might not be enough reason to launch MTV and should be supported by other competitive advantages.

In addition to the above mentioned six categories, any MTV service proposition should always be complemented with the attributes for service activation, billing and customer care and service deactivation. In contrast with the DTTB service proposition, MTV service providers should specifically consider:

- In markets where the mobile operator is the service provider, the MTV introduction should be integrated with existing service provisioning systems and organization. Special care and attention is needed for integrating the broadcast and mobile Operating Support Systems (OSS) for billing and customer care. For example, MTV services might be billed from the mobile operators billing system, requiring an interface from the MTV platform to the existing mobile platform. Also, MTV packages and services might be ordered with handhelds, requiring an interface from the mobile platform to the MTV platform. A 'mediation' platform might be required for resolving these interface requirements. Figure 3.2.3 provides a schematic overview of such a mediation platform.
- 2. In markets where the MTV service is offered as a free-to-air offering, service activation, billing and service deactivation, is relatively simple²⁵⁴. Focus will be on the promotion of the MTV platform and informing the public about the availability of MTV equipped handsets.
- 3. MTV users will expect the same service coverage for both the mobile and broadcast services. In the case of non-parallel service coverage, special attention is needed to inform the MTV users about service coverage. This information might change over time when network roll-outs are extended.

143

Not only restricted to free-to-air MTV broadcasts, mobile operators offering a single MTV package, activated once, will not necessarily require and automated interface between the mobile and broadcast OSS.



For some reference MTV service propositions, please refer to the following websites:

- 1. MTV free-to-air service based on the T-DMB standard in South Korea, see www.worlddab.org.
- 2. NOTTV offering pay-tv MTV offerings based on the ISDB-T_{mm} standard in Japan, see www.nottv.jp.

3.2.3 Implementation guidelines

The following guidance can be provided for shaping the customer or service proposition:

- When designing a DTTB or MTV service proposition, the service provider should seek those attributes that will create a sustainable competitive edge. The provided categories (see Figure 3.2.1 and 3.2.2) form a start for designing the DTTB or MTV service proposition. The DTTB/MTV service provider should have at least one service attribute, and preferably two attributes, along the axis of these diagrams. Focusing on these attributes will be essential in having a clear marketing message.
- 2. In addition to the key service attributes, any DTTB or MTV service provider should include in its service proposition, the service fulfilment process (e.g., service activation, billing and customer care and service deactivation).
- 3. DTTB providers, planning service launch in the near future (> 1-2 years) could incorporate the most recent developments in their offering:
 - Including HDTV channels (Quality axis): screen sizes of domestic television sets have been and are increasing, while the viewing distances are almost unchanged since TV broadcasting started. It is found in Japan, USA, etc. that the most popular screen of the best-seller TV sets (prime sets) ranges 40 60 inch. This, in turn, requires a higher resolution programmes, otherwise viewers see blur on the pictures. Many programmes are already produced in HD format in these countries (e.g. all programmes including news are HD-produced by the public broadcaster NHK and most of the commercial broadcasters in Japan). The competing platforms (satellites, cables) also serve HD-programmes as a key competitive advantage. In line with this development of larger screen sizes is the development of UHDTV (4k or 8k system).

- b. Including the wide availability of low cost receivers, possibly in combination with a free-to-air proposition (Price axis). The number of DTTB receivers has exploded, including USB sticks, PC-cards, small portable television screens and small/simple set-top-boxes. Also the retail/ex-factory prices have dropped significantly. These recent developments will facilitate the widespread adoption of DTTB receivers and consequently making advertising based (free-to-air) offerings economically more feasible.
- c. Including Hybrid Broadband Broadcast (HBB) services (Interactivity axis): manufactures have started producing various commercial products, enabling interactive services and reducing the disadvantage of terrestrial-broadcast-only offerings. Such services will require a wide broadband penetration, still lacking in many developing countries. However, a phased introduction could be considered (e.g. focusing on the capital or key cities).
- 4. MTV providers, considering a service launch in the near future, could consider the following:
 - a. Including dedicated/interactive television content and services (Interactivity and Additional Channels axis)²⁵⁵. In this context it is important to note that broadcasters view MTV services as auxiliary to their real-time scheduled broadcasts (e.g. offering catch-up services or highlights). Popular broadcast/channels are important consumer brands that carry the MTV service. Having the traditional broadcasters on board is essential and hence interactivity services should be developed and included in the service proposition.
 - b. MTV services fall often under a lighter regulatory regime as often they will not be considered by the regulator as part of the Universal Service. Consequently, MTV service introduction could take place before ASO. This might create a window of opportunity for MTV services and the time-to-market could be shorter than any other competing platform.
 - c. Depending on the market situation (see above text) and value chain organization, an MTV service proposition should be considered as part of a wider mobile proposition and services should be integrated as one unified and transparent service for the end-consumers (see Figure 3.2.3). This will require early cooperation between marketing departments/units which have very often a separated responsibility for the mobile telephony/data and television markets.

3.3 Receiver availability considerations

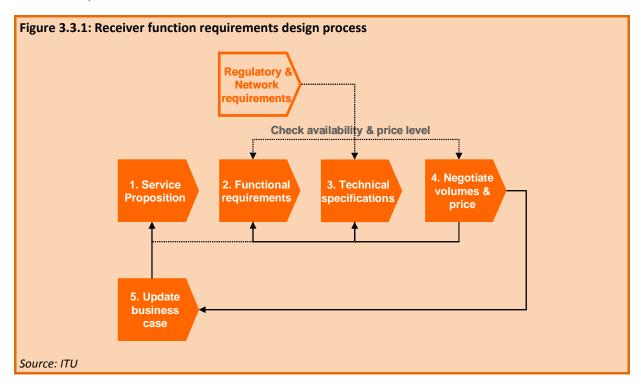
Today many different DTTB and MTV receiver types are commercially available. Also more and more integrated devices, supporting different transmission standards and platforms, are becoming available due to further chipset integration.

For a service provider it is important to draft the receiver's functional requirements based on the defined service proposition(s). Only those requirements supporting the service proposition should be incorporated. These 'must have' requirements might prove to be too expensive for the business case and therefore receiver considerations might result in a revised service proposition. At all times 'nice to have' requirements should be avoided as these will come with a price²⁵⁶ and may negatively impact the business case.

This point of having specially developed MTV content has been raised by many industry observers. See also the Communication from the Commission to the European Parliament, "Strengthening the Internal Market for Mobile TV, Brussels, 18.7.2007, COM(2007) 409 final.

Not only in higher receiver costs, but possibly also in more complicated business processes like receiver management, software updates, subscriber management and billing.

As illustrated in Figure 3.3.1, the process of determining the receiver functional requirements is very often an iterative process.



When drafting the function requirements a service provider should verify the availability of receivers and associated price levels. Very often the functional requirements will have to be 'translated' into detailed technical specifications²⁵⁷. For example the functional requirement of having a defined EPG (providing a seven day-ahead programme overview with programme title, start date, duration, parental rating, etc.) will have to be translated to technical specifications which are compliant with a technical standard (e.g. ETSI EN 300 468 v1.9.1 and Character set ISO/IEC 8859-7). It is important to note that the technical specifications might not necessarily only be driven by the functional requirements. For example regulatory requirements might stipulate the compression, transmission standard, character set, antenna output, power connectors, etc. In addition, the broadcast network operator may stipulate technical network requirements to the service providers on his platform.

Alternatively the receiver supplier could be asked to provide a complete technical solution. It should be noted that, in such cases, comparing the various offerings might be more difficult.

In the above figure volumes and receiver prices are negotiated with potential suppliers and vendors. However, in case of free-to-air DTTB/MTV services and/or the DTTB/MTV service providers are not purchasing receivers, the functional/technical requirements may also be drafted for the purpose of certifying receivers. With certified receivers the viewers know that the purchased receiver is compatible with the DTTB/MTV network.

This section will focus on the functional requirements from a commercial perspective, i.e. those requirements that are driven by the defined service proposition.

This section is structured as follows:

- 3.3.1 DTTB functional receiver requirements and availability.
- 3.3.2 MTV functional receiver requirements and availability.
- 3.3.3 Implementation guidelines.

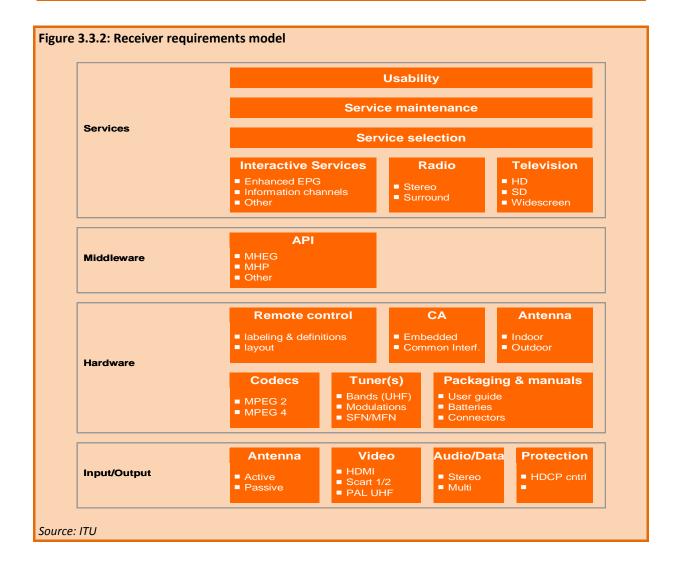
3.3.1 DTTB functional receiver requirements and availability

DTTB Receivers can be divided in the following categories:

- an STB (set-top-box) is a receiver which is a separate unit (external) from the TV Set (Display);
- an IDTV (integrated digital television set) is a receiver which is integrated into the TV set/display;
- 3. a PVR (personal video recorder or digital video recorder) is a separate unit (external) from the TV set (display) with capabilities to receive, store and playback broadcast services/programmes;
- 4. other receivers, such as a PC Cards (e.g. PCI), personal media players (PMPs or MP4 players), tablets, navigation devices or USB external receivers, these products together with the PC can be treated as an IDTV excluding the CA requirements.

For each included receiver type the service provider will have to determine the functional requirements, given the defined service proposition. The figure below provides a generic functional model, with some example requirements, for the first three receiver types (derived and adapted from the UK D-book 258).

²⁵⁸ See www.dtg.org.uk



For example, a service provider focusing on the competitive advantage of a cheaper television service and offering a single free-to-air bouquet of television and radio channels will not need all functional elements, such as conditional access, middleware and indoor antenna.

As the above figure demonstrates, many combinations are possible and in principle all receiver configurations are available on the market. However, uncommon configurations will have an additional price. DTTB service providers with a limited number of forecasted receivers will have to seek existing receiver production lines in order to keep receiver costs down. This might especially be relevant for CA requirements. Receivers with embedded CA are cheaper than receivers with a common interface (CI), but can only work with the specified CA (which is ordered by individual service providers).

For example receiver specifications please refer to:

- 1. Teracom, the Sweden based broadcast network operator, minimum receiver requirements for the DTTB networks²⁵⁹;
- 2. Freeview New Zealand set-top-box requirements for the DTTB network in New Zealand 260;
- 3. receiver specifications in respectively Japan and Brazil: ARIB STD-B21 "Receivers for Digital Broadcasting desirable receiver specifications" and ABNT NBR 15604 "Digital Terrestrial Television Receivers" 1262.

Nowadays average retail prices for DTTB receivers (Set-Top-boxes) without CA range between USD 20 and 40 in Europe and USA. As consumer product life cycles become shorter and production technologies become more advance, receiver prices keep dropping and more rapidly, also for receivers with new generation transmission standards. Receivers with CA functionality tend to be USD 5-10 more expensive (not including CA solutions based on the Conditional Access Module ²⁶³ which cost around USD 40/50) than receivers without. However viewers may not be directly exposed to those extra costs as CA receivers tend to be offered by pay-tv service providers who offer their subscribers a receiver either against a reduced charge or free of charge.

3.3.2 MTV function receiver requirements and availability

Mostly MTV receivers are compact digital television receivers integrated into a mobile phone/handset²⁶⁴. However, market developments show that compact MTV receivers are also built into other devices like navigation, Portable Media Players (PMP or MP4), tablets and game devices. Taking the same approach as that for DTTB, the MTV service providers should define the functional requirements for each included terminal type.

Mobile phone terminal producers consider the television functionality as an additional functionality (like photo camera and navigation functionality). Consequently, a major part of the MTV terminal functionality is given and is actually driven by other consumer demands and very often by a separately defined service proposition. As indicated in the implementation guidelines in section 3.2, service providers should consider an integrated approach to defining the service proposition. The necessity for such an approach will become apparent when defining the functional requirements of the MTV receiver.

See www.teracom.se

²⁶⁰ See www.freeviewnz.tv

²⁶¹ See <u>www.arib.or.jp</u>

See <u>www.abnt.</u>org.br

A conditional access module – or CAM – is an electronic device designed to be slotted into a set-top box or integrated digital television set (IDTV) enabling the viewer to access encrypted content. In turn the CAM generally incorporates a smart-card slot for inserting the smart-card. CAMs are available for a number of encryption systems in use. Some are capable of handling more than one encryption system. A CAM makes the digital television receiver independent from the encryption system as the CAM of another encryption system supplier can be inserted in the same CAM slot on the digital receiver.

Including separate MTV receivers which can be connected to the mobile phone using a wireless connection like Bluetooth.

In addition to the DTTB functional model (see Figure 3.3.2)²⁶⁵, MTV services have some specific handset functionality and requirements for the service provider to consider:

- 1. <u>Interactive television services</u>. Interactive services using a return channel will require specific functional requirements. For example, when viewing a live sports event, functional specifications need to be drafted for when/how additional or interactive information can be retrieved or sent (like match statistics, on-line betting, chat with other fans, etc.).
- 2. <u>Prioritization between television and other phone services</u>. For example, should an incoming call or text message override/stop the television viewing.
- 3. <u>Service ordering and billing</u>. The MTV enabled phone can also be used to order television services (e.g. pay-per-view services). Such functionality on a handheld will require an interface with the broadcast network. Also the billing of all phone related services should preferably be integrated to one billing platform.
- 4. <u>Battery consumption</u>. MTV devices are battery operated devices and functional requirements should be drafted for minimum stand-by time and viewing hours. Also some requirements are needed for battery consumption notification and saving energy for critical services (for example, the television services should not exhaust all battery power, so that viewers can still make a call).
- 5. <u>Channel selection and zapping speed</u>. Although also included in the DTTB functional model, MTV services require special attention for this functionality. MTV zapping time might be (too) long. A dynamic zapping service could help out. The main purpose of a dynamic zapping service is to give the user quickly an impression about the current content of the associated MTV service. The dynamic zapping service can carry different types of content such as a current snap shot, video or sound with reduced quality and data rate.
- 6. <u>Conditional access (only relevant for pay-services).</u> From a commercial perspective the key question is whether the MTV service is going to be a terminal locked-in service or not. In other words can the MTV enabled device be used between different service providers? As addressed in section 2.1 of these Guidelines, two basis options are available:
 - a. SIM card based and handset independent solutions;
 - b. CAS based and handset embedded solutions.

The current MTV devices (and chipsets) have reached satisfactory performance levels and are commercial available for any market in the world. The range of MTV enabled mobile phones is still limited in Europe (< 1 per cent of the available mobile phones is MTV enabled), while it is very popular in Japan (> 70 per cent of the available mobile phones is MTV ('OneSeg') enabled). Regionalization of technology standards for broadcast mobile television seems to divide the current MTV terminal market. After the discontinuation of DVB-H and MediaFlo based services in respectively Europe and the USA, the following MTV standards are currently in use:

- 1. T-DMB;
- 2. ISDB-T (OneSeg) and ISDB-T_{mm};
- 3. $CMMB^{266}$;

²⁶⁵ Please note: without functional requirements for the remote control. For middleware, hardware and in/output different technical specifications apply.

 $^{^{266}}$ Three other competing standards exist in the Chinese market: DMB-TH, T-MMB and T-DMB.

As mobile operators subsidize handsets between the various services no reliable public data is available on the additional ex-factory prices for equipping mobile phones with an MTV receiver. However industry analysts estimate that, with large quantities, the additional costs of an MTV receiver (tuner plus demodulator) will likely be priced in the range of USD 10-15 in mass production.

In Japan and Korea (and to a lesser extend in China), most of the mobile phones are integrated with functions of MTV reception, GPS navigation, camera, etc. and manufactures launch their new models every three months. Hence it is almost impossible to compare the prices between products with and without MTV receiver under other functions being the same. The prices tend to be determined by the models being new or old rather than by the functionality integrated into the handset.

3.3.3 Implementation guidelines

The following guidance can be provided:

- 1. Consider receiver purchasing as an iterative process between the service proposition design and the business case development (see Figure 3.3.1). As an alternative to the service proposition driven approach, service providers could consider reviewing receiver availability first and adjusting the service proposition accordingly. This might be an apt approach for markets with low levels forecasted for receivers or for MTV markets.
- Service providers having their competitive advantage in low costs should consider checking existing receiver production lines, especially when conditional access (CA) will have to be embedded in the receiver. In addition, only include CA requirements when the business model includes pay-services and the additional revenues of these services outweigh the extra CA costs.
- 3. In the case where receiver manufacturers are invited to give production proposals (see step 4 in Figure 3.3.1), draft detailed functional requirements and technical specifications so as to make comparison possible and to avoid inclusion of unexpected or unwanted functionality.
- 4. Check legal requirements for embedding CA. Although embedding CA is, in most cases, far cheaper than applying a common interface (CI)²⁶⁷, legal requirements might stipulate the adoption of CI. For example in Europe and Brazil, integrated digital television sets (IDTVs) with a screen size above 30 inches should be equipped with a CI slot.
- Service providers should determine which receivers will be supported (certified) or purchased. For pay-tv service propositions, the number of receivers is normally limited to set-top-boxes (STBs) and personal video recorders (PVRs). For free-to-air service propositions the range of receiver types can be very wide and normally covers all available receiver types. It should be noted that certification of receivers by service providers could be an expensive operation and should be carefully considered. In addition the legal framework for certification should be verified.

3.4 Business planning

Any DTTB and MTV business planning process will result in a plan for launching or introducing DTTB and MTV services in a defined market, including a set of business goals, the way they can be achieved and the required (financial) means. This DTTB/MTV launch plan is very often a business plan in the case of external funding.

Service providers offering CA on the basis of CI will have to supply the CI module (CIM), next to smartcard. The CIM costs are extra as compared with an embedded solution. A CIM costs around USD 50-80, depending on ordered volumes.

In the DTTB/MTV business planning process three key deliverables or milestones can be identified:

- 1. Agreement on the *business model* between the involved parties in the value chain. Basically this entails what each involved party will deliver and what the source of income (and the associated costs) will be.
- Finalized business case for each (set of) service proposition(s), detailing the associated revenue streams and costs. A business case is very often a spreadsheet model including the profit and loss statement, cash flow statement and balance sheet. In most cases, this spreadsheet model is also used to carry out scenario and sensitivity analysis.
- 3. Agreement on a final *business plan* between the business plan investors (and possibly management). For a business plan there is no standard format, but normally such a plan includes:
 - a. mission, strategy and objectives statement;
 - b. market and competition analysis;
 - c. service proposition definitions and market projections;
 - d. service proposition delivery, means and organizational set-up;
 - e. management structure and team;
 - f. financial projections, analysis and funding.

This section will focus on the first two steps for the introduction of DTTB and MTV services. This section is structured as follows:

- 3.4.1 Business models for DTTB services.
- 3.4.2 Business models for MTV services.
- 3.4.3 Example business cases.
- 3.4.4 Implementation guidelines.

3.4.1 Business models for DTTB services

Considering the DTTB business model the key question for DTTB service providers is really whether to launch a multi-channel/high quality offering on the basis of a free-to-air (i.e. a business model on the basis of advertising income) or a pay-tv model (i.e. a business model on the basis of subscriptions)²⁶⁸.

In countries with the analogue terrestrial platform as the main delivery platform and with a limited pay-tv offering in the market (i.e. a low penetration level) the preferred position might be a free-to-air (FTA) offering. However, whether a FTA or a pay-tv offering can be success depends on various factors, including:

- 1. For FTA models:
 - a. Additional viewers or viewing hours. Any FTA proposition will have to add additional viewers (or viewing hours) not previously addressed by existing platforms. In most cases, in such a FTA model the network transmission costs of the DTTB network have to be financed by the (commercial) broadcasters on the platform. Adding viewers or viewing hours is not necessarily restricted to un-served viewers (e.g. because the channels may not be broadcast on widely distributed networks), but can also be driven by additional (viewing) value for the end-consumers. In France and Japan for example, new viewers were attracted by offering a multi-channel HDTV offering.

Combined offerings are possible too. For example see the 'topuptv' offering on the Freeview platform (i.e. FTA DTT platform) in the UK. Please notice that his service was launched after the Freeview platform was well established. For more details see www.topuptv.com.

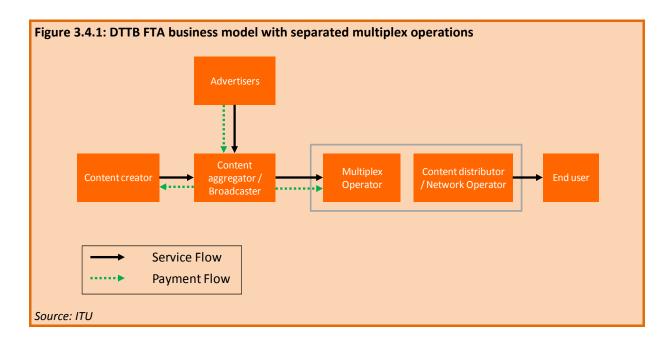
b. Absolute volume of the advertising market and market share for television advertising. Some markets may have limited advertising budgets, which may not cover the additional cost of setting up and running a DTTB services. Please note that also the advertising budget distribution should be considered. In some markets the advertising spend might be proportionally larger than for other media (e.g. such as radio or newspapers). As advertisers are known to be conservative, changing these spend patterns might be a lengthy process.

For pay-tv models:

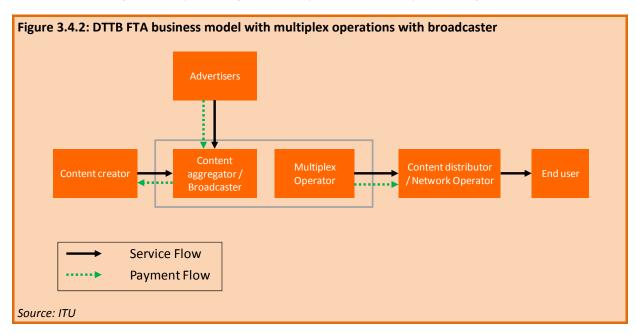
- a. Other existing pay-tv offerings in the market and their bouquet composition. Existing pay-tv service providers might address only the top segment of the market with relatively expensive packages (very often based on exclusive sport rights). There might be room in the market for offering lower-tier packages without exclusive/expensive content. In addition, existing service providers might provide a (perceived) bad service, providing a driver for viewers to switch to an alternative television offering.
- b. Existing free-to-air offerings. The potential market share for pay-tv service might be limited by the existence of widely adopted free-to-air offerings (e.g. satellite channels).
- c. Existing television content contracts in the market. Especially exclusive content deals might limit the possibility of creating attractive pay-tv packages. Conversely, the absence of exclusive contracts might create an opportunity.
- d. Willingness-to-pay²⁶⁹ for television services. The willingness-to-pay is very often historically and culturally determined. Pay-tv service providers should carefully investigate paying patterns for television services. Many examples exist of viewers refusing to pay for certain programming or services (e.g. for live sport coverage).

In Figure 3.4.1 a common business model for FTA DTTB is depicted. In this model, the multiplex operation (i.e. the assignment of the available capacity to the different broadcasters) is carried out by a separate entity from the broadcaster. In the model this functionality is part of the network operator activities (see also section 2.2.1 of these Guidelines on the value chain and the extra function of the multiplex operator). It should be noted that the function of service provisioning is not included in the figure. Strictly speaking, this function does exist and comprises of platform promotion and providing information on the DTTB services and service activation. Such an entity is very often funded by the broadcasters and network operator. However, there is no service flow through this entity and it is left out for clarity sake.

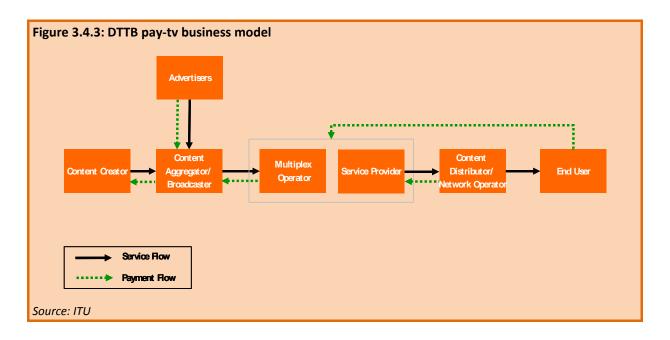
Please note that this is different from the ability to pay. In some countries the ability to pay might be relatively low but the willingness-to-pay disproportional higher. The ratio between willingness and ability can vary significantly from country to country.



An alternative business model for FTA DTTB is that the multiplex operation is assigned (by the regulator) to the broadcaster. This model resembles the analogue FTA broadcast model and broadcasters tend to adopt such a model quickly. However, such a model may be inefficient from a frequency efficiency point of view and the regulator may not assign in this way. This model is depicted in Figure 3.4.2.



For pay-tv DTTB business models the most common model is depicted in Figure 3.4.3. In most cases the service provider also manages the bandwidth/allocates the available capacity to various services (i.e. the multiplex operations). In this way the service provider can optimize the revenues.



3.4.2 Business models for MTV services

Also for MTV services the first major consideration is whether the service is going to be launched as FTA or pay-tv service. The considerations for selecting either model, as mentioned in the previous section, are no different. The business models of free-to-air MTV services do not differ from those applicable to any other DTTB service. However, a model where the multiplex operations is carried out by a separate entity (i.e. the broadcast network operator) is more likely to occur (see Figure 3.4.1 as opposed to Figure 3.4.2).

In an MTV FTA business model the broadcaster provides one or more channels to everybody who owns a device able to receive them. The user can purchase MTV devices in retail shops or any other outlet. Mobile operators may provide/subsidize corresponding mobile devices for up-selling their mobile TV services and also free-to-air broadcast services. The Korean T-DMB offering FTA MTV services may serve as an example here.

In the case of offering MTV pay-tv services the business models become more complex, especially when a single end-user device delivers two or more pay/subscription services. Most notable is the case of delivering mobile and MTV services on handhelds²⁷⁰ and having two separate licence holders for respectively the mobile and MTV licence. In such a case the two entities have to share the customer relationship with the end-user and consequently the revenues.

The issue of managing consumer relationships is fundamental. Both broadcasters and telecom operators have long and successful relationships with their respective viewers and customers, but may have initial difficulties in finding a business model where they must cooperate. There are several players in the value chain of both the broadcast and mobile industry that can take on the role of managing the customer relationship (i.e. sell the MTV services). Through (intense) negotiations the allocation of MTV customer management (and hence the resulting business model) is settled, very often prior to assigning the MTV licence.

 $^{^{\}rm 270}$ This might also be the case for navigation systems or MP4/PMP players.

The assignment procedure determines to a great extent what business model will arise. Basically by stipulating

- 1. Who is allowed to acquire the MTV spectrum: are there any parties excluded from bidding (either in a public tender or auction)?
- 2. What part of the spectrum is a single bidder allowed to acquire: how many MTV multiplexes or parts/slots of a multiplex?

If spectrum is open to any qualified bidder (i.e. the essential criteria, see section 2.6.1 of these Guidelines) the following entities could manage the customer:

- mobile network operator (including the service provisioning for mobile services);
- pay-tv service providers;
- 3. broadcast network operators.

In principle each of these entities can provide MTV services exclusively to its customers. Under such a vertical approach competition is only possible if several multiplexes are available to be used in different value chains. This may lead to an inefficient use of spectrum as the same channel might be broadcast several times (see also section 2.6 of these Guidelines).

Today in most of the markets only one multiplex is available, at least before ASO. Hence regulators tend to prefer a shared network model, where an independent MTV network provider facilitates several MTV service providers on the MTV platform. Such a situation will result in a different business model, too.

In the following, five possible business models are briefly outlined²⁷¹:

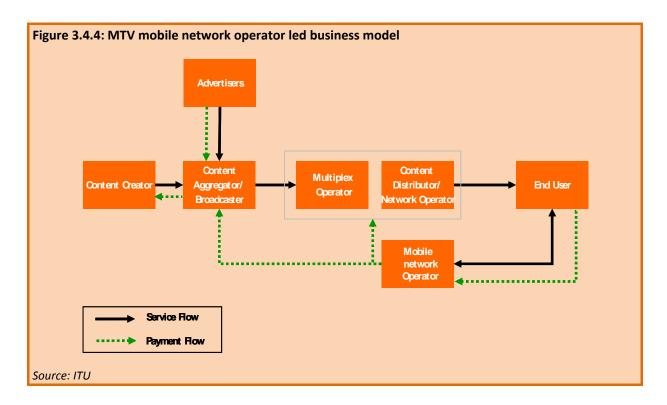
- mobile network operator led model;
- pay-tv service provider led model;
- 3. broadcast network operator led model;
- 4. MTV broadcaster led model;
- 5. shared MTV network model.

Mobile network operator led model

The mobile network operator handles the role of the MTV service provider. The mobile network operator manages the end-relationship with customers on service provision, marketing and customer care. For the MTV service, the mobile network operator will need to purchase content from broadcasters and possibly other content providers. Based on an own MTV spectrum licence the mobile operator may also play the role of broadcast network operation using its existing mobile network infrastructure. Alternatively the mobile operator is using the services of a third party broadcast network operator who either owns a frequency licence or uses the licence of the mobile operator.

Customers will have access to an integrated service proposition (i.e. mobile phone and MTV services). The mobile network operator will receive service fee payments for the use of the MTV service from the enduser (e.g. subscription fees, pre-paid or pay per view). Figure 3.4.4 depicts this business model.

²⁷¹ Partly taken (and adjusted) from BMCOForum, 'Mobile Broadcast Business Models', September 2008.



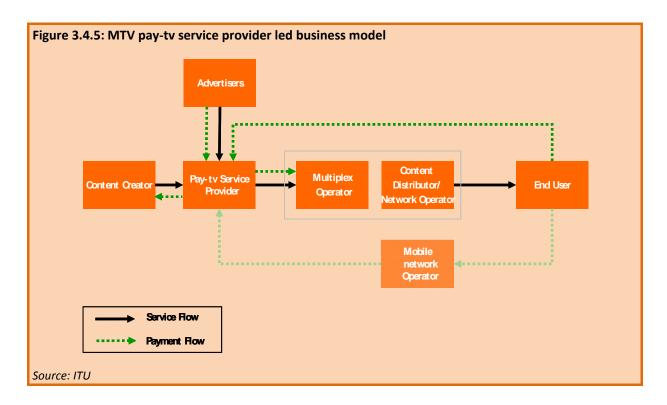
While the mobile network operator would be responsible for general marketing, it could be possible for broadcasters to market individual pay-tv television services. However the mobile network operator would remain responsible for the billing of those services. Revenues would be shared.

Pay-tv service provider led model

Pay-tv service providers may be interested in providing mobile broadcast services as an extension of their stationary pay-tv services. In this model the pay-tv service provider handles the role of MTV service provider by managing the end-relationship with customers on service provision, marketing and customer care.

Normally a pay-tv service provider will use the services of a third party broadcast network operator who either owns a frequency licence or uses the licence of the pay-tv service provider.

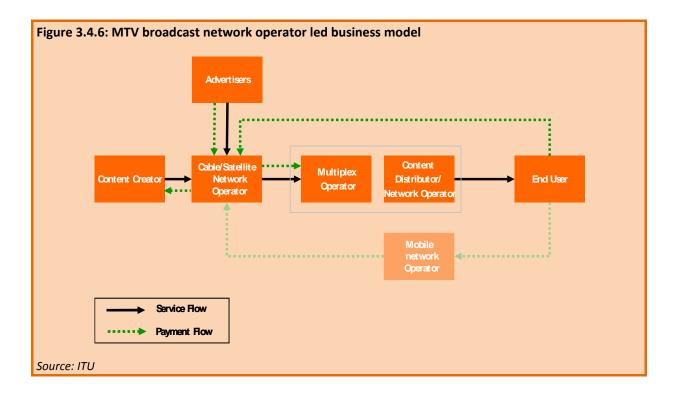
Being in the role of MTV service provider, the pay-tv service provider will define the specifics of broadcasting and service purchase and protection. This is likely in markets without subsidizing of mobile phones. Figure 3.4.5 depicts this business model.



Given the expected initial high cost of MTV enabled receivers, subsidizing the handset is likely to be necessary. It remains to be seen whether such handset subsidies are financially viable in the case of one single revenue (pay-tv) stream. Also, for interactive services, the pay-tv service provider will need to enter into an agreement with the mobile network operator regarding the device technology.

Broadcast network operator led model

Broadcast network operator may be interested in providing mobile broadcast services to their stationary access network customers. The model is similar to the pay-tv service provider led model. The broadcast network operator handles the customer relationship and all associated activities of marketing and customer care. Cable and satellite network operators providers may use the services of a third party broadcast network operator who either owns a frequency licence or uses the licence of the cable/satellite network operator. Figure 3.4.6 depicts such a business model.



For interactive services the broadcast network operator will need to enter into an agreement with the mobile network operator regarding the device technology. As an alternative, the broadcast network operator could obtain the status of a mobile virtual network operator (MVNO) or use premium SMS.

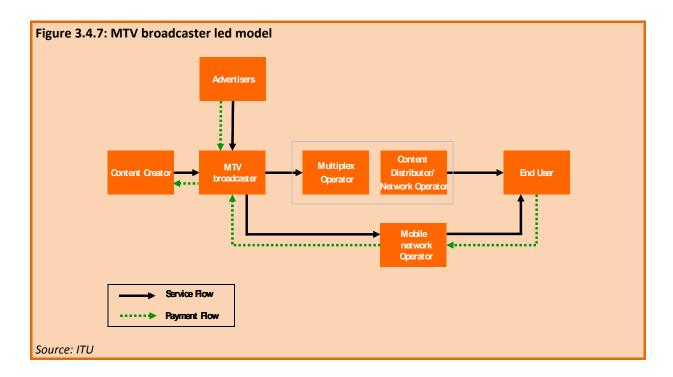
Please note that competition law may stop such a model as no single entity might be allowed to control more than one broadcast platform. Hence cable/satellite network operators may be excluded from the MTV public tender or auction.

MTV broadcaster led model

In Korea and Japan, a FTA business model for MTV services is applied. Basically this model is not different from the FTA models as applied for DTTB services. In the MTV markets of T-DMB in Korea and ISDB-T (One-Segment) in Japan, the MTV services are offered for free to the end-users. The MTV broadcasters own the (MTV) content and also directly operate their own MTV network. They directly distribute audio, video, and data (TPEG, EPG, News, Weather, etc.) to the MTV viewers through their networks.

In addition, the MTV broadcaster also provides interactive services (e.g. participation in programmes, quizzes, polls, etc.) by using the mobile telecommunication network (return path). They invoice these interactive services/data through the mobile network operator.

Mostly the MTV broadcasters are existing broadcasters that re-transmit their content in prime time over their MTV network. Also some newly produced MTV programmes (news, weather, traffic information, etc.) are broadcast too. In this FTA model, advertising income and fees for interactive/data services are the main sources of income. Figure 3.4.7 depicts this model.



Shared MTV network model

The shared network model is a horizontal business model approach. A dedicated MTV network provider (i.e. the MTV multiplex operator and content distributor/network operator) facilitates broadcasting to mobile devices and so provides shared network offers to various MTV service providers (including for example mobile network operators or pay-tv service providers).

Customers of each of the MTV service providers will have access to a package contracted by the service provider. The packages and the service offer of the various MTV service providers may differ in some parts, e.g. in bundling them with other services in different manners. The service packages might be branded differently, allowing for individualized and segment specific marketing.

The MTV service providers manage the end-relationship with customers and are responsible for service provision, marketing and customer care.

The dedicated MTV network provider will define the specifics of broadcasting and protection technologies, likely in cooperation with the MTV service providers. Hereby the MTV network provider has to take into account the special technical requirements of the MTV service providers (e.g. provision of service for connected and unconnected devices).

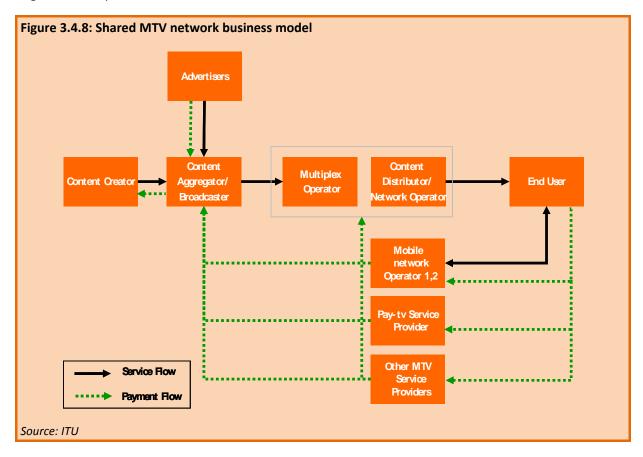


Figure 3.4.8 depicts this shared MTV network model.

While the MTV service providers would be responsible for general marketing of their competitive services, it could be possible for broadcasters to market individual television services. The billing could be carried out by one of the mobile network operator. Revenues would be shared.

Variants to the shared network model are:

- 1. the MTV network provider also purchases channels and sell this MTV services to the end-user;
- the MTV network provider establishes his own services, acquiring a broadcast licence if necessary.

3.4.3 Example business cases

Each entity in the DTTB or MTV value chain will have to draft a business case, providing financial projections (like a multi-year cash flow and profit and loss overview), key parameters (like break-even year and return on investment) and sensitivities (like the impact of the top-3 cost and revenue drivers).

The business case results will form an important basis for negotiating the role in the value chain and the mutual service contracts. It is important to note that most involved parties already have a running business. For example a mobile network operator already has the customer care and billing processes/systems in place or a broadcaster might already has the content rights and production lines in place. Also terrestrial broadcast network operators have very often the site infrastructure (partly in) already in place (e.g. towers and antennas).

Consequently, business cases for the introduction of MTV and DTTB are very often on the basis of incremental analysis (what extra costs and revenues will be generating from the DTTB/MTV service introduction). Hence, the business case for the same service might vary from entity to entity.

This section includes some example (simplified) business cases for a terrestrial broadcast network operator providing DTTB and MTV network coverage.

A terrestrial broadcaster network operator planning the roll-out of a DTTB or MTV network will have the following key cost categories:

- 1. *Head-end*: in the head-end the various programme feeds are collected (from the television studios or from satellite feeds), assembled, encoded and multiplexed onto one or more transport streams (please note that the feeds themselves are not included in the costs).
- 2. *Distribution*: the multiplexed transport streams are distributed (and monitored) to the transmitter sites in the DTTB and MTV network either through fixed wireless links, fibre or satellite links (either rented, purchase or a combination²⁷²). At each site the transport stream has to be delivered (decomposed) in the individual multiplexes.
- 3. Sites: at each site the multiplexes are fed into the transmitters. The transmitter amplifies, modulates and coverts the signal the right frequency and the combiner section combines the transmitter outputs to one antenna feed. The antenna on top of mast (or other tall construction) will emit the DTTB/MTV signal (onto various frequencies).

For either a DTTB or MTV service these cost categories exist. The key difference between both network types is really the number of sites and the transmitter sizes (i.e. ERPs). For more details see the network sections (Part 4 and 5) of these Guidelines.

For each cost category the DTTB/MTV network provider can either incur Capital Expenditure (Capex) or Operational Expenditure (Opex). These two are interchangeable. For example, rather than building a distribution network, the network provider can choose to rent such distribution capacity. The same applies to building transmitter sites.

The following three figures showing Capex and Opex figures merely function as an example and illustrate more the relative weight between different costs categories rather than absolute cost levels.

Figure 3.4.9 provides example Capex (excluding replacement investments) and Opex for a DTTB network with 19 sites (no newly built sites), with four multiplexes and with transmitter powers varying between 5 and 20 kW ERP.

-

A combined scenario might be the rental of dark fibre (just the fibre connection) and the management layer (switching and monitoring the traffic/transport streams) is carried out by the Broadcaster network operator by means of owned equipment.

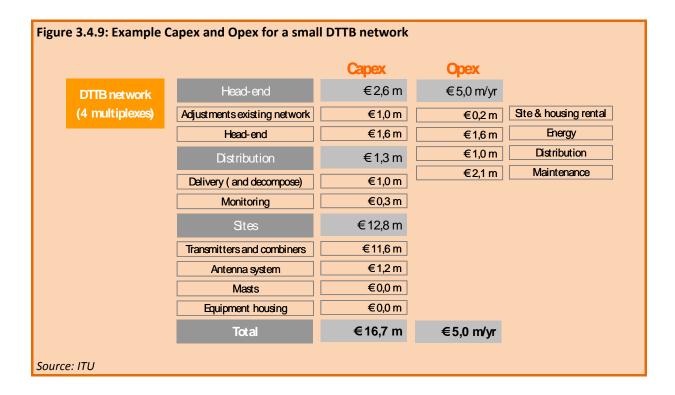


Figure 3.4.10 shows the Capex and Opex for a MTV network for one multiplex and covering the same population as for the DTTB service in Figure 3.4.9. However 39 transmitter sites were required and also some newly built sites were necessary to complete the coverage (of which 40 per cent was covered by newly built sites). Transmitter powers are mostly around the 5 kW ERP.

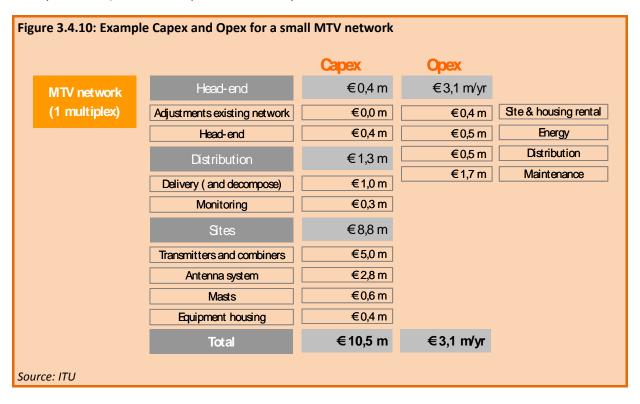
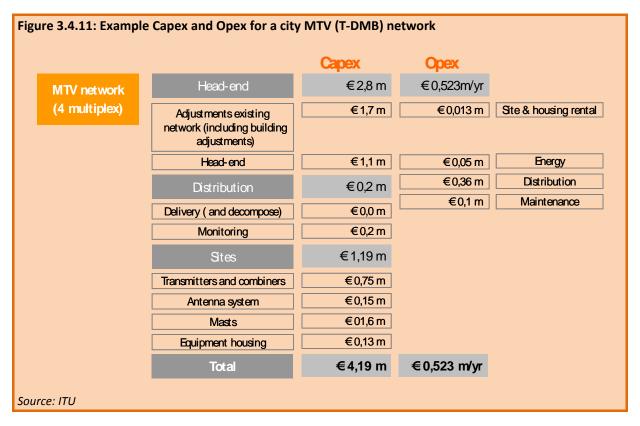


Figure 3.4.11 shows the Capex and Opex for a MTV network for four multiplexes and three transmitter sites. Two sites are high power transmitter sites (respectively 30 kW ERP and 20 kW ERP) and one smaller site of 500 W ERP. This network was used to cover a large city (244 km²). Please note that this network should not be compared with the MTV network in Figure 3.4.10 as the number of multiplexes, the covered area and the signal strength are different.



In addition to the above presented business cases, some MTV networks (like ISDB-T/OneSeg and DVB-T2 Lite) can offer MTV services without additional costs (both CAPEX and OPEX) for the DTTB network, provided no additional sites are necessary for extending the MTV coverage area. These networks incorporate MTV signals (OneSeg/Lite) with DTTB signals. The network for MTV services is built simultaneously with that for the DTTB services. Although it is an option whether to incorporate MTV services with DTTB services, all of the countries that adopted the ISDB-T standard apply this simultaneous implementation scenario.

A long experience of the hierarchical transmission system has shown that MTV reception is available in major parts of the DTTB service areas except for fringe and/or heavily shadowed areas (even though the MTV coverage is calculated to be smaller than the coverage of DTTB with rooftop antenna reception, depending on the modulation/code rate applied). Low power and hence low cost fill-ins (gap-fillers), which cover just the required/necessary places (e.g. railway stations, underground shopping arcades) within MTV unavailable areas, could be cost-effective measures.

Very often the DTTB/MTV network provider will charge a monthly charge for the DTTB/MTV network services²⁷³. Hereto the DTTB/MTV network provider has to calculate a monthly fee on the basis of:

- 1. Weighted Average Cost of Capital (WACC) or required return on investments;
- 2. contract duration and hence the depreciation time (for each network element ranging from 3 to 5 years for multiplexers and 20 to 30 years for towers);
- 3. margin on the Opex;
- 4. percentage of overhead costs.

The DTTB/MTV network operator actually sells population coverage for a fixed amount per year or month.

3.4.4 Implementation guidelines

The following guidance on business planning can be provided:

- Study and understand the implications of the regulatory framework before any business model negotiations are started. The possible DTTB/MTV business models are largely determined by the regulatory framework (see section 2.2 of these Guidelines) and the assignment procedure (see also section 2.5).
- 2. Consider and evaluate the provided factors (see section 2.4.1) for adopting a FTA business model. Although for DTTB services the FTA model seems to be the 'default' model, in some markets the pay-tv model might work too.
- 3. Keep all options open for selecting a business model for MTV services. The challenge for MTV services is to find a viable or sustainable business model. Many industry analysts have commented on the lack of a viable MTV business model and no ready-made answers are available. In any model, MTV services will require a long planning horizon and possibly synergies with other revenue streams/business lines. At the moment only strategic investors seems to comply with these requirements.
- 4. Reserve enough time for business model negotiations (or prepare in advance). Given the available regulatory room for negotiations, business model negotiations can be very lengthy. Especially for MTV markets, where many different players can be involved, the negotiations can be complex. In some countries negotiations have lasted over one year (or more). In contrast with enough regulatory pressure (i.e. very short time between MTV licensing publication and the deadline for handing in the bid), business models and contracts can be agreed in a short time.
- 5. Settle the content rights before launching any service. Also in a FTA model (subscription based) interactive services (like interactive overlays or push VoD) content rights should be carefully settled. It may be that content/rights owners might claim a share of these additional revenues. The same applies to having additional advertising space on the EPG. The commercial broadcasters on the DTTB/MTV platform may stop this or claim a revenue share.

Revenue sharing models are also possible. Under such an agreement the DTTB/MTV network provider is paid on the basis of the number of MTV/DTTB subscribers (for example a fixed amount per subscriber). As a variant on this variable model, the DTTB/MTV service provider and the DTTB/MTV network provider can agree a fixed monthly fee which is topped-up with a fee per subscriber. In such models the DTTB/MTV network provider should really have a say in the DTTB/MTV service provisioning.

- 6. Not only calculate your own business case (depending on your value chain position), but check whether the additional DTTB/MTV costs in the whole value chain can be covered by additional income. In the most favourable situation, where all involved parties can deliver their services against very low or null marginal costs, the DTTB and MTV network investments remain the major investment hurdle (for more detail see section 3.4.3).
- 7. In the case where the DTTB standard incorporates MTV signals (e.g. ISDB-T and DVB-T2 Lite) and the DTTB services are offered on the free-to-air basis, considerations specific to the MTV business models (see section 3.4.2) might not be necessary.

3.5 End-consumer support

End-consumer support is part of the DTTB/MTV service provider's customer relationship management (CRM) process comprising normally the following interrelated sub-processes:

- 1. subscription management: the process of handling and administrating subscribers' service requests, service change requests and service cancellations/subscription terminations;
- 2. order management and fulfilment: the process of collecting, scheduling and executing service and change requests generated by the subscription management process;
- 3. catalogue management: the process of administrating, introducing and changing the various DTTB/MTV service offerings, packages and tiers and pricing and discount schemes;
- 4. marketing campaign management: the process of managing periodical or one-off campaign/promotion events;
- 5. customer Service and support: the process of handling customer questions and support requests (e.g. technical problem resolving, organizing installation services, etc.);
- 6. service provisioning: the process of the actual service activation in the conditional access system (CAS) and inserting the encryption keys in the broadcast signal. In addition, service provisioning includes the smart card and receiver logistics.

In good business practice, any customer support process should be embedded in an overall designed and detailed Customer Relationship Management (CRM) business process. In the digital television industry these CRM processes can be (partly) supported in the so-called subscriber management system (SMS).

This section focuses on the key choices to be made when designing the customer/end-consumer service and support processes for mainly DTTB services and more specifically:

- 3.5.1 Customer call centre operations (as part of the CRM sub-processes of subscription management and customer service and support).
- 3.5.2 Retail shops and other channels (as part of the CRM sub-process of subscription management).
- 3.5.3 Tools to check service availability (as part of the CRM sub-process of subscription management).
- 3.5.4 Smart card and service activation (as part of the CRM sub-processes of service provisioning).

It should be noted that for MTV services with a mobile network operator led business model (see pervious section), the CRM processes are largely already in place and the functionality does not change in essence. In these situations the MTV service has to be integrated into the existing CRM processes. As indicated before a 'mediation' platform can take care of this system integration.

This section of the Guidelines is structured according to the above four key choices. This section is completed with implementation guidelines for end-consumer support.

3.5.1 Customer call centre operations

Customer call or contact centres are vital to the acquisition, retention and growth of the customers base. A badly run customer call centre can hamper the take-up of even the best quality DTTB/MTV services.

In most cases, the customer call centres carry-out the following functions in the CRM process:

- 1. Handling and administrating subscribers' service requests, service change requests and service cancellations/subscription terminations, including also activities such as:
 - placing outbound calls to check client satisfaction just after services activation;
 - b. generating and changing client profiles (e.g. address changes, service changes and service usage statistics);
 - c. placing outbound calls for selling additional services or for carrying out periodical customer satisfaction surveys.
- 2. Handling customer questions and support requests, including activities such as:
 - resolving billing issues and refunds;
 - b. service activation, picture quality and reception problems/complaints;
 - c. handling customer receiver installation requests.

When starting a new DTTB /MTV service the service provider will very often face the dilemma of outsourcing the customer call centre activities or keeping the activities in-house. The required number of staff for this function can be relatively large and hence many DTTB/MTV service providers have outsourced (partly) this function to an external outsource partner. There is no standard receipt for deciding whether this function should be outsourced or not.

When considering call centre outsourcing the following factors may play a role in the decision making process:

- 1. Financial factors: the DTTB/MTV business plan investors might require a flexible approach with low levels of financial commitment, either by having limited investments in supporting equipment/systems or (long term) personnel contracts.
- 2. Scalability factors: the forecast subscriber numbers may vary considerably and can pose a risk of not being able to handle peak customer care traffic. A scalable solution might have to be sought in a (larger) outsourcing partner. Also, the lack of qualified people or ability to quickly train (large numbers of) people might be a serious consideration.
- 3. Current assets and migration risks: the DTTB/MTV provider might already have a customer call centre in place (for other lines of business) or might have subsidiaries carrying out these activities. Integration of the DTTB/MTV call centre activities into the existing business might be an attractive option in terms of speed and investments needed. However, migration risks have to be evaluated too (especially for running the call centre business).
- 4. Service and customer insight considerations: a host of considerations fall under this category including:
 - a. DTTB/MTV network and service deployment: the network roll-out may not be completed yet and the exact timing and transmitter locations might be unknown. Also the service provider would like to test various service propositions to find out the best offering. Under such conditions the service provider might be inclined to keep the call centre activities in-house. In this way the service provider can build up customer insight quicker (at a later stage outsourcing might be easier).

- b. Complexity of the DTTB/MTV service: complex service offerings (many service tiers, varying discount schemes, many receiver types and different service outlets) might stop the service provider from outsourcing the call centre activities at the time of launching the DTTB/MTV service. However, with the availability of current SMS/CRM solutions in the market, the associated business processes can be well supported and the risk of customer dissatisfaction or churn can be minimized.
- c. Service ease of use: service providers supplying just digital converters or zapping boxes (i.e. set-top-boxes with the basic functionality) which are basically 'plug and play' receivers might tend to outsource quicker. However, the call volumes should not be under-estimated even with the simplest service. For example, it is not unusual that the most logged customer problem is the 'upside-down' insertion of the smart card in the set-top-box.

An intermediate position in this outsourcing predicament is to split the call centre functions in a first-line and a second-line call centre. The first-line call centre is then outsourced and handles the repetitive and automated tasks (like handling and administrating subscribers' service requests, service change requests and service cancellations/subscription terminations). The more complicated tasks and those activities closely related to building up customer insight can be kept in-house in the second-line call centre (for example dealing with customer questions and support requests).

3.5.2 Retail shops and other channels

In many cases the retail shops (like consumer electronics, super markets, mobile phone shops or DTTB/MTV branded shops) form the first outlet for DTTB/MTV customers to acquire the services (initial sales).

Next to the retail shops the following customer channels are also commonly applied:

- customer contact centre (see above);
- 2. Internet/website.

Retail shops (and other channels) selling DTTB/MTV services can carry out the following functions (depending on the overall CRM process design):

- 1. service demonstration and explanation;
- 2. receiver (including antenna) and smart card logistics and supply (possibly including a second smart card for a second television set);
- 3. customer and subscription registration, including identification and credit check (registration can either take place by an automated interface with CRM/SMS system or by fax).

When designing the service channels for the DTTB/MTV services, the service provider should consider the following specific aspects:

- Commissioning structure: what are the fees for the retailer to sell a receiver, subscription
 and/or deliver a smart card? Often the retailers already sell other (digital television) offerings
 and the commissioning structure should be competitive. Consequently, the commissioning
 structure is an important cost item in the business case. When a commission structure is agreed
 with the retailers, launching internet sales or sales by outbound calling of the customer contact
 centre might raise conflicts with the contracted retailers.
- 2. Product training of retailers: in 'road shows' the various retailers should be trained on the product, even when they are already familiar with selling other digital television offerings. DTTB/MTV services have some specific product characteristics (like the reception mode and in most case the lack of interactivity). Outlets could be numerous and a 'train the trainer' approach is often needed. However the needed resources and the time to run the road show shouldn't be under-estimated.

- 3. Receiver and smart card logistics: this logistic process is no different from other digital television offers and is nowadays a standardized process often supported by SMS/CRM systems. However pre-paid cards systems are not that common in the television industry. Also second (and third) smart card provisioning (for example for the 2nd television set) could increase the complexity of the logistics considerably. The retailer should be made familiar with these DTTB/MTV specific processes. Alternatively the receiver and smart card processes could be outsourced to a logistic partner.
- 4. Systems support: the contracted retailers are likely to sell other products too. Consequently the sales processes should be simple and the selected CRM/SMS system should support this. Alternatively, a fax procedure could be implemented but is receptive to errors and fraud.

3.5.3 Tools to check service availability

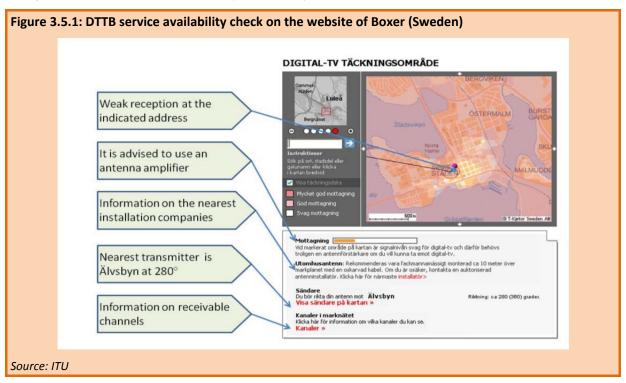
As mentioned before in this section, DTTB and MTV services have some product specific characteristics unknown with other digital television platforms, most notably the network coverage and reception quality.

Most DTTB/MTV networks do not have a (near) 100 per cent population and/or geographical coverage. Before the DTTB/MTV service is sold to a potential customer the coverage and quality of service should be verified. Moreover, DTTB/MTV networks are often rolled out in stages and frequency changes might occur, changing the network coverage profile.

The two most commonly applied methods for offering a service availability check to consumers are:

- SMS-messaging over the mobile phone network, and/or
- Internet/website.

In Figure 3.5.1 such a service availability check is depicted (Boxer in Sweden)²⁷⁴.



From the DigiTAG report 'Networks in Evolution, making changes to the digital terrestrial television platform', April 2008, available on the website www.digitag.org.

The above figure shows that after entering an address on the service provider website, the website returns the reception quality plotted on a map. In this example, reception at the entered address is weak and the viewer is advised to use an antenna amplifier. The nearest transmitter (in this case Älvsbyn at 280 degrees) is also indicated. Furthermore, information about the nearest installation companies and the channels that can be received is available by clicking on the appropriate link.

Ideally the CRM system should support this service availability check. However often this is not the case and a custom built interface is needed. It is critical that this information on service availability is kept upto-date as it directly impacts sales (it provides a sales advice) and churn (when the sales advice is wrong, selling yes when it is no). At a minimum there should be a procedure in place between the broadcast network operator (especially the network planning) and maintenance department for exchanging service availability information (including any remedies).

3.5.4 Smart card and service activation

The process of smart card handling and service activation is mainly applicable for pay-tv DTTB/MTV services²⁷⁵. Normally four ways are available to activate the smart card (activation either by the end-consumer or the retailer):

- online at the service providers website, will allow automatic request handling by the CRM system (standard functionality);
- 2. phone, possibly through an Interactive Voice Response system for automatic request handling (standard CRM functionality);
- fax, possibly used by retailers without a CRM interface (receptive to error and fraud);
- 4. email, a preformatted email will allow automatic handling by the CRM systems (standard functionality).

It is important to keep the requested information to a bare minimum to lower any service acceptance barriers. For basic subscriptions (single smart card) the following minimum information should be supplied to the Service Provider's CRM process/system:

- name (or other unique identifier) of the retailer the smart card was purchased from;
- smart card number;
- ordered services or package;
- 4. customer name and address details, including postcode and phone number;
- 5. type of decoder/receiver box the client has purchased or is using.

When the customer is accepted in the CRM system, the provided information will be 'translated' to the various service activation requests and ultimately the conditional access system (CAS) will make the service technically available to the end-consumer.

To lower the risk of credit default, reduce smart card handling/activation time (and hence customer waiting/queuing time) and serve unbanked customers, pay-tv service providers have started to offer prepaid cards, similar to the pre-paid cards offered by mobile operators. It is important to note that the business case takes such an offer into account by applying higher churn rates and lower Average Revenue per User (ARPU) at an annual basis.

Smart card systems are not only applied for pay-tv services but can also be applied for copy right protection in which the card checks whether the receiver is an authorized product (i.e. authorized products must not have unauthorized digital output streams which may be used for illegal copy).

Prepaid systems can be implemented by enabling customers to pay their monthly subscription fees with scratch cards²⁷⁶. Scratch cards can be made available from dealers, eliminating the need for customers to wait in queues to pay for their subscriptions (in countries with limited banking facilities). In order to make payments, customers will send the recharge number located on their scratch cards to a designated number of the service provider via SMS (Short Message Service). Various cards can be made available for different service packages.

A typical DTTB offering or other digital television offering is to make a second smart card available (for the second television set) to a single subscriber for a reduced price or without an extra charge. It is expected that the relevance of such a service will become more evident when the analogue terrestrial television service will be switched off (ASO). Viewers can no longer rely on the analogue platform to supply the second or third television set with a television signal. When offering second smart cards there is a higher fraud risk.

There is a possibility that the subscriber may try to purchase many cards, and sell most of them to other people at a price which is lower than the regular price (for the first TV set), but higher than the price that the subscriber has paid for them. This may cause substantial losses to the DTTB/MTV service provider.

The measures to limit the risk of fraud on a DTTB network may include 277:

- 1. limiting the number of additional smart cards (to 2 or 3);
- differentiating the service offerings between the first and the second smart card. For example
 the second card does not include the premium channels. However, customer acceptance should
 be checked (because the second smart card is issued really to resolve the second-set-in-thehome problem);
- charging a slightly lower fee for the second smart card (also check customer acceptance);
- 4. linking the smart card to the set-top-box identification number (i.e. implementing a sort of 'SIM lock' to the set-top-box²⁷⁸). When there is no match the DTTB service will not work. However this might be a problematic solution when the service provider also has to broadcast free-to-air channels (the public broadcaster or regulator might not accept such a solution).

Finally, smart card hacking is a widely discussed issue in the pay-tv industry. CAS providers have the primary task to resolve and prevent hacking. Track records are crucial for these CAS providers and when purchasing a CAS these track records should be thoroughly reviewed. It should be noted that in many reported cases the hacking was only of a temporary nature. Changing the encryption keys will normally resolve many of the hacking problems. More serious are those reports of incidents where the service provider had to swap the installed smart cards. This is a critical and expensive operation and may result in high churn rates.

DSTV has adopted the scratch card approach in most African countries where they operate their pay-tv business.

Please note that with digital cable networks (in which each individual subscriber is served by an addressable delivery path), fraud can be limited by linking the smartcard numbers to the delivery address of the subscriber.

^{&#}x27;SIM locks' are common practice in the mobile industry. SIM-locked handset will stop subscribers taking their subsidized handset to another provider (before a defined period).

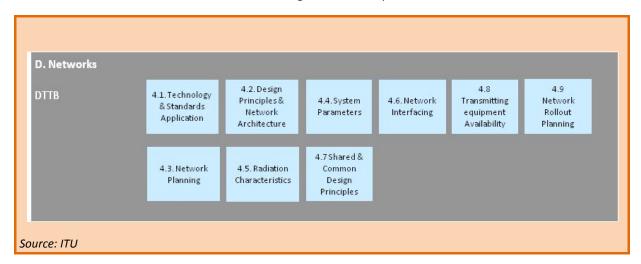
3.5.5 Implementation guidelines

The following guidance can be provided for end-consumer support:

- Design the overall CRM process first and embed the end-consumer support as a sub-process in it. Many process design methods/tools are available for carrying out such a task (often the CRM/CAS suppliers have tools available). A none-integrated CRM process can lead to many customer care problems like:
 - a. selling services that do not exist or are not supported;
 - b. pricing services wrongly (e.g. not applying tariffs or discounts incorrectly);
 - c. losing customer sales records and loss of revenue.
- 2. Design a coherent set of critical performance indicators, when outsourcing customer care activities to an outsourcing partner. Not only indictors for call handling costs and volumes but also indicators to monitor the quality of customer care services (e.g. registration of the subscription duration/churn, levels of customer complaints, etc.). Especially for outbound call activities (for example when acquiring new clients or carrying out up-sale activities) the service providers should take special care. Practice has shown that aggressive sales techniques may be applied. Sales figures might go up (temporarily) but churn levels too. Please note that with subsidized/rented set-top-boxes, churn costs per customer can be very high (including the cost of returning boxes, loss of boxes and checking/cleaning of boxes).
- 3. Only issue a second smart card in those cases where customer/market research has found such a provision to be crucial for the further take-up of the DTTB service. As mentioned in this section, the provision of a second or third smart card is to resolve the 'second-set-in-the-home' problem. In some developing countries this might be less of an issue as television set penetration is relatively low.

Part 4 – DTTB networks

Part 4 (DTTB networks) covers functional building blocks 4.1 to 4.9 of layer D of the functional framework described in section 1.2. These functional building blocks are depicted below.



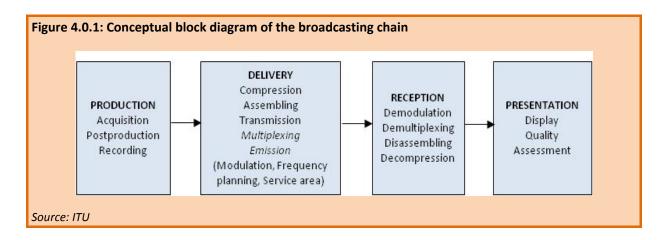
The guidelines on key topics and choices of each of the functional building blocks 4.1 to 4.9 are addressed in the subsequent sections of Part 4.

Choices regarding the above mentioned functional building blocks should be made in such a way that the licence conditions are fulfilled and that the business objectives are met. In doing so, optimum solutions should be found between often conflicting requirements regarding picture and sound quality, coverage quality and transmission costs. Many of the issues regarding technology choices, frequency planning and network planning are also be relevant to regulators, depending on the roles and responsibilities of regulator and network operator in a country.

MTV networks are covered in Part 5. However, because of the similarity of the issues, guidelines regarding functional building blocks 5.3 (Network planning), 5.5 (Radiation characteristics) and 5.7 (Shared and common design principles), are described in the corresponding sections in Part 4.

For assistance in understanding the scope of this section, a conceptual block diagram of the broadcasting chain²⁷⁹ is illustrated below in the Figure 4.0.1. The figure includes four main conceptual blocks, namely the production block, the delivery block, the reception block and the presentation block.

See Report ITU-R BT.2140 Transition from analogue to digital terrestrial broadcasting; Part 1, section 1.8, The digital broadcasting chain.



Part 4 of these Guidelines is mainly related to the Delivery block, but the impact on the other conceptual blocks of the broadcast chain is indicated.

4.1 Technology and standards

Section 4.1 provides background information and guidelines on key topics and choices regarding the selection of DTTB transmission standards and associated systems. The section consists of six sections each containing a subsection with implementation guidelines:

- 4.1.1 Technical tests to evaluate system performance.
- 4.1.2 SDTV and HDTV specifications.
- 4.1.3 Selection of DTTB transmission standard.
- 4.1.4 Compression system.
- 4.1.5 Encryption system.
- 4.1.6 Additional services.

More detailed information on some of the key topics and choices is given in:

Annex A: GE06 implementation.

Annex C: More information on some DTTB network topics.

Determining the TV presentation formats is a step that precedes the actual selection of a transmission standard and system. TV presentation formats, Standard Definition TV (SDTV) and High Definition TV (HDTV) are independent of the transmission standard and are established as part of the programme production process. However, the choices on the presentation format have an impact on the broadcast delivery process. But also choices in the delivery process are of great importance for the presentation of the picture to the viewer.

HDTV services provide viewers with a significantly enhanced television experience. HDTV services are attracting considerable attention worldwide and are becoming the norm for television viewing.

Worldwide, five DTTB standards²⁸⁰ are in use. The systems related to compression and encryption are, in principle, independent of the transmission standard. However, a number of systems for additional services are standard dependent.

 $^{^{\}rm 280}$ See Recommendations ITU-R BT. 1306 and ITU-R BT.1877.

The choice of the TV presentation format (SDTV, HDTV), transmission standard, compression system, conditional access system and systems for additional services should be made within the framework of relevant legislation and regulations and market and business development decisions. In addition, policies and regulations regarding the analogue switch-off (ASO) process can affect the actual choice.

4.1.1 Technical tests to evaluate system performance

The choice of transmission standard should be made on the basis of policy decisions (see Section 2.1) and theoretical studies, taking into account the agreed Digital-Switch-Over (DSO) objectives. Technical tests may also be carried out in the choice of transmission standard to compare or verify system performances.

Once a transmission standard has been selected, it is useful to check if suppliers can deliver equipment able to provide the signals with which the DSO objectives can be met. It may also be useful to set up test transmissions in order e.g.:

- to demonstrate DTTB services to familiarize key persons in government and market parties with DTTB;
- to test acceptance of DTTB services by consumers;
- to educate technical staff.

Furthermore test transmissions are often carried out in order assess video and sound quality, to verify the technical performance of the network and to demonstrate DTTB services before launching the operational services. These tests are described in Section 4.9.1. It should be noted that technical tests are costly and time consuming with regard to preparations, performing test and analysing results²⁸¹.

Implementation guidelines

Technical tests may be carried out in several stages of the DTTB implementation process. In the policy development phase, as part of the transmission standard selection, it is useful to check if suppliers can deliver equipment able to provide the signals with which the DSO objectives can be met. In the planning phase test transmissions are often carried out in order to verify the technical performance of the network (see section 4.9.1).

In addition to technical tests, DTTB demonstrations could be organised for e.g.:

- education of technical staff;
- familiarize key persons in government and market parties with DTTB;
- testing acceptance of DTTB services by consumers.

4.1.2 SDTV and HDTV specifications

Currently TV transmissions in most countries are still in the Standard Definition (SDTV), 625 lines/50 Hz and 525 lines/60 Hz with 4:3 or 16:9 picture format.

Television screens able to display HDTV are present in many living rooms even if only SDTV programmes are delivered. In many countries DTTB programmes are already HD-produced and broadcasted and many broadcasters are preparing themselves for HDTV broadcasts. It is to be expected that, in the near future, all TV programmes will be in HD quality and that a large number of HDTV programmes will need to be provided on the terrestrial platform in order to make it attractive for the viewers.

Report ITU-R BT.2035 provides detailed guidelines and techniques for the evaluation of digital terrestrial television broadcasting systems.

The choice of the video bit rate for SDTV and HDTV services is a trade-off between picture quality and multiplex capacity. In order to obtain a good picture quality the following aspects are of importance:

- flat screen displays are more sensitive to artefacts and require a higher bit rate for a high quality
 pictures than Cathode Ray Tubes (CRT), mainly because of larger screen size and higher
 resolution of the displays;
- compression system (MPEG-2 or MPEG-4) and encoder quality (see Section 4.1.4);
- use of statistical multiplexing (see Section 4.2.5);
- viewers demands are likely to be higher if comparisons are made with digital satellite or cable transmission (which often have a higher bitrate per programme than that of DTTB transmissions) or Blue ray disks, rather than to a noisy analogue picture.

The multiplex capacity should be sufficient to carry the required number of services with the required bit rate and depends on:

- the transmission system (see Section 4.1.3);
- modulation, code rate and guard interval (see section 4.4);
- number of services (including sound and data) that need to be transmitted in the multiplex.

Implementation quidelines

The choice of the video bit rate for SDTV and HDTV services is a trade-off between picture quality and multiplex capacity. The trade-off can only be made after multiplex composition (see Section 4.2.5) and network planning (see section 4.3) have been considered. As guidance Table 4.1.1 gives typical bit rates to achieve acceptable picture quality ²⁸². Quality requirements may differ, to some extent, from country to country depending on the viewer's sensitivity and preference regarding picture quality.

Table 4.1.1: Typical video bit rates for flat screen displays

Format	Compression	
	MPEG-2	MPEG-4
SDTV	≈ 3 Mbit/s	≈ 2 Mbit/s
HDTV	≈ 14 Mbit/s	≈ 8 Mbit/s

Regarding the sound quality the following guidance can be given:

Table 4.1.2: Typical audio bit rates

Format	Compression	
	MPEG-1 layerII	AAC
Stereo signal	0.192 Mbit/s	0.096 Mbit/s
Multi-channel signal	0.5 to 1 Mbit/s	0.320 Mbit/s

Video bit rates regarding MPEG-4 and MPEG-2-SDTV have been derived from Annex A of EBU Technical Report 015, Defining Spectrum Requirements of Broadcasting in the UHF Band. Geneva, July 2012. The video bit rate for MPEG-2-HDTV originates from Japan.

Furthermore it should be taken into account that:

- Once the multiplex composition has been decided and the services are on air, picture quality can only be improved by:
 - increasing bit rate at the cost of deleting other services in the multiplex or use of a higher order modulation, higher code rate or smaller guard interval at the cost of reduced coverage (see section 4.4);
 - adopting a more efficient compression system or transmission standard requiring replacement of all set-top boxes and integrated digital TV receivers;
 - replacement of encoders by more efficient ones, provided that the technology currently in use is not mature (see also Section 4.1.4).
- Consumers tend to purchase large flat screens, resulting in a relative small viewing distance through which artefacts in the picture become more visible. Consequently picture quality requirements will increase.

4.1.3 Selection of DTTB transmission standard

Table 4.1.3 gives an overview of the five DTTB standards in use worldwide.

Standard Modulation Recommendation **Applicable standards** ATSC Single carrier ITU-R BT.1306 System A; annex 1, table 1a A/52,A/53, A/65, A/153 8-VSB DVB-T Multi carrier ITU-R BT.1306 System B; annex 1, table 1b ETSI EN 300 744 OFDM ISDB-T Multi carrier ITU-R BT.1306 System C; annex 1, table 1c ARIB STD-B31 segmented OFDM **ABNT NBR 15601** DTMB Combination of single ITU-R BT.1306 System D; annex 1, table 1d GB 20600-2006 carrier and multi carrier **OFDM** DVB-T2 Multi carrier ITU-R BT.1877; annex 1, table 1 ETSI EN 302 755 OFDM

Table 4.1.3: Transmission standards overview

In ITU-R, the systems covered by Recommendation BT.1306 are also referred to as first generation systems, and the systems covered by Recommendation BT.1877 as second generation systems. The second generation of digital terrestrial television broadcasting transmission systems is meant as systems offering higher bit rate capacity per Hz and better power efficiency in comparison to the systems described in Recommendation ITU-R BT.1306, and there is no general requirement for backward compatibility with first-generation systems²⁸³.

Selection guidelines for ATSC (systems A), DVB-T (system B), ISDB-T (system C) and DTMB (system D) are described in Recommendation ITU-R BT.1306. The guidelines for initial selection from this Recommendation has been reproduced in Table 4.1.4.

-

²⁸³ Recommendation ITU-R BT.1877 footnote 1

Table 4.1.4: Guidelines for initial selection of transmission standard, reproduced from Recommendation ITU-R BT.1306

Requirements		Suitable systems
Maximum data rate in a Gaussian channel for a given C/N	Required	A or D
threshold	Not required	A, B, C or D
Maximum ruggedness against multipath interference ⁽¹⁾	Required	B, C or D
	Not required	A, B, C or D
Single frequency networks (SFNs)	Required	B, C or D
	Not required	A, B, C or D
Mobile reception ^{(1), (2)}	Required	B, C or D
	Not required	A, B, C or D
Simultaneous transmission of different quality levels	Of primary importance	С
(hierarchical transmission)	Required	B or C
	Not required	A, B, C or D
Independent decoding of data sub-blocks (for example, to	Required	С
facilitate sound broadcasting)	Not required	A, B, C or D
Maximum coverage from central transmitter at a given power in	Required	A or D
a Gaussian environment ⁽³⁾	Not required	A, B, C or D
Maximum ruggedness against	Required	A, C or D
impulse interference ⁽⁴⁾	Not required	A, B, C or D

⁽¹⁾ Tradable against bandwidth efficiency and other system parameters.

In addition to the selection criteria indicated above, the following aspects should also be considered when selecting a transmission standard.

- National, multilateral and international agreements:
 - the selected system should comply with the provisions of the national frequency plan, including the national channelling arrangements;
 - in countries where the GE06 Agreement applies, the selected system should comply with the provisions of the GE06 Agreement (see also Annex A);
 - multilateral agreements may include provisions regarding the transmission systems.
- Planning and compatibility criteria:
 - Recommendations ITU-R BT.1368 and BT.2033 contain protection ratios and minimum field strength values for the five DTTB systems. Table 4.1.5 shows the transmission standards for which planning and compatibility criteria are currently available in ITU recommendations.
 - Recommendation ITU-R M.1767 provides protection criteria for land mobile systems interfered with by DVB-T.
 - In countries where the GE06 Agreement applies, the planning criteria of the GE06 Agreement (see Annex A) should be used for international coordination.
 - In case planning and compatibility criteria are not complete in a given situation, the missing criteria may be taken from other sources or be derived from the above mentioned ITU documentation and implemented in the network planning software.

⁽²⁾ It may not be possible to provide HDTV reception in this mode.

⁽³⁾ For all systems in situations with coverage holes, gap-filler transmitters will be required.

⁽⁴⁾ System B and C in 8k mode are applied for this comparison.

Table 4.1.5: Protection criteria overview

DTTB transmission	Planning criteria	Protection of analogue TV
ATSC 6 MHz	ITU-R BT.1368, annex 1	M/NTSC and B/PAL
DVB-T 7 and 8 MHz	ITU-R BT.1368, annex 2	B, D, D1, G, H, I, K/PAL and B, D, K, L/SECAM
ISDB-T 6 and 8 MHz	ITU-R BT.1368, annex 3	M/NTSC, I, G/PAL
DTMB 8 MHz	ITU-R BT.1368, annex 4	D/PAL and D/SECAM
DVB-T2 6, 7 and 8 MHz	ITU-R BT.2033, annex 1	-

Implementation guidelines

For selecting a DTTB transmission standard the following guidance can be given on the basis of technical and frequency management considerations and taking into account receiver availability and receiver prices:

- Select a DTTB standard which meets the DSO objectives, complies with national, multilateral
 and international agreements, as well as spectrum compatibility as indicated in Tables 4.1.4 and
 4.1.5 respectively;
- Do not select multiple standards for the same application in a country in order to avoid inefficient use of spectrum and end-consumer confusion;
- Investigate receiver availability and prices (see also Section 3.3). Each of the five standards described in Recommendations ITU-R BT.1306 and ITU-R BT.1877 has provided its market large enough for manufacturers supplying a variety of receivers from low-price STB to high-end IDTV.

The South African Sadiba recommendation²⁸⁴ is an example of a national standard selection.

4.1.4 Compression system

Currently the key choice for a compression system is between MPEG-2 and MPEG-4. It is expected that an even more efficient compression systems (HEVC) will be standardised. New compression systems are not backwards compatible with existing systems, but receivers with the improved system could receive the old system as well.

MPEG-4 coding is also referred to as MPEG-AVC, MPEG-4 part 10 and ITU-T H.264. The MPEG-4 coding efficiency is at least 1.5 times that of MPEG-2. It should be noted that for the application of MPEG-4 licence fees may apply²⁸⁵.

Recommendations on a South African standard for Digital Terrestrial Television (DTT), minimum receiver functionality and acceptable quality of service.

²⁸⁵ See MPEG LA AVC licencing – <u>www.mpegla.com/main/programs/AVC/Pages/Intro.aspx</u>

Implementation guidelines

Selecting a compression system is basically a trade-off between:

- multiplex capacity;
- receiver availability and costs;
- transition problems if MPEG-2 receivers are already in the market.

MPEG-4 is advantageous if DTTB is newly introduced (i.e. no existing MPEG-2 services).

4.1.5 Encryption system

Encryption is, in general, applied to provide a conditional access for viewers that are entitled to receive the service and to prevent unauthorized use. The condition for access could be payment or citizenship of a country in the case where programme rights are geographically limited. In most cases, access is obtained by a smart card. When a viewer fulfils the access conditions (i.e. possesses the right smartcard and has paid for the services) an authorization signal is transmitted and accepted by the card and the viewer has access to the services.

Encryption of TV signals is a normal practice with many satellite broadcasting services. Also in a number of countries, part of the DTTB package is encrypted and access is provided if a subscription has been paid. It should be noted that as a consequence of encrypting a DTTB signal, also a Subscriber Management System (SMS) should be operated. This SMS manages the billing process and provides authorizations.

Several conditional access systems (CAS) are on the market, mainly developed for satellite broadcasting but also applicable to DTTB.

The choice for a conditional access system is a trade-off between costs of the system and security (the expected or reported chances of hacking the system).

Implementation guidelines

When selecting a conditional access system (CAS) it is important to ensure that:

- more than one system can be incorporated (multicrypt) in case different CAS systems are in use or expected in a country;
- receiver manufacturers implement the CAS in the receiver or set-top box,
 - either embedded, the cheaper but less flexible option;
 - or, by means of a common interface (CI)²⁸⁶, a more expensive solution which makes the receiver independent of the service provider²⁸⁷ and more flexible²⁸⁸.

An enhanced common interface "CI Plus" has been developed by a number of manufactures in order to provide improved copy protection functionality. CI Plus is expected to become the de facto norm in all television receivers (source: DigiTAG).

²⁸⁷ In order to promote interoperability, a government could mandate CI functionality in receivers, e.g., in the EU CI in Integrated Digital TV (IDTV) set is obligatory. However it is in the interest of service providers that consumers do not easily switch from one provider to another.

²⁸⁸ A Common interface can have other functions using other types of modules such as web browser or interactive TV.

4.1.6 Additional applications and features

In addition to the television signal (consisting of a video and one or more audio channels), a variety of other services may be implemented either in connection with the television service or independent of it. Such services could include:

- radio services;
- service information (SI), the SI is generated in the head-end and contains information on current and future programmes;
- electronic programme guide (EPG), receiver generated EPGs based on the SI are the simple solution requiring only limited bit rate;
- dedicated EPG produced by a service provider, giving the EPG the look and feel of the service provider, but requiring an extra bit stream and an adequate Application Programme Interface (API) in the receiver;
- system software update (SSU), providing over-the-air software downloads for upgrading and fixing receivers ²⁸⁹;
- data services of programme independent and programme related types. Examples of the
 former type are teletext, headline news and weather and traffic information. Examples of the
 latter type are subtitling for impaired viewers, players' profile and ranking in sports programmes
 and many more;
- access services for vision or hearing impaired viewers, Table 4.1.6 gives examples with a number of options^{290 291 292};
- emergency warning services to convey information about an on-coming natural disaster to audiences. These services have assumed vital importance in the last few years. However, payload capacity is only required when the actual warning is broadcast.

Table 4.1.6: Examples of access services

Access service	Delivery	Bitrate examples
Subtitles	DVB teletext DVB subtitling *)	>38 kbit/s ≤ 10 kbit/s
Spoken subtitles	DVB premixed extra audio channel DVB receiver mixed audio *)	>64 kbit/s 64 kbit/s
Audio description	Premixed Receiver mixed *) Other means (e.g. AM radio, Internet radio)	192 kbit/s 64 kbit/s
Signing	Incorporated in programme	-

^{*)} recommended by EBU

²⁸⁹ DigiTAG report DVB-SSU, implementing system software updates on the terrestrial platform (2007).

²⁹⁰ EBU Report – TECH 3316. Monitoring of Access Services, Requirements, Developments and Recommendations, Geneva, February 2006.

²⁹¹ EBU Report I44-2004, Access Services, June 2004.

²⁹² Many of such services have been developed in Japan.

Implementation guidelines

Capacity needed for additional services can in practice range from 4 per cent to 20 per cent of the multiplex capacity. DTTB multiplex capacity is limited; therefore the choice for additional services is guided by:

- lowest bit rate option;
- optimization of data updating intervals for each service;
- no unnecessary duplication of data (e.g. avoiding the same teletext with more than one TV service).

4.2 Design principles and network architecture

Section 4.2 provides background information and guidelines on key topics and choices regarding design principles and network architecture of DTTB networks. The section consists of seven sections each containing a subsection with implementation guidelines:

- 4.2.1 Trade-off between network roll-out speed, network costs and network quality.
- 4.2.2 Main reception mode and defining receiving installations.
- 4.2.3 Services for national, regional, or local coverage.
- 4.2.4 Frequency plan and network topology.
- 4.2.5 Head-end configuration.
- 4.2.6 System redundancy requirements.
- 4.2.7 Type of distribution network.

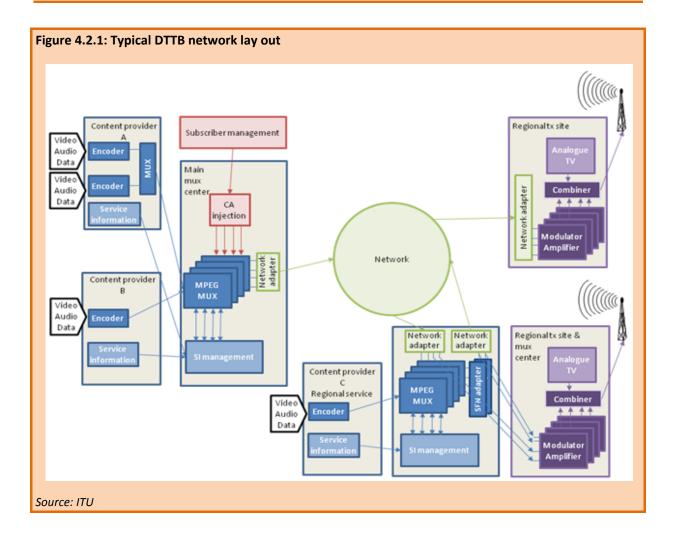
More detailed information on some of the key topics and choices is given in:

Annex A: GE06 implementation.

Annex C: More information on some DTTB network topics.

Development of a broadcast infrastructure with new technologies is a challenging and complex matter. It is essential that technical staff understands not only the main principles regarding network architecture and network planning, but also the impact of technical choices on the business plan and regulations. In addition to the documents referred to in these guidelines, training sessions and seminars will help in educating staff. In case of limited human resources, external experts may be contracted to assist staff, to perform a number of tasks or to advise the management.

A DTTB network consists basically of one or more head-ends, a distribution network and transmitter sites. A block diagram of a typical DTTB network is shown in Figure 4.2.1.



Roll-out speed of the network, network costs and network quality are interrelated and a trade-off needs to be made depending on the requirements in the business plan or licence conditions.

The head-end is the part of the network where the incoming video and audio signals from the studio are compressed (using MPEG-2 or MPEG-4). The compressed signals, together with the accompanying data signals (programme related or independent), are multiplexed into a single stream. The format of the stream differs per system and is defined in the system specifications. ATSC, DVB-T and DTMB use MPEG-TS, ISDB-T uses B-TS and DVB-T2 T2-MI. The network adapter is also system dependent. For instance with ISDB-T the stream can be fed directly to transmitters and with DVB-T2 a device called "T2 gateway" is needed.

The single data stream from the multiplexer is distributed to the transmitting sites via the distribution network. It is also possible to distribute two or more independent streams to the transmitters and apply hierarchical modulation (see section 4.4). For instance one stream can be modulated to obtain a high payload intended for fixed (rooftop) HDTV reception, another stream can be modulated for more robust reception conditions intended for portable or mobile reception. The realisation differs per system. For example, in the ISDB-T system the B-TS stream contains all information necessary for hierarchical transmission and the DVB-T2 system allows the use of Multiple Physical Layer Pipe (MPLP) technology to provide service specific robustness.

If regional or local services are required, normally these services are coded at a regional site and by means of re-multiplexing added to the data stream (MPEG-TS, B-TS or T2-MI) for the particular regional or local area (see Figure 4.2.1). DVB-T2 permits replacement of an incoming PLP by a locally generated PLP. However, depending on costs of distributions links (among other factors), other solutions may be adopted.

At a transmitting site, each data stream (MPEG-TS, B-TS or T2-MI) is modulated in a transmitter to provide the specified signal with an appropriate system variant (e.g. modulation 64-QAM, code rate 2/3, guard interval ratio 1/32 in the case of multi-carrier systems) and converted to the required transmission channel. The RF signals of all or a number of transmitters at a site are usually combined into one antenna (depending on the antenna sharing conditions). Sometimes, e.g. in case of services with different coverage requirements, more than one antenna, each having a different radiation pattern, is used.

The frequencies to be used should comply with the national spectrum plan or international agreements regional plan (such as GE06 Agreement; see Annex A) and compatibility with analogue television services (nationally and in neighbouring countries) should be ensured. In order to protect analogue TV services during the transition from analogue to digital television, it may be necessary to operate digital TV services with restricted power or to use temporary frequencies. Also for practical reasons (e.g. not sufficient room in transmitter housing or mast or mechanical limitations of the mast) it may be necessary to operate digital TV temporarily with restrictions. However it should be noted that such temporally operations may increase risks in DTTB roll out.

The kind of receiving installation has a great impact on design principles and network architecture and also network planning. If DTTB coverage with rooftop antennas is required, use of existing sites and frequencies in the same part of the frequency band as for analogue TV is an advantage, because existing receiving antennas (subject to being in good condition) can be used.

If DTTB coverage with simple receiving antennas at low height is required (e.g. indoor, outdoor and mobile reception) high transmitter powers will be needed. Depending on the situation the transmitter power requirements may exceed practical or regulatory limits and power distribution network (to cover the service area with multiple transmitter sites instead of a high power transmitter site) may be needed. Two kinds of network configuration (and combinations of the two) are possible:

- 1. Multi frequency network (MFN), consisting of a number of high or medium power transmitters with a number of fill-in transmitters, each on a different frequency.
- 2. Single frequency network (SFN), consisting of a number of high or medium power transmitters with a number of fill-in transmitters, each on the same frequency.

The activities regarding design principles and network architecture result in a document describing network principles. These principles take into account the technology choices (see section 4.1) and conditions described in the licence (see Part 2), the business plan as well as service proposition (see Part 3).

4.2.1 Trade-off between network roll-out speed, network costs and network quality

Roll-out speed, networks costs and network quality (expressed in coverage probability, signal availability and number of multiplexes) are interrelated and an optimal balance should be chosen.

Many factors could be relevant in the trade-off between roll-out speed, costs and network quality depending on local circumstances; some are indicated in Table 4.2.1.

Table 4.2.1: Elements in trade-off between roll-out speed, costs and network quality

Note and all account	l	Generally positive (Y), negative (N) or more or less neutral (O) contribution		
Network element	Impact	High roll out speed	Low network costs	High network quality
Use of existing sites	Sites available at limited costs, possibly restrictions to new services	Y	Y	O/N
Use of additional new sites	Extra costs, acquisition time	N	N	Υ
Rooftop reception	Relative low powers	0	Υ	O/N
Portable reception	Relative high powers, higher number of transmitters	O/N	N	Υ
Regional/local services	Extra multiplexer(s)	O/N	N	Υ
Sufficient human resources	If not, external staff for project planning, supervision and installation	Y	N	O/Y
Equipment redundancy	Extra costs, less services interruptions	0	N	Y
Fill-in transmitters	Extra cost, better coverage	N	N	Y
High coverage probability	Relative high power, better coverage	0	N	Υ
Temporal transmitting facilities during transition	Better coverage	N	N	Υ

The balance in this trade-off could be different for various roll-out phases and various areas (e.g. main population centres and rural areas).

Experience in many countries has shown that good coverage is of major importance. In areas where coverage is marginal, service take-up is low and competitive offers (like IPTV, cable TV or satellite TV) obtain an advantage.

Implementation guidelines

The optimal balance in the trade-off between network roll-out speed, networks costs and network quality depends to a great extent on the local situation. Network elements contributing to the trade-off are summarised in Table 4.2.2.

Table 4.2.2: Network elements contributing to the trade-off between network roll-out speed, networks costs and network quality

High roll-out speed	Low network costs	High network quality
Use of existing sites	Use of existing sites	Use of additional new sites
Well-designed deployment plan	Sharing of transmitting facilities	Portable/mobile reception
 Technical supports/aids for end- 	Rooftop reception	Regional/local services
users		Equipment redundancy
 Sufficient human resources 		Fill-in transmitters
 Frequency use in accordance with 		High coverage probability
national frequency plan		Temporary transmitting facilities
		during transition if necessary

In making the trade-off the following points need to be taken into consideration:

- network quality is of major importance; if network quality is poor at the start of DTTB introduction, service take up will be low and it may take a long time before potential consumers have confidence in the service;
- communication to the public on the roll-out phases of the project and the areas with good quality reception (the more precise the better) is essential. Also help and advice on purchasing and installing receiving equipment is very important (see also section 4.9).

4.2.2 Main reception mode and defining receiving installations

Receiving installations consist of a receiver (set top box or integrated digital TV set), antenna cable and antenna. The receiver should be equipped to receive the current transmission standard, de-compression system and (if needed) conditional access system.

Three reception modes²⁹³ are generally assumed:

- fixed reception;
- portable reception (indoor and outdoor);
- mobile reception.

For planning a DTTB service with any of these reception modes it is important to take into account that received field strength will vary depending upon the placement of the receiving antenna in its local environment. Field-strength variations can be divided into macro-scale and micro-scale variations²⁹⁴. The macro-scale variations relate to areas with linear dimensions of 10 m to 100 m or more and are mainly caused by shadowing and by multipath reflections from distant objects. The micro-scale variations relate to areas with dimensions of the order of a wavelength and are mainly caused by multipath reflections from the ground and nearby objects creating standing waves resulting in rapid field strength variations.

In principle the receiving antenna should be located at a spot with high amplitude in the standing wave pattern (micro-scale variations) for all the frequencies to be received.

Macro-scale variations of the field strength are important for coverage assessment. When the required signal strength of analogue television is decreased below the required value, the picture is still visible but becomes gradually noisier. For that reason it is common practice to plan analogue TV services with a location probability of 50 per cent. However, a characteristic of digital television is the rapid failure rate when the carrier to noise ratio and carrier to interference ratio drop below the required values. To ensure good DTTB coverage quality, a high percentage of receiving locations (macro-scale variations) should obtain satisfactory reception.

This is achieved through the addition of a margin to the minimum field strength. The margin is known as the location correction factor (C_L) , and is given by the relationship:

$$C_L = \mu \times \sigma$$

Where:

 μ normal distribution factor, being 0.00 for 50%, 0.52 for 70%, 1.28 for 90%, 1.64 for 95%, or 2.33 for 99% of locations; and

 σ standard deviation, which is taken as 5.5 dB for outdoor reception.

Examples of definitions for reception mode are given in the GE06 Agreement, Chapter 1 to Annex 2, articles 1.3.11 (fixed reception), 1.3.12 (portable reception) and 1.3.13 (mobile reception).

²⁹⁴ See Final Report of RRC-04, Chapter 3, Section 3.4.3.

In planning a broadcasting service it is therefore necessary to specify the percentage of locations in a small area (typically 500 by 500 m) where reception is possible with a certain receiving installation²⁹⁵. All "small areas" where the required percentage of coverage is reached form the coverage area.

The minimum median field strength values (Emed), that is the minimum field strength plus the location correction factor (C_L), for fixed and portable reception given in the GE06 Agreement²⁹⁶ are based on a location probability of 95 per cent²⁹⁷. The criterion of 95 per cent location probability is generally supported by broadcasters and is also applied in many countries.

With 95 per cent location probability, in general good reception can be obtained. Location percentage less than 90 per cent may well lead to complaints, in particular when more than one channel needs to be received. For portable reception, location probabilities as low as 70 per cent are sometimes used as a basis for coverage assessment, as coverage areas of portable reception are not necessarily required to be the same as those of fixed reception.

In some countries different location availability percentages are applied for rural, suburban and urban environments. For instance a location probability of 95 per cent is considered necessary at the limit of the urban environment because there is little opportunity to optimise the location of the receiving antenna. At the limit of the suburban environment a location probability of 90 per cent is applied, this recognises that suburban rooftops offer limited possibilities for antenna placement.

In case the required field strength at a receiving location is not sufficient for good reception, a number of measures can be taken to improve reception. Measures to improve reception include:

- more elevated receiving location;
- locating antenna at an optimal receiving position (e.g. escaping from shadowing objects, adjusting antenna direction to reduce interference, location at the maximum of the local microscale variations pattern);
- antenna amplifier with fixed reception and with portable reception²⁹⁸;
- antenna with higher gain and better directivity than assumed in the definitions quoted above²⁹⁹.

The required minimum median field strength values for mobile, portable, in particular indoor reception is much higher than for fixed reception because of:

- lower receiving height;
- lower receiving antenna gain and lack of antenna directivity and polarisation discrimination;
- building penetration loss in case of indoor reception;
- higher carrier to noise ratio and protection ratio due to the type of transmission channel;
- higher location correction factor in case of mobile reception.

²⁹⁵ An example of definition of coverage area is given in article 1.2.2 of Chapter 1 to Annex 2 of the GE06 Agreement.

²⁹⁶ Emed values at 200 MHz and 500 MHz for all DVB-T variants are given in GE06 Agreement, table A.3.2.-2 of Appendix 3.2 of Chapter 3 to Annex 2.

See GE06 Agreement Chapter 3 to Annex 2, Section 3.2.1.4 and Section 3.2.2.4 relating to fixed and portable reception respectively.

²⁹⁸ Portable antennas with an integrated antenna amplifier are sometime referred to as "active antenna".

Values used for receiving antenna gain and cable loss In the GE06 Agreement are given in Chapter 3 to Annex 2, Section 3.2.1.2 and 3.2.1.3 for fixed reception and Section 3.2.2.3 for portable reception.

In planning mobile and portable reception the receiving antenna height is taken as 1.5 m, while for fixed reception a receiving height of 10 m is taken. At a given location the field strength from a transmitter is lower at 1.5 m than at 10 m. The average difference, the height loss, depends on the local environment (Recommendation ITU-R P.1546 gives height loss estimation for various conditions) and various values are used. For example, in the GE06 Agreement 16 dB to 18 dB has been specified at 500 MHz and 800 MHz respectively and in Japan field measurements conducted in many places showed the value of 12 dB at 550 MHz.

In planning fixed reception a directional receiving antenna is assumed with a standard pattern as given in Recommendation ITU-R BT.419. Also the polarisation discrimination, if applicable, is given in BT.419. The receiving antenna gain minus cable loss is generally taken as 5 dB in VHF and 7 dB in UHF. For mobile and portable reception a simple antenna and a short cable is assumed; antenna gain minus cable loss is generally taken as -2 dB in VHF and 0 dB in UHF. No antenna directivity and polarisation discrimination is assumed in planning for mobile and portable reception.

In case of indoor reception building penetration loss should be taken into account. This parameter has a major impact in determining location variation of the field-strength within buildings. Building penetration loss is the difference between the median values of field strength measurements on an area outside one building and inside the building, on the same level above ground, in the vicinity of the relevant building walls (where the power is penetrating the building). The building penetration loss depends very much on the building material and the reception location inside the building. For DTTB planning it is generally assumed that indoor reception takes place at ground floor in a room with a window. Building penetration loss is often given by a mean value and a standard deviation (Recommendation ITU-R P.1812 gives the values for several frequencies). Various values are used, e.g. in the GE06 Agreement mean value and standard deviation in VHF are 9 dB and 3 dB respectively and in UHF 8 dB and 5.5 dB. The total standard deviation for indoor reception is the combination of the outdoor field strength standard deviation and the building penetration standard deviation. For that reason the location correction (C_L) for indoor reception is higher than for outdoor reception.

For planning fixed reception a Ricean transmission channel is assumed and for planning mobile and portable reception a Rayleigh transmission channel (see Section 4.4.2) resulting in a slightly higher (about 2 dB) carrier to noise ratio and protection ratio for mobile and portable reception compared to fixed reception.

For planning of mobile (vehicular) reception normally a location probability of 99 per cent is taken, resulting in a higher locations correction factor (C_L) for mobile reception compared to fixed and portable outdoor reception.

Taking into account the above mentioned factors, the difference of the minimum median field strength values (Emed) for portable and fixed reception using the same system variant as fixed reception is shown in Table 4.2.3. If for portable or mobile reception a more robust system variant is used, the difference is reduced.

Table 4.2.3: Difference of required signal strength requirements for portable and fixed reception	Table 4.2.3: Difference of re	equired signal stre	ngth requirements for	portable and fixed reception
---	-------------------------------	---------------------	-----------------------	------------------------------

Band	Emed difference portable indoor- fixed reception	Emed difference portable outdoor - fixed reception
III	30 dB (power factor: 1000)	21 dB (power factor: 125)
IV/V	34 – 36 dB (power factor: 2500 – 4000)	23 – 25 dB (power factor: 200 – 300)

Note: In the case where receiving antenna height loss and building penetration loss are those specified in the GE06 Agreement.

Because of the high field strength requirements, portable reception over large areas can, in practice, be achieved only by means of power distribution network. Two network configurations (and combinations of the two) are possible:

- 1. Multi frequency network (MFN), consisting of a number of high or medium power transmitters with a number of fill-in transmitters, each on a different frequency.
- 2. Single frequency network (SFN), consisting of a number of high or medium power transmitters with a number of fill-in transmitters, each on the same frequency.

In many cases it is not a requirement to cover a large area with portable reception and portable indoor reception of main population centres is sufficient. In these cases it is common practice to design a network in such a way that the main population centres have portable indoor coverage and the rural areas surrounding the main cities only fixed reception.

In cases where the net bit rate of the portable or mobile services could be lower than for the service with fixed reception, hierarchical modulation could be used. For example in the ISDB-T system, the required field strength of the OneSeg, containing the services for portable or mobile reception with a robust system variant, is considerably lower (e.g. -14 dB) than that for Full Segment containing the services for fixed reception with a high payload. In particular in situations where height loss or building penetration loss are less than assumed in Table 4.2.3 the coverage of OneSeg portable and mobile reception could be very close to that of fixed reception.

Implementation guidelines

For selecting the reception mode the following guidance can be given:

- Public broadcasting services often have a universal coverage obligation and require nearly full coverage. In practice, in most countries, the universal coverage obligation is related to fixed reception.
- In situations where fixed analogue TV reception is common practice, fixed DTTB reception is facilitated if the existing receiving antennas can be used, provided that:
 - analogue TV and DTTB signals arrive from the same direction, hence same sites should be used for analogue TV and DTTB;
 - analogue TV and DTTB channels are in the same band (Band III, IV and V), preferably spaced only a few channels, and have the same polarization (horizontal or vertical);
- In situations where (almost) no rooftop antennas are present, i.e. indoor reception is widely
 used for analogue TV, installing rooftop antennas may form an obstacle for accepting DTTB
 services. Indoor portable reception, at least for main population centres should then be the aim.
- In situations where DTTB has to compete with wired services such as cable TV or IPTV, portable reception gives an important advantage.
- A list of receiver specifications should be made. Such a list should include:
 - transmission system;
 - compression system;
 - conditional access system;
 - frequency band(s) to be used;
 - mains voltage and frequency;
 - RF characteristics (sensitivity and selectivity should be such that minimum field strength, cochannel and adjacent channel protection ratios as listed in Recommendation ITU-R BT.1368 and ITU-R BT.2033 are obtained).

- To benefit from low receiver prices, base line specifications of large markets 300,301,302 should preferably be adopted. Also for specifications that are beyond the baseline specifications, such as conditional access systems, larger volumes and lower receiver prices can be obtained by adopting additional specifications of large markets or common specifications with neighbouring countries.
- Agreements should be made with receiver manufacturers to ensure that adequate types of receivers are available in sufficient quantities and in time.

Furthermore it is important to take into account that:

- Practice in some countries has shown that even in cases where analogue TV and DTTB are
 operating in the same band, many receiving antennas may need to be replaced. After having
 withstood many storms and rains receiving antennas have deteriorated. The antenna condition
 could be still acceptable for a noisy analogue TV picture, but DTTB may shows block distortion
 or a black screen.
- Communication to the public is essential regarding the receiving installations to be used and help and advice on purchasing, installing or replacing of receiving equipment (see also Section 4.9.3).

4.2.3 Services for national, regional, or local coverage

The wanted service area for a multiplex of services needs to be clearly defined. In general, services could be destined for national coverage, regional or local coverage. If a service contains partly national and regional or local programmes, even for a short time (e.g. local news or advertising), the whole multiplex should be considered as regional or local because part of the service-package needs to be re-multiplexed in order to insert the regional or local service.

The next step is to determine where encoders and (re-)multiplexers will be located. In the example of Figure 4.2.1, encoders and re-multiplexers are placed together. At a central point the national services are multiplexed. A regional service is fed to one of the sites forming a regional network and re-multiplexed at that site. Other solutions are possible e.g. feeding all services (including regional ones) to a central multiplexing centre and distributing the data stream (MPEG-TS, B-TS or T2-MI) of all multiplexes to each site, where the appropriate stream will be selected and broadcasted.

An example of receiver specifications is the 'E-Book'. E-book is the colloquial name given to the IEC standard 62216 for Digital Terrestrial receivers for the DVB-T system. This standard defines the basic requirements for every DTT receiver in Europe today. Other examples are A74–ATSC Receiver Performance Guidelines and IEC 62360 Baseline specifications of satellite and terrestrial receivers for ISDB (Integrated Service Digital Broadcasting)

Specifications for "notional receiving system: used for planning – reference ACMA DTTB Planning Handbook – www.acma.gov.au/

Minimum HDTV receiver requirements of EBU Member broadcasting organizations and discussed in detail with DIGITALEUROPE (the European electronic consumer equipment manufacturers) are presented in EBU document TECH 3333 EBU HDTV Receiver Requirements; User Requirements. Geneva, March 2009.

Operational aspects regarding multiplex location are summarized in Table 4.2.4.

Table 4.2.4: Operational aspects regarding multiplex location

Operational aspect	Multiplex location
Lower equipment costs	Centralised
Easier maintenance and service	Centralised
Lower cost for gathering signals from regional studios	Regionalised
Lower cost for signal distribution (limited number of data stream (MPEG-TS, B-TS or T2-MI) to be distributed)	Regionalised
Network robustness (limited number of effected transmitters in case of failure)	Regionalised

The division in national, regional and local service areas and the geographical size of the areas is also important for the planning of single frequency networks (SFN) (see Section 4.3.2).

Implementation guidelines

Service areas for national, regional and local services need to be clearly defined. A high number of regional or local areas leads to extra costs regarding re-multiplex centres or links. The number of regions should be limited from the viewpoint of cost; however from the viewpoint of service acceptability this may not be acceptable.

The choice of re-multiplex locations depends on operational considerations, costs of multiplex equipment and the costs of links. These factors may differ considerably from country to country or part of the country.

In general the location of encoders and (re-) multiplexer is close to a studio play-out centre in order to obtain relative short distances for the signals.

4.2.4 Frequency plan and network topology

The aim of a frequency plan is to provide access to the spectrum to current and planned services in an efficient manner and to avoid unacceptable interference.

A frequency plan related to the transition from analogue to digital television plans deals with three stages in both the VHF and UHF broadcasting bands:

- the existing analogue TV plan (ATV);
- a frequency plan during the transition period, when analogue TV services require protection from DTTB transmissions or when DTTB services accept interference from analogue TV transmissions;
- 3. a frequency plan after analogue switch-off, when only DTTB exits.

During the transition period the analogue TV needs to be protected. This means that the analogue coverage areas are not to be reduced due to interference from digital TV transmissions. Depending on the number of analogue TV stations in operation, this requirement may limit the number of channels that can be used for digital TV and may also limit the radiated powers of digital transmissions.

The plan should also contain other existing or planned stations that should be taken into account, e.g. digital radio and non-broadcasting services.

Table 4.2.5 gives an example of the planning situations; TV applications are printed in bold.

In this example DTTB is introduced in UHF. After analogue switch-off digital radio is introduced in VHF and Mobile services (IMT) in part of the UHF band. In both VHF and UHF also other non-broadcasting services are allocated that need to be taken into account in DTTB planning.

Table 4.2.5: Example of planning situations

Stages	VHF plan	UHF plan
Existing	ATV Non-Broadcasting services	ATV Non-Broadcasting services
During transition	ATV Non-Broadcasting services	 ATV DTTB replacing ATV Additional DTTB Non-Broadcasting services
After ASO	Digital radio Non-Broadcasting services	 DTTB replacing ATV Additional DTTB Mobile services (IMT) Non-Broadcasting services

In order to avoid unacceptable interference the frequency plans in each band and in each stage should be compatible, not only between the TV stations but also with other services.

Analysing the coverage and compatibility in the various stages is a complex task³⁰³ requiring:

- accurate field strength prediction models;
- high resolution data bases for terrain elevation and morphology;
- accurate transmitter databases for the stages under consideration, including transmitters in neighbouring countries;
- complete set of planning parameters for the transmission systems and services involved;
- adequate planning procedures;
- calculation times of acceptable duration.

Several commercial software packages are available for executing this task.

In planning the location of DTTB transmission facilities within many countries, the existing pointing of the analogue TV receiving antennas has been taken into account toward minimizing impact on the television viewers in their transition to digital. The most effective planning takes into account antennas which correspond to those already in use for analogue TV services and the directional alignment of these receiving antennas. Co-location of transmitters to provide both analogue and digital TV services in an area will mean that consumers can use a single receiving antenna for analogue and digital reception during the transition.

Also for reasons of economy for the network provider, analogue TV sites are in general also used for DTTB. However, additional stations may be needed in cases where:

- the analogue TV network does not cover the complete wanted coverage area;
- portable or mobile reception is an important requirement and:
 - because of the high required field strength and regulatory or practical power limitations power distribution network, using SFNs, is advantageous;
 - some of the existing sites, planned for rooftop reception, are situated too far from population centres.

 $^{^{303}}$ See also Report ITU-R BT.2137

On the contrary, experience has shown that, for DTTB, fewer fill-in transmitters are needed than for analogue TV.

Within many countries the regulations which are placed on the licensing of television services restricts the exposure of the general public to electromagnetic radiation (EMR) from transmitters to a level below recognised exposure limits. Increasingly network operators are being required to demonstrate that EMR from TV transmitters does not expose the general public above recognised exposure limits. In some cases existing sites cannot be used or need to reduce the radiated power. For that reason new or additional sites need to be found.

In the countries where the GE06 Agreement applies, the technical characteristics of DTTB and analogue TV stations should comply with the provisions of the GE06 Agreement (see Annex A). Annex A also gives useful information to the countries outside the GE06 Agreement. Readers should read the terms specific to the Agreement as appropriately.

Implementation guidelines

The national spectrum plan established through domestic and international negotiations is the basis for DTTB and MTV frequency plan. In the countries where the GE06 Agreement applies, the entries in the digital plan annexed to the GE06 Agreement are the basis for the DTTB frequency plan (as well as the MTV frequency plan). However, until analogue switch-off, DTTB services may be severely restricted. If the DTTB frequency is in use at the same or nearby site for analogue TV, DTTB services are not possible until after analogue switch-off.

If compatibility problems exist with analogue fill-in stations, a frequency change of some analogue fill-in stations could alleviate the compatibility problem considerably (see Section 2.14.2, example in Japan).

Channels can be selected from Band III and Band IV/V. For instance in the GE06 plans at least eight DTTB national coverages are available and, in general, one DTTB coverage in Band III (in additional to a number of T-DAB coverages) in most countries. When Band III is used for DTTB it should be taken into account that a mixture of Band III and Band IV/V channels will be transmitted with the consequence of:

- need for Band III and Band IV/V transmitting and receiving antennas;
- use of 7 MHz channel bandwidth in Band III (in most countries in Region 1) and 8 MHz channel bandwidth in Band IV/V, has consequent need for re-multiplexing the Band III services. (In countries using a 6 MHz channel raster such re-multiplexing is not needed because of the same channel bandwidth regardless of Band III and Band IV/V).

Table 4.2.6 gives guidance on the band choice.

In Band III and Band IV/V, frequencies with least compatibility problems have preference. Furthermore in selecting frequencies for DTTB stations the following considerations should be taken into account:

- mixed use of Band III and Band IV/V in a service area should be avoided as possible;
- preferably the same frequency should be used before and after ASO, in order to avoid frequency changes;
- any coordination with neighbouring countries should be completed before installation of a station, because the international negotiations may result in power restrictions or a later date of putting the station into operation;
- preferably DTTB frequencies should not be spaced too far from analogue TV frequencies at the same site, in principle an existing rooftop antenna could then be used;
- all multiplexes should have similar coverage as long as their type of service is identical, in other
 words public broadcasting, commercial broadcasting (free-to-air) and pay-tv may have different
 coverages;
- communication to consumers about frequency changes, digital coverage and receiving installation for digital services is essential.

Table 4.2.6: Band selection

Condition	Band choice	Reason
 Fixed reception and 8 MHz channel raster in Band III Installed base of Band III receiving antennas 	Band III, where available ^{a)}	 Less power needed compared to Band IV/V
Fixed reception and 7 MHz channel raster in Band III Installed base of Band III receiving antennas 12.5 per cent reduced multiplex capacity acceptable compared to 8 MHz Band IV/V channels Band III channels available at all sites fed by the data stream b)	Band III ^{a)}	Less power needed compared to Band IV/V
Fixed reception and • 6 MHz channel raster in Band III • Installed base of Band III receiving antennas	Band III	 Less power needed compared to Band IV/V
Fixed reception in other cases	Band IV/V	 Limited Band III capacity (in case 7MHz channel raster) No need to install Band III receiving antennas Less interference probability due to abnormal propagation conditions (fading)
Portable reception	Band III	 Less power needed compared to Band IV/V Less propagation losses owing to diffraction effect in urban areas Higher man-made noise levels compared to Band IV/V Combined Band III/IV/V portable receiving antenna shows relative poor performance in Band III
Portable reception	Band IV/V	 Lower man-made noise levels compared to Band III Easier installation of fill-in transmitters with smaller transmission antennas

taking into account protection of analogue TV services and T-DAB and T-DMB requirements

in principle it possible to feed transmitters with 7 MHz and 8 MHz channels by one data stream, however care must be taken that the net bit rate of the system variant used in the transmitters 7 MHz and 8 MHz channels is higher than the data stream bitrate; inefficient spectrum use in the transmitters with 8 MHz channels may occur due to unused capacity.

4.2.5 Head- end configuration

The multiplex centre consists generally of interfaces, encoders, (statistical) multiplexer, monitoring and control equipment, and ancillary equipment. In order to achieve a flexible network, a router is installed that can connect each television signal to each encoder input.

In case of SFNs the configuration of the multiplex centre depends on the transmission system. For instance in the case of DVB-T, the multiplex centre contains equipment for the proper operation of SFNs such as:

- SFN adaptor for injecting a time stamp to allow for different transport delays in the distribution network (e.g. in the case of switching links in telecommunication circuits)³⁰⁴;
- external clock for synchronization, e.g. by means of GPS;
- network Time Protocol (NTP) server to control timing of all transmitters and the multiplexer;
- uninterruptible Power Supply (UPS) to ensure that critical parts of the installation operate continually e.g. GPS equipment.

In the case of ISDB-T, no special equipment is required in the multiplex centre because:

- B-TS data stream is fed directly to transmitters, and each transmitter timing (delay adjustment for SFN operation) is set to the prescribed value, providing that the relative delays in distribution network are kept constant or within prescribed variations (e.g. less than 10 s).
- when the delay variations are anticipated to exceed the prescribed value, similar equipment to that for DVB-T may be needed.

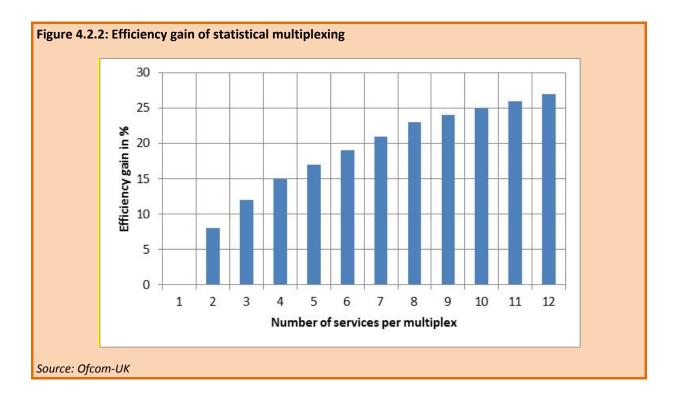
In case of DVB-T2, the T2 gateway inserts the signalling package that contains synchronisation information for SFNs.

Statistical multiplexing is widely used in situations where a number of services are multiplexed. In a statistical multiplexer the bit rate is dynamically allocated to different services depending on the programme content. Compared to a constant bit rate per service, it can provide higher picture quality of each service on average. Instead of a higher picture quality, it could also be decided to maintain the original quality by reducing the average bit rate of the services and increase the number of services in the multiplex. In adjusting the statistical multiplexer care must be taken that the minimum quality level is maintained.

Statistical multiplexing is more efficient with a high number of services and different kind of content per service. Figure 4.2.2 shows the efficiency gain as function of the number of services³⁰⁵.

More information on the SFN adaptor is given in ETSI TR 101 190 Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission; Section 8.5 The Megaframe Solution.

³⁰⁵ See Review of DTT HD Capacity Issues. An Independent Report from ZetaCast Ltd, commissioned by Ofcom, by Ken McCann, 31 October 2007.



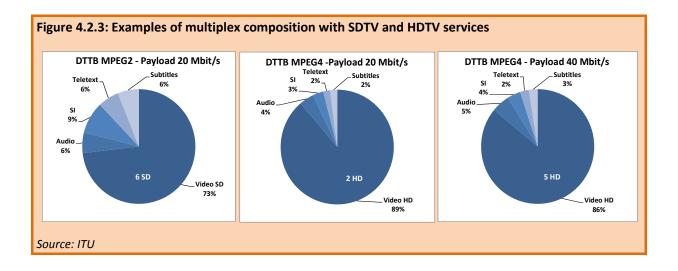
The Ofcom report indicates that "Statistically multiplexing a mix of HDTV and SDTV content is also possible, but this is likely to give significantly less benefit, as a demand peak on the HDTV channel will require several SDTV channels to reduce bit-rate to compensate. A particular case to avoid is multiplexing an HD and an SD version of the same programme on a single multiplex, as the peaks of demand will coincide."

Because of the interaction between encoder and multiplexer in statistical multiplexing, normally both need to be located close to each other and controlled by the same computer. However, some manufactures offer encoders that can be located in separate locations to the multiplexer.

Regionally inserted programmes cannot be statistically multiplexed because the bit rate must be reallocated not only to the signal to be inserted but also to all other signals included in the transport stream delivered from master multiplex centre. So the concept of deterministic multiplexing is employed to facilitate local insertion at regional levels.

The multiplex composition depends on the number of services to be multiplexed and the bit rate requirements, whereas the maximum capacity is given by the system variant of the transmitters. Figure 4.2.3 shows examples of multiplex compositions with SDTV and HDTV services in a DTTB payload of 20 Mbit/s with MPEG-2 and MPEG-4 compression and in a payload of 40 Mbit/s with MPEG-4 compression. In these examples the following bit rates are taken into account:

- video bit rates per service shown in Table 4.1.1 with the statistical multiplex gain of Figure 4.2.2. The average bitrates were increased until the multiplex was fully loaded;
- audio bit rates per service shown in Table 4.1.2, with additional multi-channel audio in case of HDTV;
- service Information (SI) of 0.3 Mbit/s per service;
- teletext or interactive services of 0.2 Mbit/s per service;
- subtitles of 0.2 Mbit/s per service.



Implementation guidelines

In specifying the bit stream of a multiplex, care should be taken of the following:

- the bit rate of the multiplex should be lower than the bit rate of DTTB system variant for which the transmitters have been adjusted in order to avoid overflow;
- in applying statistic multiplexing, the minimum bit rate that is guaranteed to a programme should be defined to keep the quality at a certain level as the subjective picture quality is often determined by the worst sequence rather than the best one;
- a network identifier (one per country and/or operator) should be obtained at the national or international organization (such as DVB project office) in order not to apply a duplicated identifier;
- a receiver generated Electronic Programme Guide (EPG), based on the requires only limited bit rate and hence limited functions, while that based on one of data streams can offer dedicated function. A receiver-independent EPG produced by a service provider gives the EPG its own look and feel, but requires a considerable bit stream and an adequate Application Programme Interface (API) in the receiver.

4.2.6 System redundancy requirements

The terms and obligations about service interruption, recovery hours from equipment failure, minimum coverage in case of failure, reporting on interruptions or failure, etc. are, in general, defined by national regulations. The requirements could be differentiated, taking into account e.g.:

- population affected by failure;
- type of station (e.g. high power transmitter or fill-in transmitter);
- type of service (e.g. free-to air, pay-tv);
- part of the day.

In addition to the above regulations, service contracts between content distributors and service providers could contain more detailed provisions about the availability of the service.

Service availability or non-availability could be expressed for instance as a percentage of time (measured over a long period) that the service should be on air or a maximum time of interruptions.

The service availability regulations and provisions are the basis for the system redundancy requirements that the content distributor will use in designing the DTTB network architecture and the equipment specifications.

In order to avoid long service interruptions in the case of maintenance or equipment failure, critical parts in the transmission chain should have a certain redundancy. Depending on the system redundancy requirements, the redundancy could range from use of parallel units in operational equipment to a complete back-up system.

In case of failure in a parallel unit in operational equipment, the transmission will continue albeit at reduced performance. For example, the power amplification part of a TV transmitter usually consists of a number of parallel amplifiers. If one fails the output signal is still present but at lower power. A back-up system could consist of a complete back-up transmitter for each operational transmitter or one back-up transmitter for a number of operational transmitters. In the latter case the back-up configurations is called "n+1". Combinations of redundancy configurations are also seen in practice, for instance a power amplification unit consisting of a number of parallel amplifiers together with a back-up driver unit.

As with analogue TV transmissions, transmitting antennas are often split in two or more parts. Each part is fed by a separate cable. In case of failure or maintenance one part of the antenna can be switched off while the station is still operational, but at reduced radiated power³⁰⁶.

Usually a distribution ring is made in order to feed each transmitting site from two sides. In this way it may not be necessary to have back-up link equipment at each site. However it depends on the regulation applied to the transmitter station whether such operation is permitted or not.

In addition to appropriate back-up equipment, an adequate equipment monitoring system is needed to identify equipment failures and alert maintenance staff. Operational status of equipment should be visible at a central monitoring centre through a few basic indicators (e.g. on/off, failure, pre-alarm). The Simple Network Management Protocol (SNMP) is a suitable remote control protocol by means of a web browser.

In SFNs synchronisation in transmitter timing has been identified as the most important issue for the correct operation³⁰⁷, monitoring of transmitter synchronisation is therefore important.

Implementation guidelines

First of all, equipment in multiplex centre, distribution networks and transmitter sites must have redundancy conforming to the national regulations.

If several transmitters are used at a site, an n+1 redundancy configuration is often used. If a site accommodates one or two transmitters, it may be appropriate to install instead a double driver unit. The RF power amplifier consists, in general, of several units, thus providing a built-in redundancy. It should be noted that also essential ancillary equipment (e.g. receivers of distribution link, pumps for cooling if used) should have adequate back-up.

Monitoring of transmitters is indispensable for proper operation. Equipment and communication links used for monitoring are of primary importance and therefore, preferably, they should have full redundancy configuration.

In the multiplex centres, encoders and multiplexers have often full or n+1 back-up configurations at least.

Synchronisation in SFN transmitter timing has been identified as the most important issue for the correct operation of an SFN. If correct synchronization is lost, transmitters in an SFN interfere with each other; all elements in relation to synchronisation should therefore be equipped in full redundancy configuration.

lt should be noted that regulations to prevent radiation hazards may restrict maintenance in an antenna that is (partly) in operation. See also Report ITU-R BT.2140, part 1, section 4.5.

Practical information on SFN operation and monitoring is given in EBU document EBU BPN 075 Single Frequency Network Maintenance, March 2007.

4.2.7 Type of distribution network

There are several ways to distribute the multiplex signals from the head-end to the transmitters³⁰⁸. In general the data stream (MPEG-TS, B-TS or T2-MI) is distributed to the transmitter sites and to regional re-multiplexing centres in the case of regional services (see also Figure 4.2.1). Alternatively, the data stream (MPEG-TS, B-TS or T2-MI) can be modulated at the head-end and distributed to the transmitters via analogue links.

In MFNs it is even possible to use off-air reception, e.g. as a back-up link. In SFNs this is only possibly in case of low power fill-in transmitters because the transmitter timing of the downstream transmitter is, in many cases, required to be advanced to the off-air reception signal (so-called artificial delay; see Section 4.3.2). Such relatively advanced timing can only be achieved by using distribution links (other than off-air reception) and giving appropriate delay to the received signal. The transmitters cannot apply demodulation and re-modulation processes because the signal delay exceeds by far the guard interval. However fill-in transmitters with off-air reception in SFN are an attractive solution (see Section 4.3.3).

In the case of off-air reception two kinds of noise should be taken into account:

- 1. Noise related to signal reception, such as receiver noise, atmospheric noise, unwanted radio waves (interference), etc.
- 2. Unnecessary components emitted by the upstream transmitter, such as third harmonic distortions due to non-linearity of power amplifiers³⁰⁹.

It should be noted that the former noise can be measured and expressed in Carrier to Noise (C/N) of the received signal, while the latter cannot because there is no way to extract only the distortion components from received signals. The noise component included in the signal of a transmitter is estimated by summing up the reception noise, unnecessary components both emitted by the upstream transmitter and generated by the transmitter under consideration. This noise estimation is important in network design especially when off-air reception is applied in tandem. Annex C, Section C4 gives information about the signal to noise ratio of OFDM transmitters.

For distribution of the data stream (MPEG-TS, B-TS or T2-MI) the choice is between microwave links, optical fibre and satellite links, using technologies like Plesiochronous Digital Hierarchy (PDH), Synchronous Digital Hierarchy (SDH) networks or Asynchronous Transfer Mode (ATM). Also IP and Direct-to Home (DTH) satellite links (see Annex F) are used for distribution. The choice depends on the local telecommunication infrastructure, operational and technical considerations and costs.

Table 4.2.7 shows the main features of these means of distribution.

DVB Type of link Description specification PDH PDH was designed for digitized signals based on 64 kbit/s. The interface at ETS 300 813 34.368 Mbit/s is suitable for the data stream. Fixed wireless SDH SDH is a newer alternative to PDH using a simplified multiplexing and de-ETS 300 814 multiplexing technique and offering improved network management Optical fibre capabilities (exclusive use)

Table 4.2.7: Distribution links for DTTB signals

More detailed information on distribution links are given in Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects (ETSI TR 101 190); Section 7.

³⁰⁹ For details see Report ITU-R BT.2209.

Type of link	Description	DVB specification
ATM	ATM ³¹⁰ uses a cell-based multiplexing technique and may be carried over different kinds of transport networks including PDH and SDH. Five different ATM Adaptation Layers (AALs) have been specified for adapting different types of signal to ATM networks. AAL1 or AAL5 may be used for the transmission of a data stream; the main difference is that AAL1 specifies error detection and correction techniques, whereas AAL5 does not.	As for PHD or SDH
Satellite DVB-S(2)	The data stream can be distributed by satellite using the DVB-S(2) standard. However, re-multiplexing will be required at each transmitter site to change the SI data to reflect the change of delivery medium.	EN 300 421

The timing of the distribution link has to be controlled to ensure that it does not induce jitter in MPEG decoders and to ensure stable synchronization of the multiplexers and the transmitter modulators. In the case using satellite or telecommunication networks, delay variations in the link must be adequately managed in order for SFN to operate properly. Satellite links require appropriate counter measures against signal interruption due to Sun transit and heavy rain attenuation. Some considerations on satellite links are given in Annex C Section C1. In the case of ATM networks, measures are required against packet loss and delay variations that might be caused by network congestion, network route switching, etc.

The output data streams of MPEG encoders are not identical even when fed by the same video signals, because the output stream of encoders is not only changed with the input video signals but also is affected by initial conditions of the encoder. Multiplexers also exhibit similar characteristics. It is essential in SFN operation to provide exactly the same signal (not only the same contents) to be emitted from all of the transmitters, and hence, encoding and multiplexing at each transmitter site should be avoided in SFN.

Implementation guidelines

The use of digital technology in distribution links (as well as contribution links) will maintain the quality of services throughout the broadcast chain and make efficient use of transport capacity. It also avoids cascading coding and decoding processes³¹¹ and use can be made of telecommunication networks. Dedicated broadcast links may not be necessary.

Use of off-air reception offers the lowest installation cost, but it can be applied in limited cases, such as MFN or low power fill-in transmitters in SFN. The signal to noise ratio should be carefully analysed to maintain the quality of signal to be emitted.

Use of a satellite is an attractive way to distribute the signals over a large area. The relative delay fluctuations between transmitter sites are negligible and therefore have no effects on SFN operation in the case where all transmitter sites receive signals via the same satellite. However, an automatic delay control mechanism is required in the case where some transmitter sites receive signals via satellite and the other sites use the terrestrial links (see Annex C, Section C1).

Use of telecommunication networks may bring about problems of packet loss, packet jitter or delay variations depending on the services offered by telecommunication operator. Use of leased lines (exclusively used for DTTB signal distribution) is advised especially for SFN operation.

Guidelines for the handling of Asynchronous Transfer Mode (ATM) signals in DVB systems are given in TR 100 815 Digital Video Broadcasting (DVB).

Advantages and constraints of various transmission systems are analysed in EBU document Tech 3291, Primary distribution of TV signals using MPEG-2 technologies, chapter 2 deals with DTTB and chapter 3 with network requirements.

4.3 Network planning

Section 4.3 provides background information and guidelines on key topics and choices regarding network planning for DTTB as well as MTV. The section consists of five sections each containing a subsection with implementation guidelines:

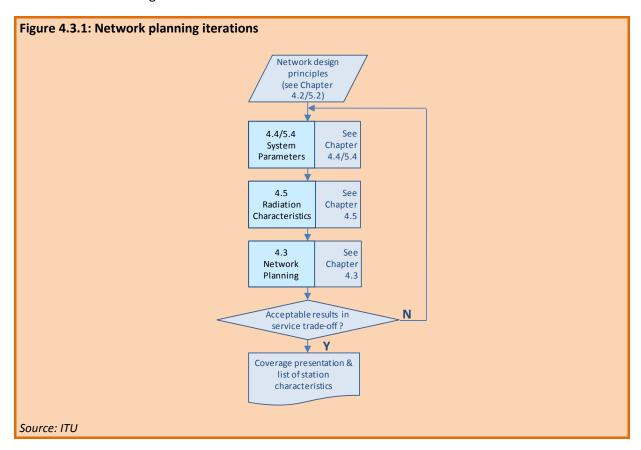
- 4.3.1 Service trade-off.
- 4.3.2 SFN or MFN.
- 4.3.3 Fill-in transmitters.
- 4.3.4 Feed back to business plan and service proposition.

More detailed information on some of the key topics and choices is given in:

Annex A: GE06 implementation.

Annex C: More information on some DTTB network topics.

Network planning is an iterative process between the functions described in this section and the functions described in section 4.4 or 5.4 (System parameters regarding DTTB or MTV respectively) and section 4.5 (Radiation characteristics), with the aim to achieve optimal coverage, multiplex capacity and radiation characteristics within the limits given by the licence conditions and business plan. A flowchart of the activities is shown in Figure 4.3.1.



After establishment of design principles, system parameters are defined and radiation characteristics specified, followed by network planning (as described in this section).

Depending on the stage of preparations for DTTB or MTV introduction and the data that are available, these functions could be done with lesser or greater accuracy. Normally more detailed assessments are made in the project planning phase than in the preparatory phase (before the licence has been granted).

It is likely that several iterations need to be done before an optimal balance in the service trade-off between transmission costs, service quality and coverage quality (see Section 4.3.1) has been achieved.

The results of network planning are coverage presentations and the lists of characteristics of each station. A coverage presentation shows coverage probability (in the presence of noise and interference) in the wanted service area, the number of people or household obtaining the required coverage quality, the system variant and bit rate of the multiplex.

A large part of the network costs is related to the number of sites and investments in transmitters and antennas. It is therefore important to carefully investigate the station characteristics and optimize coverage. With network planning, coverage problems can be identified at an early stage and solutions can be sought before the network is implemented. Furthermore, network planning can be an efficient tool for consumer marketing.

Once DTTB or MTV services have been introduced further developments will likely take place in:

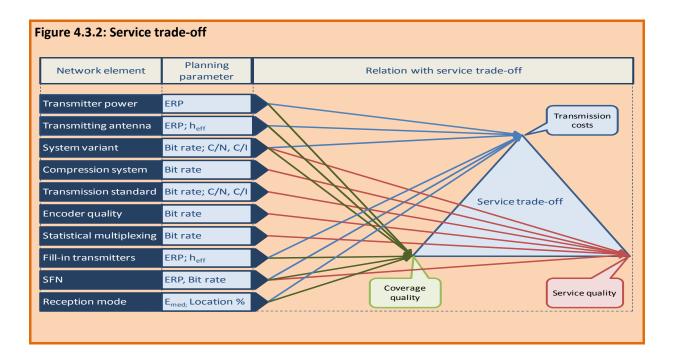
- market conditions, e.g. competitive offers (cable, satellite, IPTV);
- consumer demands, e.g. higher quality, more services, mobile TV;
- regulations resulting from political priorities;
- technology, e.g. improved compression and transmission systems.

Consequently, a further evolution of DTTB or MTV networks is to be expected³¹².

4.3.1 Service trade-off

In network planning a trade-off needs to be made between transmission costs, service quality and coverage quality. The network elements related in this trade-off are shown in Figure 4.3.2. In making this trade-off appropriate planning methods should be used. In Annex C, Section C2 a summary is given of principles, criteria and tools for planning DTTB and MTV services.

³¹² See also Networks in evolution; making changes to the digital terrestrial television platform, DigiTAG, May 2008.



Transmission costs depend to a great extent on the number of stations and the radiation characteristics. Maximum allowed radiation characteristics can be derived from the national frequency plan. Furthermore, radiation characteristics may be limited by practical circumstances such as mast space and the facilities at a site. When more power is needed than allowed or practically possible, power distribution network by means of a single frequency network (SFN) can be considered (see Section 4.3.2). Key topics and choices regarding radiation characteristics are described in more detail in section 4.5.

The net bit rate of the multiplex and the number of services in the multiplex determine the bit rate per service and consequently picture and sound quality. Multiplex capacity depends on the compression system, the transmission standard, encoder quality and the choice of system variant (carrier modulation, code rate, and guard interval in multi-carrier systems). Key topics and choices regarding systems variants for DTTB and MTV are described in more detail in section 4.4 and section 5.4 respectively.

Coverage quality is related to the reception mode (fixed, portable, mobile, and handheld) for which the service is planned. Service area, i.e. the area where the service is to be offered, should first be defined geographically or conceptually; for example, the area with no residence will be disregarded for fixed reception while it may be of interest for mobile reception. Then the location probability should be determined against each of the service areas. For example, in the digital plan of the GE06 Agreement a location probability of 95 per cent is used for fixed and portable reception. In practice sometimes lower percentages are accepted for portable reception, where it is possible to move the receiving antenna to an optimal position. For mobile (vehicular) reception often a location probability 99 per cent is chosen. It should be noted that the required location probability is related to the service area definition. A transmitter can give high location probabilities against geographically small service areas while lower probabilities against larger service areas. The definition of service area may differ depending on social requirements of a country.

In making the trade-off it should be taken into consideration that:

- station characteristics should comply with the national frequency plan and also with the provisions of the GE06 Agreement (see Annex A) where it applies;
- public broadcasters often have a universal coverage requirement for DTTB services;
- transmission costs should be weighed against the expected revenues;
- better quality and good coverage can result in more viewers; the number of viewers and the revenues are related directly in case of pay TV services, or indirectly in case of commercial services with advertising.

Implementation guidelines

The service trade-off between transmission costs, service quality and coverage quality should be made by using adequate planning software and an up-to-date transmitter station database. The more accurate the field strength predictions and the database, the more reliable are the results. When a population database is available, the number of households or people (depending on the information given in the database) obtaining at least the defined coverage probability can be calculated.

Depending on the results, further network planning exercises should be made to optimize radiation characteristics, multiplex capacity and coverage quality within the framework of the business plan or licence conditions, by performing the following activities.

Activity	DTTB guidelines	MTV guidelines	
SFN optimization (in case of multi-carrier system)	4.3.2	4.3.2	
Fill-in transmitter planning	4.3.3	4.3.3	
System parameters selection	4.4	5.4	
Radiation characteristics determination	4.5	4.5	
Feed back to business plan and consumer proposition	4.3.4	4.3.4	

Table 4.3.1: Activities for optimizing service trade-off

4.3.2 SFN or MFN

As with analogue TV, digital TV transmitters can be planned and operated as multi frequency networks (MFN). In addition, multi-carrier transmission standards have the advantage that signals from several transmitters arriving at a receiving antenna may contribute constructively to the total wanted signal. This feature makes it possible to operate transmitters as SFN³¹³. The increase of the wanted signal level at a specific receiving location due to simultaneous reception of multiple useful signals of transmitters operating in an SFN is called network gain^{314, 315}. Another effect in an SFN is the so-called OdB echo³¹⁶. When two signals of more or less equal strength are received, the required carrier to noise ratio (C/N) increases. As a result of these two effects, there can be a net performance gain or loss with multipath reception and SFN contributions, depending on the location of the receiver with respect to the contributing transmitters.

MFN and SFN are defined as follows³¹⁷:

- MFN: a network of transmitting stations using several RF channels;
- SFN: a network of synchronized transmitting stations radiating identical signals in the same RF channel.

A combination of MFN and SFN within the same network is also possible.

³¹³ See EBU Technical Report 016 Benefits and limitations of Single Frequency Networks (SFNs) for DTT, October 2012.

³¹⁴ See Final report of RRC04, Chapter 1, Section 1.6.15.

Detailed information on SFN planning for DVB-T is given in EBU document EBU Tech Report 024 SFN Frequency Planning and Network Implementation with regard to T-DAB and DVB-T. Report ITU-R BT.2209 gives detailed information on SFN calculation method and reference receiver characteristics for ISDB-T.

More information on zero-dB echo is given in EBU document Tech 3327, Network Aspects for DVB-H and T-DMB, Geneva April 2008; annex A3 and in Report ITU-R BT.2209.

 $^{^{\}rm 317}$ See GE06 Agreement, Chapter 1 to Annex 2, 1.3.14 and 1.3.15

The relative advantages and disadvantages of SFN are indicated in Table 4.3.2:

Table 4.3.2: Comparison of SFN and MFNs

Advantages of SFN compared to MFN	Disadvantages of SFN compared to MFN
Spectrum efficient due to power distribution	No option for local windows in programming
 Network gain because of simultaneous reception of multiple useful signals³¹⁸ No need to retune when travelling through an area 	 Reduced bit rate due to longer guard interval Increase of required carrier to noise ratio due to so- called 0 dB echo
 Less spectrum restrictions for additional transmitting stations 	 More complicated network planning and operation³¹⁹ Limited use of off-air reception in distribution link

SFNs are potentially restricted in size due to internal network interference, also called self-interference. Internal network interference occurs if the following conditions are fulfilled:

- 1. the time between the signal on which the receiver is synchronised³²⁰ and signals arriving from other transmitters in the SFN is more than the length of the guard interval; and
- 2. the combined values of the nuisance fields (interfering field strength plus protection ratio minus antenna discrimination, if appropriate) of the signals arriving outside the guard interval exceeds the combined values of the wanted field strengths. In this calculation, the weighting function given by the OFDM transition curve for signal arriving outside the guard interval should be taken into account for each individual signal.

The OFDM systems have different weighting curves. Figure 4.3.3 shows the weighting curves for a number of systems. The transition curve of signals arriving outside the guard interval is for ISDB-T and T-DMB signals much smoother than for DVB-T signals. Therefore DVB-T SFNs are more restricted in size than ISDB-T and T-DMB SFNs, if the same guard interval and system variant is used. It should be noted that these weighting curves vary depending on the system variants and other factors (see Report ITU-R BT.2209 for technical information).

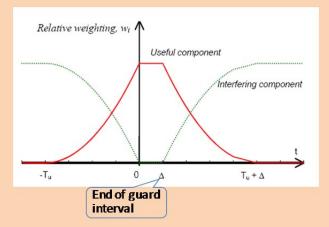
³¹⁸ See EBU report Tech Report 024 Section 4

EBU document EBU BPN 075 Single Frequency Network Maintenance, March 2007, highlights issues which are generally valid for the day-to-day operation of any SFN based on OFDM technologies.

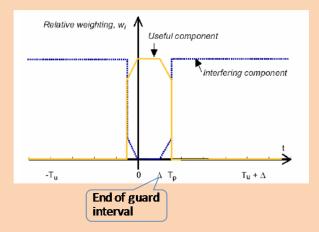
³²⁰ It is common practice to specify the reference receiver characteristics for which planning calculations are performed. Although manufacturers may or may not be obliged to conform to the reference receiver characteristics depending on the consensus in the country, network operators assume the reference receivers in planning/installing their networks.

A general review of the possible strategies for FFT window synchronization in OFDM receivers for DVB-T standard is given in EBU report BPN 059 Impact on Coverage of Inter-Symbol Interference and FFT Window Positioning in OFDM Receivers, May 2003. Different synchronisation methods of DVB-T receivers are applied, however most DVB-T receiver manufacturers apply the first signal above a certain level. Report ITU-R BT.2209 analyses receiver characteristics necessary for SFN reception of ISDB-T standard.

Figure 4.3.3: Outline of weighting curve of delayed OFDM signals



Outline of weighting curve of delayed OFDM signals in the T-DMB system; also applicable to the ISDB-T system



Outline of weighting curve of delayed OFDM signals in the DVB-T system; also applicable to the DVB-T2 system. However, for DVB-T2 the length and position of EI, the interval during which signals can be correctly equalized, must first be calculated as it is pilot pattern dependant³²¹.

Source: EBU Tech Report 024

In Figure 4.3.3, the following symbols are used:

Wi is the weighting coefficient for the i-th component;

Tu is the useful symbol length;

 Δ is the guard interval length;

t is the signal arrival time;

Tp is the interval during which signals usefully contribute.

 $^{^{\}rm 321}$ See Report ITU-R BT.2254, section 3.5

The separation distances between transmitters in an SFN corresponding to the first condition mentioned above (signals arrive outside the guard interval) ranges from a few kilometres to more than 150 km, depending on the FFT (fast Fourier transform) size, channel bandwidth and guard interval. Tables 4.4.3b.4.4.5b, 4.4.5b, 4.4.7b and 4.4.9b in section 4.4 show these separation distances for each of the OFDM systems.

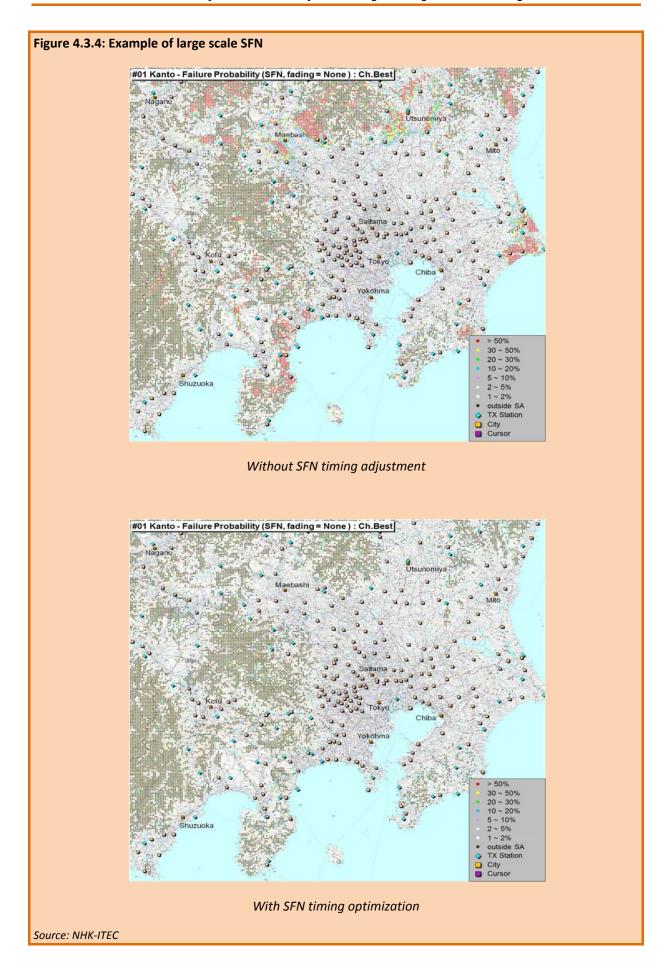
The length of the guard interval in the T-DMB standard (Mode I) is 246 μs and the corresponding separation distance 74 km.

To a certain extent, internal network interference can be reduced or resolved; a number of measures are indicated in Table 4.3.3.

Table 4.3.3: Measures to reduce self-interference

Measure to reduce self-interference	Disadvantage
Increasing guard interval (if longest guard interval is not yet applied), at all transmitters in the SFN	Reduction of net bit rate of the multiplex
Using more robust system variant at all transmitters in the SFN	Reduction of net bit rate of the multiplex
Reduction of radiated power of transmitters causing a delay time that exceeds the length of the guard interval	Possibly coverage reduction due to power reduction
Adding an additional delay in the transmitter nearest to the self-interference area	Possibly coverage reduction elsewhere due to self- interference caused by the additional delay
Optimizing radiation antenna patterns and transmitter timing of all SFN stations	Complicated network design
Using fill-in transmitter if self-interference area is small	Additional cost for new site
Using highly directional receiving antennas in self-interference area	Additional cost for viewers
Using different frequency (if available) for one of the transmitters causing the self-interference	Less frequency efficient

Figure 4.3.4 shows an example of large scale SFN with 60 transmitter sites. The pictures cover an area of 250 km x 250 km. The colours in the pictures express the failure probability at each reception point, the red shows failure probability more than 50 per cent, yellow 30 - 50 per cent, etc., and transparent shows less than 1 per cent. The black colour shows out of service area where field strength is less than the required value.



Annex C Section C3 gives some practical considerations on timing of signals in SFNs. Please note that this annex is applicable only for DVB-T and T-DMB standards. As for ISDB-T standard, Report ITU-R BT.2209 gives SFN calculation model in detail.

Implementation guidelines

In practice, SFNs are mainly used in one or more of the following circumstances:

- high field strength values are needed over large areas, e.g. for mobile, portable or handheld reception;
- fill-in transmitters;
- no frequencies are available for high and medium power stations or fill-in transmitters in MFN configuration;
- the related GE06 plan entry is an allotment.

Transmitters added to an SFN at a later stage may cause self-interference problems in areas that had good coverage before. For that reason, as far as possible, all transmitters in an SFN, also the ones that will be implemented later, should be taken into account in network planning.

For SFN planning and coverage optimization, adequate planning software is required together with detailed terrain and clutter information and an up-to-date transmitter station database. The more accurate the field strength predictions and the database, the more reliable are the results.

In practice, the following measures are often applied especially in a large scale SFN:

- optimizing transmitter timing of each SFN station;
- reducing radiation power towards the areas where self-interference might otherwise take place (such areas are to be covered by other transmitting stations in the same SFN).

4.3.3 Fill-in transmitters

The coverage area of a DTTB network is often achieved by one or more high or medium power transmitters and a number of additional low power transmitters. The transmitters may operate in single frequency networks (SFN) or multi frequency networks (MFN) or combinations of SFN and MFN. Normally high and medium power transmitters are fed by satellite, radio relay link or optical fibre. The additional low power transmitters could also be fed by satellite, radio relay link or optical fibre or by off-air reception from a high or medium power transmitter. In practice low power stations are referred to by a variety of terms often related to the way the station is fed or the frequency relation to a high or medium power station (see the Table 4.3.4). These terms may have different meanings from country to country. In these Guidelines the term "fill-in transmitter" (or in short "fill-in") is used as the general term for a low power station used to supplement the coverage achieved by a high or medium power station.

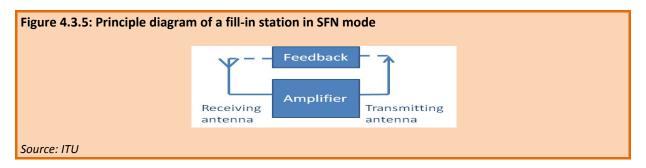
Table 4.3.4: Often used terms for lower transmitters

Input signal	Transmission frequency	Often used terms
Baseband signal (either fed by fixed link or satellite, or by off-air reception and demodulation)	Different receive and transmit frequency	Fill-in transmitter Re-transmitter
RF signal (off-air reception)	Different receive and transmit frequency	Fill-in transmitter Transposer Translator Transponder Repeater
RF signal (off-air reception)	Same receive and transmit frequency	Fill-in transmitter Active reflector On-channel repeater Gapfiller

The radiated power of a fill-in transmitter is low and often fill-ins have a directional antenna diagram. Consequently a fill-in transmitter has limited interference potential to other TV coverage areas. For this reason and because the coverage area of a fill-in transmitter is in general shielded from other transmitters, frequency reuse distances can be relatively small.

Fill-in transmitters are usually fed off-air from a high or medium power transmitter or even sometimes from another fill-in. In order to achieve sufficient selectivity the received signal is down-converted to IF and reconverted to the required transmission frequency. The transmission frequency can be different from the received frequency or the same. In the latter case the fill-in transmitter operates as SFN.

Figure 4.3.5 shows the principle of a fill-in station in SFN mode.



To prevent feedback oscillation, the gain of the fill-in transmitting equipment must be lower than the measured feedback. Measured isolation values in Europe range from about 60 to 110 dB³²². In general a safety margin of at least 10 dB is applied to the isolation value in order to allow for time variations. To increase isolation, the reception antenna can be placed separately from transmitting antenna, preferably shielded by terrain or buildings. Modern fill-in transmitter equipment with advanced echo cancellation or feedback cancellation allows amplification of 10 to 20 dB above the isolation value.

A calculation example of the allowed radiated power for two cases, a fill-in transmitter with and without echo cancellation, is given in Table 4.3.5.

Measurements results from five European countries are listed in EBU report Tech Report 022, Terrestrial digital television planning and implementation consideration, third issue, Summer 2001, Section 13.6.3.

Table 4.3.5: Calculation example of fill in transmitter power

Element	Fill-in transmitter without echo cancelling	Fill-in transmitter with echo cancelling	
Measured input signal (Pi)	-75 dBW	-75 dBW	
Measured isolation minus 10 dB safety margin (I)	65 dB	65 dB	
Gain margin (Gm)	0 dB	10 dB	
Maximum gain (I + Gm)	65 dB	75 dB	
Output power (Po = Pi + I + Gm)	-10 dBW	-0 dBW	
Transmitting antenna gain minus cable loss (Gt)	10 dB	10 dB	
Allowed radiated power (ERP = Po + Gt)	0 dBW	10 dBW	

The isolation can be improved by:

- larger separation between receiving and transmitting antenna;
- shielding by terrain or buildings;
- increased receiving and transmitting antenna directivity;
- use of orthogonal polarization between input and output signal.

At VHF, the isolation between input and output signal is lower due to lower antenna directivity, lower free space loss and lower diffraction loss (lower shielding effect).

If the radiated power is not sufficient to cover the area, either a transmitting frequency different from the receiving frequency should be used (the fill-in operates as MFN) if available, or the fill-in should be fed by microwave link, satellite or cable. In the latter case, the fill in transmitter should be equipped with a modulator.

Implementation guidelines

Detailed coverage assessment will identify the areas where fill-in transmitters are needed.

Fill-in transmitters with off-air reception are a cost effective and frequency efficient way to improve coverage in small areas, provided that a sufficiently strong input signal can be received. In order to obtain strong input values, line of sight between the main transmitting antenna and the receiving antenna of the fill-in station is likely to be required.

Fill-in transmitters with off-air reception can operate on the same frequency as the main station (SFN), but care must be taken to ensure sufficient isolation between input and output signal. The allowable output power depends on isolation value. For that reason measurements and possibly adjustments are needed at each site and at each frequency before the fill-in station becomes operational.

Fill-in transmitters with input signal being fed by other means than off-air reception or with different receiving and transmitting frequency, have no technical limitation in radiated power.

4.3.4 Feed back to business plan and service proposition

Network planning results in:

- Coverage presentations showing for the chosen reception mode:
 - site locations;
 - coverage probability (in the presence of noise and interference) in the wanted service area;
 - number of people or household obtaining the required coverage quality.

- Lists of characteristics of each station including:
 - effective radiated power (ERP);
 - horizontal and vertical antenna pattern;
 - antenna height;
 - site location:
 - system variant and bit rate of the multiplex.

These data are the bases for predicting transmission costs, potential number of customers and number of services and picture and sound quality of the planned network.

The requirements regarding transmission costs, potential number of customers, number of services and picture and sound quality are described in the network principles resulting from the application of functional block 4.2 (see section 4.2). The network principles, in turn, take into account the technology choices and the conditions described in the licence, the business plan and service proposition.

It should therefore be checked that:

- 1. after the business plan and customer proposition have been prepared or modified, the objectives can be realized with a practical network;
- 2. after the network plan has been modified or a more detailed network plan is available, the objectives of the business plan and customer proposition are still met.

If this is not the case:

- 1. the business plan and service proposition need to be reviewed.
- 2. it may also be necessary to negotiate with the regulator amendments to licence conditions or changes of plan entries through international frequency coordination.

Modification of the network plan is likely to take place at several stages in the process of transition to DTTB and introduction of MTV. For instance:

- Initially, network planning and coverage assessment will be done with limited accuracy, because
 not all network planning elements are known in detail (e.g. location of new sites, antenna
 diagrams, radiated power, system variant, interfering transmitters). When precise data are
 available more detailed network planning will be performed, which could result in modified
 coverage or station characteristics.
- In the implementation phase, changes to the network implementation plan may have to be
 accepted for practical reasons. For instance, site acquisition may not be successful, or a new site
 may be realized at a different location. It may also happen that in the detailed project planning
 antenna heights or diagrams are specified differently than originally assumed.

Implementation guidelines

Network planning is based on the network principles resulting from the activities described in "Design principles and network architecture" (sections 4.2 and 5.2 regarding DTTB and MTV respectively). The results of network planning are coverage presentations and list of stations characteristics. Which in turn is an essential input for the business plan and service proposition resulting from the activities described in "Market and business development" (Part 3).

It is necessary to check if the business and service objectives are met through network planning when preparing or modifying:

- 1. business plan and service proposition;
- design principles and network architecture;
- 3. station characteristics.

Changes in the elements listed in Table 4.3.6 require a new network planning exercise.

Table 4.3.6: Elements requiring a new network planning exercise when modified

Elements in business plan, service proposition and network principles	Elements in network plan
 Network costs 	Transmitter power
 Potential number of customers 	Antenna gain
 Number of services 	Antenna pattern
Picture and sound quality	Antenna height
Regional or local insertion	System variant
	Transmission standard
	Additional fill-in transmitters
	Additional SFN transmitters
	Reception mode
	Distribution link configuration

The resulting list of station characteristics and coverage presentations are used to check if the objectives of business plan and customer proposition are still met. If not, a review of business plan and customer proposition is needed.

Feedback of network planning to business plan and consumer proposition is likely to be necessary at several moments in the DTTB or MTV planning process, e.g.:

Table 4.3.7: Review of network planning and business plan and service proposition at different moments in the implementation process

Phase	Business plan and service proposition	Network plan	Purpose
Preparatory phase	 Initial proposition 	Initial planLimited accuracy, not all data are known	Licence application
Network planning phase	Reviewed propositionTaking into account licence conditions	Detailed coverage assessment and station characteristics	Network implementation plan
Network implementation phase	 If necessary, reviewed proposition Taking into account practical modifications to network implementation plan 	 If necessary, practical modifications to station characteristics Detailed coverage assessments 	Communication to public and content providers

4.4 System parameters

Section 4.4 provides background information and guidelines on key topics and choices regarding system parameters.

The performance of the DTTB systems is controlled by means of a great number of system parameter settings. Many of these parameters have fixed values given by the system specifications³²³. A number of parameters can be chosen by the operator. The choices are different per system.

The choice of the system parameters effects:

- the net bit rate (payload) of the DTTB transmission;
- the carrier to noise ratio (C/N) and protection ratio (C/I).

On the one hand the system parameters should be chosen in such a way that the net bit rate of the DTTB transmission is slightly higher than the data stream (MPEG-TS, B-TS or T2-MI) in order to avoid overflow. On the other hand C/N and C/I are directly related to the radiated power and should be chosen in such a way that the maximum allowed radiated power is not exceeded. System parameters are therefore a key element in the trade-off between transmission costs, service quality and coverage quality described in Section 4.3.1.

This section consists of three sections each containing a subsection with implementation guidelines on the three main system parameter choices:

- 4.4.1 Fast Fourier transform (FFT) size.
- 4.4.2 Carrier modulation and code rate.
- 4.4.3 Guard interval.

This is followed by an overview of the available choices per DTTB system in Section 4.4.4.

More detailed information on some of the key topics and choices is given in Annex A: GE06 implementation.

4.4.1 Fast Fourier transform size

OFDM systems (DVB-T, ISDB-T, DTMB-multicarrier mode and DVB-T2) make use of a frequency-division multiplexing scheme used as a digital multi-carrier <u>modulation</u> method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several <u>parallel</u> data streams. The fast Fourier transform (FFT) length specifies the number of carriers.

In practice the FFT size has an impact on:

- the allowable Doppler shift, in case of mobile reception³²⁴;
- the length of the guard interval; a higher FFT size allows a longer guard interval, making it more suitable for SFNs (see also Section 4.4.3).

A lower FFT size, with more spacing between the carriers compared to a higher FFT size, allows a higher Doppler shift and consequently a higher reception speed. The Doppler distortion is frequency dependent. The maximum speed for good reception is four times higher at 200 MHz than at 800 MHz. It should be noted that mobile reception can be improved considerably by the application of diversity reception.

³²³ See Recommendation ITU-R BT.1306 and BT.1877

Transmission standards that are designed particularly for mobile and handheld reception, e.g. T-DMB are described in Part 5.

Implementation guidelines

For static reception (fixed and potable) in general a high FFT size is chosen. If mobile reception at high speed is a major requirement, a low FFT size could be implemented. However, SFN operation may be very restricted in that case due to the relative short guard interval. Alternatively one of the standards described in Part 5 may be applied.

4.4.2 Carrier modulation and code rate

DTTB systems offer a range of carrier modulation methods and code rates.

ATSC uses vestigial side band modulation (VSB), the other systems a form of quadrature amplitude modulation (QAM). It should be noted that 4-QAM is also referred to as quadrature phase shift keying modulation (QPSK).

Higher order quadrature amplitude modulation results in a higher bit rate, but lower robustness. The code rate indicates the net bit rate (also called payload) at a certain carrier modulation. For instance with code rate 2/3, two thirds of the available bitrate is used for transmission of the DTTB signal and one third is used for protection of the signal. A low code rate results in a robust transmission, but relative low payload, whereas a high code rate results in a relative high payload but lower robustness. An example of the payload as function of carrier modulation and code rate is shown in Figure 4.4.1.

The choice of carrier modulation and code rate is a trade-off between data capacity and carrier to noise ratio (C/N). The latter is directly related to the required field strength. In the GE06 Agreement the modulation and code rate are specified for each plan entry, but use of a different modulation and code rate is possible subject to certain conditions (see Annex A, Section A.2.2).

The combination of a lower order modulation and a low code rate is used when field strength requirements are very demanding e.g. in case of portable or mobile reception. The combination of a high order modulation and a high code rate is used when a high data capacity is required e.g. in case of HDTV or a high number of services. However in practice the highest codes rates (such as 5/6 and 7/8) are not much used.

The C/N values and protection ratios are specified for three kinds of transmission channels:

Transmission channel	Description	Application
Gaussian channel	Reception with no delayed signals and taking into account thermal noise	Reference value
Ricean channel	Reception with a dominant signal and lower level delayed signals and thermal noise	Fixed reception
Rayleigh channel	Reception with several non-dominating signal with different delay times and thermal noise	Portable and mobile reception

Table 4.4.1: Transmission channels

As example Figures 4.4.1 shows the spectrum efficiency of the system variants the DVB-T system. In this graph the payload is normalized to bit/s/Hz and the C/N value is the relative value compared to a reference system variant (64QAM 2/3). In this way the curve is independent of bandwidth and guard interval.

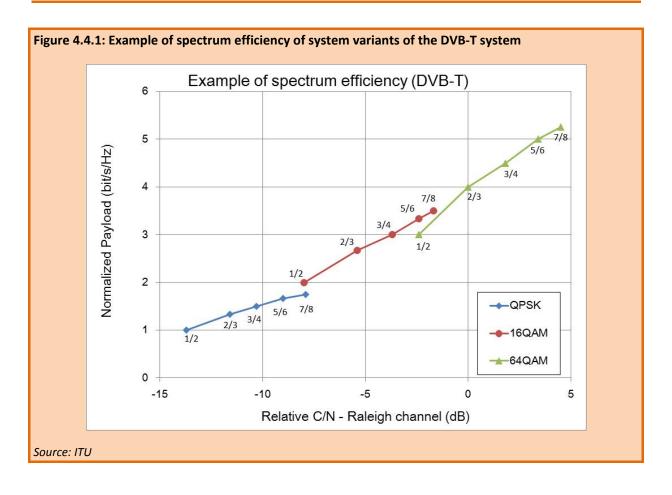


Figure 4.4.1 shows that some system variants should not be used in practise because with similar payload their power requirements (C/N) are higher than with other system variants. For instance:

- QPSK at code rate 7/8 and 16-QAM at code rate 1/2 require nearly the same C/N value, but 16-QAM at code rate 1/2 provides a higher payload. Therefore QPSK at code rate 7/8 has no useful practical application.
- 16-QAM at code rate 3/4 provides the same payload as 64-QAM at code rate 1/2, but requires a lower C/N value. Therefore 64-QAM at code rate 1/2 has no useful practical application.

Other DTTB systems show a similar pattern. Therefore in selecting the system variant, the spectrum efficiency of the variants for the transmission channel under consideration should be checked.

In addition to the non-hierarchical mode described above, some DTTB systems can also be operated in hierarchical mode. In the hierarchical mode, two or more independent streams are fed into the transmitter with different net data capacity and robustness.

Compared to non-hierarchical, hierarchical modulation needs some overhead capacity.

Hierarchical modulation can for instance be used to broadcast main services in a robust stream over a large area with portable reception. Whereas another less robust stream with a high net bit rate, can be used to broadcast for a higher number of additional services with portable reception near the transmitter and with fixed reception in the larger area. Another possibility is to use a stream with high bitrate for a service package intended for fixed reception and a robust stream for mobile TV. A typical example of this is found in OneSeg service with ISDB-T standard. OneSeg is very popular and most broadcasters using ISDB-T apply this for mobile services. In DVB-T2 different system variants can be transmitted simultaneously by using the Multiple Physical Layer Pipes (MPLP) concept.

Hierarchical modulation is not much used with the DVB-T standard in practice. Probably because service providers consider all services of equal importance, or splitting the multiplex capacity between two kinds of services offers insufficient capacity for each of these services.

Implementation guidelines

In practice a compromise needs to be made between the two conflicting requirements: high data capacity and low C/N.

Not all possible combinations of carrier modulation and code rate are used in practice:

- QPSK is not much used for rooftop or portable reception because of the low data capacity, but finds an application in cases where with higher order modulations, very high field strength would be required such as handheld reception.
- The higher code rates 5/6 and 7/8 are not much used in practice because of the high C/N values and less vulnerability in multi-path and SFN conditions.
- System variants with medium robustness are often used with portable reception (e.g. in DVB-T, 16-QAM at code rates 2/3 or 3/4) and system variants with a relative high payload are often used with fixed reception (e.g. in DVB-T, 64-QAM at code rates 2/3 or 3/4). But other compromises occur as well in practice. For example in DVB-T, 64-QAM at code rate 2/3 with portable reception in case of a requirement for a high data capacity and 64-QAM with codes rates 5/6 or 7/8 in case a very high number services need to be broadcast over a small area.
- In the case of a hierarchical transmission with ISDB-T standard, 64-QAM at code rate 3/4 and QPSK at code rate 1/2 or 2/3 are often applied respectively for fixed reception and mobile service.
- With the DVB-T2 standard often 256QAM at code rates 2/3 or 3/4 is used with fixed reception. If portable or mobile reception is a requirement, 64QAM with code rates 1/2 to 3/4 could be used.

4.4.3 Guard interval

The guard interval³²⁵ is an extension of the active symbol period. Through the guard interval the transmission is to a certain extent immune to interference caused by delayed signals. Delayed signals, received within the time period of the guard interval, contribute even positively to the wanted signal.

Delayed signals can be distinguished in:

- passive echoes, caused by reflections to obstacles;
- active echoes, being signals from other transmissions in the same single frequency network.

The guard interval is generally expressed as a fraction of the length of the active symbol period. The total symbol period is given by the formula:

Ts = Ta $(1+\Delta)$, where

Ts is the symbol period in μs;

Ta is the active symbol period in μs;

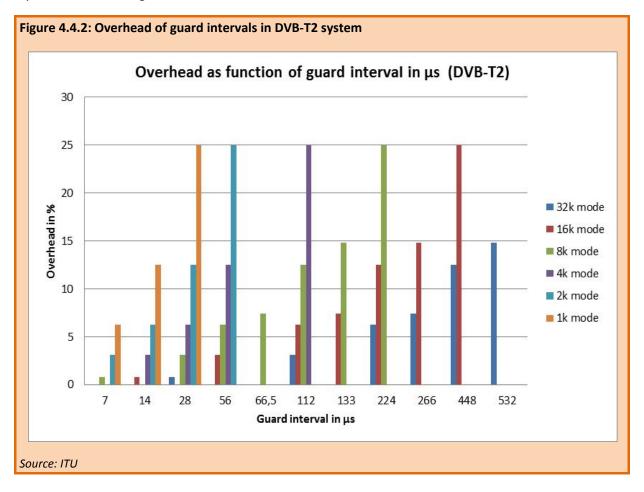
 Δ is the guard interval expressed in a faction of the active symbol period Ta.

A description of the functioning of the guard interval is given in report EBU Tech Report 024 SFN Frequency Planning and Network Implementation with regard to T-DAB and DVB-T, Section 2.3 and 2.4.

The active symbol period (Ta) is related to the FFT size (number of carriers) and the bandwidth. In Section 4.4.4 the active symbol periods and guard intervals are shown for each of the multi-carrier systems with 6 MHz, 7 MHz and 8 MHz channel bandwidths. The guard interval, expressed as fraction of the active symbol period, has a longer duration in microseconds at higher FFT sizes (see also Tables 4.4.3a, 4.4.5a and 4.4.9a). The highest guard interval fraction in all of the multicarrier DTTB system is 1/4. The duration of this guard interval is longer at higher FFT sizes. For instance in DVB-T in an 8 MHz channel bandwidth 56 μ s and 224 μ s with the 2k mode and the 8k mode respectively.

The ratio of the guard interval in microseconds and the active symbol period in microseconds is sometimes called "overhead". The overhead is an indication of the payload reduction of the chosen combination of guard interval and FFT size.

An example of the overhead of the available combinations of FFT size and guard interval in the DVB-T2 system is shown in Figure 4.4.2.



The modes in Figure 4.4.2 correspond to the FFT sizes (see Table 4.4.8). The DVB-T2 system has a normal-carrier mode and an extended-carrier mode. Since the active symbol period is the same for normal and extended mode, the overhead shown in Figure 4.4.2 applies to both modes. At a given guard interval in microseconds, the overhead is smaller at higher FFT sizes. For instance at 112 μ s, the overhead is 25 per cent with the 4k mode, 12.5 per cent with the 8k mode, 6.25 per cent with the 16k mode and 3.13 per cent with the 32k mode.

Implementation guidelines

Buildings and mountains reflect radio waves and may create strong echoes. Multi echoes (of larger than -20 dB at the direct signal level) and with delays of several tens of s are often observed at the areas near a large city or mountain fringes.

In multi frequency networks (MFN), where only passive echoes occur with intensities lower than the threshold level, the lowest guard interval can be applied. In cases where echoes occur with intensities exceeding the threshold level, an adequate guard interval to minimize interference caused by the echoes should be chosen.

In single frequency networks (SFN) passive and active echoes are present. Depending on the size of the SFN, the guard interval with no or minimal internal network interference should be chosen (see Section 4.3.2).

4.4.4 Choices per DTTB system

Per DTTB system the main choices of system parameters are indicated in the following sections.

ATSC

Most system parameters of the ATSC system are fixed by the system specifications. Regarding the code rate a choice can be made between 2/3, 1/2 and 1/4.

DVB-T

The main choices regarding system parameters are summarized in Table 4.4.2.

System parameter

Carrier modulation

FFT size

6817 carriers (8k mode) and 1705 carriers (2k mode)

Carrier modulation

QPSK, 16-QAM, 64-QAM

Code rates

1/2, 2/3, 3/4, 4/5, 5/6

Guard intervals

1/32, 1/16, 1/8, 1/4

Table 4.4.2: DVB-T system parameter choices

Active symbol period and guard interval expressed in μ s, as well as the maximum separation distance between transmitters in a SFN with which the delayed signals at a reception points are within the guard interval are shown in Table 4.4.3a and 4.4.3b.

Active Guard interval in µs System Channel FFT size symbol time 1/32 1/16 1/8 1/4 in µs 28 112 224 DVB-T 8 MHz 6817 896 56 7 56 1705 224 14 28 7 MHz 6817 1024 32 64 128 256 1705 8 16 64 256 32 6 MHz 6817 1 194.7 37.3 74.7 149.3 298.7 1705 298.7 9.3 18.7 37.3 74.7

Table 4.4.3a: DVB-T guard intervals

Table 4.4.3b: DVB-T separation distances in SFN

System		FFT size sy	Active symbol time in μs	Separation distance in km			
	Channel			1/32	1/16	1/8	1/4
DVB-T	8 MHz	6817	896	8.4	16.8	33.6	67.2
		1705	224	2.1	4.2	8.4	16.8
	7 MHz	6817	1024	9.6	19.2	38.4	76.8
		1705	256	2.4	4.8	9.6	19.2
	6 MHz	6817	1 194.7	11.2	22.4	44.8	89.6
		1705	298.7	2.8	5.6	11.2	22.4

ISDB-T

The main choices regarding system parameters are summarized in Table 4.4.4.

Table 4.4.4: ISDB-T system parameter choices

System parameter	Carrier modulation				
FFT size	5617 carriers (mode 1), 2809 carriers (mode 2), 1405 carriers (mode 3)				
Carrier modulation	DQPSK, QPSK, 16-QAM, 64-QAM				
Code rates	1/2, 2/3, 3/4, 5/6, 7/8				
Guard intervals	1/32, 1/16, 1/8, 1/4				

Active symbol period and guard interval expressed in μ s, as well as the maximum separation distance between transmitters in a SFN with which the delayed signals at a reception points are within the guard interval are shown in Table 4.4.5a and 4.4.5b.

Table 4.4.5a: ISDB-T guard intervals

System	Channel	FFT size	·			val in μs	
		symbol time in μs	1/32	1/16	1/8	1/4	
ISDB-T	8 MHz	5617	756	23.6	47.3	94.5	189
		2809	378	11.8	23.6	47.3	94.5
		1405	189	5.9	11.8	23.6	47.3
	7 MHz	5617	864	27	54	108	216
		2809	432	13.5	27	54	108
		1405	216	6.8	13.5	27	54
	6 MHz	5617	1008	31.5	63	126	252
		2809	504	15.8	31.5	63	126
		1405	252	7.9	15.8	31.5	63

Table 4.4.5b: ISDB-T separation distances in SFN

	a	FFT size	Active	Separation distance in km					
System	Channel		symbol time in μs	1/32	1/16	1/8	1/4		
ISDB-T	8 MHz	5617	756	7.1	14.2	28.4	56.7		
		2809	378	3.5	7.1	14.2	28.4		
		1405	189	1.8	3.5	7.1	14.2		
	7 MHz	5617	864	8.1	16.2	32.4	64.8		
		2809	432	4.1	8.1	16.2	32.4		
		1405	216	2.0	4.1	8.1	16.2		
	6 MHz	5617	1008	9.5	18.9	37.8	75.6		
		2809	504	4.7	9.5	18.9	37.8		
		1405	252	2.4	4.7	9.5	18.9		

DTMB

The main choices regarding system parameters are summarized in Table 4.4.6.

Table 4.4.6: DTMB system parameter choices

System parameter	Carrier modulation
FFT size	3780 carriers (multi-carrier mode) and 1 carrier (single carrier mode)
Carrier modulation	QPSK-NR, QPSK, 16-QAM, 32-QAM, 64-QAM
Code rates	0.4, 0.6, 0.8
Guard intervals	1/9, 1/6, 1/4

Active symbol period and guard interval expressed in μ s, as well as the maximum separation distance between transmitters in a SFN with which the delayed signals at reception points are within the guard interval are shown in Table 4.4.7a and 4.4.7b.

Table 4.4.7a: DTMB-multicarrier mode guard intervals

6 44 4	61	Channel FFT size		Guard interval in μs				
System	Channel FFT size symbol time in μs		1/9	1/6	1/4			
DTMB multi- carrier	8 MHz	3780	500	55.6	83.3	125		
	7 MHz	3780	571.4	63.5	95.2	78.7		
	6 MHz	3780	666.7	74.1	111.1	166.7		

Table 4.4.7b: DTMB-multicarrier mode separation distances in SFN

6	Cl.		Active	Separation distance in km				
System	Channel	FFT size	symbol time in μs	1/9	1/6	1/4		
DTMB multi- carrier	8 MHz	3780	500	16.7	25.0	37.5		
	7 MHz	3780	571.4	19.0	28.6	42.9		
	6 MHz	3780	666.7	22.2	33.3	50.0		

DVB-T2

The main choices regarding system parameters are summarized in Table 4.4.8.

Table 4.4.8: DVB-T2 system parameter choices

System parameter	Carrier modulation
FFT size	27 841 carriers (32k extended mode), 27 265 (32k mode), 13 912 carriers (16k extended mode), 13 633 (16k mode), 6913 carriers (8k extended mode), 6 817 (8k mode), 3409 carriers (4k mode), 1705 carriers (2k mode), 853 carriers (1k mode)
Carrier modulation	QPSK, 16-QAM, 64-QAM, 256-QAM
Code rates	1/2, 3/5, 2/3, 3/4, 5/6, 7/8
Guard intervals	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4

The DVB-T2 system has a normal and an extended mode regarding the number of carriers related to 8k, 16k and 32k mode³²⁶. The extended mode in 8 MHz channels is considered compatible with GE06 8 MHz channel arrangements (for more information see Annex A, Section A.2.3). An extended-carrier mode allows optimum use to be made of the channel bandwidth together with the higher FFT sizes. When this option is used (with 8K, 16K and 32K mode) the carrier spacing is the same as when the normal carrier is used, but additional carriers are added at both ends of the spectrum. The active symbol period is the same for normal and extend mode.

Active symbol period and guard interval expressed in μ s, as well as the maximum separation distance between transmitters in a SFN with which the delayed signals at a reception points are within the guard interval are shown in Table 4.4.9a and 4.4.9b.

 $^{^{326}}$ See Report ITU-R BT. BT.2254, Section 2.9

Table 4.4.9a: DVB-T2 guard intervals

			Active	Guard interval in μsec							
System	Channel	FFT size	symbol time in μs	1/128	1/32	1/16	19/256	1/8	19/128	1/4	
DVB-T2	8 MHz	27841	3 584	28	112	224	266	448	532	n.a.	
		13912	1 792	14	56	112	133	224	266	448	
		6913	896	7	28	56	66.5	112	133	224	
		3409	448	n.a.	14	28	n.a.	56	n.a.	112	
		1705	224	n.a.	7	14	n.a.	28	n.a.	56	
		853	112	n.a.	n.a.	7	n.a.	14	n.a.	28	
	7 MHz	27841	4 096	32	128	256	304	512	608	n.a.	
		13912	2 048	16	64	128	152	256	304	512	
		6913	1 024	8	32	64	76	128	152	256	
		3409	512	n.a.	16	32	n.a.	64	n.a.	128	
		1705	256	n.a.	8	16	n.a.	32	n.a.	64	
		853	128	n.a.	n.a.	8	n.a.	16	n.a.	32	
	6 MHz	27841	4 778.7	37.3	149.3	298.7	354.7	597.3	709.3	n.a.	
		13912	2 389.3	18.7	74.7	149.3	177.3	298.7	354.6	597.3	
		6913	1 194.7	9.33	37.3	74.7	88.7	149.3	177.3	298.7	
		3409	597.3	n.a.	18.7	37.3	n.a.	74.7	n.a.	149.3	
		1705	298.7	n.a.	9.3	18.7	n.a.	37.3	n.a.	74.7	
		853	149.3	n.a.	n.a.	9.3	n.a.	18.7	n.a.	37.3	

Table 4.4.9b: DVB-T2 separation distances in SFN

			Active	Separation distance in km						
System	Channel	FFT size	symbol time in μs	1/128	1/32	1/16	19/256	1/8	19/128	1/4
DVB-T2	8 MHz	27841	3 584	8.4	33.6	67.2	79.8	134.4	159.6	n.a.
		13912	1 792	4.2	16.8	33.6	39.9	67.2	79.8	134.4
		6913	896	2.1	8.4	16.8	20.0	33.6	39.9	67.2
		3409	448	n.a.	4.2	8.4	n.a.	16.8	n.a.	33.6
		1705	224	n.a.	2.1	4.2	n.a.	8.4	n.a.	16.8
		853	112	n.a.	n.a.	2.1	n.a.	4.2	n.a.	8.4
	7 MHz	27841	4 096	9.6	38.4	76.8	91.2	153.6	182.4	n.a.
		13912	2 048	4.8	19.2	38.4	45.6	76.8	91.2	153.6
		6913	1 024	2.4	9.6	19.2	22.8	38.4	45.6	76.8
		3409	512	n.a.	4.8	9.6	n.a.	19.2	n.a.	38.4
		1705	256	n.a.	2.4	4.8	n.a.	9.6	n.a.	19.2
		853	128	n.a.	n.a.	2.4	n.a.	4.8	n.a.	9.6
	6 MHz	27841	4 778.7	11.2	44.8	89.6	106.4	179.2	212.8	n.a.
		13912	2 389.3	5.6	22.4	44.8	53.2	89.6	106.4	179.2
		6913	1 194.7	2.8	11.2	22.4	26.6	44.8	53.2	89.6
		3409	597.3	n.a.	5.6	11.2	n.a.	22.4	n.a.	44.8
		1705	298.7	n.a.	2.8	5.6	n.a.	11.2	n.a.	22.4
		853	149.3	n.a.	n.a.	2.8	n.a.	5.6	n.a.	11.2

The DVB-T2 system has some additional parameters to be adjusted by the operator, including:

Pilot pattern (PP)

Eight pilot patterns are defined, however a limited number of pilot patterns is available at a given combination of FFT size and guard interval³²⁷. In general the lower PP numbers are more suitable for portable and mobile reception.

Rotated constellation

Rotated constellation should, in principle, improve reception under multipath conditions³²⁸. In practise the advantage is not always shown.

<u>Time interleaving</u>

Time interleaving improves robustness, but increases switching time between services in the receiver³²⁹. Time interleaving is in particular advantages for portable and mobile reception.

Implementation guidelines

In DTTB systems several parameters can be adjusted to optimize the system performance. In a given DTTB system not all combinations of adjustable parameters may be available.

For a given DTTB system the choice of parameters is guided by the implementation guidelines of Sections 4.4.1 and 4.4.2 and 4.4.3.

In the service trade-off described in Section 4.3.1 the net bit rate (also referred to as payload), C/N and protection ratio are essential data. The net bit rates for each of the system variants are given in the system specifications and system implementation guidelines³³⁰. Net bit rates for DVB-T are also given in the GE06 Agreement³³¹. C/N values and protection ratios are given in Recommendations ITU-R BT.1368 and BT.2033.

4.5 Radiation characteristics

Section 4.5 provides background information and guidelines on key topics and choices regarding radiation characteristics of DTTB and MTV stations. The section consists of three sections each containing a subsection with implementation guidelines:

- 4.5.1 Transmitter power and antenna gain.
- 4.5.2 Polarisation.
- 4.5.3 Use of existing antennas or new antennas.

More detailed information on some of the key topics and choices is given in:

Annex A: GE06 implementation.

Annex C: More information on some DTTB network topics.

See Report ITU-R BT.2254, Section 2.7

³²⁸ See Report ITU-R BT.2254, Section 2.6

See Report ITU-R BT.2254, Section 2.8

³³⁰ See Bibliography of Recommendations ITU-R BT.1306 and 1877

³³¹ See GE06 Agreement Chapter 3 to Annex 2, Annex 3.1

The choice of radiation characteristics affects the costs of the DTTB or MTV transmission and the coverage quality. On the one hand, the radiation characteristics should be chosen in such a way that as much as possible use can be made of existing installations in order to save investment costs. On the other hand, radiation characteristics are directly related to the coverage quality and should be chosen in such a way that within the limits of the allowed maximum radiated power, coverage is maximized at all frequencies that are transmitted from the site. Radiation characteristics are therefore a key element in the trade-off between transmission costs, service quality and coverage quality described in Section 4.3.1.

The radiation characteristics of a DTTB or MTV station are specified in the national frequency plan and normally include:

- maximum effective radiated power (ERP)³³²;
- altitude above sea level;
- height of the transmitting antenna above ground;
- maximum effective antenna height³³³ (h_{eff}) and the h_{eff} at 36 different azimuths at 10 degrees intervals;
- antenna attenuation at 36 different azimuths at 10 degrees intervals;
- polarization³³⁴;
- spectrum mask.

The above items of radiation characteristics should be commonly applied in international negotiation.

In addition, national and local regulations may limit the power at a site or field strength near the site due to health hazard and EMC considerations³³⁵.

4.5.1 Transmitter power and antenna gain

Important topics to consider with regard to transmitter power and antenna gain are:

- trade-off between transmitter power and antenna gain;
- horizontal antenna pattern;
- vertical antenna pattern;
- combining transmissions into one antenna.

These topics are described below.

Trade-off between transmitter power and antenna gain

The transmitter power of a DTTB or MTV station is defined as mean power, contrary to analogue TV where the peak envelop power is used to express the transmitter power. Transmitter power minus losses in antenna cable and combiner, plus antenna gain is the effective radiated power (ERP).

As with analogue TV there is a trade-off between transmitter power and antenna gain. Table 4.5.1 indicates the main considerations for this trade-off.

ERP is defined in the Radio Regulations, article 1.162.

The concept of effective antenna height is described in Recommendation ITU-R P.1546 Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz, Annex 1 Section 6 and Annex 5 Section 3.

Polarization of Plan entries can be horizontal, vertical, mixed or unspecified. In the latter case polarization should be decided nationally.

³³⁵ See also Report ITU-R BT.2140 Transition from analogue to digital terrestrial broadcasting; Section 4.5.

Table 4.5.1: Trade-off between transmitter power and antenna gain

	Generally less (-), more (+) or more or less neutral (0) contribution							
Trade-off element	Low transmitter power	High transmitter power	High antenna gain	Low antenna gain				
Investment costs	-	+	+	-				
Operational costs	_	+	0	0				
Space requirements	-	+	+	-				
Reception problems near site	0	0	-	+				

Digital TV transmitters are available for different power classes, ranging from less than 1 Watt to more than 10 kW in UHF.

In some cases, existing analogue transmitters can be converted to digital by replacing the analogue modulation unit by a digital modulation unit and reducing the power amplification to obtain the required linearity for digital transmissions³³⁶ (for more information see Annex C, Section C.4.), taking into account that:

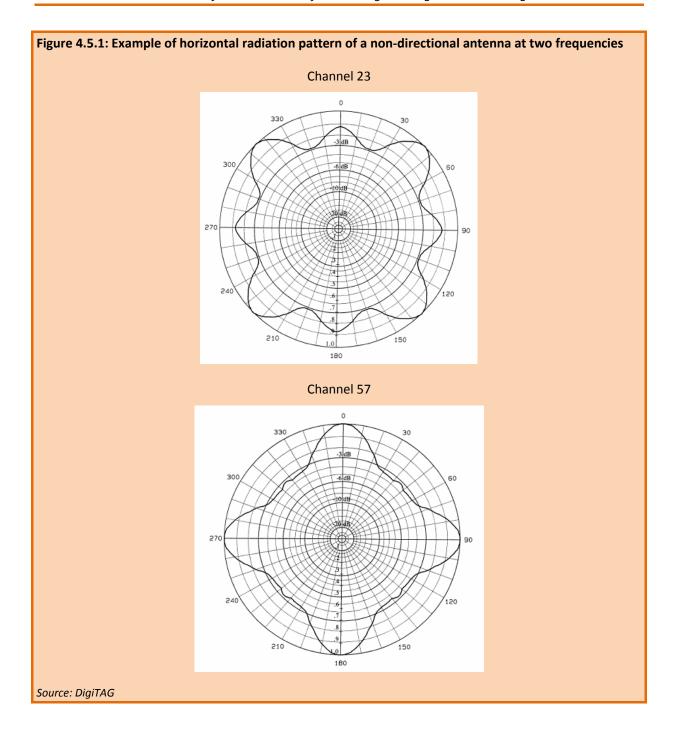
- an analogue TV transmitter with combined video and audio amplification has been equipped with the required 6 MHz, 7 MHz or 8 MHz bandwidth filter and can easily be adjusted to digital transmission;
- an analogue TV transmitter with separate video and audio amplification needs to be modified;
 only the video power amplifier can be used and a band filter should be added;
- analogue TV transmitters with klystrons are not suitable for digital transmissions because of the non-linear characteristics of the klystron;
- in the case of multi-carrier systems the mean power of a digital transmission from a converted analogue TV transmitter is about 10 20 per cent of the analogue peak envelop power;
- the noise saturation level requirement (or peak margin) when using an analogue transmitter with OFDM signals. Since an analogue transmitter has lower peak margin (< 3dB), it cannot operate at its full power level with OFDM signals (e.g. 10 kW analogue transmitter can be used as 1 kW digital transmitter (for more information see Annex C, Section C.4).

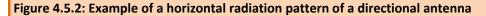
Horizontal antenna pattern

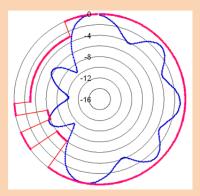
The horizontal antenna pattern shows attenuations, which are frequency dependent. Antennas are classified as:

- non-directional, when no attenuations are needed. Depending on the construction of the antenna, in practice certain attenuations are present (see example in Figure 4.5.1);
- directional, when attenuations in the radiation pattern are required to protect other services or
 to adapt the pattern to the form of the wanted coverage area. A practical antenna pattern
 should satisfy the required attenuations, without exceeding the permitted radiation pattern.
 This could result in restricted radiation over a large arc (see example in Figure 4.5.2).

 $^{^{\}rm 336}$ See also Report ITU-R BT.2140 Transition from analogue to digital terrestrial broadcasting; Section 3.6.1.







Required antenna pattern with internationally agreed attenuations to protect DTTB and analogue TV services in neighbouring countries

Practical pattern that fits best with the required attenuations

Source: DigiTAG

Vertical antenna pattern

The maximum antenna gain depends on the number of tiers of the antenna. More tiers result in a more directional vertical antenna pattern, a higher maximum gain, but also more length and weight, hence increasing requirements for the mechanical strength of the mast. The gain and length of practical non-directional antennas for main stations range from:

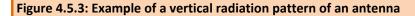
Band III: 2 to 15 dB; length: 1.2 to 25 m; Band IV/V: 7 to 18 dB; length: 2.2 to 18.5 m.

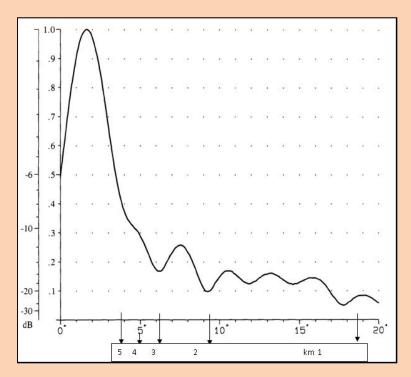
The vertical radiation pattern shows maxima and minima (nulls) (see Figure 4.5.3), causing considerable field strength variations within a few kilometres from the site. In the direction of nulls, reception may be problematic close to the transmitting site. This is more apparent with portable, mobile or handheld reception where high field strength values are required.

To cure reception problems near the site the following two solutions can be applied:

- 1. null-fill, but at the cost of some reduced gain;
- 2. an antenna with a lower number of tiers and consequently less gain.

In the direction of maxima of the vertical antenna pattern, high field strength values could be present close to the site and interference to consumer equipment and professional equipment may occur.





Vertical antenna pattern

- Antenna height 350 m
- Eight bays
- Extra null fill below 10°

Source: DigiTAG

The main beam of the vertical antenna pattern should be directed towards the coverage area and depending on antenna height and size of the coverage area, a down tilt may be applied (in the example shown in Figure 4.5.3 the down tilt is about 1.7°). Down tilt has the additional advantage that less power is radiated towards the horizon and therefore causing less interference towards other co-channel services.

Beam tilt can, in principle, be realized in two ways, mechanically and electrically. Mechanical beam tilt is only used in special occasions. There are two methods for electrical beam tilt:

- 1. by adjusting the phase of each bay;
- 2. by adjusting the phase of the main feeder.

Combining transmissions into one antenna

For economic reasons in most cases, all transmissions at a site are combined into one antenna.

In doing so, it should be taken into account that:

Horizontal radiation patterns are different per frequency (see example in Figure 4.5.1). Because
of the rapid failure characteristics of DTTB reception, differences in field strength of more than
about 1 dB between two received frequencies in the fringe area could result in good reception
of one multiplex and no reception of the other.

- Certain modern types of antennas show less differences at the lower and upper end of the band.
- In case of directional antennas, the reduction will appear on all frequencies, but the amount of attenuation is frequency dependent.
- When attenuations at certain frequencies are not acceptable and there is no space on the mast for an additional antenna, multi-pattern antenna can be considered. With a multi-pattern antenna, each frequency has its own pattern, while using the same physical antenna. This is realized at the cost of power splitters, additional combiners and additional antenna cables.
- The sum of mean power and peak voltage of all transmitters should not exceed the allowed mean power and peak voltage of the antenna system. The peak voltage issue is important especially with multi-carrier systems. TV stations are usually designed to allow operation with one antenna half, therefore one antenna half should be capable of handling the full power and peak voltage.

A calculation example of total peak voltage and average power is shown in Table 4.5.2.

Service DTTB-A DTTB-B DTTB-C DTTB-D Analogue TV 1 Analogue TV 2 52 Channel 55 37 57 28 42 Vision Sound Vision Sound 10000 10000 Peak power analogue (Ppa) [W] n.a. n.a. n.a. n.a n.a. n.a. 5950 5950 Mean power (Pm) [W] 1200 1200 1200 1200 1000 1000 Crest factor (Cs) [dB] 15 15 15 15 n.a. Peak power digital (Ppd) ([W] 37947 37947 37947 37947 n.a. n.a. 1377 1377 Peak voltage of tx (in 50 Ω) (Vp) [V] 1377 1377 1316 1316 Mean power of tx (Pmt) [W] 1200 1200 1200 1200 6950 6950 Total peak voltage (Vpm) [V] 2755 4132 1377 5510 6826 8142 Total mean power (Pmm) [W] 1200 2400 3600 4800 11750 18700

Table 4.5.2: Calculation example of peak voltage and mean power in an antenna

The following formulas are used in the example in Table 5.4.2:

- analogue mean power (Pma) = Ppa x 0,595;
- digital peak power (Ppd) = Pm x 10^{Cs/10};
- peak voltage of digital transmitters (Vp) = $V(Ppd \times 50)$;
- peak voltage of analogue transmitters (Vp) = $\sqrt{2}$ x $\sqrt{(Ppa_{vision} \times 50)}$ + $\sqrt{2}$ x $\sqrt{(Ppa_{sound} \times 50)}$;
- mean power of analogue transmitters (Pmt) = Pm_{vision} + Pm_{sound};
- total peak voltage (Vpm) = sum of peak voltages of all transmitters;
- total mean power (Pmm) = sum of mean power of all transmitters.

Combiners

The combiner is the unit that combines several transmitter outputs into the same antenna. The transmitter outputs can be DTTB multiplexes, MTV multiplexes and analogue TV. In addition, the combiner filters the output signal to avoid out-of band emissions. Combiners cause some power loss:

- about 0.4 to 0.7 dB for tuneable high power combiners;
- about 0.2 to 0.3 dB for non-tuneable combiners.

A combiner can be very voluminous, depending on the power handling capabilities and the number of multiplexes or analogue TV signals that are combined.

Spectrum limit masks for DTTB systems in the VHF and UHF bands should be based on those given in Recommendation ITU-R BT.1206, in cases where specific spectrum limit masks are required beyond the general spectrum limit masks specified in Recommendation ITU-R SM.1541.

Annexes 1, 2, 3 and 4 of ITU-R BT.1206 provide spectrum masks for the following situation.

BT.1206 Channel Application ATSC 6 MHz High power stations Low power stations and fill-in transmitters (normal and simple mask) В DVB-T 7 and 8 MHz Non-critical cases Sensitive cases C ISDB-T 6 MHz Non-critical mask Sub-critical mask Critical emission masks 7 and 8 MHz Non-critical cases Sensitive cases D **DTMB** 8 MHz Analogue TV transmitter in adjacent channel Critical with other services in adjacent channel

Table 4.5.3: Overview of spectrum masks

The spectrum masks provided for DVB-T corresponds to the spectrum masks specified in the GE06 Agreement (see also Annex A, Section A.2.3). The spectrum mask for sensitive cases is applied when using adjacent channel digital or analogue TV (in particular when I-PAL is transmitted in the lower adjacent channel relative to the DTTB signal) or to protect other (non-broadcasting) services in adjacent channels. The non-critical spectrum mask requires six filter cavities, whereas the spectrum mask for sensitive cases requires eight filter cavities.

The combiner filters characteristics should comply with the spectrum mask that is specified for frequencies in use.

Implementation guidelines

In practice, the choice of transmitter power and antenna gain depends very much on local circumstances and requirements including:

- the ASO scenario applied (such as: with or without simulcast, phased or national; see sections 2.16 to 2.18);
- a desire and a possibility to convert existing analogue TV transmitters into digital ones;
- a desire and a possibility to use existing antennas (see also Section 4.5.3);
- space in transmitter building and space on the mast for a new antenna.

Nevertheless a number of practical guidelines can be given regarding the choice of transmitter power and antenna gain.

General

If additional multiplexes (transmitters) for DTTB or MTV are expected in future, it is advised to take extra space and capacity into account in the design and layout of the transmitter building, antennas, combiners and power supply. Otherwise, later extensions to the network risk generating high costs as existing equipment and facilities become redundant and have to be replaced.

Transmitters

When converting an analogue TV transmitter into digital it should be taken into account that:

- the mean power of a digital transmission from a converted conventional analogue TV transmitter is about 10 – 20 per cent of the analogue peak envelop power;
- with modern transmitters capable of both analogue and digital transmission, the mean power of multi-carrier DTTB transmission can be about 40 per cent of the analogue peak envelop power.

It is common practice to choose a somewhat higher transmitter power than theoretically needed when subtracting antenna gain, feeder loss and combiner loss from the required ERP. A margin in transmitter power can be used (to a certain extent) when in practice it turns out that:

- antenna gain is lower than expected;
- losses in feeder and combiner are higher than expected;
- propagation losses are higher than expected (licence conditions may need to be changed if increasing ERP to offset the propagation losses).

In high power transmitters (1-3 kW or more), normally liquid cooling systems are applied, whereas in low power transmitters (less than 1-3 kW) normally air cooling systems are applied. The choice of the cooling system depends among others on transmitter price, ease of maintenance, floor space and power consumption.

Antenna gain and combiner characteristics

In specifying antennas and combiners the following aspects should be taken into account:

- the maximum allowed effective radiated power in any direction;
- antenna patterns resulting from network planning (including the conditions of the related plan entry in the GE06 Agreement where it applies);
- frequency dependent differences of the antenna diagrams of a given antenna (certain modern type of antennas have improved radiation characteristics throughout the frequency band);
- in case of fixed reception, high gain antennas are generally chosen;
- in case of portable, mobile and handheld reception, when reception near the site is required, in general antennas with medium gain (up to eight tiers) are chosen;
- beam down tilt, adapted to the size of the coverage area;
- the spectrum mask specified in the related plan entry;
- peak voltage and average power of all transmissions making use of the antenna, plus a margin for future additions or modifications.

It is important to take realistic horizontal and vertical antenna patterns into account in coverage calculations in order to identify:

- areas of poor reception near the site;
- differences in coverage of the multiplexes;
- coverage problems that need to be resolved.

4.5.2 Polarisation

The choice of polarisation of the transmitting antenna depends in principle on the following considerations.

1. The reception mode

With fixed reception, generally horizontal polarisation is chosen. If portable, mobile or handheld reception is a major requirement, vertical polarisation is recommended because:

- portable, mobile and handheld receiving antennas are generally vertically polarised,
- at low receiving height the field strength with vertical polarisation is higher than with horizontal polarisation.

2. The polarisation of the installed rooftop antennas

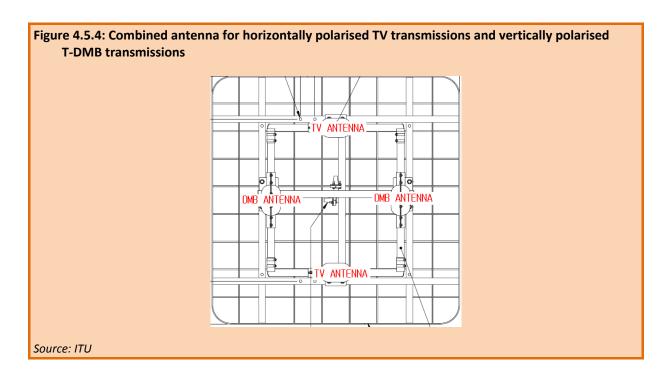
If rooftop antennas are installed on a considerable number of houses, the polarisation of these rooftop antennas (generally horizontal) should be used, otherwise many viewers have to modify their antenna installations.

3. The need to apply orthogonal polarisation between co-channel transmissions, in order to reduce interference (polarisation discrimination). However, orthogonal polarisation between high/medium power transmitting sites is not much used in practice³³⁷.

However, if existing transmitting antennas are used the polarization is given by that of the existing antenna (generally horizontally polarised).

If the existing polarization is not acceptable for DTTB or MTV services and there is no space on the mast for an additional antenna, double polarised antennas can be considered. In this case the antenna panel consist of two independent set of dipoles, horizontally polarised ones and vertically polarised ones. In practice, these kinds of antenna are offered in Band III, to combine horizontally polarised TV (analogue or digital) and vertically polarised T-DAB or T-DMB transmissions. For example, in Korea combined antennas provide horizontally polarised TV transmissions and vertically polarised T-DMB transmissions. A drawing of an antenna bay with horizontally and vertically polarised dipoles is shown in Figure 4.5.4.

lt should be noted that in the GE06 Agreement polarisation discrimination is taken into account (where appropriate) in case of fixed reception. With portable or mobile reception no polarisation discrimination has been taken into account.



Implementation guidelines

The choice of polarisation is guided by the polarisation of existing transmitting and receiving antennas. Table 4.5.4 summarizes the considerations for polarisation choice for transmissions in Band III or IV/V, where:

H is horizontal polarisation of the transmitting antenna.

V is vertical polarisation of the transmitting antenna.

Table 4.5.4: Polarization choice

Transmissions all sambined	Use of existing	Use of new transmitting antenna		
Transmissions, all combined into one antenna	transmitting antenna ^{a)}	Rooftop antennas in use a)	Almost no rooftop antennas in use	
DTTB multiplexes intended for fixed reception	Н	Н	Н	
DTTB multiplexes also intended for portable or mobile reception	Н	π	V	
Combination of DTTB multiplexes intended for fixed reception and MTV multiplex	Н	H ^{b)}	V	
Combination of DTTB multiplexes intended for portable or mobile reception and MTV multiplex	Н	H _{p)}	V	

a) assuming that existing antennas are horizontally polarised, if existing antennas are vertically polarised the choice is vertical polarisation for all indicated transmissions;

b) or a double polarised antenna (available for Band III) with MTV transmission in vertical polarisation.

4.5.3 Use of existing antennas or new antennas

When introducing DTTB or MTV services, for cost saving reasons, the aim will be to share the antenna already used for analogue TV services³³⁸. The antenna, designed for the analogue TV frequencies and powers on the site, is not necessarily optimal for DTTB or MTV transmissions (see Sections 4.5.1 and 4.5.2). In practice, use of existing antennas is not always possible or only with considerable restrictions to the DTTB or MTV services. In Table 4.5.5 a number of issues are indicated that should be considered when existing antennas are used for DTTB or MTV transmissions.

Table 4.5.5: Combination of several transmissions into one antenna

Attention point when using existing antennas for DTTB or MTV	Considerations
Impedance match at frequencies not close to the frequencies for which the antenna was designed	Digital television is less sensitive to impedance mismatch than analogue TV. Transmitter may require additional circulator to protect from reflected power due to mismatch.
Frequency depending radiation pattern	Coverage will different per frequency.
All transmissions have the same polarization	See Section 4.5.2
In case of directional antennas the attenuation will appear on all frequencies	Coverage of transmission with frequencies that require no attenuation is unnecessarily restricted
In case of non-directional antennas, no possibility for attenuations at one or more frequencies if so required	Transmitter power of transmission requiring attenuation in certain directions needs to be decreased with the value of the required attenuation. Coverage in directions where no attenuation is required is unnecessarily restricted
The maximum allowed power and voltage of the antenna is not exceeded	See Section 4.5.1

The choice between use of an existing antenna or a new antenna depends on the service trade-off between transmission costs, service quality and coverage quality described in Section 4.3.1. Emphasis on low transmissions costs tends to the use of existing antennas, while accepting restrictions in DTTB coverage and/or multiplex capacity. Emphasis on good coverage quality tends to the use of new antennas in case the issues mentioned in Table 4.5.5 would lead to restricted DTTB coverage.

The service trade-off could be different at various phases of DTTB introduction, examples are shown in Table 4.5.6.

In the case where an existing analogue TV or DTTB antenna is also used for MTV, similar considerations apply as indicated above with regard to DTTB. However, in the last two phases the combined DTTB/MTV antenna is either a compromise between DTTB and MTV coverage requirements, or is optimized for DTTB services and MTV coverage may not be optimal (see also section 4.7).

235

More information on the use of existing or new antennas is given in document EBU Tech Report 021, Terrestrial digital television planning and implementation consideration, third issue, Summer 2001; Section 8.

Table 4.5.6: Examples of practical situations regarding the use of existing antennas

DTTB introduction phase	Practical situation	Service considerations
Start of DTTB introduction	 Analogue TV on same site in operation DTTB frequencies may be in different part of the band than analogue TV frequencies at same site DTTB with restrictions in radiated power in some directions to protect analogue TV services (national and in neighbouring countries) No or limited space for new antenna 	 DTTB services restricted: Less optimal radiation pattern DTTB transmitter power reduced to comply with agreed restrictions
Switch-off of analogue TV stations for which restrictions have been agreed	 Analogue TV on the site in operation DTTB frequencies may be in different part of the band than analogue TV frequencies at same site No or limited space for new antenna 	 DTTB services less restricted: Less optimal radiation pattern DTTB transmitter power can be increased (if total permitted power and voltage of antenna is not exceeded)
Switch-off of analogue TV on the same site	 Existing antenna not needed anymore Aperture of existing antenna can be used for new antenna 	Optimal DTTB coverage with new antenna
End of technical lifetime of existing (analogue TV) antenna	Antenna needs to be replaced	Optimal DTTB coverage with new antenna

Implementation guidelines

Use of an existing antenna is possible if:

- 1. digital and analogue TV services have the same polarization;
- 2. the existing antenna, designed for transmission of the analogue frequencies of that site, will operate satisfactorily at the DTTB frequencies;
- 3. the horizontal radiation pattern satisfies any restrictions in the radiated power of the digital television which are needed to avoid interference into other services;
- 4. the vertical radiation pattern allows good portable and mobile reception near the site, if required;
- 5. the antenna system is capable of handling the total power of all services to be transmitted.

If one or more of these conditions are not fulfilled and cannot be resolved, for technical or regulatory reasons, a new antenna would be the preferred solution. If sufficient space (at the required height) is available on the mast, the new antenna can then be optimized for the digital services.

If sufficient space is not available, it could be considered to remove a half of the existing antenna and replace it by a new antenna for the DTTB or MTV services. In that case the ERP of the analogue services is reduced by 50 per cent assuming that a half of the existing antenna keeps the same horizontal radiation pattern and allows the same input power (the antenna gain is reduced by half and consequently reduced ERP). In case where the maximum allowable power of a half of the existing antenna is lower than the existing analogue transmitter power, the ERP should be reduced accordingly.

4.6 Network interfacing

Section 4.6 provides background information and guidelines on key topics and choices regarding network interfacing. The section consists of four sections each containing a subsection with implementation guidelines:

- 4.6.1 Interfaces with head-end.
- 4.6.2 Interfaces in the network.
- 4.6.3 Radio interfaces between transmitting station and receiving installations.
- 4.6.4 Interfaces between transmitter sites and network monitoring system.

A DTTB network consists basically of one or more head-ends, a distribution network and transmitter sites. A block diagram of a typical DTTB network is shown in Figure 4.2.1. The players involved in DTTB network operations are (see also section 1.1 and Figure 1.1.3):

- multiplex operator;
- service provider;
- content distributor.

In practice one organisation may encompass more than one role.

Satisfactory service delivery depends on the successful operation of all players involved. For a smooth hand-over of responsibilities it is needed that service level agreements (SLA) are made between the players involved regarding:

- signal availability;
- coverage;
- video and sound quality;
- compliance with the transmission standard and systems.

As part of the latter also interfaces need to be defined.

The network is interfaced with:

- the studio facilities that deliver video, audio and data signals;
- the receiving installation of the consumer via the radio interface;
- the network operations centre for monitoring and remote control of the network.

Furthermore in the network there are interfaces between the head-end and the distribution network.

4.6.1 Interfaces with head-end

Already with analogue TV more and more parts of the programme production facilities are becoming digital. Tapeless recording, digital archives and IP based production are common place in more and more studios. With the introduction of DTTB the whole broadcast chain will eventually be digital. A complete digital broadcasting chain, from programme production to the consumer, has major advantages, such as:

- the possibility to deliver higher quality services (including HDTV) and enhanced services (e.g. electronic programme guide, access services, interactive services);
- the avoidance of cascaded encoding and decoding processes with the inherent loss of quality.

At present not all studios can produce digital TV signals. For these studios it is possible to offer analogue TV signals to the head-end of a DTTB network. However, picture and sound quality tends to be less than it could be with a digital programme feed.

For studios with digital output signals, there are several possibilities to feed signals from the studio to the head-end:

Uncompressed video and audio, together with data

- The digital interface between the studio output and the encoder input is made using the serial digital interface (SDI)³³⁹ with a data rate of 270 Mbit/s. A related standard, known as high-definition serial digital interface (HD-SDI), has a nominal data rate of 1.485 Gbit/s. These standards are designed for operation over short distances with coaxial cable or optic fibre. Consequently encoders should be located on, or close to the studio premises.
- A service package consisting of a number of services (video, audio and data) MPEG encoded and multiplexed into a data stream (MPEG-TS³⁴⁰, B-TS or T2-MI) or a single service (video, audio and data) MPEG encoded. The interfaces are generally asynchronous serial interface, or ASI³⁴¹. It is electrically identical to an SDI signal and is always 270 Mbit/s. Sometimes Ethernet is used.

Satellite feed

In the case of remote studios or programmes from international content providers, the data stream could be transported via satellite links e.g. using the DVB-S (2) specification.

It should be noted that also the programme related data for establishing the electronic programme guide (EPG) should be delivered in the agreed format to the head-end.

Implementation guidelines

Full benefit of digital broadcast delivery is achieved if programmes are produced and distributed between the different production facilities and the MPEG encoders in digital format. The SDI/HD-SDI interface is recommended for use between studio facilities and the MEPG encoders. However, SDI/HD-SDI links are designed for short distances; therefore MEPG encoders should be located at, or close to the studio centre.

For interfacing with the MPEG-TS, the ASI interface is recommended.

4.6.2 Interfaces in the network

In the network the output signal of the head-end should be interfaced with the input of the transmitter.

The interface between the head-end and the modulation part in the transmitter depends on the transmission system. In case of ISDB-T the output of the head-end interfaces with the modulation part via the B-TS data stream. In case of ATSC, DVB-T and DTMB the head-end is interfaced to the modulation part in the transmitter via MPEG-2 Transport streams (TS). In DVB-T2 the multiplexer is first interfaced via MPEG-TS to the "T2-gateway". The latter part is interfaced to the modulation part in the transmitter via the T2-MI data stream.

Implementation quidelines

Between the different parts in the networks, interfaces should be used that are specified for the transmission standard in use³⁴².

The SDI interface for digital broadcasting is described in Recommendation ITU-R BT.656 Interfaces for digital component video signal in 525-line and 625-line television systems operating at the 4:2:2 level of Recommendation ITU-R BT.601 (Part A). Recommendation ITU-R BT.1120 specifies HD-SDI.

MPEG-TS is a communications protocol for audio, video, and data. TS is specified in MPEG-2 Part 1, Systems (ISO/IEC standard 13818-1). It is also known as ITU-T Rec. H.222.0.

ETSI TR 101 89, 1Digital Video Broadcasting (DVB); Professional Interfaces: Guidelines for the implementation and usage of the DVB Asynchronous Serial Interface (ASI), addresses interoperability issues specific to ASI data transmission links.

³⁴² See system specifications listed in the Bibliography of Recommendations ITU-R BT.1306 and 1877.

4.6.3 Radio interface between transmitting station and receiving installations

The radio interface could be described by field strength for a specified percentage of time and locations, or as the probability to obtain a satisfactory reception at a location (see also section 4.3 Network planning). In both cases also the receiving installation (receiver, receiving antenna) should be defined (see Section 4.2.2).

The description of field strength only takes into account:

- received signal from one transmitting site;
- reception quality in the presence of noise.

The description of reception probability is advised as it can take into account:

- received signals from more than one wanted transmitter in case of an SFN;
- reception quality in the presence of noise and interference.

In making service level agreements, sometimes there is a pressure (from lawyers) to guarantee a field strength or reception probability. It should be noted that field strength and reception probability cannot be guaranteed because factors are involved that are beyond control of the content distributor such as:

- time varying atmospheric conditions that affect the field strength level of wanted and interfering stations;
- local receiving conditions that affect the field strength level of wanted and interfering stations;
- changes of buildings on the propagation path;
- radiation characteristics of interfering stations;
- locally generated man made noise.

Predicted field strength and coverage probability, as described in section 4.3, are statistical values and therefore difficult to measure in practice at a given location and time. It should also be noted that all predictions have a limited accuracy. Coverage predictions can however be improved by correcting predicted results with measurement results.

For the sake of defining coverage probability as a radio interface, in principle, two situations can be predicted:

- 1. The coverage probability that will finally exist when all transmitters (wanted as well as interfering digital TV transmitters) are in operation and analogue TV switched off.
- 2. The coverage probability that will exist at the moment that a particular transmitter is taken into operation, without taking into account the transmitters in an SFN that become operational at a later stage and interfering stations that will be switched off or installed later.

The first case does not represent the coverage situation at the moment of introduction of a service and may not, therefore, be suitable as a tool for defining the radio interface as part of a service level agreement.

In the second case, information is needed about the actual status of analogue and digital TV transmitters in neighbouring countries (which may not be available). Furthermore the calculations need to be repeated after each change in the network.

Implementation guidelines

The recommended way to describe the radio interface is by means of reception probability.

Reception probability (and also field strength) should be predicted by means of adequate network planning software which includes, among others:

a reliable transmitter database (also from neighbouring countries);

- up-to-date terrain and clutter databases;
- propagation prediction models suitable for the country concerned and preferably corrected with results of field strength measurement for the most common types of terrain.

The parties involved should agree on the coverage assessment method (see also section 4.3).

4.6.4 Interfaces between transmitter sites and network monitoring system

Service contracts between content distributors and service providers normally contain provisions about the availability of the service. This could be expressed, for instance, as a percentage of time (measured over a long period) that the service should be on air or a maximum allowed time of interruptions. The service availability requirements could be variable for different parts of the day or for the kinds of programmes.

In order to avoid long service interruptions in case of maintenance or equipment failure, critical parts in the transmission chain should have a certain redundancy (see Section 4.2.6).

In addition to appropriate back-up equipment, an adequate equipment monitoring system is needed to identity equipment failures and alert maintenance staff. The actual operational status of equipment should be visible at a central monitoring centre through a few basic indicators (e.g. on/off, failure, prealarm). The Simple Network Management Protocol (SNMP)³⁴³ is a suitable remote control protocol by means of a web browser.

In practice, different ways are used for transmission of equipment status information e.g.:

Switched data link

If the status of equipment at a transmitting site changes, automatically a connection is made via public switched telephone network (PSTN) and the equipment status information is exchanged. If the operator requires further information, a PSTN data link is established to the transmitter site and the required information is sent to the operator. Also commands can be given by the operator e.g. for switching on a back-up transmitter.

Fixed data link via the distribution network

If the status of equipment at a transmitting site changes, an automatic message will be sent to the operations centre e.g. using the Ethernet standard. Also, information requests from the operator or commands to the transmitter site are made in this way.

Via public Internet or VPN on Internet

If the status of equipment at a transmitting site changes, an automatic message and data will be sent to the operations centre by either public Internet or via a VPN on the Public Internet. The Operations Centre can also access the equipment at the transmitter site to check on its health and performance, as well as bring up redundant units to operation.

Implementation guidelines

Modern equipment, including digital transmission equipment, allows remote control via SNMP and a web browser.

Simple Network Management Protocol (SNMP) is used in network management systems to monitor network-attached devices for conditions that warrant administrative attention. SNMP is a component of the Internet Protocol Suite as defined by the Internet Engineering Task Force (IETF).

4.7 Shared and common design principles

Section 4.7 provides background information and guidelines on key topics and choices regarding shared and common design principles between DTTB and MTV networks. The guidelines in this section might be useful even for the standards that provide in the same multiplex both services of fixed and mobile receptions (e.g. ISDB-T and DVB-T2-Lite). The section consists of two sections each containing a subsection with implementation guidelines:

- 4.7.1 Application of shared and common design principles.
- 4.7.2 Site and antenna sharing.

DTTB and MTV networks have different objectives and are likely to be different in:

- transmission standard;
- transmitter power;
- antenna radiation characteristics;
- net bit rate per multiplex;
- number of sites;
- coverage requirements;
- network roll-out.

Nevertheless, if design, planning and roll out of DTTB and MTV networks are carried out together or at least performed in a coordinated way, efficiency and synergy gains could be achieved by:

- sharing of sites and transmitting antennas;
- common use of the multiplex (multiplex sharing);
- simultaneous project and resource planning.

However, by doing so, compromises may have to be accepted in the performance of the DTTB services, the MTV services or both, because it is unlikely that the shared network elements have optimal characteristics for both the DTTB and MTV services.

It should be noted that similar considerations can also be made for:

- DTTB and T-DAB networks in Band III;
- MTV and T-DAB networks in Band III.

4.7.1 Application of shared and common design principles

In practice, shared and common design principles of DTTB and MTV networks will be considered in these cases:

- DTTB and MTV services are operated by the same organization;
- DTTB and MTV operators wish to obtain efficiency and synergy gains by cooperating;
- obligations are imposed by government, e.g. for site sharing.

Shared and common design principles of DTTB and MTV networks should preferably be considered as early as possible in the process of transition to DTTB and introduction of MTV as it may affect the two main trades-offs in network design and planning:

- 1. The trade-off between network roll-out speed, network costs and network quality, as described in Section 4.2.1.
- 2. The trade-off between transmission costs, service quality and coverage quality, as described in Section 4.3.1.

In making these trade-offs, it should be taken into account that:

- On the one hand, shared use and common activities will offer efficiency and synergy gains and consequently lower investment costs.
- On the other hand, the requirements of DTTB and MTV services may be so much different that roll-out schemes, multiplex capacity and coverage quality of DTTB services, MTV services or both do not comply with the business plan and service proposition.

The choices made with regard to shared and common design principles have also an impact on the activities related to other functional blocks, as illustrated in Figure 4.7.1 and Table 4.7.1.

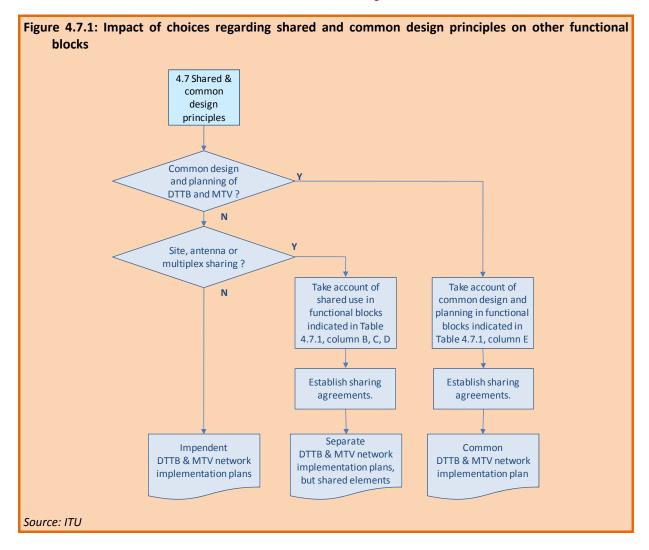


Table 4.7.1: Functional blocks and sections related to choices regarding shared and common design principles

A Related functional blocks	B Site sharing		C Antenna sharing		D Multiplex sharing		E Common design and planning	
	DTTB	MTV	DTTB	MTV	DTTB	MTV	DTTB	MTV
Design principles and network architecture	4.2	5.2	-	-	4.2	5.2	4.2	5.2
Network planning	4.3	5.3	4.3	4.3	4.3	4.3	4.3	4.3
System parameters	ı	ı	-	-	4.4	5.4	4.4	5.4
Radiation characteristics	4.5	4.5	4.5	4.5	-	-	4.5	4.5
Transmitting equipment availability	ı	-	4.8	5.8	-	-	4.8	5.8
Network roll-out planning	_	-	_	_	_	_	4.9	5.9

Site and antenna sharing is further described in Section 4.7.2.

Multiplex sharing takes place when hierarchical modulation is used. Examples are OneSeg in the ISDB-T system and Multiple Physical Layers Pipes in the DVB-T2 system (see also Section 4.4.2).

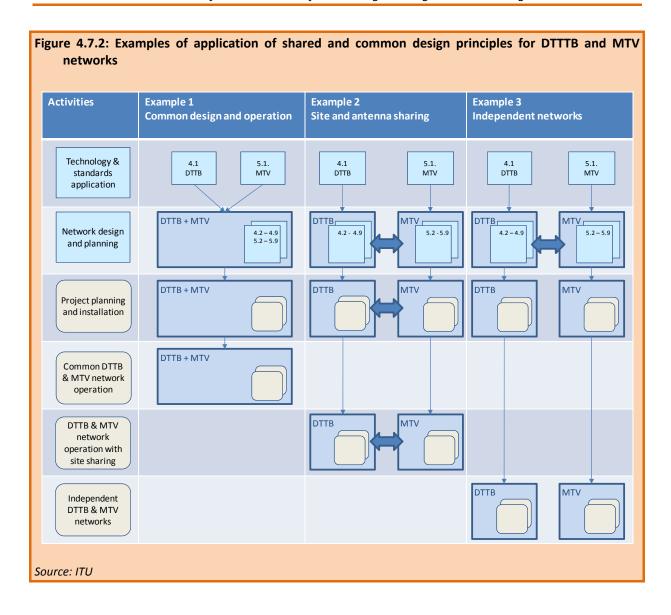
Implementation guidelines

Figure 4.7.2 shows three practical examples of the activities, in various phases of network implementation, for different degrees of application of shared and common design principles:

- 1. DTTB and MTV are operated by the same organization and a maximum benefit will be obtained from shared use of the network and common use of resources;
- 2. DTTB and MTV are operated by different organizations who wish to use site sharing and antenna sharing as much as possible;
- 3. DTTB is operated by a broadcast network operator and MTV is operated by a mobile operator and both operators use their own existing sites (TV sites and mobile base stations respectively), in which case shared and common design principles are limited to avoiding interference.

The symbols used in Figure 4.7.2 have the following meaning:

Functional building blocks described in these Guidelines. Numbers in the blocks refer to functional building block numbers in Figure 1.1.1 in section 1.1 and to the corresponding sections.
Non-specific DTTB or MTV main activity
 Sequence
Coordination between activities



In the first example, after the technology choices have been made, all further activities for DTTB and MTV are carried out together. In this way, optimal choices for site sharing and antenna sharing (and possibly multiplex sharing) will be achieved (see also Section 4.7.2). Efficiency and synergy gains will also be achieved in project planning, resource planning and site acquisition because:

- DTTB and MTV network planning, project planning and site acquisition can be done simultaneously by the same teams of experts;
- network roll out and installation can be done simultaneously by the same teams of experts.

Furthermore DTTB and MTV transmitters from the same supplier can be used with the advantage of:

- price discounts that may be achieved because of the higher volume accounts;
- fewer spare parts in stock are required;
- easier in maintenance.

Finally the DTTB and MTV networks will be operated and maintained together by using the same monitoring system and by the same team of experts.

In the second example the DTTB and MTV networks are operated separately, but coordination between the operators takes place by establishing site and antenna sharing agreements covering among others:

- fees for using facilities of the other operator;
- access to sites for installation and maintenance;
- priorities in using limited space in buildings and masts;
- information exchanges regarding intended future use, installations and antenna characteristics.

As MTV networks may consist of a higher number of sites than DTTB networks and consequently not all DTTB and MTV transmissions are co-sited, adjacent channel and masking interference may occur. The masking may occur in the presence of very high field strength regardless of channels, even if the adjacent channel protection ratio is satisfied due to overloading of the receiver. In these cases also coordination between the operators is needed to resolve the interference (see Section 4.7.2).

A further step in a coordinated approach could be that e.g. the MTV licence holder contracts the DTTB operator for network planning, project planning, installation or maintenance.

In the third example DTTB and MTV networks are designed, planned, projected and installed separately and the operators use different sites. However, coordination between the operators is needed in order to resolve adjacent channel or masking interference (see Section 4.7.2).

4.7.2 Site and antenna sharing

Site sharing has the advantage that existing facilities (building, power supply, monitoring system, distribution links, reserve equipment, mast and antenna) can be shared by DTTB and MTV services. Even in the case that shared use is not decided yet, in designing transmitting stations it is recommended to take into account future extensions of transmission equipment (DTTB or MTV). Later extensions may risk generating high costs as existing equipment and facilities become redundant and have to be replaced.

However, site and antenna sharing may involve a compromise between the economic advantages of common use of facilities on the one hand and limitations in the choice of technical characteristics on the other hand, in particular the use of a common antenna. If a common antenna is used for DTTB and MTV services it should be taken into account, regarding both the DTTB and MTV frequencies, (see also Section 4.5.3) that:

- impedance match should be satisfactory;
- the radiation pattern is frequency dependent and should be acceptable;
- polarization is the same, where different polarizations for DTTB, if aimed at fixed reception and MTV may be preferred;
- in case of directional antennas, the attenuation will appear on all frequencies, whereas different antenna patterns may be required for DTTB and MTV services; consequently the maximum radiated power on either DTTB or MTV transmissions may have to be reduced in order to comply with the required radiation restrictions;
- in case of non-directional antennas, there are no possibilities for attenuation, if so required;
- the maximum allowed power and voltage of the antenna is not exceeded;
- the vertical radiation pattern (null-fill and beam down tilt) is the same, whereas for MTV more null-fill and more beam tilt may be required than for DTTB.

DTTB and MTV antenna requirements may differ so much that coverage of DTTB or MTV service would be restricted too much if a common antenna were used. A separate antenna may be considered in that case. However available space on the mast or the mechanical strength of the mast may not allow an additional antenna or only an antenna with limited aperture and thus limited gain.

Alternatively, consideration could be given to replacing the existing antenna by a combined DTTB/MTV antenna e.g.:

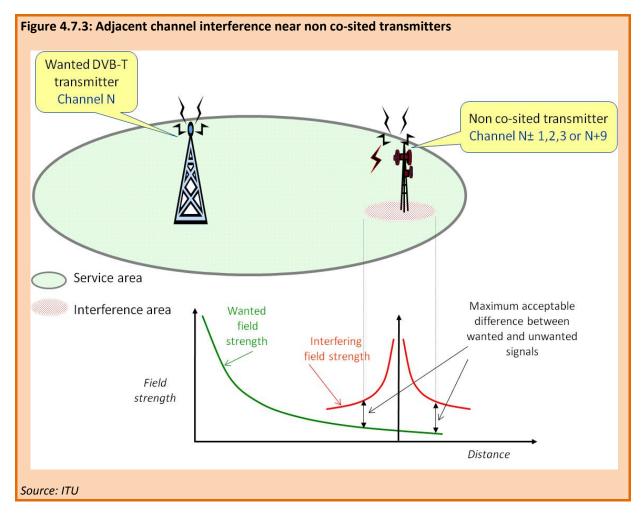
- A double polarized antenna, which consists of panels with sets of horizontally polarized dipoles and sets of vertically polarized dipoles. These types of antennas are applied in Korea where in Band III, horizontally polarized TV transmissions and vertically polarized T-DMB transmissions make use of the same physical antenna (see also section 4.5, Figure 4.5.4).
- A multi pattern antenna, with each frequency having its own pattern, while using the same physical antenna. These types of antenna are more expensive than single pattern antennas due to power splitters, additional combiners and additional antenna cables.

Before making a decision on the common use of antennas, the trade-off between transmission costs, service quality and coverage quality, as described in Section 4.3.1., should be analysed carefully.

An additional advantage of site sharing is the avoidance of interference zones around the sites due to adjacent channel or masking interference. This type of interference may occur around non co-sited stations and use of:

- 1. limited frequency separation, e.g. the first, second or third adjacent channels on both sides of the wanted channel; or
- 2. the image channel.

This situation is illustrated in Figure 4.7.3. The interference would occur where the difference of the field strength of wanted signal and interfering signal exceeds adjacent channel protection ratio or where the input voltage to a receiver exceeds the overload limit.



It should be noted that the non-co-sited transmitter could be a DTTB or MTV transmitter, but also a mobile base station (if mobile services are allocated in or near Band III, IV or V). Even mobile terminals could cause adjacent channel interference at short distances around the terminal.

Adjacent channel or masking interference can be resolved or limited by the measures indicated in Table 4.7.2.

Table 4.7.2: Measures to resolve adjacent channel or masking interference

Measure to reduce adjacent channel interference	Disadvantage
Cross polarization	Only effective in case of fixed reception
Power reduction and antenna adjustment of interfering transmitter	Reduction of coverage of interfering transmitter
Adequate frequency separation	Other frequency (not being N±1,2,3 or image channel) needed
Fill-in transmitter (in SFN on channel N) to cover interference area	Costs

In practice, site sharing may be complex when different network operators make use of the site. Priority rules have to be established for use of limited space in buildings and masts and clear agreements have to be made regarding responsibilities, costs and maintenance for use of common equipment. In a number of countries governments have regulations for site and antenna sharing.

Implementation guidelines

For economic and technical reasons it is advantageous to take into account (as far as possible) the requirements of all DTTB and MTV networks in the preparatory, planning and implementation processes. If not all requirements are known, e.g. if MTV networks will be licensed and implemented at a later stage, at least provisions for future extensions may be implemented such as:

- space in design and layout of transmitter buildings;
- capacity of the power supply;
- margin in peak voltage and average power of transmitting antennas;
- transmitting antennas with broadband radiation characteristics.

4.8 Transmission equipment availability

Section 4.8 provides background information and guidelines on key topics and choices regarding transmission equipment availability. The section consists of two sections each containing a subsection with implementation guidelines:

- 4.8.1 Market research.
- 4.8.2 Technical specifications.

A DTTB network consists basically of one or more head-ends, a distribution network and transmitter sites (a block diagram of a typical DTTB network is shown in Figure 4.2.1). When existing sites are used, some transmission equipment may be reused for DTTB, some equipment may need to be expanded and some new equipment needs to be installed. Table 4.8.1 lists the main digital transmission equipment units in a DTTB network and indicates if equipment installed for analogue TV transmissions can be reused or not.

In addition to the transmission equipment listed in Table 4.8.1, ancillary equipment is needed such as power supply, cooling, monitoring and control system, which needs to be expanded.

Availability of transmission equipment is considered in this section in relation to the following activities:

- specification of technical characteristics of the transmission equipment in the DTTB implementation plan;
- verifying if the specifications can be met by equipment that is normally available on the market;
- drafting specifications for tenders to purchase equipment.

Table 4.8.1: Transmission equipment

Transmission equipment unit	Related guidelines	Possible re-use of analogue TV equipment
Head-end	4.2.5	Not present in analogue TV; needs to be installed.
Distribution network	4.2.7	Not recommended.
Transmitters	4.5.1	Possible to adapt certain types of analogue TV transmitters. It is likely that new DTTB transmitters are needed because, during transition, analogue TV transmitters continue to be operational and in most cases more DTTB frequencies are available at a site than analogue TV frequencies
Combiner	4.5.1	Needs to be expanded, retuning may be necessary. Appropriate filtering is needed to comply with the required spectrum mask.
Antenna	4.5.1 4.5.2 4.5.3	Reuse depends on the considerations given in section 4.5 including the maximum peak voltage and average power specifications.
Mast	4.5.1 4.5.3	Mast space and mechanical specifications may limit the possibilities for mounting new antennas.

4.8.1 Market research

A large range of DTTB transmission equipment is available on the market from many manufacturers³⁴⁴. Market research of the availability of transmission equipment is important in order to get an impression of:

- practical ranges of transmitter power and antenna gain;
- technical specifications;
- operational data, such as mean time between failures (MTBF);
- warranty conditions, including delivery of spare parts in case of failure;
- services regarding installation, repair and maintenance;
- training facilities;
- price indications;
- delivery times.

For instance at the exhibitors list of IBC,

<u>www.ibc.org/page.cfm/action=ExhibList/ListID=1/t=m/goSection=6</u>, suppliers of delivery equipment and many other types of equipment, can be selected.

In general, all suppliers offer transmission equipment that can be configured to all television standards in use, including analogue TV. Transmitter powers range from less than 1 Watt to more than 10 kW.

Transmitter cooling is in general realized by:

- air cooling for transmitter powers up to 1 to 3 kW;
- liquid cooling for transmitters powers of 1 to 3 kW or more.

Liquid cooling has the advantage of a smaller footprint and less acoustic noise.

Transmitters can be delivered for installation in a transmitter building and air cooled type of transmitters also in compact outdoor shelters.

In order to avoid long service interruptions in case of maintenance or equipment failure, transmitters should have a certain redundancy (see also Section 4.2.6). If several transmitters are used at a site, an n+1 back-up configuration is often used. If a site accommodates one or two transmitters it may be appropriate to install a double driver unit. The RF power amplifier consists, in general, of several units, thus providing a built-in redundancy. Furthermore, network operators often keep in stock at a central place a few critical units, e.g. driver units.

Transmitting antennas can in general be distinguished in four types as shown in Table 4.8.2.

Antenna type **Application** Panel Arrays of several panels per tier, to achieve directional or non-directional patterns Horizontal and vertical polarization Suitable for triangular, square and round towers or masts Turnstile or Excellent unidirectional pattern super-turnstile Horizontal polarization Suitable for top mounting, mast diameter in centre of antenna should be small relative to the wavelength Cost effective Yagi Directional pattern Horizontal and vertical polarization Light weight Low power transmissions Special purpose Examples antennas Centre fed collinear antenna, narrow band, vertical polarization, top mounting Indoor relay antennas **Dual polarization antennas**

Table 4.8.2: Transmitting antenna types

Examples of antenna gains of practical (non-directional) antenna systems for high and medium power stations are shown in Table 4.8.3.

Table 4.8.3: Examples of antenna gains (non-directional) for high and medium power stations

Band	Туре	Number of tiers	Gain relative a dipole	Antenna height
Ш	Panel	1 to 8	About 2 to 15 dB	About 1.2 to 25 m
III	Super turnstile	2 to 16	About 4 to 13 dB	About 3 to 24 m
IV/V	Panel	2 to 16	About 9 to 18 dB	About 2.2 to 18.5 m
IV/V	Super turnstile	2 to 16	About 7 to 16 dB	About 2.2 to 18 m

Implementation guidelines

A first impression of equipment specifications can be obtained from datasheets that can be downloaded from the equipment supplier's websites. Furthermore, a number of manufacturers can be asked to supply information or quotations based on the operational requirements and required redundancy.

It may also be useful to visit large broadcasting shows like the NAB Show in Las Vegas or the IBC in Amsterdam. At these shows, most transmission equipment suppliers are present and, in a short period, a number of them can be visited and detailed information can be obtained about the equipment.

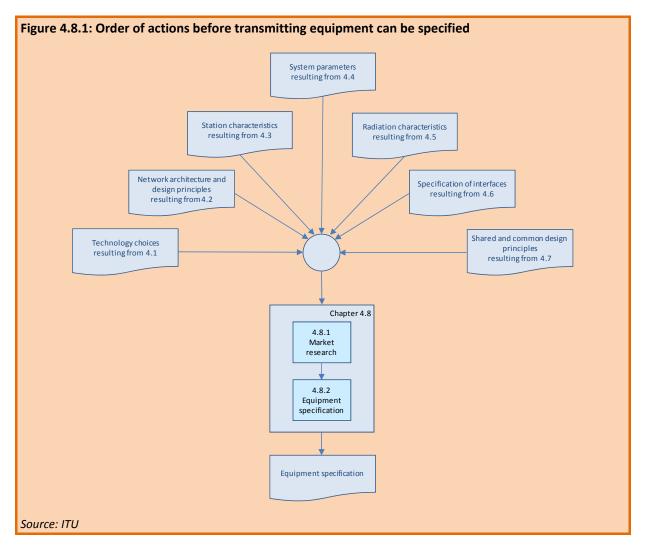
4.8.2 Technical specifications

All transmission equipment should comply with the choices made resulting from the application of the guidelines described in the following sections (see also Figure 4.8.1):

- 4.1 Technology and standards application;
- 4.2 Design principles and network architecture;
- 4.3 Network planning;
- 4.4 System parameters;
- 4.5 Radiation characteristics;
- 4.6 Network interfacing;
- 4.7 Shared and common design principles.

The choices on system parameters, resulting from the application of the guidelines in section 4.4, are mainly included to specify the system variants for which the various transmitters have to be adjusted. In principle, it is not necessary to specify the system variant in the specifications for purchasing equipment, because all transmission equipment should be able to operate on all system variants of the chosen transmission standard.

Equipment specifications of several suppliers, obtained in the market research, can be compared to check the state of the art of the equipment and get an impression of the characteristics that could normally be expected.



Implementation guidelines

The main elements for the specification of transmission equipment are listed in Table 4.8.4.

Table 4.8.4: Main elements for specification of transmission equipment

Main elements of transmission equipment specifications	Related Guidelines	Remarks
Transmission standard and systems	4.1.3 4.1.4 4.1.5	Transmission standard, compression system and conditional access system (if needed) need to be specified with reference to appropriate international specifications
Operational requirements	4.2.3 4.2.4 4.3.2 4.3.3 4.3.4 4.5.1 4.5.2 4.7.2	Operational requirements include the number of multiplexes, number of transmitter and re-multiplexing sites, transmitter powers, antenna characteristics, site and antenna sharing requirements, SFN/MFN, number and type of fill-in transmitters

Main elements of transmission equipment specifications	Related Guidelines	Remarks
Monitoring and remote control	4.2.6	Operational status of equipment should be visible at a central monitoring centre through a few basic indicators (e.g. on/off, failure, pre-alarm).
Required redundancy configurations	4.2.6	Active parts in the transmission chain should always have a certain redundancy, either a back-up system e.g. in n+1 configuration, or a built-in redundancy.
Interfaces	4.6.1 4.6.2 4.6.4	The interfaces between the network and the studio and the interfaces between parts of the network need to be specified with reference to appropriate international specifications
Specifications supplied by manufacturers	4.8.1	In general it is not necessary to specify equipment in detail. A number of manufacturers can be asked to supply information or quotations based on the operational requirements and required redundancy. In some cases it may be arranged to perform tests at the premises of the manufacturer.

4.9 Network roll-out planning

Section 4.9 provides background information and guidelines on key topics and choices regarding network roll-out and planning. The section consists of three sections, each containing a subsection with implementation guidelines:

- 4.9.1 Technical tests.
- 4.9.2 Implementation plan.
- 4.9.3 Information to end consumers.

The objective of network roll-out planning is to establish a network implementation plan, taking account of regulatory, commercial and technical provisions.

4.9.1 Technical tests

Before introducing operational DTTB services, technical tests are often carried out in order to assess video and audio quality versus required bit rates by subjective quality evaluation tests and to verify the technical performance of the network and to demonstrate DTTB services. Technical tests can be set up as a temporary arrangement, to be dismantled when the tests have been carried out. It can also be a permanent setup, meant as prelaunch of DTTB services. In the latter case, modifications or adjustments may be made depending on the tests results.

For all kinds of tests it is important to:

- specify the precise objectives (which questions should be answered by the tests);
- to prepare test protocols;
- to allocate sufficient resources (budget and staff), because test equipment is expensive and tests are labour intensive.

Five kinds of test can be identified:

- subjective quality evaluation tests;
- 2. coverage measurements;
- 3. site test;
- receiver tests;
- demonstrations.

These tests are described below.

Subjective quality assessments

Subjective quality assessment tests could be carried out to estimate required bit rate of a transmission channel that satisfies quality requirements of the assumed services (e.g. number of multiplexed programmes, SDTV, HDTV).

There are several methods for video quality evaluation; among them the subjective methods recommended by the ITU (see the overview in Table 4.9.1).

Table 4.9.1: ITU-R Recommendations and Report regarding picture quality assessment

ITU-R recommendation	Title
Recommendation ITU-R BT.500-13	Methodology for the subjective assessment of the quality of television pictures
Recommendation ITU-R BT.710-4	Subjective assessment methods for image quality in high-definition television
Recommendation ITU-R BT.802-1	Test pictures and sequences for subjective assessments of digital codecs conveying signals produced according to Recommendation ITU-R BT.601
Recommendation ITU-R BT.1129-2	Subjective assessment of standard definition digital television (SDTV) systems
Recommendation ITU-R BT.1210-4	Test materials to be used in assessment of picture quality
Recommendation ITU-R BT.2022	General viewing conditions for subjective assessment of quality of SDTV and HDTV television pictures on flat panel displays
Report ITU-R BT.2245	HDTV test materials for assessment of picture quality

In specifying tests the following attention points should be regarded:

- a. Test conditions should be clearly defined and only one aspect should be tested at the same time. The ITU-R Recommendations and Report listed in Table 4.9.1 give guidance for specifying the tests.
- b. The optimal viewing area in front of a screen is rather limited. In case of tests with groups, parallel screens and associated seats should be installed taking into account the viewing distance (see in particular Recommendation ITU-R BT.2022).
- c. Verification tests and demonstrations should be carried out by using:
 - critical scenes; test material from the ITU test scenes, referred to in Recommendation ITU-R
 BT.802-1 and Report ITU-R BT.2245 could be used;
 - selections of typical national TV programmes.

d. The source material should be of studio quality. Source material that has already been encoded and transmitted should not be used, because the quality is limited by the encoding of the original source and the transmission may cause artefacts in the received picture. Furthermore cascaded encoding results in a loss of quality.

Coverage measurements

The objective of coverage measurements is to verify, e.g.:

- field strength prediction models in order to adjust parameters in the prediction model to the local environment;
- planning criteria, in order to adapt some of the criteria, e.g. field strength standard deviation, or minimum required field strength values with an envisaged system variant under noisy and multi-path conditions;
- indoor reception, e.g. to achieve better understanding of field strength distribution in a room, or to determine building penetration loss values in the local situation;
- portable or mobile reception in areas with many extreme high buildings;
- reception in single frequency network (SFN);
- field strength values if needed for commissioning of services.

Indoor measurements are very time consuming. A statistically relevant number of measurements need to be done in different types of buildings and at different locations in a room. Obviously, permission is needed from the inhabitants to enter the premises and to carry out the measurements.

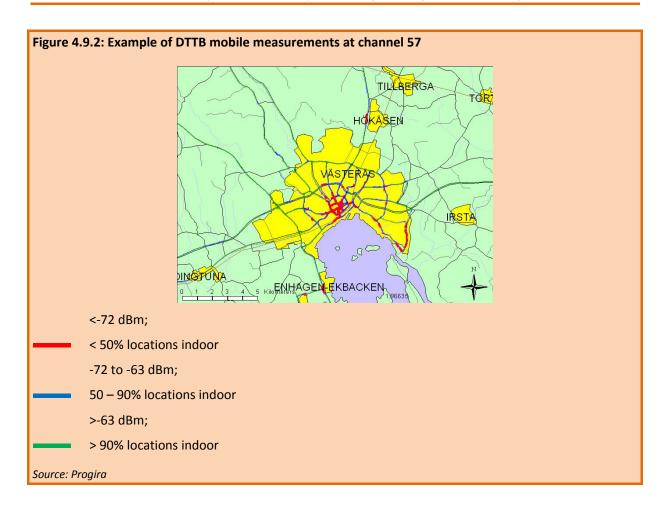
Figure 4.9.1 gives an impression of a field strength measurement set up in a living room.

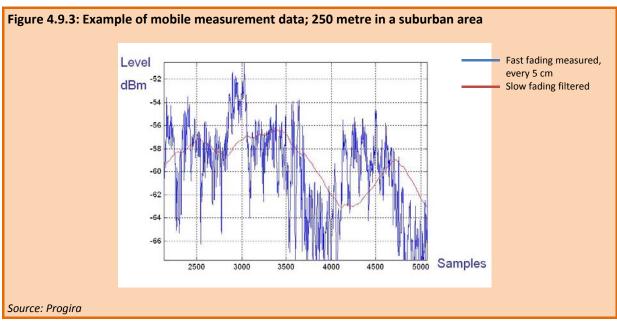


Source: Nozema

Instead of very time consuming indoor measurements, often operators content themselves with outdoor mobile measurements³⁴⁵, with a correction factor added to present indoor reception. An example of results of mobile measurements, corrected for indoor reception, is shown in Figure 4.9.2 and 4.9.3.

Mobile measurements are described in more detail in Section 5.9.2.





Site tests

The objectives of site test could be to check if transmission equipment operates within the specifications, e.g.:

- modulation Error Rate (MER) and carrier to noise ratio (C/N);
- radiation characteristics;
- SFN synchronization and timing.

The antenna performance is an important element in the radiation characteristics. However antenna measurements are complex and expensive. Some operators carry out helicopter measurements to verify horizontal and vertical antenna patterns. Figure 4.9.4 shows an antenna measurement by helicopter. With these types of measurements all TV frequencies at the site are measured in one flight.

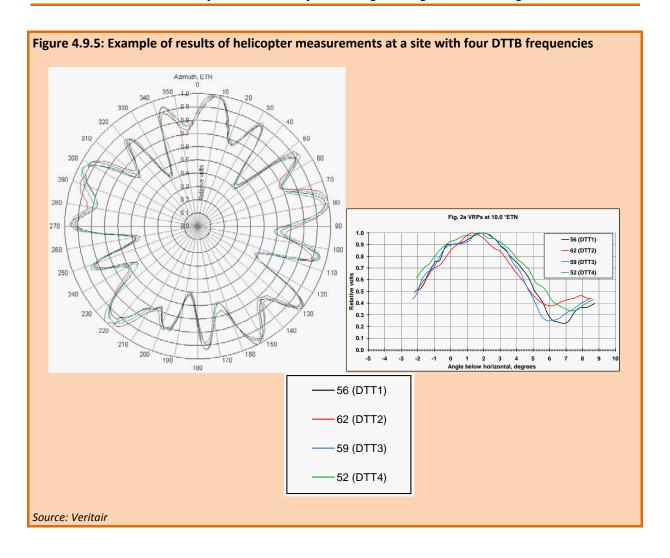


An example of results of helicopter measurements is shown in Figure 4.9.5.

On the left hand side of Figure 4.9.5 the measured horizontal antenna diagram on each of the four frequencies at the site is shown. On the right hand side the measured vertical antenna diagram at one of the bearings with a maximum in the horizontal pattern (in the example 10°) has been plotted as function of the angle below horizon.

The results of helicopter measurements can be used:

- to check if the antenna pattern is within the specifications and as basis for discussion with the supplier if this is not the case;
- as input for detailed coverage assessment calculations.



Receiver tests

The objectives of receiver tests could be to verify, e.g.:

- RF performance (including SFN synchronization);
- service information (SI) and programme specific information (PSI) performance;
- system software update (SSU);
- conditional access (CA), if required.

The service provider could recommend using receivers that passed these tests successfully.

Demonstrations

Objectives of demonstrations could be, e.g.:

- To verify acceptability of the service proposition³⁴⁶:
 - picture and sound quality;

The information related to audience research and analysis regarding MTV described in Section 5.9.3 is to a great extend also relevant to DTTB services.

- services bouquet;
- ability of viewers to adjust their receiving installations.
- To promote DTTB services with, e.g.:
 - politicians and officials;
 - key persons in the broadcast industry;
 - journalists;
 - local dealers.

Technical tests and demonstrations have very different purposes and should not be mixed. Before starting demonstrations the correct technical performance of the network should be guaranteed.

Implementation guidelines

Before DTTB services become operational it is essential to perform technical tests and to check service performance under different operational conditions.

When DTTB services are introduced for the first time in an area, it is recommended to succeed the technical test with service demonstrations to familiarize market parties, including local dealers of terminal equipment, with the service performance.

Furthermore, technical tests are recommended after each change in the multiplex to check if most used receiver types in the market perform as expected.

4.9.2 Implementation plan

The network implementation plan should take account of:

- obligations imposed by the regulator;
- commercial decisions expressed in the business plan and service proposition;
- technical choices made in dealing with other functional blocks related to DTTB networks.

A summary of obligations, decisions and choices that are important to roll out planning are indicated in Table 4.9.2.

Table 4.9.2: Obligations and choices determining roll-out planning

Functional blocks to be taken into account	Reference	Elements for roll-out planning
Licence terms and conditions	2.6	Roll-out timing and coverage obligationsFrequency availability during and after transition
ASO planning and milestones	2.14	Analogue switch-off dates per areaMinimal simulcasting periods
Receiver availability considerations	3.2	Agreements with receiver manufacturers and local dealers about time, quantities and types timing of receivers available for sale
Business planning	3.4	Commercial roll-out priorities regarding areas and timing
Design principles and network architecture	4.2	 Roll-out speed, as a trade-off between networks costs and network quality Regional and national services
Network planning	4.3	List of station characteristics and coverage presentations in different implementation phases, before and after ASO
Transmission equipment availability	4.8	Delivery times

In addition account should be taken of operational conditions such as:

- resources and capacity of the content distributor;
- time periods for acquiring new sites;
- limitations in the use of existing facilities (site, mast, antennas);
- time periods in which sites have limited access or working circumstances are unfavourable, due to weather conditions;
- minimal service interruptions.

The above mentioned obligations, choices and conditions could be conflicting in some cases and interim solutions may be necessary. The choice for interim solutions is also a trade-off between roll-out speed, network costs and network quality, as described in Section 4.2.1. Some examples of interim solutions are:

- delayed introduction of DTTB services in some areas;
- temporary transmitting equipment (e.g. transmitter or antennas) at some sites;
- temporary sites;
- reduced coverage.

The implementation plan generally consists of several phases. Two main phases are:

- DTTB implementation before analogue TV switch-off;
- DTTB implementation and modifications to already existing sites after analogue TV switch-off.

In addition to both main implementation phases, sub-phases could be planned for introduction of DTTB stations, taking account of e.g.:

- regional areas;
- areas covered by one SFN;
- population distributions;
- type of station (e.g. main stations, fill-in transmitters).

In an implementation phase the following steps can be identified:

- test transmissions:
- communication to end consumers;
- putting DTTB site into operation.

Implementation guidelines

The roll out plan should be made on the basis of:

- 1. Obligations from the regulator given in:
 - licence terms and conditions:
 - ASO planning and milestones.
- Commercial decisions given in:
 - service proposition and business plan;
 - agreements with receiver manufacturers and dealers.
- 3. Technical choices made regarding:
 - design principles and network architecture;
 - network planning;
 - transmission equipment availability.

Any remaining freedom left in planning roll-out is often used to satisfy practical considerations. Examples of such practical consideration are:

- Main sites implemented first and fill-in transmitters implemented last, however with priority given to areas where people live or work that have a great influence in the media world (politicians, journalists, regulators, managers of other players in the value chain).
- Combining DTTB equipment installation with already planned transmitter or antenna replacements.
- Start of DTTB introduction at a site close to the headquarters of the content distributor. The first DTTB introduction is likely to require more attention than further DTTB introductions when experience has been gained. A site close to the headquarters is therefore more efficient.
- Preceding operational DTTB services by a relatively long test period to obtain sufficient time for testing and have flexibility in allocating resources to testing.
- Installations requiring relatively long service interruptions during periods in which TV watching
 is limited (night time, holiday periods), and avoiding periods with major sports or national
 events.

4.9.3 Information to end consumers

The DTTB implementation plan has to take into account many different obligations, commercial and technical choices and operational considerations. The resulting plan is often very complex and is likely to consist of several phases. Furthermore DTTB service quality may be different in the various phases of introduction. End consumer support, as described in section 3.5 is therefore essential.

End consumer support should be based on realistic data concerning coverage, service quality and implementation schedules. These data should be made available as part of the network implementation plan.

In the transition from analogue to DTTB several network elements that have a direct impact on reception will change. Consequently, the consumer may have to adjust, modify or replace parts of the receiving installation in order to receive all DTTB services with good quality. Changes to receiving installations that may be necessary in the transition to DTTB are listed below.

- 1. Retuning of the receiver resulting from:
 - frequency changes (of analogue TV or DTTB transmissions);
 - introduction of new DTTB multiplexes;
 - installation (or removal) of fill-in transmitters.
- 2. Installation of improved receiving antennas (more gain or antenna amplifier), because:
 - DTTB frequencies are in another part of the UHF band than analogue TV frequencies, or change of frequency of existing DTTB services to a frequency outside the bandwidth of the receiving antenna;
 - the DTTB transmitting antenna has (temporary) restrictions;
 - the system variant is changed to a less robust one with higher capacity;
 - the receiving location is situated in an area with internal SFN interference;
 - new DTTB multiplexes with frequencies outside the bandwidth of the current antenna.
- 3. Replacement of the receiver or set-top-box because:
 - introduction of DTTB services requires a DTTB set-top-box (STB) or integrated digital TV set (IDTV);
 - transmission system is changed and, or presentation format is changed to e.g. HDTV;
 - compression system is changed e.g. from MPEG2 to MPEG4.

- 4. Antenna adjustment as a result of changing to another azimuth bearing to improve reception of the transmitter after:
 - installation (or removal) of fill-in transmitters;
 - installation of new DTTB sites.

Communications tools used in practice are:

- websites;
- telephone helpdesks;
- advertisements in newspapers, magazines, radio and TV;
- road shows organized by the service provider;
- information from local dealers (who have to be well informed in advance);
- information channels in the DTTB multiplex;
- information on teletext.

The application of these communication tools will depend on the practical situation and the access consumers have in general to these means of communication.

Much of the guidelines on communication on ASO (see section 2.15) are also valid for communication on DTTB introduction and changes in DTTB networks.

The basis for the information to consumers is the detailed coverage assessments resulting from network planning (see section 4.3). These data have to be converted to presentations that suit the different means of communication.

An example of a website in Sweden is shown in Figure 3.5.3 in Section 3.5.3.

Implementation guidelines

Introduction of DTTB services is likely to be very confusing for the end-consumer. Information to the consumer is therefore essential regarding:

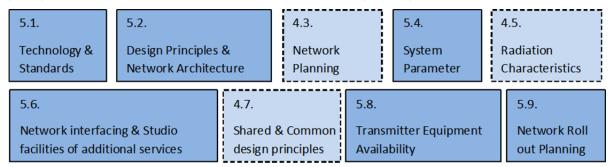
- changes in the network and reception possibilities of each multiplex in the various phases of introduction;
- information and help about modifications to receiving installations that have to be made in order to have good DTTB reception.

The various players in the value chain (see Figure 1.1.3 in section 1.1) have different responsibilities and different needs for communication with the end consumer. Very clear agreements have to be made between the various players about the information that is communicated to the consumers. Confusing or even conflicting information should be avoided. The best solution is one central point for communication.

Part 5 – MTV networks

Introduction

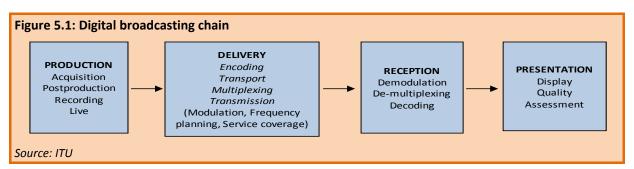
MTV networks are represented by layer D in the functional framework for the Guidelines (section 1.2). The functional building blocks related to MTV networks are shown below. Because of the similarity of the issues, guidelines regarding network planning, radiation characteristics, and shared and common design principles are covered in Part 4 in sections 4.3, 4.5, and 4.7 respectively.



Choices regarding the above mentioned functional building blocks should be made in such a way that the licence conditions are fulfilled and that the business objectives are met. In doing so, optimum solutions should be found between requirements regarding picture and sound quality, coverage quality and transmission costs. Some of these requirements may often be conflicting.

Some of the issues regarding technology choices, frequency planning and network planning may also be relevant to regulators, depending on the roles and responsibilities of the regulator and network operator in a country.

The broadcasting chain³⁴⁷ is illustrated in Figure 5.1 to get a better understanding of this layer. The figure includes four main conceptual blocks, namely the production block, the delivery block, the reception block and the presentation block.



Part 5 of these Guidelines addresses mainly the delivery block, but the impact on the other conceptual blocks of the broadcast chain is also indicated.

5.1 Technology and standards application

MTV offers the viewers innovative media services. MTV services are attracting considerable attention worldwide and are expected to add another dimension to television viewing, particularly in the mobile and portable environment. Viewers can enjoy MTV services anywhere and anytime through various types of receivers such as handheld, portable and vehicle-mounted.

262

See Report ITU-R BT. 2140 Transition from analogue to digital terrestrial broadcasting; Part 1, section 1.8.2, The digital broadcasting chain.

Currently there are many MTV standards in use; T-DMB, ISDB-T_{mm}, CMMB, etc³⁴⁸. Since detailed technical specifications of these standards are explained in the relevant reference materials, these Guidelines will deal with only the key factors necessary for MTV introduction.

Recommendation ITU-R BT.1833 deals with nine standards for mobile service of which two are satellite systems and the other seven are terrestrial systems. The major features of the five standards currently in use are listed below (taken from the Recommendation):

- Multimedia system "A" (T-DMB): This system, also known as terrestrial digital multimedia broadcasting (T-DMB) system, is an enhancement of T-DAB system to provide multimedia services including video, audio, and interactive data services for handheld receivers in a mobile environment. Multimedia System "A" uses T-DAB networks and is completely backward compatible with T-DAB system for audio services. The Advanced T-DMB (AT-DMB) system is an enhancement of T-DMB system to increase channel capacity of T-DMB and is completely backward compatible with T DMB system.
- Multimedia system "B" (ATSC Mobile DTV): This system, also known as ATSC Mobile DTV, is an enhancement of the ATSC system to provide multimedia services including video, audio, and interactive data service delivery to small (power efficient) receivers, for fixed, handheld and vehicular environments. Multimedia System "B" uses IP-based mechanism with control of time synchronized delivery via buffer modelling for an end-to-end broadcast system including enablement of a return path to facilitate delivery of any type of digital content and service.
- <u>Multimedia system "C" (ISDB-T OneSeg)</u>: The stream signal of this system can be multiplexed with the signal for the fixed reception that coexists within a single stream. And rich content format such as script programme support provides good interactivity on a small device.
- Multimedia system "F" (ISDB-T_{mm}): This system is designed for real time and non real-time broadcasting of video, sound, and multimedia content for mobile and handheld receivers based on the common technology of multimedia System C (ISDB-T). High quality video, audio, and multimedia data services can be configured flexibly. In addition, support of a script interpreter for rich content format provides flexibility for the content and service.
- <u>Multimedia System "T2"</u>: An end-to-end broadcast system for delivery of multimedia broadcasting signal to handheld devices based on PLP (physical layer pipes) concept with T2 time slicing technology. This system is designed to optimize and sufficiently improve efficiency of multimedia broadcasting system in trade-off between system parameters such as C/N performance, bit-rate, receiver complexity, etc. enables the simulcasting of two different versions of the same service, with different bit-rates and levels of protection, which would allow better reception in fringe areas.

The objective of this section is to provide information for selecting appropriate technologies for optimized MTV networks and MTV services. One of the main activities is to review and compare basic technologies and characteristics of systems for MTV services, as follows:

- comparison of MTV standards;
- selection of an MTV standard in accordance with national requirements as well as conforming to national and international regulations;
- guidance for formation of services and channels;
- case studies of MTV services in some countries;

Recommendation ITU-R BT.1833 Broadcasting of multimedia and data applications for mobile reception by handheld receivers.

- review of encryption system (if needed);
- review of types and systems for additional services such as EPG (electronic programme guide),
 BIFS (binary format for scene), interactive services, etc.

Composition of the MTV service bouquet has to be determined before the actual selection of a transmission standard and its particular system variant. The MTV channel service package, which may or may not be independent of the transmission standard chosen, is established as a part of programme production and head-end set up process. This is due to the MTV payload capacity considerations as these are not the same in all the available system standards. The choice of the MTV channel structure (or service bouquet) has an impact on the broadcast delivery process, and the choice in the delivery process is of great importance for the MTV services.

Worldwide MTV standards³⁴⁹ use generally similar compression systems. The systems related to compression and encryption are, in principle, independent of transmission standards. However, a number of systems for additional services are standard dependent.

The choice of system elements such as MTV channel structure and payload size, transmission standard, encoding system, conditional access system and systems for additional services, etc. should be made within the framework of relevant legislation and regulations (see section 2.1, 2.3, 2.4, 2.6). Their selection should also be made within the framework of market and business development decisions (see section 3.4). In addition, the framework of shared and common design principles (see section 4.7) may be used for co-location of MTV transmission station infrastructure with the DTTB facilities. However, the optimum network configuration and infrastructure for some MTV coverage areas may not coincide with that of the DTTB services, particularly in high density urban coverage areas.

The following sections give guidelines for the review and comparison of the basic technologies and the characteristics of the systems for MTV services.

5.1.1 Comparison of MTV Standards

To date, MTV has been implemented in many countries in all regions and the transmission standards have proven their performance in practice. However, there are distinct differences between these transmission standards in technical performance and in frequency management. Therefore, it is desirable to perform technical evaluation tests, not only in laboratories but also in actual use "in the field" in the country concerned, to select or investigate a transmission standard.

Research on technical factors should be conducted before selecting an MTV standard, or determining its system parameters, as described in the following text. Analysis of deployment of MTV in countries that have already introduced such services should also be conducted in a similar manner.

- Research on technical options of each standard such as channel bandwidth, modulation techniques, applicable compression modes and so on. Various technical documents on these subjects have been released from relevant organisations such as ITU, EBU, ABU, DVB, WorldDMB, ARIB, ETRI, DMB Forum, EU, etc.
- Understanding on the requirements/environment specific to each country (e.g. frequency usability, channel demand, indoor reception, indoor relay transmission and single frequency network (SFN) operation).
- Making a comparison table of features and technical characteristics of MTV standards (e.g. T-DMB, ISDB-T OneSeg, ISDB-T_{mm} and DVB-T2 Lite). This can help to distinguish the features specific to each standard.

-

³⁴⁹ See footnote 2

Implementation guidelines

In addition to the technical characteristics, service and channel requirements are important issues in selecting an MTV standard and these should be included in the items to be compared.

Table 5.1.1 shows typical values of the main characteristics of T-DMB, DVB-T2 Lite and ISDB- T_{mm} / OneSeg implementations.

Table 5.1.1: Main characteristics of some MTV standards

Items	T-DMB /AT-DMB ³⁵⁰		DVB-T2 Lite ³⁵¹	ISDB-T _{mm}
Frequency	Band-III (174-240MHz)		Band-IV/V (470- 862MHz)	Band III for ISDB-T _{mm} Band IV/V for OneSeg
Bandwidth	1.536 MHz (3-Multiplexs in 6MHz)		1.7/5/6/7/8/10 MHz	Any combination of 1, 3 and 13 segments; bandwidth of a segment are 0.429, 0.5 and 0.571 MHz respectively for 6, 7, and 8 MHz system
Bit-rate availability ¹⁾	1.728~5.184 Mbit/s at 6MHz (0.576~1.728 Mbit/s*3 MUX)	B mode: 2.592~6.912 Mbit/s at 6MHz (0.864~2.304 Mbit/s*3MUX) Q mode: 3.456~8.640 Mbit/s at 6MHz (1.152~2.880 Mbit/s*3MUX)	Approx. 15-17 Mbit/s at 6MHz Max of 4 Mbit/s per PLP	8.1 Mbit/s at 6 MHz
Modulation	DQPSK	DQPSK / B mode: BPSK over DQPSK / Q mode: QPSK over DQPSK	QPSK / 16QAM / 64QAM	DQSPK / QPSK / 16QAM / 64QAM
Number of channels (bit-rate: 384Kbps) ²⁾	9 channels at 6MHz	B mode: 6~18 channels at 6MHz (2~6 channels*3MUX) Q mode: 9~21 channels at 6MHz (3~7 channels*3MUX)	Up to 11 channels per PLP	21 channels at 6MHz
Transmission mode	Eureka-147 Stream Mode (OFDM)		OFDM	OFDM
Channel coding and error correction methods	Reed-Solomon Coding (204,188 T=8), Convolution Interleaving	Reed-Solomon Coding (204,188 T=8), Basic Layer: Convolution Interleaving Enhanced Layer: Turbo Interleaving	LDPC in combination with a BCH code	Inner code: convolutional code, mother rate 1/2 with 64 states. Puncturing to rate 2/3. 3/4, 5/6. 7/8 Outer code: RS (204, 188, T=8)
Required C/N ³⁾	9.6dB at 120km/h		depending on modulation/code rate applied	depending on modulation/code rate applied

AT-DMB: Advanced T-DMB which provide existing T-DMB plus more high quality services (and bigger screen) by introducing hierarchical modulation technology, TTAK.KO-0070, Specification of the Advanced Terrestrial Digital Multimedia Broadcasting(AT-DMB) to mobile, portable, and fixed receivers.

www.tta.or.kr/English/new/standardization/eng_ttastddesc.jsp?stdno=TTAK.KO-07.0070

 $^{^{351}\,}$ Data has been obtained from the DVB (www.dvb.org)

Items	T-DMB /AT-DMB ³⁵⁰	DVB-T2 Lite ³⁵¹	ISDB-T _{mm}
Video service format	Video: MPEG-4 Part 10 AVC (H.264)	Video: MPEG-4 Part 10 AVC (H.264), VC-1 (optional)	Video: MPEG4 Part-10 AVC (H.264)
	Audio: MPEG-4 Part 3 ER-BSAC	Audio: AAC+, AC-3	Audio: AAC+
	Additional data: MPEG-4 BIFS Core2D Profile	Additional data: OMA BCAST	Storage type service:
Audio service format	MPEG 1/2 Layer 2 (MUSICAM)	HE AAC v2 AMR-WB+	MPEG2 AAC + SBR + PS, Surround MPEG4 ALS/SLS (option)
	AAC+		
	Visual-radio: the same as video service format exception the video frame-rate(2-5 frame/sec)		
Data service format	MP4 file, JPEG, PNG, MNG, BMP, etc. ASCII text, etc.	3GP and MP4 file, JPEG, GIF, PNG Character encoded (3GPP timed text) or bitmap	
Particular national requirements (for example)4)	Frequency availability: Yes/No (whether or not)	Frequency availability: Yes/No (whether or not)	Frequency availability: Yes/No (whether or not)
	To meet the required channels: Yes/No	To meet the required channels: Yes/No	To meet the required channels: Yes/No
	To meet the required indoor reception rate: Yes/No	To meet the required indoor reception rate: Yes/No	To meet the required indoor reception rate: Yes/No
	To meet the required coverage under their unique conditions: Yes/No	To meet the required coverage under their unique conditions: Yes/No	To meet the required coverage under their unique conditions: Yes/No
	To meet the required spill over issues: Yes/No	To meet the required spill over issues: Yes/No	To meet the required spill over issues: Yes/No

- 1) For an easy comparison, 6 MHz bandwidth is equally applied to each standard.
- 2) In practice, a variety of bit-rates is applied to video services. For an easy comparison, 384 kbit/s at 6 MHz bandwidth are equally applied. If a different bit-rate or bandwidth is applied, the number of channels will change.
- 3) Since each standard provides many options for modulation and code rate, the figures are shown³⁵² with the modulation/code rate applied. The figures are also shown with RF frequency, environment of the service area, etc.
- 4) ATSC-M/H (Advanced Television Systems Committee Mobile/Handheld) is a standard in the USA for mobile digital TV which allows TV broadcasts to be received by mobile devices³⁵³. ATSC-M/H is an extension to the available digital TV broadcasting standard ATSC A/53. The ATSC transmission scheme is not robust enough against doppler shift and multipath radio interference in mobile environments. To overcome these issues, additional channel coding mechanisms are introduced in ATSC-M/H to protect the signal.

 $^{^{352}\,}$ Refer to EBU-TECH 3317 'Planning parameters for hand held reception'.

³⁵³ From Wikipedia http://en.wikipedia.org/wiki/Mobile_digital_TV#Digital_TV

The above table can give an approximate comparison between standards with regard to the technical performance and state of play in the relevant countries. With addition of items that are of interest to the relevant countries, it is possible to analyse in more detail for selecting a standard as described in the next section (5.1.2).

5.1.2 Selection of MTV standard

To select an MTV standard, decision makers (regulators, broadcasters, other stakeholders, etc.) have to consider many aspects such as technology, frequency spectrum, multiplex capacity, content, cost, viewers, receivers and capability of extension in the future. Among these, technology³⁵⁴ and financial³⁵⁵ aspects are to be thoroughly reviewed and considered. Table 5.1.2 compares three MTV standards from these aspects:

Table 5.1.2: Comparison of some MTV standards

Items	T-DN	1B/AT-DMB	DVB-T2 Lite ³⁵⁶	ISDB-T _{mm}	Remarks
Frequency character	Band III		Band IV/V Even when the specification will be used predominantly for UHF services, it can also be used in other frequency bands. The 1.7 MHz mode is foreseen for L-Band applications	Band III, IV/V	Free space loss: Band III < Band IV/V T-DMB: advantage for large coverage
Frequency allocation	With DAB		With DVB-T2 or independent	Independent (able to coexist with DTTB)	T-DMB: advantage for countries that have already allocated Band III for DAB services
Bit-rate usability	3.5 Mbit/s at 6 MHz	B mode: 2.592~6.912 Mbit/s at 6MHz (0.864~2.304 Mbit/s*3MUX) Q mode: 3.456~8.640 Mbit/s at 6MHz (1.152~2.880 Mbit/s*3MUX)	Approx. 15-17 Mbit/s at 6MHz Max of 4 Mbit/s per PLP	8.1 Mbit/s at 6 MHz	DVB-T2 LITE /ISDB- T _{mm} : advantage for countries that want many services

EBU doc. Tech. 3327, Network aspects for DVB-H and T-DMB EBU, April 2008. EBU doc. Tech. 3317: Planning parameters for hand-held reception EBU, July 2007.

EBU trev-299: What's the difference between DVB-H and DAB, July 2004 / EBU trev-305: Broadcasting to handhelds, January 2006 / EBU trev-305: An economy analysis of DAB & DVB-H, January 2006.

³⁵⁶ Data has been obtained from the DVB.

Items	T-DN	IB/AT-DMB	DVB-T2 Lite ³⁵⁶	ISDB-T _{mm}	Remarks
Number of channels	9 channels at 6 MHz	B mode: 6~18 channels at 6MHz (2~6 channels*3MUX) Q mode: 9~21 channels at 6MHz (3~7channels*3 MUX)	11 channels per PLP	21 channels at 6 MHz	DVB-T2 LITE /ISDB- T _{mm} : advantage for countries that want multi-channel services
Requirement of content supply	Low		High	High	T-DMB: advantage for countries that have low capability for content supply
Construction cost for production facility	Low		High	High	T-DMB: advantage for countries that have low budget for facility construction
Construction cost for transmission facility	Low		Low when DVB-T2 network is already available	High	
Needs of viewers	To meet the	core needs	To meet the various needs	To meet the various needs	
Kinds of receivers	Variety		Limited	Variety	T-DMB: phone, car, laptop, handheld, USB, PDA, PMP, and STB.
Price of receivers	Cheap			Low cost	T-DMB: scale of economy of chip set and module, competition among the manufacturers
Business model	Variety		Variety	Variety	
Capability of extension	AT-DMB ³⁵⁷				AT-DMB technologies finished technical test and are preparing the new services.

⁻

AT-DMB: Advanced T-DMB which provide existing T-DMB plus more high quality services (and bigger screen) by introducing hierarchical modulation technology, TTA.KO.0070, Specification of the Advanced Terrestrial Digital Multimedia Broadcasting(AT-DMB) to mobile, portable, and fixed receivers.

Implementation guidelines

Technical issues are very important factors in the selection of an appropriate MTV standard; however technologies used in the above standards are already verified by many technology trials and the results of such trials are available in many papers³⁵⁸. The use of these technologies has also been verified through commercial services in many countries. Therefore, the decision makers may compare advantages/disadvantages of the standards based mainly on their national environment and conditions, and requirements such as frequency spectrum availability, investment budget, coverage, business plans and viewers' needs.

For example, a country which requires coverage of relatively large areas with limited capability of content supply may be recommended to select T-DMB, whereas a country which requires smaller coverage areas with high population densities and has plentiful programme content may be recommended to select DVB-T2 Lite. A country which wants to introduce MTV services simultaneously with DTTB at a low incremental cost is recommended to select ISDB-T OneSeg. Similarly, a country requiring flexibility in combination of services (e.g. different services for hand-held reception and vehicle reception) may be recommended to select ISDB-T_{mm}. Application of multiple standards or hybrid method (e.g. use of DVB-T2 Lite in main cities and T-DMB in rural areas), though feasible, will actually depend on the national/business requirements, but this method requires new types of receivers that can receive the signals of both the systems.

In summation, selection of an MTV standard depends on the situation of a country and requirements of the business plan rather than only the technical superiority of the relevant systems.

5.1.3 Formation of services and channels

An MTV multiplex provides various configurations of services, each of which could comprise several channels of video, audio, data, etc. depending on the broadcaster's service plan. Each of the channels is allocated appropriate bit-rates according to target quality of the service. The examples are shown in Table 5.1.3.

 $^{^{358}\,}$ EBU doc. Tech. 3327, Network aspects for DVB-H and T-DMB EBU, April 2008

EBU doc. Tech. 3317, version 2: Planning parameters for hand-held reception, concerning the use of DVB-H and T-DMB in Bands III, IV, V and 1.5 GHz. EBU, July 2007

ETSI TR 102 377 Digital Video Broadcasting (DVB); DVB-H Implementation Guidelines, Nov 2005

ETSI EN 302 304 Digital Video Broadcasting (DVB); Transmission System for Hand held Terminals (DVB-H)

ETSI TS 102 428 Digital Audio Broadcasting (DAB); DMB video service; User Application Specification

ETSI EN 300 401 Radio broadcasting systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers

Table 5.1.3: Typical MTV standard characteristics

Standard	Service	Channels (bit-rate: kbit/s)			Remarks	
Standard	Service	Video	Audio	Data	Remarks	
	Case-1	VC-1 (460) VC-2 (460)	AC (112)	DC-1 (64) DC-2 (56)	Audio: minimal visual radio data: BWS, EPG	
T-DMB (1152 kbit/s at 1.536MHz)	Case-2	VC-1(472)	AC*3 (384)	DC-1 (96) DC-2 (72) DC-3 (128)	AC*3: enhanced visual radio DC-1: BWS / DC-2: EPG DC-3: enhanced TPEG	
	Case-3	VC-1(496) VC-2(496)		DC-1 (64) DC-2 (96)	Video: added BIFS Data: TPEG, BWS and EPG	
AT-DMB (2304 kbit/s at 1.536MHz)	B-mode	VC-1(640) VC-2(640 VC-3(640)	AC-1(112) AC-2(112)	DC-1 (32) DC-2 (32) DC-3 (96)	VC: VGA class AC: minimal visual radio DC-1: BWS / DC-2: EPG DC-3:TPEG	
AT-DMB (2880 kbit/s at 1.536MHz)	Q-mode	VC-1(460) VC-2(460) VC-3(460) VC-4(460) VC-5(460) VC-6(460)		DC-1 (64) DC-2 (56)	VC: QVGA class DC-1: BWS DC-2: EPG	
ISDB-T _{mm} (Typical 8.1 Mbit/s at 6MHz)		A number of combinations of video, audio and data services are possible. Different payloads with different degrees of protection can be employed in the same multiplex. Any combination of 1, 3 and 13 segments is possible.				
DVB-T2 Lite (Approx 15 -17 Mbit/s at 6 MHz)		A number of combinations of video, audio and data services are possible. Different payloads with different degrees of protection can be employed in the same multiplex. This is subject to the total available bit rate. Also subject to the maximum bit rate of 4 Mbit/s for each PLP.				

Note: The acronyms used in Table 5.1.3 have the following meaning:

VC: Video Channel / AC: Audio Channel / DC: Data Channel

TPEG: Transport Protocol Experts Group

BWS: Broadcast Web Site

EPG: Electronic Programme Guide
ESG: Electronic Service Guide

BIFS: Binary Format for Scene description

Implementation guidelines

After selecting the MTV standard (and its system variant), broadcasters have to decide the services they want to provide within the available multiplex capacity. Factors to be considered when deciding the complement of services:

- desired services;
- desired number of channels in each service;
- types and numbers of pay services;

- types and numbers of interactive services;
- target quality (screen size, audio mode, complexity of BWS and depth of TPEG service etc.);
- target reception environment (e.g. handheld, portable, vehicular, indoor portable etc)
- target viewers (demographic, region, etc.);
- needs of viewers (contents, fee and schedule, etc.);
- outline of business models;
- capability of content supply;
- human resource for operating the services;
- facilities necessary for the services etc.

Broadcasters should decide on the setting up of services and channels taking into account the above factors. Setting up of services and channels is a key decision in the provision of successful MTV services in determining whether or not the MTV service is able to include all the viewers' needs.

5.1.4 Case studies of MTV services

MTV services with T-DMB standard are in commercial service in several countries, including Korea Republic, Ghana, Norway, and China. Those with ISDB-T standard are in commercial service in Japan, Brazil, and several South American countries. These Guidelines will highlight two major case studies for different standards respectively from Korea³⁵⁹ (for T-DMB) and Japan (for ISDB-T).

The two countries were chosen because:

- these countries have started commercial services since 1 December 2005 in Korea and 1 April 2006 in Japan respectively;
- these countries have many subscribers, channels and receivers;
- these countries have considerable experience in free-to-air services, pay services, and additional services, as well as audience consumption behaviour.

T-DMB in Korea

Under the EUREKA-147 DAB system, audio services using the MPEG-1/2 audio layer 2(MUSICAM), data services closely related to audio services (PAD: programme associate data), and data services independent of audio services (NPAD: non-programme associate data) are all possible. T-DMB enhances EUREKA-147 to deliver video services by applying MPEG-4 technology to the EUREKA-147, even in a moving vehicle. Moreover, it upgrades the data service specification of EUREKA-147 DAB and adds new data services' technologies such as Binary Format for Scene description (MPEG-4 BIFS), traffic and travel information service (TPEG), disaster warning broadcasting technology (enhanced EWS³⁶⁰; emergency warning system), conditional access technology (CAS) and combines the technology of broadcast and mobile telecommunication networks.

www.tta.or.kr/English/new/standardization/eng ttastddesc.jsp?stdno=TTAK.KO-07.0046/R2

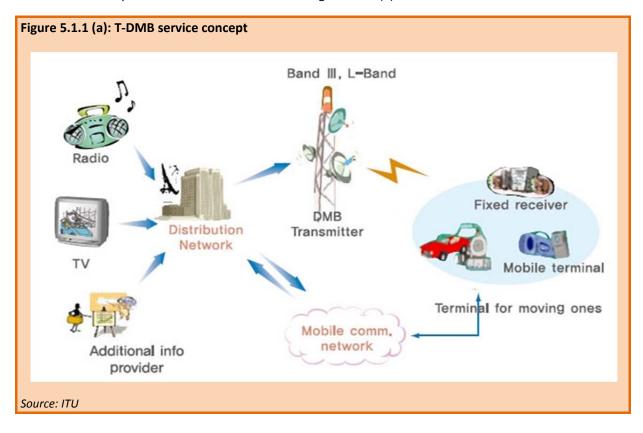
http://eng.t-dmb.org/, http://dmb-alliance.org/

TTAS.KO-07.0046/R2, Interface Standard for Terrestrial Digital Multimedia Broadcasting (T-DMB) Automatic Emergency Alert Service

As an enhancement to the T-DMB system, the AT-DMB system was developed. The technical tests of the latter technology have been completed satisfactorily and currently preparations for new services are underway.

Service concept of T-DMB

The service concept of T-DMB services is shown in Figure 5.1.1 (a)



Technology parameters

The main technology parameters used in Korea are:

- Frequency: Band-III (174-216 MHz);
- Bandwidth: 1.536 MHz;
- Guard Interval: 246us;
- Modulation Mode: QPSK (Quadrature Phase-Shift Keying);
- Transmission Mode: Eureka-147 Stream Mode;
- Video service format;
 - Video: H.264 | MPEG-4 Part 10 AVC (advanced video coding) baseline profile, level 1.3;
 - Audio: MPEG-4 Part 3 ER-BSAC (bit sliced arithmetic coding);
 - Additional Data: MPEG-4 BIFS Core2D Profile;
- Audio Compression: MPEG 1/2 Layer 2 (MUSICAM) / AAC+;
- Multiplex: MPEG-4 over MPEG-2, MPEG-4 SL (Sync Layer), MPEG-2 TS (PES);
- Channel Coding: Reed-Solomon Coding (204,188), Convolution Interleaving;
- Required BER (Bit Error Rate) performance: under 10⁻⁸.

Services

Main features of the services are:

- launch date: 1 December 2005;
- business model: free-to-air service (TPEG and EPG in data channel are pay services);
- coverage: nationwide (including all subways in metropolitan area).

A summary of the services offered in Korea is shown in Table 5.1.4.

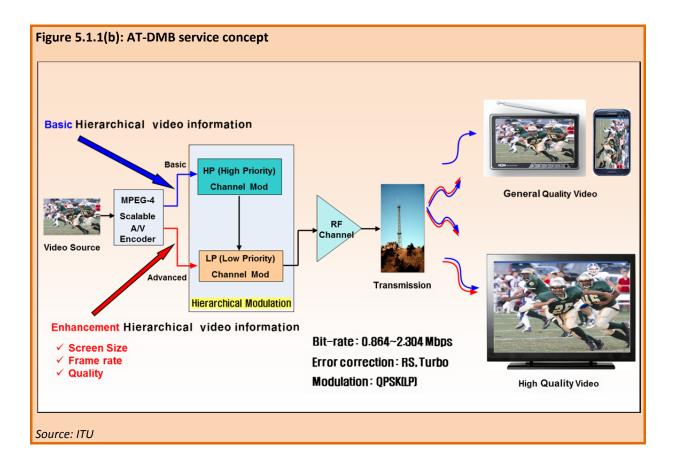
Table 5.1.4: Summary of T-DMB services in Korea

Broadcasters (EID)	Block (Freq.: MHz)	Video(14-channels) (bit-rate: kbit/s)	Audio(5-channels) (bit-rate: kbit/s)	Data (13-channels) (bit-rate: kbit/s)
		U1 (384)		
U1 Media	8A (181.280)	U1 PLUS (384)		U1-BWS (32)
(U1 DMB)		MBN (352)		
		mYTN (432)	TBN (128)	4DRIVE (128)
YTN	00 (403 000)			NBEEN (64)
(YTN DMB)	8B (183.008)	WOW-TV (352)		Broad&tv (16)
				DGPS (32)
		QBS (424)		
Korea DMB (QBS)	8C (184.736)	tvN go (352)		QBS Data (24)
(QB3)		#Love tbs (352)		
МВС	124 (205 200)	MY MBC (512)	MADO DADIO (130)	MBC TPEG (128)
(MBC DMB)	12A (205,280)	MBC every1 (352)	MBC RADIO (128)	MBC BWS (32)
		KBS STAR (432)		UKBS-TTI (32)
	KBS (U-KBS) 12B (207.008)	KDC LIEADT (422)	KBS MUSIC (128)	KBS TPEG (128)
(U-KB3)		KBS HEART (432)		KBS AEAS (FIDC)
SBS	126 (200 726)	SBS(u) (440)	SBS V-Radio (96)	SBS ROADi (128)
(SBS(u))	12C (208.736)	SBS CNBC (344)	Arirang Radio (128)	SBS DGPS (16)

Receivers

A wide variety of receivers is available in the Korean market: 41-manufacturers, 760-kinds, 34 million-devices (June 2010).

In addition, AT-DMB has completed the technical test, standardization and trial service. Broadcasters will be able to use AT-DMB to implement more channels and/or enhanced quality than existing T-DMB. Figure 5.1.1(b) shows the concept of AT-DMB service.



ISDB-T in Japan

Two kinds of MTV are in commercial service in Japan; OneSeg with ISDB-T standard and "NOTTV" with ISDB- T_{mm} standard. OneSeg services are carried out by most of DTTB multiplexes (129 in total) as a part of free-to-air DTTB. The "NOTTV", a mobile multimedia broadcasting service, has launched on 1 April 2012, features of which are indicated below.

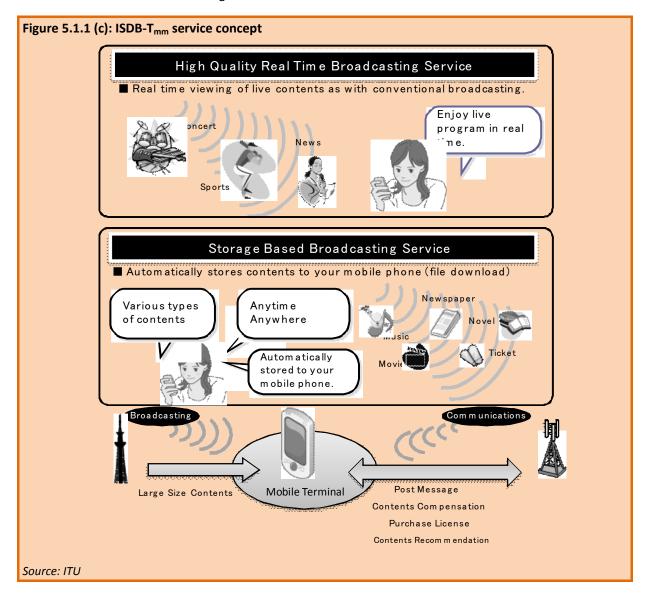
General

- Coverage: Japan (60 per cent of households as of April 2012, more than 90 per cent by 2017).
- Service launch date: 1 April 2012.
- Business model: combination of Free-to-air, pay-tv, and pay-per-view.
- Numbers of services: 3.
- Tariffs: JPY 420 (approx. USD 4) per month for basic programming; JPY 100 to 1 000 for pay-per-view programming.

The "NOTTV" enables access to contents without caring about broadcast schedule or place of use, by combining DTTB with telecommunications on the premise of the use of mobile receivers. As shown in Figure 5.1.1 (c), there are two types of multimedia broadcasting:

- high-quality real-time broadcasting (conventional broadcasting using video, audio, data, or combination of these elements); and
- 2) storage-based broadcasting in which the receiver stores various types of contents composing of video, audio, images, texts, data, or combination of these elements.

The system provides coordinated broadcasting and communications services in such a way that large size contents are transmitted through broadcasting channels while licence purchase, contents recommendation and message posting is through communications channels, as shown in the bottom picture in Figure 5.1.1 (c). In the storage-based service, when a receiver fails to receive some portion of the content over the broadcasting channel due to poor reception conditions etc., the remaining portion of the content can be obtained through the telecommunication channel.



Technical parameters

- Transmitters: 126 transmitters with power ranging from 75 W to 25 kW covering 90 per cent of Japanese households.
- Frequency band: 207.5-222 MHz.
- ISDB- T_{mm} parameters: FFT = 8k; Modulation 16QAM; code rate = 1/2; Guard Interval = 1/8; MPE-FEC = 3/4; Time interleaving = 0.4 sec.
- Amount of bandwidth: 14.5 MHz (33 segments).
- Video and Audio format: H.264/AAC+I.
- Interactivity platform.
- Conditional access/DRM type: Compas.

Other case studies

Information on some case studies on some of the other standards is included here.

Please refer to the proposal for Annex D

DVB-T2 Lite

In July 2011, BBC commenced trial transmissions of DVB-T2-Lite in West London. The objective was to evaluate the DVB-T2 Lite profile. The new T2-Lite profile is designed to make use of some features of DVB-T2 and with a careful selection of a sub-set of modes, it allows for receivers to be implemented using much smaller and more efficient silicon chips. This enables T2-Lite to efficiently deliver TV and radio to mobile devices such as phones and tablets (for which power consumption is an important issue) and incar at the same time as providing services to existing fixed receivers. An objective was to find out how this technology may play a part in delivering content to an ever-growing 'mobile audience' 1361.

In early 2013, one of the first mobile TV trials started based on DVB-T2 Lite profile. Being conducted in the Copenhagen area, the three year trial covers around 700,000 households. The increasing popularity of tablet devices has created demand for linear TV viewing on smaller screens and this has led to an increased interest in mobile TV.

The trial consists entirely of DVB-T2 Lite TV and radio channels carried on up to 16 PLPs. Each of these can be regarded as a separate data-pipe with its own bit-rate and robustness characteristics, a feature of the system standard.

Calculations show that configured in this manner, a DVB-T2 Lite multiplex can match the data-rate offered by a DVB-T one and yet still offer good mobile reception (unlike DVB-T as generally configured). These figures are provided for an 8 MHz channel.

Reception mode	Standard	Multiplex capacity	Standard	Multiplex capacity
Fixed reception	DVB-T	20 – 22 Mbit/s	DVB-T2	37 – 40 Mbit/s
Mobile reception	DVB-H	10 – 13 Mbit/s	DVB-T2 Lite	20 – 25 Mbit/s

The difference between the DVB-T2-base multiplex data-rate (generally up to around 40 Mbit/s) and that of a DVB-T2 Lite mux data-rate (20-25 Mbit/s) is explained by the fact that the PLPs within the latter are configured to be much more robust for mobile reception purposes. The PLPs are thus run at lower bitrates (a maximum of 4 Mbit/s per PLP when DVB-T2 Lite is used).

It is estimated that it would be possible to build a mobile T2 broadcast network with the same capacity as DVB-T (around 20-25 Mbit/s) and twice the capacity compared to a DVB-H multiplex. This means that DTTB operators no longer need to build a separate broadcasting set up for mobile TV only.

This also means that the DVB-T2-Lite signals can easily be captured by fixed aerials too. Therefore, the same DVB-T2 Lite channel offer is receivable on both in the living-room displays (fed from a fixed rooftop antenna) and handheld devices equipped with a DVB-T2 Lite tuner. These channels will, of course, not be HD quality, but the advantage is that no separate mobile TV network is needed. ³⁶²³⁶³

www.bbc.co.uk

www.csimagazine.com

^{363 &}lt;u>www.farncombe.com</u>

ATSC Mobile TV

With more than 130 stations now transmitting mobile digital TV signals based on the ATSC A/153 standard, broadcasters are now offering services that give viewers the ability to take along their favourite channels wherever they go. Broadcaster business groups are now working to add affiliates, with the objective of enhancing the utility of mobile devices.

Mobile DTV devices now or soon to be available include phones, tablets and portable televisions with built in receiving capability. External adapters for existing tablets and phones are also available. Since broadcast-originated mobile DTV does not utilize cellular services for TV reception, the enjoyment of favourite video programmes will not tax a data plan for devices that are equipped to do both. Mobile DTV is a very spectrum-efficient technology, giving broadcasters the flexibility to reach viewers on the move, wherever they go.³⁶⁴

Implementation guidelines

There are several system standards for MTV in the world such as T-DMB, ISDB-T, DVB-T2 Lite and ATSC Mobile TV. The standards applied for these commercial services have advantages and disadvantages. Depending on the situations/requirements of a country, suitable standards can be selected.

The selection of standards involves a process of trade-off between the number of services and the quality of services. The multiplex capacity is set up after choosing the standard and multiplex composition (see section 5.2). Following this, network planning has to be considered (see section 5.3). But in order to achieve an acceptable quality and optimal MTV network, it is advisable to bench-mark it against these case studies.

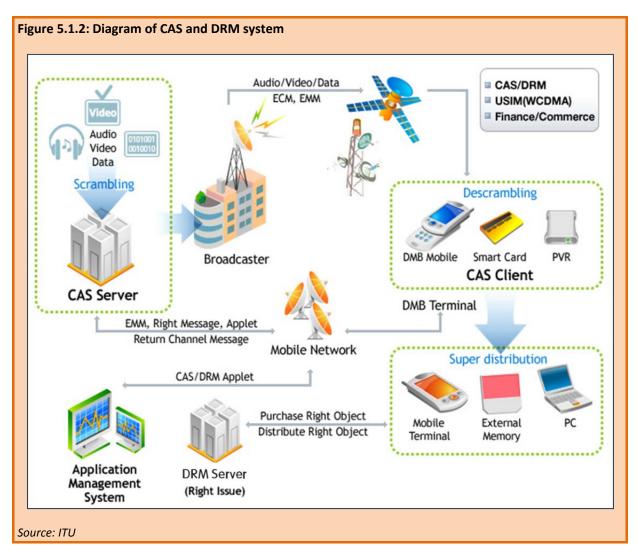
5.1.5 Encryption system

Encryption is generally applied to provide a conditional access for viewers that are entitled to receive a service and to prevent unauthorized use. Subscribing to a service can be the condition for access for pay services or citizenship of a country can be the condition for access in the case where programme rights are geographically limited. In general, access is obtained by a number key. When a viewer fulfils the access conditions (i.e. possesses the right authentication) an authorization signal is transmitted for the service provider and the viewer can have access to the services. For this type of encryption system, the CAS (conditional access system) and DRM (digital rights management) technologies are used. Figure 5.1.2 shows general diagram of CAS and DRM process for mobile broadcasting. This process consists of the following steps:

- 1. multimedia content is scrambled in the CAS server;
- 2. the scrambled signals are delivered to the client via the broadcasting network;
- 3. an encrypted entitlement signal is transmitted to each receiver by using EMM (entitlement management message);
- an encrypted CW (Control Word) is delivered to every receiver by using ECM (entitlement control message);
- 5. to get the CW, the receiver uses an IC card to crypt-analyse the ECM by using the key delivered by the EMM;
- 6. finally, the scrambled multimedia source, which is delivered through the broadcasting network, is descrambled at the client's device.

From ATSC Report 2013 www.atsc.org/cms/pdf/ATSC2013 PDF.pdf

In the reverse direction, client requests and charging information are returned to the CAS operator through a telecommunication network (the interactive return-channel). All issues on using rights of delivered contents are controlled with the DRM.



Implementation guidelines

Choosing a conditional access system is a trade-off between the cost of the system and the level of security required (the expected or reported chances of hacking the system). Since the required bit-rate for CAS (including SMS) depends on the number of subscribers (users), the format designers have to reserve a suitable bit-rate for CAS in the total payload. On the other hand, it is essential that CAS technologies match with receiver processing technologies, so CAS designers have to cooperate with receiver manufacturers in the design of the CAS. In general, the providers of CAS will propose reasonable solutions for each condition and the designers can select a suitable CAS solution through trade-off between costs, required bit-rate and level of security of the system.

5.1.6 Additional services

In addition to the main signal which consists of video, audio and data channels, a variety of other additional services may be implemented, either in connection with the MTV service (PAD: programme associated data) or independent of it (NPAD: non programme associated data).

Such additional services could include:

- Multiplex configuration information (MCI for T-DMB): The MCI is generated in the head-end, contains information on configuration of multiplex and is transmitted through the FIC (Fast Information Channel);
- Transmission and multiplexing configuration control information (TMCC for ISDB-T): The TMCC is generated in the head-end, contains information on the configuration of transmission and multiplexing, and is transmitted by the prescribed carriers of OFDM signal.
- Service information (SI): The SI is generated in the head-end, contains information on current and future programmes, and is transmitted through the FIC or MPEG-TS;
- Emergency warning system (EWS): The EWS is generated in the head-end, contains emergency warning information by using data from an external emergency warning organisation, and is transmitted through the FIC or SI;
- Automatic receiver activation signal is optionally transmitted together with the EWS information depending on specifications of the transmission standard.
- Traffic message channel (TMC)³⁶⁵: The TMC is generated in the head-end, contains traffic information by using data from an external traffic information gathering organization, and is transmitted through the FIC;
- Dynamic label segment (DLS): The DLS is generated with text type in the radio studio, contains NPAD (variety notices, news, event introductions and programme information etc.) and PAD (introduction of song title, singer, lyric, album, concert and so on), and is transmitted through the audio channel;
- Slide show (SLS): The SLS is generated with image type in the radio studio, contains NPAD (variety notices, news, introduction of events and programme information etc.) and / or PAD (introduction of song title, singer, lyric, album, concert and so on), and is transmitted through the audio channel;
- Binary format for scene description (BIFS): The BIFS is generated in the TV studio and contains variety notices, introduction of actors/story/place/PPL (Product Placement), programme information, M-commerce (Mobile-commerce) and so on, and is transmitted through the video channel;
- Electronic programme guide (EPG)³⁶⁶:
 - receiver generated and based on the SI; this simple solution requires no production facilities and has only a limited bit rate;
 - dedicated EPG is produced by a service provider; this gives the EPG its own look and is the concept of the service provider, but requires a considerably larger bit stream and an adequate Application Programme Interface (API) in the receiver.

³⁶⁵ ETSI TS 102 368: "Digital Audio Broadcasting (DAB); DAB – TMC (Traffic Message Channel)".

ETSI TS 102 818: "Digital Audio Broadcasting (DAB); XML Specification for DAB Electronic Program Guide (EPG)" / ETSI TS 102 371: "Digital Audio Broadcasting (DAB); Transportation and Binary Encoding Specification for DAB Electronic Program Guide (EPG)".

Implementation guidelines

The bit rate capacity needed for additional services can reach up to 10 per cent of the multiplex capacity. As the MTV multiplex capacity is rather limited, the choice for additional value-added services is guided by:

- lowest bit rate option;
- no unnecessary duplication of data.

However, some of the above value-added services, generally not provided through the existing media platforms, are unique and could therefore attract audience interest. Furthermore, some services such as BIFS and SLS can become good business models; these additional value-added services can therefore be recommended for commercial broadcasters who want to earn benefits from MTV services.

There are many kinds of systems for the value-added services in the market. SLS, DLS and BIFS authoring tools are designed based on a general PC and the interface part between MTV equipment and the tools are included. Therefore broadcasters can easily introduce systems for additional services at reasonable costs.

5.2 Design principles and network architecture

The objective of this section is to provide information for optimized network design and effective network architecture. The main activities are to review and define the key factors of network design and network architecture, as follows:

- service area;
- service quality;
- reception environment and type of reception (portable, vehicular, indoor portable);
- bit rate payload or channel capacity;
- network architecture;
- trade-off between network costs and service quality;
- trade-off between radiation characteristics, multiplex capacity and coverage;
- selection of main transmission mode;
- review of services for national, regional, or local coverage;
- network topology for MTV (low level cellular, high power high antenna mast, combination of the two);
- review of use of existing sites and/or setting up new sites;
- review of head- end configuration: ENC (encoder), MUX (multiplexer), Monitor, Divider;
- review of STL: type of distribution network;
- review of network roll-out phases: basic transmitters, fill-in transmitters (repeaters, gap fillers).

To implement MTV services after selecting the MTV standard, broadcasters have to design the MTV network with a focus on technical and financial efficiency. To meet these objectives, a trade-off between various factors would be required, such as transmission modes, network costs, service quality, multiplex capacity and service bouquet offered. Broadcasters also have to consider other components of the network, for example, STL, electric power, CAS, cooling system and monitoring system.

The following sections provide guidelines for the key topics and choices regarding design principles and network architecture of MTV.

5.2.1 Trade-off between factors

Taking into account the standard selected (as described in the previous section), broadcasters have to design the MTV network with consideration for technical and cost effectiveness. In order to achieve this, there are some trade-offs among the factors for optimal network design, e.g.:

- transmission mode and performance;
- trade-off between radiation characteristics, multiplex capacity and coverage;
- trade-off between network costs and service quality;
- services for national, regional or local coverage and network implementation costs;
- use of existing sites and/or new sites;
- sharing of MTV and DTTB facilities;
- co-siting of MTV and DTTB facilities;

Transmission mode

Firstly, the trade-off among transmission modes will be considered. Several transmission modes are provided with DVB-T-2 Lite, T-DMB and ISDB-T systems.

DVB-T2 Lite³⁶⁷ is defined as a profile of the DVB-T2 standard which allows for more cost efficient receiver implementations for very low capacity applications such as mobile broadcasting. However, it may also be received by conventional fixed receivers. DVB-T2 Lite is based on a limited sub-set of the DVB-T2 coding tools. This subset will allow for a more cost efficient receiver designs; a chip supporting only T2-Lite will be 50 per cent cheaper.

DVB-T2 uses the LDPC (Low-Density Parity Check) coding combined with BCH (Bose, Chaudhri, Hocquenghem) coding, offering a very strong FEC (Forward Error Correction) scheme. The number of carriers, guard interval sizes and pilot signals can be adjusted, so that the overheads can be optimised. Multiple PLPs (Physical Layer Pipes) allow separate adjustment of the robustness of each delivered service within a channel to meet the required reception conditions, allowing receivers to save power by decoding only a single service.

One possible scenario for the use of DVB-T2 Lite may involve simulcasting two different versions of the same service, with different bit-rates and levels of protection (a higher bit-rate less well protected version and a lower rate, more highly protected version), to provide a fall-back signal towards the edges of a service area or in critical locations such as indoor rooms or shadowed areas.

The system allows DVB-T2 Lite and DVB-T2 signals to be transmitted in one RF channel, even when the two profiles use different FFT sizes or guard intervals. For example, a complete RF signal may be formed by combining a DVB-T2 signal carrying HDTV services for fixed receivers using 256-QAM modulation, together with a DVB-T2-Lite signal using QPSK modulation to serve mobile receivers from the same network.

The T2-Lite modulation schemes are QPSK, 16QAM and 64QAM. The maximum size of a single PLP (physical layer pipe) is limited to 4 Mbit/s. In SISO (Single Input Single Output) transmission operations the 2k and 4k modes can operate with guard intervals from 1/32 to 1/4. Similarly, the 8k and 16k modes can operate with the above guard intervals and also in 1/128, 19/256 and 19/128. In MISO (Multiple Input Single Output) transmission operations the 2k and 4k modes can operate with guard intervals from 1/32, 1/16 to 1/8. In this case, the 8k and 16k modes can operate with guard intervals of 1/128, 1/32, 1/16, 19/256, 1/8 and 19/128.

-

³⁶⁷ Published as ETSI EN 302 755 v.1.3.1

T-DMB provides four transmission modes; mode I, mode II, mode III, and mode IV. Mode I is the most suitable mode for terrestrial single frequency networks (SFN) in the VHF Band III, because it allows the largest transmitter separations. Mode II is preferred for use by medium-scale SFNs in the 1.5 GHz band. Larger transmitter spacing can be accommodated by inserting artificial delays at the transmitters and by using directive transmitting antennas. Mode III is appropriate for cable, satellite and complementary terrestrial transmission at all frequencies since it can be operated at all frequencies up to 3 GHz for mobile reception and has the greatest tolerance of phase-noise. Mode IV is also used in the 1.5 GHz band and allows larger transmitter spacing in SFNs. However it is less robust to degradation at higher vehicle speeds³⁶⁸. Mode II, III, and IV cannot be used for T-DMB in the countries where GE06 applies because the frequency ranges associated with these modes do not coincide with the GE06 frequency allotment plan³⁶⁹.

ISDB-T provides three transmission modes, FFT size of 2k, 4k and 8k. The system employs time-interleaving technology which improves transmission robustness for mobile reception and makes it possible to use 8k mode. As all parameters are the same as those applied for ISDB-T based DTTB, the network design principles including SFN are the same (see section 4.3).

Network Designers have to select the optimal mode considering the conditions and target services, such as reception environment, receiver type and distance between transmitters, frequency availability and coverage plan. However, 4k or 8k modes are likely to be chosen for DVB-T2 Lite and ISDB-T (see also section 5.4) and mode I for T-DMB.

Radiation characteristics

To meet the requirements of coverage area, payload or transmission capacity, signal robustness and the available spectrum, selection of the radiation parameters needs careful consideration. There are a large number of system variants available for DVB-T2-Lite, T-DMB and ISDB-T. Generally, different modulation schemes (QPSK, 16-QAM and 64-QAM) can be combined with different code rates and Multi-Protocol Encapsulation — Forward Error Correction (MPE-FEC) to provide different payload capacities, signal robustness and coverage areas.

As always in network planning, there will be a need to make a trade-off between transmission capacity (bit rate), coverage quality and the size of the coverage area required. Other factors being the same, higher capacity requirements mean that a less robust system variant would need to be used, which may also result in higher power and/or more sites needed to cover a specified area with a given signal strength. This will increase the investment cost as well as the operational cost of the network.

From a consumer's point of view, as also for running a successful business, it seems desirable to provide indoor handheld reception, which is the most demanding receiving mode. In order to provide indoor reception with sufficient quality in most cases, there will be a need to use more robust modulation system parameters such as QPSK with a code rate such as 1/2 with MPE-FEC 3/4.

In many situations, including indoor reception, it is generally more effective to use SFNs (dense or medium sized) to enhance signal strength (including in indoors) because of the signal diversity provided by the transmitters in the SFN network. Among other measures, it is necessary to choose a sufficiently long guard interval, adapted to the structure and the size of the network, in order not to create problems arising from self-interference. A longer guard interval reduces the payload capacity proportionately.

As against this, in the single (high power) transmitter case, a shorter guard interval may be used, resulting in a higher net bit rate available to provide the services.

³⁶⁸ Refer to EBU-TECH 3317 'Planning parameters for hand held reception (page-12)

Refer to GE06 Agreement Article 3, T-DAB frequency allotment plan in 174-230 MHz band.

In general, high power with a suitable modulation scheme (e.g. QPSK) and a suitable code rate (e.g. 1/2) results in wide coverage and a good reception rate but this combination would lead to lower transmission capacity (i.e. lower bit-rate availability). Therefore designers have to consider various issues for the intended services (required bit-rate), propagation issues, indoor reception, and interference issues.

Table 5.2.1 shows a comparison of each modulation type versus C/N and bit rate availability (C/N in dB for PER=10⁻⁴ in typical urban channel for single antenna receiver³⁷⁰.

Expected mobile performance in TU6 channel profile GI = 1/42k FFT 4k FFT 8k FFT C/N C/N C/N C/N Modulation Code Bit-rate Speed max (at Speed max (at Speed max (at C/N min+3dB, C/N min+3dB, C/N min+3dB, -rate (Mbit/s) Rayleigh min min min 500 MHz) 500 MHz) 500 MHz) (dB) (dB) (dB) (dB) (km/h) (km/h) (km/h) QPSK 1/2 4.98 5.4 13.0 242 119 13.0 365 13.0 2/3 6.64 8.4 16.0 291 16.0 194 16.0 97 16-QAM 1/2 9.95 11.2 18.5 246 18.5 166 18.5 86 2/3 13.27 14.2 21.5 207 21.5 21.5 136 65 1/2 14.93 23.5 23.5 23.5 64-QAM 16.0 162 108 54 2/3 19.91 19.3 27.0 27.0 27.0 84 58 32

Table 5.2.1: Modulation type vs. C/N and bit rate availability

Network costs and service quality

The trade-off between network costs and service quality is addressed here. There are various kinds of head-end and transmission equipment with considerably different prices, reliability and stability. Also the cost and quality depend on the system design plan, for example, equipment redundancy, construction of new sites specifically for mobile services and modulation schemes (which might also affect receiver complexity). In general, better availability and quality of services entail higher costs. However designers have to consider the economic efficiency which includes the number of services, quality of video or audio channels, equipment redundancy, minimum reception field strength and the location availability probability percentage of indoor reception.

As an example, a network model could be based on a main higher power transmission facility supplemented by a number of smaller low power facilities. If an existing site is used for the main transmitter, capital costs would need to be estimated for the new equipment complement, including the transmitter and accessories, possibly a combiner, STL and additional air-conditioning. In addition operating costs / rentals would be required for space, electric power, air-conditioning, use of antenna feeder and antenna mast aperture. There may be other expenses as well.

For the smaller low power transmitters, unless a suitable mobile phone facility site is available, a new site would have to be set up. The costs entailed will include site costs, building, power supply, security, transmitter and other associated equipment, mast, feeder and some other elements. As this facility is a low power facility, the costs will not be very high.

Quoted from ETSI TR 102 377 v1.2.1, 2005-11. Refer to EBU-TECH 3327 network aspects for DVB-H and T-DMB (page-11)

In another network model, where many transmitters are used in a cellular configuration, the total costs will be the summation of the costs of all the sites plus the costs of the feeder network.

Coverage

An MTV service may be required to cover all areas as the audiences can travel within or across any type of area such as urban, rural, mountains, coastal, road, indoors, even in subways and tunnels. Therefore, broadcasters should have a clear decision on the target service areas where MTV services are to be covered and the location probability figures before making detailed network plans. One of the approaches would seem to be to cover all areas using a single solution. However, the all-in-one approach is somewhat inefficient economically and technically as the radiated power and the operating costs for such a system would be very high. Such a system would require too much time and effort to set up. Furthermore, the all-in-one approach is undesirable for the strategy of service promotion and implementation of locality of services. Therefore, the gradually expanding approach is preferred and recommended.

The crucial issue in MTV services is the provision of appropriate coverage (and signal strength) in the areas identified for this purpose. Often portable reception at the street level and in the indoor environments is quite demanding in terms of reception conditions of signals in MTV services. In these cases, the man-made noise levels are relatively high, with the indoor reception facing signal penetration attenuation. The movement of the portable receivers and their lower antenna gain adds a further difficulty.

Optimum coverage in MTV can be achieved in two ways. Firstly, a main higher power transmitter would provide the basic signal in the coverage area, in most of the coverage area. This coverage may be supplemented by a number of low power facilities, mainly to cover areas not covered by the main transmitter. All the transmitters may also operate in the SFN mode.

Secondly, another solution for MTV coverage of urban and congested areas is similar to the mobile phone solution, i.e. deploying several MTV transmitters in a cellular network configuration, each of these covering smaller areas with a high density signal. This model may be better suitable in case of MTV services with high bit rate payload. The antenna masts for such a network configuration are shorter so as to direct the maximum amount of radiation to the usage areas. This network arrangement, while efficient, is a bit more complex to set up.

Sites

Finally, the use of existing sites or building of new sites is considered. The best approach is to use existing sites because this can reduce costs by common use of the basic infrastructure (e.g. cooling system, electric power supply facility and tower) and operational man power. It is useful for propagation prediction as reference can be made to the coverage of existing services (e.g. FM, DTTB) on the site.

However there are some restrictions; more sites are necessary for MTV due to the higher field strength required for mobile reception conditions and additional sites are required to achieve efficient coverage design for MTV. The reasons are that existing TV networks are designed mainly to target residents with rooftop Yagi antennas (normally at 10 m height above ground). In contrast, MTV networks have to be designed to cover the receivers with whip or rod antennas (normally at 1.5 m above the ground/floor).

Therefore, a practical approach in case of coverage of urban areas may be to use an appropriate existing TV main site and then additionally build new sites (e.g. fill-ins) where specially needed for MTV services.

Implementation guidelines

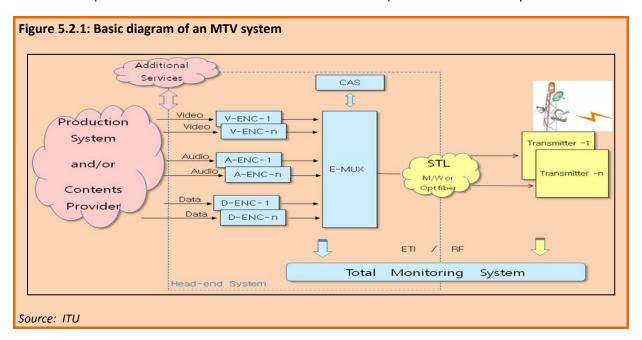
As the trade-off between the wanted service grade and economical aspects are deeply dependent on conditions such as the target of services, existing transmitter sites and the extent of viewers' interests, the network designers have to undertake an extensive review of the economic as well as the technical aspects.

Taking into account the trade-off between technical factors, target of services and economic factors, the following are recommended:

- Transmission mode for T-DMB: Mode I with code rate=1/2, MPE-FEC=3/4, QPSK. This mode
 meets the requirements of extensive coverage with SFN, good reception and robustness against
 high speed movement. This is especially applicable with this system using a Band III frequency in
 conformity with the GE06 Agreement.
- For DVB-T2 Lite, transmissions can operate with guard intervals from 1/32 to 1/4 in SISO mode, depending on the number of carriers. Similarly, MISO transmissions can operate with guard intervals from 1/128 to 1/8, depending on the number of carriers.
- Modulation mode for T-DMB: QPSK because of receiver simplicity. This mode is also in conformity with the GE06 Agreement.
- Modulation mode for DVB-T2 Lite: 16-QAM could be considered because of a good balance between bit rate availability and reasonable receiver complexity.
- Transmission mode for ISDB-T OneSeg: QPSK and code rate of 1/2 or 2/3. The other parameters are fixed with those applied for DTTB service.
- Transmission mode for ISDB-T_{mm}: 16QAM, code rate of 1/2 or 2/3 and guard Interval of 1/4 or 1/8.
- Combination of existing sites for other services (e.g. FM, DTTB) and newly constructed sites for MTV; this provides a good solution in terms of cost and good reception rate.
- Use of SFN because this can increase the coverage areas as well as viewer's convenience that
 they can enjoy the services without re-tuning when moving across the areas covered by
 different transmitter sites.
- The gradually expanding approach regarding the coverage extension plan is a good solution in terms of cost and degree of technical difficulty.

5.2.2 Network architecture: Head-end

Figure 5.2.1 shows the basic diagram of a MTV service system. As seen in this basic diagram, the MTV network is composed of content providers, head-end, transmitters, distribution links (such as STL), monitoring system, CAS and additional service authoring. Among these components, production and transmission parts are treated in other sections so the head-end part is dealt with mainly in this section.



The configuration of the head-end is absolutely dependent on the types of services and channels. Therefore, the set up can be decided according to the services, channels and bouquet offered, the types and numbers of encoders and authoring tools for additional services, the type of the CAS and the complexity of the monitoring system.

Video encoders for video services accept various types of inputs signal such as composite NTSC/PAL, SDTV/HDTV-SDI (Serial Digital Interface)³⁷¹, or S-video / analogue stereo, or AES/EBU³⁷². The input signals are compressed according to the compression standard (e.g. MPEG-4 part 10 AVC / MPEG-4 ER BSAC or AAC+). Output signals of the encoders are generated using interface formats such as UDP (User Datagram Protocol)³⁷³, DVB-ASI (Digital Video Broadcasting - Asynchronous Serial Interface), ETI (Ensemble Transfer Interface)³⁷⁴ and STI-D (Service Transport Interface –D)³⁷⁵. There are many kinds of in/out signal formats, however these signals do not have special technical superiority and the various options are provided for connection flexibility. Meanwhile, additional services in video channel are included by using multiplexing technology such as MPEG-4 part 1 BIFS, OD, and packetizing.

Audio encoders for audio services accept various inputs such as stereo, or signals using the AES/EBU interface. Audio signals are compressed according to the compression standard (e.g. MPEG-2 part 1/2 or AAC+). Similar to video, output signals are generated using interface formats such as UDP, DVB-ASI, ETI and STI-D. Meanwhile, various additional services in audio channel such as PAD, DLS, and SLS are incorporated. In addition, visual radio services (e.g. music with snap shot of studio or live performance, traffic information on simplified map and weather information with graphic) may be made available by using video encoding technology but with a lower frame rate(2 ~ 10 fps).

Data encoders for data services accept various inputs. These signals are processed with MOT (Multimedia Object Transfer)³⁷⁶, IP tunnelling (Internet Protocol Datagram Tunnelling)³⁷⁷ and TDC (Transparent Data Channel)³⁷⁸ technology. Output signals are generated using UDP, ETI, STI-D and so on. There are several data services such as BWS, EWS, TPEG, etc. For the information on details of data services, refer to Section 5.6.2.

Multiplexer accepts various input formats such as STI-D, ETI and UDP, configures the output stream according to the services/channels formation and bit-rate allocation.

Meanwhile the CAS and monitoring system are added for controlling subscribers and monitoring services.

Implementation guidelines

Among the network architecture, head-end equipment in the MCR (master control room) is the core part of the MTV services. MTV service plans such as the encoding method, channel configuration, and bit-rate allocation are implemented with head-end equipment in the MCR. Items such as the type and quality of services, and programme schedules are implemented in this process. This implies a trade-off between price, performance and function, and the provision for flexibility, extensions and modifications.

³⁷¹ SMPTE 259M and Recommendation ITU-R BT.1120.

EBU tech 3250, specification of the digital audio interface (The AES/EBU interface).

www.ietf.org/rfc/rfc0768.txt?number=768

ETSI ETS 300 799: "Digital Audio Broadcasting; Distribution interfaces; Ensemble Transport Interface (ETI)".

ETSI ETS 300 797: "Digital Audio Broadcasting; Distribution interfaces; Service Transport Interface (STI)".

ETSI EN 301 234: "Digital Audio Broadcasting (DAB); Multimedia Object Transfer (MOT) protocol".

ETSI ES 201 735: "Digital Audio Broadcasting (DAB); Internet Protocol (IP) Datagram Tunneling".

ETSI TS 101 759: "Digital Audio Broadcasting (DAB); Data Broadcasting – Transparent Data Channel (TDC)".

Also, a proper redundancy or back-up system, for example active-standby or passive standby (e.g. N+1 configuration), a monitoring and auto-alarming system and an effective cooling system should be taken into account (see also section 4.2.6).

It is also important to ensure skilled system engineers, which may include IT professionals, periodical maintenance and upkeep of replacement spares.

5.2.3 Network architecture: transmission

Before setting up the coverage plan, the relevant frequency allotment and assignment plans have to be consulted. The national regulators have the authority to make those plans and these are generally in conformity with the relevant ITU regulations and international agreements including the GE06 Agreement (where this applies). Therefore the coverage plans made by network designers have to observe the frequency allotment and assignment plans set up and approved by the national regulators.

In the countries where the GE06 Agreement applies, regulators allocate MTV frequencies in their respective countries in conformity with the Agreement (for the details, refer to Annex A) and in accordance with the MTV service policy which includes the number of broadcasters and coverage plans for nationwide/regional area/local area.

There are many issues of interest regarding frequency planning, such as interference with co-channel or adjacent-channel services, MFN or SFN and spill over. Network designers have also to consider the special aspects of SFNs, which include guard interval, space between transmitters, static or dynamic delay.

The preparation of frequency plans and the resulting network plan includes propagation modelling for coverage which results in an appropriate network topology.

The first step is to make a network organisation map that covers the entire target service area. There are three approaches to make the map:

- construction of new sites;
- using existing sites;
- 3. using existing sites plus new sites.

MTV's reception conditions are very demanding and all targeted areas have to be coved in a manner generally quite different from fixed TV services. So, new approaches are necessary to guarantee proper reception for MTV services where the reception conditions are quite different from that of DTTB services. A compromise solution may be the use of existing sites and adding new sites as required.

The second step is to make plans for roll-out phases considering technical and financial aspects.

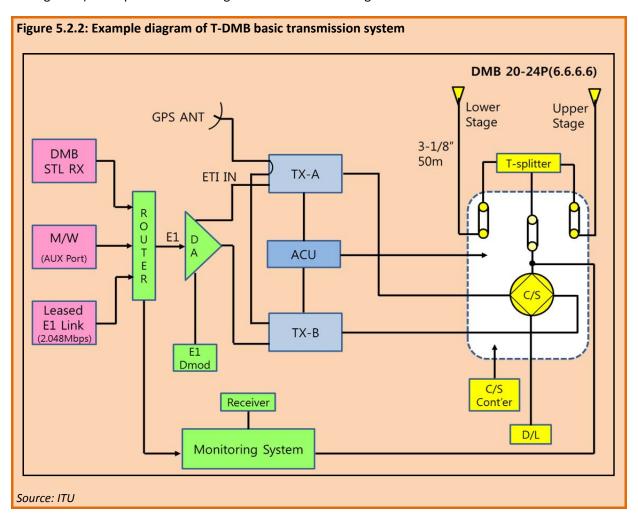
- Firstly, a network design plan is made to cover the core areas such as metropolitan areas or big
 cities. The main transmitter should be placed in a location to cover the targeted audiences such
 in densely populated habitations, urban centres and mobile routes for the effective site
 planning. For this purpose, there is a high possibility of using an existing site.
- It may not be possible to cover the entire area satisfactorily, particularly the mobile routes, and also the indoor operation of MTV receivers, with the above arrangement. In practice, several lower power transmitters would need to be located at or near the mobile routes and for indoor coverage (in areas away from the main transmitter).
- Secondly, the plan may have to provide for expanding the service coverage, for example to the provinces or the countryside. To meet such requirements, main transmitters or fill-in transmitters should to be placed to cover the locations (preferably on existing sites). Extra fill-in transmitters may need to be added in the areas that cannot be covered from the second stage (new site to be exploited).
- It is recommended that the transmitters and the fill-in transmitters should be located making full use of the existing sites considering economical and geographical factors.

Finally, shaded locations should be covered, such as group of buildings, tunnels and subways. Fill-in transmitters with off-air reception may need to be placed to get good quality reception in poor reception areas in the local area (where the line of sight is blocked by artificial or geographical barriers) and in strategic key places (such as highways, main roads, tourist areas and shopping areas). These fill-in transmitters are new facilities required mainly for mobile broadcasting and these can easily be co-installed at the repeater or the base station sites of a mobile company and use a commercialised ICS (interference cancellation system) type of onchannel repeater.

The final step is to make a plan for construction of unit transmission sites which include STL (studio to transmitter link) installation. There are three methods for providing the STL; leased optical fibre link, directly operated microwave link (fortunately, an STL for T-DMB is easily made by using the auxiliary E1 port in a micro wave link) or by a dedicated VPN-based IP link. There are many activities involved in the construction of a transmission site, for example finding space for transmitters and antennas, installation of transmitter, antenna, feeder and cooling system.

For cost reduction or due to space restrictions, common-use of the existing antenna system, feeder, and/or cooling system should be reviewed in order to satisfy all technical requirements.

Figure 5.2.2 shows an example of a T-DMB basic transmission system. The STL receiver terminals receive T-DMB signal from a site (head-end). The received signal is divided into the main transmitter and sub transmitter. A suitable transmitter is connected to the antenna under control of the ACU (automatic change unit). The specified T-DMB signal is transmitted through the antenna.



Implementation guidelines

It is recommended to make a network organisation map using a simulation tool and/or with reference to existing TV/FM coverage maps. Frequency and coverage planning software tools are quite useful for designing an optimum transmission network. While some such tools may be obtained from ITU, several frequency planning companies either provide the software platform for this purpose, and / or help in frequency planning, on a commercial basis. It is recommended that use of such tools should be considered in preparation and in optimisation of transmission networks.

Propagation simulation tools need the precise geographic information and transmission specifications. Digital terrain databases are now readily available for all countries in the world and these are specifically incorporated in the software tools for specific countries. The simulation result is also used to make a plan for fill-in transmitter arrangements. Meanwhile, TV/FM coverage maps may be used to obtain an initial impression of MTV coverage. As a rule of thumb, coverage of a 10 kW FM service is similar to the coverage of 2 kW T-DMB service.

Figure 5.2.3 shows the result of a field test in which field strengths of FM and T-DMB signals were measured. Specifications of each service are:

FM

Frequency 97.3 MHz ERP 27 kW

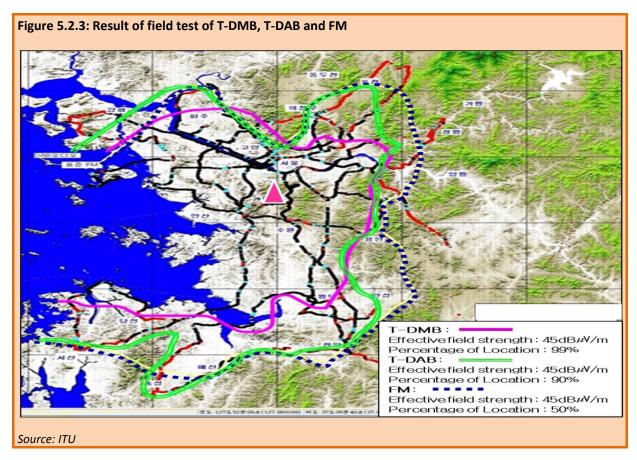
Antenna CP-dipole/16-panal, height; 629 + 48 m.

T-DMB (T-DAB)

Frequency 207.008 MHz ERP 15.09 kW

Transmission mode Mode I, code-rate 1/2, MPE-FEC 1/2

Antenna Omni-directional/vertical/2-dipole/24-panel, height; 629 + 48 m.



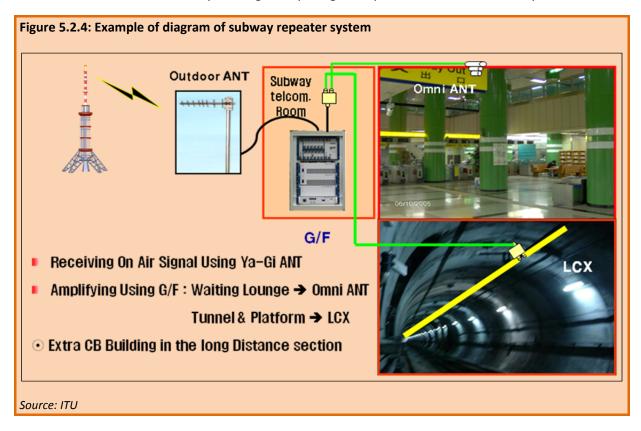
The example comparison with FM coverage as shown above may be used as initial impression. For more detailed estimation, please refer to Annex D Part A for coverage assessment (Annex D: More information on some MTV network topics).

After constructing the basic transmission site, field strength tests are necessary to check whether the transmission system was properly installed and is operating normally. Furthermore, measurements can be made to assess the coverage area.

The fill-in transmitter arrangement plan, made by using a simulation tool, is modified according to the field test result.

In the process of fill-in transmitter arrangement and construction, it is important to consider the provision of the signal link. An exclusive link is expensive and it may be difficult to get a licence for the frequency. There is a good solution in market: the use of an fill-in transmitter (on-channel repeater) with ICS (Interference Cancellation System) technology. This type fill-in transmitter can be used not only in medium power (1-20 W) for open areas but also low power (below 1 W) for use in-buildings and tunnels (see also section 4.3.3). On the other hand, a leaky coaxial (LCX) cable is good solution for long tunnels or subways.

Figure 5.2.4 shows the example of a diagram of a subway fill-in transmitter system. A Yagi antenna placed outside the subway station receives T-DMB signal from an on-air transmitter. The received signal is then amplified by an amplifier in the telecom room. The amplified signal is transmitted by using an omnidirectional antenna in the subway building and by using a leaky coaxial cable in the subway tunnel.



5.3 Network planning

Guidelines regarding MTV network planning have been incorporated in section 4.3 because of the similarity of the issues involved.

5.4 System parameters

The objective of this section is to select system parameters through a trade-off between coverage, multiplex bit rate payload and radiation characteristics, which serve as input to the network planning.

The main activities are:

- evaluation of FFT size (ISDB-T, T-DMB; DVB-T2 Lite);
- evaluation of carrier modulation;
- evaluation of code rate;
- evaluation of guard interval.

System parameters are a key element in the trade-off between transmission costs, service quality and coverage quality described in section 5.2.1.

The following sections give guidelines for the key topics and choices regarding system parameters. For reasons mentioned in the previous section (5.1 Technology and standards application) the description and examples are based on the DVB-T2 Lite, T-DMB and ISDB-T system.

5.4.1 FFT size

As described in the previous section (5.2 Design principles and network architecture), 4k mode/8k mode is used as the transmission mode of ISDB-T. The 4k mode enhances the inefficiency of the 2k mode in terms of network planning and eases the terminal implementation complexity of 8k mode to suit mobile broadcasting. In some cases, the 8k mode is used to meet specific conditions such as high multiplex capacity and large SFN. In case of DVB-T2 Lite, 2k, 4k, 8k, 16k modes can be employed. An appropriate mode will depend on the payload capacity required for a particular service offering and the desired signal robustness.

In the case of T-DMB, mode I is effective for designing SFNs. In addition, in the countries where GE06 Agreement applies, the discussion will be restricted to mode I to be in conformity with frequency assignment in the GE06 Agreement which allotted Band III for T-DAB.

The fast Fourier transform (FFT) length specifies the number of carriers:

- the number of carriers in T-DMB mode I is 1 536;
- the number of carriers in DVB-T2 Lite 4k mode is 3 096;
- the number of carriers in ISDB-T 8k mode is 432 per segment (i.e. 5 616 per 13 segments).

In practice the FFT length has an impact on:

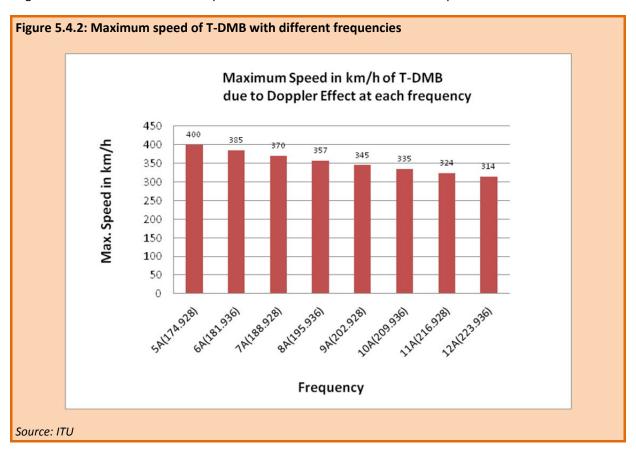
- the allowable Doppler shift decides the allowable speed of mobility of the user under a mobile reception environment;
- the length of the guard interval decides the allowable delay time of delayed signals to overcome multipath signal interference (within 264 μ s in the case of T-DMB) and the separation distance between transmitters in SFN (96 km in the case of T-DMB) (see also section 5.4.3).

EXAMPLES: Calculation of the maximum speed ν for the modes I, II, III and IV of T-DMB operating on frequency fo of 200MHz, 1.5GHz, 1.5GHz and 3GHz respectively.

- Mode I: Tu = 1 ms = 0.001 s and fo = 200 MHzFrom equation 5.4.4: the maximum speed is 70 / $(0.001 \times 200) = 345 \text{ km/h}$
- Mode IV: Tu = 500 s = 0.0005 s and fo = 1.5 GHz = 1,500 MHzFrom equation 5.4.4: the maximum speed is 70 / (0.0005 × 1,500) = 593 km/h
- Mode II: $Tu = 250 ext{ s} = 0.00025 ext{ s}$ and $fo = 1.5 ext{ GHz} = 1,500 ext{ MHz}$ From equation 5.4.4: the maximum speed is $70 / (0.00025 \times 1,500) = 186 ext{ km/h}$

Mode III: Tu = 125 s = 0.000125 s and fo = 3 GHz = 3,000 MHz From equation 54.4: the maximum speed is 70 / (0.000125 × 3,000) = 186 km/h

Figure 5.4.2 shows the maximum speed of T-DMB mode I with different frequencies.



Implementation guidelines

- Mode I is used as the transmission mode of T-DMB.
- 4k mode and 8k mode are used as the transmission modes of ISDB-T.

5.4.2 Carrier modulation and code rate

The ISDB-T system has several types of carrier modulation:

- DQPSK
- QPSK
- 16QAM
- 64QAM

Together with each type of carrier modulation, one of the five inner protection code rates should be chosen: 1/2, 2/3, 3/4, 5/6, 7/8.

The T-DMB system has only one type of carrier modulation: QPSK with code rate of 1/2.

The choice of carrier modulation and code rate is a trade-off between data capacity and carrier to noise ratio (C/N). The latter is directly related to the required field strength.

The combination of a lower order modulation and a low code rate is used when field strength requirements are very demanding e.g. in case of portable or mobile reception. The combination of a high order modulation and a high code rate is used when a high data capacity is required e.g. in case of a high number of services. However in practice, in particular for mobile broadcasting, the highest codes rates (3/4, 5/6 and 7/8) are not much used.

The C/N values and protection ratios are specified for three kinds of transmission channels:

Transmission channel	Description	Application
Gaussian channel	Reception with no delayed signals and taking into account thermal noise	Reference value
Ricean channel	Reception with a dominant signal and lower level delayed signals and thermal noise	Fixed reception
Rayleigh channel	Reception with several non-dominating signals with different delay times and thermal noise	Portable and mobile reception

Table 5.4.1: Transmission channels and application

As indicated in the above table, the Rayleigh channel is applied to mobile broadcasting, with different C/N values demanded by the Gaussian channel and the Rayleigh channels.

As demonstrated by the examples in the previous section (5.1.3 Formation of services and channels), MTV using DVB-T2 Lite technology aims to provide a number of video channels and other services, but its payload capacity in a single PLP is limited to 4 Mbit/s. Furthermore, in a poor reception environment, such as λ /4-long antenna and high speed (150 km/h) of travel, 64-QAM with high C/N demand can have many restrictions in use, as it requires complexity of the receiver and enhanced output of the transmitter.

QPSK provides high-quality reception, but since the bit-rate is too marginal to offer 20 or more services, there are a lot of restrictions in designing the service/channel formation. However, if the reception environment is very poor and a relatively small number of services are planned, QPSK modulation can be a reasonable choice.

ISDB-T_{mm} system consists of segmented OFDM signals and allows any combination of 1, 3 and 13 segments (see Table 5.1.1 for segment bandwidth). This feature offers flexibility in RF channel bandwidth, e.g. 0.429 MHz (applied for OneSeg service) and 14.5 MHz (applied for "NOTTV" with 33 segments). The system provides hierarchal transmission with a variety of carrier modulations/code rates, thus it can be best optimized to requirements/environments of the services given by business plan.

T-DMB, on the other hand, has low available bit-rate but the modulation and code rate are set to provide an optimal mobile broadcasting reception performance: modulation is QPSK and code rate is 1/2.

In addition, to allow a more flexible choice, the development of AT-DMB (Advanced T-DMB) has been completed. It provides high resolution, mobility, and at the same time, an improved reception performance by using hierarchical modulation and other diverse modulation methods.

Implementation guidelines

Taking diverse issues into consideration, the recommended modulation and code rate for mobile broadcasting are as follows:

- in the case of T-DMB; QPSK, ½;
- in the case of ISDB-T_{mm}; 16-QAM, 1/2 or 2/3;
- in the case of DVB-T2 Lite, a combination of 16-QAM, 1/2 or 2/3 could be used.

In order to serve specific purposes or unique conditions, choices other than the above mentioned recommendations – and technical implementation to satisfy these – can also be made.

5.4.3 Guard interval

General description on guard interval can be found in section 4.4.3 (Guard interval). This section deals with issues of particular relevance to mobile broadcasting:

• Guard interval lengths of DVB-T2 Lite at 8MHz (4k mode is used for mobile broadcasting) and ISDB-T_{mm} ar 6MHz (8k mode is used).

Table 5.4.5: Guard interval lengths of ISDB-T_{mm} and DVB-T2 Lite

Contain and DE handwidth	Constitutement	Transmission mode			
System and RF bandwidth	Guard interval	8k mode	4k mode	2k mode	
	1/4	224 μs	112 μs	56 μs	
DVD TO Lite of Q MILE	1/8	112 μs	56 μs	28 μs	
DVB-T2 Lite at 8 MHz	1/16	56 μs	28 μs	14 μs	
	1/32	28 μs	14 μs	7 μs	
	1/4	252 μs	126 μs	63 μs	
ICDD T -+ C MILL-	1/8	126 μs	63 μs	31.5 μs	
ISDB-T at 6 MHz	1/16	63 μs	31.5 μs	15.8 μs	
	1/32	31.5 μs	15.8 μs	7.9 μs	

Note: For other RF channel bandwidth systems, see Table 4.4.5 (ISDB-T) and Table 4.4.9 (DVB-T2)

Guard interval lengths of T-DMB (Mode I is used due to frequency allotment of GE06).

Table 5.4.6: Guard interval lengths of T-DMB

Mode	Mode I	Mode II	Mode III	Mode IV
Guard interval length	246 μs	62 μs	31 μs	123 μs

Implementation guidelines

For mobile broadcasting, the size of the designed single frequency network (SFN) has to be taken into consideration, while a long guard interval length is required in order to properly respond to the interference generated through multipath propagation (refer to section 4.3.2):

- for T-DMB, 246 μs of mode I is selected as guard interval length;
- for ISDB-T, GI = 1/4 (126 μ s at 6 MHz) with 4k mode or GI = 1/8 (126 μ s at 6 MHz) with 8k mode is recommended;
- for DVB-T2 Lite, GI=1/4 (112 μs at 8MHz) with 4k mode is recommended.

5.5 Radiation characteristics

Guidelines regarding radiation characteristics of MTV networks have been incorporated in section 4.5 because of the similarity of the issues involved.

5.6 Network interfacing and studio facilities of additional services

The objective of this section is to define network interfaces and prepare studio facilities for creating additional services.

This section will discuss the factors for the link between studio and head-end system (and/or CAS) and for the interface for monitoring equipment. We will also discuss the factors for the preparation of the authoring system for additional service (use of the existing TV studio and radio studio for the production of basic video and audio content).

In addition, for the radio interface and interface with the monitoring centre, refer to section 4.6.3 (radio interface between transmitting station and receiving installations) and section 4.6.4 (interfaces between transmitter sites and network monitoring system).

5.6.1 Connection between studio and head end system

The number and types of sources supplied to one multiplexer is numerous. In order to consolidate and multiplex the different sources (programmes or content), factors such as signal quality, credibility and cost issues should carefully be considered.

In-house signals can be delivered easily by base-band signal format (SDI; Serial Digital Interface, SMPTE 259M, AES/EBU, etc.). However, receiving content from an external programme or content provider is more complex in that one has to consider factors such as signal distortion and delay. Fortunately, a large part of this problem can be solved thanks to the digital transmission technology.

Also, because there are external link rental businesses, there is a choice of signal delivery using either optical fibre link, microwave link or Internet based private VPNs. MTV multiplex operators have to consider the stages from CDR (central distribution room) to MTV MCR (master control room). In the case of renting an external link for signal transmission, transmitting the signal in base band format will be expensive. Thus, it will be much more competitive in terms of expense and robustness of the signal to reduce the size to the level that the MTV service can accept or to contract the MTV service signal format beforehand (e.g. reduced to H.264 and in ETI format for T-DMB video).

Moreover, for connection among head-end equipment within MCR such as an encoder/MUX/ monitoring device, it is important to pay attention to the input specification, since most equipment provides ETI/STI/UDP (user datagram protocol)/TCP (transmission control protocol).

Implementation guidelines

The following must be considered so that head-end equipment can accept various sources;

- be flexible with head-end input specification so that it can accept various types of signal formats;
- in the case of a unique signal format, use an all-purpose converter so that the head-end equipment can convert the unique signal to that of an acceptable format;
- prepare a reference clock (e.g. GPS receiver) for signal synchronisation and be flexible with clock input specification (1 PPS, 10 MHz, 2.048 MHz, etc.);
- in the case where signal transmission fails due to the distance (e.g. over 500 m of coaxial cable) between the in-house production facilities and head-end, set an additional divider (or amplifier) mid-way or use an optical fibre link system (transmitter - optical fibre link - receiver).

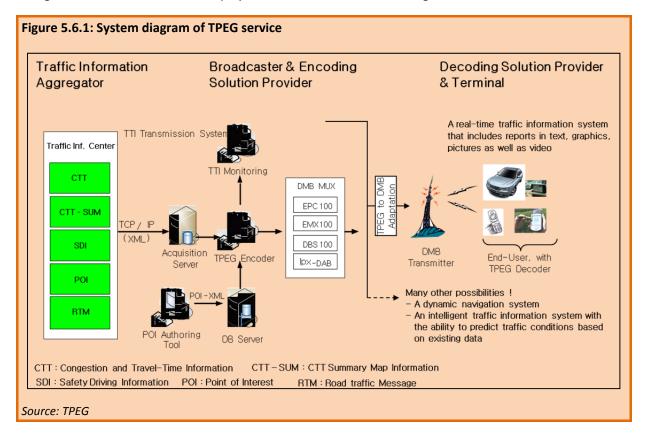
5.6.2 Production facility for data services or additional services

MTV service provides diverse data services and additional services, unlike existing TV or radio services. Examples of this are TPEG service within the data channel, BWS service and BIFS (video channel additional service), SLS and DLS (radio channel additional service). For these special services, new systems that were not embedded in the existing facilities must be included. Also, CAS for pay-services, subscription management and EWS (emergency warning service) will be required additionally.

TPEG 379

TPEG (Transportation Protocol Expert Group) is a protocol to provide traffic information for navigation devices. The service transmits various traffic and road related information to mobile users. The most typical application of TPEG service is to broadcast CTT (Congestion and Travel-Time information, CTT-SUM (CTT summary information, SDI (safety driving information), POI (point of interesting), RTM (road traffic message).

Figure 5.6.1 shows the diagram of TPEG service. The traffic information aggregator aggregates traffic information from various providers such as centre of city traffic information, road management office, vehicle accident part of police office, drivers, etc. The broadcaster encodes the received traffic information by using an encoder and authoring tools and transmits the encoded traffic information. At the receiving terminal, the received signal is decoded and overlaid onto the map in the terminal. Integrated traffic information is displayed on the screen with music or guide announcements.



BWS

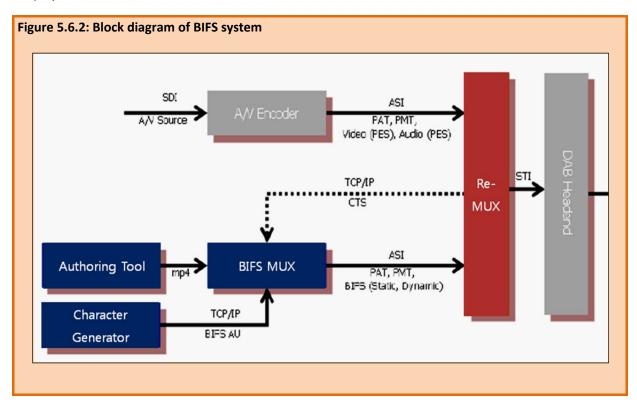
BWS (broadcasting website service) provides HTML data through independent data channels. HTML content such as weather, news, culture and art and travel information are transmitted repeatedly by the carousel concept and the receiver stores and retrieves the carousel data by local interaction. Languages other than HTML (e.g. BML - broadcast mark-up language) may be used depending on the country, business plan and so on.

TTAS.KO-07.0034, Terrestrial Digital Multimedia Broadcasting Systems; Specification of the Traffic and Travel Information services for VHF Digital Multimedia Broadcasting (DMB) to mobile, portable and fixed receivers. www.tta.or.kr/English/new/standardization/eng ttastddesc.jsp?stdno=TTAS.KO-07.0034

BIFS Service

BIFS (binary format for scene description) service, also known as interactive data service, is based on MPEG-4 technology. BIFS service uses 2D and 3D to enable users to transmit video or data simultaneously or selectively using image, text or video other than audio/video broadcasting. It also provides interactive features, enabling interactive services to user requirements.

Figure 5.6.2 shows the block diagram of BIFS system. Various source clips (for example picture, graphic, and text) are authored to provide additional services. The authored contents are re-multiplexed with exciting audio or video programme. At the terminals, the multiplexed signals are de-multiplexed and displayed.

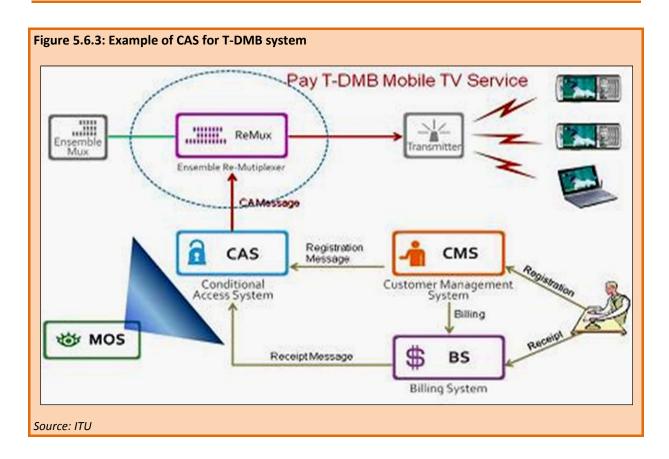


CAS Service

CAS (conditional access system) is generally a part of the control system for pay services. The latter consists of:

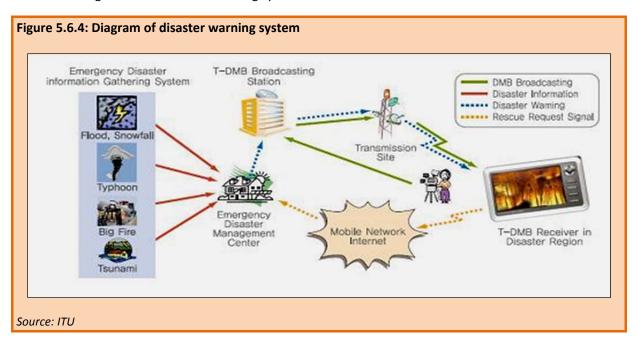
- customer management system;
- billing system;
- monitoring system;
- conditional access.

Section 5.1.5 (Encryption system) gives general information on CAS. Figure 5.6.3 shows an example of CAS applied for T-DMB system. It encrypts broadcasting signals via REMUX process for T-DMB system protection. It provides blocking access to unauthorized terminals to prevent unauthorized service use and illegal content distribution, and supports effective pay services.



Emergency warning broadcasting system

T-DMB service provides a feature that broadcasts warning information on natural calamities or disasters (typhoons, earthquakes, tsunamis or emergencies) in real time, anytime and anywhere for public safety. On receiving an alert from the concerned national authority, the FIDC (fast information data channel) and EWS (emergency warning systems) of the T-DMB system reminds terminal users of an immediate urgency or alerts them on the occasion of disaster to prepare for emergency via interactive service. Figure 5.6.4 shows the diagram of the disaster warning system.



In addition to the information relating to emergency warning, the ISDB-T systems transmit a remote activation signal that activates receivers if these are in standby mode.

The information relating to EWS should be provided and managed by the authorised agency of the country.

MTV can play a major role in disseminating EWS services among the audiences due to the MTV receiver proximity to the public and ready access to MTV receivers round the clock. Thus MTV can become a major player in providing warning of impending natural disasters and also post-disaster relief. It can also help to establish communications with the affected people and also convey "wellness messages".

Implementation guidelines

Equipment and floor space are needed for additional services such as TPEG (data channel service), BWS, BIFS, SLS, and DLS. The equipment for CAS and EWS are generally installed in the Master Control Room (MCR).

- TPEG: needs to edit and convert the data from external traffic information centre(s) into an appropriate signal format for MTV. Encoding equipment may be installed in data channel centre.
- BWS: needs a system to align and update information from various sources such as news centre, travel information data base etc. Additional floor space may be needed for production and management of the contents.
- BIFS/SLS/DLS: needs a system to edit meta-data and/or to generate new information. Additional floor space may be needed for production and management of the contents.
- CAS: realised/maintained in general by a separate supplier and interface equipment can be embedded in the MCR configuration.
- EWS: needs interface equipment for information transmitted from the authorized agency. Monitoring devices can be installed in MCR.

5.7 Shared and common design principles

Guidelines regarding shared and common design principles of DTTB and MTV networks have been incorporated in section 4.7, because of the similarity of the issues involved.

5.8 Transmission equipment availability

The objective of this section is to review and draft the transmission equipment availability to comply with network architecture, design principles, and network planning.

The main activities are:

- drafting of equipment specifications;
- market research including price indications and delivery time;
- testing of equipment.

Transmission equipment should comply with the transmission standard and system specifications defined and based on the above mentioned conditions and, accordingly, the planned services may be implemented. In addition, specifications of the transmitter, antenna, studio-to-transmitter link (STL) and other relevant equipment are to be defined and the price and delivery time of the equipment confirmed. As the next step, before installing the equipment at the transmission site, any operational abnormality of equipment is examined through a rigorous operation test.

In addition, although the issues in section 4.8 are mainly relevant to DTTB, many parts of section 4.8 can also be applied to MTV.

5.8.1 Transmission equipment specification

Transmission equipment consists of a transmitter, antenna and STL. The example specifications are provided for T-DMB in Tables 5.8.1 and 5.8.2 showing the specifications of transmitter³⁸⁰ and antenna respectively.

Transmitter specification

Table 5.8.1: Specification of transmitter for T-DMB

lte	ems	Specification (examples)	Remarks
T-DMB frequency Transmitter		VHF (170 – 250 MHz)	Check compliance with local frequency specification
	Power	Power amplifier 1 000 Wrms	Check whether the power specification can cover the planned coverage area
	Input impedance	75 Ohm ETI Input impedance or High Impedance ETI Input (>10 kOhm)	Check compliance with input specification and electrical property
	AC Power supply	90 V to 265 V / 60 Hz	Check compliance with local AC power supply specification
	Dimension	600*2 200*1 000	Need to be verified to review method
	Weight	330 kg	and cost of delivery, space for installation, and building load
Sub items		Mains power buffer capacitor battery	Need to be reviewed for temporary operation in case of AC power supply disorder
		DAB Band-pass filter 6 Cavities VHF 170 MHz to 240 MHz	Check to avoid adjacent channel interference
		Operational manual	Check availability of translation into local language

³⁸⁰ An example of specifications for DVB-T2, ISDB-T, ATSC Mobile DTV transmitters can be found in http://cdn.rohde-

schwarz.com/dl downloads/dl common library/dl brochures and datasheets/pdf 1/NHNV8300 bro en.pdf

Antenna specifications (including feeder)

Table 5.8.2: Specification of antenna for T-DMB

	Items	Specification (examples)	Remarks
Antenna System	Frequency range	VHF (170 - 250 MHz)	Check compliance with frequency specification designated for the relevant transmitter
	Power rating	rated for 2.4 kW (average power) per input	Check acceptability of the planned output power taking potential increase of output into account
	Impedance	50 ohm	Check consistency with transmitter output impedance
	connector	Single 7/8" EIA Input	Check compliance with feeder specification
	VSWR	≤1.05 in the operating channels	Review possible reduction of transmission efficiency due to reflection wave
	polarization	Horizontal / Vertical	Vertical polarisation is favoured over horizontal polarisation under mobile transmission environment
	Lightning Protection	All Metal Parts DC Grounded	Avoid lightning accidents
	Gain	8 dB	Means of increasing ERP
	Wind Load	1.36 kN (150 km/h)	Need to be verified to review method
	Dimension	1300*1300*660	and cost of delivery, space for installation, and building and tower
	Weight	38 kg	load
Coaxial Feeder	r and Accessories	Cell flex feeder cable including drum	
		7/8" EIA Connector	
		7/8" EIA Coupling Element	
		Earthing kit	
		Hoisting Stocking	
		Cable clamp / RSB clip	

STL

Major factors to be considered relating to STL (studio-to-transmitter link) are transfer quality, signal delays and counter measures against link shut-down and/or quality degradation of signals. Three types of STL can be identified:

- Leased optical link: Signal is transmitted through a link leased by network operator. Factors
 including guarantee of signal credibility, distance between transmission site and operator
 terminal, smooth interfacing with broadcast equipment, and path redundancy and other
 countermeasures in emergency situation are to be reviewed.
- Self-operated microwave link: Link is operated directly by broadcasters. Factors including
 availability of a frequency suitable for the distance between studio and transmission site, and
 availability of LOS (line of sight) need to be reviewed.
- STL employing IP network: IP networks using private VPN networks on the public internet provide an effective solution for the STL. Factors to watch out for include SLA (service level agreement) availability, jitter and latency.

Implementation guidelines

Besides the above mentioned specifications, review the following factors based on the use of existing infrastructure, cost-efficiency, and availability of manpower:

- Transmitter: Cooling system, air chamber, remote-control, generator, UPS (uninterruptible power supply system).
- Antenna: Consider different types of antennas or combination with other media depending on availability of space for tower installation.
- STL: Review possibility of multiplexing with links operated by other service providers, network operators, or platforms.

5.8.2 Market research of transmission equipment

Price, delivery schedule, installation support, operational training, follow-up maintenance service, and accessibility to spare parts are key considerations when introducing transmission equipment. In addition, it is essential to verify whether the equipment is in conformity with the aforementioned specifications and suitable for the broadcasting site condition, such as air cooled/water cooled type, size, weight, etc. The cost of the equipment may be based on the "cost of ownership" rather than just the equipment price. Cost of ownership includes the operating costs, such as electricity consumption, spares and other materials, over a period of time of operation (say 10 years). Many of the power efficient transmitters (using green technologies), which may be slightly more expensive initially, could turn out to be quite cost effective if operating costs are accounted for.

Performance, operational ease, and reliability of the manufacturer are other criteria to be taken into consideration. While performance will be examined in the next step through a test process, operational ease needs to be examined through comparison and analysis of availability of manpower, distance between the transmission site and broadcasting station, and other conditions of the broadcaster and features of the transmission equipment.

Transmitter

- Price: A reasonable price for the transmitter can be arrived at by comparing prices offered by different manufacturers; check whether cost of delivery, customs, installation, training, and spare parts are included in the price. Cost of acquisition, as defined above, should be examined and taken into account.
- Delivery time and method: Make sure in-time delivery to the broadcaster is guaranteed, and if equipment manufacturer is a foreign company, check where and how the delivery will be made.
- Installation support and operation training: Check scope of support for installation and operational training provided by the manufacturer.
- Follow-up service and availability of spare parts: Check follow-up service measures, e.g. repair and maintenance, and supply method and warranty period of spare parts for emergency use.

Antenna

- Consider the same factors as the transmitter in terms of price, delivery schedule, support measures, and follow-up service.
- As electrical properties of antennas are affected by mechanical damage, delivery method and other measures for stable supply are of key consideration.
- Since installation of transmission equipment requires expertise, availability of support from an installation expert or instruction for proper installation process and method need to be ensured.

Implementation guidelines

Manufacturers of transmission equipment provide a wide range of products with different prices and diverse features, such as equipment type, delivery time, and scope of support. Detailed and in-depth negotiations with the manufacturers need to be based on technical, environmental, and other trading conditions relevant to the broadcaster, keeping the cost of ownership in view. With other factors being equivalent, transmitters using green technologies should be given preference.

There is a large number of reputed transmission equipment manufacturers and not only global companies but also domestic companies can be considered for certain services. For installation of transmission equipment, domestic companies may also be considered, as installation per se does not necessarily require specific technical expertise related to mobile broadcasting. Ability to comply with requirements from the equipment manufacturers and faithfully fulfil supervisory activities of broadcasting engineers are the key criteria when selecting the company.

Selection of equipment manufacturers can be guided by:

- Transmitter manufacturers: Global manufacturers³⁸¹.
- Antenna manufacturers: Global manufacturers³⁸².
- Installation companies: Domestic companies.

5.8.3 Testing of transmission equipment

Several tests need to be conducted to examine the mechanical and electrical properties of major transmission equipment, such as the transmitter and antenna. Criteria for the test include credibility and stability regarding mechanical properties, and diverse tests regarding electrical properties. Refer to the Annex D Part A: Testing of transmission equipment in detail; items in the Annex are based on T-DMB standard.

Implementation guidelines

A thorough review of the specifications provided by the manufacturer is as important as the price in the selection of transmission equipment for purchase. Most of the characteristics regarding the equipment are described in the specification; the most important item to check is whether these characteristics comply with the specification described in the above section (5.8.1) as well as the requirements from the broadcaster.

This examination process will verify the characteristics provided in the specifications. The verification will allow broadcasters to make any further requests deemed necessary for the manufacturer to meet these conditions or to demand customization to achieve desired characteristic.

In addition, as the laboratory test result can differ from the post-installation outcome, after installation it is essential to extensively check whether the equipment complies with the specifications.

R&S, Harris, itelco, Ampegon, Nautel, Broadcast Electronics, Plisch, etc. / www.dvb-h.org/products.htm You may also wish to contact associations of manufacturers, such as the IABM (www.theiabm.org) for contact details of transmitter and other associated manufacturers.

³⁸² RFS, ADC, Hy-Gain, Katherine, etc.

However, even after installation and thorough examination for excellent performance, unless the manufacturer's requirements (for example; ambient temperature, proper supply voltage, and rated output maintenance) are met, the equipment will fail to operate normally or maintain its ratings. It is, therefore, of absolute importance to meet the specifications for input (power) supplies and ambient environment while the equipment is in operation.

5.9 Network rollout and planning

The objective of this section is to provide a comprehensive master plan and an implementation schedule for the MTV services through the activities described below:

- setting up of Pilot transmission system;
- pilot trial and field measurements;
- evaluation of service quality from field tests;
- research of consumer demand from audience surveys;
- full knowledge of the relevant legislation regarding digital transition and setting up of digital broadcasting services;
- full knowledge of the relevant regulations set up by the national spectrum regulator;
- identification of coverage area(s) using the results of consumer surveys and based on the business plan;
- close discussions with the national regulator regarding the spectrum and site requirements;
- identification of transmitter sites and generation of an efficient frequency and network plan using software tools and digital terrain databases;
- setting up an implementation plan and phasing out of network implementation;
- finalisation of equipment requirements;
- commencement of installation in accordance with the business and implementation plans.

This section will focus on designing a pilot system and developing a service roll-out plan, which will be based on factors considered for the diverse conditions and situations mentioned above.

In this process, a pilot system will be installed and the technical feasibility and required complementary measures will be derived by conducting field tests and analysis. In addition, a plan for a nationwide service, measures to improve reception, and other technical initiatives will be defined.

At the same time, with technological analysis and planning, it is necessary to conduct a survey on audiences' response to identify the demand for services and viewing patterns.

Based on collective consideration of data acquired through the above mentioned process and funding, content development, and manpower planning, the final version of the service roll-out plan can be confirmed, which will enable the launch of diverse and comprehensive promotion activities.

In addition, although the issues in section 4.9 that are mainly relevant to DTTB, many parts of 4.9 can be applied to MTV.

5.9.1 Setting up a pilot system

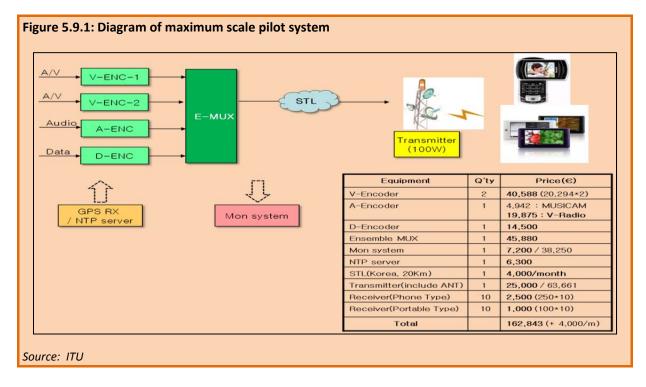
The objective of setting up a pilot system is to test diverse functionalities through a pilot operation and acquire data that will serve as the foundation for future planning. To achieve this goal, a highly flexible transmission system, an infrastructure for the transmitting station, prevention of crosstalk with other channels, and other technical preparations need to be completed along with assembling a skilled workforce, funding expenses for operation, solving licence-related issues (frequency/ power output), and other general preparatory measures.

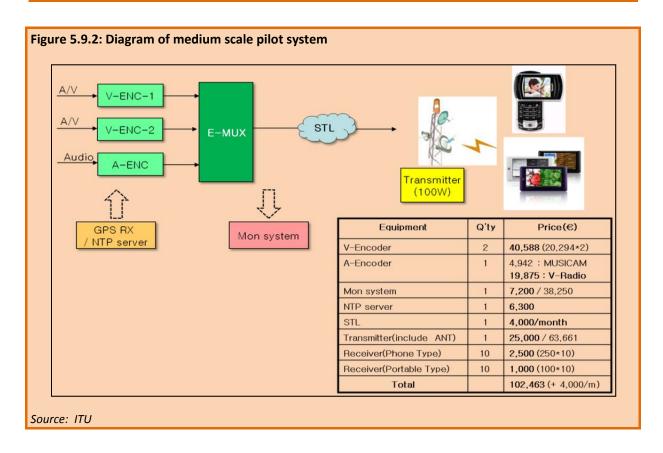
The scale of the pilot system will differ depending on the purpose pursued by the broadcaster but, generally, it can be categorized into three different levels of scale: maximum, medium and minimum.

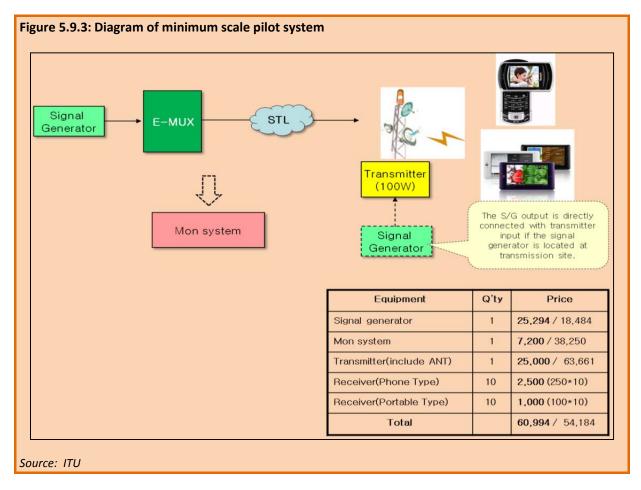
- Maximum scale: Complete system with simple production, transfer, and transmission parts (a pilot service system that can be converted to commercial use immediately after resolving contents- and licence-related issues).
- Medium scale: Consists of the transfer and transmission parts (a system that enables tests on channel composition and transmission properties).
- Minimum scale: Consists of the signal generator and transmission part (only allows transmission performance tests).

The choice of the type of the pilot trial system will largely depend on the level of expertise attained by the broadcaster. In the case of a new venture into MTV, the third type of pilot set up (minimum scale) could be considered. In case the broadcaster has already gained some experience in MTV or is venturing into a new service configuration or area, the first type (Maximum scale) could be considered.

Example cases and projected approximate cost are presented in the Figure 5.9.1, 5.9.2, and 5.9.3 (based on the Korea T-DMB):







Implementation guidelines

In obtaining the licence for a pilot system operation, it is important to secure some flexibility in the specifications. If the output is licensed with flexibility, it is a useful means to verify coverage projection and to check interference with other services using adjacent frequencies. It also allows broadcasters and the audience to familiarise themselves with the system during the pilot service period and adjust to the commercial service without major difficulties.

Selecting the site to install the transmission equipment for the pilot system is another important factor to consider. Factors, such as restrictions in utilizing the site infrastructure, distance from the broadcasting station and the range of expected coverage, need to be reviewed prior to choosing the site.

It is recommended to install the pilot MTV head-end system within the broadcasting station for convenient content distribution, tests of diverse items, altering channel composition, changing default values of each channel's configuration and ease of equipment operation and maintenance.

It is also critical to build capacities and train mobile broadcasting staff during the pilot service period. While terrestrial broadcasters usually have a number of experts in the existing services of TV and radio, mobile broadcasting is a brand new area with little prior field experience. Together with digital technologies the concept of multiplexing is introduced in MTV. To respond to such needs, it is essential to secure expertise in this field through basic training on theory as well as proactive participation of field engineers in the pilot broadcasting.

In addition, broadcasters need to take into account that establishing and operating the pilot system will generate certain costs. Funding the implementation of some of the new equipment will not be a critical issue as this equipment can be used later for commercial services. For efficient cost management for links, operation, and labour, it is essential to have a detailed plan and systematic preparation in order to acquire as much knowledge and information as possible during the pilot period.

5.9.2 Field test and analysis

Once the pilot system is established, various trials will be conducted through the actual use of the pilot system. Beyond testing the basic functionality of receiving broadcasts while on the move, the technological basis for commercialisation has to be built-up through collecting data, analysing, and organizing it to enable the use of this complex set of technical data. Previous sections presented the theoretical or empirical explanations for service quality changes according to changes in diverse parameters. The verification of such projections and changes, as well as whether these meet the requirements of the broadcaster, can be conducted through rigorous field tests, which may require a considerable planning effort and extensive expertise. ETI analyser and RF measurement systems are useful tools or conducting field tests and analysis to assist broadcasters in these trials.

Field test and analysis process

- Set basic transmission parameters: Refer to previous sections to set transfer parameters (Code-Rate, Guard Interval, MPE-FEC) and reception parameters (reception mode, transmission, antenna pattern).
- Carefully select the measurement area and the mobile measurement route. Several sets of the
 measurements need to be taken in the same area under similar conditions to ensure reliable
 measurement results.
- 3. Conduct field measurements: Use ETI analyser, RF measurement system and spectrum analyser to measure field strength, bit error-rate, and C/N ratio while on the move.
- 4. *Make approximate checks* to assess whether the field measurements meet the desired outcome.
- 5. Categorize and consolidate data: Consolidate measurement data for each measuring tool in database files.

- 6. *Process and analyse data*: Properly mark consolidated data and document whether the requirements are met.
- 7. Change parameters: If parameters set in step 1 do not meet the requirements or, if another verification process for potential quality improvement is needed, set up new parameters.
- 8. Repeat steps: With the received signal using the newly set parameters, repeat steps 2 to 7.

Implementation guidelines

The conventional RF measurement system used for analogue or digital TV is a system to measure transmission in a fixed reception environment. To a large extent, it is different from the RF measurement system for mobile broadcasting. New approaches to measure and analyse transmission and reception data in the mobile environment have been developed; a brief description and field measurement case examples are provided in Part B of Annex D Measurement system for MTV and field measurement case examples.

5.9.3 Audience research and analysis

The aim of building a pilot system and conducting trial broadcasts has two main objectives; verification of technical assumptions and identifying the needs of the audience. This section will focus on the process of identifying the needs of the audience and to gauge audience response to the MTV services. This survey may also give an indication of the uptake of such services by the audiences.

Audience research can be divided into the following technical and service aspects.

- Research of audience needs from the technical aspect:
 - reception coverage requirements: width, depth, specific region;
 - quality: picture resolution, audio quality;
 - terminal requirements: type, function, size, price affordability;
 - terminal performance: reception sensitivity (transmission output), screen size, screen brightness, UI (user interface), battery life.
- Research of audience needs from the service aspects:
 - demographic information: gender, age, education, occupation, income level, use of other media, telecommunication fee, broadcast subscription fee;
 - level of awareness: recognition, intention to use, free/charged service, willingness to pay, satisfaction level, necessities, reason for use;
 - desired number of services: number of video, audio, and data channels;
 - genre preference: soap opera, news, entertainment, sports, documentary, education, art, culture, history, fashion;
 - viewing patterns: when and where, how long and how often.

To obtain accurate statistics, it is essential to have a sample size as large as practicable and to collect data from many diverse audience segments. Analysing and consolidating data gathered using standard methods will serve as a foundation for developing plans for technical preparation and service roll-out.

The following are recommendations on how to consolidate and utilize data:

- reception coverage requirements: decide and prioritize issues for output and network design;
- quality: decide on bit-rate allocation and receiver screen size;
- terminal requirements: establish service strategies by type of use (for use in cars, mobile phones, handheld portable, high-end and low-end services);

- terminal performance requirements: set up strategies for programming and content configuration;
- demographic information: identify target customer;
- awareness: establish a basis for promotion strategies and estimated subscription fee;
- desired number of services: develop strategies for optimum channel configuration;
- genre preference: establish programming strategy and content distribution plan;
- viewing pattern: identify target service and establish programming strategy.

5.9.4 Developing the master plan

The details of the master plan can be divided generally into content, infrastructure and operation, each of which requires a significant amount of time and effort to be developed. The master plan can differ substantially depending on government policy, environment, broadcaster's plans and goals, and audience demand. The direction for services, and content strategies, as well as a matching plan for infrastructure construction, can be decided based on these high-level criteria. It is also a necessity to establish a strategy for the operation of the established system and profitability projection. Staff training strategies can also benefit from the results.

The following is the description of the main criteria for establishing the master plan.

- Content (related section; 5.1.3 and 5.9.3):
 - Channel configuration: Multiplexer operation plan including the number of video, audio, and data channel, bit-rate allocation, and channel lease.
 - Programming: A programme scheduling plan including programme genre by channel, content, length, allocation, and proportion by format.
 - Securing content: Plan re-transmission, in-house production, re-production, outsourcing, and purchasing.

Infrastructure:

- Production facility: Decide on whether to use existing facilities, build new studios, or use sub-contracted production facilities to meet the content securing plan, size and level of facility, and the construction plan including the budget plan (related section; 5.2.3).
- Transmission (head-end) facility: Develop a plan for building the transmission facility, including size, weight, and budget regarding equipment configuration, purchase, and installation, in order to implement the programming plan (related section; 5.2.2).
- Transmission (RF) facility: Plan to build main transmitting stations, relay stations, and fill-in transmitters for optimum reception, and plan to expand coverage to provide nation-wide services (related section; 5.2.1, 5.2.3, 5.8.2, and 4.7).

Operation:

- System operation: Plan for staffing and repair and maintenance for the established facilities;
- Programme/production/ transmission operation: Develop plans for manpower and budgeting regarding programme production, programming, traffic control, transmission, and advertising;
- Additional service development: Establish development and operation plans for additional services, such as BIFS, DLS, SLS, besides the already existing audio and video services (related section; 5.1.6).

- Business model development: Planning of a viable business model covering all aspects of this
 new service. This includes plans to develop and operate new value-added services, such as
 TPEG, BWS, VoD and push service (down load automatically the booked contents for latenight VoD), that can generate income and meet the demands of the audience in a different
 way from the existing media (related section; 5.1.4).
- Profitability projection: Project expenses regarding content, infrastructure, and operation, and develop a projection report on profit generated through advertising, additional services, and data service (related section; 5.1.5).

Implementation guidelines

Once an actual system is prepared and a plan for future services is established for broadcasting, a forward-looking work plan for brand and service promotion has to be established to attract audiences to the new service and invite them to enjoy the benefits of mobile broadcasting. Securing a broad audience base is a pivotal condition for early stabilisation of the service and future success in the business. For this objective, plans for promotion, audience targeting, and terminal penetration strategies are to be established. The following points should be taken into account when preparing such a plan.

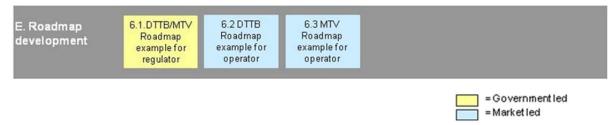
- Promotion and targeting audiences:
 - Promotion through existing media: Service launch date, contents, features of service, special
 promotion programme and other extensive promotion activities, and financial support for
 advertising new terminals.
 - Promotion using terminal sales network: As the newly introduced mobile broadcasting requires purchase of new terminals, promotion campaigns at mobile phone agencies, and terminal retailers such as tablet sellers, TV shops and hypermarkets can be effective.
 - Special events: Host special events to promote the launch of service, such as open broadcasting through existing media and special discount offers for terminals.
 - Consider operation of call centres and a website for customer complaints and requests, as well as service instructions.
 - Initially secure an audience base through development of bundled services in a link-up with the existing media or mobile telecommunications and time-limited discount offers.
- Promoting MTV receiver / terminal take up:
 - Establish close cooperation system with terminal distributors through promoting diverse services and introducing functionalities of the terminals via existing media.
 - Establish close cooperation system with terminal distributors to align the embedding of new functions for the implementation of diverse services, UI (user interface) tuning, roll-out schedule, roll-out units, etc.

5.10 Additional Information on MTV

Additional information pertaining to MTV systems and services is contained in Annex D to these Guidelines.

Part 6- Roadmap development

Part 6 (Roadmap development) deals with a set of generic roadmaps regarding the whole process of transition to DTTB and introduction of MTV by the regulator and DTTB and MTV network operator and service provider. It covers functional building blocks 6.1 to 6.3 of layer E of the functional framework described in section 1.2. These functional building blocks are depicted below.



The guidelines for each of the functional building blocks 6.1 to 6.3 are addressed in the subsequent sections of Part 6. In addition section 6.4 deals with the development of a national roadmap and gives information on national roadmaps that have been prepared with ITU assistance.

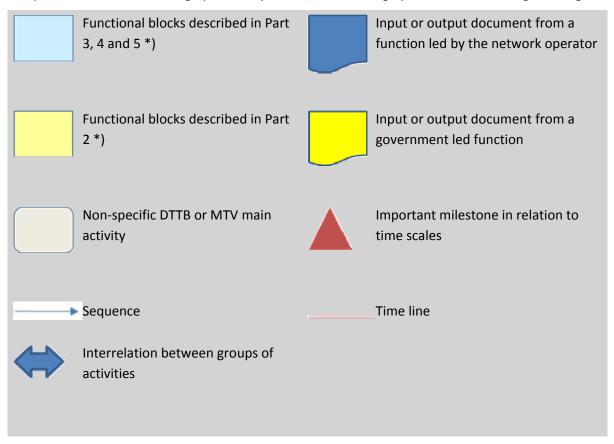
A roadmap is a plan that matches short-term and long-term goals and indicates the main activities needed to meet these goals. Developing a roadmap has three major uses:

- 1. It helps to reach consensus about the requirements and solutions for transition to DTTB and introduction of MTV.
- 2. It provides a mechanism to help forecast the key milestones for the transition to DTTB and introduction of MTV.
- 3. It provides a framework to help plan and coordinate the steps needed for transition to DTTB and introduction of MTV.

The roadmaps shown in sections 6.1 to 6.3 represent generic cases of transition to DTTB and introduction of MTV. In practice the roadmaps may differ (see examples in section 6.4), depending on:

- the national TV market, regulatory situation and DSO objectives;
- the choices that have already been made and key topics that have already been addressed;
- the responsibilities of the organisation for which the roadmap is made.

This part contains a number of graphs. The symbols used in these graphs have the following meaning:



^{*)} Numbers in blocks in the roadmap refer to functional block numbers in Figure 1.1.1 in section 1.1 and to the corresponding sections.

6.1 Roadmap for the regulator

Section 6.1 provides background information and guidelines on key topics and choices regarding the development of a roadmap for transition to DTTB and introduction of MTV by a regulator. This section consists of three sections:

- 6.1.1 Construction of a roadmap
- 6.1.2 Generic roadmap for transition to DTTB and introduction of MTV by a regulator
- 6.1.3 Implementation guidelines

6.1.1 Construction of a roadmap

The roadmap for transition to DTTB and introduction of MTV by a regulator is divided in four phases:

- 1. *DTTB* and *MTV* policy development: The policy regarding DTTB and MTV introduction is established based on the existing national telecom, broadcast and media acts and international agreements (including the GE06 Agreement where this applies).
- 2. Analogue switch-off (ASO) planning: The analogue switch-off plan is made taking into account the DTTB and MTV policy and before the licensing policy and regulation is concluded.
- 3. Licensing policy and regulation: The licensing policy and regulations are developed based on the DTTB and MTV policy and the ASO planning.
- 4. *Licence administration*: After licences have been granted, the administration/regulator should verify that the licence conditions have been met and notify operational stations to ITU.

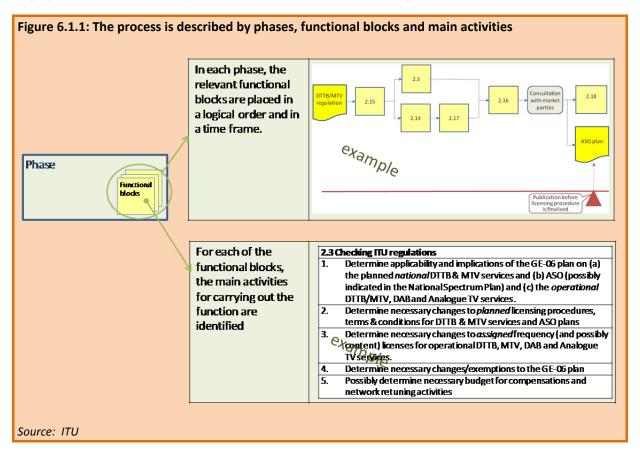
In each phase a number of functional blocks (see Figure 1.1.1 of section 1.1) have to be addressed. Guidelines regarding key topics and choices of these functional blocks are described in the corresponding sections.

For each of the functional blocks, the main activities for carrying out the function have to be identified. These main activities may be supplemented by additional main activities that are not specific for DTTB or MTV, but are nevertheless needed for a successful transition to DTTB and introduction of MTV. Examples of such non-specific DTTB or MTV activities are:

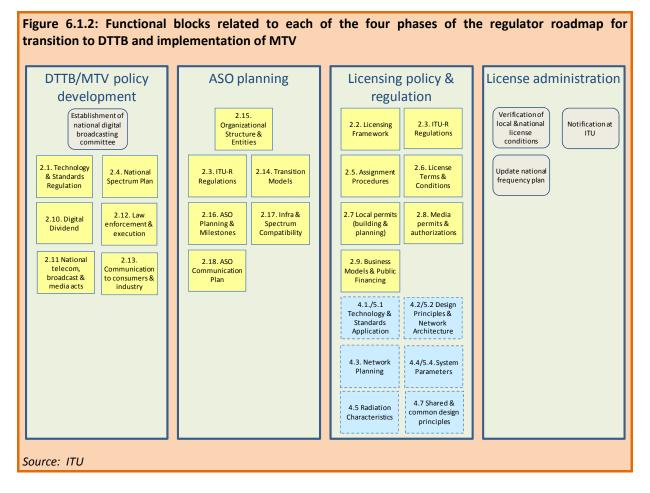
- consultation with market parties;
- international frequency coordination;
- notification of frequency assignments to ITU.

The roadmap is constructed by placing the relevant functional blocks in each phase in a logical order and in a time frame. It is important that the order of activities to be carried out by the different players, including the regulator, fits with each other. Hence, for determining the order of the functional blocks, information exchange and negotiations between market parties and the regulator is essential.

A graphical illustration of the process described above is shown in Figure 6.1.1.



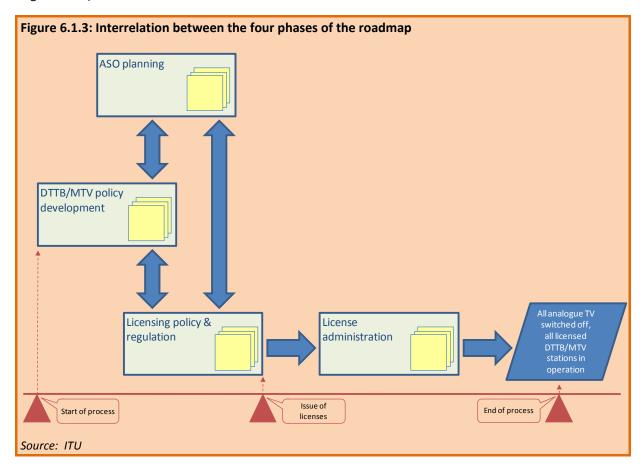
The functional blocks connected to each of the four phases of the roadmap are shown in Figure 6.1.2.



It should be noted that Figure 6.1.2 represents a generic case. The actual selection of functional blocks may differ from country to country, in particular regarding the following functions:

- In some countries some of the technical choices and part of the network planning is done by the regulator, these functions are described in Part 4 and 5 and are indicated with dotted lines in the roadmaps in this section.
- The mandate and tasks of the national digital broadcasting committee are likely to differ from country to country. In the roadmap given in this section it is assumed that the committee deals with DTTB and MTV policy and regulations only. It is also possible that the committee deals with (parts of) the licensing procedure. For ASO planning a different committee is assumed. However, the ASO committee could be the same as the DTTB/MTV policy committee.

The four phases can be carried out sequentially, but in practice often the first three phases are carried out partly in parallel with regular checks for verifying if results of these phases are still in line (see Figure 6.1.3).



There is no clear marker that will indicate the start of the process. The start could be triggered by the wish of broadcasters to introduce DTTB or MTV services, or by mobile operators wishing to use part of the "digital dividend" for mobile services. Sometimes governments may initiate the process taking into account international agreements or with the aim of more efficient use of spectrum. For example, GE06 Agreement stipulates that the transition period ends on 17 June 2015 and for a number of countries on 17 June 2020 with regard to Band III.

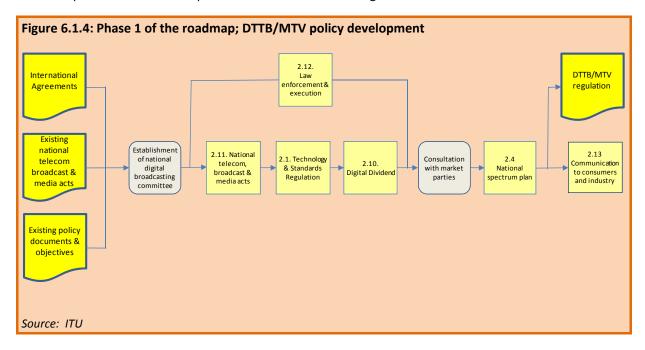
The process ends when all analogue TV services are switched-off and all DTTB and MTV stations are in operation without any restrictions that were necessary to protect analogue TV.

315

The countries with a prolonged transition period in Band III are listed in footnote 7 related to Article 12 of the Geneva 2006 Agreement.

6.1.2 Generic roadmap for transition to DTTB and introduction of MTV by a regulator

The four phases of the roadmap are described in the following sections.



6.1.2.1 DTTB/MTV policy development

Input data

International agreements (including the GE06 Agreement where this applies) and existing relevant legislation and policy documents are the basis for establishing the DTTB/MTV policy.

Establishment of a national committee

Normally the first step is to set up a national digital broadcasting committee. DTTB and MTV introduction is a complex process, involving many players and many interrelations between the players. Good communication between all players (government and market parties) is essential. Therefore a DTTB introduction committee, in which all players are represented, would be advisable. In practice these kinds of committees could have different forms and mandates, ranging from informal set-ups to official government led commissions or independent organizations taking final decisions.

National Telecom, broadcast and media acts

Taking into account the advice of the national committee, existing relevant documents and acts will be reviewed by carrying out the activities related to functional block 2.11 National Telecom, broadcast and media acts (see Table 6.1.1).

Table 6.1.1: Main activities related to proposing changes in national telecom, broadcast and media acts

2.1	2.11 Proposing changes in national telecom, broadcast and media acts	
1.	Make inventory of current legislation	
2.	Map inventory on DTTB/MTV introductions and compare with 'best practices'	
3.	Identify gaps and draft proposals for additional and/or changes in legislation (based on 'best practices')	
4.	Determine planning for changes in the law and determine 'must haves' for launching DTTB/ASO and MTV	

Preparing technology and standards regulations and defining digital dividend

The above mentioned activities are followed by the activities related to functional blocks:

- 2.1 Technology and standards regulations (see Table 6.1.2);
- 2.10 Digital dividend (see Table 6.1.3).

Table 6.1.2: Main activities related to the preparation of technology and standards regulations

Carry out market research/surveys to identify industry and consumer needs for standardization Determine minimum set of receiver Standards for the DTTB and MTV market, based on the market developments and the planned licensing procedures, terms and conditions Map on existing standardization policies/rules and determine additional standardization needs Assess impact on industry and end consumers Determine receiver requirements and include in frequency licence terms and conditions and/or media permits and authorizations Determine communication messages, planning, standardization/testing bodies and methods (including logos and labelling) Update, if necessary national spectrum plan and legislation

Table 6.1.3: Main activities to identify possible allocations for the digital dividend

2.10	2.10 Defining digital dividend	
1.	Analyse current and future market developments and possibly conduct market consultation(s) in the broadcast (and telecoms) industries	
2.	Assess current and future market needs for DTTB and MTV services, possibly based on formulated legislation and Policies	
3.	Assess available spectrum after ASO, based on ASO plans, national spectrum plan and, where applicable, ITU-R Regulations	
4.	Map spectrum needs on available spectrum and determine priorities and assign spectrum to broadcasting	
5.	Possibly draft spectrum re-farming plans and compensation schemes (for network and receiver re-tuning activities), reserve budgets	
6.	Update national spectrum plan and align licence Terms and Conditions for DTTB and MTV services	

Convergence of broadcasting and telecommunication services (e.g. by introducing MTV, or combined DTTB and internet TV services) may initiate the need to review the entities dealing with law enforcement and execution. Functional block 2.12 deals with these issues and the main activities are listed in Table 6.1.4. These activities are preferably carried out in parallel to the activities related to 2.1, 2.10 and 2.11, but could also be carried out later. Introduction of DTTB and MTV is not dependent on it but, once introduced, law enforcement and execution in relation to DTTB and MTV will be more effective.

Table 6.1.4: Main activities related to reviewing national institutions

2.12	2.12 Reviewing law enforcement and execution	
1.	Make inventory of current regulatory bodies	
2.	Map inventory on DTTB/MTV introductions and compare with 'best practices'	
3.	Identify gaps and draft proposals for additional regulatory bodies and/or changing existing bodies (based on 'best practices')	
4.	Determine planning for either establishing new regulatory bodies or changing existing bodies and determine 'must haves' for launching DTTB/ASO and MTV	

Consultation with market parties

Consultation with market parties will take place in order to inform the market parties about the DTTB and MTV policy and to receive feedback from the market parties about the practical implementation of the policies. As far as necessary, the policies will be modified taking into account the comments from the market parties.

Update of national spectrum plan

The next step is to carry out the activities for updating the national spectrum plan (functional block 2.4), as listed in Table 6.1.5.

Table 6.1.5: Main activities for updating the national spectrum plan

2.4 L	2.4 Update of the national spectrum plan	
1.	Make an inventory of current spectrum use in the broadcast bands(bands III, IV and V)	
2.	Register use and provide rules for self-registration	
3.	Carry out market analyses and consultations and forecast future spectrum needs	
4.	Determine re-farming needs and assess impact on existing and future users (including service and financial impact), possibly reserve budget for re-farming efforts and damages	
5.	Determine publication content, dates and formats for the national spectrum plan	
6.	Determine budget for spectrum management and administrative fees	

Communication

The DTTB/MTV policy development phase ends with a set of documents describing regulations for transition to DTTB and introduction of MTV and communication plans regarding the DTTB and MTV policy and regulations. The communication plans are drafted by carrying out the activities related to functional block 2.13 Communication to end consumers and industry (see Table 6.1.6).

Table 6.1.6: Main activities related to communication to end consumers

2.13	2.13 Communication to end consumers and industry	
1.	Make inventory of communication scope	
2.	Determining the key communication moments and topics	
3.	Determine communication tools for each target group/audience	
4.	Instruct communication bodies and committees	

Figure 6.1.5: Phase 2 of the roadmap; analogue switch-off planning 2.3 ITU-R regulations 2.15 DTTB/MTV 2.16 Consultation 2.18 Organizational regulation ASO planning & with market ASO structure & milestones parties communication entities Infra & Transition models compatibility ASO plan

6.1.2.2 Analogue switch-off planning

Input data

Source: ITU

The national DTTB and MTV regulations resulting from Phase 1 of the roadmap is the basis for the analogue switch-off (ASO) planning.

Publication before licensing procedure is finalised

Establishment of organizational structures and entities

The first step is to perform the activities relating to functional block 2.15 (Organizational structures and entities) as indicated in Table 6.1.7.

Table 6.1.7: Main activities related to the establishment of organizational structures and entities

2.15 Establishment of organizational structures and entities 1. Establish overall coordination needs 2. Form or extend special purpose organisational vehicle, establish clear mandate 3. Establish budget and communication means (air-time, website, etc)

ASO planning

These activities are followed by the actual ASO planning through the activities related to functional blocks:

- 2.3 ITU-R regulations, as far as appropriate to ASO (see Table 6.1.8);
- 2.14 Transition models (see Table 6.1.9);
- 2.16 ASO planning and milestones (see Table 6.1.10);
- 2.17 Infrastructure and spectrum compatibility (see Table 6.1.11).

Table 6.1.8: Main activities related to checking of ITU-R regulations

2.3 Checking ITU regulations

- 1. Determine applicability and implications of ITU Radio Regulations and the GE06 plan (where this applies), on (a) the planned *national* DTTB and MTV services and (b) ASO (possibly indicated in the national spectrum plan) and (c) the *operational* DTTB/MTV, DAB and analogue TV services.
- Determine necessary changes to planned licensing procedures, terms and conditions for DTTB and MTV services and ASO plans
- Determine necessary changes to assigned frequency (and possibly content) licences for operational DTTB, MTV, DAB and Analogue TV services.
- 4. Determine necessary changes/exemptions to the GE06 plan where this applies
- 5. Possibly determine necessary budget for compensations and network retuning activities

Table 6.1.9: Main activities related to defining transition models

2.14 Defining transition models

- 1. Check existing legislation and policies for Public (and commercial) television service (e.g. FTA) and coverage stipulations (e.g. nationwide coverage)
- 2. Check ITU-R Regulations and any existing/formulated receiver regulations for impact on ASO
- 3. Carry out market research on ASO affected viewers/listeners. Identify any hidden viewers/listeners (2nd television sets, regional programming, prisons, etc.), Identify impact and risk areas
- 4. Analyse and assess complexity and size of network modifications and receiver transitions
- 5. Involve and discuss ASO with Content Aggregators (esp. public broadcaster) and consumer associations
- 6. Decide transition model (simulcast period and ASO phasing)

Table 6.1.10: Main activities related to setting up ASO planning and miles stones

2.16 Setting up ASO planning and milestones

- 1. Draft comprehensive ASO planning (milestones and activities) and assign tasks and responsibilities (including core project management team)
- Establish ASO project monitoring framework and reporting structure
- 3. Identify ASO project risks and draft risk mitigation plans (including fall back and/or roll back scenarios)

Table 6.1.11: Main activities related to identifying infra and spectrum compatibility

2.17 Identifying infrastructure and spectrum compatibility

- 1. Check legislation, ITU-R Regulations, national spectrum plan and establish service priorities and acceptable interferences levels
- 2. Assess available antenna space and sites and site/antenna sharing possibilities/options
- Calculate interference levels, service coverage and check EMC compatibility
- 4. Develop site transition scenarios (including temporary installations and sites)
- 5. Assess costs, time lines and service impact

Consultation with market parties

After the ASO planning has been formulated, consultation with market parties will take place. The purpose of this consultation is to inform the market parties about the ASO planning and to receive feedback from the market parties about the practical implementation. As far as practicable the policies will be modified, taking into account the comments from the market parties.

Communication

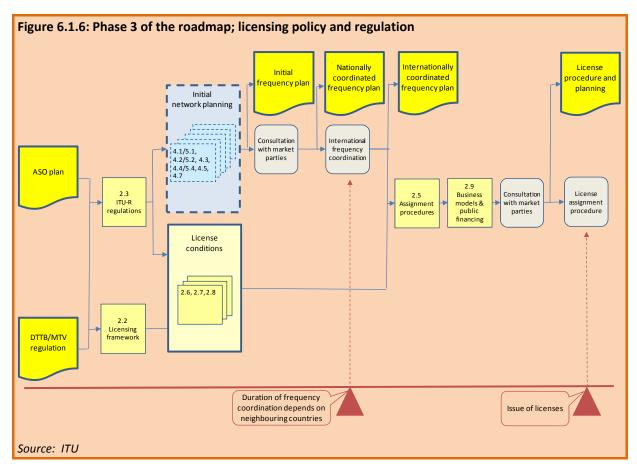
Taking into account the comments received from the consultation with the market parties, the final ASO plan will be adopted and the ASO communication plan (functional block 2.17) will be drafted. The activities related to the drafting of the ASO communication plan are listed in Table 6.1.12.

Table 6.1.12: Main activities related to drafting ASO communication plan

Drafting ASO communication plan Draft communication plan (including target audiences, timing, means, etc.) Continuous alignment with ASO planning Determine and establish compensation schemes and systems, include in communication plan

The ASO plan should be taken into account in the licence terms and conditions.

6.1.2.3 Licensing policy regulation



Input data

Licensing policy and regulations will be developed with the DTTB/MTV regulations and the ASO plan, resulting from Phase 1 and Phase 2 of the roadmap respectively, as input.

ITU-R regulations

Functional block 2.3 (ITU-R regulations), is addressed with the aim to identify the frequency assignments or allotments that are available according to ITU-R regulations and in particular the GE06 Agreement (where this applies). The activities, as far as appropriate to this part of the roadmap, are listed in Table 6.1.8 in Subsection 6.1.2.2.

Establishment of technical criteria

A series of activities takes place in order to establish the technical criteria of the DTTB /MTV stations. The activities are described below.

Initial network planning

In some countries, some of the technical choices and part of the network planning is done by the regulator. These functions are indicated with dotted lines in the roadmap. The related activities are listed in sections 6.2 and 6.3 for DTTB and MTV networks, respectively.

Depending on the detail with which the regulator wants to prescribe station characteristics and coverage that should be achieved, the activities related to the functional blocks 4.1 to 4.7 and 5.1 to 5.7 regarding DTTB and MTV respectively, may involve detailed calculations with advanced planning software. This is in particular the case when:

- a certain degree of coverage will be defined in the licence;
- licence assignments will be necessary in the countries applying GE06 plan, of which entries are allotments.

In functional blocks 4.3, as described in the guidelines in section 4.3, the results of network planning exercises are compared with the principles defined in section 4.2 (Design principles and network architecture), which in turn is based on business plan and customer proposition. In the case where the regulator is carrying out these activities, instead of business plan and customer proposition, network planning results should be compared with the objectives formulated in DTTB/MTV regulation and ASO plan.

Consultation with market parties in international frequency coordination

The activities related to functional blocks 4.1 to 4.7 and 5.1 to 5.7 result in a network plan, of which three versions will be needed:

- 1. the initial network plan;
- 2. the national coordinated network plan in which the comments from the market parties are incorporated;
- 3. the internationally agreed network plan in which the agreements with neighbouring countries have been incorporated.

Between the first and second version of the network plan, consultation with market parties will take place. The purpose of this consultation is to inform the market parties about the network plan and to receive feedback from the market parties about the practical implementation.

Between the second and the third version of the network plan, international frequency coordination will take place, in accordance with ITU Regulations or the provisions of the GE06 Agreement (where this applies). In the case where detailed network planning is carried out by the licence holder or network operator, international coordination is done at a later stage at the request of the licence holder or network operator.

Establishment of administrative licence regulations

In this series of activities the administrative licence regulations will be established. These activities are described below.

Licensing framework

First the licensing framework is set up by carrying out the activities related to functional block 2.2, Licensing framework (see Table 6.1.13).

Table 6.1.13: Main activities related to the setting up of a licensing framework

Make inventory of current licensing framework and check applicability for DTTB and MTV service introductions Assess and evaluate different options for licensing DTTB and MTV services Assess compatibility with ASO plans and national spectrum plan Possibly revise current licensing framework and assess impact Draft planning for licence assignment, framework changes and update national spectrum plan (and possibly legislation)

Defining licence conditions

With the results of functional block 2.2 and the information on the available assignments or allotments resulting from functional block 2.3 (ITU-R regulations), the licence conditions will be defined by carrying out the activities related to functional blocks:

- 2.6 Licence terms and conditions (see Table 6.1.14)
- 2.7 Local permits (see Table 6.1.15)
- 2.8 Media permits and authorizations (see Table 6.1.16)

Table 6.1.14: Main activities related to formulating licence terms and conditions

2.6 Formulating licence terms and conditions	
1.	Check relevant paragraphs/ entries in legislation/Policies, ASO plans, national spectrum plan,
2.	Analyse market conditions and assess 'level-playing-field' requirements/provisions
3.	Determine DTTB/MTV licence Terms and Conditions and align with local Building permit policies and Media permits/authorizations and their planning
4.	Update national spectrum plan (and possibly ASO plans)

Table 6.1.15: Main activities related to drafting policies for local permits

2.7 Dr	2.7 Drafting policies for local permits	
1.	Check relevant paragraphs/ entries in legislation/policies and Licensing Framework for DTTB and MTV service introductions	
2.	Determine and align Building permit policies with intended DTTB/MTV licence Terms and Conditions	
3.	Publish policies for DTTB/MTV planning and building permits (may include waivers)	
4.	Possibly conduct local hearings and/or expert investigations which may result in changes in permitted spectrum usage/transmitter site parameters (and delays)	
5.	Monitor actual transmitter site operations and check/test emitted radiation	
6.	Possibly update national spectrum plan	

Table 6.1.16 Main activities related to drafting of media permits and authorizations

2.8 Drafting of media permits and authorizations1. Check existing media legislation, Policies and Licensing Framework

- 2. Check Technology and Standards Regulation (receiver regulations) and include in media permits policies
- 3. Determine Media permits/authorizations and procedures and align with DTTB/MTV licence Terms and Conditions and planning
- 4. Publish policies for media permits and authorizations (may include waivers)

Assignment procedures

After having defined the licence conditions, the assignment procedures (see Table 6.1.17) will be formulated by carrying out the activities related to functional block 2.5.

Table 6.1.17: Main activities related to the formulation of assignment procedures

2.5 Fc	2.5 Formulation of assignment procedures	
1.	Consult market (industry players and consumers) on assignment methods and licence Terms and Conditions	
2.	Evaluate results and select assignment method and procedures	
3.	Draft detailed plans and planning for DTTB and MTV assignment procedures	
4.	Publish assignment planning and procedures and update national spectrum plan (and possibly legislation)	

Determining business models and public financing

The last functional block deals with business models and public financing. The related activities are shown in Table 6.1.18.

Table 6.1.18: Main activities related to determining business models and public financing

2.9 [2.9 Determining business models and public financing	
1.	Check existing media legislation, policies and Licensing Framework	
2.	Consult public broadcaster(s) on current/future analogue television, DTTB and MTV transmissions	
3.	Analyse market situation and assess possible market distortions	
4.	Define or complete required public service offering on DTTB and MTV platform (if not defined in legislation yet)	
5.	Align defined public service offering with other DTTB/MTV licence terms and conditions and media permits, and their planning	
6.	Determine and establish budget for public broadcast service offering and/or subsidizing consumer equipment	

Consultation with market parties

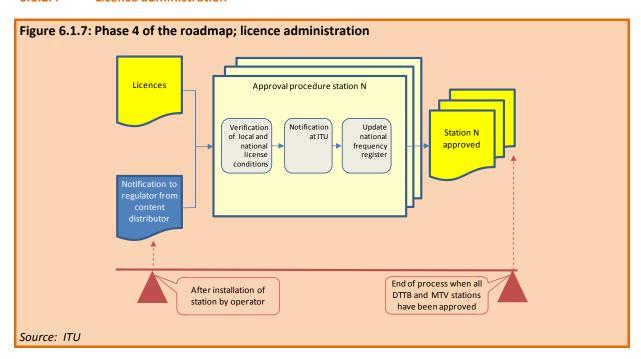
The series of activities to establish administrative licence regulations is finalized with consultation of market parties. The purpose of this consultation is to inform the market parties about the licence regulations and to receive feedback from the market parties about the practical implementation. As far as necessary the regulations will be modified taking into account the comments from the market parties.

Licence assignment procedure

The licensing procedure phase ends with the licence assignment procedure at the announced date.

It is not necessary and often not possible, because of the restrictions to DTTB or MTV stations during transition, to licence all DTTB and MTV networks at the same time.

6.1.2.4 Licence administration



Verification of licence conditions

After licences have been granted and the operator has informed the regulator that a station is in operation, the regulator should verify if the station operates in accordance with the licence conditions, including:

- station characteristics;
- roll-out obligations;
- media permits;
- local permits.

Notification to ITU

Subsequently the station will be notified to ITU. In case where the GE06 Agreement applies, ITU-BR will check the provisions given in Article 5 of the GE06 Agreement (see Annex A), such as:

- conformity check;
- power density check (if appropriate).

Update of national frequency register

The licence administration phase ends with the formal approval of the licensed stations and an update of the national frequency register, with the operational characteristics of the station.

The process ends when:

all analogue TV services are switched-off;

- all DTTB and MTV stations are in operation without restrictions that were necessary to protect analogue TV;
- national frequency register has been up dated with the operational characteristics of all DTTB and MTV stations.

6.1.3 Implementation guidelines

The roadmap for transition to DTTB and introduction of MTV depends very much on the national situation.

The regulator should address the functional building blocks that are within its responsibility. This could include some of the functions described in Part 4 and 5 of these Guidelines. The regulator should also consider the functional building blocks that are within the responsibility of other players of the value chain in order determine the interfaces.

Furthermore it has to be estimated to what extent key topics and choices of the selected building blocks have to be considered and consequently the activities that have to be carried out, taking into account:

- the actual status on DTTB and MTV regulation and licensing;
- the market situation;
- responsibilities of regulator and licence holder regarding technology choices and network planning.

Finally a realistic time schedule for the whole process needs to be adopted, taking into account:

- international recommendations or agreements related to analogue switch-off;
- time schedules in neighbouring countries;
- preparation and installation time for market parties;
- time needed for the receiver industry (manufactures, retail) to supply digital TV consumer equipment.

It should be noted that the period between DTTB launch and completed analogue TV switch-off ranges from 3 to 14 years, based on the experience of the countries that have introduced DTTB. Analogue switch-off has already been completed in some countries and is in the process in the others.

6.2 Roadmap for transition to DTTB by a network operator

Section 6.2 provides background information and guidelines on key topics and choices regarding the preparation of a roadmap for transition to DTTB by a network operator. The section consists of three subsections:

- 6.2.1 Construction of a roadmap.
- 6.2.2 Generic roadmap for transition to DTTB by a network operator.
- 6.2.3 Implementation guidelines.

6.2.1 Construction of a roadmap

The roadmap for transition to DTTB by a network operator consists of four phases:

- 1. *Preparation*: The preparatory phase starts when the regulator is preparing the licensing policy and regulation (See Phases 1, 2 and 3 of the regulator roadmap in section 6.1). The aim of the preparations is to apply successfully for a DTTB licence.
- 2. *Planning*: The planning phase starts at the date of issue of the licence and ends with the adoption of the network implementation plan. This plan describes station characteristics and a time schedule for implementation.

- 3. *Implementation*: The implementation phase is the follow-up of the planning phase and ends when all DTTB transmitters are operational.
- 4. Analogue TV switch-off: The time schedule of the analogue switch-off phase is given by the ASO plan of the regulator. Engineering work on DTTB sites is likely to continue even after analogue switch-off.

In each phase a number of functional blocks (see Figure 1.1.1 of section 1.1) have to be addressed. Guidelines regarding key topics and choices of these functional blocks are described in the corresponding sections.

For each of the functional blocks, the main activities for carrying out the function have to be identified together with the entity that is responsible for the activities. These main activities may be supplemented by additional main activities that are not specific for DTTB, but are nevertheless needed for a successful transition to DTTB. Examples of such non-specific DTTB activities are:

- service provisioning and contracting content providers;
- project and resource planning;
- site acquisition;
- equipment installation.

The roadmap is constructed by placing the relevant functional blocks in each phase in a logical order and in a time frame. It is important that the order of activities in each phase by the different players, including the regulator, fits with each other. Hence for determining the order of the functional blocks, information exchange and negotiations between market parties and the regulator is essential.

A graphical illustration of the process described above is shown in Figure 6.2.1.

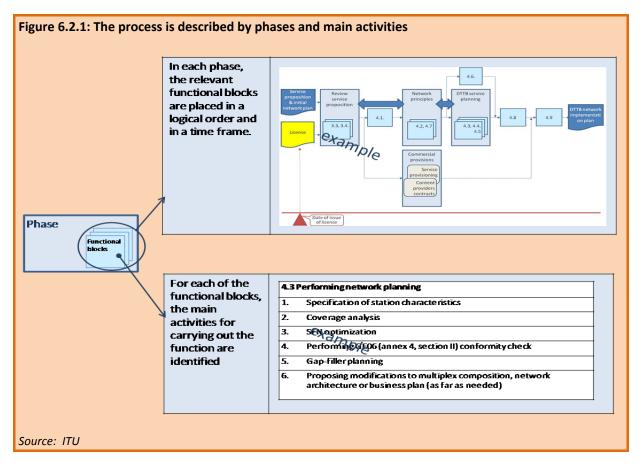
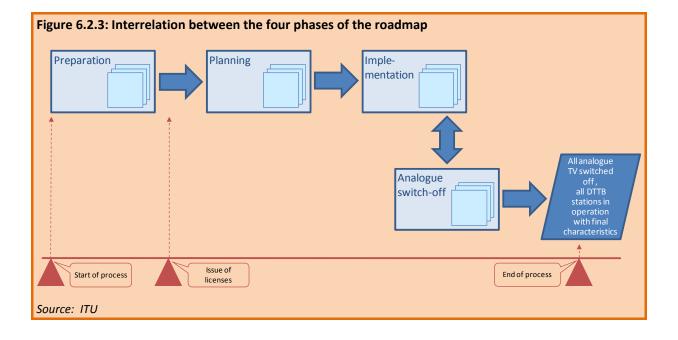


Figure 6.2.2: Functional blocks connected to each of the four phases of the network operator roadmap for transition to DTTB Preparation **Planning** Implementation Analogue switchoff processes 3.1. Custome Insight & Research 3.5 End consumer support 3.2. Customer Proposition 3.4. Business Planning 4.3. Network Planning 3.2. Customer Proposition 4.2. Design Principles & 4.1. Technology 3.3. Receive 3.4. Business 4.4. System Parameters 4.5. Radiation Availability & Standards Switch-off analogue TV Planning Network Architecture Characteristics Considerations Application 4.2. Design Principles & 4.1. Technology Project planning, installation and Re-engineering DTTB installations & Standards Application Network Architecture operational activities 4.3. Network Planning 4.4. System Parameters 4.5. Radiation 4.6. Network Character-istics 4.7 Shared & 4.7 Shared & 4.8 Transmitting 4.5. Radiation ommon design common design equipment Characteristics principles principles Availability 4.9 Network

The functional blocks connected to each of the four phases of the roadmap are shown in Figure 6.2.2.

It should be noted that Figure 6.2.2 represents a generic case. The actual selection of functional blocks may differ from country to country.

Phases 1, 2 and 3 are carried out sequentially and Phase 4 is carried out partly in parallel to Phase 3 with regular checks to verify if the results of these parts are still in line. The sequence of the four parts of the roadmap is illustrated in Figure 6.2.3.



Source: ITU

The process ends when all analogue TV is switched-off and all DTTB stations are in operation without any restrictions that were necessary to protect analogue TV. However, further evolution of the network is likely to take place resulting from the introduction of new services, regulatory obligations or technology changes.³⁸⁴

6.2.2 Generic roadmap for transition to DTTB by a network operator

In the roadmap shown in this section, the following assumptions have been made:

- no existing DTTB services;
- one DTTB network operator, acting as multiplex operator, service provider and content distributor;
- multiplexes contain also the TV services that are transmitted via analogue TV networks;
- DTTB network operator is also responsible for the analogue TV transmissions.

When multiplex operator, service provider, content distributor and analogue TV operator are different organizations, the order of the functions will not be different. However the interfaces between the respective parts of transmission chain need to be clearly defined and service agreements should cover a smooth hand-over of responsibilities.

The roadmap described in this section is for the case where the operator takes the technical decisions and performs the network planning. In some countries, the regulator has a broader role than in others. In the case where some of the technical choices e.g. standard and system choices or (part of) network planning is a responsibility of the regulator, the roadmap is not basically different. The network operator will still make his own assessments about service quality, coverage quality and radiation characteristics. Normally the network operator wishes to make these assessments with higher accuracy and in more detail than the regulator.

The four phases of the roadmap are described below.

6.2.2.1 Preparations

Figure 6.2.4: Phase 1 of the roadmap - preparations Market & Initial DTTB service Business principl planning Development Licence procedure 4.2.4.7 4.3, 4.4, 4.5 3.1. 3.2. 3.3. 3.4 See also flowchart Date of publication of Date of submission Source: ITU

³⁸⁴ See also Networks in evolution, making changes to the digital terrestrial television platform. DigiTAG, May 2008.

Input data

In the roadmap shown above, the preparatory phase starts when the licence procedure has been published. This is the latest moment for the start. A start during first three phases of the regulator roadmap (see section 6.1) has the advantage that well informed reactions can be given to proposals from government or regulator in consultation with market parties during:

- 1. DTTB/MTV policy development;
- 2. analogue switch-off planning;
- 3. licensing policy and regulation.

Market and business development

In the preparatory phase, the network operator will first address market and business development by carrying out the activities related to functional blocks:

- 3.1 Customer insight and research (see Table 6.2.1).
- 3.2 Customer proposition (see Table 6.2.2).
- 3.3 Receiver availability considerations (see Table 6.2.3).
- 3.4 Business planning (see Table 6.2.4).

Table 6.2.1: Main activities related to investigate customer insight and carrying out market research

3.1 Investigation of customer insight and carrying out market research Determine need, timing and scope for market research Analyse competitive offerings, substitutes and technology developments Design and develop preliminary DTTB (and MTV if necessary) service propositions Draft market research plan, staff and budget market research project Carry out market research and analyse results, translate into DTTB/MTV service propositions, if necessary carry out additional market research

Table 6.2.2: Main activities related to defining customer proposition

3.2 De	3.2 Defining customer proposition	
1.	Analyse earlier DTTB (and MTV if necessary) service launches and compare with customer research results/local market conditions	
2.	Define DTTB/MTV service propositions and check feasibility/cost levels with key suppliers, i.e. Distributor (broadcast network operator) and Content Aggregators, Content Creators	
3.	Possibly redefine DTTB/MTV service propositions and test in market again, i.e. additional market research	

Table 6.2.3: Main activities related to carrying out receiver availability considerations

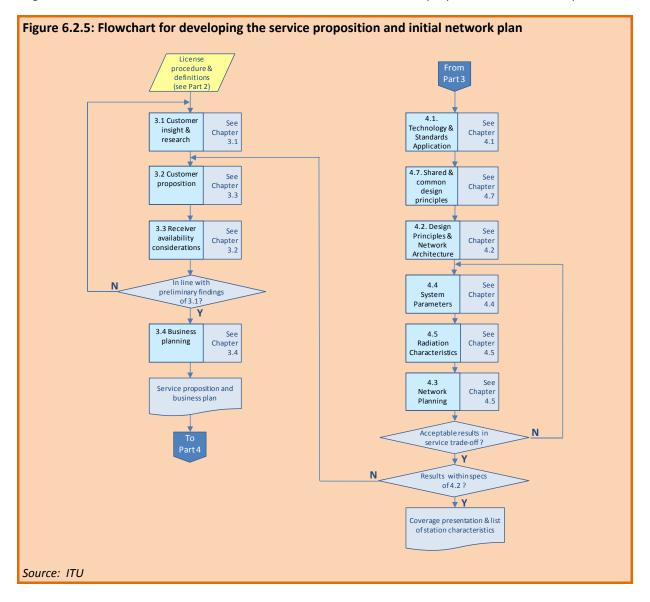
3.3 Ca	3.3 Carrying out receiver availability considerations	
1.	Analyse earlier DTTB (and MTV if necessary)service launches, assess local substitutes and technology developments	
2.	Check any prescribed Technologies and Standards, Receiver regulations and analyse market research results	
3.	Assess and make inventory of availability and roadmaps of various receiver types/attributes	
4.	Check network compatibility and interoperability (radio interfaces and API/applications)	
5.	Assess and detail ex-factory and retail pricing for various receivers	
6.	Decide key receivers and their attributes, draft receiver/service roadmap	

Table 6.2.4: Main activities related to performing business planning

3.4 Performing business planning

- Analyse legal/regulatory framework (may include prescribed Technologies and Standards, Assignment
 Procedure, Licence Terms and Conditions, Business Models and Public Financing), determine impact and
 opportunities
- 2. Assess market take-up and project revenue streams, based on customer research and proposition
- 3. Assess and calculate associated costs (considering concepts of 'total cost of ownership'), project costs ahead
- 4. Carry out profitability and sensitivity analysis, draft business plan scenarios
- 5. Quantify total investments and their associated risks, assess financing and public funding possibilities, consider co-operation/joint venture/vendor financing/revenue sharing

The functional blocks 3.1 to 3.4 include some iteration as shown on the left hand side of the flowchart in Figure 6.2.5. The activities indicated above result in an initial customer proposition and business plan.



Technology and standards application and initial network principles

After the initial customer proposition and business plan have been approved, the activities related to the following functional block are carried out:

- 4.1 Technology and standards application (see Table 6.2.5).
- 4.2 Design principles and network architecture (see Table 6.2.6).
- 4.7 Shared and common design principles (see Table 6.2.7).

Table 6.2.5: Main activities related to technology and standards application

Describing tests Evaluation of characteristics of compression systems Evaluation of SDTV and HDTV specifications (including sound channels) and estimation of required bit rate Evaluation of standards characteristics with GE06 provisions(where this applies), business plan and receiver availability Evaluation of conditional access systems (if applied) Evaluation of additional systems (including access systems if needed) and estimation of required bit rate

Table 6.2.6: Main activities related to developing design principles and network architecture

4.2 De	4.2 Developing design principles and network architecture	
1.	Education and training of technical staff	
2.	Evaluation of roll-out options	
3.	Evaluation of type of distribution network	
4.	Evaluation of network topology	
5.	Drafting multiplex composition plan	
6.	Establishing frequency plan per multiplex/network	
7.	Drafting transmitting station lay out	

Table 6.2.7: Main activities related to deciding shared and common design principles

4.7 D	4.7 Deciding shared and common design principles	
1.	Investigate national regulations regarding site sharing	
2.	Determine in principle shared use of DTTB and MTV networks and which elements (sites, antennas, multiplex), if necessary	
3.	Determine in principle on common design and planning of DTTB and MTV networks, if necessary	
4.	Prepare site sharing agreements	

Initial DTTB service planning

In the next series of activities an initial DTTB network plan is developed, which includes several iterative steps and possibly a review of the service proposition and business plan, technology choices and network principles (see in Figure 6.2.5).

For drafting the initial network plan the activities related to the following functional blocks are carried out:

- 4.3 Network planning (see Table 6.2.8).
- 4.4 System parameters (see Table 6.2.9).
- 4.5 Radiation characteristics (see Table 6.2.10).

Table 6.2.8: Main activities related to performing network planning

4.3 Performing network planning	
1.	Location of site and specification of station characteristics
2.	Coverage analysis
3.	SFN optimization (if necessary and the adopted system supports SFN)
4.	Fill-in transmitter planning
5.	Proposing modifications to multiplex composition, network architecture or business plan (as far as necessary)

Table 6.2.9: Main activities related to determining system parameters

4.4 Determining system parameters	
1.	Evaluation of FFT size (e.g. 2k, 4k or 8k)*
2.	Evaluation of carrier modulation
3.	Evaluation of code rate
4.	Evaluation of guard interval*
5.	Evaluation of hierarchical transmission, if used

Note *:these parameters apply only for multi-carrier systems

Table 6.2.10: Main activities related to assessing radiation characteristics

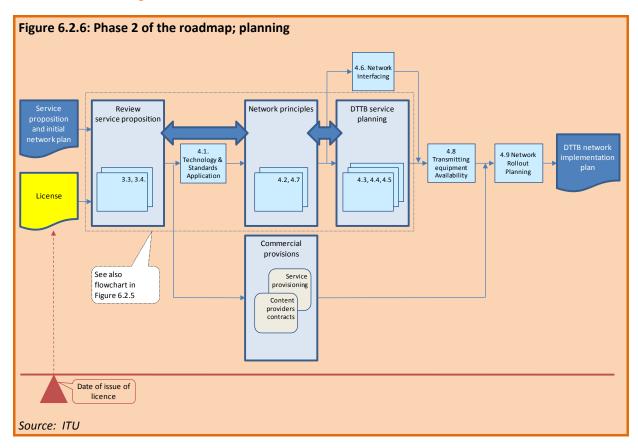
4.5 Assessing radiation characteristics	
1.	Determining height of antenna
2.	Evaluation of transmitter power, antenna gain and polarization
3.	Evaluation and optimizing antenna diagram
4.	Calculation of antenna power budget

In the preparatory phase not all station characteristics are known in detail, nor is it necessary to achieve a detailed initial network plan. The purpose is:

- to verify business plan and customer proposition;
- to be able to react to proposals from government or regulator in consultation with market parties (see Phase 1, 2 and 3 of the regulator flowchart in section 6.1), in the case where the preparatory phase has been started before the licence procedure has been published;
- to have sufficient information for a successful licence application.

The preparatory phase ends with a set of documents describing the service proposition, business plan and an initial network plan. This should be finalized in time for the licence application.

6.2.2.2 Planning



Input data

The planning phase starts when the licence has been issued. Licence conditions and the service proposition, business plan and initial network plan, resulting from Phase 1, are the input data for Phase 2.

Review service proposition

Depending on the licence conditions, customer proposition and business plan (functional block 3.2 and 3.4 respectively) may need to be reviewed by carrying out appropriate activities from Tables 6.2.2 and 6.2.4 (see in Section 6.2.3.1).

Commercial provisions

After review of customer proposition and business plan, the network operator will start the following commercial activities:

- service provisioning;
- contracting content providers.

Technology and standards application and initial network principles

In parallel with the commercial activities, the initial technical choices will be reviewed and defined in more detail by carrying out appropriate activities related to functional blocks:

- 4.1 Technology and standards application (see Table 6.2.5 in Section 6.2.2.1).
- 4.2 Design principles and network architecture (see Table 6.2.6 in Section 6.2.2.1).
- 4.7 Shared and common design principles (Table 6.2.7 in Section 6.2.2.1).

DTTB service planning

Following the review of technical choices the DTTB service planning will be reviewed and defined in more detail by carrying out the activities related to functional blocks:

- 4.3 Network planning (see Table 6.2.8 in Section 6.2.2.1).
- 4.4 System parameters (see Table 6.2.9 in Section 6.2.2.1).
- 4.5 Radiation characteristics (see Table 6.2.10 in Section 6.2.2.1).

As in the preparatory phase, this includes several iterative steps and possibly a review of the service proposition. The order of steps is similar as in Figure 6.2.5 in Section 6.2.2.1).

Network interfacing

In parallel to service planning, the activities related to functional block 4.6 (Network interfacing) will be carried out (see Table 6.2.11).

Table 6.2.11: Main activities related to specifying network interfaces

4.6 Specifying network interfaces	
1.	Drafting interface specifications between studio and multiplex head end
2.	Drafting interface specifications of signal distribution links between multiplex head end and transmission sites
3.	Drafting interface specifications between network monitoring system and transmitting equipment
4.	Describing the radio interface

Transmitting equipment availability

When the optimum network plan has been achieved and network interfaces have been specified, transmitting equipment availability will be considered and network roll out be planned by carrying out the activities related to functional blocks:

- 4.8 Transmitting equipment availability (see Table 6.2.12).
- 4.9 Network roll out planning (see Table 6.2.13).

Table 6.2.12: Main activities related to considering equipment availability

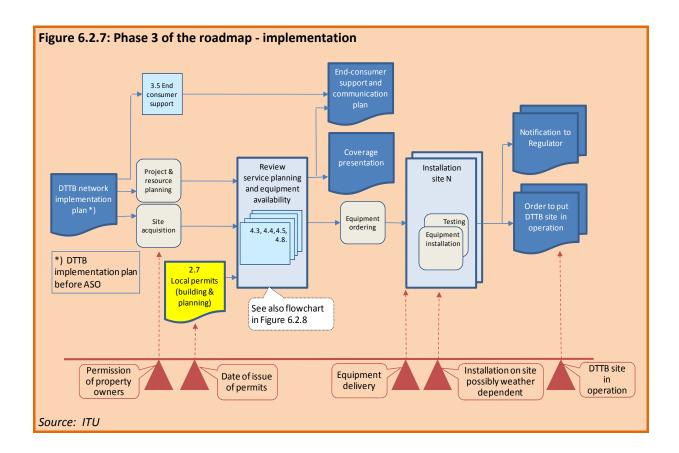
4.8 Considering equipment availability	
1.	Carrying out market research
2.	Drafting transmitter specifications
3.	Drafting antenna specifications
4.	Drafting distribution link specifications
5.	Drafting multiplex head end specification
6.	Equipment testing

Table 6.2.13: Main activities related to planning network roll out

4.9 Network roll out planning	
1.	Describing pilot tests
2.	Roll out planning (e.g. main cities, provincial cities, rural areas), before and after ASO
3.	Agreement with receiver manufacturers to deliver receivers in sufficient quantities, in time
4.	Coverage assessment at each stage of implementation
5.	Setting up communication plan and related provisions (e.g. helpdesk, website)

The planning phase ends with a set of documents describing the DTTB network implementation plan.

6.2.2.3 Implementation



Input data

The implementation phase of the DTTB network starts when the network implementation plan, resulting from Phase 2 of the roadmap has been adopted. A number of DTTB stations contained in this plan probably have temporal restrictions, necessary to protect analogue TV during transition.

Project- and resource planning and site acquisition

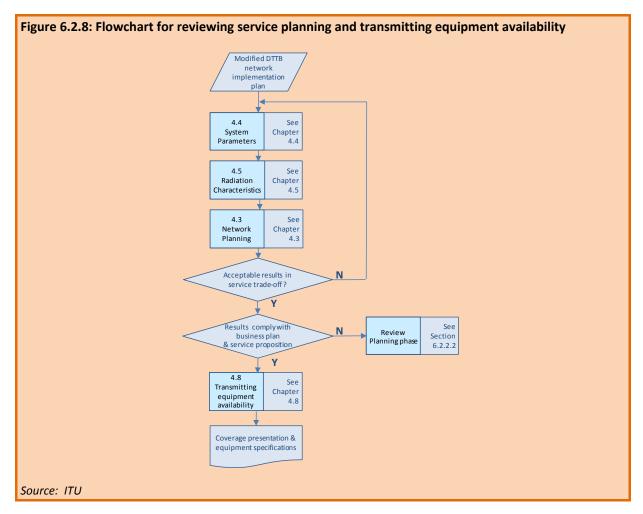
On the basis of the DTTB network implementation plan, project and resources planning and site acquisition will start and local building and planning permits need to be acquired.

Review of service planning and transmission equipment availability

In carrying out the above mentioned activities, modifications to the network implementation plan may have to be accepted. For instance site acquisition may not be successful; or a new site may be realized at a different location than assumed in the DTTB network implementation plan. It may also happen that in the detailed project planning antenna heights or diagrams are specified differently than originally assumed. In such cases, service planning and equipment availability needs to be reviewed by carrying out the appropriate activities relating to the following functional blocks:

- 4.3 Network planning (see Table 6.2.7 in Section 6.2.2.1).
- 4.4 System parameters (see Table 6.2.8 in Section 6.2.2.1).
- 4.5 Radiation characteristics (see Table 6.2.9 in Section 6.2.2.1).
- 4.8 Transmitting equipment availability (see Table 6.2.12 in Section 6.2.2.2).

This includes several iterative steps as shown in Figure 6.2.8.



If the results of the review of the service planning do not comply anymore with the customer proposition or business plan, the planning phase should be reviewed.

When the optimum set of station characteristics has been obtained, the equipment specifications will be reviewed and detailed coverage presentations will be made. The latter will be used for communication to public and content providers to show reception possibilities in the various implementation stages.

Equipment ordering

On the basis of the equipment specifications, equipment tender procedures will be initiated. After comparing several offers, suppliers will be selected and equipment ordered.

Consumer support

Before a site is brought into use, the end-consumers in the related coverage area should be informed about the new digital services and the necessary receiving equipment by addressing functional block 3.5 (End consumer support). The main activities are listed in Table 6.2.14.

Table 6.2.14: Main activities related to defining end consumer support

Check relationships with ASO plan and communication and determine impact Consult and carry out 'Road shows' for Device Creators (i.e. manufacturers and retailers), Content Aggregators, and mobile operators for return channel if used Draft end-consumer support and communication plan and determine means and budget, possibly align business planning

Installation

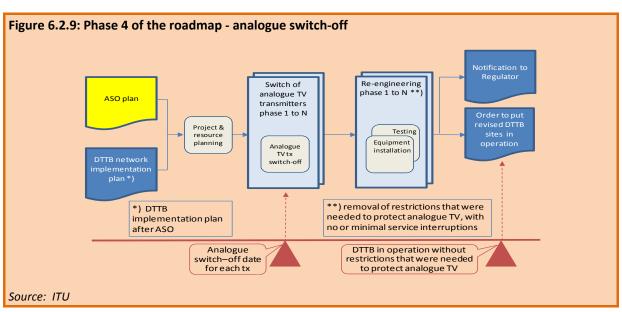
When the equipment has been delivered, installation of transmitting equipment starts followed by site acceptance tests.

During the installation stage it could happen that, for unexpected reasons, stations cannot be installed as planned. In that case, the DTTB implementation plan may need to be reviewed in order to provide information on the consequences of the changes and to prepare amended coverage presentations.

The installation work should be planned in such a way that the transmitters can be put into operation at the agreed date, taking into account that some sites may be inaccessible during certain periods of the year (e.g. due to heavy snow in winter).

When installation of a station has been completed, the regulator will be notified that the station will be put into operation in accordance with the licence terms and conditions.

6.2.2.4 Analogue switch-off



Input data

The analogue switch-off phase starts during the transition period in accordance with the ASO planning and milestones documents. The DTTB station characteristics during and after simulcasting are contained in the DTTB network implementation plan resulting from Phase 2 of the roadmap.

Project and resource planning and analogue switch-off

Switching-off analogue TV transmitters will be carried out in accordance with the ASO planning provided by the regulator.

Re-engineering

After switch-off, re-engineering of the sites begins. These activities may consist of three parts:

- removal of superfluous analogue TV equipment;
- modification of radiation characteristics in order to remove restrictions that were needed to protect analogue TV;
- installation of additional DTTB or MTV transmitters that are licensed after analogue switch-off.

Normally it is required to carry out these activities with minimal interruptions of the DTTB services.

When the re-engineering work has been completed, the regulator will be notified that the station has been modified in accordance with the licence terms and condition specified for the situation after analogue switch-off.

6.2.3 Implementation guideline

Each player in the value chain (see Figure 1.1.3 in section 1.1) should select for each of the four phases of DTTB network operator roadmap:

- a) the functional building blocks that are within the operational responsibility of the organization;
- b) the functional building blocks that are within the operational responsibility of other players of the value chain in order determine where interfaces and service agreements are needed;
- c) the functional building blocks, within the responsibility of government and/or regulator, that are inputs to a).

Furthermore, it has to be estimated to what extent key topics and choices of the selected building blocks have to be considered and the activities that have to be carried out, taking into account:

- the status of implementation of the regulator roadmap;
- market situation, including already licensed DTTB transmissions and competing offers by satellite, cable or IPTV;
- existing transmitter network infrastructure;
- responsibilities of regulator and licence holder regarding technology choices and network planning.

A realistic time schedule for the whole process needs to be established, taking into account that a number of milestones in the process is not or not entirely in the control of the network operator such as:

- publication of the licence procedure, describing the way licences are assigned and may include applicable standards and site sharing regulations;
- issue of the licence, with terms and conditions prescribing, among others, service roll out obligations and permitted frequency use;

- analogue switch-off planning and milestones prescribing start of simulcast and analogue switch-off dates;
- building and planning permits from local authorities for setting up new sites or changing existing sites;
- permission of property owners to use property for setting up new sites or changing existing sites;
- equipment delivery times;
- installation periods, seasonal weather conditions may restrict access to some sites.

The starting point should preferably be in an early stage of implementation of the regulator roadmap (see section 6.1) in order to be able to react to proposals from government or regulator in consultation with market parties. Latest moment for start is when the licence procedure has been published and a licence application can be submitted.

6.3 Roadmap for introduction MTV by a network operator

Section 6.3 provides background information and guidelines on key topics and choices regarding the preparation of a roadmap for introduction of MTV by a network operator. It should be noted that the following sections are applicable to the cases where the MTV system is introduced independently of DTTB system. The cases where the DTTB system incorporates MTV signals simultaneously (e.g. ISDB-T, DVB-T2 Lite, ATSC Mobile TV) are included in section 6.2. This section consists of three subsections:

- 6.3.1 Construction of a roadmap.
- 6.3.2 Generic roadmap for introduction of MTV by a network operator.
- 6.3.3 Implementation guidelines.

6.3.1 Construction of a roadmap

The roadmap for introduction of MTV by a network operator consists of three phases:

- 1. *Preparation*: The preparatory phase starts when the regulator is preparing the licensing policy and regulation (See Phase 1, 2 and 3 of the regulator roadmap in section 6.1). The aim of the preparations is to apply successfully for a MTV licence.
- 2. *Planning*: The planning phase starts at the date of issue of the licence and ends with the adoption of the network implementation plan. This plan describes station characteristics and a time schedule for implementation.
- 3. *Implementation*: The implementation phase is the follow-up of the planning phase and ends when all MTV transmitters are operational.

Contrary to the roadmap for transition to DTTB by a network operator (see section 6.2), analogue switch-off (ASO) is not an integral part of the MTV introduction process. Consequently, the MTV roadmap does not have any phase regarding ASO. However, MTV frequencies may only be available when ASO is in an advanced stage, or completed.

In each phase, a number of functional blocks (see Figure 1.1.1 of section 1.1) have to be addressed. Guidelines regarding key topics and choices of these functional blocks are described in the corresponding sections.

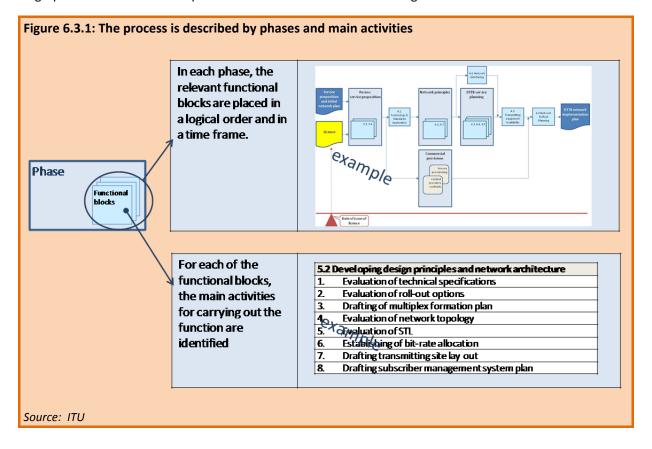
For each of the functional blocks, the main activities for carrying out the function have to be identified together with the entity that is responsible for the activities. These main activities may be supplemented by additional main activities that are not specific for MTV, but are, nevertheless, necessary for a successful introduction of MTV. Examples of such non-specific MTV activities are:

service provisioning and contracting content providers;

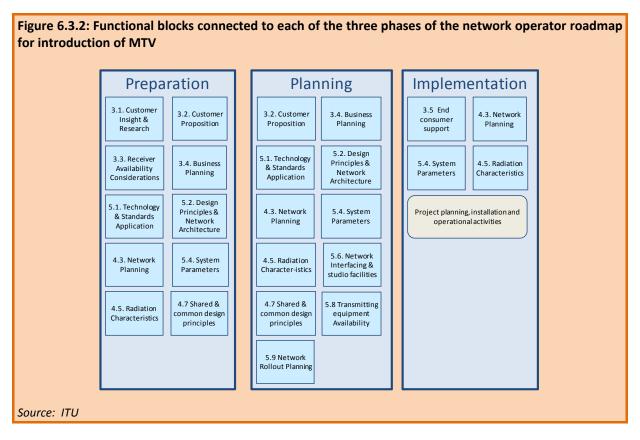
- project and resource planning;
- site acquisition;
- equipment installation.

The roadmap is constructed by placing, the relevant functional blocks in each phase in a logical order and in a time frame. It is important that the order of activities in each phase by the different players, including the regulator, fits with each other. Hence, for determining the order of the functional blocks, information exchange and negotiations between market parties and the regulator is essential.

A graphical illustration of the process described above is shown in Figure 6.3.1.

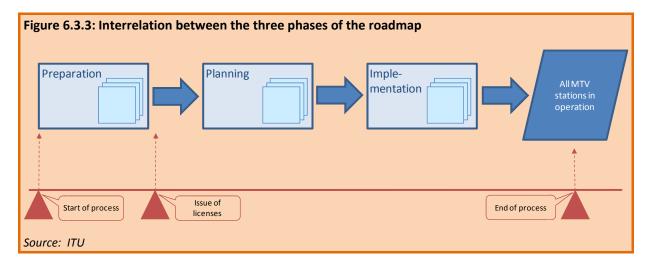


The functional blocks connected to each of the three phases of the roadmap are shown in Figure 6.3.2.



It should be noted that Figure 6.3.2 represents a generic case. The actual selection of functional blocks may differ from country to country.

Phases 1, 2 and 3 are carried out sequentially (see Figure 6.3.3).



The process ends when all MTV stations are in operation. However further evolution of the network is likely to take place resulting from the introduction of new services, regulatory obligations or technology changes. ³⁸⁵

6.3.2 Generic roadmap for introduction of MTV by a network operator

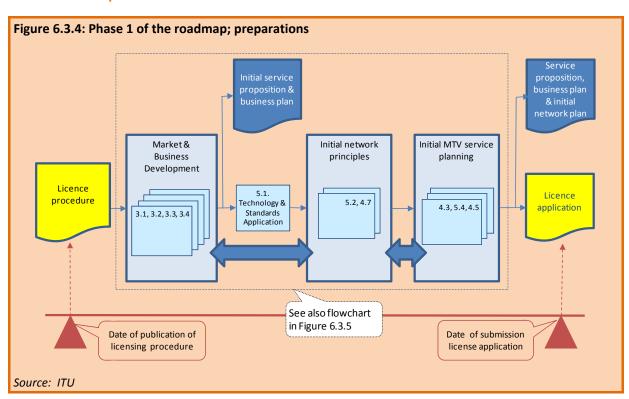
In the roadmap shown in this section it has been assumed that one MTV network operator is involved, acting as multiplex operator, service provider and content distributor.

When multiplex operator, service provider, content distributor are different organisations, the order of the functions will not be different. However the interfaces between the respective parts of transmission chain need to be clearly defined and service agreements should cover a smooth hand-over of responsibilities.

The roadmap described in this section is for the case where the operator takes the technical decisions and performs the networks planning. In some countries the regulator has a broader role than in others. In cases where some of the technical choices e.g. standard and system choices or (part of) network planning is a responsibility of the regulator, the roadmap is not basically different. The network operator will still make his own assessments about service quality, coverage quality and radiation characteristics. Normally the network operator wishes to make these assessments with higher accuracy and in more detail than the regulator.

The three phases of the roadmap are described below.

6.3.2.1 Preparations



 $^{^{385}}$ See also Networks in evolution, making changes to the digital terrestrial television platform. DigiTAG, May 2008.

Input data

In the roadmap shown above, the preparatory phase starts when the licence procedure has been published. This is the latest moment for the start. A start during the first three phases of the regulator roadmap (see section 6.1) has the advantage that well informed reactions can be given to proposals from government or regulator in consultation with market parties during:

- 1. DTTB/MTV policy development;
- 2. licensing policy and regulation.

Market and business development

In the preparatory phase the network operator will first address market and business development by carrying out the activities related to functional blocks:

- 3.1 Customer insight and research (see Table 6.3.1).
- 3.2 Customer proposition (see Table 6.3.2).
- 3.3 Receiver availability considerations (see Table 6.3.3).
- 3.4 Business planning (see Table 6.3.4).

Table 6.3.1: Main activities related to investigate customer insight and carrying out market research

3.1 I	3.1 Investigation of customer insight and carrying out market research		
1.	Determine need, timing and scope for market research		
2.	Analyse competitive offerings, substitutes and technology developments		
3.	Design and develop preliminary MTV (and DTTB if necessary) service propositions		
4.	Draft market research plan, staff and budget market research project		
5.	Carry out market research and analyse results, translate into MTV (and DTTB if necessary) service propositions, if necessary carry out additional market research		

Table 6.3.2: Main activities related to defining customer proposition

Analyse earlier MTV (and DTTB if necessary) service launches and compare with customer research results/local market conditions Define MTV (and DTTB if necessary) service propositions and check feasibility/cost levels with key suppliers, i.e. Distributor (broadcast network operator) and Content Aggregators, Content Creators Possibly redefine MTV (and DTTB if necessary) service propositions and test in market again, i.e. additional market research

Table 6.3.3: Main activities related to carrying out receiver availability considerations

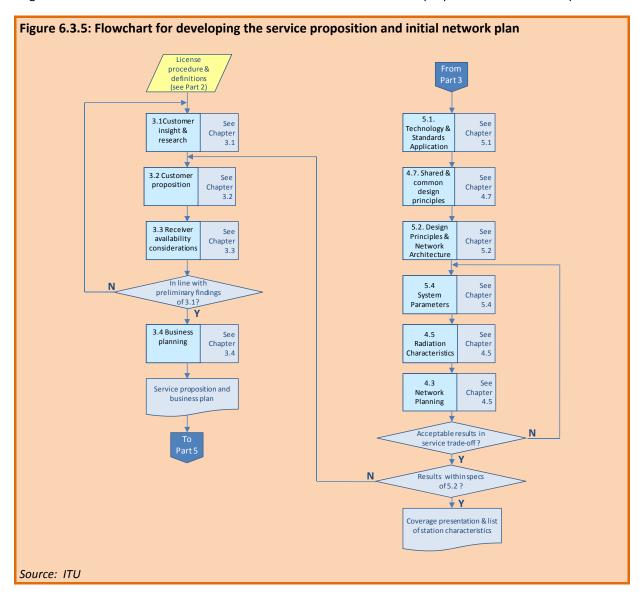
3.3 C	3.3 Carrying out receiver availability considerations		
1.	Analyse earlier MTV service (and DTTB if necessary) launches, assess local substitutes and technology developments		
2.	Check any prescribed Technologies and Standards, Receiver regulations and analyse market research results		
3.	Assess and make inventory of availability and roadmaps of various receiver types/attributes		
4.	Check network compatibility and interoperability (radio interfaces and API/applications)		
5.	Assess and detail ex-factory and retail pricing for various receivers		
6.	Decide key receivers and their attributes, draft receiver/service roadmap		

Table 6.3.4: Main activities related to performing business planning

3.4 Performing business planning

- 1. Analyse legal/regulatory framework (may include prescribed Technologies and Standards, Assignment Procedure, Licence Terms and Conditions, Business Models and Public Financing), determine impact and opportunities
- 2. Assess market take-up and project revenue streams, based on customer research and proposition
- 3. Assess and calculate associated costs (considering concepts of 'total cost of ownership'), project costs ahead
- 4. Carry out profitability and sensitivity analysis, draft business plan scenarios
- 5. Quantify total investments and their associated risks, assess financing and public funding possibilities, consider co-operation/joint venture/vendor financing/revenue sharing

The functional blocks 3.1 to 3.4 include some iteration as shown on the left hand side of the flowchart in Figure 6.3.5. The activities indicated above result in an initial customer proposition and business plan.



Technology and standards application and initial network principles

After the initial customer proposition and business plan have been approved, the activities related to the following functional block are carried out:

- 5.1 Technology and standards application (see Table 6.3.5).
- 5.2 Design principles and network architecture (see Table 6.3.6).
- 4.7 Shared and common design principles (see Table 6.3.7).

Table 6.3.5: Main activities related to technology and standards application

5.1 Te	5.1 Technology and standards application		
1.	Collecting data of MTV standards		
2.	Making comparison table of standards		
3.	Planning services and channels		
4.	Planning interactive services		
5.	Evaluation of encryption system		
6.	Evaluation of additional system and estimation of required bit-rate for each services		
7.	Case studying in the other regions or countries		
8.	Selecting a suitable technology of MTV for each cases		

Table 6.3.6: Main activities related to developing design principles and network architecture

5.2 D	5.2 Developing design principles and network architecture		
1.	Evaluation of technical specifications		
2.	Evaluation of roll-out options		
3.	Drafting of multiplex formation plan		
4.	Evaluation of network topology		
5.	Evaluation of distribution links including Studio-Multiplex Link		
6.	Establishing of bit-rate allocation		
7.	Drafting transmitting site lay out		
8.	Drafting subscriber management system plan		

Table 6.3.7: Main activities related to deciding shared and common design principles

4.7 Deciding shared and common design principles		
1.	Investigate national regulations regarding site sharing	
2.	Determine in principle shared use of DTTB and MTV networks and which elements (sites, antennas, multiplex), if necessary	
3.	Determine in principle on common design and planning of DTTB and MTV networks, if necessary	
4.	Prepare site sharing agreements	

Initial MTV service planning

In the next series of activities an initial MTV network plan is developed, which includes several iterative steps and possibly a review of the service proposition and business plan, technology choices and network principles (see in Figure 6.3.5).

To draft the initial network plan, activities related to the following functional blocks are carried out:

- 4.3 Network planning (see Table 6.3.8).
- 5.4 System parameters (see Table 6.3.9).
- 4.5 Radiation characteristics (see Table 6.3.10).

Table 6.3.8: Main activities related to performing network planning

4.3 Performing network planning		
1.	Location of site(s) and specification of station characteristics	
2.	Coverage analysis	
3.	SFN optimization (if necessary and the adopted system supports SFN)	
4.	Fill-in transmitter planning	
5.	Proposing modifications to multiplex composition, network architecture or business plan (as far as needed)	

Table 6.3.9: Main activities related to determining system parameters

5.4 D	5.4 Determining system parameters	
1.	Evaluation of FFT size (e.g. 2k, 4k or 8k)*	
2.	Evaluation of carrier modulation	
3.	Evaluation of code rate	
4.	Evaluation of guard interval *	
5.	Evaluation of hierarchical transmission, if used	

Note *: these parameters apply only for multi-carrier systems

Table 6.3.10: Main activities related to assessing radiation characteristics

4.5 A	4.5 Assessing radiation characteristics	
1.	Determining height of antenna	
2.	Evaluation of transmitter power, antenna gain and polarization	
3.	Evaluation and optimizing antenna diagram	
4.	Calculation of antenna power budget	

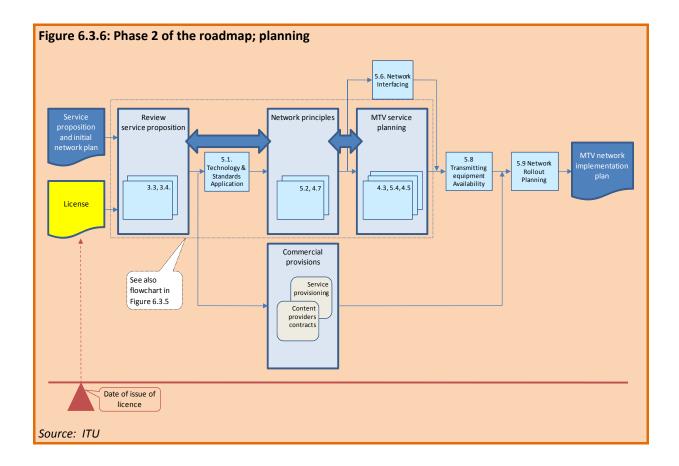
In the preparatory phase not all station characteristics are known in detail, nor is it necessary to achieve a detailed initial network plan. The purpose is:

- to verify business plan and customer proposition;
- to be able to react to proposals from government or regulator in consultation with market parties (see phases 1, 2 and 3 of the regulator flowchart in section 6.1), in the case where the preparatory phase has been started before the licence procedure has been published;

to have sufficient information for a successful licence application.

The preparatory phase ends with a set of documents describing the service proposition, business plan and an initial network plan. This should be finalized in time for the licence application.

6.3.3.2 Planning



Input data

The planning phase starts when the licence has been issued. Licence conditions and the service proposition, business plan and initial network plan, resulting from Phase 1, are the input data for Phase 2.

Review service proposition

Depending on the licence conditions, customer proposition and business plan (functional block 3.2 and 3.4, respectively) may need to be reviewed by carrying out appropriate activities from Tables 6.3.2 and 6.3.4 (see in Section 6.3.2.1).

Commercial provisions

After review of customer proposition and business plan, the network operator will start the following commercial activities:

- service provisioning;
- contracting content providers.

Technology and standards application and initial network principles

In parallel to the commercial activities, the initial technical choices will be reviewed and defined in more detail by carrying out appropriate activities related to functional blocks:

- 5.1 Technology and standards application (see Table 6.3.5 in Section 6.3.2.1).
- 5.2 Design principles and network architecture (see Table 6.3.6 in Section 6.3.2.1).
- 4.7 Shared and common design principles (Table 6.3.7 in Section 6.3.2.1).

MTV service planning

Following the review of technical choices the MTV service planning will be reviewed and defined in more detail by carrying out the activities related to functional blocks:

- 4.3 Network planning (see Table 6.3.8 in Section 6.3.2.1).
- 5.4 System parameters (see Table 6.3.9 in Section 6.3.2.1).
- 4.5 Radiation characteristics (see Table 6.3.10 in Section 6.3.2.1).

As in the preparatory phase, this includes several iterative steps and possibly a review of the service proposition. The order of steps is similar to Figure 6.3.5 in Section 6.3.2.1).

Network interfacing and studio facilities

In parallel to service planning, the activities related to functional block 4.6 (Network interfacing) will be carried out (see Table 6.3.11 below).

Table 6.3.11: Main activities related to specifying network interfaces

Drafting interface specifications between studio and multiplex head end Drafting interface specifications of signal distribution links between multiplex and transmission sites. Drafting interface specifications between network monitoring system and transmitting equipment Preparing system and space for additional service

Transmitting equipment availability

When the optimum network plan has been achieved and network interfaces have been specified, transmitting equipment availability will be considered and network roll out be planned by carrying out the activities related to functional blocks:

- 5.8 Transmitting equipment availability (see Table 6.3.12).
- 5.9 Network roll out planning (see Table 6.3.13).

Table 6.3.12: Main activities related to considering equipment availability

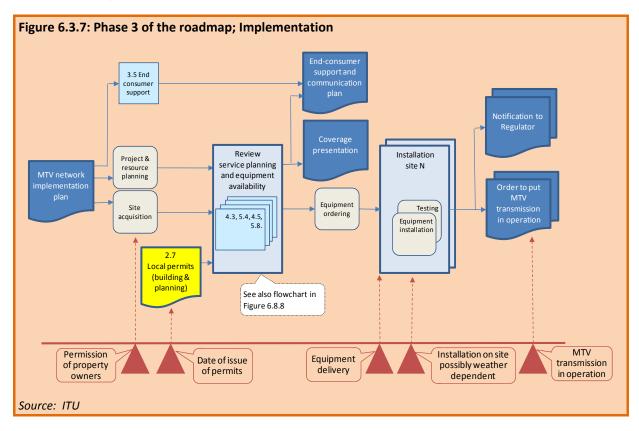
5.8 C	5.8 Considering equipment availability	
1.	Carrying out market research	
2.	Drafting transmitter specifications	
3.	Drafting antenna specifications	
4.	Drafting distribution link specifications	
5.	Drafting multiplex head end specification	
6.	Equipment testing	

Table 6.3.13: Main activities related to planning network roll out

5.9 Network roll out planning		
1.	Describing pilot tests	
2.	Roll out planning (e.g. main cities, provincial cities, rural areas)	
3.	Agreement with receiver manufacturers to deliver receivers in sufficient quantities, in time	
4.	Gap-filler implementation planning	
5.	Coverage assessment at each stage of implementation	
6.	Setting up communication plan and related provisions (e.g. helpdesk, website)	

The planning phase ends with a set of documents describing the MTV network implementation plan.

6.3.3.3 Implementation



Input data

The implementation phase of the MTV network starts when the network implementation plan, resulting from Phase 2 of the roadmap has been adopted.

Project- and resource planning and site acquisition

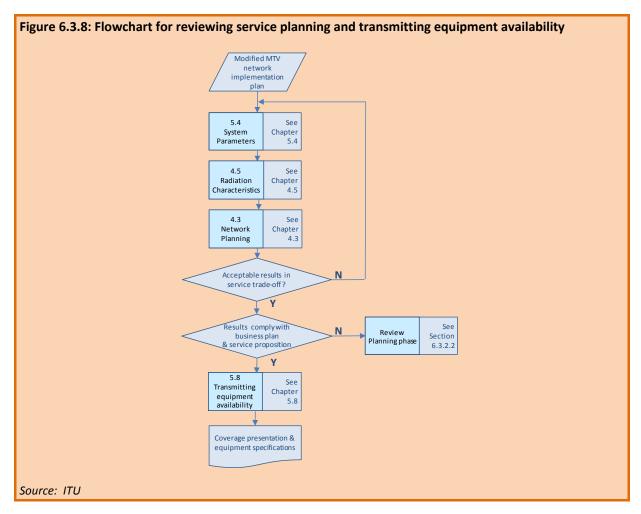
On the basis of the MTV network implementation plan, project and resources planning and site acquisition will start and local building and planning permits need to be acquired.

Review of service planning and transmission equipment availability

In carrying out the above mentioned activities, modifications to the network implementation plan may have to be accepted. For instance, site acquisition may not be successful; or a new site may be realized at a different location than assumed in the MTV network implementation plan. It may also happen that, in the detailed project planning, antenna heights or diagrams are specified differently than originally assumed. In such cases service planning and equipment availability needs to be reviewed by carrying out the appropriate activities relating to the following functional blocks:

- 4.3 Network planning (see Table 6.3.7 in Section 6.3.2.1).
- 5.4 System parameters (see Table 6.3.8 in Section 6.3.2.1).
- 4.5 Radiation characteristics (see Table 6.3.9 in Section 6.3.2.1).
- 5.8 Transmitting equipment availability (see Table 6.3.12 in Section 6.3.2.2).

This includes several iterative steps as shown in Figure 6.3.8.



If the results of the review of the service planning do not comply anymore with the customer proposition or business plan, the planning phase should be reviewed.

When the optimum set of station characteristics has been obtained, the equipment specifications will be reviewed and detailed coverage presentations will be made. The latter will be used for communication to public and content providers to show reception possibilities in the various implementation stages.

Equipment ordering

On the basis of the equipment specifications, equipment tender procedures will be initiated. After comparing several offers, suppliers will be selected and equipment ordered.

Consumer support

Before a site is brought into use, the end-consumers in the related coverage area should be informed about the new digital services and the necessary receiving equipment by addressing functional block 3.5 (End consumer support). The main activities are listed in Table 6.3.14.

Table 6.3.14: Main activities related to defining end consumer support

3.5 Defining end consumer support

- 1. Consult and carry out 'road shows' for device creators (i.e. manufacturers and retailers), content aggregators, and mobile operators
- 2. Draft end-consumer support and communication plan and determine means and budget, possibly align business planning

Installation

Installation of transmitting equipment is followed by site acceptance tests.

During the installation stage it could happen that, for unexpected reasons, stations cannot be installed as planned. In that case, the MTV implementation plan may need to be reviewed in order to provide information on the consequences of the changes and to prepare amended coverage presentations.

The installation work should be planned in such a way that the transmitters can be put into operation at the agreed date, taking into account that some sites may be inaccessible during certain periods of the year (e.g. heavy snow in winter).

When installation of a station has been completed, the regulator will be notified that the station will be put into operation in accordance with the licence terms and conditions.

6.3.3 Implementation guidelines

Each player in the value chain (see Figure 1.1.3 in section 1.1) should select for each of the three phases of the network operator roadmap:

- a) the functional building blocks within the operational responsibility of the organization;
- b) the functional building blocks within the operational responsibility of other players of the value chain in order determine where interfaces and service agreements are needed;
- the functional building blocks within the responsibility of government and/or regulator, that are inputs to a).

Furthermore it has to be estimated to what extent key topics and choices of the selected building blocks have to be considered and consequently the activities that have to be carried out, taking into account:

- the status of implementation of the regulator roadmap;
- market situation, including already licensed MTV transmissions, existing or planned DTTB/MTV networks and competing offers by mobile operators;
- existing transmitter network infrastructure;
- responsibilities of the regulator and licence holder regarding technology choices and network planning.

A realistic time schedule for the whole process needs to be established, taking into account that a number of milestones in the process is not or not entirely in the control of the network operator such as:

- publication of the licence procedure, describing the way licences are assigned and may include applicable standards and site sharing regulations;
- issue of the licence, with terms and conditions prescribing among others service roll out obligations and permitted frequency use;
- building and planning permits from local authorities for setting up new sites or changing existing sites;
- permission of property owners to use property for setting up new sites or changing existing sites;
- equipment delivery times;
- installation periods, seasonal weather conditions may restrict access to some sites.

The starting point should preferably be in an early stage of implementation of the regulator roadmap (see section 6.1) in order to be able to react to proposals from government or regulator in consultation with market parties. Latest moment for start is when the licence procedure has been published and a licence application can be submitted.

6.4 National roadmap development

This section describes the steps for developing a national roadmap and consists of the following subsections:

- 6.4.1 Analysis of national TV market.
- 6.4.2 Formulation of DSO objectives.
- 6.4.3 Construction of the national roadmap.
- 6.4.4 Implementation guidelines.

The sections are illustrated with examples from national roadmaps that were developed with ITU assistance in a number of countries in Africa³⁸⁶ and the Asia and Pacific region³⁸⁷ as part of ITU/BDT activities on the implementation of regional Initiatives projects approved by WTDC-10.

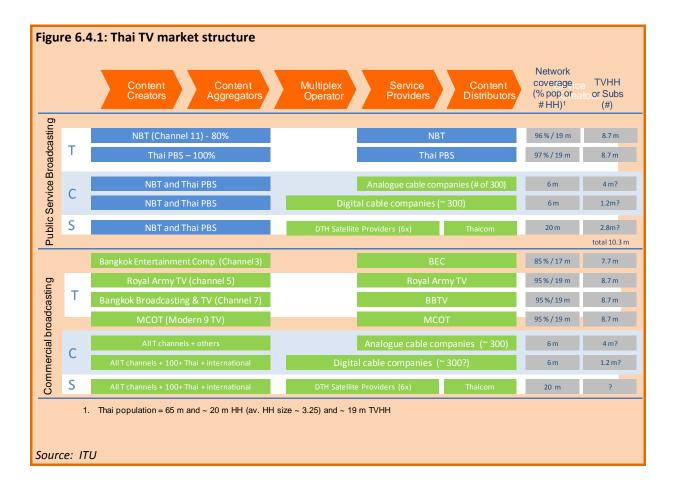
6.4.1 Analysis of national TV market

The development of a national roadmap for transition to digital terrestrial television starts with an analysis of the current TV market structure, analogue TV networks and regulatory framework.

The market analysis indicates among others the current players, existing terrestrial TV coverage and competing means of TV delivery, including their coverage and the price the viewer has to pay for getting access to the services. The market analysis is a tool for assessing the market position of the new DTTB and MTV services. As an example, the overview of the market structure from the roadmap report of Thailand is shown in Figure 6.4.1

 $^{{\}sf See} \ \underline{\sf www.itu.int/en/ITU-D/Technology/Pages/Projectonthe digital broadcasting transition road map in Africa. as {\sf px} and {\sf px} and {\sf px} are {\sf px} and {\sf px} are {\sf px} are$

See www.itu.int/en/ITU-D/Technology/Pages/ProjectonDigitalBroadcastingTransitionRoadmapinAsiaPacific.aspx



Other important TV market characteristics should also be identified e.g. growth of competing delivery means, terrestrial TV reception mode (rooftop or indoor), the main TV players and an indication on the size of the advertising market. For instance in the TV market in Thailand (see Figure 6.4.1) the penetration of satellite TV is growing fast. Consequently the number of viewers of analogue terrestrial TV is decreasing rapidly. Terrestrial analogue TV is considered as inferior to satellite TV due to the limited number of services and the often poor reception quality. The window of opportunity for the introduction of DTTB is therefore limited. For these reasons the regulator puts high priority on the roadmap phase related to licensing and regulated the introduction of DTTB services first, while it was decided to consider the analogue switch-off (ASO) later. Furthermore the DTTB unique selling points were emphasised, such as the ease of reception with simple antennas at outdoor and indoor locations, low receiver costs for viewers and the possibility to transmit local services.

The regulatory framework indicates the current regulatory authorities and main laws and regulations regarding spectrum rights, broadcasting rights, operating rights (if applicable), public service broadcasting obligations, site and antenna sharing regulations and local planning regulations (such as building permits). Also any (preliminary) regulations or policy documents regarding the DTTB service introduction or analogue TV switch-off (ASO) should be identified.

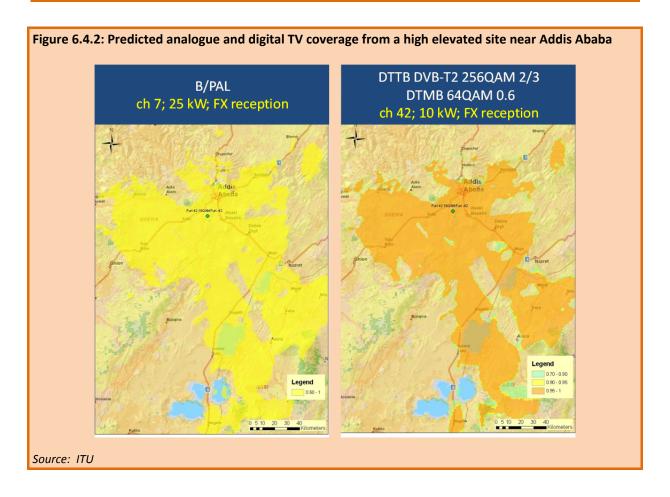
6.4.2 Formulation of DSO objectives

The aim or end milestones of the roadmap are identified by formulating the digital switch-over (DSO) objectives. The DSO objectives are often defined for the transition period and for the period after ASO and could include topics like:

- Smooth transition from analogue to digital, with requirements such as:
 - DTTB coverage should match analogue TV coverage;
 - phased introduction and simulcasting for a certain period;

- DTTB start date;
- local or regional services as in analogue TV;
- areas with indoor reception.
- End of transition period, including:
 - date or reference to international agreement (e.g. GE06) or regional telecommunication recommendations;
 - phased switch-off or national switch-off.
- Additional services or coverage, such as:
 - number of services or number of multiplexes for free-to-air services for public and commercial TV or pay-tv;
 - extended coverage;
 - special services e.g. early (emergency) warning systems (EWS), services for visual or hearing impaired people.
- Better quality, including:
 - HDTV;
 - stereo or multi-channel audio.
- Financial compensations, including:
 - to all households or differentiated between household types for purchasing set-top-boxes;
 - for information and help in installing DTTB receiving installations;
 - to broadcasters for simulcasting costs or DTTB investment costs.
- Digital dividend, including:
 - reallocation of certain parts of the broadcasting bands to new broadcasting technologies or other services (e.g. IMT);
 - whether restacking / repacking of the vacated analogue channel assignments into a contiguous is required;
 - use of digital radio in the VHF band.

The DSO objectives could include potentially conflicting requirements. For instance, in the roadmap of Ethiopia one of the objectives is that DTTB coverage should match existing analogue coverage. Another requirement is that existing facilities should be used. The potential conflict lies in the circumstances that existing analogue TV coverage is achieved by transmissions in VHF, whereas DTTB should be introduced in UHF with transmitters that were bought recently in the framework of a project to improve analogue TV coverage. These transmitters are equipped with analogue TV and DTTB exciters. But when converted to digital, the ERP is not sufficient to achieve a coverage area that is as large as the VHF coverage from the same site. This situation is illustrated in Figure 6.4.2. The left hand side shows analogue TV coverage from the main site near Addis Ababa. The left hand side shows DTTB coverage from the same site with the available UHF transmitter. At the time of preparing the roadmap two DTTB standards were under consideration, therefore two DTTB standards and their respective system variants are indicated.



In the policy phase of the roadmap the regulator investigated if either the loss of coverage in digital is acceptable (note that the built-up area of Addis Ababa is well covered in both cases), or to improve digital coverage e.g. by using a more robust system variant.

6.4.3 Construction of the national roadmap

After the analysis of the national TV situation and the formulation of the DSO objectives, the relevant functional building blocks should be selected.

Not all functional building blocks of the functional framework described in Part 1 may be relevant in the national situation and for the stakeholders for which the roadmap is developed. E.g. in some countries functional building block 2.9 (local permits) is not a major issue in design and roll-out of DTTB networks, because either no strict rules are in force or the national regulator can guarantee the required rights. Also for instance functional building block 2.12 (law enforcement and executing) may not be essential for managing the DSO process if the current regulatory framework allows DTTB introduction in an adequate way. Another example is that in the regulator roadmap detailed network design and implementation (functional building blocks 4.6 to 4.9) may not be relevant if the rights to operate a DTTB network will be assigned by public tender to a network operator.

After the functional building blocks have been selected the phases of the roadmap should be defined and the roadmap be constructed by placing the selected functional building blocks per phase in a logical order and timeframe. Part of the roadmap construction is the consideration of main topics and choices and the identification of the decisions that have already been taken, have partly been taken, still need to be taken, or need review. For those issues that are not (fully) decided or need revision the main activities should be indicated.

As example, the top level presentation of the roadmap of Angola is shown in Figure 6.4.3. An important aspect of this roadmap is that the government decided to set up a new company (NewCo) that will act as a common multiplex/network operator for the multiplexes that will be financed from public sources.

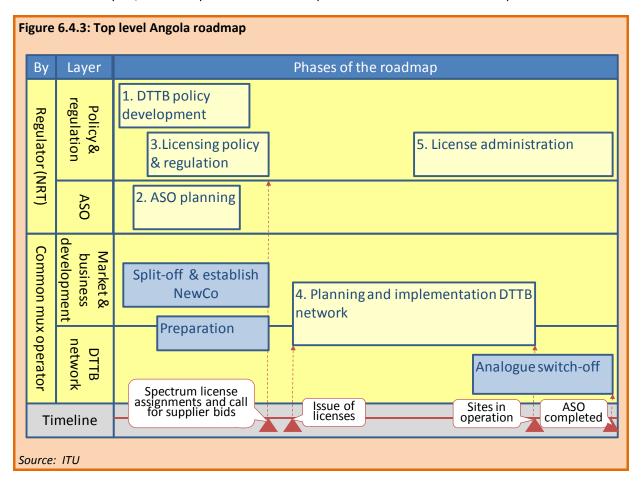


Figure 6.4.3 shows that preparations are needed for splitting off the network operations from the public broadcaster and establishing the new company. This effort may impact the critical path because rolling out the DTTB network without the establishment of NewCo is impossible. In Figure 6.4.3 the preparations for splitting off the network activities from the public broadcaster and establishing NewCo are indicated in blue as it is assumed that these activities will be carried out under the direct responsibility of public broadcaster's management and are not managed by the government (yellow shaded blocks). In the roadmap report, each of the phases managed by government (yellow shaded) is described in detail and the order of related functional building blocks as well as the input and output documents are indicated.

Depending on the status of the national preparations, the national roadmap report may contain a long and diverse list of activities. It is therefore useful to identify the top-five or top-ten most critical issues. These issues could form a combination of activities related to more than one functional building block.

As an example the top-ten most critical topics of the roadmap of Cambodia is shown in Table 6.4.1. The order of addressing the topics does not express their level of priority or importance. This priority is determined by the ASO planning and whether the topic is on the critical path of the ASO planning.

Table 6.4.1: Top-10 most critical key topics and choices in Cambodia

No	Key choices/decisions to be taken	(Part of) Block
1	Single and low costs STBs	2.1, 4.1
2	Customer proposition (services and coverage)	3.2
3	Licensing Model A or B	2.2
4	Required and available budget (for ASO process)	2.9, 2.15, 3.1 3.4
5	ASO model (simulcasting phases and areas)	2.14
6	ASO planning and milestones (e.g. switch-off date)	2.16
7	ASO communication plan	2.18
8	Business model and conditional access	3.3, 3.4
9	Digital TV frequency plan	2.10,2.4, 4.3
10	Allocation to Mobile services (LTE)	2.10

In this example the TV market was characterised by a great number of existing national TV services and a wide choice of TV platforms (analogue and digital terrestrial, analogue and digital cable, IPTV and satellite TV). The DSO objectives showed a great demand for DTTB services resulting in spectrum requirements that could exceed the capacity of the frequency band. In the DTTB policy development phase, the government was faced with very challenging choices regarding the size of DTTB services package, the allocation of part of the band to IMT (LTE), the licensing model (either a common multiplex /network operator – model A, or each broadcaster its own network- model B), while keeping the costs of the transition for government, broadcasters as well as viewers at a low level.

6.4.4 Implementation guidelines

In developing the national roadmap, the following steps should be taken:

- 1. analysis of the current TV market structure, analogue TV networks and regulatory framework;
- 2. formulation of the digital switch-over objectives;
- 3. scoping of the roadmap by selecting the relevant functional building blocks and determining the phases of the roadmap;
- 4. construction of the roadmap by placing the functional building blocks in a logical order and in a timeframe;
- 5. considering the main topics and choices of each of the functional building blocks and determining topics that have been decided, partly decided, not decided yet or need review;
- 6. determining the main activities needed to conclude on topics that have not or not fully been decided;
- 7. selection of the top-ten or top-five most critical issues to be considered.

It is not uncommon that in the course of the development of the roadmap previous steps need to be reviewed or more precisely defined.

The national roadmap reports developed with ITU assistance and published on the ITU website could be used as examples in developing a national roadmap.

After the roadmap has been finalised the following steps should be taken:

- 1. approval of the roadmap report at either ministerial level and/or political level and acquiring a mandate to plan and manage the process in accordance to the phases of the roadmap;
- 2. formation of a project management office (PMO) and start drafting an initial detailed DSO planning and determine the progress reporting procedures and structures.

Bibliography

Source	Title	Part	Annex
ABU	Asia Pacific Broadcasting Union (ABU) – Handbook on EWBS, June 2009 www.abu.org.my/upload/EWBS Handbook.pdf		F
ABU	Asia Pacific Broadcasting Union (ABU) Guidelines – Publication Television Archiving – 1999		E
ABU	Asia Pacific Broadcasting Union (ABU) – Publication File Formats for sound programme exchange		E
A@R	Archives at Risk Alliance: www.archivesatrisk.org		Е
CEPT	ECC REPORT 65. AUCTIONS AND BEAUTY CONTESTS IN CEPT ADMINISTRATIONS Brijuni, May 2005	2	
CEPT	ERC REPORT 76. THE ROLE OF SPECTRUM PRICING AS A MEANS OF SUPPORTING SPECTRUM MANAGEMENT. Marbella, September 1999	2	
CEPT	ECC REPORT 80. ENHANCING HARMONISATION AND INTRODUCING FLEXIBILITY IN THE SPECTRUM REGULATORY FRAMEWORK. Oulu, March 2006	2	
CEPT	ECC REPORT 104. COMPATIBILITY BETWEEN MOBILE RADIO SYSTEMS OPERATING IN THE RANGE 450-470 MHz AND DIGITAL VIDEO BROADCASTING – TERRESTRIAL (DVB-T) SYSTEM OPERATING IN UHF TV CHANNEL 21 (470-478 MHz). Amstelveen, June 2007	2, 4	
CEPT	ECC Report 116. The possibilities and consequences of converting GE06 DVB-T allotments/assignments in Band III into T-DAB allotments/assignments, Athens, February 2008	2, 4, 5	
СЕРТ	CEPT Report 29. Report from CEPT to the European Commission in response to the Mandate on "Technical considerations regarding harmonisation options for the digital dividend in the European Union" "Guideline on cross border coordination issues between mobile services in one country and broadcasting services in another country". 26 June 2009	2	
CEPT	CEPT Report 30. Report from CEPT to the European Commission in response to the Mandate on "The identification of common and minimal (least restrictive) technical conditions for 790 - 862 MHz for the digital dividend in the European Union". Final Report on 30 October 2009	2	
СЕРТ	CEPT Report 31. Report from CEPT to the European Commission in response to the Mandate on "Technical considerations regarding harmonisation options for the digital dividend in the European Union"; "Frequency (channelling) arrangements for the 790-862 MHz band" (Task 2 of the 2nd Mandate to CEPT on the digital dividend). 30 October 2009	2	
DCMI	Dublin Core Metadata Initiative; http://dublincore.org/		Е
Digitag	DigiTAG report Digital Terrestrial Television in Eastern and Central Europe (December 2007)	3	
Digitag	DigiTAG report DVB-SSU, implementing system software updates on the terrestrial platform (2007)	4	
Digitag	DigiTAG report, HD on DTT, key issues for broadcasters, regulators and viewers (2007)	2,3,4	
Digitag	DigiTAG report Mobile Broadcast Television in Europe (January 2007)	3,5	
Digitag	DigiTAG report Network in Evolution; making changes to the digital terrestrial television platform, May 2008	4,5	
Digitag	DigiTAG report, Analogue Switch-off, learning from experiences in Europe (2008)	2	
Digitag	DigiTAG report, Understanding DVB-T2 Key technical, business, and regulatory implications (2009)	2,3,4	
Digitag	Digitag Guide to digital switch-over (2013)	2,3,4	F

Source	Title	Part	Annex
DVB	DVB fact sheet; Digital terrestrial broadcasting. November 2008	4	
DVB	DVB fact sheet; 2 nd generation terrestrial. August 2008	4	
DVB	DVB-T2- Lite Fact Sheet	5	D
EBU	"Digital Video Archives – facing the facts" EBU Technical Review – Geneva Summer 1999, 11 pages		E
EBU	EBU Tech Report 021 Technical Bases for T-DAB services network planning and compatibility with existing broadcasting services.	5	
EBU	EBU Tech Report 022 Terrestrial digital television planning and implementation consideration	4	
EBU	EBU BPN 037 Final Report on Statistical Multiplexing; Jan 2001	4	
EBU	EBU BPN 059 Impact on Coverage of Inter-Symbol Interference and FFT Window Positioning in OFDM Receivers, May 2003	4	
EBU	EBU Tech Report 024 Guide on SFN Frequency Planning and Network Implementation with regard to T-DAB and DVB-T	4	
EBU	EBU BPN 075 Single Frequency Network Maintenance, March 2007	4	
EBU	EBU BPN 083 Broadcasting aspects relating to the procedures for Coordination and Plan Conformity Agreement in the GE06 Agreement, November 2007		А
EBU	EBU-Tech 3250, Specification of the digital audio interface (The AES/EBU interface), 2004	5	
EBU	EBU-Tech 3291, Primary distribution of TV signals using MPEG-2 technologies,	4	
EBU	EBU-TECH 3312 Digital Terrestrial HDTV Broadcasting in Europe. The data rate capacity needed (and available) for HDTV, Geneva, February 2006	4	
EBU	EBU-TECH 3316 Monitoring of Access Services, Requirements, Developments and Recommendations, Geneva, February 2006	4	
EBU	EBU-TECH 3317, version 2 Planning parameters for hand-held reception, concerning the use of DVB-H and T-DMB in Bands III, IV, V and 1.5 GHz. July 2007	4,5	
EBU	EBU-TECH 3327 Network Aspects for DVB-H and T-DMB. Geneva, April 2008	4,5	
EBU	EBU-TECH 3328 Current Status of High Definition Television Delivery Technology. Geneva, Spring 2008	4	
EBU	EBU-TECH 3298 An EBU 'route map' to high definition (HD), Geneva, October 2004	4	
EBU	EBU-TECH 3333 HDTV Receiver Requirements; User Requirements. Geneva, March 2009	4	
EBU	EBU-TECH 3334 Accommodation of HDTV in the GE06 Plan, February 2009		Α
EBU	EBU-TECH 3348 Frequency and Network Planning Aspects of DVB-T2, May 2011	4	
EBU	EBU Technical review trev-299: What's difference between DVB-H and DAB? July 2004. Andreas Sieber and Chris Weck	5	
EBU	EBU Technical review trev-305: Broadcasting to handhelds, January 2006. Chris Weck and Edgar Wilson	5	
EBU	EBU Technical review trev-305: An economy analysis of DAB and DVB-H, January 2006. Daniel Skiöld	3	
EBU	EBU Technical Review trev-309: Implementation of the Digital Dividend-technical constraints to be taken into account; Jan Doeven. January 2007	2	
EBU	EBU Technical Review No 308: GE06 – overview of the second session (RRC-06) and the main features for broadcasters; Terry O'Leary, Elena Puigrefagut and Walid Sami. October 2006		А
EBU	EBU Technical review 2008 Q4: Mobile TV standards: DVB-T vs. DVB-H. G. Pousset, Y. Lostanlen and Y. Corre	5	

Source	Title	Part	Annex
EBU	EBU Technical Review 2011-Q1: Digital dividend, how can mobile and broadcast networks use adjacent band?	2,4	
EBU	EBU Technical review trev-2009 Q4: Spectrum usage and requirements- for future terrestrial broadcast applications. Roland Brugger and Abiodun Gbenga-Ilori	4	
EBU	EBU Technical Information 137-2006: Guidelines for the RRC-06. EBU, Geneva		Α
EBU	EBU Technical Information 144-2004, Access Services ,includes recommendations, June 2004	4	
EBU	EBU Technical Report 015, Report on the Future of Terrestrial Broadcasting. Geneva, October 2010	3	F,G
EBU	EBU Technical Report 015, Defining Spectrum Requirements of Broadcasting in the UHF Band. Geneva July 2012	4	
EBU	EBU Technical Report 016 Benefits and limitations of Single Frequency Networks (SFNs) for DTT, October 2012	4	
EBU	EBU View. How should the digital dividend be used? Long-term public interest versus short-term profit	2	
EBU	EBU Project Group P/FTA (Future Television Archives), "EBU Report Future content Management Systems Architecture, Services and Functionality" Geneva December 2001, 111 Pages		E
EBU	EBU Project Group P/FTA (Future Television Archives), "Supplement to the EBU Report Future content Management Systems Architecture, Services and Functionality" Geneva December 2001 -109 pages		E
EBU	Technical Report 003, Radio Archives: Conception and Practice, Geneva July 2009		Е
EBU	Recommendation R105-2008 Digitisation of programmed material in Audio Archives: Geneva March 2008; www3.ebu.ch/cms/en/home		E
EBU	Wright, Richard, "What Archives want-requirements for digital technology", EBU Technical Review –Geneva Oct 2006 10 pages		E
EC	A BIPE consulting study for the European Commission, Digital Switchover in Broadcasting (Final Report, April 2002).	2	
EC	Study on the Regulation of Broadcasting Issues under the New Regulatory Framework, prepared for the EC by Cullen International SA.	2	
EC	European Mobile Broadcasting Council; Technical Workstream document. Final version (January 2007).	5	
ETSI	ETSI EN 300 401 Radio broadcasting systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers.	5	
ETSI	ETSI EN 300 744 Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television.	4	
ETSI	ETSI EN 300 813 specifies the transmission of MPEG-2 Transport Streams (TS) between two DVB interfaces within Plesiochronous Digital Hierarchy (PDH) networks working in accordance with ITU-T Recommendation G.702.	4,5	
ETSI	ETSI EN 301 234: "Digital Audio Broadcasting (DAB); Multimedia Object Transfer (MOT) protocol".	5	
ETSI	ETSI EN 302 296 (Electromagnetic compatibility and Radio spectrum Matters (ERM); Transmitting equipment for the digital television broadcast service, Terrestrial (DVB-T).	4	
ETSI	ETSI ES 201 735 V1.1.1 (2000-09): "Digital Audio Broadcasting (DAB); Internet Protocol (IP) Datagram Tunnelling".	5	
ETSI	ETSI ETS 300 797: "Digital Audio Broadcasting; Distribution interfaces; Service Transport Interface (STI)".	5	
ETSI	ETSI ETS 300 799: "Digital Audio Broadcasting; Distribution interfaces; Ensemble Transport Interface (ETI)".	5	

Source	Title	Part	Annex
ETSI	ETSI ETS 300 814 specifies the transmission of MPEG2 Transport Streams (TS) between two DVB interfaces within Synchronous Digital Hierarchy (SDH) networks working in accordance with ITU-T Recommendation G.707	4,5	
ETSI	ETSI TS 101 759: "Digital Audio Broadcasting (DAB); Data Broadcasting – Transparent Data Channel (TDC)".	5	
ETSI	ETSI TS 102 368: "Digital Audio Broadcasting (DAB); DAB - TMC (Traffic Message Channel)".	5	
ETSI	ETSI TS 102 371: "Digital Audio Broadcasting (DAB); Transportation and Binary Encoding Specification for DAB Electronic Program Guide (EPG)".	5	
ETSI	ETSI TS 102 428 Digital Audio Broadcasting (DAB); DMB video service; User Application Specification.	5	
ETSI	ETSI TS 102 818: "Digital Audio Broadcasting (DAB); XML Specification for DAB Electronic Program Guide (EPG)"	5	
ETSI	ETSI TR 100 815 Digital Video Broadcasting (DVB); Guidelines for the handling of Asynchronous Transfer Mode (ATM) signals in DVB systems.	4,5	
ETSI	ETSI TR 101 89, 1Digital Video Broadcasting (DVB); Professional Interfaces: Guidelines for the implementation and usage of the DVB Asynchronous Serial Interface (ASI).	4,5	
ETSI	ETSI TR 101 190 Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects.	4	
ETSI	ETSI TR 101 496-3 V1.1.2 (2001-05) DAB guidelines and rules for implementation and operation part-3 broadcasting network.	5	
IPTV Forum Japan	IPTVFJ STD-0001, "IPTV STANDARD Overview"		G
IPTV Forum Japan	IPTVFJ STD-0005, "Operational guidelines for the IP retransmission of terrestrial digital television broadcasting"		G
ITU-D	Digital Dividend: Insights for spectrum decisions; www.itu.int/ITU- www.itu.int/ITU-		

Source	Title	Part	Annex
ITU-R	Recommendation ITU-R BT.709-5 Parameter Values for the HDTV standards for production and international programme exchange	4	
ITU-R	Recommendation ITU-R BT.802-1 Test pictures and sequences for subjective assessments of digital codecs conveying signals produced according to Recommendation ITU-R BT.601	4	
ITU-R	Recommendation ITU-R BT.1120-8 Digital Interfaces for HDTV studio signals	4	
ITU-R	Recommendation ITU-R BT.1122-2, User requirements for codecs for emission and secondary distribution systems for SDTV and HDTV		G
ITU-R	Recommendation ITU-R BT.1206-1 Spectrum limit masks for digital terrestrial television broadcasting	4	
ITU-R	Recommendation ITU-R BT.1210-4 Test materials to be used in assessment of picture quality	4	
ITU-R	Recommendation ITU-R BT.1306-6 Error correction, data framing, modulation and emission methods for digital terrestrial television broadcasting.	4	
ITU-R	Recommendation ITU-R BT.1368-10 Planning criteria for digital terrestrial television services in the VHF/UHF bands.	4	
ITU-R	Recommendation ITU-R BT.1833-2 Broadcasting of multimedia and data applications for mobile reception by handheld receivers.	5	
ITU-R	Recommendation ITU-R BT.1877-1 Error-correction, data framing, modulation and emission methods for second generation of digital terrestrial television broadcasting systems	4	
ITU-R	Recommendation ITU-R BT.2020 Parameter values for ultra-high definition television systems for production and international programme exchange	2,3,4	
ITU-R	Recommendation ITU-R BT.2022 General viewing conditions for subjective assessment of quality of SDTV and HDTV television pictures on flat panel displays	4	
ITU-R	Recommendation ITU-R BT.2033 Planning criteria, including protection ratios, for second generation of digital terrestrial television broadcasting systems in the VHF/UHF bands	4	
ITU-R	Recommendation ITU-R P.618-10 Propagation data and prediction methods required for the design of Earth-space telecommunication systems		F
ITU-R	Recommendation ITU-R P.1058-2 Digital topographic databases for propagation studies.	4	
ITU-R	Recommendation ITU-R P.1546-4; Method for point-to-area predictions for terrestrial services in the frequency range 30MHz to 3000MHz.	4	
ITU-R	Recommendation ITU-R P.1812-2 A path-specific propagation prediction method for point-to-area terrestrial services in the VHF and UHF bands.	4	
ITU-R	Recommendation ITU-R M.1767 Protection of land mobile systems from terrestrial digital video and audio broadcasting systems in the VHF and UHF shared bands allocated on a primary basis	4	
ITU-R	Recommendation ITU-R SM.1541-4 Unwanted emissions in the out-band domain	4	
ITU-R	Recommendation ITU-R BO.1408-1 Transmission system for advanced multimedia services provided by integrated services digital broadcasting in a broadcasting-satellite channel		F
ITU-R	Recommendation ITU-R BO.1516-1 Digital multiprogramme television systems for use by satellites operating in the 11/12 GHz frequency range		F
ITU-R	Recommendation ITU-R BO.1659-1 Mitigation techniques for rain attenuation for broadcasting-satellite service systems in frequency bands between 17.3 GHz and 42.5 GHz		F

Source	Title	Part	Annex
ITU-R	Recommendation ITU-R BT/BO.1774-1 Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief		F
ITU-R	Recommendation ITU-R BO.1776-1 Maximum power flux-density for the broadcasting-satellite service in the band 21.4-22.0 GHz in Regions 1 and 3		F
ITU-R	Recommendation ITU-R BO.1784 Digital satellite broadcasting system with flexible configuration (television, sound and data)		F
ITU-R	Recommendation ITU-R BO.1785 Intra-service sharing criteria for GSO BSS systems in the band 21.4-22.0 GHz in Regions 1 and 3		F
ITU-R	Report ITU-R BT.2035-2 Guidelines and techniques for the evaluation of digital terrestrial television broadcasting systems.	4	
ITU-R	Report ITU-R BT.2137 Coverage prediction methods and planning software for digital terrestrial television broadcasting (DTTB) networks	4	
ITU-R	Report ITU-R BT.2140-5 Transition from analogue to digital terrestrial broadcasting.	3,4	
ITU-R	Report ITU-R BT.2143-2 Boundary coverage assessment of digital terrestrial television broadcasting signals	4	
ITU-R	Report ITU-R BT.2209 Calculation model for SFN reception and reference receiver characteristics of ISDB-T system	4	
ITU-R	Report ITU-R BT.2245 HDTV test materials for assessment of picture quality	4	
ITU-R	Report ITU-R BT.2254 Frequency and network planning aspects of DVB-T2	4	
ITU-R	Report ITU-R SM.2015 Method for determining national long-term strategies for spectrum utilization	2	
ITU-R	Report ITU-R SM.2093-1 Guidance on the regulatory framework for national spectrum management	2	В
ITU-R	Report ITU-R BO.1227-2 Satellite broadcasting systems of integrated services digital broadcasting		F
ITU-R	Report ITU-R BO.2008-1 Digital multiprogramme broadcasting by satellite		F
ITU-R	Report ITU-R BO.2071-1 BSS System parameters between 17.3 GHz and 42.5 GHz and associated feeder links		F
ITU-R	Report ITU-R BO.2101 Digital satellite broadcasting system (television, sound and data) with flexible configuration		F
ITU-R	ITU-R : Radio Regulations, Edition of 2012	2	F
ITU-R	Handbook on Satellite Communications, Third Edition, John Wiley & Sons, 2002.		F
ITU-R	DTTB Handbook – Digital terrestrial television broadcasting in the VHF/UHF bands	2,4,5	
ITU-T	Recommendation ITU-T G.703 Physical/electrical characteristics of hierarchical digital interfaces.	4,5	
ITU-T	Recommendation ITU-T G.704 Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels.	4,5	
ITU-T	Recommendation ITU-T F.790 Telecommunications accessibility guidelines for older persons and persons with disabilities		G
ITU-T	Recommendation ITU-T P.10/G.100 Vocabulary for performance and quality of service		G
ITU-T	Recommendation ITU-T E.800 Definitions of terms related to quality of service		G
ITU-T	Recommendation ITU-T J.112 Transmission systems for interactive cable television services		G
ITU-T	IPTV Focus Group Proceedings, 2008		G
Linder, Jim	"Videotape Restoration – Where Do I start" www article, New York, November 2008, 3 pages		E

Source	Title	Part	Annex
Metaglu e Corp	Morgan, O, "Metadata Systems Architecture" Metaglue Corporation USA, 2002, 9 pages		E
NFSAA	National Film and Sound Archives Australia, "How to Care for your Audio"		E
National Media Laborat- ory	Sadashige, Koichi, "Data Storage Technology Assessment 2000, Current State and Near Term Projections for Hardware Technology" National Media Laboratory, St Paul Minnesota, August 2000, 137 pages		E
National Media Laborat- ory	Sadashige, Koichi, "Data Storage Technology Assessment 2000, Storage Media Environmental Durability and Stability" National Media Laboratory, St Paul Minnesota, August 2000, 79 pages		E
SMPTE	Society of Motion Picture and Television Engineers, www.smpte.org		E
TRT	Turkish Radio and Television Corporation, www.trt.net.tr		E
John Wiley and Sons	Gerard Maral and Michel Bousquet – Satellite Communications Systems, 5 th Edition, 2009		F

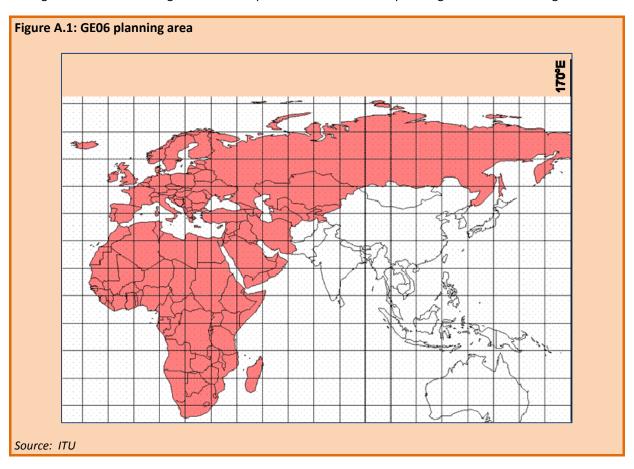
Useful websites

Source	Title	Part	Annex
A@R	www.archivesatrisk.org		Е
ABU	www.abu.org.my	4, 5	E, F
ARIB	www.arib.or.jp/english	4, 5	
BMCO forum	www.bmco-berlin.com/	5	
CEPT	www.ero.dk/	2,4,5	
CNES	http://logiciels.cnes.fr/PROPA/en/logiciel.htm		F
DiBEG	www.dibeg.org/	2,3,4,5	
Digitag	www.digitag.org/	2,3,4,5	
DMB alliance	http://dmb-alliance.org/	5	
DMB portal	http://eng.t-dmb.org/	5	
DMCI	http://dublincore.org/		Е
DVB	www.dvb.org/	2,3,4,5	
EBU	http://tech.ebu.ch/	2,3,4,5	A, F, G
EC	http://ec.europa.eu/information society/policy/ecomm/radio spectrum/index en.htm	2,3	
ETRI	www.etri.re.kr/eng/		E
ETSI	www.etsi.org/WebSite/homepage.aspx	4,5	
FIAT / IFTA	www.fiatifta.org		E
ITU-D	www.itu.int/net/ITU-D/index.aspx	2,3,4,5	
ITU-R	www.itu.int/ITU-R/index.asp?category=information&rlink=rhome⟨=en	2,3,4,5	A, F,G
ITU-R soft ware	www.itu.int/ITU-R/index.asp?category=study-groups&rlink=rsg3-software-ionospheric⟨=en, www.itu.int/ITU-R/terrestrial/broadcast/software/ge06calc/index.html		A,F
ITU-T	www.itu.int/ITU-T/index.html		G
NFSAA	www.nfsa.gov.au		E
World- DMB	www.worlddab.org/	5	

Annex A – GE06 implementation

The Final Acts of RRC-06³⁸⁸ contain the Regional Agreement GE06, adopted by RRC-06, which governs the use of frequencies by the broadcasting service and other primary terrestrial services in the frequency bands 174-230 MHz and 470-862 MHz. They also contain frequency assignment and frequency allotment plans for the digital broadcasting service (television and sound), the analogue television plan applicable in the transition period, the coordinated list of assignments to other terrestrial primary services in these bands, and the Resolutions adopted by RRC-06.

The planning area has been defined as parts of Region 1 (as defined in No. 5.3 of the *Radio Regulations*, situated to the west of meridian 170° E and to the north of parallel 40° S) except the territories of Mongolia and also including the Islamic Republic of Iran. The GE06 planning area is shown in Figure A.1.



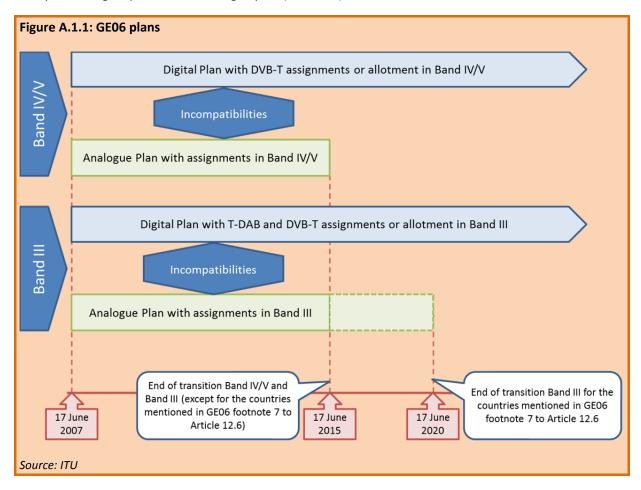
In countries situated in the GE06 planning area, the provisions of GE06 are of great importance in applying the Guidelines described in Part 4 and 5 and in particular Sections 4.1, 4.2, 4.3, 4.4 and 5.1, 5.2, 5.3 and 5.4. In this Annex, additional guidelines are described in relation to GE06 implementation regarding:

- 1. GE06 plans;
- 2. GE06 compliance of stations in the national frequency plan.

Regional Radiocommunication Conference for planning of the digital terrestrial broadcasting service in parts of Regions 1 and 3, in the frequency bands 174-230 MHz and 470-862 MHz.

A.1 GE06 plans

In countries situated in the GE06 planning area the technical characteristics assigned to DTTB stations and analogue TV stations should be in accordance with the GE06 Agreement. The GE06 Agreement contains two plans, a digital plan and an analogue plan (see A.1.1).



Each of the plans consists of two parts: entries in Band III (174 to 230 MHz) and entries in Band IV/V (470-862 MHz). After the expiry of the transition period(s) only the digital plan will remain in existence³⁸⁹. The transition period is specified in Article 12.5 and 12.6 of the GE06 Agreement. The transition period ends on 17 June 2015, however in a number of countries the transition period for Band III ends on 17 June 2020³⁹⁰.

DTTB entries in the digital plan are assignments, allotments or a combination of allotments and assignments.

Article 12.8 of the GE06 Agreement allows the continuation of analogue stations on a non-interference and non-protection basis.

Note 7, related to Article 12.6 of the GE06 Agreements lists the countries where the transition period for Band III end on 17 June 2020.

Allotment planning is defined in GE06³⁹¹ as:

"In allotment planning, a specific channel is "given" to an administration to provide coverage over a defined area within its service area, called the allotment area. Transmitter sites and their characteristics are unknown at the planning stage and should be defined at the time of the conversion of the allotment into one or more assignments."

Details regarding the allotment area, reception mode, system variant and Reference Network³⁹², to determine outgoing interference, are specified in the plan entry.

Assignment planning is defined in GE06³⁹³ as:

"In assignment planning, a specific channel is assigned to an individual transmitter location with defined transmission characteristics (for example, radiated power, antenna height)."

Details regarding the reception mode, system variant and ERP are specified in the plan entry.

In network planning, in principle, a choice can be made of frequencies in Band III and Band IV/V. Band III contains eight channels if a 7 MHz channel raster has been adopted or seven channels in the case of an 8 MHz channel raster³⁹⁴, whereas Band IV/V contains 49 channels of 8 MHz. In a number of countries Band III is also planned for T-DAB (T-DAB plan entries can be used for T-DMB as well) and some countries may even wish to convert their DVB-T plan entries into four T-DAB blocks³⁹⁵.

A major advantage of Band III is the lower propagation loss and lower minimum median field strength values, resulting in lower power to cover the same area compared to Band IV/V. However, in Band III higher man-made noise levels are present and larger antenna dimensions are required compared to Band IV/V. Furthermore if 7 MHz channels are used, the multiplex capacity is 7/8 of the bit rate in an 8 MHz channel with the same system variant.

During transition, operation of DTTB stations is possibly restricted or totally blocked because analogue TV services in the same country and in neighbouring countries need to be protected. National compatibility problems between DTTB and analogue TV can be identified by:

- comparing the DVB-T plan entries of a given site with the existing use of the site. Obviously
 when the DVB-T plan entry is in use for analogue TV, it cannot be used for DTTB until the
 analogue service is switched off;
- performing a compatibility analysis to determine the restrictions needed to protect analogue TV services transmitted from other sites.

International compatibility problems can be divided into three categories:

- 1. incompatibilities with entries in the analogue TV plan;
- 2. incompatibilities with entries in the digital plan;
- 3. incompatibilities with existing assignments of other primary terrestrial services.

³⁹¹ A definition of allotment planning is given in the GE06 Agreement, Chapter 1 to Annex 2 article 1.3.1.

A Reference Network is defined in the GE06 Agreement, Chapter 1 to Annex 2 article 1.3.17: A generic network structure representing a real network, as yet unknown, for the purposes of a compatibility analysis. The main purpose is to determine the potential for and susceptibility to interference of typical digital broadcasting networks.

³⁹³ A definition of allotment planning is given in the GE06 Agreement, Chapter 1 to Annex 2 article 1.3.2.

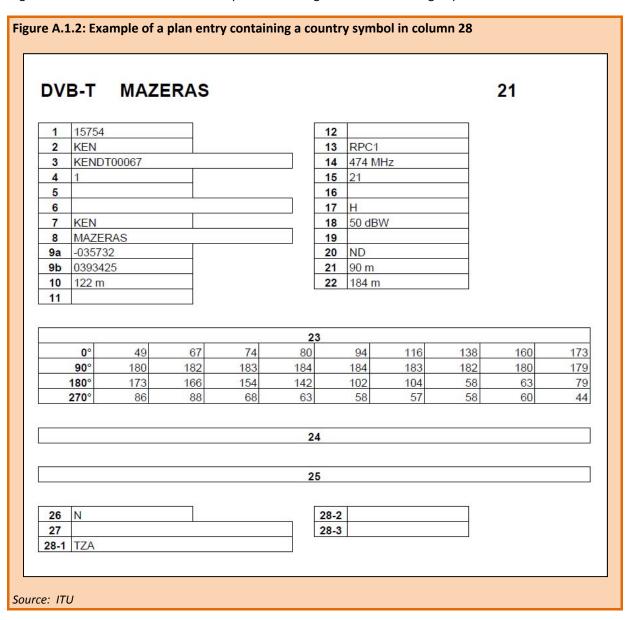
In the GE06 Agreement, Chapter 3 to Annex 2, Appendix 3.1, tables are given showing the DVB-T channel arrangements in Band III.

See ECC Report 116 The possibilities and consequences of converting GE06 DVB-T allotments/assignments in Band III into T-DAB allotments/assignments, Athens, February 2008.

The international compatibility problems are identified in:

- bilateral agreements between the administrations concerned;
- a country symbol in the digital plan, in column 28-1, 28-2 or 28-3 in case of a DVB-T assignment and in column 18-1, 18-2 or 18-3 in case of a DVB-T allotment³⁹⁶ respectively.

Figure A.1.2 shows an example of a plan DVB-T plan entry for an assignment on channel 21. In this case agreement should be reached with respect to an assignment in the analogue plan of Tanzania.



³⁹⁶ The three columns refer respectively to assignments in the analogue plan, entries in the digital plan, or existing assignments to other primary terrestrial services, of the administration mentioned in the note.

Because of the required restrictions during transition, DTTB frequency choice may be limited. Before the related analogue stations have been switched off, some DTTB stations may have severely restricted coverage and at some sites no DTTB frequency may be available. In some cases, it may be possible to improve coverage during transition by selecting (if possible) a frequency for temporary use or by using a SFN. When the related analogue TV stations have been switched-off the restrictions can be removed and the transmitters retuned. However, frequency changes should be avoided as far as possible, because of the involved costs and the burden for viewers to retune their TV sets.

In practice, a frequency change requires retuning of transmitter and combiner filter. In the case of an SFN all transmitters in the SFN must change frequency. If not done at the same time, the SFN is partly a multi frequency network (MFN) and "network gain" may be lost and poor reception in part of the coverage area may be the result. It should also be noted that the antenna may have differences in radiation characteristics on the old and new frequency (see section 4.5), another cause of possible poor reception in part of the coverage area.

A frequency change requires retuning of the receiver. Most DTTB receivers have automatic tuning facilities, but in many cases (re)tuning should be selected in a menu and in some cases after entering a pin code (which may have been forgotten). Therefore, frequency retuning is a nuisance to many consumers and help may be necessary. Practice in Europe has shown that frequency changes could lead to complaints. DTTB services could even get a bad reputation and competitive offers (such as IPTV, cable TV or satellite TV) may gain an advantage.

Implementation guidelines

The entries in the digital plan annexed to the GE06 Agreement are the basis for the national DTTB frequency plan (as well as the national MTV frequency plan) in countries situated in the GE06 planning area. However, until analogue switch-off, DTTB services may be severely restricted. If the DTTB frequency is in use at the same or nearby site for analogue TV, DTTB services are not possible until after analogue switch-off.

If compatibility problems exist with analogue relay stations, a frequency change of some analogue relay stations could alleviate the compatibility problem considerably (see Section 2.14.2, example in Japan).

Channels can be selected from Band III and Band IV/V. With the GE06 plan in most countries at least eight DTTB national coverages are available and, in general, one DTTB coverage in Band III (in additional to a number of T-DAB coverages). When Band III is used for DTTB it should be taken into account that a mixture of Band III and Band IV/V channels will be transmitted with the consequence of:

- need for Band III and Band IV/V transmitting and receiving antennas;
- use of 7 MHz channel bandwidth in Band III (in most countries in Region 1) and 8 MHz channel bandwidth in Band IV/V, has consequent need for re-multiplexing the Band III services.

A.2 GE06 compliance of stations in the national frequency plan

The GE06 Agreement was the result of the ITU Regional Radio Conference 2006 (RRC-06). At the closing ceremony of the conference, Mr Yoshio Utsumi, Secretary-General of ITU, remarked that "The most important achievement of the conference is that the new digital plan provides not only new possibilities for structured development of digital terrestrial broadcasting but also sufficient flexibilities for adaptation to the changing telecommunication environment."

In order to achieve this flexibility, a set of rather complex procedures for implementation (Article 5 of the GE06 Agreement) and modification of the plan (Article 4 of the GE06 Agreement) were agreed.

Guidance on the application of Article 4 (modification procedure) and Article 5 (notification procedure) of GE06 can be found at the ITU website³⁹⁷. Detailed background information on these procedures is given in EBU report BPN 083³⁹⁸.

The possibilities for flexible implementation of digital GE06 plan entries (Article 5) are summarized in Table A.2.1.

Option Service **Examples** Condition Different location, power, system Different characteristic of a **Broadcasting** Conformity check digital plan entry variant, reception mode (GE06, Section II of SFNs on basis of allotments or Annex 4) assignments Alternative application of Broadcasting DTMB, ISDTB-T, DVB-T2, T-DMB Power density check digital plan entry (GE06, Article 5.1.3) Fixed and Downlink applications of WiMAX or

UMTS

Table A.2.1: Flexible use of plan entries (Art.5)

The following sections deal with:

- 1. implementation conditions
- 2. use of different characteristics of a digital plan entry;

Mobile

- 3. application of other transmission systems;
- 4. modifications of the GE06 plans.

A.2.1 Implementation conditions

Some GE06 plan entries can only be brought into use after agreements with neighbouring countries have been reached, because of:

- bilateral agreements asking for coordination before the plan entry is brought into operation;
- remarks in the plan entry in relation to:
 - 1. incompatibilities with entries in the analogue TV plan;
 - 2. incompatibilities with entries in the digital plan;
 - 3. incompatibilities with existing assignments of other primary terrestrial services.

These remarks (if any) are contained in:

- column 28, in case of a DVB-T assignments;
- column 18, in case of a DVB-T allotment;
- column 26, in case of a T-DAB assignment;
- column 17; in case of a T-DAB allotment.

³⁹⁷ www.itu.int/ITU-R/terrestrial/broadcast/plans/ge06/index.html

EBU report BPN 083 Broadcasting aspects relating to the procedures for Coordination and Plan Conformity Examination in the GE06 agreement. Geneva, November 2007

A.2.2 Use of different characteristics of a digital plan entry

A digital plan entry can be used with different characteristics if it complies with the conformity check, described in GE06, Section II of Annex.

In the conformity check, three conditions are verified:

- same channel should be used as the plan entry;
- 2. location of the station should be within 20 km of geographical coordinates of the plan entry or no more than 20 km outside the allotment area;
- 3. interfering field strength, calculated at a great number of test points outside the territory, should not exceed the interfering field strength of the plan entry.

In using a GE06 plan entry with different characteristics, it should be remembered that the incoming interfering field strength levels do not change and that protection can be claimed as provided by the plan entry.

Without increasing the interference potential (as defined by the conformity check) it is possible to change the characteristics of a plan entry. For instance, a higher antenna height combined with a reduced power could be used, or an allotment or an assignment could be converted into an SFN. The conformity check is a complex procedure for which adequate software is needed, either incorporated in the planning software or as a separate tool obtained from ITU-R³⁹⁹.

The digital plan of the GE06 comprises, for DTTB, DVB-T assignments and DVB-T allotments. In case of assignments, both carrier modulation and code rate are specified, or a "Reference Planning Configuration" (RPC), in which a reference C/N is incorporated, is specified. In case of allotments, always a RPC is specified.

A principle choice regarding the system variant and reception mode, or RPC, of a plan entry has been made by each administration during the ITU conference RRC-06. However, in practice when establishing the network design principles and network architecture, followed by network planning, the choice of system variant or reception mode may be reviewed. It should be noted that in these cases the ERP and usable field strength⁴⁰⁰ provided by the plan entry may not be optimal for the chosen system variant and reception mode.

Use of a different system variant than specified in the GE06 plan entry or a system variant having a different C/N value than the one incorporated in the "Reference Planning Configuration" (RPC) specified in the GE06 plan entry is possible. It does not cause a higher interference potential (if the ERP is not increased), but the usable field strength may change, compared to the value provided in the plan. Table A.2.2 indicates the impact.

³⁹⁹ GE06 Calc software is intended to be an easy-to-use tool to unofficially examine the conformity of notices with respect to the GE06 Plan before sending them to the BR and can be found on www.itu.int/ITU-R/terrestrial/broadcast/software/ge06calc/index.html.

 $^{^{400}}$ The definition of the usable field strength is given in GE06, Chapter 2 to Annex 2, Section 1.3.6

Table A.2.2: Impact of system variant different form GE06 plan entry

Choice of system variant	Impact compared to GE06 plan entry
C/N and protection ratio higher than derived from GE06 plan entry	 Higher usable field strength and consequently reduced coverage. Protection may be claimed for lower usable field strength provided by the plan.
C/N and protection ratio lower than derived from GE06 plan entry	 Lower usable field strength and consequently increased coverage. Protection to be claimed for higher usable field strength provided by the plan. Increased coverage might decrease when new stations are added to the plan.

In case a GE06 plan entry is specified for fixed reception and in practice portable reception over a large area is required, the ERP of a single station or the combined ERP from an SFN may not comply with the "conformity check" and power reductions may be necessary.

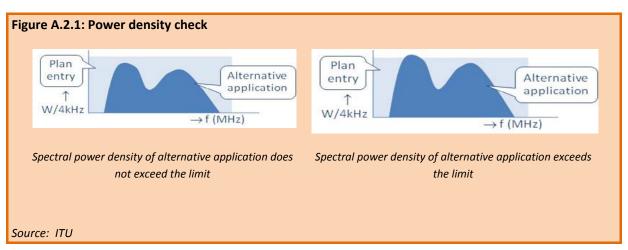
If a GE06 entry is specified for portable reception, the usable field strength is at a high level because of the high minimum median field strength for portable reception. Using a plan entry specified with portable reception, for fixed reception, does not change the incoming interfering field strengths. Although the nuisance fields with fixed reception may be reduced due to the antenna discrimination, the resulting usable field strength could be at a much higher level than in case the plan entry was originally planned for fixed reception.

Network planning exercises will show the impact of these power limitations or high interference levels on coverage (see section 4.3).

A.2.3 Application of other transmission systems

Article 3.1 of the GE06 Agreements indicates that with regard to DTTB, GE06 is based on the DVB-T system. However according to Article 5.1.3, a GE06 plan entry may be used for an alternative application (e.g. another DTTB transmission system, or a non-broadcasting service), provided that that the spectral power density check has been fulfilled. In the spectral power density check, three conditions are verified:

- 1. In case of a non-broadcasting service, the frequency band should be allocated in the Radio Regulations to that service. If not, the alternative application may operate on the condition of not causing unacceptable interference and not claiming protection.
- 2. The peak power density in any 4 kHz of the alternative application should not exceed the spectral power density in the same 4 kHz of the plan entry (see illustration in Figure A.2.1).
- 3. The alternative application should not claim more protection than is afforded to the associated plan entry.



If a plan entry is used for another application using OFDM and with the same bandwidth and the same radiated power, the spectrum density is the same as the plan entry. Therefore, DVB-T plan entries can be used without any restrictions for DTMB (multi-carrier mode) or ISDB-T respectively, provided that radiated power and bandwidth are the same. The use of ATSC or the single carrier mode of DTMB is in principle not excluded, but power restrictions may be necessary in order to comply with the spectral power density check. The 7 MHz and 8 MHz variants of DVB-T2 that are considered compatible with GE06 7 MHz and 8 MHz channel arrangements, and the 1.7 MHz variants that are considered compatible with the GE06 T-DAB frequency blocks, are listed in Tables A.2.3 to A.2.5⁴⁰¹.

Table A.2.3: GE06 compatible 7 MHz channel DVB-T2 variants

Modulation	FFT size	Code rate*	Guard interval
QPSK or	2k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/32, 1/16, 1/8, ¼
16-QAM or	4k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/32, 1/16, 1/8, ¼
64-QAM or 256-QAM	8k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, ¼
	16k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, ¼
	32k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128

^{*} For block sizes of 16 200 and 64 800 bits

Table A.2.4: GE06 compatible 8 MHz channel DVB-T2 variants

Modulation	FFT size	Code rate*	Guard interval
QPSK or	2k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/32, 1/16, 1/8, ¼
16-QAM or	4k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/32, 1/16, 1/8, ¼
64-QAM or	8k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, ¼
256-QAM	16k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, ¼
	32k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128
	8k extended	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, ¼
	16k extended	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4
	32k extended	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128

^{*} For block sizes of 16 200 and 64 800 bits

See <a href="www.itu.int/ITU-R/index.asp?category=information&rlink=faq&faq=broadcasting&lang=en&ID={A9D36158-693C-4104-9F12-5215A2585054}

Table A.2.5: GE06 compatible 1.7 MHz block DVB-T2 variants

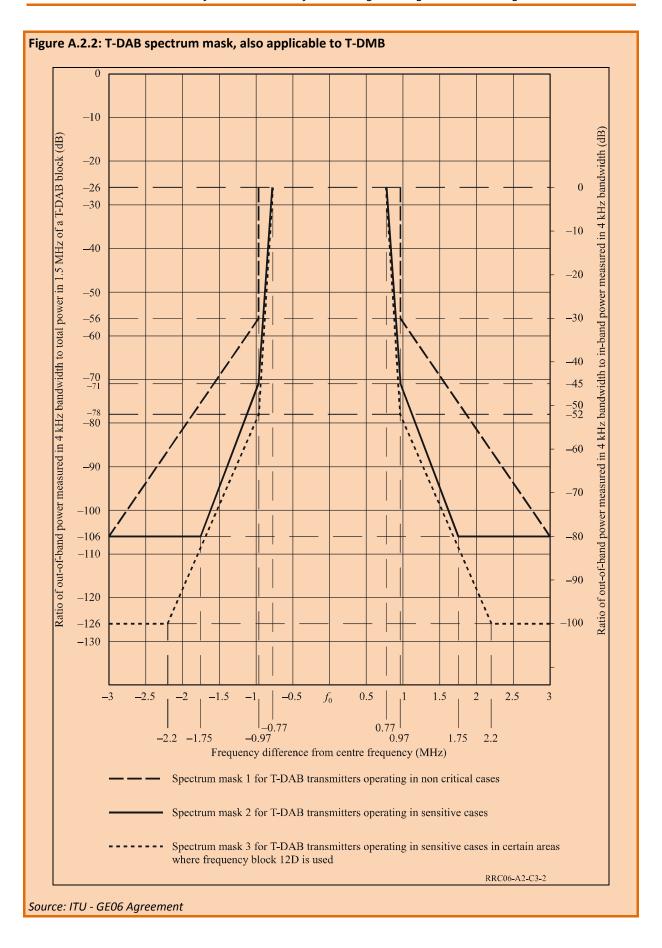
Modulation	FFT size	Code rate*	Guard interval
QPSK or	1k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/16, 1/8, ¼
16-QAM or	2k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/32, 1/16, 1/8, ¼
64-QAM or	4k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/32, 1/16, 1/8, ¼
256-QAM	8k	1/2, 3/5, 2/3, 3/4, 4/5, 5/6	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, ¼

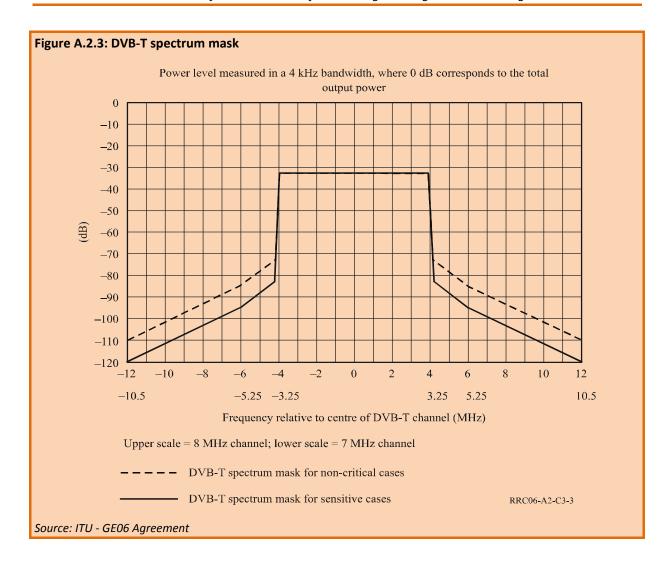
^{*} For block sizes of 16 200 and 64 800 bits

MTV applications, such as T-DMB and combined DTTB/MTV applications such as ISDB-T OneSeg and DVB-T2-lite can also be considered as an alternative application. A plan entry could be used for these applications if the radiation characteristics comply with the spectral power density check and no more protection is claimed than provided by the plan entry.

The alternative system implementation should apply at least the same level of filtering as that of the plan entry to ensure that the out-of-band emissions are limited to the same level. The GE06 Agreement prescribes the non-critical spectrum masks shown in Figures A.2.2 and A.2.3⁴⁰². The spectrum mask for critical cases may be used to facilitate coordination between administrations.

 $^{^{\}rm 402}$ See GE06 Agreement, Chapter 3 to Annex 2, Section 3.6





A.2.4 Modifications of the GE06 plans

In the case where a satisfactory service cannot be obtained by using a plan entry, the regulator could consider to modify the plan entry in accordance with the provisions of Article 4 of GE06. A modification could involve a change of characteristics of a plan entry, or a new station.

If neighbouring countries are potentially affected by the modification, depending on the characteristics of the plan entry and the distance to the border of neighbouring countries, agreement of these potentially effected countries is required.

The Article 4 procedure should be completed in about 2¼ years, if no agreement has been reached within that time, the request for modification lapses.

Obviously, before applying Article 4, it should be checked that coverage of other national DTTB of MTV transmissions is not adversely affected by the proposed station characteristics.

Implementation guidelines

As part of the network planning process, the characteristics of DTTB and MTV stations should be specified in such a way that compliance with GE06 provisions is ensured through:

- completed international coordination, including the cases identified in the remark column of the plan entry;
- fulfilling the conformity check (Section II of Annex 4 of GE06);

- complying with the spectral power density limit check (Article 5.1.3 of GE06);
- checking that coverage of national DTTB of MTV transmissions is not adversely affected.

The conformity check, the spectral power density check and the check regarding the remark columns, are carried out by the Radiocommunication Bureau of ITU-R, after a station has been notified by an administration. It is the duty of the regulator to ensure that DTTB and MTV transmitting sites fulfil these conditions before being brought into operation. However, it is advised that these conditions are taken into account in network planning. If not, restrictions may have to be applied after the equipment has been ordered and installed. Consequently delays, extra costs and loss of coverage may be the result.

Also national compatibility should be checked with existing or planned DTTB, MTV, T-DAB (in Band III) and other services (if applicable).

If the conformity check cannot be fulfilled, a modification of the plan entry may be considered, taking into account that international agreement may be needed.

If a content distributor has good connections with content distributors in neighbouring countries, it could facilitate the international coordination process if the operators concerned agree informally on the modified characteristics. The regulator could then be asked to formally approve the agreement.

Annex B – More information on some regulatory topics

This annex comprises more detailed information on some of the regulatory topics as included in Part 2 (Policy and Regulation) of these Guidelines. This annex is structured as follows:

- 1. Overview of spectrum management approaches (section 2.4).
- 2. Economic effects of assigning licences (section 2.5).
- 3. Assignment procedure steps (section 2.5).
- 4. Overview of different auction designs (section 2.5).

1. Overview of spectrum management approaches (section 2.4)

Transparency on the applied or intended spectrum management approaches is paramount for developing the DTTB and MTV markets. Especially investors in these capital intensive markets will seek this transparency and guidance.

Nowadays, spectrum management approaches run across two dimensions and spectrum managers have to balance these dimensions:

- 1. 'command and control' versus flexible approaches;
- 2. 'technical-driven' versus market-based approaches (including both market-based principles between applications ⁴⁰³ and when assigning licences).

'Command and control' versus flexible approaches

The 'command and control' approach is currently applied by most national spectrum managers around the world. This approach is embedded in the ITU-R Radio Regulations in which, for specified frequency ranges, the different radio services and their relative status are allocated 404.

At a national level the spectrum manager specifies these allocations⁴⁰⁵ (i.e. exact frequencies, locations, radio interface, technology, standards, etc.) and assigns them to individual users or service providers ('command'). Subsequently, the spectrum manager monitors appropriate use of the assigned spectrum rights ('control'). In this way, harmonization of frequency bands is promoted and hence the equipment can generally work across borders and can be produced at a large (regional/global) scale.

At a national level, this 'command and control' approach is under increasing pressure because:

- compartmentalization of spectrum by assigning spectrum to types of services (such as aeronautical radio navigation or broadcasting) and users (federal, non-federal, and shared) is becoming inefficient as frequency scarcity increases;
- technologies become available that can improve spectrum utilization (such as 'smart' receivers/transmitters and shared spectrum technologies)⁴⁰⁶;

⁴⁰³ Introducing market-based principles in determining which services should be allocated in a specified band, is currently a key topic in the broadcast and telecommunication markets for the UHF band, referred to as the digital dividend (see also section 2.10).

 $^{^{404}}$ See Report ITU-R SM.2093, 'Guidance on the regulatory framework for national spectrum management'.

National spectrum managers generally follow the National Frequency Allocation Table (which is generally based on the allocations provided in the Article 5 of the RR, but there are many instances where the national allocations do not follow the RR in respect of some of the frequency bands).

 $^{^{406}}$ See U.S. Government Accountability Office report on Spectrum Management of May 2004 on www.gao.gov.

technology life cycles are becoming shorter (and very often shorter than the licence duration)
and individual users or service providers would like to have the flexibility to switch to more
efficient/better technologies.

Consequently, flexible approaches to spectrum management are advocated, for example in Europe and the United States. Such alternative approaches comprise elements such as:

- 1. allowing licence free spectrum utilization in defined ranges of the available spectrum;
- 2. allowing smart technologies to operate across different spectrum categories;
- assigning technology and/or standards free licences.

'Technical driven' versus market based approaches

Next to advocating more flexible approaches to spectrum management, also promoting more economic incentives for assigning the available spectrum, has been discussed and applied over time. Traditionally, spectrum has been assigned by technological considerations (like application type, spectrum efficiency, number of services, etc.). Increasingly, economic incentives have been incorporated in spectrum management approaches and most notably:

- 1. Pricing and assigning spectrum accordingly to the (perceived) market value. Regularly applied instruments in this philosophy are assigning spectrum by auction and levying spectrum licence fees based on earned revenues or profits.
- Allocating spectrum to applications or services that will generate the highest economic value. This is the current debate around the 'Digital Dividend'; allocating broadcast spectrum to applications or services which generate the most economic value for society. This can result in telecom and broadcast operators/service providers competing for the same spectrum in the same auction.

2. Economic effects of assigning licences

Assigning spectrum rights is about assigning a defined set of rights in the most efficient way. In general the term 'most efficient' could refer to either:

- 1. 'Technical' efficiency, including:
 - a. Spectrum efficiency: which application or bid (proposal in a spectrum auction) uses least frequency spectrum? Technical efficiency is however difficult to define in general terms; the definition can vary from system to system. How, for example, can the efficiency of a DTTB television signal be compared with the efficiency of a GSM system? Efficiency comparisons are probably only possible between related systems.
 - b. Subjective forms of efficiency: which application/bid is closest to fulfilling the set requirements or objective? For example, when assigning DTTB licences the bid with the most balanced channel bouquet and the best service acquires the licence.
- 2. Economic efficiency: which application or bid can generate the highest economic return or value for society? In a spectrum or license auction, the bidder with the highest bid will acquire the licence. If there are competing demands for licenses, an efficient auction assignment will award a license to the (broadcast) service operator that can generate the highest economic value or greatest welfare from the license. The lower a potential cost of service and the higher the revenues the licensee can expect to generate through offering better services, an award mechanism in which a license goes to those who are prepared to pay most is most likely to result in an efficient outcome. There is one important caveat to this objective which if the

willingness to pay is constrained by the conditions and obligations imposed on the licensee. Therefore restrictions on content or obligations such as USO⁴⁰⁷ or mandatory coverage requirements will reduce the expected producer surplus and hence final bid prices.

In recent years various spectrum management instruments, based on economic principles, have been introduced, like auctions, tradable spectrum rights and administrative incentive pricing. It is important to note that these different instruments deal with different types of efficiency. The following three types can be distinguished:

- 1. Allocation efficiency relates to the allocation of a frequency (band) to the organization which will be able to obtain the highest economic return. It is, for example, possible that two operators want to provide an identical service. The expected return can differ significantly between one operator and the other, because one of them can achieve substantial cost savings by using better network planning or can realize higher returns through a more effective marketing strategy. Situations falling into this category are dealt with by using the auction instrument.
- 2. Production efficiency can be created when an operator can provide services at a lower cost. In the case of licences, it is possible that an operator can make savings through synergy between related systems. As an example, a DTTB network operator/service provider could operate a MTV system significantly cheaper by making common use of a large number of system components such as broadcast sites or billing systems. Situations falling into this category are dealt with by using instruments such as administrative incentive pricing as licence holders could be given an incentive to produce more efficiently by basing the licence fee on this higher value (not included in the scope of this section).
- 3. Dynamic efficiency comes into the picture when the distribution of frequency bands adapts itself very rapidly to trends in supply and demand. In order to obtain dynamic efficiency, it is necessary that the licence holder is given freedom in how the frequency band is used. It is quite conceivable, for example, that an operator acquires the availability of a band for digital television and is entitled to divide it as he sees fit between DTTB and MTV. The operator will adjust the bandwidth continuously according to the return he can achieve on each system. Situations falling into this category are dealt with by using instruments such as application/technology 'free' licensing and tradable spectrum rights (not included in the scope of this section).

3. Assignment procedure steps

A general overview of the steps in a typical assignment procedure is described in Table B.1.

383

USO stands for Universal Service Obligation and more details on this concept can be found in the ICT Regulations Toolkit from infoDev and ITU, see www.ictregulationtoolkit.org

Table B.1: Elementary steps in an assignment procedure

Step	Description	Objective	Activities/Results
1	Formulate detailed assignment policy	Determination of assignment instrument and procedure for DTTB and MTV spectrum licences	Carry out market consultation and survey Determine available frequencies and bandwidth Determine number of licences Determine licence duration Establish general licence terms and conditions Determine primary assignment instrument
2	Setting up assignment planning and schedule	Determining key milestones in DTTB and MTV licensing procedure	Determining completion date for application document Determining opening of licence application Determining duration of appraisal phase Determining final assignment date
3	Draw up and publish procedure for granting the licence	'translating' the detailed assignment policy into frequency management items	Define procedure, including possibilities to ask clarification and/or questions, appeal procedures, etc. Define assignment instrument (e.g. type and design of auction) Formulate admissibility requirements (i.e. minimal requirements to qualify) Formulate technical system requirements (e.g. radio interfaces and/or broadcast system) Formulate service requirements (e.g. number of channels, roll-out pace, etc.) Define detailed licence terms and conditions
4	Collect applications	Collecting completed and timely applications (application acceptance)	Check whether all received applications are complete Return incomplete applications Check whether all corrected applications have been received
5	Appraise applications	In case of public tender: selecting the best plan (i.e. plan that most closely matches requirements/objectives) In case of auction: selecting qualified bidders	Evaluate all accepted applications for admissibility/qualification (threshold) Evaluate and score all qualified applications on technical requirements (threshold) Evaluate and score applications on service requirements (threshold) Carry out comparative evaluation (only for public tendering) Announce best bid (only for public tendering) Announce qualified bidders (only for auctions) Handle any objections or complaints
6	Assigning spectrum rights (and obligations)	Assigning the available DTTB or MTV licences	Organize auction (auctioneers, location and bidding facilities – might be computer based) (only for auctions) Register and instruct bidders (including assign anonymity to bidders) (only for auctions) Collect up-front payments (if any) (only for auctions) Stop, pause and close auction (only for auctions) Collect down payment (could be in instalments) (only for auctions) Assigning frequencies by issuing the licence (both auction and tender)

4. Overview of different auction designs

Table B.2 gives an overview of the advantages and disadvantages of the different types of auction. The table is divided into three parts. The aforementioned types of auction are compared with one another in each part.

Table B.2: Advantage and disadvantages of the various auction designs

Auction type	Advantages	Disadvantages	Risks	Use if
Dutch Auction	 does not drive up prices 	 starting price is difficult to fix no information about value of product so danger of winner's curse little allocation efficiency practically only possible sequentially so no use of synergy 	 incorrect starting price can result in no bid or no realistic price relatively more prone to collusion 	 homogeneous products which are not interdependent product value is known or can be derived from previous auctions high speed is required product value is low
Conventional Auction	 Different versions possible (Vickery, multi–round simultaneous, etc.) easier to set starting price/minimum bid information about value of product in open auction more allocation efficiency 	 has a greater potential to push up prices (however countermeasures possible such as not bidding on price and limiting the number or rounds 	 pushing up prices 	 Flexibility is required in the auction design little information is known about the value of the asset assets/products are interdependent
Closed/Single round (sealed bid)	 more protection against collusion fast reduces upward price pressure simple and hence cheap 	 winner's curse less allocation efficiency less transparent 	 large price differences possible (and with Vickery it can lead to very low prices, embarrassing the regulator) 	 product value is low (other types of auctions are too expensive in relationship to the product value) there is a large number of products and speed is required relatively little importance is attached to allocation efficiency there is deemed to be a high risk on collusion value of the product is more or less known in the market

Auction type	Advantages	Disadvantages	Risks	Use if
Open/multi-round	 less risk of the Winner's curse higher allocation efficiency is generally considered as fair (chance to revise bid) 	 less protection against collusion greater risks of pushing up prices auction can last a long time, depending on the stopping rules more complex and hence more expensive to organize 	 pushing up prices 	 allocation efficiency is considered to be important a fair auction is required, considering the 'public/market opinion' there is uncertainty about the value of the product product value is deemed to be high
Sequential	 simple and hence cheap results in slight upward pressure on prices 	 problem with the sequence when there are several products: which products first and in which combinations? little utilization of synergy (less allocation efficiency if interdependence) 	 sequence not correctly set not seen as `fair' (no opportunity to revise bid) 	 no dependency between one product and another Low product value
Standard simultaneous/ open/multi-round	 high degree of allocation efficiency when products are dependent on one another less danger of winner's curse no sequencing problems 	 complex but manageable (even with greater number of bidders), but more expensive complex for bidders many rules and much preparation necessary auction can last a very long time depending on activity and stopping rules 	 can take a long time greater chance of errors in how auction is set up because of the many rules needed pushes up prices 	 products are interdependent product value high
combinatorial / open/ multi-round	 highest degree of allocation efficiency for interdependent products analogous to standard simultaneous auction 	 the most complex (probably no longer manageable when there are many bidders) and therefore most expensive type of auction the 'free rider' problem as a result of which there is a good chance that only package bidders win 	 free rider problem analogous to standard simultaneous auction 	 analogous to standard simultaneous auction

As can be concluded from the table above there are many different auction methods available to regulators, although two main formats are typically used:

- 1. open multi-round ascending auction format where the price increases over a number of rounds until there is no more bidding; and
- sealed bid auction formats.

A third method has gained prominence lately given the changes taking place in mobile spectrum with new bands being allocated to IMT services and older services vacating bands which can be used again for IMT services. With the availability of these numerous bands, regulators are creating opportunities for bidders to bid for different combinations of spectrum. Hence the name given to this method is 'combinatorial auctions'.

Annex C – More detailed information on some DTTB network topics

This annex gives more detailed information about a number of DTTB networks aspects and describes:

- 1. considerations on satellite links used for DTTB signal distribution;
- planning principles and criteria and tools;
- 3. practical considerations on timing of signals in SFN;
- 4. consideration on signal-to-noise ratio of transmitters.

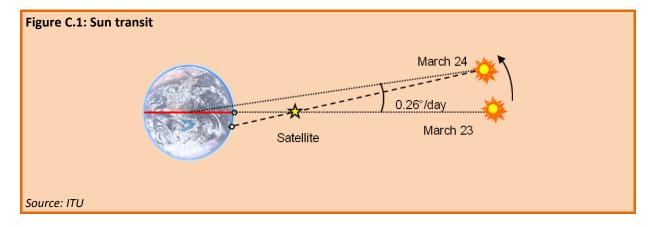
C.1 Considerations on satellite links used for DTTB signal distribution

This appendix considers two issues, signal interruption due to Sun transit and variations in propagation delay due to satellite orbit fluctuations.

Sun transit

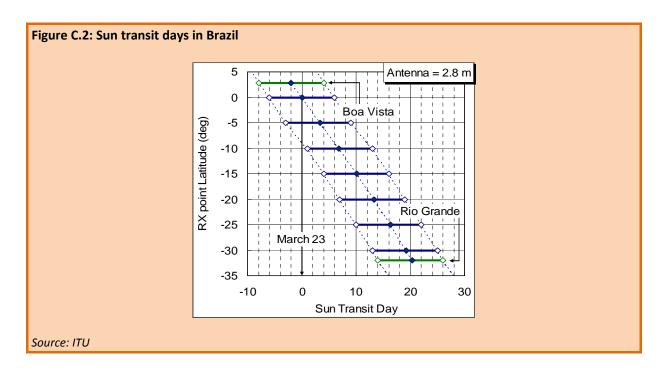
An antenna normally receives cosmic noise with the intervening atmosphere absorbing part of it (accounted for as a noise temperature). This is referred to as the sky noise or sky noise temperature. The sky noise component in the earth station receiver is, in practice, relatively small and may be ignored unless the antenna illuminates the sun, moon or certain radio nebulae such as Cassiopeia A, Taurus A or Cygnus A.

When the directions of geostationary satellites and of the Sun coincide with each other around the spring and autumn Equinoxes, satellite links are shut down due to high noise of the Sun, as shown in Figure C.1. The phenomenon is called Sun transit and takes place after spring and before autumn Equinoxes in the southern hemisphere, and before spring and after autumn Equinoxes in the northern hemisphere.



As the elevation angle of the Sun changes at a rate of 0.26°/day, the days that Sun transit takes place are different depending on the latitude of reception locations. The duration and days of it depend on a number of elements, such as reception antenna diameter and required CNR of the transmission system. Figure C.2 shows an example of Sun transit days in Brazil in the case of C band satellite.

Figure C.3 illustrates an example of the antenna directivity and position of the Sun. When the Sun approaches closer to the centre of the antenna directivity, C/N of the received signal becomes lower due to the Sun noise.



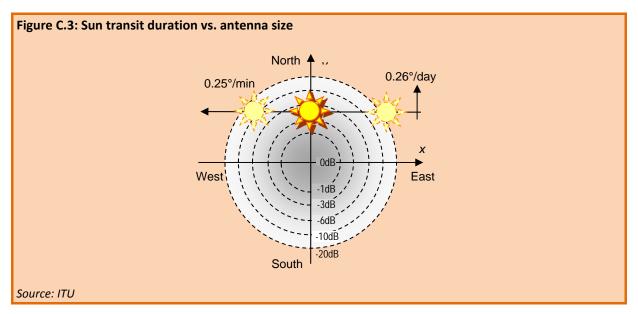
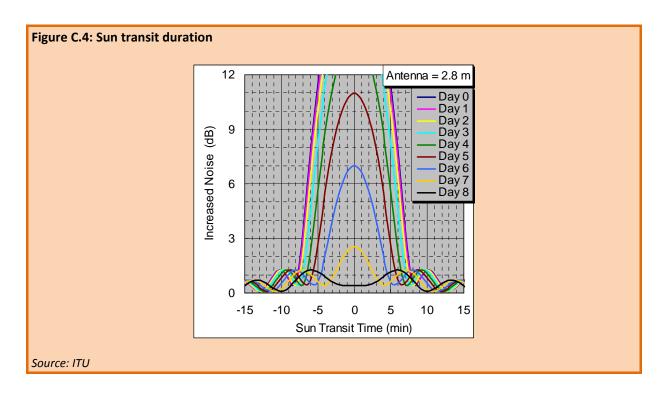
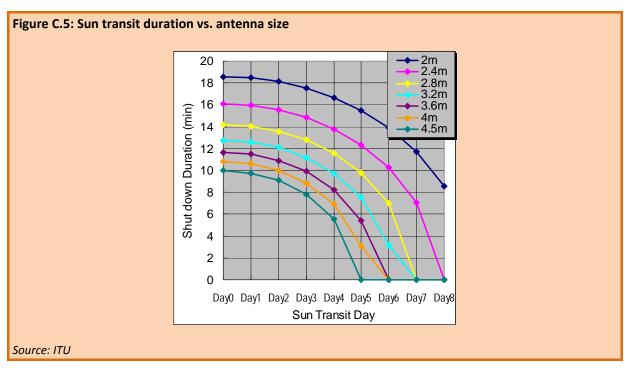


Figure C.4 shows an example of noise increase due to Sun transit. Assuming that the system provides a C/N margin of 3 dB in normal days, the link shut down will take place in ±6 days (13 days in total), and the duration will be 7 to 14 minutes a day. Figure C.5 shows the relationship of Sun transit days and shut down duration for several antenna sizes in the case of C band satellite.

With satellites using Ku/Ka band, potential signal interruption due to rain attenuation should be taken into account in addition to Sun transit.

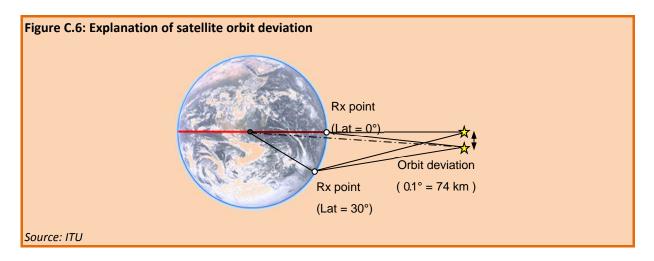




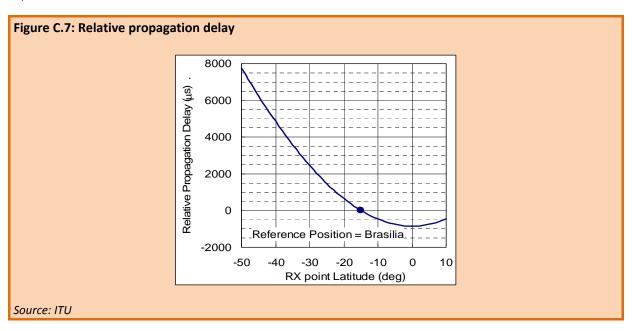
Propagation delay in satellite path

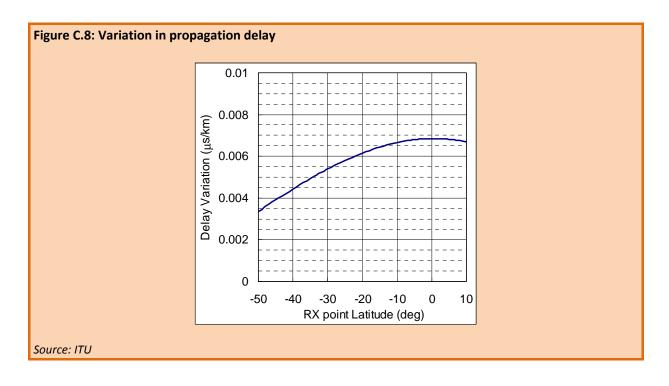
Propagation delays in satellite path depend on the reception locations. Figure C.6 shows propagation delay relative to that at city Brasilia in Brazil. The delay difference between two reception locations is considerably large, for example 1.0 s/km at latitude 15°, 1.9 s/km at latitude 30° and so on. If the distance between two SFN stations is 100 km, both located at latitude 30°, the received signals will have a delay difference of 190 s, which may be large enough to break SFN operation. The location dependency of delay must be taken into account in delay adjustments of SFN transmitters.

The orbit of a geostationary satellite is fluctuating in latitude, longitude and radius directions with a 24-hour period due to imperfect sphere of the Earth, disturbance by moon and other factors. The allowable orbital deviation is specified by international regulations to be within $\pm 0.1^\circ$, which corresponds to approx. ± 75 km at the orbital positions. Figure C.7 shows delay variations caused by orbit deviations. The difference in relative delay variation between two transmitter sites is, for example ± 0.0068 s/km at latitude 0° , ± 0.0054 s/km at latitude 30° and so on. If the distance between two SFN transmitter sites is 100 km, both located at latitude 0° , the relative delay variation is calculated to be ± 0.68 s, which should be multiplied by $\sqrt{2}$ to be ± 0.96 s when considering the orbit deviation in the latitude and longitude directions (effects of deviation in radius direction is negligible). The relative variation is small and need not be taken into account in the delay adjustment of SFN transmitters, when all transmitters are fed by a satellite link.



However, SFN operation will be broken in the case where one transmitter site is fed by a satellite link and the other by terrestrial links. Assuming the orbital fluctuation in radius direction to be in the same order of latitude/longitude fluctuations (75 km), the absolute delay variation of a satellite link is calculated to be 500 s or more, while the terrestrial links have no delay variation. This situation is enough to break SFN operation.





C.2 Planning principles, criteria and tools

In the tables below, a summary is given of principles, criteria and tools for planning DTTB and MTV services. The methods and values in the tables are generally applied in many countries, while different methods and values may be applied depending on the situation of a country.

Propagation

Table C.2.1: Propagation

Principles , criteria and tools	Method/value	Remark
Field strength prediction	 Path general propagation curves⁴⁰⁸ Path specific methods using terrain data bases⁴⁰⁹ 	1
Time percentage for predicting wanted signal	• 50 per cent	
Time percentage for predicting interfering signal	• 1 per cent	
Location percentage for predicting wanted and unwanted signals	• 50 per cent	

⁴⁰⁸ The generally applied method for path general field strength prediction is given in Recommendation ITU-R P.1546 Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz.

⁴⁰⁹ A method for path specific field strength predictions is given in Recommendation ITU-R P.1812 A path-specific propagation prediction method for point-to-area terrestrial services in the VHF and UHF bands. Several other methods exist.

Principles , criteria and tools	Method/value	Remark
Transmission channel characteristic	Fixed reception: RicePortable and mobile reception: Rayleigh	
Terrain database	 Horizontal resolution ≤ 1 km 	2, 4
Ground cover database	Specification depending on national situation	3, 4
Height loss for reception at different heights than 10 m	 ITU-R P.1546 method: see Annex 5, § 9 Path specific methods: field strength directly calculated at desired height 	5
Building penetration loss	 DTTB portable indoor reception⁴¹⁰ VHF: 9 dB UHF: 11 dB (8 dB) MTV indoor reception⁴¹¹ VHF: 9 dB UHF: 11 dB MTV reception inside cars: 8 dB ⁴¹² 	6
Standard deviation of the field strength (outdoor)	• 5.5 dB ⁴¹³	7
Standard deviation of the field strength (indoor); this is the combined result of the outdoor standard deviation and the standard deviation due to building penetration	 DTTB portable indoor reception⁴¹⁴ VHF: 6.3 dB UHF: 8.1 dB (7.8 dB) MTV indoor reception⁴¹⁵ VHF: 6.3 dB UHF: 8.1 dB MTV reception inside moving car: 6.3 dB⁴¹⁶ 	7

Remarks

 The method of Recommendation ITU-R P. 1546 and path specific propagation models are implemented in commercially available planning software. The accuracy of the methods can be improved for the local situation by verifying predictions with field strength measurement results.

⁴¹⁰ The values are from Recommendation ITU-R P.1812, Section 4.9, while the values specified in the GE06 Agreement are expressed in parentheses.

Building penetration loss values for MTV planning purposes, based on the ETSI DVB-H implementation guidelines, are given in EBU document Tech 3317, version 2: Planning parameters for hand-held reception, concerning the use of DVB-H and T-DMB in Bands III, IV, V and 1.5 GHz. EBU, July 2007; section 1.3.3.5.

⁴¹² See footnote 4.

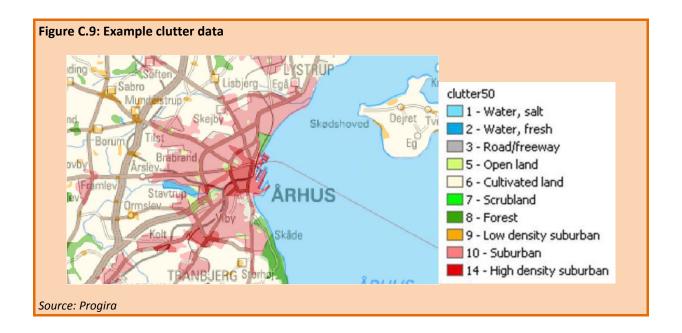
Value from Recommendation ITU-R P.1812, Section 4.8; also specified in Recommendation ITU-R P.1546, Annex 5, Section 12.

⁴¹⁴ See footnote 410.

Standard deviation values for MTV planning purposes are given in EBU document Tech 3317, version 2: Planning parameters for hand-held reception, concerning the use of DVB-H and T-DMB in Bands III, IV, V and 1.5 GHz. EBU, July 2007; section 1.3.3.7.

⁴¹⁶ See footnote 415.

- Terrain data with a horizontal resolution of 100 m or less is commercially available. A free worldwide terrain database (Globe) is available with a horizontal resolution of about 1 km. The GLOBE data are available at the website www.ngdc.noaa.gov/mgg/topo/globe.html or can be purchased on CD-ROM. The GLOBE data are used also by the ITU spectrum management software (SMS4DC).
- 3. Ground cover databases are commercially available. An example of ground cover data, also called clutter data, is shown below:



- 4. Guidance on the content and format of topographic data suitable for propagation studies is given in Recommendation ITU-R P.1058 417
- 5. For initial planning purposes height loss values for portable DTTB reception in suburban areas are 418:

200 MHz: 12 dB 500 MHz: 16 dB 800 MHz: 18 dB

For MTV planning purposes the height loss values indicated below are recommended by EBU⁴¹⁹

 $^{^{\}rm 417}$ Recommendation ITU-R P.1058 Digital topographic databases for propagation studies.

The values are derived from Recommendation ITU-R P.1546 and are also specified in the GE06 Agreement Chapter 3 to Annex 2, Section 3.2.2.1.

Height loss values for MTV planning purposes, based Recommendation ITU-R P.1546 are given in EBU document Tech 3317, version 2: Planning parameters for hand-held reception, concerning the use of DVB-H and T-DMB in Bands III, IV, V and 1.5 GHz. EBU, July 2007; section 1.3.3.4.

Table C.2.2: Height loss for MTV reception (by EBU)

Reception environment	Band III	Band IV	Band V
Urban	19 dB	23 dB	24 dB
Suburban	12 dB	16 dB	18 dB
Rural	12 dB	16 dB	17 dB

- 6. Building penetration loss depends on type and construction of the buildings. In Europe a large range of values has been measured up to 15 dB for office buildings.
- 7. Different values of standard deviation may be adopted for various types of ground cover (e.g. open areas, urban areas), also depending on standard deviation of the building penetration loss. Field strength measurements (see also remark 1) are needed to determine the standard deviation for the most common types of terrain and ground cover in a local situation.

Frequency planning

Table C.2.3: Frequency planning

Principles, criteria and tools	Method/Value	Remark
Transmitter database	Format depending on planning software	1
Receiver noise figure	Band III: 6 to 10 dB Band IV/V: 6 to 7 dB	2
Required C/N	 According to Recommendation ITU-R BT. 1368 and BT. 2033⁴²⁰ MTV: EBU document Tech 3317⁴²¹ 	
Receiving antenna gain	 Fixed reception Band III: 5 to 7 dB Fixed reception Band IV: 8 to 10 dB Fixed reception Band V: 9 to 12 dB Portable and mobile reception Band III: -2 dB Portable and mobile reception Band IV/V: 0 dB 	2
Feeder loss	 Fixed reception Band III: 2 dB Fixed reception Band IV: 3 to 4 dB Fixed reception Band V: 4 to 5 dB 	2
Antenna discrimination	 Fixed reception Band III: max 12 dB Fixed reception Band IV/V: max. 16 dB Portable and mobile reception: none 	2, 3
Polarization discrimination	 Fixed reception: max. 16 dB⁴²² Portable and mobile reception: none 	3

 $^{^{\}rm 420}$ In the GE06 Agreement, C/N values are given in Chapter 3 to Annex 2, Appendix 3.2.

⁴²¹ Information on C/N values can be found in EBU document Tech 3317, version 2: Planning parameters for hand-held reception, concerning the use of DVB-H and T-DMB in Bands III, IV, V and 1.5 GHz. EBU, July 2007; section 1.2.1.2 for DVB-H and section 1.2.2.2 for T-DMB.

⁴²² Recommendation ITU-R BT.419 Directivity and polarization discrimination of antennas in the reception of television broadcasting.

Principles, criteria and tools	Method/Value	Remark
Receiving antenna height	Fixed reception: 10 mPortable and mobile reception: 1.5 m	
Protection ratios	 According to Recommendation in ITU-R BT.1368 and BT.2033⁴²³ MTV: EBU document Tech 3317⁴²⁴ 	4
Location probability for coverage assessment	 Fixed reception: 90 per cent to 95 per cent Portable reception: 70 per cent to 95 per cent Mobile (vehicular) reception: 90 per cent to 99 per cent 	4
Combination of multiple signals	Statistical method	5

Remarks

- 1. Several transmitter databases may be necessary such as:
 - Database, using data of the GE06 digital plan and analogue plan, for interference calculations;
 - National database with actual station characteristics for wanted signal calculations;
 - Variants of the above mentioned databases e.g.:
 - containing station characteristics during transition and after analogue switch-off
 - restrictions requested or negotiated in international coordination (in relation to bilateral agreements or remarks in columns 18 or 28 of the GE06 plan entries of DVB-T allotment or DVB-T assignments respectively).
- 2. Recommendation ITU-R BT.[DTVRX] provides the values applicable for all transmission systems and those for specific systems.
- 3. In case of orthogonal polarization, the combined discrimination value of 16 dB should be applied for all angles of azimuth.
- 4. Normally 95 per cent is taken for good fixed, portable and handheld reception and 99 per cent for good mobile (vehicular) reception. However lower values may be adopted nationally.
- 5. In network planning and coverage calculations normally statistical methods are used for combining multiple interfering signals and in case of SFNs also for combining multiple wanted signals. The Monte Carlo method is the most accurate but also most time consuming. Other often used methods are the Log normal method (LNM) and variant thereof (t-LNM and k-LNM)⁴²⁵. One or more of these methods is normally implemented in the planning software.

⁴²³ In the GE06 Agreement, protection ratios are given in Chapter 3 to Annex 2, Annex 3.3 for terrestrial broadcasting systems and in Chapter 4 to Annex 2 with regard to other services.

Protection ratios for MTV are given in EBU document Tech 3317, version 2: Planning parameters for hand-held reception, concerning the use of DVB-H and T-DMB in Bands III, IV, V and 1.5 GHz. EBU, July 2007; section 1.4.1 for DVB-H and section 1.4.2 for T-DMB.

A description of these methods is given in Section 3.4 of EBU report Tech Report 021 Terrestrial digital television planning and implementation consideration, third issue, Summer 2001.

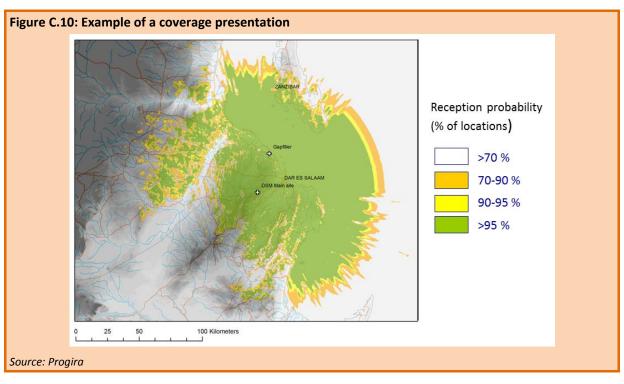
Coverage presentation

Table C.2.4: Coverage presentation

Principles , criteria and tools	Method/Value	Remark
Geographic information system (GIS)	Specification depending on national requirements and planning software options	1
Population data base	Format depending on national situation	2
Classification of coverage probability	 Specification depending on national requirements and planning software options Example for fixed, portable and handheld reception ≥ 70% < 90% ≥ 90% < 95% ≥ 95 % Example for mobile (vehicular) reception ≥ 95% < 99% ≥ 99 % 	3

Remarks

- The planning software will contain electronic maps for presenting the coverage area. Some
 planning software offers also the possibility to present coverage on Google-maps. Advanced
 Geographic Information Systems contribute to high quality coverage presentations needed for
 communication purposes.
- 2. Population data bases are prepared by national institute or commercially available in many countries and contain the number of people or households per postcode, or coordinate grid system.
- 3. Coverage is normally presented in several ranges of location probability in different colours as map overlays. An example of a coverage presentation of an SFN on channel 40 with fixed reception is shown below. In this example the following system variants of DVB-T standard are applied: Modulation 64-QAM, Code rate 2/3, Guard interval 1/4, Bandwidth 8 MHz. The net bit rate is 19.9 Mbit/s.



C.3 Practical considerations on timing of signals in SFN

In an SFN all transmitters of a network use the same channel, have a common coverage area and cannot be operated independently.

When operating an SFN, the signals transmitted from individual transmitters should:

- be approximately synchronous in time (within the prescribed value);
- be nominally coherent in frequency (e.g. within a few Hz); and
- have identical multiplex content (identical bit stream in strict sense).

In particular, the time synchronisation needs considerable attention.

In order to obtain the required time synchronisation of each transmitter in the SFN, a Synchronisation Time Stamp (STS) is applied in the multiplex signal to allow for different transport delays in the distribution network (e.g. in case of switching links in telecommunication circuits). With the help of a standard time signal, in practice often GPS, a time delay is provided in the transmitter by comparing the inserted time stamp (STS) with the local time at the transmitter site. STS may not be required in the case where transport delays ensure to remain within allowable range (e.g. a few s).

Additional fixed delays are added at each transmitter site to ensure that transmitter equipment from different manufacturers can be operated safely within a single network.

At the receiving site, signals from transmitters in the SFN should, in principle, arrive inside the guard interval. However, in the case of T-DMB and ISDB-T, due to the smooth transition curve at the end of the guard interval, signals arriving outside the guard interval are not immediately harmful. Sometimes it is necessary to provide an additional delay of signals from one or more transmitters in the SFN in order to resolve internal network interference.

The delay with which the signals arrive at receiving antenna is the composite delay of:

- 1. Transport network, consisting of:
 - a. transport network padding delay;
 - b. transport network path delay;
 - c. dynamic transport network compensation delay.
- Transmitter, consisting of:
 - a. transmitter processing delay;
 - b. fixed transmitter compensation delay;
 - additional time offset.
- SFN network, consisting of propagation path delay depending on distance between transmitter and receiver.

In case of 2.c. in the paragraph above, the maximum offset delay is included in the time stamp and the compensation delay at each transmitter is set to achieve the required additional delayed signal.

The maximum network delay is set for the whole network and is given by the following formula:

Where: Tmax is the maximum delay time of the network;

Ttn is the transport network delay (padding delay plus path delay);

Tnc is the network compensation delay;

Ttx is the transmitter compensation delay;

Toffset is the additional time offset.

C.4 Consideration on signal-to-noise ratio of transmitters

Amplifiers saturate at a certain level, in which the input-output characteristics are generally expressed by 3rd order polynomial as below:

$$Y = X - BX^3 \tag{C.E.1}$$

where, X and Y denote the input and output levels, and B is the coefficient expressing the degree of non-linear characteristics that cause inter-modulation. When the output saturation level is Y_{sat} , the corresponding input level X_{sat} and coefficient B are given as below:

$$X_{sat} = (3/2)Y_{sat}$$
 and $B = (4/27)/Y_{sat}^2$ (C.E.2)

In the OFDM signal in equation (C.E. 3), the distortion component D can be written by equation (C.E. 4).

$$X = \sum_{k} A_k \cos(\omega_k t)$$
 (C.E.3)

$$D = B X^{3} = B \left\{ \sum_{k} A_{k} / 2 \left[\exp(j\omega_{k} t) + \exp(-j\omega_{k} t) \right] \right\}^{3}$$

$$= B / 8 \sum_{k} A_{k} \left[\exp(j\omega_{k} t) + \exp(-j\omega_{k} t) \right] \times \sum_{l} A_{l} \left[\exp(j\omega_{l} t) + \exp(-j\omega_{l} t) \right]$$

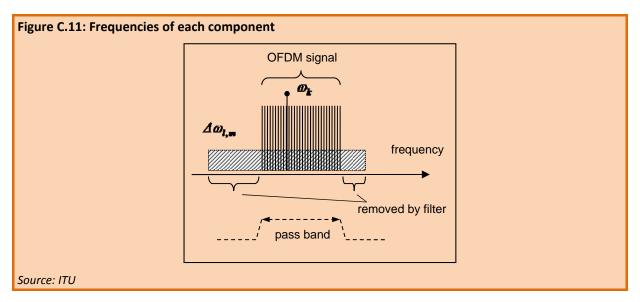
$$\times \sum_{m} A_{m} \left[\exp(j\omega_{m} t) + \exp(-j\omega_{m} t) \right]$$

$$= B / 4 \sum_{k} \sum_{l} \sum_{m} A_{k} A_{l} A_{m} \left[\cos((\omega_{k} + \omega_{l} + \omega_{m})t) + \cos((\omega_{k} + \omega_{l} - \omega_{m})t) + \cos((\omega_{k} + \omega_{l} - \omega_{k})t) \right]$$

$$+ \cos((\omega_{m} + \omega_{k} - \omega_{l})t) + \cos(-(\omega_{l} + \omega_{m} - \omega_{k})t) \right]$$
(C.E.4)

The first components $(\omega_k + \omega_l + \omega_m)$ in the above equation fall into the frequency range of approximately three times the signal frequencies, and will be removed by the output filter. The second components $(\omega_k + \omega_l + \omega_m)$ can be regarded as the carriers ω_k being modulated by $\Delta \omega_{l,m} = (\omega_l - \omega_m)$.

Half of the 2^{nd} components will be removed by the output filter as shown in Figure C.11. Half of the third and fourth components will also be removed. Thus the consequent power of distortion components within signal bandwidth becomes 3/8 (=3/4 ÷ 2) times the total distortion power calculated by equation (C.E.4).



To express amplitude probability density of the input OFDM signal by P(X), the output SNR is calculated by the equation below.

$$\frac{1}{SNR} = \frac{3}{8} \times \int_{0}^{\infty} D^{2}(X)P(X)dX = \frac{3}{8} \times \left[\int_{0}^{X_{sat}} (B X^{3})^{2} P(X)dX + \int_{X_{sat}}^{\infty} (X - X_{sat})^{2} P(X)dX \right]$$
 (C.E.5)

Figure C.12 shows the calculated S/N assuming the amplitude distribution of OFDM signal takes a normal distribution. In Figure C.12, horizontal axis "saturation level" is normalized by the *rms* amplitude of OFDM signal. The graph "without equalize" is calculated by equation (C.E.5). This can be approximately expressed by the following equation (C.E.6):

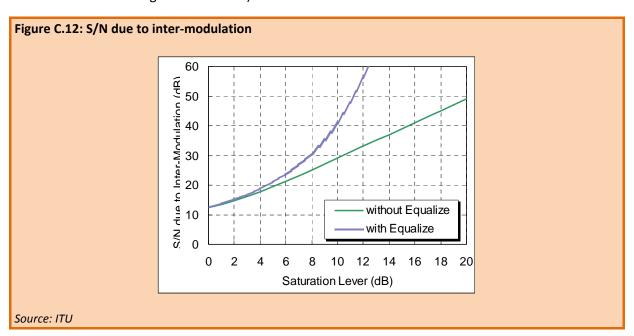
$$SNR \approx 2 \times Y_{sat} + 9.1$$
 (in dB expression) (C.E.6)

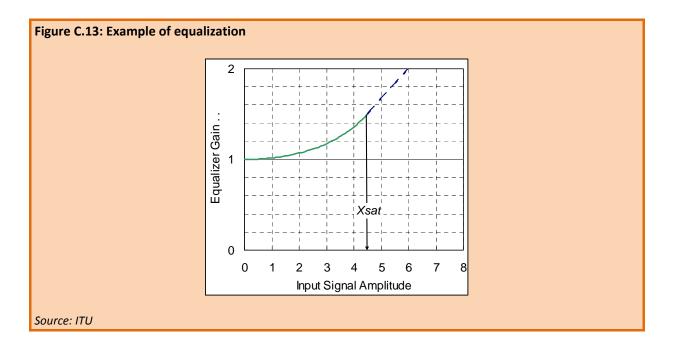
The distortion can be reduced by applying non-linear equalization prior to the amplifier, example characteristic of which is shown in Figure C.13. In this case, the output signal has no distortions against the input amplitude lower than X_{sat} , and the SNR can be calculated by equation (C.E.7).

$$\frac{1}{SNR} = \frac{3}{8} \times \int_{X_{sat}}^{\infty} (X - X_{sat})^2 P(X) dX$$
 (C.E.7)

The graph "with equalize" is calculated by equation (C.E.7), which corresponds to the case of ideal equalization. The actual transmitters would exhibit the SNR in between both graphs. To obtain S/N of 40 dB or more, it is required, even with ideal equalization, to set the amplifier saturation level at least 10 dB higher than the *rms* amplitude.

This saturation level requirement (or peak margin) must be taken into account when using an analogue transmitter with OFDM signals. Since an analogue transmitter has lower peak margin (< 3dB), it cannot operate at its full power level with OFDM signals (e.g. 10 kW analogue transmitter can be used as 1 kW digital transmitter).





Annex D – More information on some MTV network topics

D.1 Testing of transmission equipment in details

Items in this part are based on experience with equipment for the T-DMB standard.

Transmitter

- Physical properties (credibility and stability)
 - Temperature test: Test operate at -20°C and +50°C for four hours respectively and check changes of properties, including output, frequency, out-of-band emission, spurious emission, harmonics, and frequency response.
 - DC voltage regulation: Measure no-load and loaded output voltage of power supply using DC voltage meter to check whether output voltage is within rated range (±5 per cent) based on the following formula:

Voltage regulation (%) = $(Vo - V) / V \times 100$ (%)

Vo: No-load power supply voltage, V: Rated power supply output voltage.

RIPPLE content: Use an oscilloscope to measure DC voltage and AC voltage included in DC voltage on the side of power supply output, and check whether the value calculated based on the following formula is within rated range (±3%)

RIPPLE content = $V_{pp} / V_d \times 100$ (%)

V_{pp}: AC voltage (p-p), V_d: DC voltage.

 Heat generation test at continuous operation: After operating the transmitter for eight consecutive hours, measure the temperature of designated spots using surface thermometer. The outcome value of the below formula has to be 50 °C or below:

Degree = Measured temperature (°C) – ambient temperature (°C)

Measurement point: Internal temperature of transmitter, cooled exhaust temperature, power amplifier heat sink, exciter, heat sink at power supply, power transformer temperature, mask filter temperature, combiner, out cable.

- Stability of transmission output: While operating for four consecutive hours or longer, check whether the change in output power is within rated range of ±0.5dB every hour. Check the same for changes in frequency (to satisfy the specified value or regulation).
- Stability of intermittent operation: Repeat switching on/off every 0.3 second (0.1 second for switching off, 0.2 second for switching on) for five times or more using power intermittence tester or by manually operating AC input power switch to check changes in output and any abnormal operation of the transmitter.
- Stability of changes in supply voltage: Using voltage adjuster, adjust rated voltage of AC input supply voltage by ±10% to check whether change in DC voltage is within rated range (±3%), and measure operational abnormality of the transmitter, oscillation frequency, and changes in output.

Voltage regulation (%) = $(Vo - V) / V \times 100(\%)$

Vo: DC voltage at higher/lower limit supply voltage,

V: DC voltage at rated supply voltage

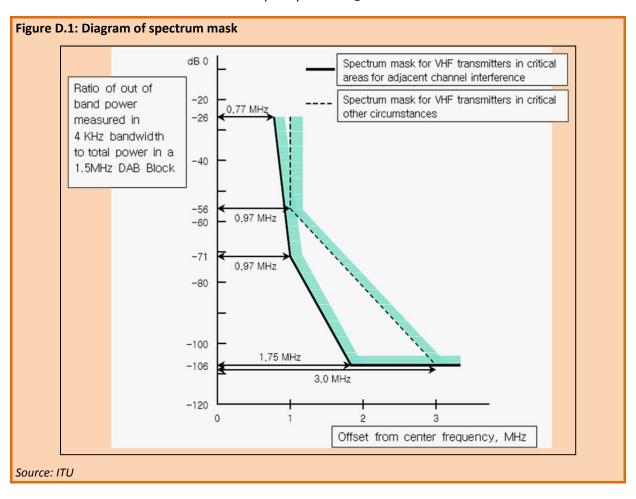
Efficiency: Measure the current, voltage, and AC input current to check whether the
efficiency is higher than rated value (70%)

Efficiency = Output voltage (V) \times output current (A) / input power (W) \times 100 (%)

- Harmonics content: Measure harmonics content of voltage output using harmonic wave meter. The generated harmonic back current has to be 5 per cent or below (including distortion of test power supply).
- Insulation resistance: Insulation resistance measured using DC 500V Megger among the input, output, and the case has to be 5 M Ω or higher.
- Internal pressure test: When imposing AC 1.5 kV (10 mA) for one minute on the input, output, and the case respectively, internal pressure tester should not display shortcircuit or be short-circuited.
- Power consumption at rated RF power output.

Electrical properties

- Measure transmitter output (use power metre with 5 per cent or higher accuracy): Read process value displayed by the power meter at output port to check whether output is within ±0.5 dB of rating.
 - When using analogue power meter, output has to be within 12 per cent (higher limit) to -11 per cent (lower limit) range. [10 log (P1/P0) = ± 0.5 dB]
- Measuring out-of-band spectrum of an emission against a prescribed mask. For example, the mask for T-DMB (same as the FCC MASK) is described as follows:
- ±0.77MHz offset from centre frequency: –26 dB@4kHz RBW
- ±0.97MHz offset from centre frequency: –71dB@4kHz RBW
- ±1.75MHz offset from centre frequency: –106dB@4kHz RBW



- Measure spurious and harmonics: Check whether the value is 70dBc or 46+10log (PY). (*PY = average power of carrier wave).
- Frequency response (in-band ripple): Using spectrum analyser, check whether changes in inband amplitude meet ±1 dB range of transmission bandwidth (RBW 30 KHz).
- Group delay property: Switch network analyser format to DELAY and set scale to AUTO to check whether in-band group delay is within ±2.5μs range.
- Frequency tolerance: Using frequency counter, measure frequency of output signal (f_0 + set up single frequency) to verify whether frequency is within ±10 Hz range from centre frequency.
- Frequency bandwidth: Using spectrum analyser, measure occupied bandwidth to check whether the value equals 1.536 MHz.
- Effective-transfer rate: Measure transfer rate using DMB analyser to check whether the rate is between 0.8 Mbit/s and 1.7 Mbit/s range.
- Service signal format: Measure transfer cycle using DMB analyser to check whether programme association table (PAT) is within 500ms, programme map table (PMT) within 500ms, programme clock reference (PCR) within 100ms, object clock reference (OCR) within 700ms, and composition time stamp (CTS) within 700 ms.

Using DMB analyser, measure video signal to check the following:

```
In the syntax for picture parameter sets:
The value of "num_slice_groups_minus1" is "0",
the value of "redundant_pic_cnt_present_flag" is "0"
In the syntax for sequence parameter sets:
The value of "pic_order_cnt_type" is "2",
the value of "num_ref_frames" is "3"
```

Using DMB analyser, measure audio signal to check the following:

```
epConfig for AudioSpecificConfig(): 0 frameLengthFlag for GASpecificConfig(): 0, DependOnCoreCoder: 0 sba_mode for bsac_header(): 0 ltp_data_present for general_header(): 0
```

Check slide show, BWS, TPEG reception using DMB analyser;

Check any occurrence of BER, video frame error, audio frame error, and FIFS error using DMB analyser.

 Input VSWR (voltage standing wave ratio): Measure return loss within frequency band of transmitter, convert measured value into VSWR, and check whether it is within 1.2

```
VSWR 1.2 = Return Loss 20.8dB;
```

- Input mode operation test: By altering the setting of ETI signal generator to NI (G.703) and NA (G.704), check whether it is automatically recognized without interruption, and using the DMB analyser, check errors in different factors
- Transmitter input sensitivity test: Input ETI signal generator output by attenuating and distorting as described below into the transmitter:

```
Amplitude: 2.37V±10% threshold;
```

Jitter: 1.5UI@20Hz to 100kHz, 0.2UI@18kHz to 100kHz;

Overshoot: 237mV ± 20% threshold;

Pulse width: Lower limit 194ns, upper limit 269ns threshold.

During the test, check normal recognition of inputs by transmitter and check normal operation of different factors using DMB analyser.

 Peak power vs. PAPR (peak to average power ratio): Measure PAPR against peak power using power meter to ensure peak power level does not exceed 13dB of average power level.

Antenna

Physical properties

- Temperature test: Apply temperature test prescription mandated in the specification with priority. If there is no special instruction, check for cracks, deformation, and other abnormalities after 30 minutes at -20°C and +45°C respectively.
- Internal pressure and insulation resistance test: It has to be 1000 M Ω or higher when measured with DC 1000V Megger Tester.
- Allowable wind pressure test: This test is to be conducted for every possible direction, including the front and the side. Actual wind pressure given in the specification has to be applied for the allowable wind pressure test, but if such application is impossible, convert wind speed into wind pressure load, and conduct the test as described below:

Wind pressure load (kg) $P = C \times A \times Q$

A: Area of antenna (m^2) = Width (W) × Height (H)

Q: Wind pressure coefficient (round type: 0.7, panel: 1.2)

G: Air density - kg m/s (0.1293)

V: Wind speed (m/sec)

C: $1/2 * GV^2 = Velocity pressure (kg), wind pressure coefficient applied to 1 m² (kg/m²)$

Equally apply the same load as the calculated wind pressure load on the antenna to check any abnormality.

 Air leak test: Conduct air leak test in order to prevent penetration into RF feeder of the antenna and antenna system; before assembling the antenna panel and after installing the system, inject 3.2 kg/cm³ air into RF input port, submerge connected and welded parts into water to check on bubbles and air leakage for three minutes.

Electrical properties

- VSWR (Voltage Standing Wave Ratio): Install the antenna to be measured at 3λ (3xwavelength) height above the ground or higher, calibrate the network analyser within the frequency range that includes the operating frequency band of the antenna, and measure the VSWR of the antenna to verify whether the measured value fits within the specification.
- Radiated gain: Measure electric field strength of the standard antenna and the measured antenna to calculate the relative gain according to the following formula:

Absolute gain = Relative gain + 2.15 (dBi)

Relative gain = Field strength of the measured antenna – field strength of loss-free $\lambda/2$ dipole 2.15 (dBi) is the gain of isotropic antenna of half wave dipole

 $E1 = \frac{\sqrt{30\,\mathrm{Pr}}}{R(km)} \qquad \text{(mV/m)}$ Field strength of isotropic antenna:

 $E = \frac{7\sqrt{\Pr}}{R(km)}$ Field strength of $\lambda/2$ dipole antenna: (mV/m)

Regarding loss-free $\lambda/2$ dipole antenna: Absolute gain = field strength of $\lambda/2$ dipole antenna / field strength of isotropic antenna = 2.15dBi

Radiated gain: $Ga(dB) = Aa - A_0 + G_0$ or $Ga(dB) = 20 * log(Ea / E_0) + G_0$

where

Aa: Field strength (dB) of measured antenna

 A_0 : Field strength (dB) of standard ($\lambda/2$ dipole) antenna

 G_0 : Radiated gain (dB) of standard ($\lambda/2$ dipole) antenna

Ea: Received voltage (μV) of measured antenna

E₀: Received voltage (μV) of standard antenna

 Measuring radiation front to back ratio of antenna: Orient the measured antenna to source antenna (0°) and adjust the source antenna up, down, left, right to maximize field strength.
 Turn the direction of measured antenna 180°, record the field strength, and calculate with the following formula:

Front to back ratio = Field strength of 0° direction – filed strength of 180° direction

Front to back ratio FBR (dB) = AF (dB) - AR (dB)

AF (dB): Field strength at the main radiation direction (0°) of the antenna

AR(dB): Field strength at the opposite radiation direction (180°) of the antenna or FBR (dB) = 20 * log (EF / ER)

EF: Received voltage (μV) at the main radiation direction (0°) of the antenna

ER: Received voltage (μV) at the opposite radiation direction (180°) of the antenna

- Attenuation of branch cable: Calibrate the network analyser without the cable for the to-bemeasured antenna, then detach measurement cable and connect the former between the two ports to read the attenuation displayed in the network analyser.
- Insertion loss of power divider: Measure insertion loss to check whether the value by direction is within the allowed range:

Insertion loss = $10 \log \frac{1}{n}$ (dB) n: distribution pole

Distribution tolerance has to be within the below described ranges:

Within 0.5 dB for UHF range

Within 0.2 dB for VHF range

D.2 Measurement system for MTV and field measurement case examples

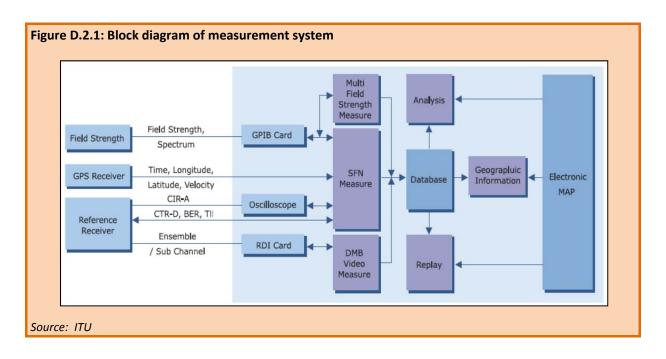
Field measurements provide an authentication of the transmission results originally envisaged through selection of various parameters in the available environment. Depending on the terrain, urban build-up and the RF ambience, the tests provide a first-hand experience of the functioning of the selected transmission system and are, therefore, deemed essential. Field tests for mobile broadcasting services are more demanding as the tests are to be conducted while the test receiver is mobile, i.e. going over the route of interest. This Appendix describes some of the considerations for testing of the T-DMB system.

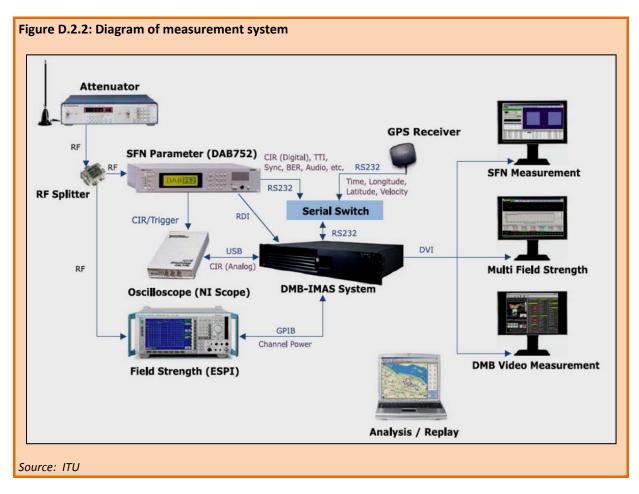
RF measurement system for mobile broadcasting

- Main features:
 - Coverage measurement; TII (Transmitter Identification Information), CIR (Channel Impulse Response), Sync, Field strength, BER (bit error ratio), longitude, latitude, etc.;
 - Multi-field strength measurement; RF spectrum, Field strength (up to 6 broadcasters);
 - DMB Video measurement; TP error, RS (Reed Solomon) error, Frame error, PSI (Programme Service Information) error, Clock error, etc.;
 - Analysis; post-processing of measured data, tracing specific error point;
 - Geographic Information; Transmitter site view, geographic altitude profile, concentric circle.

JK comment: Definition for "TP" is required.

- Equipment requirements (examples):
 - Main server;
 - DAB receiver (e.g. DAB752);
 - Field strength metre(e.g. ESPI);
 - Oscilloscope (e.g. NI-20 MS/s);
 - GPS receiver;
 - RF magnet-mount antenna (e.g. K51164);
 - RF measurement van;
 - Electronic map.
- Block diagram and map





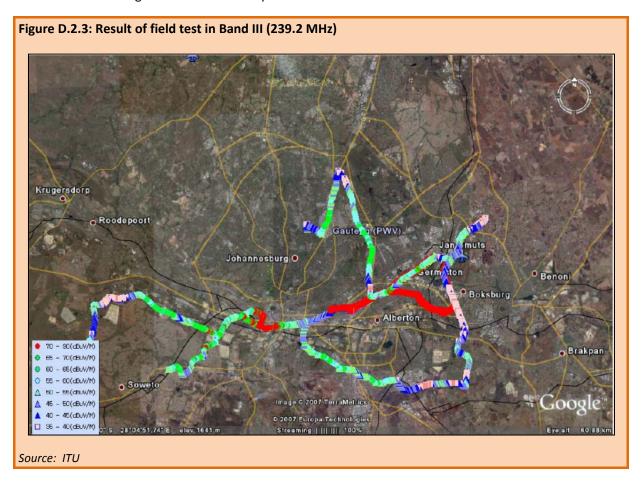
Working processes of the measurement system are briefly explained as follows.

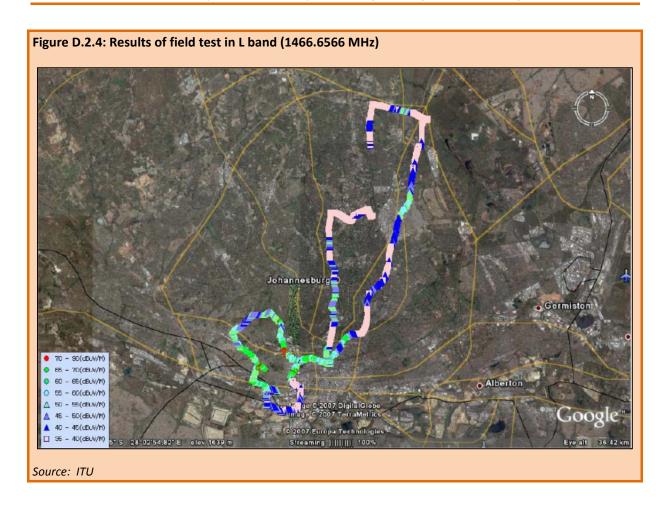
- The measurement and associated equipment is mounted in the measurement van, which also provides "RF emission-free" power supplies. The van is driven over a pre-determined route(s) and the measurement process is continuously carried out; The T-DMB signal, captured from an antenna installed on the roof of the measurement van, is delivered to the DAB receiver (e.g. DAB 752) through an attenuator. Various parameters such as CIR, TTI, BER, and audio are forwarded to the DMB-IMAS system which is the main unit of this measurement system.
- The RF signals, through the attenuator, are also delivered to the field strength measurement system (ESPI). The data pertaining to field strength from ESPI output is forwarded to the DMB-IMAS system.
- The geographical information of the measurement point, supplied by the GPS receiver, is also delivered to the DMB-IMAS system.
- All the information, collected from all the measurement sub-systems, is integrated and analysed in the DMB-IMAS system, and the resulting data is displayed at the monitor, such as SFN measurement, multi-field strength, and DMB video measurement.

It should be noted that the presented system above is an example of a "full-set" system installed in a vehicle with the whole set of equipment; antenna, diverse meters, emission-free power generator, display units, etc. A portable system that implements most of the system functions in a laptop or PC environment is also available on the market.

Actual examples of application

Field strength marked on the map





Analysis result

Items	Band Ⅲ	L-Band
Total measured length of road (km)	205.692	57.942
Length of road in signal shadow (below 70 uV/m, red colour in the map) (km)	40.67	0
Average speed of a measurement vehicle (km/h)	35.370	25.87
The ratio of the shadowed and un-shadowed part of the road (%)	17	0

As can be seen from the plots above, while the field strength requirement is met in several areas on the route, it is quite low in some parts of the routes. Several measures can be taken to mitigate the low field strength, if it is so required.

As indicated in this section, a single high power transmitter may not be an ideal solution for an efficient MTV coverage. However, in some cases, it may be an acceptable solution from cost considerations. Even in that situation, several null fillers may require to be deployed.

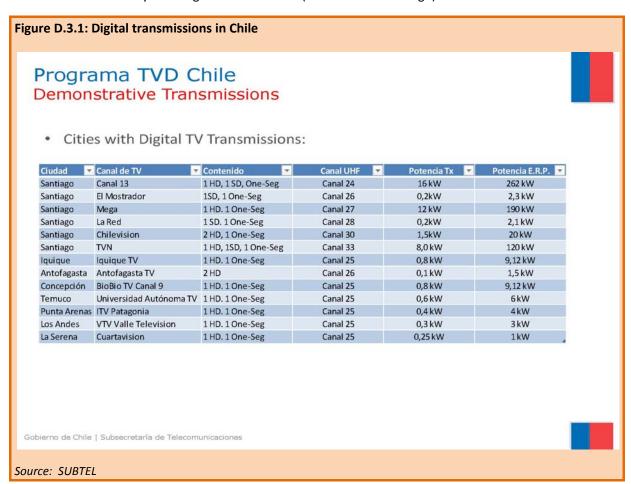
D.3 MTV in Chile: Status of OneSeg services⁴²⁶

The usage of the OneSeg signals is currently experimental, mainly because the type of licence provided allows only experimental broadcasts. This also means that the OneSeg broadcast content is the same as the main channel HD signal (adapted for OneSeg receivers).

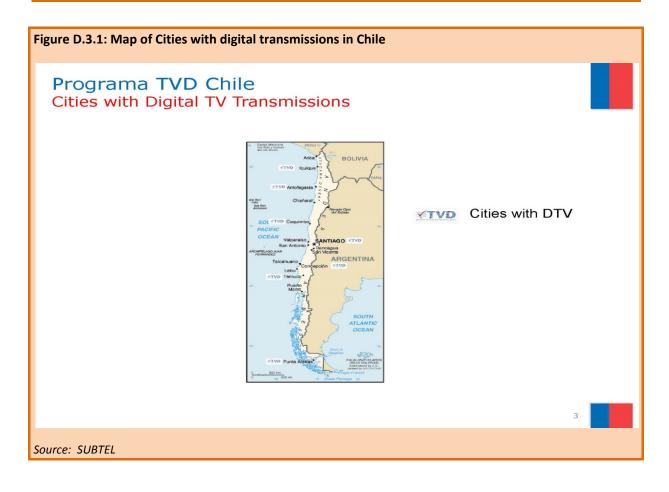
Regarding new business models for OneSeg, these are discussed in the bill of law. One option is that the OneSeg broadcasts content should be mirror the main channel content (should be the same). Another option is that broadcaster may separate the content between HD and OneSeg channels, but both of the channels should be free-to-air (free of charge).

In respect of the coverage, the coverage of the OneSeg signals is better than the coverage of the HD channel signals. This is mainly because of the robustness provided by the OneSeg transmission system parameters. Currently, all metropolitan areas of all cities in Chile are covered by OneSeg transmissions. The coverage area exceeds the coverage area of the HDTV channels.

Information on OneSeg (and other HD services) transmissions is presented below, together with a map of the cities which already have digital transmissions (marked with TVD logo).



 $^{^{426}}$ Information in this part is based on inputs received from official sources in Chile.



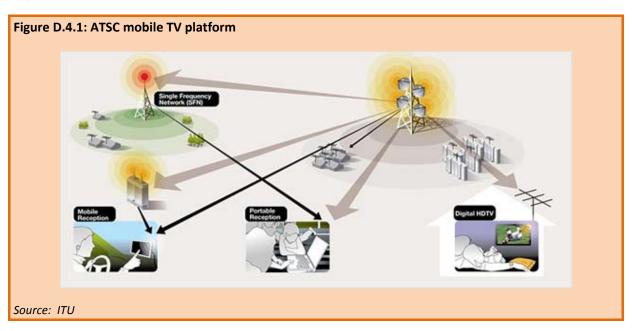


D.4 How ATSC mobile TV works⁴²⁷

The current network of broadcast transmission towers that carry TV signals to homes can be retrofitted to also deliver a mobile TV signal. That signal has the ability to deliver local, full-motion digital broadcasts on multiple mobile devices, without the need for additional broadcast spectrum.

The mobile TV platform enables local TV stations to deliver live, digital content to ATSC-capable mobile and video devices such as mobile phones, portable media players, laptop computers, personal navigation devices and automobile-based "infotainment systems." The service is "in-band", meaning local broadcasters are providing mobile TV services as part of their terrestrial transmission within the same, existing 6 MHz channel they use for their current ATSC DTV programming.

With a little additional cost, broadcasters can install the mobile TV exciter and signal encoding equipment on existing TV transmission systems and gain the ability to transmit a robust, digital mobile TV signal. The mobile TV system allows the splitting of the 19.4 Mbit/s of capacity into a slice for delivery to current home digital TV receivers and a slice for mobile TV technology that can be received on new mobile TV-capable receivers.

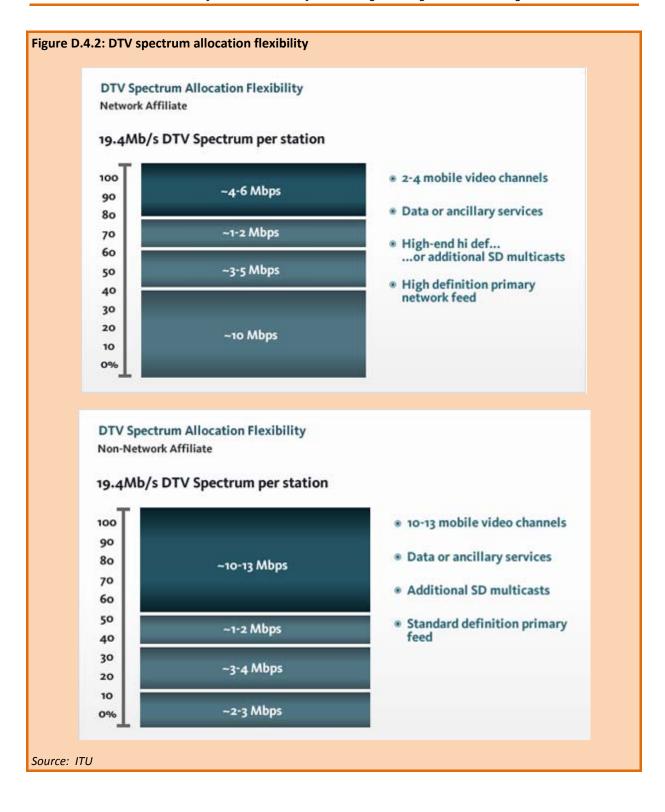


Bandwidth flexibility for mobile transmission

Digital TV allows for bandwidth flexibility, providing a number of possibilities for broadcasters to divide bandwidth and distribute channel usage. The illustrations in Figure D.4.2 show examples of channel usage for mobile operation.

413

Text adapted from www.nab.org/mobiletv/learnMore.asp



Mobile TV performance capabilities

Mobile TV enables broadcasters to deliver consistent performance and functionality across a range of service requirements:

- **Video quality** Delivering one or more high-quality mobile/handheld video programmes that provide excellent viewing experiences using H.264 base profile video encoding now, and even better resolution (up to 480p) in the future.
- Mobile reception Clear, consistent reception tested at speeds greater than 100 miles per hour. The system processes the mobile programme stream(s) with additional forward error correction and data redundancy to help ensure successful reception.
- Efficient/flexible use of spectrum Bandwidth flexibility is evident in the number of audio/video services, data rates and the signal robustness attainable with main ATSC data requirements.
- Backward compatibility Fully backward compatibility with all existing/deployed ATSC consumer equipment/receivers. Compatibility eliminates the risk of digital TV service disruption and reduces additional equipment cost for broadcasters.
- Device/UI parameters With only a single receiving antenna required, design options are
 maximized and ease of use is enhanced. Convenience features (e.g. programming guide, timeshifting and storage) are part of the system architecture. Significant mobile/handheld receiver
 power savings result from "bursted" transmission that maximizes receiver battery life.

Mobile TV Receiving Devices

Video-enabled devices capable of receiving broadcast TV services continue to be developed and upgraded by manufacturers. These devices include mobile phones, portable media players, laptop computers, personal navigation devices and automobile-based infotainment equipment.

D.5 Overview of NOTTV mobile TV service in Japan 428

NOTTV is Japan's first broadcasting service for smartphones, was launched in April 2012. Viewers can enjoy high-quality audio, high-definition real-time and storage-type broadcasting services on mobile devices. NOTTV offers new services, bringing TV, mobile and social media together, something never experienced before.



Features of NOTTV

The service offers real-time viewing (as with traditional TV broadcasts) and time-shifted viewing enabling stored programmes and content in a wealth of genres to be consumed anytime. Its offering package includes a variety of digital content, from newspapers to magazines. Also on offer are 24-hour news channels and broadcasts of pertinent information during disasters. This service delivers a whole new range of broadcasting content, with interactive programming linking broadcasts and communications, and programming combining real-time viewing and social media.

Business planning

The business plan to increase the uptake includes creating attractive programmes and content, expanding the broadcasting area, a line-up of NOTTV enabled devices and setting affordable rates. The broadcasting area is being gradually expanded with a view to nationwide coverage. For a fee of JPY 420 (approx. USD 4,

⁴²⁸ Text adapted from www.nttdocomo.co.jp and www.nottv.jp

tax included) a month, users can access programming and content in a wide range of genres. In the future, premium programming and content will be on offer for additional fees.

A trial campaign was run through early September 2012 for customers who wanted to see what the service is like before signing up. The service aims to deliver a full line-up of digital content for various books, and magazines. It also delivers emergency warning services, providing up-to-date information to the users.

Time-shifted content is delivered multiple times to the receiving devices through the broadcast network. The desired content is temporarily stored in the receiving device automatically, allowing this content to be used anywhere and at any time.

NOTTV is a joint venture between Telecom, broadcasting companies, equipment manufacturers and other players in the industry.

D.6 Examples of system parameters data for DVB-H⁴²⁹

Implementation of DVB-T2 Lite for MTV is currently evolving. Several trials have been conducted in the last two years and data so gathered is being examined to set up appropriate implementation modes.

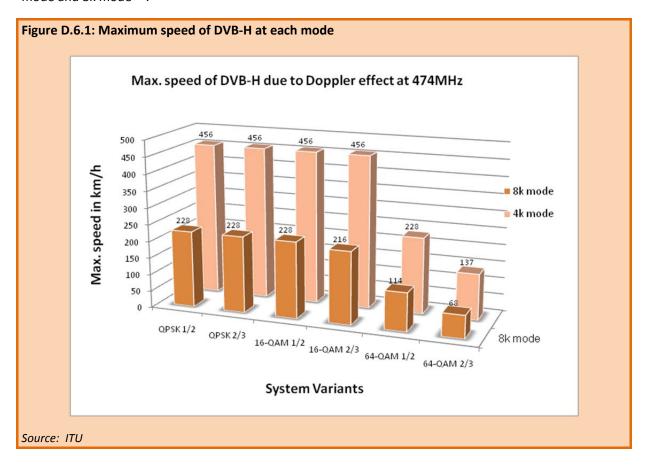
DVB-H was previously considered for MTV services. The first version of the "Guidelines" contained a lot of information regarding MTV networks using DVB-H. In order not to lose that information, an abstract is provided in the following sections.

System parameters

FFT size

In case of DVB-H, 2K, 4K, 8K, 16K modes can be employed. The fast Fourier transform (FFT) length specifies the number of carriers. The number of carriers in DVB-H 4k mode is 3,096.

The impact of the Doppler effect is shown in Figure D.6.1 for DVB-H 4k and 8k modes. It needs to be noted that the maximum speed occurs if the vehicle is driving along radials towards or from the transmitter. In all other circumstances the maximum speed is higher. The Figure shows the maximum speed of DVB-H reception due to the Doppler effect at 474 MHz for different system variants and 4k mode and 8k mode 430 .



⁴²⁹ Information extracted from the previous version of the Guidelines

⁴³⁰ Refer to EBU – TECH 3317, Planning parameters for hand held reception, page-48.

Implementation issues

4k mode and 8k mode are used as the transmission modes of DVB-H. With Guard Interval 1/4, 16-QAM, Code Rate 2/3, and PER 10^{-4} , good reception is possible at speeds shown in Table D.6.1.

Table D.6.1: Maximum speed with DVB-H reception at different frequencies

Frequency	Max. speed with 4k	Max. speed with 8k	
474 MHz	456 km/h	216 km/h	
746 MHz	290 km/h	138 km/h	

The DVB-H system has several types of carrier modulation:

- QPSK
- 16QAM
- 64QAM

Together with each type of carrier modulation, one of the five inner protection code rates should be chosen: 1/2, 2/3, 3/4, 5/6, 7/8.

The combination of a lower order modulation and a low code rate is used when field strength requirements are very demanding e.g. in case of portable or mobile reception. The combination of a high order modulation and a high code rate is used when a high data capacity is required e.g. in case of a high number of services. The C/N values and protection ratios are specified for three kinds of transmission channels:

Table D.6.2: Transmission channels and application

Transmission channel	Description	Application	
Gaussian channel	Reception with no delayed signals and taking into account thermal noise	Reference value	
Ricean channel	Reception with a dominant signal and lower level delayed signals and thermal noise	Fixed reception	
Rayleigh channel	Reception with several non-dominating signals with different delay times and thermal noise	Portable and mobile reception	

As indicated in the above table, the Rayleigh channel is applied to mobile broadcasting, with the following C/N value demanded by the Gaussian channel and the Rayleigh channel of DVB-H⁴³¹:

Table D.6.3: Required C/N value of DVB-H

Modulation	Code rate	Gaussian MPE-FEC Code Rate=3/4	Static Rayleigh MPE-FEC Code Rate=3/4
QPSK	1/2	2.4	3.9
QPSK	2/3	4.3	6.9
16-QAM	1/2	8.3	9.7
16-QAM	2/3	10.4	12.7

 $^{^{431}}$ EBU – TECH 3317 Planning parameters for hand held reception, page-10

Each modulation for actual mobile and hand held reception as well as C/N and available bit-rate required by code rate are as follows 432:

Table D.6.4: Modulation vs. code rate / bit-rate / minimum C/N value for DVB-H

4K mode, GI=1/4, 8 MHz , PER=10 ⁻⁴					
Modulation	Code rate	Bit-rate(Mbit/s)	C/N min (dB)		
QPSK	1/2	4.98	13.0		
QPSK	2/3	6.64	16.0		
16-QAM	1/2	9.95	18.5		
16-QAM	2/3	13.27	21.5		
64-QAM	1/2	14.93	23.5		
64-QAM	2/3	19.91	27.0		

Taking diverse issues into consideration, the suitable modulation and code rate for DVB-H would be 16-QAM, 1/2 or 2/3.

Guard interval

Guard interval lengths of DVB-H at 8MHz (4k mode is used for mobile broadcasting).

Table D.6.5: Guard interval lengths of DVB-H

Contains and DE handwidth	Guard interval	Transmission mode		
System and RF bandwidth		8k mode	4k mode	2k mode
DVB-H at 8 MHz	1/4	224 μs	112 μs	56 μs
	1/8	112 μs	56 μs	28 μs
	1/16	56 μs	28 μs	14 μs
	1/32	28 μs	14 μs	7 μs

Implementation

For mobile broadcasting, the size of the designed single frequency network (SFN) has to be taken into consideration, while a long guard interval length is required in order to properly respond to the interference generated through multipath propagation. For DVB-H, GI = 1/4 (112 μ s at 8 MHz) is suitable.

 $^{^{432}\,}$ ETSI TR 102377.v1.4.1(2009-04) DVB-H implementation guideline, page-35.

Annex E – Guidelines for migration of broadcast archives from analogue to digital

The guidelines on migration of broadcast archives have been prepared as a supplement to the ITU Guidelines on the transition from analogue to digital broadcasting. Consistent with the approach taken in the transition guidelines, the guidelines on migration of broadcast archives from analogue to digital are intended to help build a roadmap for the migration of archives from analogue to digital.

The transition guidelines are mostly concerned with the conversion of the radio frequency elements of the broadcast chain, that is the conversion of the means of transmission from analogue to digital and its impact on spectrum, government, broadcasters, the public, and other relevant parties. These guidelines do not address the question of migrating analogue studio equipment to digital technology.

Virtually all media archiving equipment available today uses digital technology. The process of migration to digital equipment is already well underway within broadcasting studios in almost all countries, though full migration may not have been achieved in all the archiving facilities. In a large percentage of such facilities, digital technology has been introduced in many of the functional subsystems. But still there is scope for improvement and technology enhancement. However, there are many archives in other regions of the world where the archiving material is kept in its native format, such as film, tapes and sometimes even in vinyl records. It is here that use of digital archiving technologies and the associated management regimes would be most effective and the investments in digital archiving facilities would pay high dividends.

Studio migration is inevitable if not already fully accomplished; however, broadcasters across the world have many years of programme content stored in their archives in analogue formats. Many of these formats are now obsolete and the equipment to retrieve the content will become increasingly scarce and difficult to maintain. At the same time, the legacy media (tape etc.) upon which this content has been recorded, deteriorates over time and unless it is kept in ideal environmental conditions, the content may already be unrecoverable.

Much of the material contained in these archives may be of significant historical and cultural significance to the countries in which it was created. ITU and other UN agencies have long recognised the importance of preservation of this material and the World Telecommunications Development Conference (WTDC-10) identified assistance to broadcasters in the migration of archives from analogue to digital as a broadcasting development priority.

These guidelines focus on the broader strategic and operational questions of archives migration, including the benefits that can flow from migration in addition to the basis proposition of preservation of historical programme content. The guidelines do not attempt to provide the technical solutions to archives migration because those solutions depend very much on individual needs, resources and available funds. Further assistance with identification of technical solutions is widely available from equipment suppliers, broadcasting organizations, and other sources.

E.1 Introduction

The Oxford English Dictionary defines "archives" as "a place in which public records or other important historic documents are kept". This tends to suggest that archives are essentially static repositories of historical significance. Broadcast archives are certainly repositories for the storage of old programmes, but this is only one part of the function of the archives. Other functions of the archives include:

- support of production and post-production workflow by providing indexes and resources to assist in locating relevant content for use in programmes, and for providing that content in a form suitable for use in the production;
- providing information about content including Intellectual Property Rights, and the details of the content of the stored programmes;

- making available archived programmes for broadcasting (in a format that is suitable to the prevailing technology of broadcast production and transmission);
- making available programmes for programme exchange;
- harvesting the archiving material for commercial use by other broadcasters and media industry players.

Archiving involves four distinct processes. These are:

- Selection of media content or materials to be archived, which is predicated on many factors. This is a process that should be based on several considerations such as:
 - historical considerations that vary from country to country;
 - geographical factors such as a beautiful country landscape, touristic venues and so on;
 - events of national / local importance;
 - immaculate content produced by the broadcaster itself or by any other entity;
 - content that can be re-used as it is or re-purposed for other delivery platforms, including on MTV and webcast or OTT;⁴³³
 - content that can be of commercial value, either in the near future and / or in the long term, such long-tail content;
 - storage capacity of the archives facility.
- Preparation of index of the materials selected for archiving and putting together the content
 details, copyright details and highlights of the content (keywords or key shots –thumbnails). This
 process actually develops the metadata associated with the archived material and is the key to
 the management of the archive.
- Physical conversion of the material to be archived. The format or technology used for conversion may either be a uniform format employed by the archiving facility or may depend on whether the archived material is a near-line archived material or a long term archive (deep archive).
- Management of the archived material is perhaps the most important task. The management process involves many factors, including the following:
 - general upkeep of the archived material and the whole archive infrastructure. This also depends on the type of storage media used in archiving such as DVD, Blue- Ray, data tape or hard drive or a combination of all of these;
 - management of the archive for content re-use (in-house and for external parties) and its commercial exploitation;
 - rights management of the archived material and clearing of rights;
 - verification of the integrity of the archived material and its periodic re-recording to prevent bit-rot.

In the fields of broadcasting and content delivery, Over-The-Top Content (OTT) refers to content that arrives from a third party and is delivered to an end user device, leaving the internet provider responsible only for transporting IP packets. The provider may be aware of the contents of the IP packets but is not responsible for, nor able to control, the viewing abilities, copyrights, and/or other redistribution of the content.

Analogue based broadcast archives have long performed these functions for both radio and television but the processes were usually manual labour intensive and involved creating multiple copies of content from the archives master so that it could be previewed by the programme makers to make a selection of the actual content they required. Many of these copies were discarded in the production process.

Broadcast programmes or the content that is used to create them is transitory, and is captured and retained on some form of storage media. During the past 80 years there have many different type of media used for storage of content. These range from early gramophone recordings and movie film, through various different types of magnetic tape storage, with varying formats and different recording and playback devices, through to the more recent digital media of data-tape, CD, DVD, Blue-Ray and solid-state storage.

In the main, the transition from one type of media to another has been driven by significant improvements in technology and storage media capability. This onward march of technology is unlikely to relent, and if anything, the pace of technological advancement in storage media is likely to accelerate. Therefore, the expected operational life of any given media type or format is probably around 10 years or even less as the technology advances. Its actual life, when stored well, may be very much longer, but unless the technology to recover the content from the media is available the content will be useless.

Some storage media may, under ideal conditions (which could be very expensive), have an expected shelf life of up to 100 years, however, even if retention of all of the different playback devices to recover the content were practical, the supported life of these devices (spare parts availability etc.), can rarely be guaranteed much longer than 7-10 years after the last production run by the manufacturer of the equipment. Some familiar examples of now obsolete formats include 2" and 1" VTRs and UMATIC video tape, reel to reel audio tape, MiniDisk Audio Recorders/Players, disk storage software formats etc.

The solution to this complex problem requires regular transfer of content from one format to another. In the analogue domain, this process would certainly result in progressive technical degradation of the fidelity of the content from that of the original, though at the current juncture, analogue storage is neither practicable nor workable. However, content in a digital format can, in principle, be copied serially from one storage media to another without any degradation, provided the requisite software programmes are still available together with the requisite hardware. Furthermore, while the conversion from analogue to digital is a difficult and labour intensive task, conversion of digital content from one media type to another can be largely automated.

Digital content does not need to remain as reels of tape held on a shelf in the archives, today it will generally be held in a computer data warehouse on computer disks or computer tape libraries, or even in the cloud-based databanks and can be available on-line, and accessed remotely from the desk top.

Computing technology and data storage has now advanced to the stage where it can provide a suitable storage for broadcast content and thus in the modern broadcast production environment, the only need for proprietary media formats is generally for original capture of the content in field recorders or cameras.

E.2 The concept of digital work flow and archives

The following scenario serves to illustrate the potential change that can be driven through the digital archives:

Bill, a research assistant for a television current affairs programme in an analogue based production centre, has been asked by his producer to find a number of specific pieces of content on a noted person, preferably captured on location in a particular city. Under traditional analogue archives arrangements, he may need to engage assistance from research staff in the archives and also engage in his own research of the various databases and records that contain information about the content stored in the archives. Those records could be paper-based, computer-based or both. Having identified several potentially useful items, archives staff must access the working copies from the archives and dub the appropriate selections to VHS tape, so that Bill can view them.

Bill receives the VHS tapes and decides that of the ten tapes received from the archives; only three seem to meet the requirement. Those three are passed on to the producer who ends up selecting one segment in one of them. Bill goes back to the archives, to request a broadcast quality copy of the required footage. The archives staff goes back and again retrieves the working copy from the shelf and then dubs it to a Digital Betacam tape and provide appropriate clearance of intellectual property rights etc.

The tape arrives, and then is manually loaded into a tape machine in an edit suite to compile the programme, which eventually ends up on another Digital Betacam tape for transmission. A copy of the finished programme must be passed to the archives, together with programme rundowns, scripts etc., for storage and cataloguing. Eventually, the new programme is catalogued and on the shelf available for future programmes.

Consider now, a different technological approach. This time the complete archives database is available electronically through a common on-line interface at Bill's desktop. All archives footage has been converted to a digital file format and is held as broadcast quality content in an automated storage system containing thousands of hours of content. Coupled with this is a compressed copy of the content, available from an on-line server that can be accessed via the intranet. The system is supported by an on-line ordering system.

With access rights as an authorized user, Bill is able to browse the archives footage index from his desktop aided by a powerful search engine he is returned the same ten items identified above. By clicking on the items one at a time, Bill now views the browse footage either as thumbnails marking scene changes or as browse video on his desktop computer. He quickly decides that only three of the items are relevant, and emails his producer with brief details and a pointer to the three items he has identified. (Note the email does not need to carry the video footage, only its identifying references.)

The producer receives the email and clicks on the referenced items and is immediately able to browse them on her desktop PC. She selects one of them and sends an on-line request to the archives to confirm and obtain the necessary rights clearance and to place a broadcast quality copy of the required content on a specific broadcast server on the date editing is to commence. The archives staff then proceeds to clear rights and schedule the transfer of the content to occur as requested on the nominated date/time. If, for any reason, the transfer cannot occur, the system will automatically notify the producer and archives asking for an alternative destination.

The programme is finished and forwarded electronically to the transmission server and simultaneously, a copy is passed back to archives along with programme rundowns etc., where it is placed in a holding store in the archives digital repository. A job is listed for archives to complete the indexing of the programme. When this is completed, the programme passes to the working store, automatically copies are created for off-site storage, and a browser copy is created and becomes available for further use and retrieval.

Note that in the digital process, no archives handling of the storage media has been necessary. VHS dubs have become unnecessary, there are no tapes to lose, and no dubs have been made by archives in the production stage of the process and the finished programme is automatically archived.

An archives researcher using these same tools may have assisted the search process, but in general the role and contribution of the specialist archivists can move away from custodial activity to direct support of clients to apply their specialist expertise in cataloguing and research.

Because the content and access is managed down to item level by a secure database, access rights can be set for both groups and individual users. Footage for which access rights are limited, or for which even knowledge of its existence must be restricted, can be secured in a way as to be invisible to searches without authorized access. From this high level of security, through to general access, the content in the archives can be secured. For example, one class of client may have rights to search and view footage, but no rights to transfer or copy it to others without authorization.

In a digital production and archives environment, the archives become an integral part of the production workflow and contribute to more efficient production. Furthermore, with the advent of on-line services and the Internet, digitally stored programmes in the archives or other parts of the system may be made available for on-line viewing with limited additional labour involved beyond rights clearances and some formatting for the different media. Transcoding from broadcast to on-line or MTV transmission formats may occur automatically in many cases and/or different versions of a programme can be held electronically.

E.3 What material is a candidate for conversion

In the context of broadcasting, all content (both contribution and distribution content) held in analogue form on whatever media is a candidate for conversion to digital. Depending on the size of the existing archives (which may reside both in a formal archives location, and in the desk drawers and cupboards of production units), the task of migration could be very large and could take thousands of staff and machine hours for both the physical transfer and quality control of the converted product.

Most analogue archiving media equipment (tape etc.) is now obsolete. As such a critical part of the planning for migration will be to secure access to well-maintained playback machines that will have sufficient operating life or spare parts to enable the task to be completed. The availability of spare parts, and technical staff skills with the ability to maintain and operate these old machines, will create a degree of urgency to complete the task (particularly for the oldest formats).

Unfortunately, archives are often kept in less than ideal environmental conditions. Often, the material is stored in an office environment with office air-conditioning or without any climate control at all. Without appropriate humidity and temperature control, the shelf life of magnetic tapes, vinyl records and other such media can be considerably reduced. Some of the earliest production of magnetic tape etc. did not have the same longevity as the more recent production and this life is much shorter in poor storage.

Commencement of any archives migration project involves a comprehensive inventory and analysis of all existing holdings. In addition to the requirements to store the existing archival content, the archiving migration project must also take into account that broadcasting production is continuous, and new content generated each day will add to the archives. To avoid migration becoming a continual catch-up process, capture and archiving of new content, as it is created, should also become an integral part of a migration and digital archives strategy.

It is quite important to make an assessment of what constitutes the archiving material. Most often, the process of judgement of what is archiving material lies beyond the control of the technical staff. However, this issue is very important. All content producers feel that all of the content they produce is worth archiving. This leads to an unnecessary pile up of archiving materials and thereby undermines the efficacy of the archiving process. Archivists are trained to determine the archival value of the material produced every day or already available. So they need to exercise their professional judgement and select only the material appropriate for archiving.

In making such a selection, many factors have to be kept in mind, such as material of historical value, commercial value, high quality productions, materials with news value and so on. Most of these factors are influenced by the country environment and particular requirements. Often, broadcasters are entrusted by the governments to archive material of national importance and preserve it. The subtle point here is that selection of the archiving material has a direct impact on the functioning of the archiving facility.

E.4 Archives and content strategies

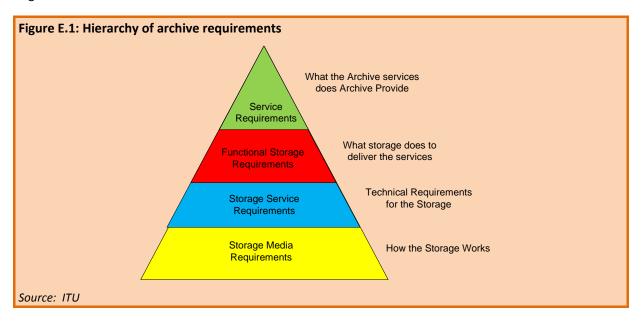
Considerable work on archives migration and operational strategies has been done by the European Broadcasting Union (EBU), the European Commission and some European broadcasters in the past 12 years which can serve as valuable reference to the migration task. Some of these have been listed in the references cited at the end of these guidelines.

Around about the year 2000, relatively cheap digital storage developed for the IT industry started to be adapted to the storage of audio and video media. This opened the way for fully digital migration and elimination of the on-going manual process of media conversion when transfer from one proprietary format was required. A file-based approach to content production and archives is now widely integrated in production, edit and play-out facilities, taking into consideration appropriate technology solutions. In general, these allow for the storage of content using IT-centric storage for both on-line and near-line storage.

In the IT environment, data storage solutions for retention and access to critical records have been in place for over 30 years. In that time the storage platforms themselves have evolved through a number of generations of technology. At the same time, the suppliers of this technology claim that their clients have never lost a single byte of data (generally correctly) in the evolution and migration from one storage solution to another. This is actually in contrast to the analogue archives where older tapes can become unplayable because the media has deteriorated beyond the state of recovery.

A successful migration strategy requires an assessment of what the archives are required to do. A primary concern of archivists is that they can retrieve from the archives what they put in and that they can use what they get back. This implies a transparent archiving process, and one which allows the content retrieved from the archives to be formatted in a way that meets the current requirements of the day (perhaps some future technology or format).

As a top-down design, all elements of the archived strategy flow from a clear definition of the services the archives is expected to perform (now and in the future). All other elements flow from this as depicted in Figure $E.1^{434}$.



Adapted from Wright, R, EBU Technical Review October 2006, What Archives Want – the requirements for digital technology, EBU Geneva October 2006

426

A forward looking strategy will provide greater assurance that the archives will endure the test of time and require less resources to maintain than one which simply takes today's functions and attempts to replicate them in the digital domain. Functions that the archives need to perform other than to act as a repository for content include:⁴³⁵

- input for new final programmes from production;
- documentation (rights, content logging, contracts, etc.);
- programme exchange (import/export of programmes from/to external sources);
- digitization of the legacy archives.

Ingesting new programme elements (such as original field recordings that may serve as content for a number of productions) is not necessarily an archiving function. This function belongs to the near-line storage area in a production facility.

The present guidelines focus on the primary concern of migration of archives from analogue to digital with the principle focus on preserving existing archives and capturing new archiving content in an appropriate digital form. The guidelines do not address the integration of the digital archives into the production work flow. This is a much more complex question which generally needs to be tailored to individual broadcaster's capabilities, resources and needs. Some of the workflow functions are integral to modern news room and other systems and for many these may be the kernel of a future integrated solution. It is, however, entirely possible to setup a simple archiving facility from the grass-roots with minimal costs. 436

The archives migration roadmap will need to take account of possible future strategic directions for the development of an integrated system. However, this may prove to be economically difficult for many of the countries for which these guidelines have been prepared. The guidelines are, therefore, structured around priorities for migration that will allow migration to digital to proceed in a staged way with the emphasis being on preservation of analogue content, while at the same time putting it into a form where it can be exploited more easily by both basic or comprehensive integrated workflow arrangements as the capability and affordability evolve over time.

E.4.1 Access and repurposing content

In modern digital archives, the content will most likely be stored either on computer disk arrays or as deep archives data tapes held off-line on shelves or on optical disks. It may even be held at the premises of a secure data storage provider or, more recently, on the cloud. Thus like the files on a personal computer, a comprehensive and well devised indexing system is essential if the items are to be relocated quickly in the future. This information about the content is very important for its eventual retrieval for reuse and may include items such as:

- name of the programme or programme element (content which is a building block for a complete programme);
- a locator reference for the content (e.g. file number, shelf number, item number);
- a description of the content of the package of content (programme or programme element);
- information about personalities, events, shot lists etc. within the content;

⁴³⁵ EBU Technical Report 003, Radio Archives Conception & Practice, EBU, Geneva July 2009

A sample archive has been set up by the Asia-Pacific Broadcasting Union (ABU) for the Bhutan Broadcasting Service, the public service broadcaster in Bhutan.

- information about the time, date and place it was created;
- information about the format of the content or the storage media including information about any transformations that it may have undergone in the past (migration to a different media, conversion from one format to another);
- related content (such as different versions, different language versions, or compressed versions for internet viewing, etc.) which may exist;
- information about intellectual property rights;
- possibly information about its acquisition (contract documents);
- information about its permissible use (governed by the rights), such as number of runs permitted, numbers of runs used, etc.

This and similar information, collected and stored together, is called metadata (information about the content). It is information that can be indexed and searched, and which can point to the location of the actual content container itself. Metadata is the most important element in archive management which facilitates all the functions that the archive needs to perform.

Modern digital cameras and recorders start capturing elements of metadata at the source (e.g. location, time, job number); and further information is usually added along the steps of the production chain, e.g. ingest, edit, post production, presentation, etc. Some of this may be added automatically, other elements must be added by production staff. Finally, relevant archival references are added by archivists before the indexing and metadata file is complete.

Widely used metadata models include the Dublin Core Metadata Model⁴³⁷ and the SMPTE model⁴³⁸. These models cannot simply be taken and applied directly to a broadcaster's content. These are comprehensive descriptive models from which the most appropriate elements should be selected to the needs of the individual broadcaster or production unit. The model can be augmented over time if the original data model proves too restrictive. It is generally better to start with a basic model and to enhance it over time, rather than to waste storage, complicate searches, and increase the documentation work load by trying to include data items that have no immediate value or for which accurate records do not currently exist.

It should be noted that there is no international harmonisation of metadata schemes (metadata schema) among the broadcasters and, as such, unless further measures are instituted, broadcasters cannot take advantage of the metadata facilities while exchanging content internationally. Often, even within the same broadcasting organisation, metadata schema may be different among different areas of production, on-line storage and archiving.

E.4.2 Content metadata

Hopefully, many elements of the required metadata will already be held in existing archives or production records. Some of the information is probably scattered through production area files, and the archives record may contain only basic identification and catalogue information, some items may have been lost or never recorded.

Dublin Core Metadata Initiative: The Dublin Core Metadata Initiative, or "DCMI", is an open organization engaged in the development of interoperable metadata standards that support a broad range of purposes and business models. DCMI's activities include work on architecture and modelling, discussions and collaborative work in DCMI Communities and DCMI Task Groups, annual conferences and workshops, standards liaison, and educational efforts to promote widespread acceptance of metadata standards and practices.

⁴³⁸ Society of Motion Picture and Television Engineers, <u>www.smpte.org</u>

Planning the metadata model, identification of the sources of data, and defining the required data format must be part of the planning process. The metadata is frequently stored in separate databases or paper records which point to the actual content file and / or browse quality copies of the content. In a modern system all metadata would be stored electronically, and ideally along with the content using approaches like Materials Exchange Format (MXF) discussed later. The metadata should be loaded at the time the analogue to digital conversion takes place because it is an integral part of the content record.

The Unique Material Identifier (UMID) is a globally unique audio-visual (AV) material identifier standardized as SMPTE ST 330 and RP 205. With more than 10 years that have passed since its initial standardization, UMID is present in AV products using the MXF (Material Exchange Format) files as its mandatory component. Its use has been widespread throughout the industry. But, its originally intended use as a unique material identifier to link AV material to its metadata has seldom been seen in practice.

AV material management using a unique identifier is a common practice in variety of products, but a problem with the material identifier often occurs when such products are combined to form a media production system. The UMID, as an industry common AV material identifier, is expected to address this problem. Most products have their own proprietary material identification schemes with little or no interoperability between them. Furthermore, although certain products have adopted the UMID for their material identifier, they have no capability to communicate with other products via the UMID, resulting in failure of their integration into a system. Recently, it was found that the issue is mainly due to lack of industry common rules for the UMID applications and, in order to address the UMID application issue, a new project has just begun in the SMPTE SC (Standard Community).

E.5 Storage and preservation of content

The introduction to these guidelines discussed some of the reasons why migration of archives from analogue to digital is necessary, and some of the potential benefits. This section further expands on that discussion.

E.5.1 Need for and benefits of migration

All types of storage media upon which sound, moving and still images are recorded have a finite life. The actual life depends very much on the conditions under which the media are stored, and to some extent the care that was taken and the quality of the media used in the original recording. Often life expectancy projections made when a storage medium is first introduced are over time found to be optimistic, particularly when over time unforeseen chemical or physical deterioration occurs.

Some movie films created almost 100 years ago and kept in ideal conditions may still be completely retrievable, yet colour film masters on more modern stable stock have been found to require extensive restoration after around 20 years. Many early films that have not been well stored have been found to have disintegrated to a pile of dust through a range of possible chemical and physical reactions that impacted on much of the film stock of the day. For many countries the earliest television images and news events were captured on film, because video recording technology did not exist. Television programmes, other than film, had to be presented live and if a copy was needed for the future it was captured on film.

Magnetic tape made recording dramatically changed the way radio and television programmes could be captured, produced, and presented. It also allowed easy capture of a copy of the programme for future use. The earliest video tape format in common use was 2" video tape. While some broadcasters and archives still hold such tapes and some playback machines, the machines are frequently very difficult to maintain (they generally predate solid state technology, have complex electro-mechanical control and transport systems) and, unless the tape stock has been kept in ideal conditions, it has probably deteriorated to the point where extensive restoration work would be needed to retrieve a reasonable quality copy. The same is true for the earliest cassette video tapes formats.

1" tape formats followed 2" and as the technology had matured somewhat by that time, it enjoyed a longer life. Large archives of 1" tape exist around the world. However, the tape stock again is aging and machines have not been manufactured for a number of years. While it remains possible to find spare parts and technicians able to keep these machines running, time is fast running out.

Even the more recent digital video-tape formats are becoming obsolete, for more recent formats, manufacturers have built tape machines that are able to playback several different tape formats including legacy formats. So while the tape stock remains in reasonable condition urgency for transfer to a modern format will be a lower priority than for the older analogue formats.

E.5.2 Machine availability

Irrespective of how well preserved the storage media may be, there needs to be a playback device for the format otherwise it will be irretrievable. Movie film is an example where the playback device is relatively simple and it would be fairly easy to manufacture a movie film projector 100 years from now. The same is perhaps true for gramophone records. As technology has progressed, the playback devices have become more complex. Miniaturization of these devices and pressures to reduce cost has meant that they rely heavily on special integrated circuits, which would be very difficult and costly to reproduce once the existing stock of manufactures and other spares are exhausted.

Most of the archives formats "at risk" continue to rely on complex electro mechanical playback devices that now have a relatively short future life. Any migration project needs to ensure that there will be sufficient life in the available machines to complete the necessary playback for conversion.

While more modern digital and solid-state storage may have a longer life than older formats, many rely on proprietary encoder/decoder (CODECS) which tend to be replaced rather rapidly by technology improvements that allow more information to be stored in less space, and or provide improved quality. Such CODECS often rely on proprietary integrated circuitry and software and would inevitably be difficult to obtain much beyond 10 years after last manufacture, and perhaps earlier. Archives migration, therefore, needs to select storage formats that can be converted from one to another format in the future with the least possible, and ideally with no loss or degradation of the content. Storage media is developing at such a rate that projections beyond five years are highly unreliable, and archival storage in the future will involve a quasi-continuous upgrade path where storage will become cheaper, and old formats will need to migrate to new in under 10 years.

E.5.3 Digital archives options

While proprietary digital television and audio recording technologies using storage on removable media continue to be available, adoption of one of these formats for future archives migration would not be sensible because they:

- will have a finite life;
- provide no opportunity to change the archives paradigm;
- cannot extract benefits from archives migration (e.g. on-line access);
- will generally be far more expensive than alternatives.

Some archives adopted recordable CD formats or DVD for digital storage of audio and video. However, these carriers were only a useful stop-gap while IT type solutions evolved as the former suffer from many of the difficulties of the older formats. Playback often must be done in real time; most devices suited for handling multiple CDs are slow to retrieve items. DVD is not of sufficient quality for broadcast contribution but may be suitable for some lower quality play-out applications. But once again, players for multiple DVDs generally have operational problems. Disk warping over time is another problem.

By contrast, hard disk based storage (and solid state capture devices) have now matured, digital tape formats such as LTO are highly reliable, have high storage density (many items per tape) can be automated, and when copies are required, these can be made accurately at several times faster than real

time. Likewise, coping from tape to disk occurs at high speed. These observations are now valid for both audio and video content. However, due to the phenomenon of "bit-rot" the archived files need to be rerecorded around every five years. Optical disk media do not exhibit "bit-rot" the archived files need to be re-

Data storage media like hard disk drives and recordable CD's and DVD's and even digital videotape, are not perfect. Any storage medium has a native bit error rate (BER) and is equipped with Error Checking and Correction (ECC) to improve the native bit error rate from something like one bad bit in a million $(1 \times 10e-6)$ to a net error rate after correction of something like 1 bad bit in 100 quadrillion $(1 \times 10e-14)$.

Many software applications providers do wrap their files in ECC codes to overcome the silent corruption, or "bit-rot" that is well known to occur on hard disks. Internet based discussion forums indicate a problem even with RAID arrays, for which tools like "scrubbing" are used to find and correct the 'rotten bits' on the hard disks done on a regular basis in the background.

However, archives aren't just AV files. Archives can include graphics components, subtitles, edit decision lists, and all the metadata that are now acquired for content. There can be in the order of hundreds of assets associated with one title in the broadcaster's library, and every one of those data files is prone to bit errors, which all means that a generic way of ECC wrapping any file in a convenient way so that it's transparent to the user. This should perhaps be a standard feature built in to all new versions of operating systems.

Guideline 1: When migrating analogue archives to digital use, file-based storage solutions adapted for audio and video content should be employed in preference to the proprietary audio and/or video recording formats and media.

Many new storage solutions currently available use the Material Exchange Format (MXF) which provides a "container" or "wrapper" in which a number of different file formats can be placed for content exchange purposes. MXF supports a number of different streams of coded "essence" or content, encoded with any of a variety of CODECS. Importantly, MXF wrappers also include metadata so that content and metadata are carried in the same "container". This is an effective interchange format because it is increasingly supported by a number of manufacturers and allows easy transfer between systems, archives, and for programme exchange.

Archives storage solutions do not need to meet the demands of broadcast production or play-out servers, which must be frame accurate for video. Rather the storage can be straight forward disk and tape storage (depending on whether the need is on-line or near-line). On-line storage (disk) provides virtually immediate access to current in-use or high-demand content, while content in near-line storage (usually held in an automated robot storage unit) can be automatically retrieved and brought forward to on-line on demand. Near-line storage generally relies on digital data tape and for content that is accessed only occasionally, this saves both cost and energy compared with on-line. For very large archives, there may also be off-line storage where the digital data tapes containing content, that is rarely accessed, can be removed from the robot and stored in suitable physical storage and reloaded if required.

Guideline 2: There must be stringent quality control and supervision of the transfer from analogue to digital and comprehensive checking of the quality of the transfer and the accuracy of the linked metadata at the time of transfer. If (hopefully) the analogue copy is still available, priority should be given to make a further copy if there are any problems with the transfer.

 $^{^{\}rm 439}$ Description of the phenomenon of "bit-rot" is adapted from a discussion forum on LinkedIn.

E.5.4 Analogue-Digital

The conversion of analogue formats to digital is the most time-consuming and risky operation that archives can undertake. It is time consuming because it requires an enormous amount of manual effort to retrieve, load, playback and monitor each conversion to ensure that the converted content is a close to perfect reproduction of the original as the state of the original will allow.

If stringent quality control and assessment of the conversion process are not carried out, the converted content may be useless. Tools for electronic monitoring of the conversion quality are available, but these can, at best, detect only some of the problems such as loss of audio or video, head clogs, level shifts, timing latency, etc. Quality control of the conversion must be given high priority, to ensure the content is preserved optimally, and to ensure that the correct and accurate metadata is attached to the content. If metadata attached is incorrect, then searches will turn up the wrong material, and finding the correct content in a large archive will prove very difficult. Such materials could even be lost.

However, in order to ensure that the content can be retrieved and converted to different needs for later usage, there may be a need to transcode original materials to a more universal format (e.g. audio Broadcast Wave; MPEG Video) which will ensure that later migration to future technology platforms is provided for.

E.5.5 Digital-Digital

Transfers from proprietary (traditional broadcast) digital formats to a digital archives format are much easier to carry out than from analogue formats. Firstly, the playback machines usually have extensive error checking and alarms which can relive the tedium of visual/aural monitoring of the transfer. However, the need to ensure correct metadata association and quality checking of the finished master digital recording is still important. One advantage of the MXF approach is that the metadata travels safely and is stored with the content.

Once the digital copy has been confirmed, modern file-based storage can reliably create additional copies for off-line, on-line or for security storage. Copies can be made at several speeds, real-time, faster than real-time, all with full error and validity checking, and error correction within the limits of the hardware.

Once the content exists in the digital domain (preferably with lossless compression), then in principle it will be relatively easy to transfer to any future format, be easy to transcode to meet the needs of world wide web (www), Internet display on mobile devices etc.

E.5.6 Preservation of quality, a critical decision

An essential consideration in the migration of archives from analogue to digital is to maintain the best possible quality of transfer to the digital domain. This implies that the conversion should occur from the highest quality source material available if there are multiple versions or copies in the archives. Many old analogue recordings contain artefacts such as noise, poor audio or image quality etc. that could possibly be improved in the conversion process. However, most archivers conclude that the digital conversion should, as far as possible, preserve the analogue content as close as possible to its original form. Then as enhancement software and hardware improves in the future it can, if necessary, be used to make improved copies.

A similar question arises about the digital conversion process. Digital compression systems achieve a reduction in the amount of storage needed by discarding information that should not be noticed by listeners or viewers. The highest amounts of compression in the broadcast chain generally take place in the final transmission link, where no further operations are required on the content. Within the production studio, the lowest levels of compression (ideally lossless) are used to ensure that in the subsequent production or transcoding processes, the content is not degraded. Likewise, a similar practice should be applied to the archives in order to keep the best quality copy. Ideally, the digital conversion should be uncompressed, noting that this will significantly impact the storage capacity of the archive. That said, there is little point in up converting a format to a higher one (e.g. SDTV to HDTV) for archiving. Upconversion cannot transparently replace information that does not exist in the original and the up conversion would introduce unwanted artefacts.

E.6 Establishing priorities for migration

The starting point for archives migration is an inventory of what material must be converted and to establish priorities for its conversion. Most broadcasters find that valuable content is contained not only in the archives, but in production centres, news rooms and other places, and there may be many copies of the same content. Unfortunately, the names and records associated with these copies are often inconsistent and even the names on the packages with the same content may be different. There may also be different versions of the same content that have similar names (e.g. different language versions).

Identification of the material may require some viewing or listening to the content, finding the associated metadata (records about the content), and some preliminary assessment of the quality of the analogue copies (e.g. is it a master copy, sub-master, original recording or programme elements etc.). This information and sorting is important to allow the size of the migration task to be scoped, to assess the most urgent needs for migrations, and if migration is to be done as an integrated part of a larger content management and production workflow strategy, then priorities may be influenced by the content that is in highest demand and which could assist in activating the new workflow.

Some broadcasters have reported that by starting from the material in high demand, digitisation of 20 per cent of the archives has enabled more than 80 per cent of their programme needs to be satisfied. This then freed up archives staff to address other issues including continuation of the migration work.

E.6.1 Estimating workload

Once the inventory and risk profile of the inventory has been established then the number of hours of content in each category for migration must be estimated. Suitable machines for transfer must be identified and assessed for capacity to provide sufficient hours and maintenance to allow the transfers to be completed. In addition to the challenge of securing sufficient machines and the maintenance support for them, the single largest dimension of the migration task is the amount of staff work hours needed to load, supervise, conduct the transfer, and to carry out quality assurance on the final converted copy and then to make additional digital copies both for backup and, possibly, secondary masters depending on the workflow requirements.

For large archives, where the time required could run to years of effort, this is a major concern where obsolete hardware must be operated for many hours and fully supported during the period of transfer. Strategies for securing suitable machines can range from stockpiling machines as they are replaced from the operating inventory, sourcing critical consumables (e.g. recording heads, or head drums), or perhaps finding a source from which to purchase machines.

Guideline 3: The format in which content is stored in the digital archives should, where possible, result in an accurate reproduction of the original analogue content and be easily transcoded in the future. This implies the use of widely accepted digital content format.

A further option may be to pool resources with other broadcasters, or archives where they exist in the country so that the costs associated with establishing a migration centre can be shared. The simple fact of providing a clean air, air-conditioned environment for the transfer process can often extend the life of the playback heads many times over compared with a standard office environment.

Some archives have contracted the migration work to commercial companies but this requires careful management to ensure proper quality control by the contractor and the archives to ensure that material is not lost in the conversion and the quality conforms to the specifications. For most countries for which these guidelines have been produced, contracting out of the migration may be prohibitively expensive.

E.6.2 Managing new content

Broadcast organisations create new content almost every day. Some of this will have archival significance; therefore, there will be a continual flow of new material coming into the archives during the transition period. For most broadcasters, this new material will be in digital formats, but for some there may still be some analogue material arriving.

Coping with this on-going flow of new material must be planned into both the archives workflow and into the migration and storage strategies. In the ideal, the new material will be ingested directly into the digital storage system and archives along with relevant metadata. If this is not possible, a plan needs to be established as to how and when this material can be incorporated into the archives. The best strategy is to start new material going direct to the archives as early as possible; however, as much of this material may be in current use, arrangements need to be made to service this production need in the period between the start of the project and the provision of access systems.

In practice, this means that most organisations will need to maintain parallel systems of operation during the early stages of a migration programme. As far as possible the duration of parallel operation should be minimised because it will be costly in staff and other resources.

E.7 The migration roadmap

Similar to the roadmap for migration from analogue to digital broadcasting, an archives migration roadmap is a plan that sets out the key objectives of the project, the projected timetable, key decisions to be made, responsibilities and directions and related projects that may impact on the task. It generally starts from an explicit statement about the current state of the archives, the system and content to be included in the migration task, and defines the desired end state and the steps, and decisions needed to achieve that.

The desired end state would include:

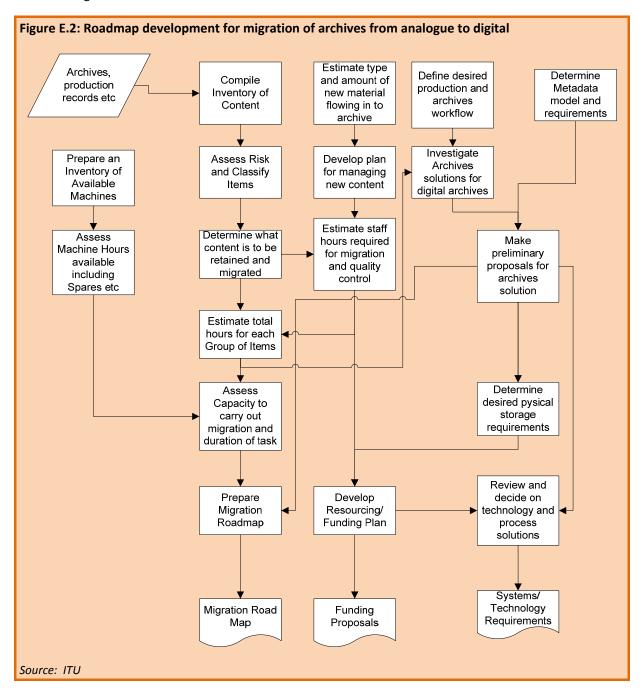
- completion of migration of various classes of content by a projected date;
- priority of migration for particular types of content and whether any interim arrangements may be necessary to do this pending establishment of the full migration plan;
- a description of the key attributes of the proposed archives system including high level functional requirements and options that may be feasible to allow the project to proceed over an extended time period should funding or other constraints so dictate;
- discussion of how the archives migration project might integrate with other production workflow projects or decisions.

The roadmap should set out decisions or paths to decisions on issues such as metadata standards, broad systems requirements such as storage objectives and growth over time, determination of priorities for migrations, initial estimates of the volume of material to be migrated and arrangements for refining these estimates in the manner set out earlier in this document. It will also define key milestones including, in principle approval of the project, development of requirement specifications, preparation of funding proposals and options, sourcing strategies for systems, and determining systems requirements.

The roadmap should be progressively reviewed and updated as the project proceeds and further decisions which may impact on the strategy and long-term goals are taken. A typical migration project can take years to complete so many things can intervene during that period which might change the direction or approach. For example, one large broadcaster established a plan in 1990 to migrate its archives to digital using the best available broadcast tape format of the day. By 2000 that solution was completely superseded by the arrival of mature file-based storage and rapidly developing media management systems. As a consequence, the strategy changed from one of replicating the analogue content onto a digital format with no change in workflow, to one where the workflow solution and migration was all achievable within the budget previously estimated for tape stock alone. Furthermore, had the earlier strategy been followed and implemented, the same broadcaster would now be migrating the digital tapes

to a more modern format (again in real time) compared with a fully automated digital to digital transfer to new storage media as that media has evolved. Again, the introduction of an integrated archives/production workflow has opened up enormous improvements in production efficiency, freed up archives staff to add greater value, and simplified the repurposing of content for new platforms such as the Internet.

A flow chart of the decision processes and actions need to develop an archive migration roadmap is shown in Figure E.2.



Work on the four streams of activity:

- compiling the inventory;
- estimating the rate of accumulation of new product to be managed;
- considering overall workflow and demands for retrieval/access to content in the archives; and
- establishing the metadata requirements.

All of these tasks can commence in parallel. The most complex and time consuming task will be compilation of the inventory.

E.7.1 Compile an inventory of content assets

This step establishes the list of items to be migrated, and should also list those existing assets already in digital formats which will eventually need to be ingested into the new archives storage. During this exercise the length of the item should be documented, as well as reference to any associated metadata records, shelf number, Intellectual Property Rights, Runs available/used etc.

The inventory should incorporate items currently held in the archives, sub-archives, or official or unofficial archives held by production units in whatever form, and should extend to tapes kept in personal lockers and drawers. The long term objective of the migration process, particularly migration to a centralised server based storage solution, is to remove duplicate and difficult to track assets, and also to ensure that valuable content that has not found its way to the archives is not lost. If a fully integrated workflow arrangement is achieved then items will always be available for review from the desk top and the need to hold dub copies will be eliminated.

Initial compilation of the list of products is perhaps the easy step. The next is to group the content so that identical items (copies), and programme elements that made up those items, are grouped together. This enables decisions to be made on which version is the highest quality candidate for migration, and to identify products which may be identical but have different names.

E.7.2 Assess risk and classify items

Once the products are grouped as above, a critical assessment needs to be made as to the value of the content for archival purposes. How valuable is this content to the organisation? Is it unique and will it have a significant value to national heritage or the organisation's history in time to come? These are questions that competent archives staff are trained to answer in consultation with content creators. The content can then be ranked in importance to the organisation.

Once the products are grouped and ranked, an assessment needs to be made of the state of the copies: Are these master copies? What condition are these in? What is the format? Is it the one for which it may be difficult to source a player? How old is the tape or copy?

From this inventory, a priority order for conversion can be established to ensure that highest value and at risk content is given highest priority.

Linder⁴⁴⁰ has suggested a useful and systematic approach to prioritisation of video-tape (the logic can also be applied to audio). He suggests that the process commence from determination of the production elements and "Grouping the collection by elements for each project or title to determine which elements were used as intermediate processes in production and which recordings are the complete project in its full length." He suggests that the organisation must then determine the element most useful to them (e.g.

 $^{{}^{440} \} Linder, Jim, VidiPax \ , \\ \underline{\text{http://cool.conservation}} \text{-us.org/byauth/linder/linder2.html}$

edited master, camera original etc.), but suggests that in general, the highest quality, longest length Edited Master should receive the first priority.

Linder offers the following suggestions on priorities:

- locate the material of most importance from an historical or organisational perspective;
- amongst these give priority to those with obsolete video formats and those which have a poor track record of long-term storage performance;
- tapes that are 10 years or older, have been mistreated or appear to be in an unusual container;
- any unusual or esoteric formats such as early cartridge, cassette, or reel to reel formats because these obsolete machines are often rare and the tapes often have experienced a difficult life;
- high priority must be given to single copies of a production, because if this tape is lost or damaged the content will be lost.

Linder⁴⁴¹ also offers a simple scoring system that can be used to establish priorities amongst material of equal value to the organization. He suggests that tapes with the highest numerical values from the following scoring system should be restored first. It is assumed that all candidates are of equal value to the organisation.

- Does the tape exhibit any symptoms of "sticky shed syndrome" (squealing during playback, frequent head clogging, flaking or sticky surfaces)? If yes add 5 points.
- Is the tape a single copy and exhibit any symptoms of "sticky shed syndrome" (squealing during playback, frequent head clogging, flaking or sticky surfaces)? *If yes add 5 points*.
- Is the tape a single copy? If yes add 5 points.
- Is the tape an obsolete format? If yes add 5 points.
- Is the tape physically damaged? If yes add 4 points.
- Is the tape the highest quality element in the production? If yes add 3 points.
- Is the tape an early example in a format popular format? If yes add 3 points.
- Is the tape 10 years old or younger? If yes add 2 points.
- Is the tape between 10 and 15 years old? If yes add 3 points.
- Is the tape between 15 and 20 years old? If yes add 4 points.
- Is the tape 20 years or older? If yes add 5 points (older than 25 years add one point per year over 25 (example 30 years old add 10 points)).
- Has the tape been in a stable environment with proper temperature and humidity control? If yes deduct 4 points.

E.7.3 Estimate conversion workload for each group

For each content format (different tape or other carrier formats), estimate the total hours to be converted. Time must be allowed for cleaning, loading, reviewing, as well as actual transfer time. For tapes in poor condition additional time should be allowed for additional preparation of the tape, frequent cleaning of heads etc.

-

⁴⁴¹ Linder, Op Cit

This process will establish the total machine and work hours needed for each format and hence serve as the basis for identifying how these machine hours will be provided, and what staff is needed for the task. Machine maintenance needs also should be estimated at this stage including the need for critical spares to sustain the machines through the conversion process.

E.7.4 Estimation of work hours

The type of staff skill-set required needs to be determined before a full assessment of staff hours can be made. For example, if the task is to be assigned to archives staff in addition to their current duties then the actual available migration throughput may be very low. The archives workload will include receiving and cataloguing new material, locating and retrieving existing archives material, and other duties. If the production units have already migrated to digital formats, then it may be necessary for the archives to transfer analogue content required by production to a digital format outside of the migration project. All of this should be taken into account in the workload estimation.

If the migration task is assigned to a dedicated team or contractor, then the throughput will be higher, but so also will be the demands for quality control of the final product before it is accepted as the new "digital" archives master copy.

E.7.5 Ingest of new material

Until there is agreement about the ultimate storage format for the archives, and on the metadata standards, the work of ingesting cataloguing and managing new incoming content will need to continue to use current arrangements. However, for many organisations which generate a considerable amount of new content each day/month/year, this represents an ever-growing backlog of work for the archives. Hence, the earlier the ingestion and management of current content can migrate to the new workflow system, the easier the overall migration task will become. For a start, while cataloguing remains an ongoing task, retrieval and ingest tasks etc. can be significantly reduced once these become a normal part of the production workflow.

E.7.6 Definition of desired production and archives workflow

The modern digital archives should become an integral part of the production workflow; therefore, decisions on production and archives systems should ensure that the systems will interoperate, capture metadata progressively through the production process, and establish rules and processes that will ensure that content is filtered through the process to determine what items are of enduring archival value, which items are required for the duration of a production. Remember that first and foremost, the issue is about content, its preservation, management, and reuse rather than technology. Technology solutions are easier to design once the true business needs have been codified.

E.7.7 Metadata definition

Modern production equipment (cameras etc.) start to capture metadata from the time of capture of the sound or image (e.g. place, time, project no, image/sound bite number, device upon which the sound or image was captured etc.). Additional metadata is created through the production process.

Metadata is made more useful if there are standards for use within the production facility. In this way duplicate material can be quickly identified, its capture at the point where the data is created reduces the difficult task of trying to reconstruct this form different records later. Metadata is even more useful if global standards could be adopted as these facilitate international programme exchange, as well as ensure that the metadata is more readily incorporated into any new systems which are acquired.

The best starting point could be one of the existing general metadata models such as the Dublin Core Metadata Model or the SMPTE models. These generic models have been created to take account of a wide range of production types extending from film, though video, still images, sound etc. This means that adoption of the complete model would be wasteful in database resources as many items will have no relevance in a particular archives or production context. The best approach is to identify a sub-set of

these models to provide a customized model for the archives/broadcaster needs which is harmonised with the global standard. Additional items can be added later if the need evolves.

The metadata model will need to be built into the new archives solution because it will be used for searching and identifying content into the future. It is generally stored in a separate on-line database and suitable search tools are used to interrogate the database. Such tools have been developed by a number of providers, and some are tailored to the needs of specific types of production industry. Most of the larger storage solution providers have arrangements and or partnerships with content management systems providers and can offer a complete service for the definition and establishment of a media asset management system that includes these tools, as well as storage solutions. Many also provide tools to assist in repurposing content for different platforms.

E.7.8 Physical storage

The most appropriate type of physical storage for the migrated content would be a computer data store, using both hard-disk, and background digital tape management systems. The optimal storage solution and hardware solutions will depend on the total volume of content to be archived, and the retrieval demands. For example, there is little point in investing in an automated tape retrieval system if there is very low turnover of content because it may be more economical to hold the low use material on shelf and load it as required. One benefit that comes from an automated store is that it can be programmed to review, and copy content from time to time based on time or condition assessment. Rules can also be established that determine when and what content moves from more expensive on-line storage to background near line storage with minimal operator intervention.

Storage decisions include where the storage will be located (will it be located in the IT department, in the archives, or on the premises of a third party storage provider). Along with decisions about the primary storage location/characteristics, decisions need to be made about how back-up copies will be created and stored. Back-up copies should be stored in a separate physical location, be secure, and be regularly reviewed. Backup storage may involve anything from physically storing a copy of the main store on data tape and holding it on shelving with appropriate environmental control, through to completely automate off-site storage that replicates the main storage solution.

Consideration of these options must be done in conjunction with determination of overall systems requirements. As for all elements of the system, the final solutions for any given organisation will depend on the cost and availability of funds.

Storage solutions should be planned to grow over time. The preferred approach to storage is to purchase no more than one or two years storage capacity at a time because the technology will evolve, probably become cheaper, and certainly store more content per dollar. Any media asset management system should be able to accommodate this evolution and questions about it should be contained in any request for tender.

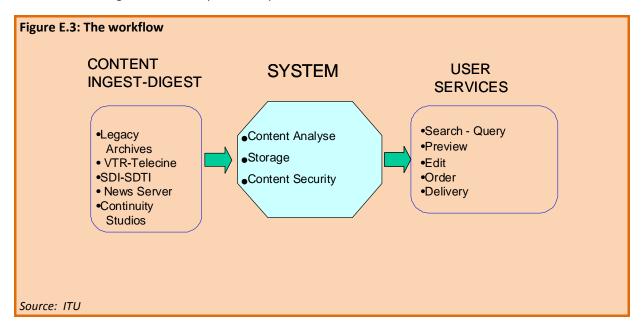
Attachment 1 to Annex E – Example of a digital television archiving project⁴⁴²

Project vision

The basic objective of a digital television archive facility is to provide effective use of all accumulated audio-video archive material in accordance with the organisational and national benefits by the utilisation of most of the recent technological developments in an economical manner.

In its scope, the following objectives are intended to be achieved:

- purchasing a system that has 10,000 hours storage capacity for the first two years (4000 hours in the first year and 6000 hours in the second year);
- being able to expand the system in order to cover both the requirements of the existing content (110,000 hours of material) and gradually increasing in upcoming years (10,000 hours / year);
- centralising management of archive material kept in various places and formats;
- providing reliability, immediate access and standardisation of operations in the archive;
- allowing authorized users to search, query and make EDL via intranet and internet from their desktop computers;
- defining different user profiles to present data in various formats.



The following terms in the example are described as below (as per EBU P/Meta Group) in accordance with SMPTE documents relevant to the subject.

Essence: Physical representation (analogue or digital) of a still image, graphic, sequence of images, sound, text, independent of its method of coding or the processing by which it is represented for use in a system.

Material: Material is a subset of "Content". It is essence in a form that supports storage and exchange.

This write up is based on an archiving project set up by Turkish Radio and Television Corporation (<u>www.trt.net.tr</u>) a few years ago.

Metadata: Metadata is data describing the material.

Content: Content is "Essence plus Metadata". But in this document it shall be taken as sum of material and metadata (content = material + metadata).

IPR (Intellectual Property Right-IPR):

- Content creator
- Content copyright
- Content owner

The above information defines general IPR and it is formed according to above issues on every contract.

Asset: is combination of content and IPR related information (Asset = Content + IPR). When an asset is formed, it is ready for any usage in that broadcast organisation.

Clip: Basic UMID describes a clip or group of clips in a unique way. The clip can consist of the below items:

- video frame;
- audio file;
- still image file;
- group of relational images / pictures in a file;
- a related sequence of still images in a single file;
- a continuous long video;
- a 90-second sequence of picture and stereo sound captured by a camcorder between "record" and "stop" operations, etc.

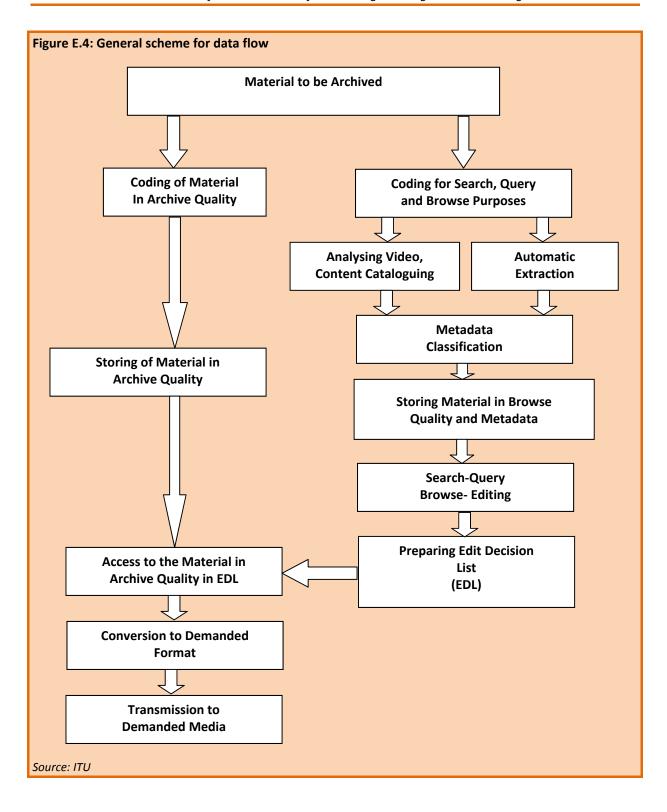
The Basic UMID uniquely identifies either:

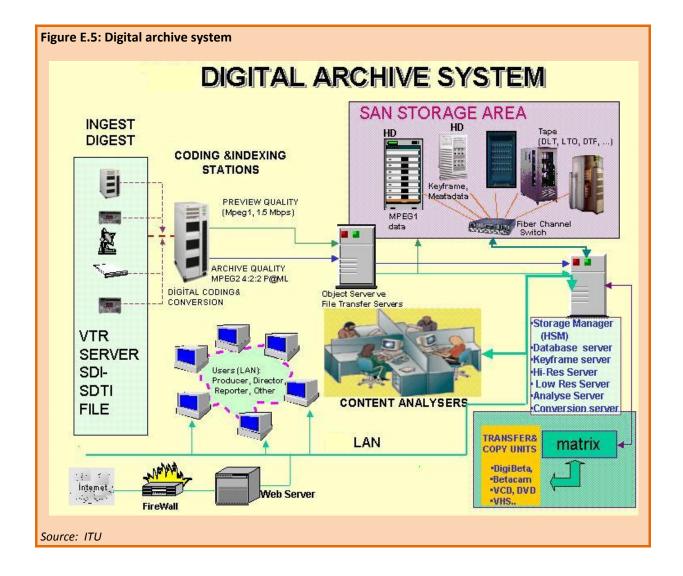
- a single instance of a clip of material, or
- a bounded group of instances of clips of related material.

The Basic UMID is mandatory for all applications.

The Extended UMID adds "signature" information to the Basic UMID, elements of which enable unique identification at the level of Content Unit. Use of the Extended UMID is optional.

The detailed process and data flow scheme for adding the incoming archive material from various resources to the system and serving the analysed content to the users on different platforms is shown in Figure E.4:





System overview

The general overview of the system is given in Figure E.5.

The phases of ingesting incoming material, analysing the content and presenting to the users need a comprehensive hardware and software solution. Expected minimum functions of the project during these processes are clarified in the following sections. The project shall be formed in an adaptable structure depending upon the rapid developments of hardware and software technology.

There shall be a Key-frame Server, High Resolution Server, Low Resolution Server, Database Server, Content Management Server, Analysis Server, Conversion Server and Web Server in the system for providing presentation and storing of content. The services performed by these servers have to be realized either by separate physical servers or by virtual servers implemented in the same machine.

Content Management and Database Server shall be UNIX Server(s) either configured as clustered or in parallel servers.

Database Management System shall be RDBMS (Relational Database Management System) and OODBMS (Object Oriented Database Management System).

The networking infrastructure is installed on 100 Mbit/s switches over a 1 Gbit backbone. The backbone of network cabling is fibre optic and connection within the rest of the system is via UTP Cat5e cables. The interconnection with other sites is supplied via hired lines serving varying from 128Kbit/s to 512 Kbit/s in different bit rates.

System inputs

Selection of the material to be archived

The 10,000 hours of material will be selected by the Television Archive Committee, according to IPR and priorities. Then, the process of transferring the material to the archiving system and cataloguing will start.

At this step, the user will control the process of recording the archive material coming in from different resources and will add at least the basic metadata (UPID - Unique Program Identifier) needed by the users for reaching the material.

Resources

The System shall be able to accept the material coming from the following resources. The metadata determined by the international broadcast standards and information defining the content will be added to this material.

The system shall have the capacity of recording material coming from (5 different resources) simultaneously.

Tapes

Current archive material

The organization has about 110 000 hours of archive material. Around 10 000 hours of material will be recorded to the system in two years. The resources of these materials will be 1", 1"B, Betacam SP, U-Matic, Telecine players (for film). The video outputs of the machines in legacy archive system are PAL and/or SDI; audio outputs are Analogue Audio and/or SDI Embedded Audio.

Video stream

News studios

There exists a Video Server system with 90 hours of capacity in the News Department. This system includes high-resolution video and its low-resolution (MPEG-1@1.5 Mbit/s) browse copy. The News Archive Department prepares the clips, which will be recorded to the system and transfers them to Betacam SP tapes for archiving.

Bi-directional high-resolution video transmission must be provided between the system and News Video Server. The material produced in News Department should be transferred to the system and the material produced in the system should be transferred to the News Department directly. SDI and/or SDTI format will be used for video. Analogue Audio and/or SDI Embedded Audio format will be used for audio.

There will be an interconnection between the system and the Continuity Studios. SDI and/or STDI format will be used for video transmission. Analogue audio and/or SDI Embedded Audio format will be used for audio transmission.

System

The system fundamentals are given in Figure E.5.

The system is administrated by a content management system, which is a distributed management solution for all media assets and which includes all the applications and tools needed to manage a piece of essence together with its related metadata.

The system administration will be effected using desktop workstations. Since the administrators need access to the full system functionality in order to maintain and supervise smooth performance, all system functions must be managed and controlled from their desktops.

The system shall be able to use local characters, wherever needed, without any problem.

Coding of material

Archive material will be coded both in archive and browse quality simultaneously. Materials will be transferred to the system after this coding process.

Material in archive quality shall be in a format that can be used for production and/or broadcasting. Material in browse quality will be used for easing search, query and edit operations both for Intranet and Internet Users.

Material in archive quality

The material in archive quality shall be coded in "MPEG-2 4:2:2 P@ML 50Mb/s I-Frame Only" format.

But for the efficient usage of storage area, the system should be able to select coding bitrates between 8-50 Mbit/s in "MPEG-2 4:2:2 P@ML" format for each material recorded. In this bitrate range, the GOP structure shall support I, IB, IP, IBPB formats according to the complexity of the video.

Material in browse quality

Different formats will be used for the "Browse Quality", for users in the organisation and Internet users because of network restrictions. For each preview quality, filigree shall be added. This filigree can be any picture file (in tga, gif or bmp format) that will be selected.

"MPEG-1 @ 1.5 Mbit/s" format which can support frame accurate editing shall be used for the browse of internal network users.

Content analysis

The automatic and manual functions during the content analysis process are explained in the following:

Automatic description

Concurrent to the recording of the Essence, the system should provide various possibilities for real-time generation of metadata, such as:

- automatic video analysis (shot-clip detection, key frame extraction;
- UMID generation (Basic UMID, Extended UMID);
- automatic image analysis (face recognition, OCR from screen;
- automatic audio analysis (key word spotting, speaker identification, simple audio classification.

In order to retrieve the incoming material for further analysis, during recording a minimum set of data including name, recording time code, date of feed and other specific information within the feed shall be manually added.

Cataloguing (manual description)

Cataloguing process is carried by cataloguing staff that can access browse copies, key frames and metadata generated up to this point to modify, manipulate and enter new metadata.

Content analysing software shall be supported by all web applications (i.e. IIS/ISAPI, NSAPI, WRB).

In order to provide archive material exchange between broadcasters, metadata sets and attributes shall be compatible with EBU and SMPTE standards (i.e. SMPTE 292M, 330M).

Storage

HSM (Hierarchical Storage Management) represents different types of storage media such as Hard Disk Systems, optical storage, or tape, each type representing a different level of cost and speed of retrieval when access is needed. Incoming material shall be simultaneously encoded in two formats, namely archive quality (i) and browse quality (ii), and stored as explained in this section.

The system storage shall be composed of

- disks configured in RAID structure as on line devices;
- tape library(s) as near-line device(s);
- under the control of HSMS (Hierarchical Storage Management System).

The low and high resolution copies of the material, metadata and key frames shall be kept in above storage devices. Tape library(s) shall be the basic data storage device(s). All data in the system (except data on Tape Libraries, Low Resolution Copies on Hard Disks) shall be backed-up on tape library(s).

For the first two years (10 TB) on-line disk capacity and (250 TB) tape library capacity shall be required. But the System Storage shall be expandable for the future requirements.

Low-resolution copies of material shall be kept on tape library(s) and some part of this material will also be available on disk. Regarding the decreasing cost of storage media due to technological improvements, the system shall be planned to be able to store especially all of the low-resolution copies on disks gradually for future usage.

The data in the system will be allocated in storage units as below:

- Key frame, Metadata: Online storage (Hard Disk; in RAID structure);
- Material in archive quality: Near-line storage (Tape Library) and some part also Online Storage (as in Hi-Res Server Cache for video processing);
- Material in Browse Quality: Near-line storage (Tape Library) and Online Storage (HD).

Storage network shall be configured as hybrid configuration of SAN (Storage Area Network) and NAS (Network Attached Storage) for its extendibility in order to provide high-speed material transmission and backup operations between different storage devices.

Data shall be stored in SAN/NAS system units by a Storage Manager and shall be called and used in an optimum way. System database shall be capable of handling whole metadata stored on Hard Disks and shall be expandable in order to acquire the future requirements.

Security

Content security

Content security includes the steps and precautions to prevent usage of archive content without the permission of the identified authority. The content has to be marked (watermark) in order to express the statue of the material (i.e. whether that programme belongs to the organisation with all its IPR or only for limited usage, etc.). Marking level and marking stage (Input or output) may differ.

Watermark data, proving that material is a property of the organisation, shall be buried within the material; it may be either visible or invisible to the user.

System security

System security will ensure continuity of service of the system, prevent loss of data, and protect against the attacks to the system.

Main security stages shall be:

- Content security: Database server unavailable, key frame server unavailable
- Application security: Service or appliance unavailable
- Operating system security
- Storage security: Online system unavailable, near-online system unavailable
- Network security: network unavailable
- Recovery

With the software policies determined in the security processes, the security includes keeping redundant hardware and backing-up all the data in the system. So, continuity of the services will still be maintained under hardware and software failures.

User services

Each user shall log on to the archive system with a user name and password. Access for each function can be arranged for user and user groups.

Search - Query

Search and Query functions shall provide access to key frame and browse quality material by making dynamic queries over metadata.

Some users prefer to have a very simple query interface — just one single line for full text query. Others want to make use of sophisticated search facilities, limiting the range of the full text query as well as accessing all the attributes of the database scheme and including them in the query. The user interface provided with the Retrieval Client should be flexible and configurable enough to support both user groups, e.g., by providing a configurable search interface that allows entering the following combinations:

- simple full text queries;
- attribute-based queries;
- segment queries, which are full text queries against strata.

User application interfaces should be web based. This will provide all users access to the archive by using standard web browsers without installing any programmes. User interfaces can be rearranged on demand. Dynamic query of the data hold by relating the information saved in the database and defined index space should be able to make queries depending on image similarity along with detailed text based search.

Two hundred users can edit at the same time (concurrently). Users may be able to search and query depending on pattern recognition, face recognition, OCR from screen and voice recognition.

Authorised users shall be able to access material in browse quality (MPEG-1@1.5 Mbit/s). Illegal copy of material in browse quality has to be avoided.

Editing

Users will be able to make editing (cut-edit) by key frames and/or by material in browse quality accessed by search and query. Edit Decision List (EDL) shall be saved and converted to orders.

Two hundred users can edit at the same time (concurrently).

Order

Orders shall be received referring to users' demands after editing process. Orders will be offered to the users with its IPR and price.

The user will be informed after the order is evaluated and prepared.

EDLs formed in editing shall be transformed into orders.

Delivery to Users

Basic output for archive material shall be SDI. The system shall have the capacity of three different SDI outputs simultaneously.

Depending on the media and file format request of the user, different formats may be supported by a conversion service.

Additional options

The System will be offered as per specifications cited and explained above. However, additional options and capacity differences could be examined, as indicated in the following.

Transmission and delivery

SDTI Format for transmission of material in archive quality

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

Conversion service

The Conversion-Delivery Service allows for automatic transcoding between different media formats or file formats. The CMS should provide a well-defined framework for the Conversion Service that allows easy integration of well established third party products into the CMS, thus leveraging the expertise of specialists.

Important application areas for the Conversion Service are:

- Automatic conversion between different production qualities, e.g.
 - MPEG-2 4:2:2P@ML to DV or DV-based and back
- Automatic generation of browsing copies from high quality archiving material, e.g.;
 - MPEG-4 low bit rate video for Internet distribution from high quality digital video
- File format changes for production quality material during some steps of the production chain, e.g.,
 - Migration between OMFI, GXF, MXF, and AAF
 - Migration between WAV and BWF

For the service mentioned above:

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

Preview for Internet users

Key-frame and low quality audio

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

Low quality video and audio

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

Automatic analysis and recognition

Automatic image analysis and pattern recognition

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

Automatic audio analysis and voice recognition

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

Content security

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

Capacity analysis

Storage capacity

Online

How can you scale the system for the capacities given below?

- 30 TB
- 20 TB

For each capacity above:

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

Tape Library

How can you scale the system for the capacities given below?

- 200TB
- 150TB
- 100TB

For each capacity above:

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

User capacity

Browse users

Two hundred users can edit at the same time (concurrently). How can you scale the system for the concurrent users given below?

- 400 users
- 500 users

For each user capacity above:

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

Edit users

Two hundred users can edit at the same time (concurrently). How can you scale the system for the concurrent users given below?

300 users

For each user capacity above:

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

System Inputs and outputs

There shall be a high resolution Server (Hi-Res Server) in the system in order handle Archive quality material both for input and output stages. What is your solution for such a system under the following minimum capacity definition of Hi-res Server?

High-resolution server can be either a file server or a video server. In the first case, the system shall have at least 8 stream converters for import-export processes. In the second case it shall have at least 8 ports that can be dynamically configured whether as inputs or outputs. High-Resolution Servers should have enough storage for archive quality video processes.

System inputs

The system shall have the capacity of recording material coming from 5 different resources simultaneously. How can you scale the system for the number of simultaneous inputs given below?

- 8 inputs
- 10 inputs

For each input capacity above:

- What are the additional hardware and software requirements?
- What is the estimated additional cost?

System outputs

The system shall have the capacity of 3 different SDI outputs. How can you scale the system for the number of simultaneous outputs given below?

- 5 outputs
- 8 outputs

For each output capacity above:

- What are the additional hardware and software requirements?
- What is the additional marginal cost?

Attachment 2 to Annex E – Archiving showcase project⁴⁴³

"Preserving the Archives"

Quite often, broadcasters (including public service broadcasters) are called upon to help in preservation of national records of historic value. Additionally, organising and preserving audio-visual archiving material is one of the most urgent needs of broadcasters. Generally, most of the broadcasters need expertise and assistance in setting up of cost-effective methods of setting up archiving facilities. They also need help in developing a practical search and evaluation methodology (based on a metadata schema) to be able to manage and harvest the archives.

In absence of suitable archiving facility to safeguard and preserve the archives, loss of entire episodes of the national heritage takes place in a short span of time. Responding to this call, the Asia-Pacific Broadcasting Union set up a cooperative initiative with the UNESCO to showcase implementation of a digital archive in South Asia and sharing the results with other broadcasters in the region.

The principal objective of the Archiving Project was to implement a digital archive from the ground up and showcase it to other broadcasters in Asia-Pacific. The project educated archivists, production and programming teams with proper information on the steps involved in digitally archiving audio-visual content. It also helped train staff and disseminate information on the pilot scheme and through a workshop to contribute to the spread of know-how amongst other broadcasters in the region.

In implementing the project, a relatively smaller broadcaster (Bhutan Broadcasting Service) was selected to set up an archiving facility from "ground level up". A part of their analogue archives library was converted to digital for the purposes of demonstration. All the steps in the process were documented. Training was provided on cataloguing the archiving content and in establishing a database for retrieval. Training was provided on identifying fresh archive material. This project was used as a showcase for informing and training other smaller broadcasters in the region to allow them to share findings. All the material was documented as reference material.

As a part of the project, a workshop helped participants from other developing countries to view the pilot project, so that they can see for themselves the process of implementing a digital archive and also to inform them of the various steps taken. In parallel, participants received training on setting up a metadata system for cataloguing their archives, providing immediate access due to the content.

In preparation for the project, two experts (with considerable expertise in content, cataloguing, technical and data retrieval aspects of digital archiving) initially set up a detailed proposal for this project. The project was executed on the basis of the blue print prepared by the experts and completed in 9 months.

Objectives

- 1. To expose the staff of broadcasters to modern archiving concepts, methods and practices.
- 2. Skills of archivists, content creators, content managers, archiving engineers to be enhanced in this area.
- 3. Convert existing analogue archives library to digital.
- 4. Set up a showcase on this project to transfer expertise other smaller broadcasters.
- 5. To enhance the capacity, expertise and ability of developing country media to successfully digitally archive their content.

This project was jointly conducted by the UNESCO and the Asia-Pacific Broadcasting Union (ABU) in 2009-2010 in BBS, Bhutan.

Deliverables

- Training on cataloguing content and establishing a database for retrieval.
- Training on identifying fresh archive material.
- Workshop to share findings and enhance archiving skills.
- A group of archivists, content creators, content managers, archiving engineers with considerable experience all spheres of archiving.

Budget

The project, including the training complement, was completed with an expenditure of around USD $35\,000.00$

Attachment 3 to Annex E - Archiving in Vietnam

The Voice of Vietnam sets up its archives

Some 30 000 hours of analogue audio tape were stored in the archives of the radio broadcaster *The Voice of Vietnam* (VoV) – including unique recordings of prominent leaders, performances by the VoV orchestra and in-house radio drama productions. Because of their age and the tropical climate, these tapes were on the verge of decay and badly in need of restoration and proper storage.

In 2003, the Deutsche Welle-Akademie ⁴⁴⁴ (<u>www.dw-akademie.de</u>) began advising the Vietnamese state broadcaster, the Voice of Vietnam (VOV), on how to digitise its audio archives. Over a six-year period, external specialists introduced their Vietnamese colleagues to new archiving technologies (now standard in most parts of the world). Together, they planned and created a digital archive in Hanoi. Located in Hanoi, Vietnam, the project took 6 years to complete, from 2003 – 2008. Public broadcaster, Radio The Voice of Vietnam (VOV) partnered with the DW-Akademie on the implementation project. The work focused on the areas of modern radio technology, studio technology, measurement technology, electronics, network technology, digital archiving and new media.

Though the consulting project was completed in mid-2008, but the process of digitizing the tapes is expected to take until 2015. Nearly all the recordings have been saved – preserving some of Vietnam's priceless cultural heritage.

453

⁴⁴⁴ DW-AKADEMIE is Deutsche Welle's international centre for media development, media consulting and journalism training.

Attachment 4 to Annex E – UNESCO facilitates archiving activity 445

Audio-visual documents, such as films, radio and television programmes, audio and video recordings, contain the primary records of the 20th and 21st centuries.

Transcending language and cultural boundaries, appealing immediately to the eye and the ear, to the literate and illiterate, audio-visual documents have transformed society by becoming a permanent complement to the traditional written record. However, these are extremely vulnerable and it is estimated that the world has no more than 10 to 15 years to transfer audio-visual records to digital to prevent their loss. Much of the world's audio-visual heritage has already been irrevocably lost through neglect, destruction, decay and the lack of resources, skills, and structures, thus impoverishing the memory of mankind. Much more will be lost if stronger and concerted international action is not taken. It was in this context that UNESCO set up a mechanism to raise general awareness of the need for urgent measures to be taken and to acknowledge the importance of audio-visual documents as an integral part of national identity.

The UNESCO programme seeks to preserve the audio-visual heritage comprising film, television and sound recordings. UNESCO objective is the development of audio-visual archival infrastructure, trained professionals and accepted professional reference points to ensure the safeguard and preservation of the audio-visual heritage of humanity. Working in close cooperation with the seven NGOs which make up the Co-ordinating Council of Audio-visual Archives Associations (CCAAA), the Organisation supports the production policy statements and position papers on key issues such as copyright, legislation and technical standards; promotes the exchange of information on audio-visual issues and implements projects in support of audio-visual archiving throughout the world.

The Co-ordinating Council of Audio-visual Archives Associations is an umbrella group of organisations whose primary objective is the support of professional audio-visual archive activities, and whose membership is primarily institutional and international (worldwide or regional). Its current members are:

Specialist NGOs:

- AMIA Association of Moving Image Archivists
- FIAF International Federation of Film Archives
- FIAT/IFTA International Federation of Television Archives
- IASA International Association of Sound and Audio-visual Archives
- SEAPAVAA Southeast Asia-Pacific Audio Visual Archives Associations

General:

- ICA International Council on Archives
- IFLA The International Federation of Library Associations and Institutions

UNESCO publishes regularly specialist studies and guidelines, which cover basic issues of records and archives management such as:

- Archival infrastructure development
- Archival legislation
- Training and education
- Protection of the archival heritage
- Research in archival theory and practice

-

www.unesco.org/new/en/

Annex F – Television broadcasting via satellite

The main focus of the ITU Guidelines is the transition from analogue to digital terrestrial television. The additional information on satellite TV (television broadcasting via satellite), IPTV, cable TV and broadcasting via telecommunication networks is intended to obtain insight in the prospects of alternative means of television delivery. These alternative delivery means may have an impact on DTTB (digital terrestrial television broadcasting) and ASO (analogue switch-off) regulation and on market and business development regarding the DSO (digital switch-over) process.

This annex describes the features of satellite delivered TV services. Other aspects, like considerations on satellite link used for DTTB signal distribution are reflected in Section C1 of Annex C where the impact of Sun spot outage and propagation delay in satellite path on the DTTB signal distribution are described.

The guidelines in this Annex F focus on the broader strategic and operational questions of satellite TV. The guidelines do not attempt to provide the technical solutions to satellite architecture because those solutions will depend very much on local needs, policies and available funds. Further assistance with identification of technical solutions is widely available from satellite manufacturers, broadcasting organizations, and other sources.

F.1 Introduction

The main features of satellite TV delivery in terms of advantage and disadvantage are as follows:

Advantages

- (1) Wide bandwidth: By exploiting the advantage of wide bandwidth, high quality broadcasting like HDTV and UHDTV (Ultra HDTV) with 5.1 or multi-channel sound services are possible.
- (2) Wide coverage area: A much wider coverage area is achieved with a satellite at once compared to DTTB (digital terrestrial television broadcasting).
- (3) Rapid set-up and ease of reconfiguration 446
- (4) Low cost: Since a wide area can be covered by a satellite, the transmission cost is, in general, much lower than the terrestrial broadcasting.
- (5) Initiation of new services: Since new spectrum and new orbital positions are available for the satellite TV, it is easier (as compared to DTTB spectrum) to initiate new services like UHDTV, 3DTV (3 Dimensional TV) etc.

Disadvantages

Disauvantage

- (1) Vulnerable to rain attenuation: Disruption of services due to the rain attenuation caused by heavy rain in the band above 10 GHz, particularly in low latitude areas.
- (2) Difficult to provide local programmes: A complicated and huge satellite system may be needed for satellite TV that provides local programmes for each individual small local areas.

⁴⁴⁶ Gerard Maral and Michel Bousquet – Satellite Communications Systems, 5th Edition, John Wiley and Sons, 2009

Taking the above features into account, satellite TV or a satellite in general is considered to have the following roles depending on the requirements and objectives.

- Providing new services and programmes in addition to the terrestrial broadcasting. In this case, the satellite TV can be competitive to DTTB or supplement the DTTB coverage. The TV programmes may or may not be provided by the contents providers for terrestrial broadcasting.
- Providing means to achieve a 100 per cent coverage of the intended DTTB service area. It is said
 that although depending on the situations of a country, the expense of providing DTTB coverage
 to the last 10 per cent of the population can be more costly than to the first 90 per cent of the
 population 447. In order to properly cover the low signal DTTB reception areas, the DTTB
 programmes are re-transmitted by a satellite.
- Feeding the TV programmes directly from a satellite to DTTB transmitter sites as the distribution network. Considerations on satellite link used for this purpose are described in Section C1 of the Annex C which includes impact of sun spot time outage and propagation delay in satellite path on the DTTB signal distribution.

This annex examines the regulations/procedures, facilities required in broadcasting stations, business and technical issues of satellite TV, as well as the issues of the cease of analogue satellite TV in conjunction to DTTB.

F.2 ITU Radio Regulations, Procedures

The satellite TV is categorized in two types; DTH (Direct To Home) by GSO (Geostationary Satellite Orbit) FSS (Fixed Satellite Service) and BSS (Broadcasting Satellite Service). Table F.1 shows the allocation of frequencies to FSS and BSS in RR (Radio Regulations), which could be used for satellite TV.

Table 1.1. Allocation of frequencies to 030 133 (space-to-Laitif) and 033 iii NN	Table F.1: Allocation of free	auencies to GSO FSS	(space-to-Earth	and BSS in RR ⁴⁴⁸
--	-------------------------------	---------------------	-----------------	------------------------------

Frequency	Nomenclature	Region 1	Region 2	Region 3
2500-2520 MHz	S band		FSS	FSS
2520-2535 MHz	S band	BSS	FSS, BSS	FSS, BSS
2535-2655 MHz	S band	BSS	FSS, BSS	BSS
2655-2670 MHz	S band	BSS	FSS, BSS	FSS, BSS
3400-4200 MHz	C band	FSS	FSS	FSS
10.7-11.7 GHz	Ku band	FSS	FSS	FSS
11.7-12.2 GHz	Ku band	BSS	FSS	BSS
12.2-12.5 GHz	Ku band	BSS	BSS	FSS
12.5-12.7 GHz	Ku band	FSS	BSS	FSS, BSS
12.7-12.75 GHz	Ku band	FSS		FSS, BSS
17.3-17.7 GHz	Ka band	FSS	BSS ⁴	
17.7-17.8 GHz	Ka band		BSS ⁴	
21.4-22.0 GHz	Ka band	BSS		BSS

⁴⁴⁷ DigiTAG – Guide to Digital Switchover, ver.1, 2013

In many cases, these allocations are not on an exclusive basis.

In order to use the frequencies and the orbital positions for satellite TV, international or regional agreements are necessary. For the use of FSS in Table F.1 and BSS not subject to a plan in the band 2520-2670 MHz in all Regions, 12.5-12.75 GHz in Region 3, provisions of Article 9 (Coordination), Article 11 (Notification), Article 21 (Sharing with terrestrial services) and Article 22 (Cessation of emissions, Station keeping of space stations, etc.) of the RR are applied. The satellite network has to be brought into use within 7 years from the submission of the advance publication.

For the use of BSS subject to a plan (11.7-12.5 GHz in Region 1, 12.2-12.7 GHz in Region 2, 11.7-12.2 GHz in Region 3), the provisions of AP30 (Appendix 30 to RR) is applied and no coordination is necessary. For the modification of the Region 2 plan or for the additional uses (List) in Regions 1 and 3, Article 4 (Procedures) and Article 5 (Notification, examination, recording in the MIFR (Master International Frequency Register)) of AP30 are applied. The satellite network has to be brought into use within 8 years from the submission of the relevant information listed in Appendix 4 (AP4). Regulations for feeder-link in the bands 14.5-14.8 GHz (Region 3) and 17.3-18.1 GHz in all Regions are given in AP30A.

For the use of BSS not subject to a plan in the band 21.4-22.0 GHz ⁴⁴⁹, WRC-12 (World Radiocommunication Conference 2012) Resolutions 552 (Due Diligence), 553 (Special procedure applied once for the first submission), 554 (Power flux density mask as threshold for triggering coordination), 555 (Alignment of technical parameters) are applied as well as the provisions of Article 9, Article 11, Article 21 and Article 22 of the RR. The satellite network has to be brought into use within 7 years from the submission of the advance publication information (API).

Note that the provision of 23.13 of the RR applies to all BSS networks regardless of subject or not subject to plan. That means an Administration has a right to request the exclusion of its territory from the proposed service area or the removal of test points⁴⁵⁰, if the submitted satellite network includes the Administration's territory in the service area or puts its test points on its territory. Requests for the exclusion from BSS service area requested by Administrations are published on the web site of the ITU-R SNL (Space Network List)⁴⁵¹.

Regarding the BSS band licence issues, similar to the DTTB, national regulators should determine the number of multiplexes or services that a single operator can provide, the process for licence renewals (duration), coverage requirement and public service broadcast obligations.

Regarding the FSS band, licence is issued by an administration with satellite parameters in conformity with the international or regional agreements.

F.3 Satellite network design principles and roll-out planning

F.3.1 System parameters

The system parameters of the BSS in the plan band are specified in Article 10 (Region 2) and Article 11 (Regions 1 and 3) of AP30 (downlink), and in Article 9 (all Regions) of AP30A (feeder-link). The downlink parameters are (1) Orbital position of satellite, (2) Boresight of space station antenna beam, (3) Radiation pattern and antenna gain of space station antenna, (4) Radiation pattern and antenna gain of Earth station antenna, (5) Polarization, (6) e.i.r.p. (Equivalent Isotropically Radiated Power) of space station and (7) Bandwidth. Under assumed free-space propagation conditions, the power flux-density of a proposed new or modified assignment in the List shall not exceed the value of $-103.6 \, \mathrm{dB}(\mathrm{W}/(\mathrm{m}^2 \cdot 27 \, \mathrm{MHz}))$.

⁴⁴⁹ Report ITU-R BO.2071. Recommendation ITU-R BO.1659, BO.1776, BO.1785.

⁴⁵⁰ Service area is defined by a contour of a certain level of the antenna radiation pattern or a country symbol or a name of Region (Region 1 for example). Test points are put for defining the points on which interference analysis is carried out and define the service area accordingly.

www.itu.int/ITU-R/go/space/snl/en

The feeder-link parameters are (1) Orbital position of satellite, (2) Boresight of space station antenna beam, (3) Radiation pattern and antenna gain of space station antenna, (4) Radiation pattern and antenna gain of Earth station antenna, (5) Polarization, (6) e.i.r.p. of Earth station and (7) Bandwidth. The maximum permitted power levels for unwanted emissions in the spurious domain are specified in AP3 of the RR. Under assumed free-space propagation conditions, the power flux-density of a proposed new or modified assignment in the feeder-link List shall not exceed the value of – 76 dB(W/($m^2 \cdot 27 \text{ MHz}$)) at any point in the geostationary-satellite orbit.

The system parameters of the modification or the additional uses (List) of BSS in the plan band or BSS not subject to plan or FSS are determined by international agreement, i.e., coordination with concerned Administrations.

F.3.2 Network architecture and planning

Satellite TV networks are one-way networks and are classified as a star architecture ⁴⁵². The reception is individual (DTH) or collective (head-end of cable TV or re-transmission of DTTB). The flow of signal is programme providers – multiplexing centre – transmitting Earth station (feeder-link) – satellite – homes (DTH), head-ends of cable TV or re-transmission of DTTB.

Design life of a satellite is about 15 years. It takes several years of preparing spacecraft specifications, developing request-for-proposals (RFP), RFP evaluation, and ordering and construction of the spacecraft. Therefore, new satellites are put into space about every 15 years. The Earth station facilities may also be updated every 15 years in order to introduce newly evolved technologies. A back-up satellite is necessary to stably provide the services. In addition to procurement of satellite and Earth station facilities, the preparation for licence including international coordination should be carried out.

F.3.3 Satellite interference

The permissible interference level of BSS in the plan band are specified in AP30 (downlink) and AP30A (feeder-link). For the protection of digital downlink assignments from digital emissions, the protection value of 21 dB (co-channel signals) is applied for calculation of EPM (Equivalent Protection Margin) for Regions 1 and 3 plan. For the threshold for triggering coordination, the pfd (power flux density) masks are specified in AP30. An administration in Region 1 or 3 is considered as not being affected if either of the two conditions (pfd mask and EPM criterion) is met. The pfd thresholds for the interference cases other than the BSS's are shown in AP30.

Similar regulations in AP30A are applied for the feeder-link in the band 17.3-18.1 GHz. An administration in Region 1 or 3 is not considered as being affected if, under assumed free-space propagation conditions, the effect of the proposed new or modified assignments in the feeder-link List is that the feeder-link equivalent protection margin corresponding to a test point of its assignment in the feeder-link plan or the feeder-link List or for which the procedure of Article 4 has been initiated, including the cumulative effect of any previous modification to the feeder-link List or any previous agreement, does not fall more than 0.45 dB below 0 dB, or, if already negative, more than 0.45 dB below the reference value. The other interference cases are also shown in AP30A (T/T criterion).

F.3.4 Feed for terrestrial television stations via satellites

Some TV services / programmes are directly fed from a satellite to terrestrial transmitter sites which act as a part of terrestrial transmission network. These are often found in rural and remote areas which are at distances beyond which terrestrial delivery of the original service is possible. Important features in these

458

⁴⁵² ITU-R: Handbook on Satellite Communications, Third Edition, John Wiley & Sons, 2002. or www.itu.int/pub/R-HDB-42-2002

networks are to properly re-transmit the original TV services / programmes, i.e. to reconstruct the same transmission signals as the original terrestrial system at the re-transmitter sites. This includes such features as wide screen signalling, reproduction of ancillary data, EPG, CAS (if required) keeping the audio and video quality as high as possible. Beyond network design there would be a number of issues for reception of the re-transmitted signals and the correct configuration / set up of DTV receivers, if the re-transmitted signals are different from those applied in the DTTB services.

F.4 Facilities in broadcasting stations

Several facilities in a digital broadcasting station or transmitting Earth stations (feeder-link) for satellite TV have to be installed, as required for the types of services planned. An example of the services that may require specific facilities, is given as follows.

- (1) HDTV and SDTV simultaneous transmission.
 - A capacity which accommodates a full quality HDTV programme can transmit multi SDTV programmes. By utilizing this large capacity, it is possible to transmit an HDTV programme with a little reduced quality (e.g. for scheduled programme) and an SDTV programme (e.g. for prolonged sports match) simultaneously in the same channel capacity.
- (2) 5.1 channel surround sound.
- (3) EPG (electronic programme guide).
- (4) Data broadcasting (ancillary service).
- (5) EWBS (emergency warning broadcasting system)⁴⁵³.
- (6) Receiver upgrade by software (SSU: system software upgrades).
- (7) Hierarchical transmission (graceful degradation) in order to avoid service disruption on the occasion of large rain attenuation.
- (8) CAS (conditional access system).
- (9) Site diversity for feeder-link, backup station.

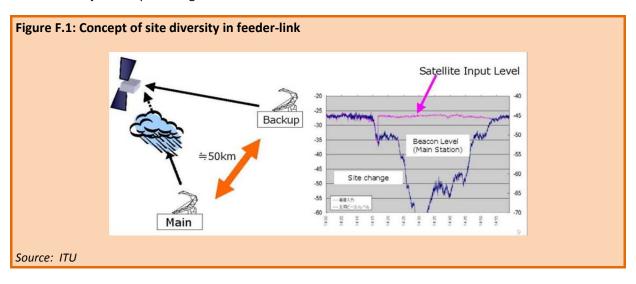
In order to avoid the disruption of feeder-link signal due to the rain attenuation, a backup transmitting earth station is also established and one of the two Earth stations is selected according to the rain situation (Figure F.1). The site diversity gain can be calculated by using Recommendation ITU-R P.618- 10^{454} . An example of the site diversity gain in the feeder-link in the 17 GHz band is shown in Figure F.2 with parameters in Table F.2. It is obvious in Figure F.2 that the distance of 10 km between two feeder-link stations is enough for the site diversity in terms of site diversity gain. However, in actual operation, the switching period should be considered. If the distance between two feeder-link earth stations is 10 km, it has to be switched in a short time, since the rain area moves at a speed of 30 km/h to 70 km/h and the large rain attenuation travels in several 10 minutes for 10 km. The longer the distance is, the more reliable the feeder-link is. But the longer distance needs higher link transmission cost. As such, the distance of about 50 km seems appropriate from a practical view point.

Recommendation ITU-R BT/BO.1774-1 Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief.

Asia Pacific Broadcasting Union (ABU) – Handbook on EWBS, June 2009. www.abu.org.my/upload/EWBS_Handbook.pdf

Recommendation ITU-R P.618-10 Propagation data and prediction methods required for the design of Earth-space telecommunication systems. 2.2.4.2 Diversity gain.

In case the total loss of facilities of earth station caused by enormous disaster, a backup station may be needed. In this case the geographical separation required between the two earth stations is much larger than that for just compensating the rain attenuation.



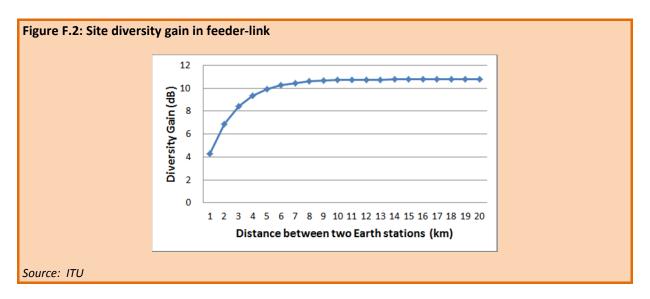


Table F.2: Parameters in feeder-link (See Rec. ITU-R P.618-10, p.11, 2.2.4.2)

Frequency (GHz)	17.6
Rain attenuation (dB)	19.66
Time percentage in a year (%)	0.01
heta: path elevation angle (degrees)	38
ψ : angle (degrees) made by the azimuth of the propagation path with respect to the baseline between site	0

F.5 Satellite TV policies and framework

The revenues for the broadcasters or platform, TV programmes, etc. are different from country to country, depending on the policies for satellite TV.

- FTA (free-to-air) or pay TV: Revenue is from license fee, payment direct generated through services, indirectly from advertisement. It is difficult especially for public broadcasters and FTA broadcasters to migrate from SDTV to HDTV once the multi SDTV services have started. It is desirable and possible to introduce directly HDTV from the beginning, especially for the free-to-air or public broadcasters yet started digital satellite TV.
- TV programmes provided by broadcasters: This issue strongly depends on the policies in a country whether providing the same TV programmes as the terrestrial broadcasting (simulcast of DTTB), different TV programmes or more services in addition to DTTB.
- CAS (conditional access system) and CRP (Copy Right Protection): This is not the issue pertaining only to satellite TV, but for satellite TV it may be important for the broadcasters to retain control over the receivers with specific CAS. Also the mechanism to enforce CRP is important.

The technical parameters below should be investigated within the framework of setting up new services:

- (1) Picture presentation format (or production format)
- (2) Transmission system including modulations, code rates, hierarchical transmission
- (3) Multiplexing
- (4) Channel capacity
- (5) Transmission bandwidth
- (6) Service availability
- (7) CAS

F.6 Consumer Side, Receivers, Technical Issues

Digital television systems for satellite TV⁴⁵⁵ are specified in a number of ITU-R documents⁴⁵⁶. Common receivers for DTTB and satellite TV, that is, functions for the both services equipped in only one receiver, are desirable in order for the consumer convenience. Full penetration of such common receivers is important to cease analogue terrestrial and satellite TVs.

Service availability can be calculated by using, for example, PROPAGATION Dynamic Link Library⁴⁵⁷ provided by CNES (*Centre National d'Etudes Spatiales*).

F.7 Equipment Availability

Equipment for Earth station transmitters and receivers for DVB-S (System A), DSS (System B), GI-MPEG-2 (System C), ISDB-S (System D) and DVB-S2 is available in the market.

DVB-S (System A), DSS (System B), GI-MPEG-2 (System C), ISDB-S (System D), DVB-S2 (System E) described in Recommendation ITU-R BO.1784.

⁴⁵⁶ Report ITU-R BO.1227, BO.2008-1, BO.2101. Recommendation ITU-R BO.1408, BO.1516, BO.1784.

www.itu.int/ITU-R/index.asp?category=study-groups&rlink=rsg3-software-ionospheric&lang=en, or http://logiciels.cnes.fr/PROPA/en/logiciel.htm

F.8 Cease of analogue television broadcasting via satellite

In general, with satellite TV it is easier to initiate digital broadcasting compared to terrestrial broadcasting. For broadcasters, it may be desirable to first start the digital satellite TV, then start DTTB, in order to divide the investment to digitalization with a certain time interval, for example, a couple of years. In implementation of satellite TV, while the roadmap may follow the same pattern as that for DTTB, some critical elements are somewhat different. In order to make use of a satellite platform, it is either required to launch a satellite (which could take three to four years for the satellite procurement, more than seven or eight years from the initiation of international satellite coordination), or hire satellite payload capacity on a functional satellite. In order to cease the analogue satellite TV (analogue DTH) smoothly, as same as in the case of terrestrial broadcasting, aid by government, public relations and providing enough information to viewers are essentially important.

F.9 Future issues

After ceasing satellite TV, the vacant spectrum, which was used by analogue, is possible to be used by new comers (broadcasters) or by new services like UHDTV and 3DTV, or used to migration to new broadcasting systems employing the newest technologies (H.265, etc.).

The satellite platform provides a higher payload capacity per channel than the DTTB platform. This factor will be useful to deliver new services with a high flexibility. This factor needs to be kept in view while planning for introduction of the new services.

F.10 Conclusions

The migration from analogue to digital technology on the satellite TV, similar to the terrestrial TV, provides opportunities for increasing TV qualities and new services. Viewers have increased choice, not only in terms of the high quality of television offered, but also with the type of services offered.

The efficient use of spectrum by digital broadcasting can make frequencies available for new entrants and services. The digital migration increases the economic viability of the satellite broadcasters. It can also provide a means of distribution of terrestrial programmes to its transmitter sites, or play a role of compensation for DTTB in the poor reception area.

For the future issues, the satellite TV continues evolving technical innovations and satisfying the viewer's needs.

Bibliography

Report ITU-R BO.1227-2 Satellite broadcasting systems of integrated services digital broadcasting

Report ITU-R BO.2008-1 Digital multiprogramme broadcasting by satellite

Report ITU-R BO.2071-1 BSS System parameters between 17.3 GHz and 42.5 GHz and associated feeder links

Report ITU-R BO.2101 Digital satellite broadcasting system (television, sound and data) with flexible configuration

Recommendation ITU-R BO.1408-1 Transmission system for advanced multimedia services provided by integrated services digital broadcasting in a broadcasting-satellite channel

Recommendation ITU-R BO.1516 Digital multiprogramme television systems for use by satellites operating in the 11/12 GHz frequency range

Recommendation ITU-R BO.1659-1 Mitigation techniques for rain attenuation for broadcasting-satellite service systems in frequency bands between 17.3 GHz and 42.5 GHz

Recommendation ITU-R BT/BO.1774-1 Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief

Recommendation ITU-R BO.1776-1 Maximum power flux-density for the broadcasting-satellite service in the band 21.4-22.0 GHz in Regions 1 and 3

Recommendation ITU-R BO.1784 Digital satellite broadcasting system with flexible configuration (television, sound and data)

Recommendation ITU-R BO.1785 Intra-service sharing criteria for GSO BSS systems in the band 21.4-22.0 GHz in Regions 1 and 3

Recommendation ITU-R P.618-10 Propagation data and prediction methods required for the design of Earth-space telecommunication systems.

Gerard Maral and Michel Bousquet – Satellite Communications Systems, 5th Edition, John Wiley and Sons, 2009

DigiTAG – Guide to Digital Switchover, ver.1, 2013.

ITU-R: Radio Regulations, Edition of 2012.

ITU-R: Handbook on Satellite Communications, Third Edition, John Wiley & Sons, 2002. or www.itu.int/pub/R-HDB-42-2002

Asia Pacific Broadcasting Union (ABU): Handbook on EWBS, June 2009. www.abu.org.my/upload/EWBS Handbook.pdf

Dynamic Link Library (DLL) for calculation of propagation losses for Earth to space (or space to Earth) transmission links, www.itu.int/ITU-R/index.asp?category=study-groups&rlink=rsg3-software-ionospheric&lang=en, or

CNES, PROPAGATION Dynamic Link Library, http://logiciels.cnes.fr/PROPA/en/logiciel.htm.

List of abbreviations

ABU	Asia-Pacific Broadcasting Union
AP	Appendix
ASO	Analogue Switch Off
BSS	Broadcasting Satellite Service
CAS	Conditional Access System
CRP	Copy Right Protection
DTH	Direct To Home
DTTB	Digital Terrestrial Television Broadcasting
DVB	Digital Video Broadcasting
e.i.r.p.	Equivalent Isotropically Radiated Power
EPM	Equivalent Protection Margin
EWBS	Emergency Warning Broadcasting System
FSS	Fixed Satellite Service
GSO	Geostationary Satellite Orbit
HDTV	High Definition Television
UHDTV	Ultra High Definition Television
ISDB	Integrated Services Digital Broadcasting
ISDB-S	Integrated Services Digital Broadcasting-Satellite
MIFR	Master International Frequency Register
pfd	power flux density
RR	Radio Regulations
SDTV	Standard Definition Television

Annex G – Television delivery via cable TV networks and IPTV

This Annex has been prepared as a supplement to the ITU Guidelines on the Transition from Analogue to Digital Broadcasting. Consistent with the approach taken in these Guidelines, this Annex provides additional information on IPTV, cable TV and broadcasting via telecommunication networks to give insight in the prospects of means of television delivery. These delivery systems may have an impact on DTTB (digital terrestrial television broadcasting) and ASO (analogue switch-off) regulation and on market and business developments regarding the DSO (digital switch-over) process.

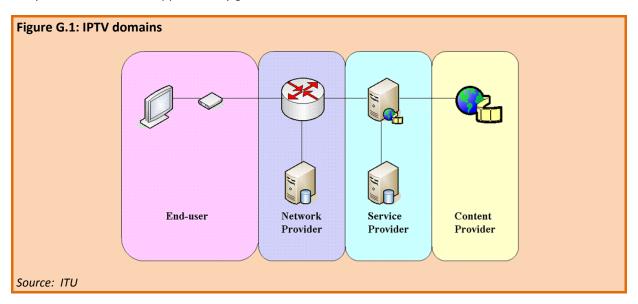
This Annex focuses on the broader concept of IPTV and cable TV networks as complementary or competing platforms to DTTB and does not attempt to provide the technical solutions to install means of television delivery. Further assistance with identification of technical solutions is widely available from ITU and other sources.

G.1 Introduction

The "IPTV service" and "cable TV service" deliver video content over IP networks and cable networks, respectively. Although a variety of delivery methods and service models can be identified for the delivery of video content via the IPTV or cable TV, this Annex focuses on services that can be considered as complementary or competing means to deliver broadcast programmes.

G.2 IPTV domains

Figure G.1 shows the main domains that are involved in the provision of an IPTV Service. Please note that these domains do not define a business model and the description does not preclude that one provider may be involved in the support of any given IPTV service across more than one domain.



The four IPTV domains are described below:

Content Provider: The entity that owns or is licensed to sell content or content assets.

Network Provider: The organization that maintains and operates the network components required for IPTV functionality. A network provider can optionally also act as service provider.

Service Provider: It is a general reference to an operator that provides telecommunication services to customers and other users, either on a tariff or contract basis. A service provider may or may not operate a network. A service provider can optionally be a customer of another service provider. Typically, the service provider acquires content rights from content providers and packages this into a service that is

consumed by the end-user. Although considered as two separate entities, the service provider and the Network Provider may in fact be one organizational entity.

End User: An individual consumer, organization, or telecommunication system that accesses the network in order to communicate via the services provided by the network. An end-user is not necessarily a subscriber

Recommendation ITU-T J.700 describes the service requirements and functional framework architecture for support of IPTV services to provide enhanced broadcasting, where broadcast programmes are delivered over existing cable-based secondary distribution networks composed of HFC or FTTx with some enhancements by applications and/or services provided over IP-enabled networks. It addresses the service requirements, use cases and functional components required to support these requirements.

G.3 Cable TV

Cable TV distributes television programmes to subscribers via radio frequency (RF) signals transmitted through coaxial cables or fibre-optic cables. Aural content, high-speed Internet, telephone service, and similar non-television services may also be provided through these cables.

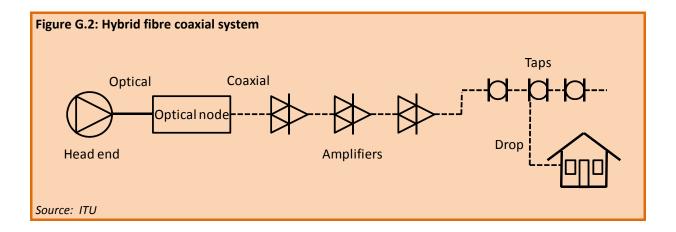
In the most common system, a number of television channels are distributed to subscriber residences through a coaxial cable, which comes from a trunk line supported on utility poles originating at the cable company's local distribution facility, called the head end. Multiple channels are transmitted through the cable by frequency division multiplexing. At the head end, each television channel is translated to a different frequency. By giving each channel a different frequency "slot" on the cable, the separate television signals do not interfere.

At the subscriber's residence, either the subscriber's television set or a set-top box provided by the cable company decodes the desired channel to display on the TV screen. In modern digital cable systems the signals are encrypted, and the set-top box must be activated by an activation code sent by the cable company before it will function, which is only sent after the subscriber signs up. There are also usually "upstream" channels on the cable, to send data from the customer set-top box to the cable head end, for advanced features such as requesting pay-per-view shows, cable internet access, and cable telephone service. The "downstream" channels occupy a band of frequencies from approximately 50 MHz to 1 GHz, while the "upstream" channels occupy frequencies of 5 to 42 MHz. Subscribers can choose from several levels of service, with "premium" packages including more channels but costing more.

At some of local head ends, the feed signals from the individual television channels are received by dish antennas from satellites or by fibre networks. Additional local channels, such as local terrestrial broadcast television stations are usually included on the cable. Commercial advertisements for local business are also inserted in the programming at the head end.

G.3.1 Hybrid fibre coaxial systems

Modern cable systems are large, with a single network and head end often serving an entire metropolitan area or county. Most systems use hybrid fibre coaxial (HFC) distribution (Figure G.2); this means the trunk lines that carry the signal from the head end to local neighbourhoods are optical fibre to provide greater bandwidth and also extra capacity for future expansion. At the head end the radio frequency electrical signal carrying all the channels is modulated on a light beam and sent through the fibre. The fibre trunk line goes to several distribution hubs, from which multiple fibres fan out to carry the signal to boxes called optical nodes in local communities. At the optical node, the light beam from the fibre is translated back to an electrical signal and carried by coaxial cable distribution lines on utility poles, from which cables branch out to subscriber residences.



G.3.2 Other cable-based services

Coaxial cables are capable of bi-directional carriage of signals as well as the transmission of large amounts of data. Cable television signals use only a portion of the bandwidth available over coaxial lines. This leaves plenty of space available for other digital services such as cable internet, cable telephony and wireless services, using both unlicensed and licensed spectrum.

G.4 IPTV and cable TV services

There are a number IPTV and cable TV services with different characteristics from an end-user's perspective. Among them, broadcast services, on-demand services, public services, and retransmission service are described in this clause.

G.4.1 Broadcast services

Broadcast services comprise a one-way transmission of content from one point (the source) to two or more points (the receivers), whereas the end-user has no control over the content or timing of what he receives, apart from the ability to select a particular channel.

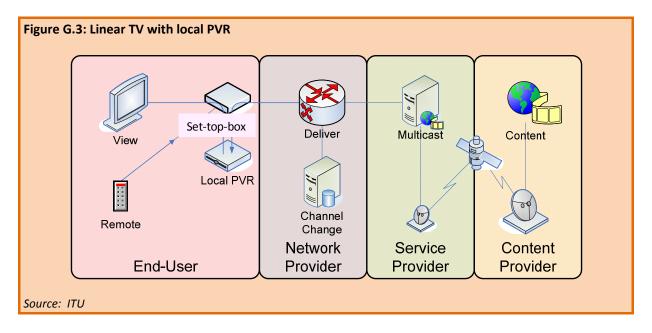
G.4.1.1 Linear TV

Linear TV is a broadcast TV service that is the same as the classic form of television services that are provided by cable, terrestrial and direct-to-the-home satellite operators, where the programme content is transmitted according to a defined schedule and is intended for real-time consumption by the end-user. The service therefore provides an essentially continuous stream flowing from the content provider to the terminal device located in the end-user network.

Linear TV includes (but is not necessarily limited to) the following approaches:

- **Linear TV with audio and video:** Audio and video (audio-visual) signals are transmitted and distributed to the downlink without control of the broadcaster.
- **Audio only:** Audio signals are transmitted and distributed to the downlink without control of the broadcaster.
- Linear TV with audio, video, and data: Audio and video services are supplemented by interactive data for the related or supplementary information of A/V programmes. If uplink is available, the end-user can access more detailed or value-added information.

Linear TV can be recorded by the end-user using Personal Video Recorders (PVR) either in standalone attached to set-top-boxes or in the home network. Figure G.3 shows an example of a Linear TV service with local PVR capabilities. The PVR can support "time-shift" viewing.



G.4.1.2 Pay-per-view (PPV)

Pay-per-view (PPV) is a streaming service where end-users can purchase events or programmes to be seen on TV. The user can buy the PPV service e.g. via an on-screen guide, a telephone, or through the Internet and see the events or programme at any time within the expiration date.

- Order-ahead PPV (OPPV): The ability to order PPV programming ahead of time.
- Impulsive PPV (IPPV): The ability to order PPV programming impulsively.

G.4.1.3 Electronic programme guide (EPG)

Electronic programme guide (EPG) is an on-screen guide to scheduled programmes, contents with additional descriptive information, allowing a viewer to navigate, select and discover content by time, title, channel, genre, etc., by using a remote control, a keyboard, a touchpad or even a phone keypad. Generally, EPG can be displayed in several types such as Mosaic EPG, Box EPG, Text EPG, Mini EPG, Tree EPG etc., possibly depending on the service provider's business model.

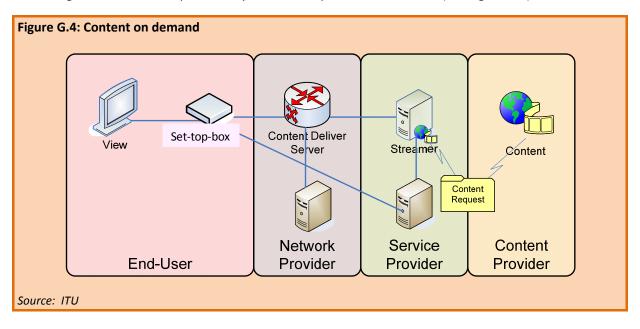
G.4.1.4 Retransmission service

A retransmission service uses the IPTV or cable TV platforms to complement the coverage of the digital terrestrial/satellite television broadcasting service, by providing solutions to areas that cannot be reached by the radio waves of digital terrestrial /satellite television broadcasting. In this case, digital terrestrial/satellite television broadcasting content is first received and then converted for retransmission. Users can have the same service experience as that of receiving radio-wave-based digital television broadcasting. The following general requirements should govern the retransmission service.

- (1) Service area: It should be possible, if required, to limit the service area of the retransmission service within the service area of the digital broadcasting provided by the broadcaster.
- (2) Copy right protection: Content protection functionality, if provided by the digital broadcasting, should be provided by the retransmission service.
- (3) Consistency: The retransmission service should provide the same programming as provided by the digital broadcasting including video, audio, data, captioning and supplemental services.
- (4) Quality: The quality should be as high as that provided by the digital broadcasting. Network characteristics should not degrade the video and audio quality.
- (5) Tuning/channel selection: Multiple receivers can be installed within a household. Channels can be independently selected by each receiver within a household.

G.4.2 On-demand services

Content prepared and delivered by the content provider for retrieval is received and stored by the service provider. If necessary, trans-coding of the content can be performed to meet various requirements of the customers. The end-user can then select and retrieve such contents from this storage at any time, according to the constraints provided by the content protection metadata (see Figure G.4).



G.4.2.1 Video on Demand (VoD)

VoD is a video service which allows the end-users to select and watch video content at any point of time. The end-user has full control over choosing which programme or clips to watch and when starting to watch.

G.4.2.2 Near VoD (NVoD)

Near VoD is a video service where multiple copies of a programme are broadcast at short time offsets (typically 10-20 minutes) providing convenience for the end-users. The end-user can watch the programme by tuning in to a specific point in time. The end-user waits a maximum offset time to get the start of the programme. The end-user has no control over the session except in choosing which programme to watch.

G4.3 Public services

G.4.3.1 Support for end-users with disabilities

End-users with and without disabilities can benefit from supplementary content alongside and in synchronization with the main content. The most familiar services are subtitling, which provides language translation of the dialogue, and captioning, which provides a transcript of sound effects as well as the dialogue to aid people with hearing disabilities. The subtitling and captioning services can come in one of two forms; either as a text stream that must be rendered in the receiver with a local font or as a series of graphical bitmaps. Another form of supplementary content is visual sign language translation for deaf people. A sign language interpreter appears in-vision, using hand gestures and mouth movements to convey the dialogue to viewers. Ideally, the position of the interpreter can be set by the end-user, as well as whether there is a solid or transparent background.

Audio description is a commentary explaining the significant visual aspects of the main content, primarily for the benefit of people with seeing disabilities, though it is also useful for people with learning difficulties. The commentary fits between the dialogue so as not to interfere with the main content, but

to work in conjunction with it. Ideally the volume level and positioning of the audio description can be adjusted by the end-user.

Digital television equipment usually provides a user interface comprising a remote control and on-screen display. Some end-users need clearer, larger text or alternative colour combinations in order to read it. Others cannot see the screen at all and need alternative forms of information, such as spoken. The remote control also presents a challenge to those who cannot see or those who have dexterity limitations. Voice control or a much simpler form of button control can be provided.

G.4.3.2 Emergency communications

Under emergency communications circumstances, public authorities generally act as emergency message providers in charge of emergency messages generation, audit and distribution. People have different preferences for delivery of notifications. As examples, output should be spoken, text, sign language, and output at different rates. The ITU-T Accessibility Checklist and Recommendation ITU-T F.790 should be consulted.

Message content should include all pertinent details presented in a way that is easily and quickly understood by the population. This includes multiple languages in some cases, as well as the use of multimedia for illiterate or hearing/visually impaired individuals.

Spoken messages are particularly useful where the natural language text is not well supported by technology, and for reaching anyone who is unable to read at the moment.

The terminal notifies the user of an incoming Emergency Alert Notification (EAN) message both visually and audibly, or according to the user's preferences and capabilities if they specify otherwise.

G.4.3.3 Community related information

These are services providing community related information, such as announcements, bus routes, weather and government services related information.

One of the example services is the government service treats civil appeal, tax payment, public poll, Government Issue notice and etc. It could enhance the government productivity and transparency by unifying and opening administration service.

G.5 Quality of Experience (QoE) and Quality of Service (QoS)

To ensure that the appropriate service quality is delivered, target quality should be established for each service and be included in system design and engineering processes. Quality will be an important factor in the marketplace success of services and is expected to be a key differentiator with respect to competing service offerings.

G.5.1 Introduction to QoE and QoS

Quality of Experience (QoE) is defined in Recommendation ITU-T P.10/G.100 as the overall acceptability of an application or service, as perceived subjectively by the end-user. It includes the complete end-to-end system effects (client, terminal, network, services infrastructure, etc.) and may be influenced by user expectations and context. Hence the QoE is measured subjectively by the end-user and may differ from one user to the other. However it is often estimated using objective measurements.

Quality of service (QoS) is defined in Recommendation ITU-T E.800 as the collective effect of performance which determines the degree of satisfaction of a user of the service. In telecommunications, QoS is usually a measure of performance of the network itself. QoS mechanisms include any mechanism that contributes to improvement of the overall performance of the system and hence to improving end-user experience. QoS mechanisms can be implemented at different levels. For example at the network level it includes traffic management mechanisms such as buffering and scheduling employed to differentiate

between traffic belonging to different applications. Other QoS mechanisms at levels other than the transport include loss concealment, application forward error correction (FEC), etc.

Related to QoS are the QoS performance parameters. Similar to the QoS mechanisms, QoS parameters can be defined for different layers. At the network layer those parameters usually include information loss rate and information delay and delay variations.

G.5.2 QoE for video and audio

QoE requirements for video and audio may be defined by the subjective scales such as the quality scale and the impairment scale Recommendation ITU-R BT.500-13. One of the main components of QoE for video and audio is digitization and compression of video and audio source materials and the various settings and parameters selected. Since video compression schemes such as MPEG are lossy and an identical copy of the original cannot be recovered, there are potentially negative impacts on video picture quality and therefore on viewer QoE.

Quality requirements for broadcast emission and secondary distribution systems are given in Recommendation ITU-R BT.1122-2. IPTV and cable TV when used as a means of broadcasting should fulfil the requirements.

G.5.3 Network QoS parameters affecting QoE

Key criteria for network transmission include loss, latency and jitter. In general, reasonable end-to-end delay and jitter values are not problematic due to STB de-jitter buffers, provided the de-jitter buffer size is provisioned to match network and video element performance. Video streams, however, are highly sensitive to information loss and the QoE impact is in turn correlated to a number of variables including types of data lost, codec used, transport stream packetization used, loss distance and loss profile, and decoder concealment algorithms. Requirements for IP packet transport loss and jitter to achieve satisfactory service quality targets can be found in Recommendation ITU-R BT.1720.

Bibliography

ITU-T IPTV Focus Group Proceedings, 2008

IPTV Forum Japan, IPTVFJ STD-0001, IPTV STANDARD Overview

IPTV Forum Japan, IPTVFJ STD-0005, Operational guidelines for the IP retransmission of terrestrial digital television broadcasting

Recommendation ITU-T F.790 (01/2007), Telecommunications accessibility guidelines for older persons and persons with disabilities

Recommendation ITU-T P.10/G.100 (07/2006), Vocabulary for performance and quality of service

Recommendation ITU-T E.800 (09/2008), Definitions of terms related to quality of service

Recommendation ITU-T J.112 (03/1998), Transmission systems for interactive cable television services

Recommendation ITU-T J.700 (12/2009), IPTV service requirements and framework for secondary distribution

Recommendation ITU-R BT.500-13 (2012), Methodology for the subjective assessment of the quality of television pictures

Recommendation ITU-R BT.1122-2 (2011), User requirements for codecs for emission and secondary distribution systems for SDTV and HDTV

Recommendation ITU-R BT.1720 (2005), Quality of service ranking and measurement methods for digital video broadcasting services delivered over broadband Internet protocol networks

International Telecommunication Union (ITU) Telecommunication Development Bureau (BDT) Office of the Director

Place des Nations

CH-1211 Geneva 20 - Switzerland Fmail: +41 22 730 5035/5435 Tel: +41 22 730 5484 Fax:

Deputy to the Director and Director, Administration and Operations Coordination Department (DDR)

Email: Tel.: +41 22 730 5784 +41 22 730 5484 Fax:

Africa

International Telecommunication Union (ITU) Regional Office P.O. Box 60 005 Gambia Rd., Leghar ETC Building

3rd floor

Addis Ababa - Ethiopia

Email: +251 11 551 4977 Tel · Tel.: +251 11 551 4855 +251 11 551 8328 Tel.: Fax: +251 11 551 7299

Americas

União Internacional de Telecomunicações (UIT) Regional Office SAUS Quadra 06. Bloco "E"

11° andar, Ala Sul Ed. Luis Eduardo Magalhães (Anatel) 70070-940 Brasilia, DF - Brazil

Email: +55 61 2312 2730-1 Tel.: Tel · +55 61 2312 2733-5 +55 61 2312 2738 Fax:

Arab States

International Telecommunication Union (ITU) Regional Office

Smart Village, Building B 147, 3rd floor Km 28 Cairo - Alexandria Desert Road Giza Governorate Cairo - Egypt

Email: Tel:

+202 3537 1777

+202 3537 1888

Infrastructure Enabling Environmnent and

e-Applications Department (IEE)

Email: +41 22 730 5421 Tel.: +41 22 730 5484 Fax:

Union internationale des télécommunications (UIT) Bureau de zone

Immeuble CAMPOST, 3e étage Boulevard du 20 mai Boîte postale 11017 Yaoundé – Cameroon

Email: + 237 22 22 9292 Tel · Tel.: + 237 22 22 9291 + 237 22 22 9297 Fax:

International Telecommunication Union (ITU) Area Office United Nations House

Marine Gardens Hastings, Christ Church P.O. Box 1047 Bridgetown - Barbados

Email: +1 246 431 0343/4 Tel.: Fax: +1 246 437 7403

Asia and the Pacific

International Telecommunication Union (ITU) Regional Office

Thailand Post Training Center, 5th

111 Chaengwattana Road, Laksi Bangkok 10210 - Thailand

Mailing address P.O. Box 178. Laksi Post Office Laksi, Bangkok 10210 - Thailand

Email: +66 2 575 0055 Tel: Fax: +66 2 575 3507 Innovation and Partnership Department (IP)

Email: Tel.: +41 22 730 5900 +41 22 730 5484 Fax:

Senegal

Union internationale des télécommunications (UIT) Bureau de zone

19, Rue Parchappe x Amadou Assane Ndoye Immeuble Fayçal, 4e étage B.P. 50202 Dakar RP Dakar - Senegal

Email: +221 33 849 7720 Tel· Fax: +221 33 822 8013

Unión Internacional de Telecomunicaciones (UIT) Oficina de Representación de Área Merced 753. Piso 4 Casilla 50484, Plaza de Armas Santiago de Chile - Chile

Email: +56 2 632 6134/6147 Tel.: Fax: +56 2 632 6154

International Telecommunication Union (ITU) Area Office

Sapta Pesona Building, 13th floor Jl. Merdan Merdeka Barat No. 17 Jakarta 10001 - Indonesia

Mailing address: c/o UNDP - P.O. Box 2338 Jakarta 10001 – Indonesia

Fmail: +62 21 381 3572 Tel · +62 21 380 2322 Tel.: +62 21 380 2324 Tel.: +62 21 389 05521 Fax:

Project Support and Knowledge Management Department (PKM)

Email: +41 22 730 5447 Tel.: +41 22 730 5484 Fax:

International Telecommunication Union (ITU) Area Office

TelOne Centre for Learning Corner Samora Machel and Hampton Road P.O. Box BE 792 Belvedere Harare - Zimbabwe

Email: +263 4 77 5939 Tel · +263 4 77 5941 Tel.: +263 4 77 1257 Fax:

Honduras

Unión Internacional de Telecomunicaciones (UIT) Oficina de Representación de Área Colonia Palmira. Avenida Brasil Ed. COMTELCA/UIT, 4.º piso P.O. Box 976

Tegucigalpa - Honduras

Email: +504 22 201 074 Tel.: +504 22 201 075 Fax.

International Telecommunication Union (ITU) Area Office

4, Building 1 Sergiy Radonezhsky Str. Moscow 105120 Russian Federation

Mailing address: P.O. Box 25 - Moscow 105120

Russian Federation

Fmail: +7 495 926 6070 Tel· Fax: +7 495 926 6073

Europe

Fax:

International Telecommunication Union (ITU) Telecommunication Development Bureau (BDT) Europe Unit (EUR) Place des Nations

CH-1211 Geneva 20 - Switzerland Switzerland

Fmail: +41 22 730 5111 Tel.:



International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland
www.itu.int