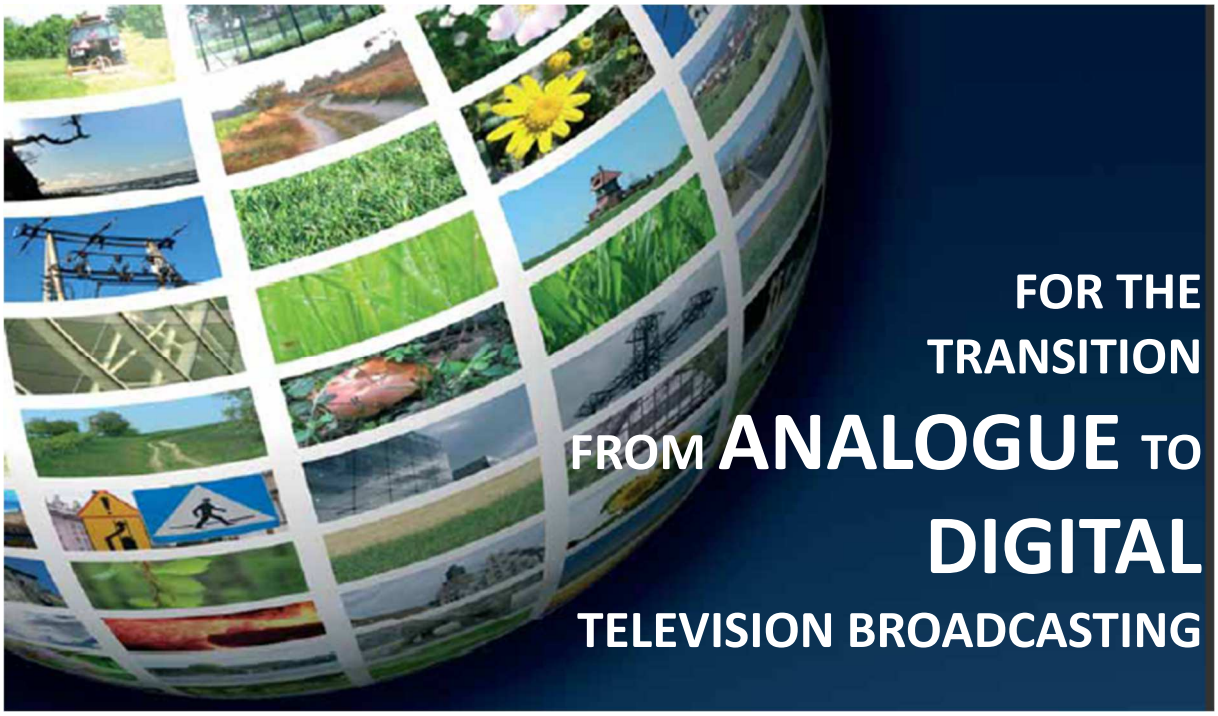
Bhutan Roadmap Report



May 2015

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This report has been prepared by International Telecommunication Union (ITU) experts Jan Doeven, Hakim Ebdelli and Peter Walop. The report covers the results of a country visit in the month February 2015 to Bhutan, as well as the analysis of the collected data in the period March to April 2015.

ITU would like to express its gratitude for the contributions and support of the National Broadcasting and Telecommunications Commission of Thailand (NBTC) to make this mission and report possible, as well as the constructive and valuable cooperation with the Ministry of Information and Communications of Bhutan (MoIC), Bhutan InfoComm and Media Authority (BICMA), Bhutan Broadcasting Service (BBS) and the National Cable Association of Bhutan.

Content

1. Introduction

ITU has published Guidelines for the transition from analogue to digital broadcasting[1]. These Guidelines provide assistance to member countries to smoothly migrate from analogue to digital broadcasting. In a further effort to help countries to switch over to digital broadcasting ITU has selected a number of countries for assistance in developing a national Roadmap for the Digital Switch-Over (DSO) and Analogue Switch-Off (ASO) process.

With the kind support of the National Broadcasting and Telecommunications Commission of Thailand (NBTC), ITU has selected Bhutan as one of the beneficiary countries for this assistance.

This Roadmap report for the transition from analogue to digital terrestrial television broadcasting (DTTB) in Bhutan has been jointly developed by a team of ITU experts consisting of Jan Doeven, Hakim Ebdelli and Peter Walop and the National Roadmap Team of Bhutan (NRT) comprising representatives of the Ministry of Information and Communications (MoIC), Bhutan InfoComm and Media Authority (BICMA), Bhutan Broadcasting Service (BBS) and National Association of Cable Operators.

In December 2014 a Bhutan delegation of the MoIC visited representatives of the ITU Regional Office in Bangkok. During this visit the Bhutan situation was covered and need for assistance formulated. Following a preparatory phase in which country data was analysed and a questionnaire was completed, a country visit for collecting additional data and exchanging proposals took place from 25th of February to 4th of March 2015. In the months March and April 2015 this Roadmap report was drafted.

This report is structured as follows:

1. This Introduction;
2. Current TV market and objectives;
3. National roadmap;
4. Top-5 most critical topics and choices;
5. Recommendations;
6. Glossary of Abbreviations.

The report has the following Annexes:

Annex 1: Preliminary review of the BICM Act;

Annex 2: Checklist;

Annex 3: System and planning parameters;

Annex 4: More details on Reference Offers;

Annex 5: Example tracker board;

Annex 6: Example receiver specifications.

[1] See www.itu.int, latest edition of January 2014 : http://www.itu.int/en/ITU-D/Spectrum-Broadcasting/Documents/Guidelines%20final.pdf

2. Current TV market and objectives

The development of the Bhutan Roadmap for the transition of analogue to digital terrestrial television starts with an analysis of the current TV market structure, analogue TV networks and regulatory framework, described in Section 2.1 to Section 2.3 respectively.

The aim of the Roadmap is indicated by the Digital Switch-Over (DSO) and Analogue Switch-Off (ASO) objectives, as described in Section 2.4.

2.1 Market structure

The market structure of the television market in Bhutan is depicted in Figure 1[2].

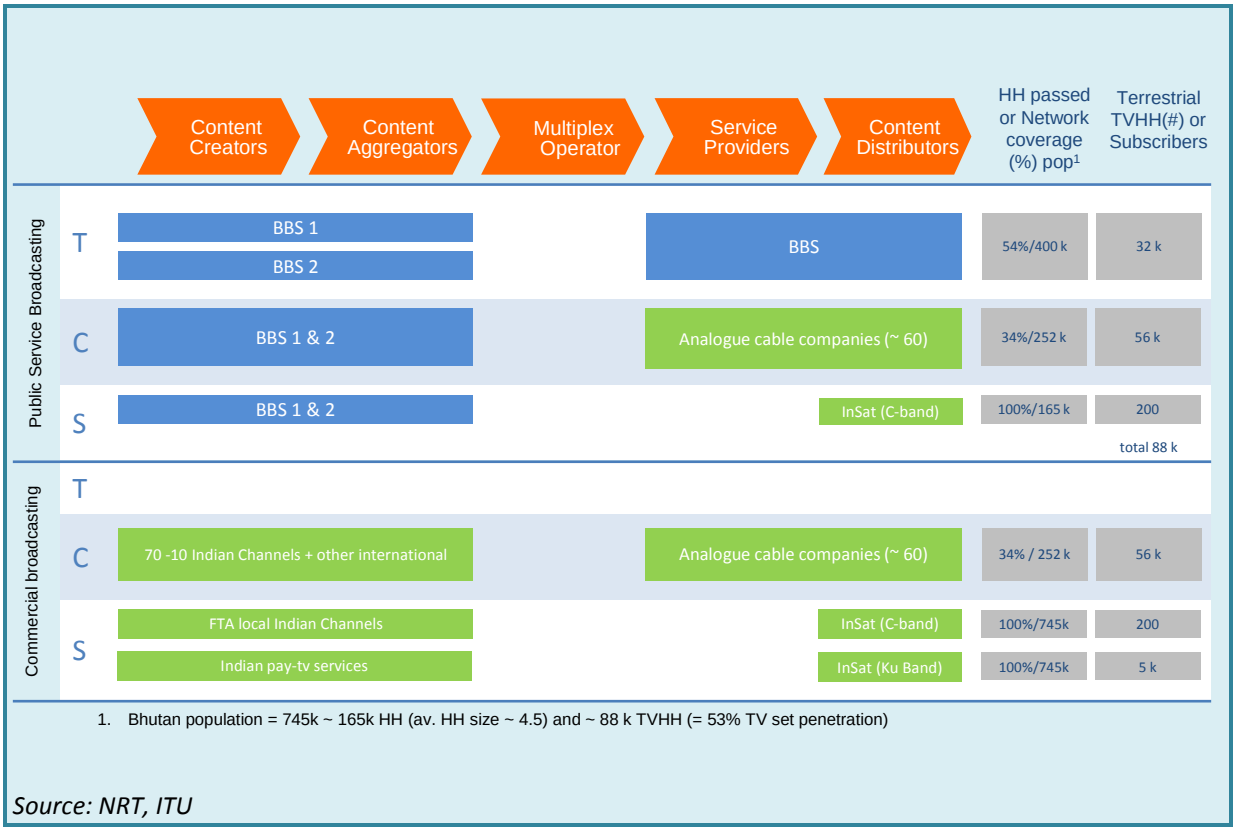


FIGURE 1: MARKET STRUCTURE OF THE TELEVISION MARKET IN BHUTAN

From Figure 1 the following can be observed:

1. The Bhutan television market is relatively small with 165,000 households (HH) of which the TV set penetration is relatively low (53%), resulting in 88,000 television households (TVHH);
2. The analogue cable platform is assessed to be the largest platform with approximately 56,000 TVHHs as compared to 32,000 on the analogue terrestrial platform;

[2] The market structure is based on the value chain as described in the ITU Guidelines, January 2014, see pp5-6.

3. The network coverage of both the terrestrial and cable platform is still larger[3] than their respective uptake and hence there is room for future growth, as it is assumed that the number of TVHHs will increase in the near future;
4. BBS uplinks it's two services (BBS1 and BBS2) for satellite Direct-to-Home (DTH) distribution to InSat (an Indian satellite network operator and service provider) as well as for feeding its ATV transmitter sites. This DTH service is distributed in the C-Band which entails the necessity of having large receiving dishes. Only 200 TVHHs make use of this service in Bhutan, due to the relatively expensive satellite receiving installation. People having such an receiving installation can receive other international (mainly Indian) Free-to-Air (FTA) services;
5. Next to the FTA satellite services there are also pay-tv DTH services in the Ku-Band (smaller dishes) present in the market. Approximately 5,000 TVHHs have this service. During the country visit it was understood from the cable operators that they expect significant growth of this pay-tv platform in the near future (as the multi-channel service offering is appealing to the Bhutan people). However as can be observed from Figure 1, there is no service provisioning of these pay-tv DTH services in the country. Equipment is purchased in neighbouring country India and subscription payments are either done in cash or by family living in India. It is important to note that these services are considered illegal by MoIC and BICMA[4].

People watching television by means of the ATV network receive two FTA services (BBS1 and BBS2). BBS1 is broadcasting news and is not on-air from 12:00 until 18:00. BBS2 is broadcasting entertainment and educational programs and is on-air 24 hours a day, 7 days a week (24/7). Both services are produced in Standard Definition (SD) with an aspect ratio of 4:3. Most television sets in Bhutan are analogue SD sets. No other television content, originating from Bhutan, is produced. This is explained by the small home market.

The approximately 60 cable systems are mainly analogue systems. Digital cable networks do exist in Thimphu. A cable offering ranges from 20 to 70 SD services and the average monthly subscription fees is 5 USD (~300 Ngultrum). Next to BBS1/BBS2 and Indian (FTA) services, such a package includes popular mainstream foreign services such as CNN, National Geographic, Discovery and BBC.

The pay-tv DTH package includes BBS1/BBS2, 150 Indian (FTA) services and the popular mainstream foreign services. A subscription is priced at 5 USD (~300 Ngultrum) for SD services. A package including also 20 HD services is priced at a premium of 500 Ngultrum.

[3] It should be noted that the homes passed with cable is likely not to entail that these homes have network terminating equipment in their homes. Hence investments will be need to connect these unserved homes passed. Also the ATV network coverage of 400,000 people as included are guestimates. Initial ATV coverage calculations (as can be found in Section 2.2) point in a different direction (only 15% area coverage, unfortunately the population coverage could not be accurately calculated).

[4] This is the reason why BBS has its DTH services in the C-Band as the Ku-Band services are considered illegal. See also Section 2.3.

With these pay-tv DTH and cable offering price points in the market, it can be expected that with economic growth the market share of pay-tv DTH services will grow without any changes in the current market offerings.

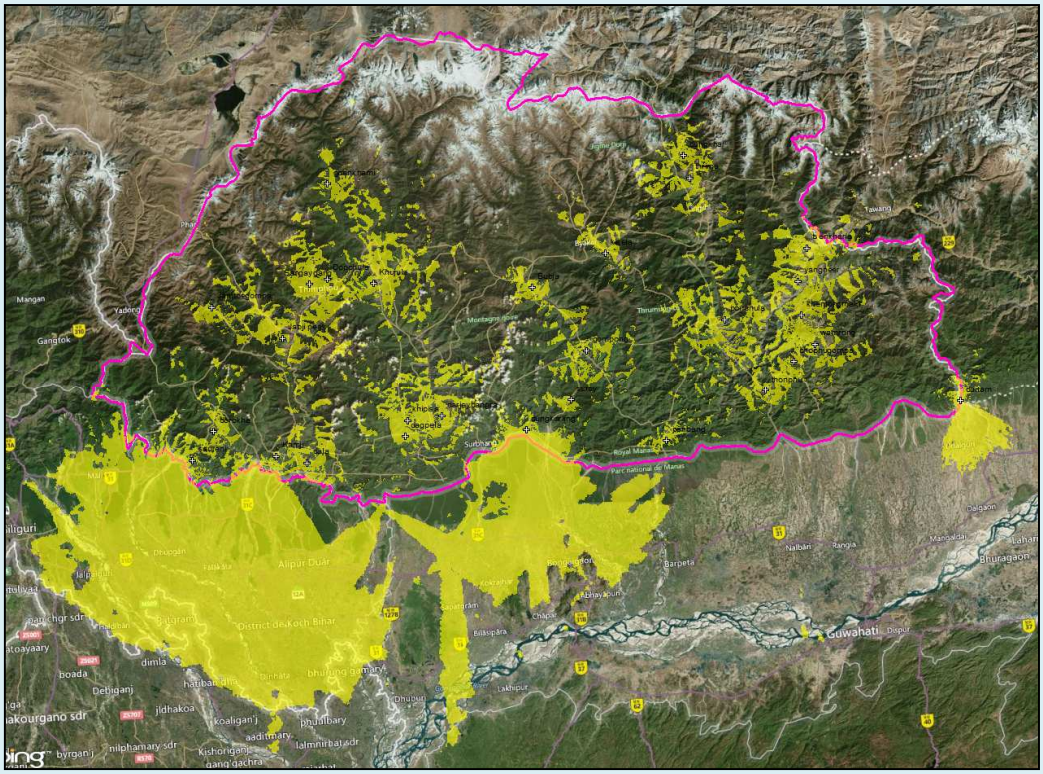
2.2 Analogue TV networks

Currently BBS operates two analogue TV networks (for two television services) in Band III using the B/PAL system. The network consists of 29 sites, transmitting both the services BBS 1 and BBS 2. At the sites either the combination of channel 5 and 7, or channel 9 and 11 are used for BBS 1 and BBS 2 services respectively.

The ERP of the stations ranges from about 70 W to 1,500 W and most stations are located at very high elevated sites. At most stations non-directional transmitting antennas are used. The stations are fed by DTH satellite links with the DVB-S standard.

An impression of the noise limited coverage analogue TV coverage based on the transmitting station data that was provided to the ITU-team is given in Figure 2. Interference other than noise has not been taken into account in this coverage assessment. Parts of the indicated noise limited coverage could be interfered by analogue TV stations and the actual coverage could therefore be smaller. However this could form a digital coverage target if the digital terrestrial network has to cover the analogue network (for providing simulcasting, see also Section 2.4). The existing 29 analogue TV stations were calculated to cover up to 15.6 % of the territory of Bhutan[5]. When planning for the DTTB coverage it is recommended to also include accurate population data (if available), as to optimise the network further (and possibly reduce costs).

[5] The population coverage could not be calculated although population data was provided at the level of 205 Gewogs. Unfortunately the population data could not be related to the vector map (describing the geographical area of the Gewogs) due to different names and mismatches. The population data could only be correlated to the vectors describing the Dzongkhags. However these Dzongkhag areas are much larger than the projected coverage areas and hence population percentages will have little meaning.



Source: BBS, ITU

FIGURE 2: INDICATION OF ANALOGUE TV COVERAGE IN BHUTAN

The coverage assessment in Figure 2 assumes the use of directional rooftop antennas as defined in ITU[6]. However, in practice these types of rooftop antennas are hardly present. Therefore, the coverage (with good reception) may be less in practise because of impairments by noise and ghost images.

BBS planned to extend the analogue TV coverage by installing 75 additional stations. However, it was decided to cease any further analogue TV development and to extend coverage by means of DTTB. It is the intention to use the current 29 analogue TV sites and the 75 sites that were envisaged for the extension of analogue TV coverage for DTTB.

With regard to the analogue TV networks the following observations can be made:

1. The coverage shows a large spill-over across the southern border, due to terrain circumstances and the use of non-directional transmitting antennas;
2. Due to the lack of directional rooftop antennas and the presence of narrow and steep valleys in many parts of Bhutan, the reception quality of analogue TV is poor in many houses because of impairments by noise and ghost images;
3. For one network in Band III, two channels are used. Consequently it cannot be avoided that adjacent sites use the same channel which would cause severe interference in most

[6] See recommendations ITU-R BT.417 and ITU-R BT.419.

countries. Due to the mountainous character of Bhutan and the relative low EPRs it is apparently possible to use only two channels per network.

2.3 Regulatory framework

As described in the ITU Guidelines a licensing framework for any television service 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;
2. Broadcast rights: the right or permission to broadcast television services on a defined broadcast platform in a designated geographical area and for a specified time period, very often both at a programme level (for specific programs 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;
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.

Currently the Company and Bhutan InfoComm and Media (BICM) Act of 2006 is arranging for the assignment of these three rights. This 2006 BICM Act is currently under review and it is expected that the new BICM Act (the November 2014 draft) will be passed by Parliament within a year. Consequently all three rights are assigned to the terrestrial and cable parties in the value chain (see Figure 1) as follows:

1. BBS holds the spectrum, broadcasting and operating rights for broadcasting two terrestrial services (BBS1 and BBS2) in the VHF Band III (see Section 2.2) on a nationwide basis. The spectrum rights are assigned under the BICM Act 2006 and the BICMA is periodically reviewing the content in a special purpose department. A part of BBS' operating rights (i.e. installation, maintenance and site sharing rights) are assigned under the BICM Act and its administrative 'operating' rights under the Bhutan Company Act[7];
2. The cable operators hold broadcasting and operating rights for broadcasting a bouquet of television services on their cable network in a defined geographical area. BICMA have assigned these rights by a single 'Cable Service Provisioning' license which comprises the content and operating right.

[7] In other words, BBS is established as any other commercial company and hence has no formal status as a Public Broadcasting Service (yet). Its funding is a mixed model with (limited) commercial revenues and Government financial contributions. The Government financial contributions are all originating from the Treasury and no special purpose taxes are collected for BBS, like television license fees.

It should be noted that no Content Charter or Code of Conduct is available for arranging/guiding the content of BBS (and the cable operators). As such no Bhutan/foreign content production ratios are prescribed in a separated content charter (and/or in the BICM Act)[8].

As said, the BICM Act is under review and the proposed text of the new BICM Act (November 2014 version) has been analysed and assessed on possible enhancements and bottle necks for the DSO/ASO process. This review is included in Annex 1: Preliminary review of the BICM Act.

2.4 DSO and ASO objectives

The Digital Switch-Over (DSO) and Analogue Switch-Off (ASO) objectives were defined during the country visit with members of the NRT. Table 1 shows an overview of these objectives, with the third column spanning the period before ASO and the fourth column the period after ASO.

No	Objective	2015 - 2018	> 2018
1	**Smooth transition from analogue to digital**	• All analogue services areas (BBS 1 & 2) covered with digital first (=29 sites) • Simulcasting in all areas • DTTB in the UHF Band	
2	**End of analogue transmission**	• A set ASO date • National switch-off • Target date = mid 2018	
3	**New entrants/services**	• 1 MUX carrying approximately 20 SD services of which 2 are 'must carry' FTA BBS services (BBS1 & BBS2) • The remaining capacity is for pay-tv services, grouped together and offered by a single SP	• For the next 2 MUX, capacity will be reserved for converting BBS1/2 into HD and a 3rd BBS HD service + 1 commercial new HD service • Rest of capacity is for the existing pay-tv SP • End state will be (at least) 5 MUX for DTTB of which 1 PLP will be reserved for MTV
4	**Extended population coverage**	• Matching current analogue coverage areas (see objective 1) • 10 additional sites	• Near national coverage (+65 sites)
5	**Better picture quality**	• Picture ratio (4 x 3) • SD	• Additional HD services
6	**Compensation for viewers**	• Minimize viewer migration costs (financial aid for STB & RX antenna) – if possible (partly) financed from pay-tv revenues • For terrestrial dependents only	
7	**Compensation for analogue broadcasters**	• BBS gets double OPEX compensated	
8	**Digital Dividend**	• No formal decisions (yet) – as for now follow ITU-RR/WRC'15	

TABLE 1: DSO AND ASO OBJECTIVES

[8] See also Annex 1: Preliminary review of the BICM Act.

The following explanation can be provided for the defined DSO and ASO objectives as included in Table 1:

1. As a relatively large proportion (36%) of the Bhutan TVHHs are dependent on the ATV network (32,000 out of the 88,000, see Figure 1), a simulcast period is provided in all ATV service areas (see Figure 2). During simulcast the same ATV services (BBS1/2) are also broadcasted on the DTTB network;
2. In order to have a short as possible simulcast period (as to shorten the financial burden of having two platforms in operations providing the same services), the ATV service areas are covered with the DTTB service first. Terrestrial network coverage extensions will follow in the next DTTB deployment step;
3. DTTB will be launched in the UHF band, although the current ATV network is operated in the VHF Band III. This decisions is based on two key considerations (a) a limited number of VHF Band III rooftop receiving antennas are installed and hence no or limited re-use of these antennas for DTTB and (b) the number of SD/HD services required in the long term, which cannot be facilitated in the relatively small VHF Band III (see also Section 4.4.1);
4. An ASO date with a target date of mid 2018 has been set as to speed up the migration to DTTB. ASO will be carried out on a single date and time for all ATV sites (i.e. a national ASO, see also Table 5 how the simulcast period can be shortened). With a phased approach to ASO the simulcast period for all phases together will be longer and consequently the operational costs for running the ATV and DTTB networks higher;
5. As financial means are limited in Bhutan, a model is pursued whereby industry and Government are working together to execute and finance the DSO/ASO process. In such a public-private partnership a bouquet of services is offered on the DTTB platform comprising FTA (BBS1/BBS2) and pay-tv services. The revenues generated from the pay-tv services can help financing the DTTB network and receiver subsidies. Building on this premises, a minimum number of FTA and pay-Tv services should be offered to be competitive on the Bhutan market (see Section 2.1). Such a bouquet should be balanced against the investments need (i.e. the number of sites and multiplexes). It was assessed that approximately 20 SD services will suffice for the launch proposition (see also Section 4.2). Having adopted the DVB-T2 standard (see Annex 2: Checklist) such a bouquet of services can be carried in one multiplex (MUX), depending on the selected system parameters (see Annex 3: System and planning parameters);
6. In addition, it was assessed that the strength of the DTTB platform was to serve the unserved in the rural areas. Hence it was proposed to have the launch proposition available on the 29 existing (i.e. the current ATV network coverage) plus 10 additional sites. The decision to have these additional 10 sites deployed would depend on the financial means available and required investments;
7. These pay-tv DDTB services should be grouped together and offered by a single service provider (SP). An alternative scenario of having multiplex SPs would result in duplication of costs (in running multiple subscriber management – SMS - and conditional access systems - CAS) as well as additional regulations and coordination efforts (to assure the same CAS in the market and sharing service information to build up a common electronic programming guide – EPG);

8. In a next deployment stage (after 2018), the number of multiplexes can be extended with two, increasing the available DTTB capacity. Of this additional capacity, first capacity will be reserved for BBS to convert its 2 FTA SD services to HD[9] as well as having a third HD service. The next reservation is for a new Bhutan market entrant offering a FTA service in HD format (if interest has been shown at the time of extending the number of multiplexes to three). The remaining capacity (either in or exclusive of the new market entrant's capacity reservation) will be reserved for the single incumbent DTTB SP;
9. Also in this next deployment stage (after 2018) the DTTB network coverage would be extended to near nationwide coverage. It was assessed that this could be accomplished by having 75 additional transmitter sites[10]. It still have to be decided if the number of multiplexes or transmitter sites will be increased first (or a combination) in the next deployment stage;
10. Viewer's financial compensation is deemed necessary for purchasing a DTTB Set-Top-Box (STB) and receiving antenna. Integrated Digital Television Sets (IDTV) are explicitly excluded as these households are considered not eligible for receiving such financial compensation. The amount of STB subsidy is still to be decided and is dependent on public resources and the business case (see also Section 4.3). The number of eligible people are limited to those who are dependent on receiving televisions services over the ATV network (i.e. 32,000 as included in Figure 1);
11. BBS will get its double operational expenditure (OPEX) for running its two FTA services on both platform (i.e. ATV and DTTB) compensated from Government contributions. This is a result of setting the requirement to have simulcasting in all ATV network coverage areas;
12. The Digital Dividend is not a directly relevant issue for Bhutan as spectrum for both broadcasting and mobile services are available in the UHF band. Hence no decision will be taken as part of this Roadmap (see also Section 4.4).

[9] It should be noted that with a requirement to broadcast BBS services in both SD and HD for a certain period, this additional capacity reservation is temporarily additional to already existing SD capacity. After this 'SD/HD-simulcast' period a new multiplex loading should be agreed.

[10] This assessment was carried by BBS when planning the network extension for the ATV network (see also Section 2.2.

3. National roadmap

After having determined the aim of the Roadmap, as described in Section 2.4, this Chapter describes the Roadmap itself and starts with an introduction on the concept of a Roadmap, followed by the description of the construction of the Roadmap in Section 3.2. In Section 3.3 the selected functional building blocks of the Bhutan Roadmap are shown. Section 3.4 describes each of the Phases of the Roadmap for Bhutan.

3.1 Roadmap concept

A *Roadmap* is a management forecasting tool and is directed to the implementation of a strategy and related to project planning. A Roadmap matches short-term and long-term goals and indicates the main activities needed to meet these goals. Developing a Roadmap for the transition to DTTB has three major uses:

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

A Roadmap consists of various phases, normally related to preparation, development and implementation of the strategy. A Roadmap is often presented in the form of layers and bars, together with milestones on a time scale.

3.2 Roadmap construction

Part 6 of the ITU Guidelines for transition to digital television describes a method for developing a roadmap. Also a set of generic roadmaps regarding the whole process of transition to DTTB and introduction of MTV is given. The methodology described in Part 6 of the ITU Guidelines will be followed in the development of the national Roadmap for Bhutan.

The basis for constructing the roadmap is a functional framework consisting of five layers as shown in Figure 3.

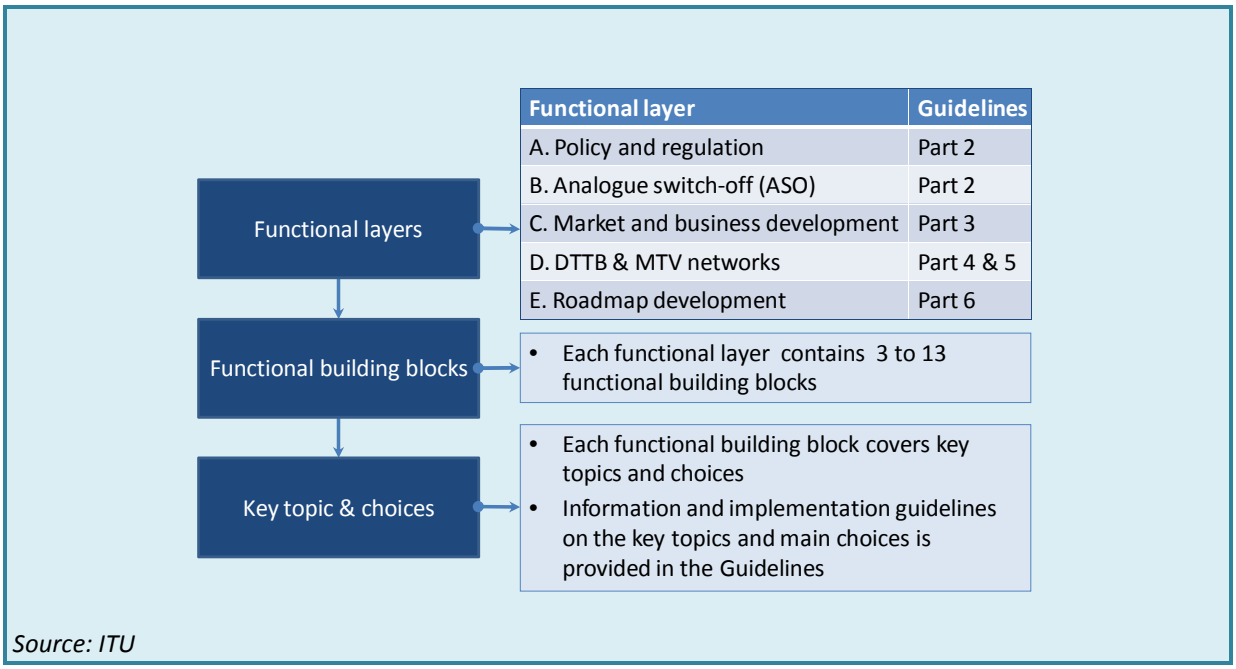


FIGURE 3: FUNCTIONAL FRAMEWORK

Each layer consists of a number of functional building blocks. In each functional building block key topics and choices have been identified.

The Roadmap is constructed by defining the phases and by placing the relevant functional blocks in each phase in a logical order and in a time frame. For each of the functional building blocks the decisions already taken and not yet decided on key topics and choices are identified, as well as the activities to be carried out. Figure 4 illustrates the construction process.

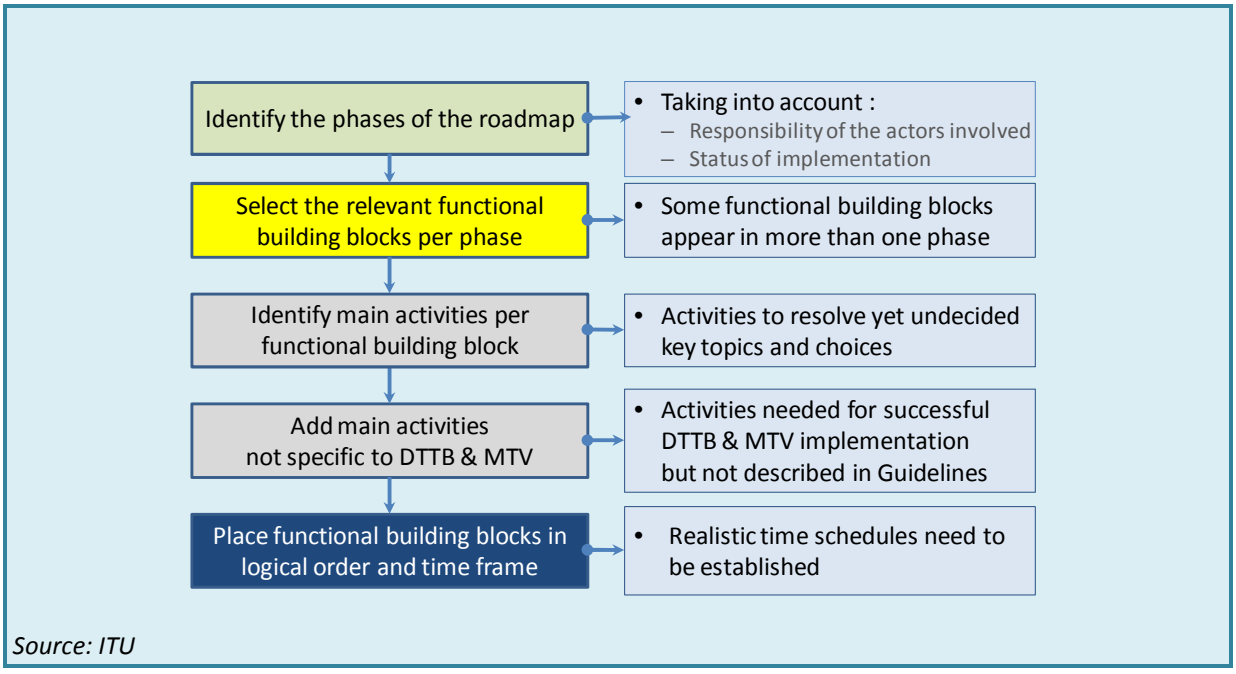
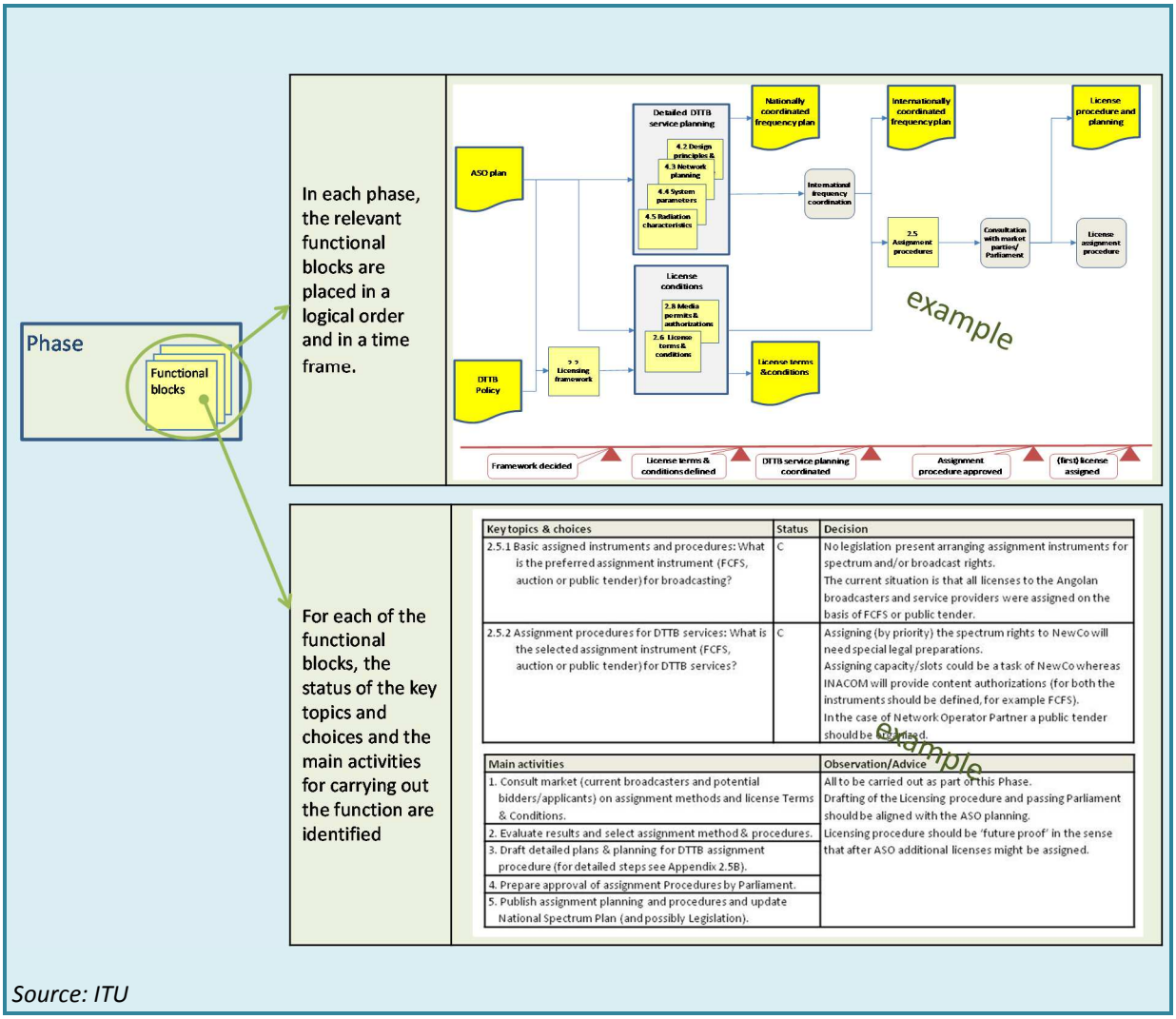


FIGURE 4: ROADMAP CONSTRUCTION

The result is a Roadmap consisting of three levels:

1. Phases of the Roadmap with the selected functional building blocks per phase;
2. For each phase, the functional building blocks placed in a logical order and time frame;
3. For each functional building block in a phase, the status on key topics and choices and the main activities to be carried out.

The Roadmap structure is illustrated in Figure 5.



Source: ITU

FIGURE 5: ROADMAP STRUCTURE

The selected relevant functional building blocks are shown in Figure 6 in Section 3.3. Key topics and choices related to the selected functional building blocks of functional layers A (Policy & Regulation), B (ASO), C (Market & Business Development) and D (Networks) have been considered and it has been identified which decisions have (partly) been taken and which still need to be taken.

An overview of the status of the selected functional building blocks is given in Annex 2: Checklist.

3.3 Relevant functional building blocks for Bhutan

Out of the five functional layers as described in the ITU Guidelines, layer E is "Roadmap development" and hence covered by this report. The other functional layers A (Policy & Regulation),

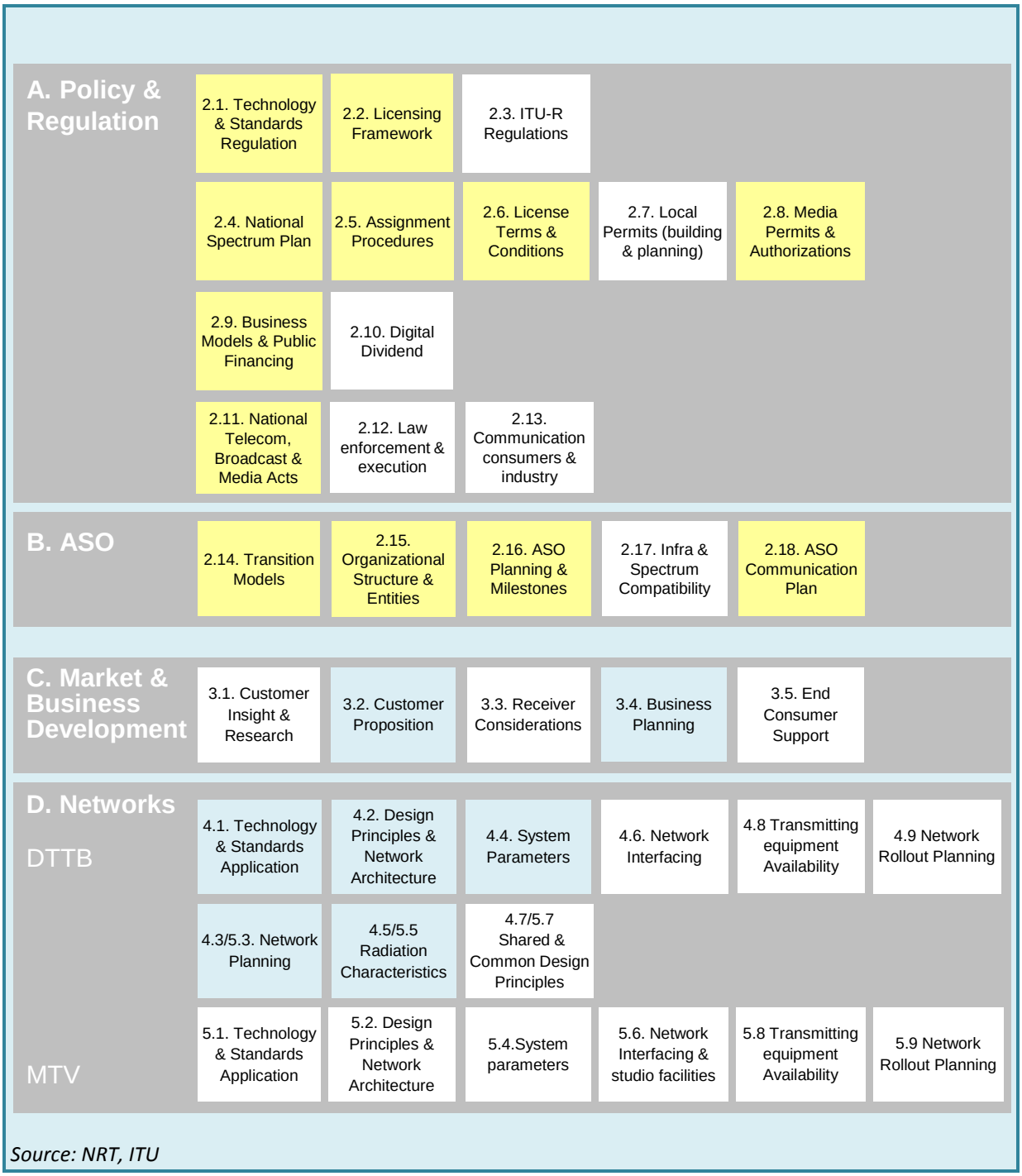
B (ASO), C (Market & Business Development) and D (Networks) contain in total 38 functional building blocks (see Figure 6). Out of the 38 functional building blocks, 19 blocks were selected to construct the Roadmap for transition to DTTB in Bhutan.

Figure 6 shows three types of functional building blocks (FBB):

1. Non-shaded/white blocks:
   These blocks were not selected to be included in the Roadmap for the transition to DTTB in Bhutan (see Table 2 below);
2. Yellow shaded blocks:
   These blocks are included in the Roadmap for the transition to DTTB in Bhutan and will led by the Government representatives in the NRT (Government led, i.e. MoIC and BICMA[11]);
3. Blue shaded blocks:
   These blocks are included in the Roadmap for the transition to DTTB in Bhutan and will be led by the industry representatives in the NRT (Market led, i.e. BBS and National Association of Cable Operators[12]).

[11] This will mean in practice that these parties will report in the NRT meetings on progress and results of the activities included in the scope of these functional building blocks.

[12] See footnote 11.



Source: NRT, ITU

FIGURE 6: SELECTED FBB

The considerations for not including the white functional building blocks (as included in Figure 6) are provided in Table 2.

No	Functional building block	Consideration
2.3	ITU-R regulations	There is no ITU DTTB Frequency Plan for Region 3. The frequency use should comply with the Radio Regulations, but it is not considered as a main topic to be controlled by the NRT. However FBB is

No	Functional building block	Consideration
		included 2.4 National Spectrum Plan is included as to ensure that enough spectrum is (made) available for the DSO/ASO objectives (see also Section 4.4).
2.7	Local permits (building & planning)	Limited or no (specific) regulations in place which could result into a critical path in the Roadmap planning.
2.10	Digital dividend	No formal decisions have been taken on the allocation of IMT in the 700 MHz band. It is not expected that broadcasting and mobile spectrum requirements are competing under the assumption that channels 37 to 49 are allocated to broadcasting.
2.12	Law enforcement & execution	Is not considered essential or a task to be undertaken in DSO/ASO process.
2.13	Communication consumer & industry	As the policy and regulation activities will be carried out as part of the transition process, the decisions and activities related to 2.13 will be included in 2.18 (ASO communication plan).
2.17	Infra & spectrum compatibility	Infra-structure incompatibility is not considered as a major issue in Bhutan, as well as for any spectrum incompatibilities. Analogue TV and DTTB will use different frequency bands. VHF Band III (see Section 2.2) and UHF Band IV (see Section 4.4.1) respectively. Hence spectrum compatibility is not an issue.
3.1	Customer insight & research	As financial resources are limited, a practical approach is adopted for collected or assessing missing market data and information.
3.3	Receiver considerations	The DVB-T2 transmission standard was selected for Bhutan (see Annex 2: Checklist). DVB-T2 receivers (STBs, IDTVs and other receivers are widely and cheaply available). It should be noted however that the availability and pricing of CAS[13] embedded STBs (possibly in combination with antenna powering[14]) should be checked.

[13] In Section 2.4 it was described that a financing model is sought whereby subscription revenues can help financing the STB subsidies. Subscription television services will require the application of a Conditional Access System (CAS).

[14] For portable indoor reception the coverage can be improved by having an active receiving antenna. These type of antennas require an electric powering of the antenna. For example in Thailand this requirement was included in the receiver specifications. For these specifications see Annex 6: Example receiver specifications.

No	Functional building block	Consideration
3.5	End consumer support	As the activities related to Market and business development will all be carried out as part of the transition process, the activities related to 3.5 will be included in 2.18 (ASO communication plan).
4.6	Network interfacing	As Bhutan as opted for the licencing model B whereby BBS (possibly together with other industry parties) as multiplex operator will deploy the DTTB network, this activity is considered an activity to be carried out by this operator without involvement of the NRT. It should be noted however that as discussed during the country visit (see Introduction), the interface for the transport streams to the transmitter sites should be DVB-T2 TS-MI[15].
4.7	Shared & common design principles	The introduction of MTV services is considered at a later date and is out of scope of the current Roadmap.
4.8	Transmission equipment availability	See FBB 4.6
4.9	Network roll-out planning	See FBB 4.6
5.1 to 5.9	MTV networks (all FBB)	See FBB 4.7

TABLE 2: FBBS NOT INCLUDED IN THE NATIONAL ROADMAP

3.4 Description of the Bhutan Roadmap

In this section first and overview is provided of the overall Roadmap. In line with the ITU Guidelines the Roadmap comprises four phases. Following this top-view of the Roadmap a more detailed description per Roadmap phase is included in the subsequent sections.

3.4.1 Overall Roadmap

As described in Section 2.4, the objective is to complete the ASO by the middle of 2018. This would result in an overall Roadmap duration of a little bit more than 3 years. Furthermore a key decision impacting greatly the Roadmap, is the decision on the licensing model. The ITU Guidelines have outlined two basic model; model A and B[16]. The Bhutan NRT has adopted model B (see Annex 2: Checklist). This implies that the multiplex and network operations will be carried out by a single entity, serving both the BBS and the single pay-tv SP (see Section 2.4).

[15] See ETSI TS 102 773 V1.1.1 (2009-09), Digital Video Broadcasting (DVB); Modulator Interface (T2-MI) for a second generation digital terrestrial television broadcasting system (DVB-T2), available on www.etsi.org.

[16] See ITU Guidelines, January 2014, pp24-25.

Also as the DSO/ASO process will be prepared, implemented and financed in public-private partnership, the planning of the network and services will be carried out as part of the NRT tasks and responsibilities. The actual detailed planning, design and implementation can be carried out by the newly established common multiplex operator.

Figure 7 shows a top overview of the Bhutan Roadmap, including the five Roadmap phases.

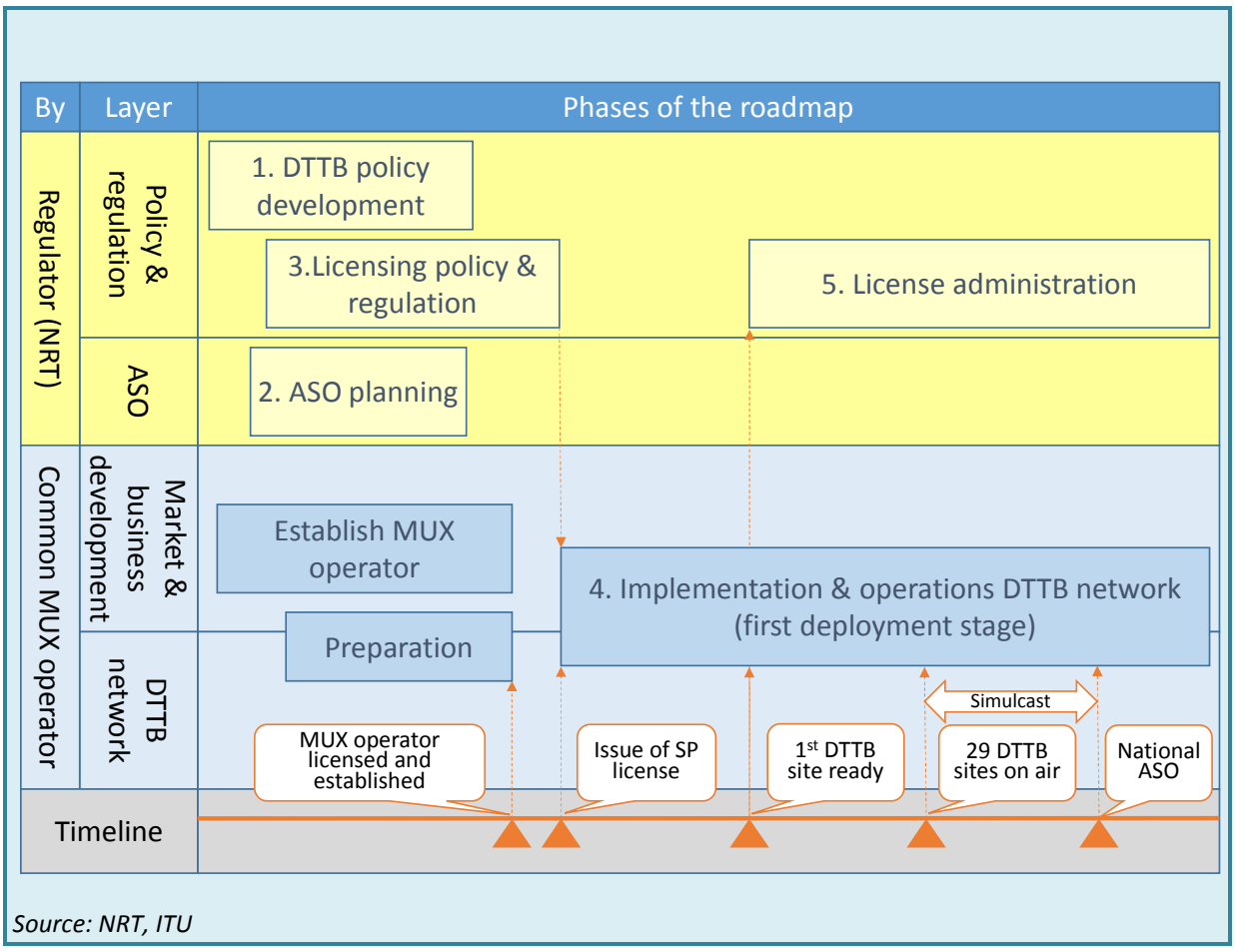


FIGURE 7: OVERALL ROADMAP

Figure 7 shows the following:

1. The Roadmap Phases 1 to 3 are carried out in parallel as many decisions in these Phases are interdependent;
2. Prior to the implementation of the DTTB network, the multiplex operator has to be established. BBS would be well positioned to participate in these multiplex operations as they own most of the tower infrastructure[17]. Third parties (like the national association of cable operators) could participate in the ownership of this new entity (what is still to be

[17] Please note that next to BBS' current distribution network (carrying the ATV services) a new distribution network has to be built to carry the DVB-T2 TS-MI transport stream. This can be a satellite, fibre or microwave based network. See also Section 4.5.

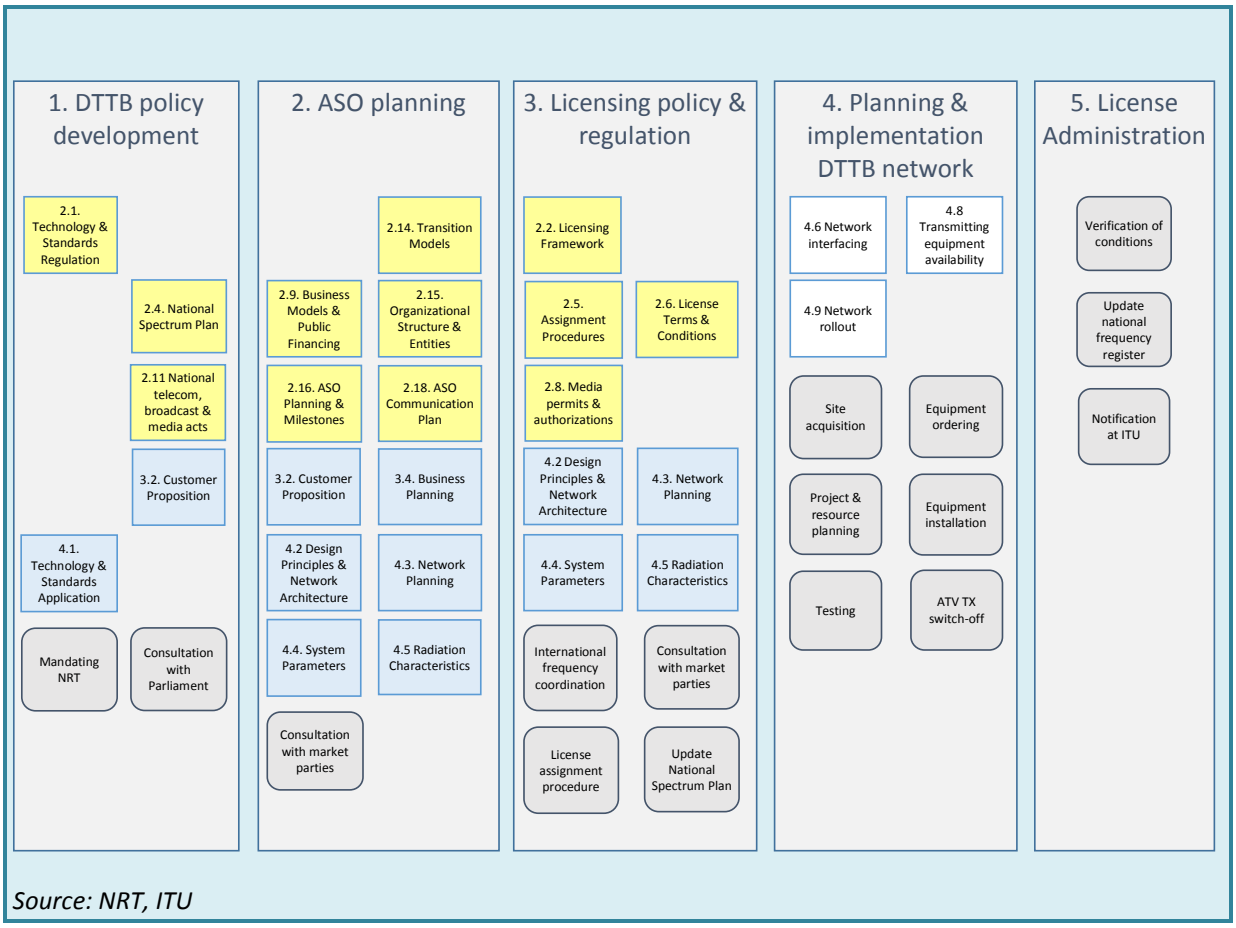
determined and dependent on negotiations). Participation of third parties would automatically result in the establishment of a separated legal entity for network operations;

3. The preparations for splitting off the network activities from BBS and establishing a new company (NewCo) are indicated in blue as it is assumed that these activities will be carried out under the direct responsibility of BBS management. This will require a formal decision. The NRT will have to get progress reports on the establishment of NewCo and ultimately management of NewCo will have to participate in the NRT;
4. Alternatively the network operations are not separated (and hence no third party participation) and BBS reorganise its operations in such a way that it can serve third party clients in a transparent way for network distribution services. Accounting separation is part of such a reorganisation (see also Section 4.1);
5. License administration (Phase 5) entails the administrative process of transmitter station approval and registration. Before a DTTB transmitter station is taken into operations BICMA as the national spectrum manager should approve the station's characteristics and proper installation. It will register this new station in their register of spectrum usage and will then notify the ITU. In turn the ITU will register this station in their global register (i.e. Master International Frequency Register - MIFR).

The NRT will resume responsibility for the proper deployment of the DTTB network by designing and assigning the network/multiplex license. It will also determine and endorse which DTTB services will be launched onto the Bhutan television market. In addition, the NRT will determine the network roll-out and the associated planning by including network roll-out obligations in the network license. Hence the Roadmap will also include functional building blocks of the Market and Business Development and DTTB Network layer:

1. Market and Business Development layer:
    a. Customer Proposition (functional building block 3.2): the NRT will have to determine the most compelling attributes of the DTTB services, such as coverage areas, number of services, picture quality, reception mode/quality and price tables for the various services (including multiplex capacity reservations);
    b. Business Planning (functional building block 3.4): the NRT will also have to resume responsibility for an economically viable DTTB offering for the network provider, broadcasters and other market parties. Hence the NRT will have to assess the future cash flows of the network provider and broadcasters. And what type of public financing is required;
2. DTTB Network layer:
    a. Technology & Standard Application (functional building block 4.1) to Radiation Characteristics (functional building block 4.5): all these five technical functional building blocks have to be included as to determine what the required DTTB network(s) will look like. This includes aspects such as the design of the key network elements (i.e. the head-end/multiplex centre, the distribution links and the transmitter sites), the various system parameters (i.e. transmission mode, guard interval, etc.) and the applied frequencies per site (i.e. ERP, antenna height and diagram).

With reference to the selected functional building blocks in Section 3.3, Figure 8 shows the blocks to be included in each Phase of the Bhutan Roadmap. Please note that the yellow and blue shaded blocks are described in the Chapters of the ITU Guidelines with corresponding numbering. The grey shaded blocks are not described in the ITU Guidelines. These blocks represent activities that are not specific to the introduction of digital terrestrial television services.



Source: NRT, ITU

FIGURE 8: FFBS PER ROADMAP PHASE

In the follow Sections the subsequent Phases of the Bhutan Roadmap are described in more detail.

3.4.2 Phase 1 DTTB policy development

The DTTB policy development Phase of the Roadmap is aimed at getting the DTTB Policy objectives agreed at a political level. Political consensus and commitment lies at the heart of any successful ASO project. Politicians will have to commit to the ASO objectives, deadlines, necessary budget and endorse the establishment of a NRT with a clear mandate to plan and execute the ASO process.

Inputs

The inputs for this Phase are International Agreements, such as for example agreements made in the Association of Southeast Asian Nations (ASEAN), existing regulatory framework (see Section 2.3) and policy objectives (see Table 1). It should be noted that the DSO policy objectives as included in Table 1 still have to be confirmed and politically endorsed.

Outputs

The key output of the DTTB policy development Phase is a politically endorsed DTTB Policy document to be published to the general public (in the 'Official Gazette'). Such a DTTB Policy document typically includes the following items:

- Policy justification. This includes the benefits and necessities of introducing DTTB services in Bhutan. The customer benefits/competitive edge of DTTB for the key markets (e.g. terrestrial served and non-served) should be clearly outlined;
- The legal framework: This entails the legal basis (and any necessary changes) for the DTTB service introduction and the ASO;
- Technical framework. Detailing the current spectrum in use by existing broadcasters and the available spectrum for the DTTB services. Also the spectrum available for non-broadcasting services (i.e. the digital dividend) could be clarified;
- Starting (i.e. the introduction of the first DTTB broadcasts) and ending date of the ASO process (i.e. switching of the last analogue broadcasts and lifting any restrictions on the DTTB broadcasts). These dates have to be exact as to inform the general public and the industry accurately;
- The principle ASO model. It was decided in the NRT that this model was to include simulcasting and a national ASO. The policy document should also include the justification for this model;
- DTTB services. Describing which existing television services and additional content/services will be distributed on the DTTB platform and at which districts/provinces these services will be made available. In the NRT it was decided that these DTTB services include pay-tv and FTA services;
- DTTB standards: what standards (DVB-T2 and MPEG4 for respectively the transmission and compression standard) will be mandatory and its justification. In Bhutan also a decision on the CAS regulation should be made as it was decided to include pay-tv services;
- Funding principles. In Bhutan it was decided to fund the DSO/ASO process in a public-private partnership. The policy paper should include this model and indicate what items are dependent on negotiations and what are possible fall back scenarios;
- Communication and Plan of Action. Outline of how viewers (and other stakeholders) will be informed about the ASO process and Plan of Action with major regulatory and operational milestones (e.g. the establishment date of the NRT, the start of the simulcast period, the date of when the new BICM Act will pass Parliament, etc.).

For an example DTTB Policy document please refer to "Strategy for Switchover from Analogue to Digital Broadcasting of Radio and Television Programs in the Republic of Serbia" as published in the Official Gazette of the Republic of Serbia, No. 55/05, 71/05 – correction 101/07, the Government of the Republic of Serbia on July 2nd 2009[18].

[18] Also available on the ITU website.

Roadmap

The Roadmap of the DTTB policy development Phase and the associated functional building blocks is shown in the Figure 9. The decisions taken, partly taken and not yet taken on the key topics and choices per functional build block are indicated in Annex 2: Checklist.

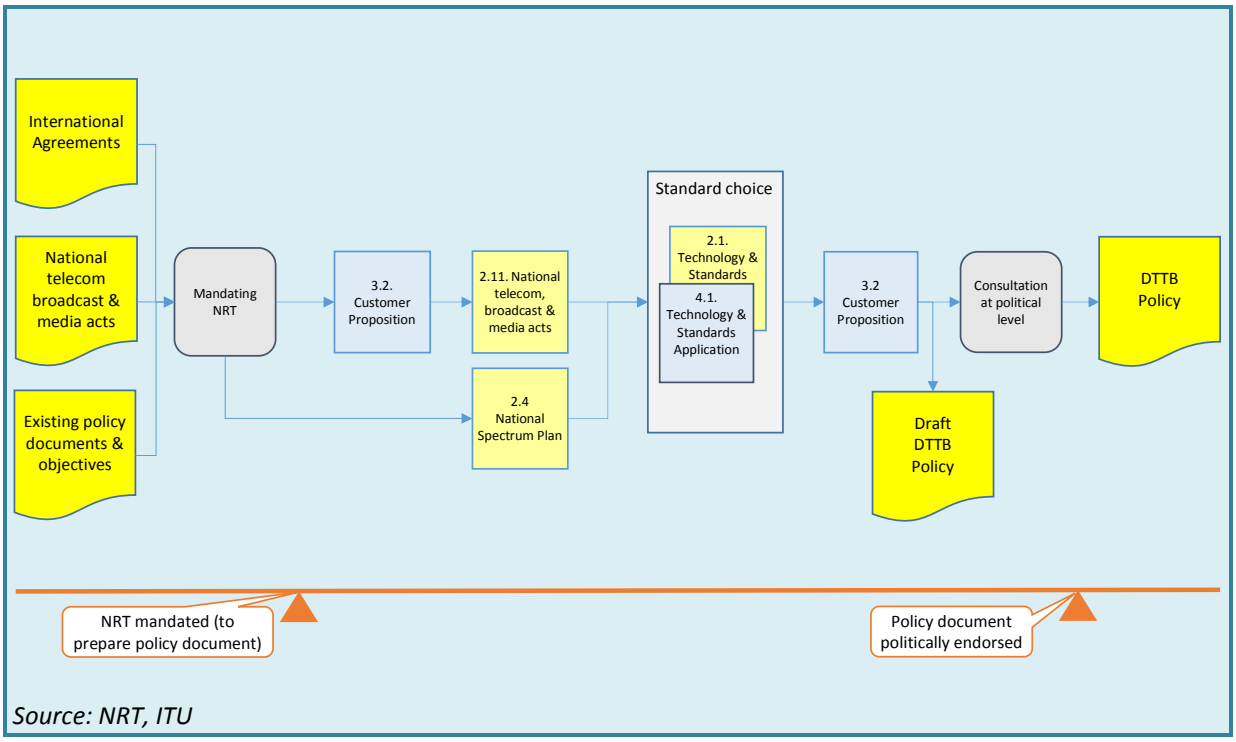


FIGURE 9: DTTB POLICY DEVELOPMENT (PHASE 1)

As can be derived from Figure 9, the following steps (i.e. functional building blocks and non-DTTB specific activities) are included in the first Phase of the Roadmap:

1. Mandating the NRT. Although the NRT has been formally established, its mandate should be checked. In order to deliver the aforementioned DTTB Policy document it should have at least a clear mandate to do so. After this policy document has acquired political approval, the NRT's mandate can be extended to prepare, plan and execute the Roadmap. In this Phase of the Roadmap this NRT can have a limited membership. At the second Phase of the Roadmap (i.e. ASO planning) the NRT membership can be extended to include all stakeholders in the DTTB value chain (and structured in line with the implementation guidelines of functional building block 2.15). Alternatively the NRT can be mandated at once for the whole DSO/ASO process;
2. Determining the Customer Proposition (functional building blocks 3.2). Conducting market research of the current television and future DTTB market in Bhutan was excluded from the Roadmap because (a) resources are limited and (b) NRT members are well aware of the possibilities on the Bhutan television market. Consequently this step includes only the functional building 3.2. At this Phase of the Roadmap the NRT should provide support/justification for the proposed DTTB customer proposition. Section 2.1 can serve as an initial bases for collecting and completing the market data. Market data will have to cover the following elements:

a. *Current* television market in Bhutan. A profound and *agreed* understanding of the current television market provides a sound basis for any policy document. This part of the data will include the following:
    i. Current market players (to include broadcasters, content creators, network operators, service providers etc) and their television services. Figure 1 as included in this report, provides an initial overview of services on the Bhutan market;
    ii. Television viewing 'demographics'. This entails the common market parameters like number of television sets deployed, the number of television households , the number of viewing hours (per channels), the number of subscriptions, etc;
    iii. Size and growth of the total pay-tv (subscription) and television advertising markets in Bhutan. Also the impact of the ASO and DTTB introduction on this advertising market should be assessed;
    iv. Current reception situation and conditions. This entails having insight in what the different viewing groups (to include individual viewers, household size, group viewing, hotels, multi-dwelling units, etc) look like, their numbers and under what conditions current analogue television is received (e.g. the antenna installation and type of television sets). This part should also include the reception from other platforms (cable and satellite);
    v. Current analogue service coverage. Given the current reception conditions, it should be clarified where what service can be received. This might entail an analogue service planning exercise (see Section 2.2 and Figure 2);
    vi. Television market logistics and supplies. The current logistic chain for television sets will be important for the distribution of DTTB receivers. An understanding of its structure, volume (e.g. how many outlets where) and operations will be necessary;

b. *DTTB* market for Bhutan. The DTTB Policy document should illustrate that there is a need for DTTB. This part of the market description should provide an insight in what the Bhutan viewers and industry players expect, including:
    i. Content. To include the number and the type of programs/channels and other service to be broadcasted (for example the EPG, subtitling, theme channels). Also the willingness to pay for the STB and the television services is an important aspect to include. Knowing this willingness can help to determine any necessary financial support for the Bhutan viewers;
    ii. Supplies. Bhutan distributors might show an interest in distributing and provisioning DTTB receivers;
    iii. Content creators. Bhutan content creators (e.g. BBS and the cable service providers) might be interested in provided dedicated content for the DTTB platform;

3. National Spectrum Planning (functional building blocks 2.4). The *current* available spectrum for DTTB should be identified. The *future* available spectrum for digital terrestrial television services should be clarified and agreed (see also Section 4.4), taking into account:

   a. Spectrum already assigned (not necessarily in use yet) for analogue and/or digital television services (as indicated/to be incorporated in the National Spectrum Plan and Register);
   b. Neighbouring spectrum usage. Spectrum may not be readily available in Bhutan as the same spectrum is in use in neighbouring countries (especially near the borders[19]). Coordinating this spectrum is in the interest of all involved countries and may require bilateral/multilateral coordination;
   c. Spectrum required for future digital radio services (as indicated/to be incorporated in the National Spectrum Plan and Register);
   d. Spectrum requirements for non-broadcasting services, for example spectrum for LTE services[20] (as indicated/to be incorporated in the National Spectrum Plan and Register);
4. Checking compliancy with current legislation and identifying required changes (functional building block 2.11). A first assessment should be carried out of what parts of the current legislation will be impacted by the introduction of DTTB services (see Section 2.3). At this first Phase of the Roadmap, the assessment is focused on identified the areas that might be impacted, how required changes can be achieved (e.g. legal and parliamentary procedures) and what time this will take. This assessment will then provide input for the Plan of Action (as part of the DTTB Policy document). During the third Phase of the Roadmap (i.e. determining the DTTB regulations) specific DTTB regulations are defined (e.g. the licensing framework and procedures), a further detailed assessment of necessary changes may be necessary;
5. Selecting system standards (functional building blocks 2.1 and 4.1). As the Figure 9 shows the procedure for deciding standards is an iterative process between the functional building blocks 4.1 Technology standards application (i.e. addressing the technical performance) and 2.1 Technology standards regulation (i.e. considering regulatory aspects)[21]. For Bhutan the transmission and compression standard (DVB-T2 and MPEG4) were already decided in the NRT. Also the DTTB services will be launched in standard definition (SD) and 4:3 (aspect ratio). For political endorsement these choices should be justified with market and technical data. Under the assumption that these choices will also be politically endorsed, the only decision to be made is on the regulations of the CAS. And if decided to regulate, what CAS would be prescribed;
6. Determining the first Customer Proposition. After checking the available spectrum and compliancy with existing regulations, a shared definition of the Customer Proposition will

[19] It was understood that the current ATV networks (BBS1 and BBS2) suffer interference from two stations in India in the south of Bhutan. This interference from foreign stations should be included when planning the DTTB services.

[20] LTE is an application of the International Mobile Telecommunications (IMT) as meant in ITU Radio Regulations RR 5317A.

[21] Receiver availability was excluded from the Roadmap, as DVB-T2 receivers are widely available and priced cheaply. However DVB-T2 STBs with CAS embedded (or a slot for the CA module) should be checked on receiver availability and pricing. The choice of the CAS could be driven by this availability and pricing.

have to be agreed. This proposition should be as concrete as possible in terms of six dimensions as explained in the ITU Guidelines[22]. It should be consistent as it will have a knock-on effect on other decisions of the NRT in other Phases of the Roadmap. An evident example is that if picture or reception quality is changed, that the number of DTTB services may be reduced and hence the number of frequencies to be assigned;

7. Consultation at political level. In this step a draft DTTB Policy document is offered to politicians to approve. This might include many consultation sessions, extensive lobbying and several revisions. Sufficient time should be planned for these activities. It should be noted that in this set-up of the Roadmap, the DTTB Policy document should leave room for the NRT to further detail the Customer Proposition, Frequency Plan (including the service planning process) and ASO Plan (including the organizational structure, budget and planning). After any simplification/adjustments, the approved DTTB Policy document (including the Customer Proposition) can then be published in the Official Gazette as a first communication to the general public and television industry.

3.4.3 Phase 2 ASO planning

The second Phase of the Bhutan Roadmap is aimed at providing a detailed insight in the roles and responsibilities of the various involved parties, the process of transitioning from analogue to digital terrestrial television Broadcasting, the milestone planning and the communication/support process. The ASO planning Phase also serves the purpose of getting support from various involved market parties and politicians.

Inputs

The key input for this Phase is the (passed) DTTB Policy document.

Outputs

The main outputs for the ASO planning Phase are an Initial Frequency Plan (based on an initial DTTB service planning) and the ASO Plan. For drafting the ASO Plan the functional building blocks included in this second Phase of the Roadmap will help the NRT in detailing their ASO Plan.

In general terms, an initial Frequency Plan describes how the available spectrum will be utilized in a deployed network and which service (including the number of frequencies and reception mode) will be provided in what areas and with what quality levels (including picture quality and coverage probability). In more specific terms, the Frequency Plan details all the decisions and trade-offs as included in the functional building blocks 4.2 to 4.5.

The ASO Plan describes in detail the transition process from analogue to digital and will include at least:

- The applied ASO model (see functional building block 2.14). The applied model might be different from area to area. To start with, the non-served areas in Bhutan will have a different model to the served ATV areas (see also Figure 2): the non-served areas will have no simulcasting. For the served areas it has already been decided to have a simulcast period.

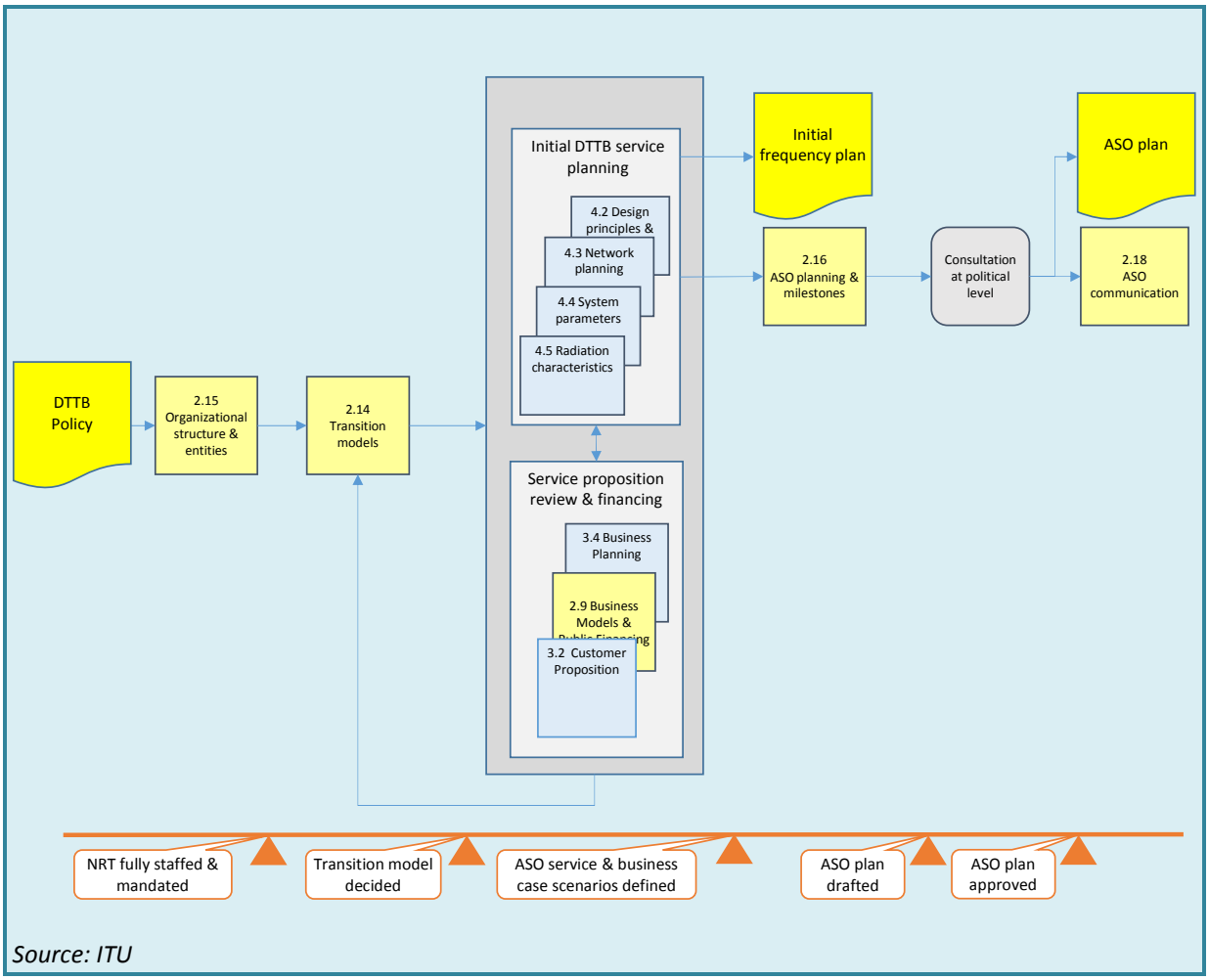
[22] See the ITU Guidelines, section 3.2.1.

In this Phase a further decision is needed on the simulcast model (phasing and duration) for the served areas;

- The Customer Proposition (see functional building block 3.2). Including the details about which services can be received under what conditions (i.e. the reception conditions – rooftop/indoor reception) in what areas;
- The ASO planning (see functional building block 2.16). This planning describes when what Customer Proposition will be made available and how this proposition will be provided. As indicated in the Guidelines this planning comprises several works streams or result paths, including:
    - Regulation & political approval;
    - Frequency Plan;
    - Licensing (further detailed in Phase 3 of the Roadmap)
    - Content/service production and delivery;
    - Network roll-out (includes service delivery details);
    - STB (and other receivers) delivery;
    - Communications (further detailed in functional building block 2.18);
    - Financial & installation support;
    - Consumer & Market monitoring;
- The Business Planning and Public Financing (see functional building block 3.4 and 2.9). A business case should detail what the DSO/ASO process will cost (under various scenarios) and what financial resources should be made available. The initial Frequency Plan will provide the basis for a first estimate of the network costs. Please note that, as Table 2.15.2 in the Guidelines illustrates, the network costs are just one item of the overall budget.

Roadmap

The Roadmap of the ASO Planning Phase and the associated functional building blocks is shown in Figure 10. The decisions taken, partly taken and not yet taken on the key topics and choices per functional build block are indicated in Annex 2: Checklist.



Source: ITU

FIGURE 10: ASO PLANNING (PHASE 2)

As can be observed from Figure 10, the following steps (i.e. functional building blocks and non-DTTB specific activities) are included in the second Phase of the Roadmap:

1. Establishing the organizational structure and participating entities (see functional building block 2.15). Dependent on the exact mandate of the NRT in first Phase of the Roadmap, this might include an additional (political) mandate. The participating parties and their responsibilities in the ASO planning process might be political sensitive and needs a further approval. In this step also the reporting structure and escalation procedures should be clarified so that the NRT can efficiently operate and manage the ASO process;
2. Determining an initial transition model (see functional building block 2.14). In the first Phase of the Roadmap a first understanding of the available spectrum was established. In this Phase of the Roadmap, the NRT should assess what various ASO models are possible and if any changes of DSO/ASO objectives are needed. This assessment together with the implementation guidelines in the Guidelines (see Subsection 2.14.4) on the ASO model decision, an ASO model can be selected (which will vary for served and non-served areas). During the country visit the transition or ASO model was decided to include simulcasting and having a national ASO (date);

3. Balancing DTTB service planning, Customer Proposition and financing (functional building blocks 4.2 to 4.5, 3.2, 2.9 and 3.4). This step entails and iterative process where three elements (i.e. Service Proposition, Network Planning and Business Case) are balanced against each other as illustrated in Figure 3.1.1 in the Guidelines. Although in the Guidelines this process is explained for a commercial DTTB service provider, the process is in essence no different for the NRT. As discussed before, within the NRT the public-private partnership should be detailed and this part of the Roadmap will be at the heart of these partnership negotiations. As the above figure illustrates, this iterative process consists of two parts:
    a. Initial DTTB service planning (which in turn is an iterative process of four functional building blocks 4.2 – 4.5);
    b. Service proposition review and financing (which are also in turn an iterative process of three functional building blocks 2.9, 3.2. and 3.4);

    Figure 11 below provides a flow chart of the two feedback loops that are incorporated in the balancing of these three elements[23]. For example, due to a lack of available spectrum this step may result in a revision of the initially selected transition model (hence the feedback loop in Figure 11);
4. Drafting ASO planning and milestones (see functional building block 2.16). The above mentioned balancing of three elements will result in one optimum scenario to be selected by the NRT. Based on this scenario the initial ASO planning can be (re)drafted. As mentioned before, in case the ASO Plan will require a political approval, it is advisable to draft a planning based on one or two additional scenarios, but perhaps not in all its details;
5. Consultation at political level. In this step a draft ASO Plan is offered for political endorsement (possibly with several ASO model options). Again this might include many consultation sessions, extensive lobbying and several revisions. Sufficient time should be planned for these activities;
6. Finalization of ASO Plan and detailing the ASO communication plan (see functional building block 2.18). After having the ASO Plan approved, the ASO Plan can be finalized for the selected scenario. This ASO Plan will act as the working document for the NRT which will be continuously revised and updated. It will also include the ASO planning on the basis of which the ASO implementation can commence. As discussed previously, one work stream or result path of the ASO planning includes the ASO Communication. Following the guidance provided in the Guidelines (functional building block 2.18) a detailed strategy for informing/supporting the viewers and industry parties can be developed (included for each communication target group a planning for the various messages).

[23] Please note that the chapter numbers in the figure refer to chapter numbers of the ITU Guidelines.

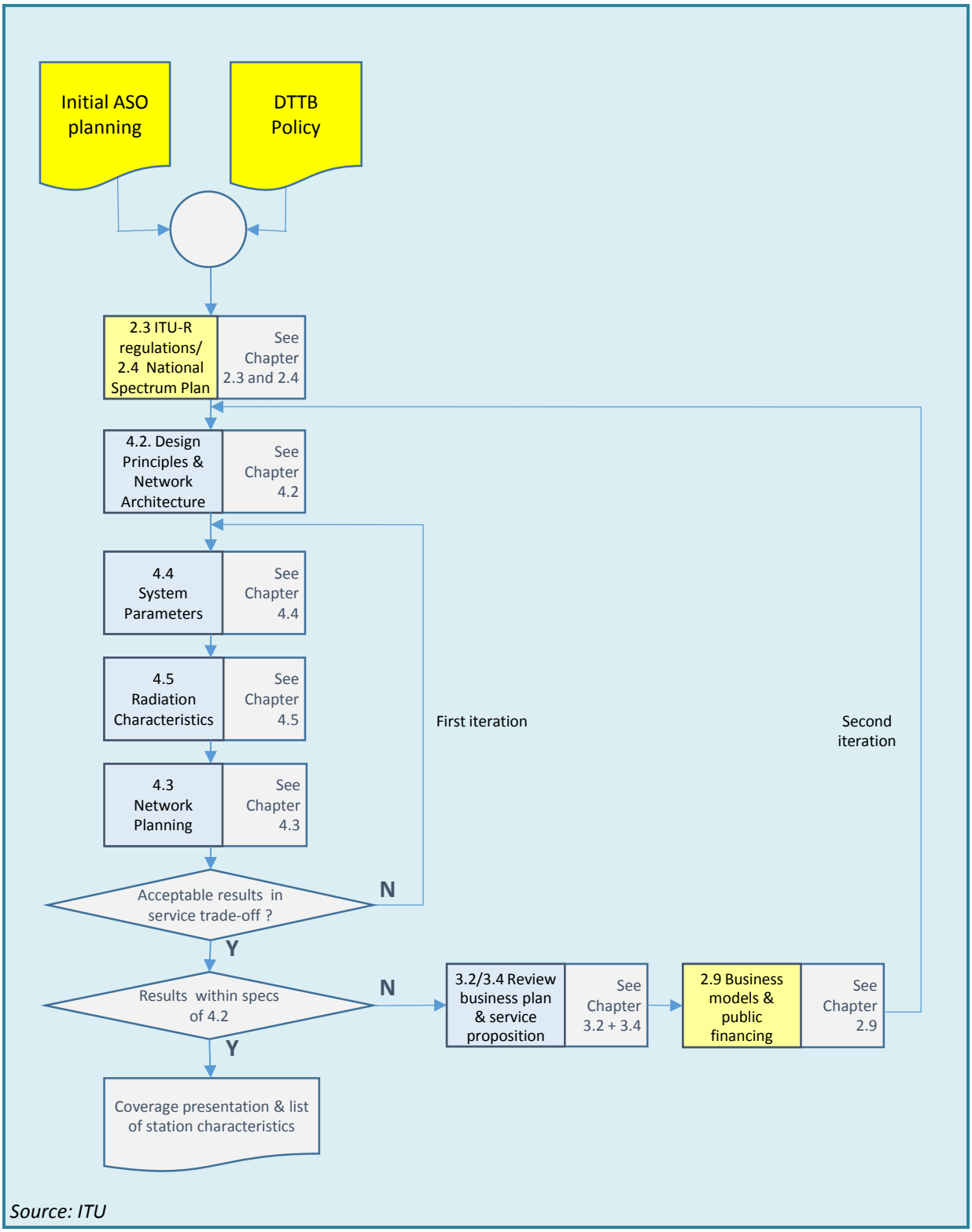


FIGURE 11: FREQUENCY AND BUSINESS PLANNING ITERATIONS

In Figure 11, the first iteration is the so-called service trade-off. In this trade-off transmission costs (given by the number of transmitters and the radiation characteristics), service quality (given by the multiplex capacity) and coverage quality (given by the coverage area which depends in its turn on receiving installation and location probability) are balanced. The optimum solution should be found

within the limits given by the decisions taken in the functional building blocks 4.1 (Technology & standards application) and 4.2 (Design principles & network architecture).

The second iteration is a further balancing of the service trade-off optimum against the financial possibilities. If no satisfactory solutions can be found in the service trade-off, the service proposition and business plan may need to be reviewed, resulting in a possible review of functional building blocks 4.1 (Technology & standards application) and 4.2 (Design principles & network architecture).

Further details on the service trade-off and network planning can be found in Annex 3: System and planning parameters.

3.4.4 Phase 3 Licensing policy and regulation

The objective of this third Phase of the Bhutan Roadmap is to have the required DTTB licenses defined and the associated licensing procedure and planning published. In this way, clarity is provided to market parties operating on the Bhutan television market, as well as television viewers. It also serves the purpose of ensuring uninterrupted broadcasts, free of any interference from any other spectrum users.

Inputs

The input data for this phase are the DTTB Policy document resulting from the first Phase of the Roadmap and the ASO Plan resulting from the second Phase. As indicated in Figure 7 in this report, the third Phase may start in parallel to the execution of Phase 1 and 2. For example, the NRT could start working on the activities in this Phase before the DTTB Policy document and ASO Plan have been endorsed. Such an approach might entail some later changes/revisions of the resulting documents.

Outputs

This third Phase has the following output documents, of which the latter two might be published in the Official Gazette, including:

- A nationally coordinated frequency plan defining which DTTB frequencies will be used when and in which geographical areas. This plan will have to be in line with the National Spectrum Plan or reversely made part of this National Spectrum Plan (please refer to functional building block 2.4 of the Guidelines);
- An internationally coordinated frequency plan. As indicated previously this may require bilateral/multilateral coordination;
- The DTTB license conditions & terms and assignment procedures:
    - *The spectrum and operating rights*. The spectrum rights will have to be assigned to the common multiplex/network operator (possibly a NewCo). To ensure spectrum efficiency and compatibility the spectrum license will have to specify detailed frequency use. Assignment of these spectrum rights can be on the basis of a public tender (or auction) or by priority (as part of the public-private partnership agreement). An assignment by priority has to be support and motivated by sound policy considerations;
    - The broadcast rights (i.e. the content approval for a part/slot of the DTTB capacity) will be assigned to service providers (including BBS and a single pay-tv SP). However, the NRT still have to decide which entity can decide the number of pay-tv services

and the change over time of these pay-tv services. For example this can be the single SP (see Section 2.4) after approval of the *content* by BICMA (for example per service). Also the assignment procedure for the broadcast rights has to be decided. The multiplex capacity for the pay-tv services can be assigned to a bidder (i.e. service provider) in a public tender[24]. Alternatively the assignment of these broadcast rights is part of the public-private partnership agreement and the rights are assigned by priority. Such an assignment has to be support by sound policy considerations. In both cases the NRT will have to arrange for Open Network Provisioning (OPN) rules (including capacity access, reservation, pricing and publication rules) for the common multiplex/network operator (NewCo)[25];

Roadmap

The Roadmap of the Licensing policy & regulation Phase and the associated functional building blocks is shown in Figure 12. The decisions taken, partly taken and not yet taken on the key topics and choices per functional build block are indicated in Annex 2: Checklist.

[24] In such a tender procedure the assigned license will include the service bouquet the service provider/bidder defined in its bid. The license terms and conditions will also have to stipulate under what conditions (and the procedure) the service provider may change its service bouquet during the license duration.

[25] Access to and fair pricing of 'essential facilities', i.e. infrastructure that cannot duplicated under normal market conditions or infrastructure which operations is uniquely licensed to a single market party. The ONP rules stipulate under what conditions access to this infrastructure should be made available and against what costs/prices. See also the ITU Guidelines section 2.6.1.

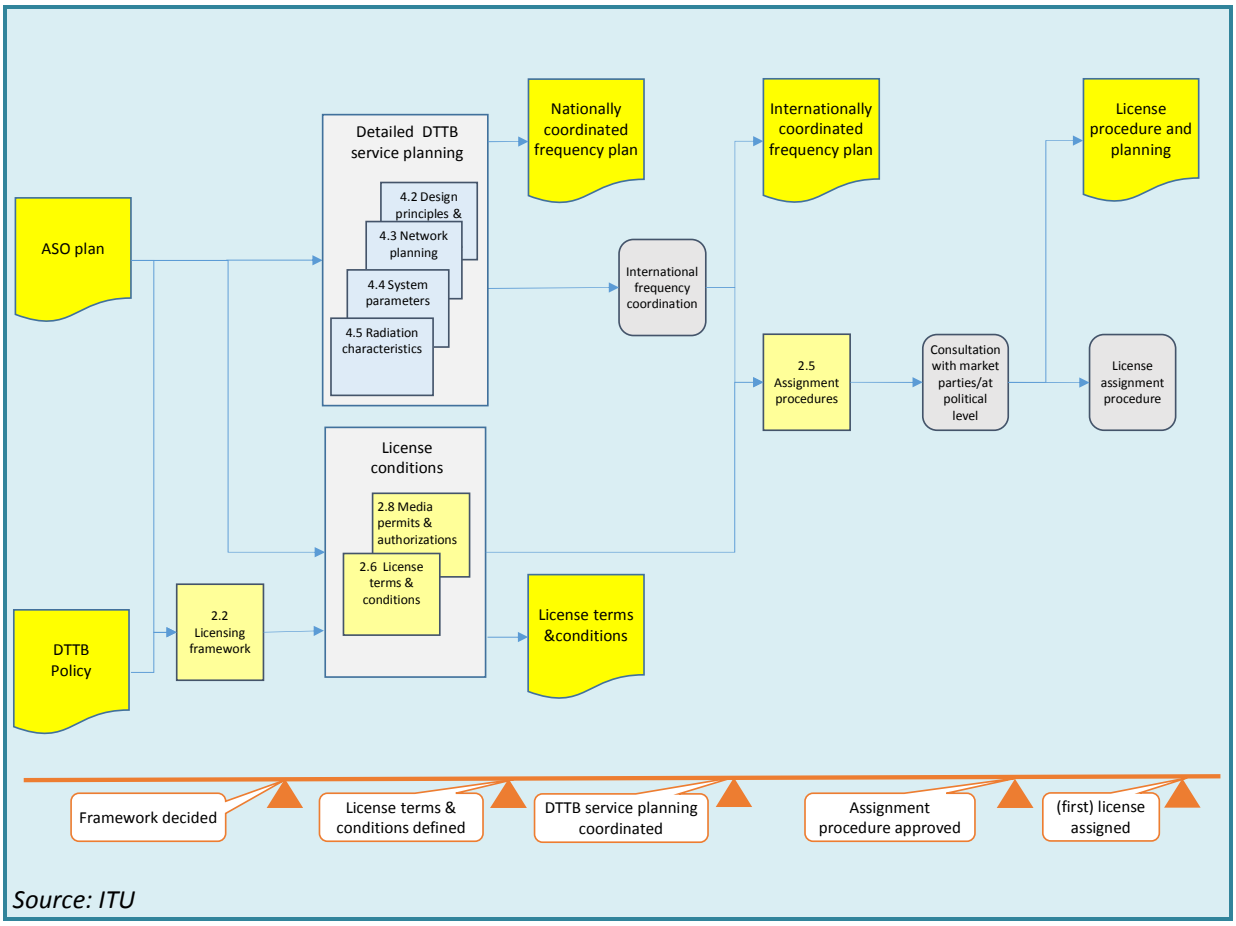


FIGURE 12: LICENSING POLICY AND REGULATION (PHASE 3)

As can be observed from Figure 12, the following steps (i.e. functional building blocks and non-DTTB specific activities) are included in the third Phase of the Roadmap:

1. Detailing DTTB service planning (see functional building blocks 4.2 – 4.5). After having agreed the ASO Plan (including the initial DTTB service planning) a detailed service planning can now be drafted. This detailed planning is different from the initial planning as on the basis of this planning:
    a. License conditions are defined. Hence it will have to consider all characteristics that determine the coverage that should be achieved and the interference potential that should not be exceeded;
    b. Viewers are informed what to do. It will have to provide the details for the communication plan so that viewers know exactly what services they will receive where and what they have to do (e.g. instructions for (re)directing their existing rooftop antenna or acquiring a new one);
    c. Network roll-out will be organized. The detailed planning is a working document. During the roll-out changes will take place and the detailed planning will have to be updated. Consequently the ordering of equipment (a rolling forecast system is also advised here) will have to be updated and the resources to have transmitter sites equipped re-planned;

2. Coordinating the required spectrum with national and international users. Based on the detailed planning, stipulating the exact spectrum use, the DTTB frequencies can be coordinated with other spectrum users. Coordination should take place at an international and national level. First international frequency coordination will be needed (to obtain at each required site 5 UHF channels (for more details see Section 4.4). At a national level this is carried out by matching the detailed DTTB spectrum plan with the National Spectrum Plan or reversely the NSP should be aligned with this detailed spectrum plan. For example, this might entail changing frequencies in the detailed planning and/or changing existing (digital) spectrum rights;
3. Determining the licensing framework (see the functional building block 2.2). As Bhutan has already decided to have model B as their principle licensing model, the remaining key decisions to be made are:
    a. Spectrum rights;
    b. Capacity management/service portfolio;
    c. Open Network Provisioning (ONP) and Reference Offer (RO);
    d. Accounting separation;
4. License conditions and procedures (see functional building blocks 2.6, 2.8 and 2.5). After having the above key remaining decisions clear, the license conditions and procedures can be defined. License terms and conditions will have to be stipulated for the spectrum rights for the common multiplex operator and the pay-tv/commercial SP;
5. Consultation with market parties and political endorsement. Before deciding the licensing regime (to include licensing framework, conditions and procedures), the NRT can organize a market consultation to check the validity and market support for its plans. Given the number of directly involved market parties on the Bhutan television market (see also Figure 1 in this report) this might be organized in a closed set-up with invited parties only. After market consultation, the NRT can support its proposal to the politicians with the feedback acquired in this consultation. Finally, the licensing regime can be officially published after the regime has been endorsed. Sufficient time should be incorporated in the DSO/ASO planning for this endorsement;
6. Assignment procedures. These procedures entail:
    a. Assignment of the spectrum and operating rights to the common multiplex operator (by priority or public tender), and;
    b. Assignment of the broadcast rights to the pay-tv SP (by priority or public tender)[26].

3.4.5 Phase 4 Planning and implementation DTTB network

This Roadmap Phase can only commence when the common multiplex operator has been established (or a separated entity has been created – NewCo) and regulations are in place to arrange for the service levels and pricing of the DTTB transmission services (including a Reference Offer and OPN rules).

[26] Please note that BBS will only broadcast existing services on the DTTB platform in short term. The broadcast rights for these services have already been assigned to BBS. However it should be checked if these rights are not defined for the ATV network only.

The aim of the DTTB implementation Phase is to have the DTTB networks deployed and in operation and the ATV networks switched-off in accordance with the ASO Plan (including the planning and the budget). In this implementation Phase the (inter)nationally coordinated frequency plan is translated into a network rollout or implementation planning. As mentioned in the second Roadmap Phase (ASO planning), the ASO planning comprises a 'Network Plan & Roll-out' work stream or result path. The network implementation planning feeds into this work stream.

It should be noted that this implementation Phase only covers the steps to be taken for the DTTB network rollout. The other work streams or result paths in the ASO planning will need further detailing too and all result paths will have to be kept coordinated with the network deployment progress.

Inputs

The input data for this Phase are the License procedure and planning (including the license terms and conditions which also provide the timing of frequency (de)activation) and the (inter)national coordinated frequency plan from Phase 3.

Outputs

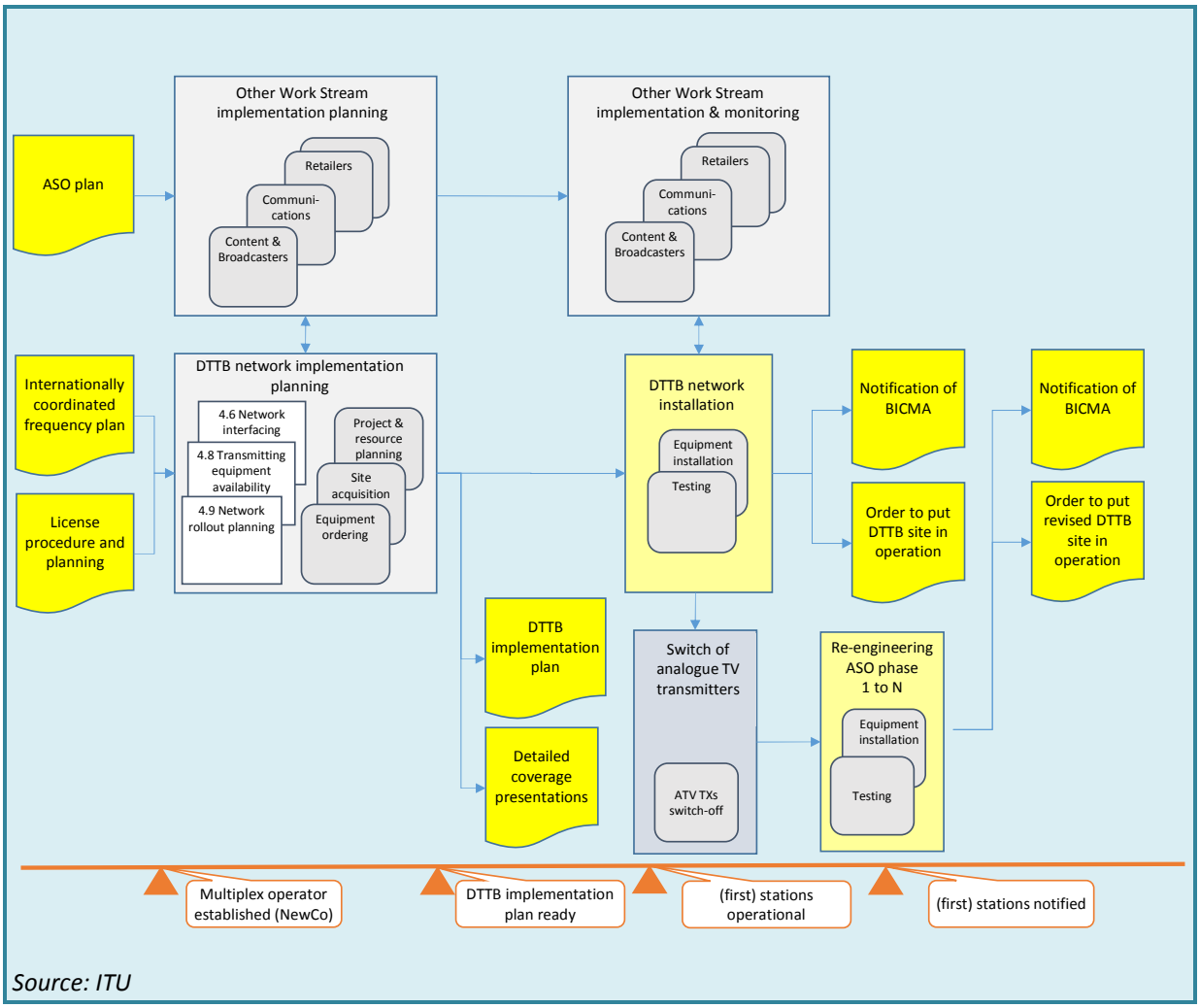
The output of Phase 4 is a set of documents describing:

- DTTB implementation plan. Other than the actual DTTB network rollout planning, this plan also includes the project management structure and resources (including tasks, responsibilities and escalation procedures), detailed and broken down project budget and operational/financial progress reporting;
- Detailed coverage presentations. As the network deployment progresses the coverage predictions become definite (i.e. when the sites have been equipped and no changes can occur any more). These detailed coverage predictions or presentations will feed into work stream Communication of the ASO plan. Please refer to section 5.3 of the ITU Guidelines for more details on service availability checks and tools;
- Notifications to BICMA that DTTB stations have been installed. BICMA as the national spectrum manager should be notified by the common multiplex/network operator that stations are ready to be taken into operations. In the ASO planning a timely reporting of these Notifications to SMA should be taken into account as to avoid that this activity will be part of the critical path;
- Notifications to BICMA that an analogue TV transmitter has been switched off by the ATV broadcaster (BBS). For the purpose of updating its National Frequency Register BICMA also has to be notified when an analogue transmitter is taken out of operations;
- Order to take a DTTB transmitter into operation. After checking compliancy with the DSO/ASO planning the NRT issues an order to the common multiplex/network operator to bring the site into operation.

Roadmap

The Roadmap of the Planning & Implementation DTTB network Phase and the associated functional building blocks are shown in Figure 13. The figure also shows the relationship with the other work streams or result paths, which should be coordinated with the planning and implementation of the

DTTB network (see the grey blocks in the top half of the figure). Although it was decided to have functional building blocks 4.6, 4.8 and 4.9 outside the scope of the Roadmap (see Section 3.3), the common multiplex operator should report to the NRT on these activities. Hence a short description on these blocks is included in this Section. The decisions taken, partly taken and not yet taken on the key topics and choices per functional build block are indicated in Annex 2: Checklist.



Source: ITU

FIGURE 13: PLANNING AND IMPLEMENTATION DTTB NETWORK (PHASE 4)

As Figure 13 shows, the following steps (i.e. functional building blocks and non-DTTB specific activities) are included in the fourth Phase of the Roadmap:

1. Developing and executing the DTTB network implementation planning (see functional building blocks 4.6, 4.8 and 4.9). Developing the network implementation planning entails a large amount of work and the functional building blocks of the Guidelines cover an important part of this work but not all. The Guidelines blocks cover the actual design and implementation of the network infrastructure ranging from the head-end(s), distribution network, transmitter sites, monitoring system and all interfaces of this infrastructure (see also Section 4.5). For developing and executing a DTTB network implementation planning other critical activities will have to be incorporated in the planning, including:

a. Project management. This includes the project structure and resources, budget management and reporting and progress reporting (not only to the multiplex operator's project team members but also to the NRT);
b. Site acquisition. Although an important part of the transmitter sites are already present (the first 29 sites), new sites may have to be acquired for completing the network (10 additional new sites before middle of 2018 – see Table 1). This may entail long preparations (e.g. meeting/negotiations with local councils, land owners, public hearings, etc.);
c. Equipment ordering. Network equipment ordering is not an off-the-shelve ordering process. Manufacturers tend not to keep transmitters in stock. Production times are long (i.e. 3-6 months and beyond). Also the testing and acceptance procedures can take several stages (for example, in-factory testing, on-site testing and end-to-end testing);

2. DTTB network equipment installation. An important part of the installation process is managing the available resources. Especially since the ASO model stipulates a national ASO and the minimum simulcast period will start to commence when the last DTTB site (site 29) is taken into operation. In case the installation process is outsourced to the supplier/manufacturer, this capacity planning will be part of the equipment ordering process. It should also be considered that the multiplex operator will be just established and people and processes might not be fully in place. Hence capacity might initially be limited;
3. Switching off stations (by BBS). As the DTTB network implementation planning is part of the ASO Plan, analogue transmitters will be switched-off too. It is important that this will not only be reported to the BICMA (so that they can update their National Frequency Register) but also coordinated and agreed with the NRT. These reports will feed into the work stream 'Consumer & Market monitoring' too. In this work stream this information will be used to monitor the progress of the ASO process and improve the logistics and communications;
4. Re-engineering DTTB network sites. Cross border spectrum restrictions might change during the network roll-out. This could entail frequency changes to sites that are already taken into operations. Re-engineering of these sites might be necessary. Special care should be taken for avoiding service interrupts. For this reason solutions with temporary frequencies and carousel like planning methods are not uncommon in the network implementation planning. The approval procedures for these re-engineered sites are no different to the approval procedure for new sites, as explained above.

3.4.6 Phase 5 License administration

The objective of the License administration Phase is to check compliancy with the issued license (to the multiplex operator), to update the National Frequency Register and to notify the ITU of any new DTTB station put into operation, as well as ATV stations taken off-air.

The same procedure also applies for changing the station characteristics (e.g. when restrictions on the digital transmissions have been lifted or temporary frequencies are replaced) and when taking

stations out of operations. In the latter situation no approval will be issued by BICMA. However, as indicated before, the NRT will have to approve of the national switch-off of all analogue television transmitters.

Inputs

The input data for this Phase are the notifications of the common multiplex operator to BICMA.

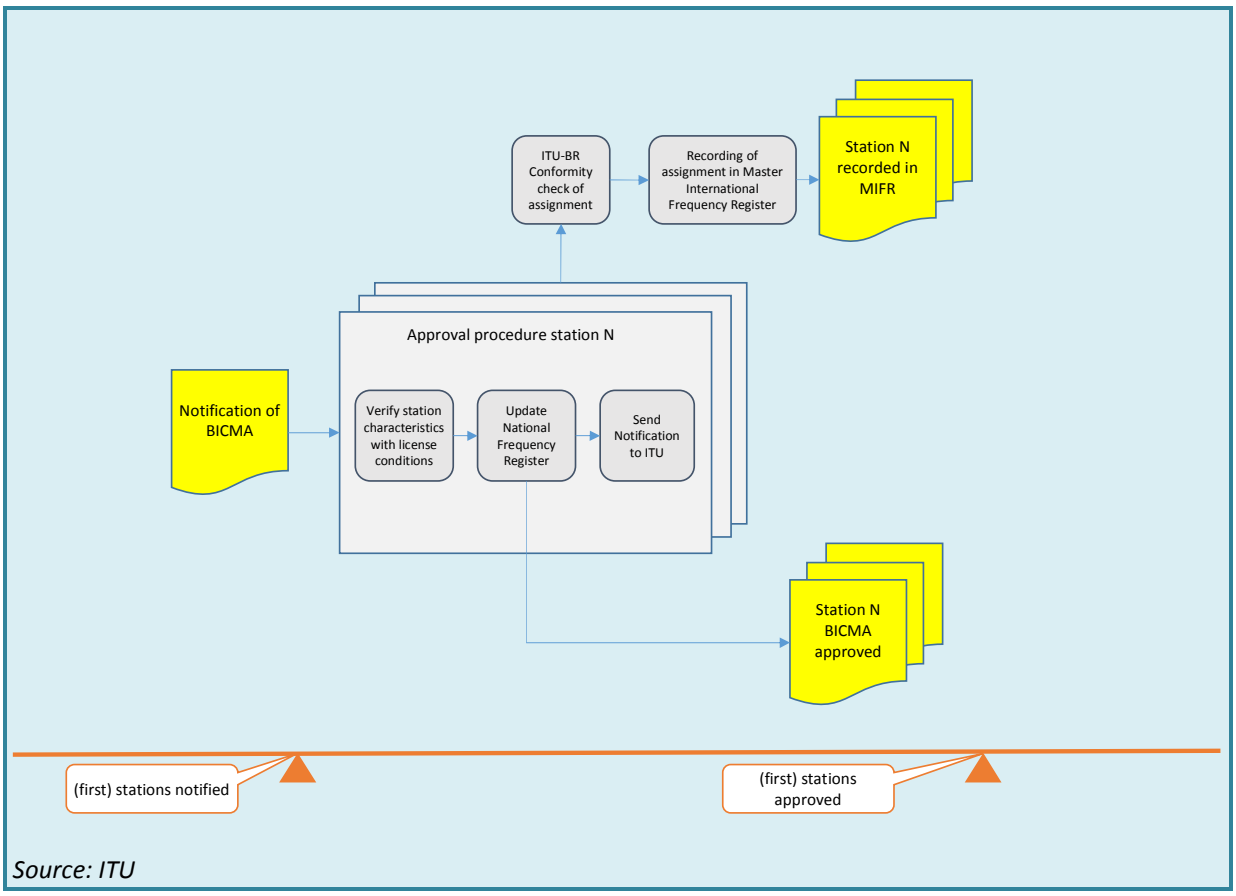
Outputs

The Phase will have two outputs:

- Approval by BICMA of the stations. After having checked whether the transmitter station is compliant with the DTTB spectrum license terms and conditions, BICMA will provide an official approval;
- Recording of the assignment (i.e. station) in the Master International Frequency Register (MIFR). In turn BICMA will notify the ITU (i.e. Bureau Radio) of the new DTTB station taken into operation. The ITU will check the station's conformity and will, after approval, record the station/assignment in the MIFR.

Roadmap

The Roadmap of the License administration Phase and the associated activities is shown in Figure 14.



Source: ITU

FIGURE 14: LICENSE ADMINISTRATION (PHASE 5)

As Figure 14 shows, the following activities are included in the fifth Phase of the Roadmap:

1. Approving the subsequent DTTB stations. After having checked respectively the spectrum license compliancy BICMA will issue an approval to the multiplex operator. BICMA will then update its National Frequency Register and will notify the ITU-BR of the new DTTB station;
2. Recording of the assignment in the MIFR. The recording of a frequency assignment in the Master Register is preceded by various checks, including:
    a. Conformity with the Table of Frequency Allocations and the other provisions of the Radio Regulations (regulatory examination); this examination consists in checking that the assignment (frequency, class of station, notified bandwidth) does indeed correspond to an allocation in the Table of Frequency Allocations in Article 5;
    b. Conformity with the procedures relating to coordination with other administrations applicable to the radiocommunication service and the frequency band concerned;
    c. Conformity with a regional allotment or assignment plan and the associated provisions.

4. Top-5 most critical topics and choices

In this Chapter the top-5 most critical key topics and choices are discussed in more detail. The order of addressing the topics in this section does not express their level of priority or importance. The planning of these topics is indicated in the Roadmap (see Section 3.4).

Please note that some of the top-5 most critical key topics and choices not necessarily correspond to the full scope as addressed in the functional building blocks of the ITU Guidelines.

Table 3 provides an overview of the top-5 most critical key topics and choices.

No	Topic	Part of FBB
1	Licensing framework	2.2
2	Customer proposition	3.2
3	Financing & business model	2.9, 3.2 and 3.4
4	Frequency plan	2.4. and 4.3
5	Network architecture	4.2

TABLE 3: TOP-5 MOST CRITICAL TOPICS AND CHOICES

4.1 Licensing framework

The NRT of Bhutan has decided to adopt licensing model B: the spectrum rights are assigned to a common multiplex/network operator. In addition this common multiplex/network operator will be formed by separating the network activities from BBS. This can accomplished either by establishing a new legal entity (NewCo) or by creating a network department within BBS (in combination with accounting separation). These important decisions should be further detailed in its consequences for the DTTB licensing policy and regulation.

In further detailing the licensing model the NRT should consider the following remaining aspects and decisions:

1. *Spectrum and operating rights*: as indicated in Section 3.4.4 licenses should be assigned to a common multiplex operator:
    a. In case of assigning these spectrum rights directly (by priority) to this common multiplex operator, a legal basis should be found for assigning these rights in this way. Next to this legislative aspect, the NRT should define:
        i. Duration of the rights. For what period and also when spectrum can be revoked or extended;
        ii. Roll-out obligation which stipulates the speed in which sites and services will be deployed. Once the public-private partnership is agreed, it is advised that

the pay-tv operator participates in the NRT and that the network roll-out is jointly planned and managed;

iii. Must carry regulations. The common multiplex operator should first reserve capacity for the 'must-carry' services. Only remaining capacity can be offered for other (pay-tv) services. In the first stage of the DTTB deployment, with only one multiplex, this reservation is clear (see Table 1). The second stage (>2018) the order of reservations for the following should still be agreed and endorsed formally:
   - BBS1 and BBS2 in HD[27];
   - BBS3 in HD;
   - Market entrant/new Bhutan broadcaster offering one HD service;
   - MTV capacity (one PLP);

iv. License fees to be paid. The common multiplex operator might be exempt from paying any license fees. However, this will require a legal justification as to avoid anti-competition claims. Especially considering that Bhutan cable operators pay special purpose taxes[28];

v. Other license conditions. Please refer to the Guidelines section 2.6 'License terms and conditions';

2. *Broadcast rights*: (a group of) private parties may offer the pay-tv service package. The NRT should have the objective to have a joined roll-out between the FTA services (BBS1 and BBS2 in the first stage) and the commercial services. In this way a comprehensive and single DTTB offer can be launched into the market. Hence the license procedure, terms and conditions should include:
   a. Aggregation rules stipulating the number of capacity slots and multiplexes a single SP can acquire (in subsequent tender procedures – if this assignment instrument would be adopted and not by priority). The basic aggregation rules are already included in Table 1;
   b. CAS requirement stipulating which services can be encrypted. It was decided in the NRT that the BBS services would be broadcasted FTA and that the remaining services could be broadcasted as pay-tv services. However this does not necessarily implies that BBS services are not encrypted. It could be that smartcards can be obtain free of charge and that no charges apply for receiving the BBS services decrypted. This model is commonly applied for satellite television services, including also FTA services. For satellite distribution this is however applied to limit the content rights to be paid (as the footprint spans often more than one country/one region). For terrestrial services this situation does not apply. Although such a system can increase

[27] Please note that this reservation should also stipulate whether BBS1 and BBS2 should be continued to be broadcasted in SD for a certain period, as HD services will require HD receivers (including 16:9). Modern STBs will be able to handle both services. However older IDTVs may not. It should be checked at that time how many of these older IDTVs are still deployed (likely to be very low).

[28] Cable companies pay 69 Ngultrum (of the monthly subscription fee of 300 Ngultrum) to the Treasury.

the uptake of pay-tv services as potential DTTB viewers should first contact the DTTB SP for such a free smartcard;

c. Obligation to promote and communicate the DTTB bouquet together with the other FTA services. It is advised that the pay-tv SP participates in the NRT and will help drafting the Communication Plan;

3. *Open Network Provisioning rules (ONP):* when having a common multiplex operator it is good practice to formulate some basic ONP rules, including[29]:
   a. Grounds for refusing requests for carriage (i.e. to be distributed);
   b. Rules for capacity reservation;
   c. Maximum and/or minimum capacity to be allocated to one single service;
   d. Fair and transparent pricing of carriage and the associated service levels(i.e. the DTTB distribution fees to be paid)[30];
   e. Publication of access and pricing rules.

   Service levels and pricing of the DTTB distribution fees can be regulated by having the common multiplex operator preparing a Reference Offer (RO). A reference offer is a binding offer from the multiplex operator in which the distribution service is defined, as well as the service levels and pricing. DTTB broadcasters (i.e. BBS, pay-tv SP and possibly a new broadcaster/market entrants for HD and MTV services) can only distribute their television services by contracting the common multiplex operator. Consequently this DTTB network provider has an exclusive position. In addition, in the case of a BBS network department or BBS having a significant shareholding in the common multiplex operator, BBS would simultaneously carry out network and service provisioning in the same television market. Hence to ensure a level playing field between service providers, it is critical that the BICMA (and in close cooperation with the NRT) requests the common multiplex operator to publish, in sufficient detail, a RO for these network services. The RO subsequently has to be approved by BICMA. More details are provided in Annex 4: More details on Reference Offers;
4. *Scope of activities and assets of the common multiplex operator*: The NRT will have to decide the service portfolio of the common multiplex operator. This will be determined to a large extend by what assets and activities (people) will be transferred from BBS. Based on experience in other countries, it is common practice to split off all distribution services to include infrastructure and people for television and radio services (including head-end equipment and the distribution network to the transmitter sites). It is also advised to transfer all the current analogue transmitter (sites) and associated activities to the multiplex operator and not only the antennas and towers. In this way the separation is clear and resources will be shared as little as possible. In addition the business planning for the common multiplex operator will be easier. The operator should be sufficiently financed to cover all network related ASO costs, including CAPEX for rolling out multiplexes and OPEX for running the analogue (simulcasting) and the digital networks;
5. *Accounting separation*: in the case of a wider service portfolio (radio and television) and in order to provide fair and transparent pricing a sound financial administrative set-up will be

[29] See also the ITU Guidelines p60/61.

[30] For example SD and HD services can charged differently.

required (for both the BBS network department as the separated legal entity). This administrative system should allow for accounting separation (i.e. the direct and common costs can be allocated in a transparent way to the individual services or cost 'carriers'). It should be noted here that allocating costs to the different services may not stop at the level of the multiplex. It may be required that clients of the common multiplex operator will request a capacity slot in a limited coverage area. Consequently the price per so called 'point of service' (i.e. per site for a specific frequency) should be made available (see also Annex 4: More details on Reference Offers;

6. *Special duties*: the common multiplex operator may have assigned special duties of national interest. For example resolving interference issues or providing national disaster services. The first one may cover carrying out investigation and proposing solutions when interference on equipment and other spectrum users occur.

4.2 Customer proposition

The competitive advantage of the DTTB offering will be of crucial importance to the public-private partnership agreement (see Section 2.4 and 3.4.3) as this partnership is proposed to finance the DSO/ASO process.

Table 4 below provides an overview of the service coverage areas of the main television platforms in Bhutan, expressed in household (HH) percentages (i.e. the potential market)[31]. It also includes an estimate of the service uptake per platform, expressed in the actual number of viewers or subscribers and as percentage of television households (TVHH, which equals to 88k in Bhutan).

Platform	Service coverage area		Service uptake	
	% HH	HH (k)	Subs or TVHH (k)	% TVHH
Satellite – pay-tv services (Ku-band)	100%	165	5	6%
Satellite – FTA (C-band)	100%	165	0.2	<1%
Cable – pay-tv services	34%	252	56	64%
ATV – FTA services (BBS1/2)	54%[32]	400	32	36%

TABLE 4: MAIN TV PLATFORMS AND MARKET SHARES IN BHUTAN

From Table 4 the following can be concluded that:

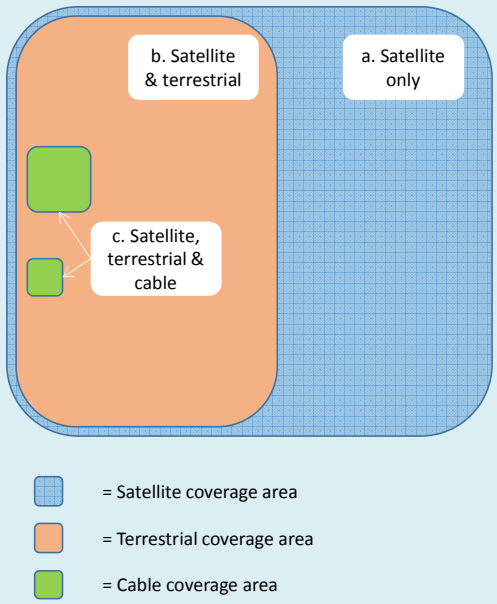
1. Both satellite offerings have a footprint covering the whole of Bhutan. It should be noted that the Ku-Band offering is not officially intended for Bhutan and that the footprint may change as content rights owners may require the satellite operator (InSat) to change/limit the satellite's footprint. Also the offering is not supported in Bhutan (i.e. there is no service provisioning in Bhutan – see also Figure 1). Hence service availability is not guaranteed to these viewers;

[31] Data taken from Figure 1.

[32] See footnote 3

2. The C-band service uptake is below 1% and the Ku-band offering has approximately 6% of the TVHHs. The Ku-band offers a wide range of services of approximately 150-200 services, including HD services and BBS1/2 (and hence with the 'must have' services). Its price level, ranging from 300 to 500 Ngultrum/month, is in the range of the willingness to pay for Bhutan households (see below);
3. The cable offering has the highest uptake (64%) of the TVHH and the average price is approximately 300 Ngultrum/month for a service package ranging between 20 and 70 SD services, which is apparently well within the range of the willingness to pay;
4. The analogue terrestrial network coverage is assessed to be reaching 36% of the TVHH in Bhutan. Figure 2 showed that the calculated geographical coverage is approximately 16 %. Due to missing data it was not possible to calculate the corresponding population coverage. For the time being it is assumed that 36% of the TVHHs can view BBS1 and BBS2 FTA;
5. There are three principle reception situations for households in Bhutan (illustrated in the Figure 15)[33]:
    a. Areas with just satellite reception (with a relative large number of services). Given an assumed network coverage of the analogue terrestrial network of 16 % and the cable networks only being present in urban areas, these satellite areas are theoretically 84% at the most (i.e. 100% - 16%, assuming a complete overlap between terrestrial and cable networks);
    b. Areas with satellite and terrestrial reception (approximately 16%). The number of terrestrial services is two (BBS1 and BBS2) in all ATV coverage areas. There are no regional ATV services or regional broadcast windows;
    c. Areas with satellite, terrestrial and cable reception. These areas are actually limited to the urban areas.

[33] These reception situations are also important to define as they will provide input for the ASO communication to the viewers (especially in the conversion phase when they have to change the cabling of their television set and connect a STB).



Source: ITU

FIGURE 15: DIFFERENT RECEPTION SITUATIONS IN BHUTAN

It is assumed that in the areas with only satellite (situation a in Figure 15) the number of TVHHs is very low (as the penetration of TV sets is relatively low at 53% and most of them will be in the cable and ATV served areas). Consequently the DTTB service offering has to initially[34] compete on two basic markets:

1. Non-cabled areas (situation b in Figure 15). In these areas analogue terrestrial viewers will compare its current analogue offering (including 2 services) with the costs of switching to satellite or DTTB (next to comparing the channel line-up). This is comparing the purchasing costs for a DTTB STB and antenna (including any subsidies/vouchers) to the satellite STB and dish. For ATV viewers with also satellite this trade off will be different (they may decide not to switch to DTTB);
2. Cabled areas (situation c in Figure 15). In these areas people will have to decide between the DTTB, satellite and the (digital) cable offering.

In the following Sections these two basic markets are further analysed. As the C-band offering is very small (below 1%) this offering is not included in the further analysis.

[34] Initially because the DSO/ASO objectives state that first all ATV service areas (BBS1 and BBS2) will be converted to digital. At later stages the DTTB network can be extended to non-served areas (with 10 additional sites and later with 65 sites). In this later stages the DTTB network will mainly compete with satellite only.

4.2.1 Non-cabled areas

The Guidelines (see Section 3.2.1) identifies six competitive advantage categories. Applying these categories on the Bhutan non-cabled areas (where satellite is the only alternative after switching off ATV services) result in the following considerations:

1. *Interactivity/enhanced television services*: the DTTB platform could offer interactive service as a competitive edge. However without any return path, these interactive services are limited to services like the Electronic Program Guide (EPG), additional program information and enhanced teletext. These services are also offered on the satellite platform and hence little competitive edge can be expected in this category;
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/broadcasters a platform to launch pay-tv services, such as tiered television packages, pay-per-view offerings and pre-paid facilities. It should be noted that in the case of a combined pay-tv/FTA offering the possibilities of offering tiered television packages is relatively limited on a DTTB platform (even with 5 multiplexes), let alone the cost consequences for content production/sourcing. On satellite the possibilities to create packages and tiers are almost end-less. For ATV viewers billing is not an advantage in itself;
3. *Additional services/multi-service offering*: in Bhutan the ATV platform offers only 2 services. The introduction of a multi-service DTTB offering could be a key demand driver. As the DSO/ASO objectives states (see Section 2.4) Bhutan intends to launch one multiplex carrying 20 SD services. This advantage should be handled with care as satellite offers a multi-service line-up too (pay-tv satellite). Compared to satellite the DTTB platform is faced with a lower distribution capacity. However the satellite service providers operate in a higher price range (i.e. receiver installation and subscription prices). Hence the DTTB platform does not necessarily have to compete directly with satellite;
4. *Lower costs (one-off and recurring)*: The DTTB platform in Bhutan has the advantage of having lower receiver costs as compared to satellite. Especially the one-off costs form a major barrier for consumers to adopt digital television. DTTB STB retail prices are in the range of USD 20 and don't require any installation (and consequently an installation fee to be paid). The recurring costs (i.e. the pay-tv services in the DTTB service line-up) can be lower as the number of services is significantly lower than on satellite. It should be noted however, as the DTTB launch is part of an ASO process (a government led operation), low purchasing costs (including subsidies/vouchers) for the Bhutan people is really a prerequisite rather than a competitive edge;
5. *Picture and reception quality*: The introduction of DTTB could entail for many Bhutan viewers a significantly better picture quality. Most terrestrial viewers have an indoor reception installation (the so called 'rabbit ears') or a 'coat hanger' in an ATV network that was basically designed for rooftop reception. Hence, due to multipath propagation viewers will have distorted reception and picture quality. This does apply less to viewers with rooftop antennas. However, the number of rooftop antennas is limited in Bhutan. Hence this could provide a competitive edge for DTTB and will help ATV viewers to migrate to DTTB;
6. *Usability/Portability*: DTTB services are wireless and can be received on compact receivers. Hence DTTB services have the competitive advantage of portability, especially when the receiver comes with a small (active) antenna. In Bhutan DTTB can deliver better coverage

and in more places of the home. As Figure 23 to Figure 27 show the Portable Indoor (PI) coverage is almost identical to the fixed (FX) coverage for DTTB broadcasts (see Annex 3: System and planning parameters). Accompanied with proper communications, this portability can provide a competitive advantaged, especially compared to satellite reception.

From the above considerations the following competitive profile of the DTTB platform in non-cabled areas can be drafted:

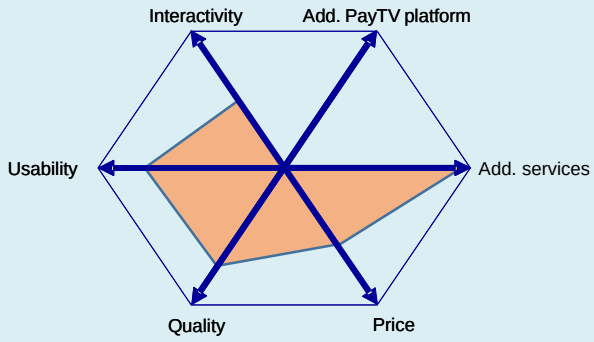


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FIGURE 16: DTTB'S COMPETITIVE PROFILE IN NON-CABLED AREAS IN BHUTAN

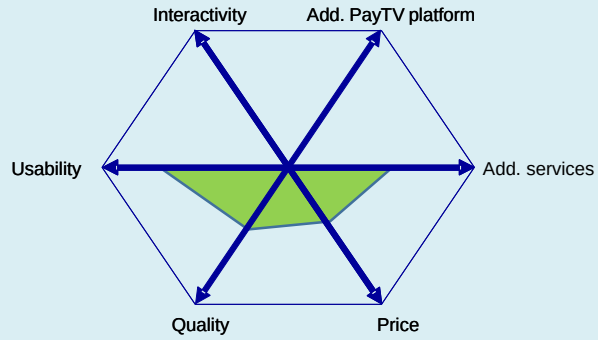
4.2.2 Cabled areas

When applying the six competitive advantage categories on the Bhutan cabled areas results in different considerations. The following category can be assessed *differently*:

1. *Additional services/multi-channel offering*: As said the introduction of a multi-channel DTTB offering could be the key demand driver. For people in the cabled areas this argument seems to be less strong. The cable networks can offer service bouquets over 50 services. In areas where the cable offering have been in the market for some years the window of opportunity may be gone as people have already switched from analogue terrestrial television to cable. Consequently additional services may be a less stronger competitive edge for DTTB;
2. *Lower costs (one-off and recurring)*: most cable networks in Bhutan are analogue networks and a STB is not necessary. Considering this aspect the DTTB offering is not offering an advantage. However the Bhutan cable industry is migrating to digital too. The cable STB is also a 'plug & play' device like the DTTB STB. For satellite providers the tuning of the dish remains a competitive disadvantage as many consumers find this dish tuning too difficult and will call in help;
3. *Picture and reception quality*: For cable subscribers their reference point for picture quality is most likely to be the picture quality of digital cable. DTTB cannot provide a competitive advantage here as cable will always be able to match the DTTB picture quality (as cable networks have far more bandwidth available than the DTTB platform). Hence the argument of having a better picture quality should be handled with care as competition can outperform the DTTB platform on this aspect;

4. *Interactivity/enhanced television services*: Digital cable has the ability to offer a return channel. Integrated interactive services are well developed for cable offerings (including the API on the STB) and hence digital cable has a clear advantage over the DTTB platform. Moreover as most digital cable offerings come very often with so-called 'multi-play' packages (e.g. television, phone and Internet).

From the above considerations the following competitive profile of the DTTB platform in cabled areas can be drafted:



Source: ITU

FIGURE 17: DTTB'S COMPETITIVE PROFILE IN CABLED AREAS IN BHUTAN

The above analysis can help in:

1. Positioning and defining the DTTB offering (including pricing), which in turn can contribute to the business modelling and public-private partnership negotiations;
2. Designing the DSO/ASO communications as it shows the different reception situations and what should motivate viewers to migrate to DTTB;
3. Designing the network as it shows what the DTTB offering should be in terms of network coverage, number of services and type of reception. As was concluded in the NRT, one of the advantages of DTTB is that it could move relatively easier into non-served area (situation a in Figure 15) and hence it was proposed that 10 additional sites would be added to start serving these unserved households (see Table 1). It should be noted that DTTB uptake in these areas will also depend on the television set penetration growth. However this penetration rate was expected to grow rapidly as these households will now get an affordable DTTB offering (as compared to satellite).

4.3 Financing and business model

In the NRT financing the DSO/ASO process was identified as one of the key challenges because:

1. Government's financial resources are limited;
2. Television Industry earning capacity is limited as the advertising and pay-tv markets are small (88k TVHHs);
3. Spectrum scarcity is relatively low and hence spectrum auctions will generate low proceeds.

Hence it was proposed to engage in a public-private partnership whereby the cable industry, BBS and Government would work together in financing the DSO/ASO process. These partnership negotiations will have to consider:

1. DSO and ASO costs;
2. Public and private revenue sources;
3. License terms and conditions (including obligations, rights and industry incentives).

In the following Sections these considerations are addressed in more detail.

4.3.1 DSO and ASO costs

The Guidelines provide in Table 2.15.2 an overview of DSO/ASO cost categories. Table 5 shows the DSO/ASO cost categories for Bhutan.

No	ASO Activity	ASO organisation function	Considerations for Bhutan	Relative costs
1	Migrating viewers to digital	Logistic function for administrating and handing-out vouchers Logistic function for RX antenna retuning and installation Contact centre function for (technical) assistance Customer support function Consumer communication function Media and Public Affairs function	Size of the operations depends on the actual number of ATV dependent TVHHs. Assuming that 32k TVHHs are dependent the size is limited (see Figure 1). Financial impact can be further limited if financial compensations is minimized (see brackets in next column): 1. Selection of cheap set-top-boxes only (no IDTVs); 2. Partly financial compensation (not the whole purchase costs) or loan system (please note this will include interest/finance charge for the Government); 3. Roll-out indoor coverage network, as to avoid roof-top antenna purchase costs (see also Annex 3: System and planning parameters).	+(++)
2	Transmitter network migration efforts	Network planning function	Depends on the actual/final coverage of the DTTB network. The first deployment stage would entail 29 existing sites to be converted to DTTB. The top-3 cost drivers are (a) the number of sites (b) number of multiplexes and (c) the ERP per site.	++(++)

No	ASO Activity	ASO organisation function	Considerations for Bhutan	Relative costs
			A cost model can help running different cost scenarios: 1. For the first deployment stage the number of sites is 29 (and in further stages 10 + 65 additional sites); 2. The number of multiplexes ranges from one up to 5 in the final stage; 3. The DTTB ERPs needed to match ATV can be derived from Table 15). The ERPs needed for the other sites will result from detailed planning work (still to be carried out). Detailed network planning (with advanced software) can reduce costs as the transmitter site characteristics can be optimised (whilst still complying with the business plan and service requirements).	
3	Re-farming of spectrum and compensations	Network planning function	According to the current information provided (but should be double checked) there are no existing spectrum users to be migrated. Also the consequences of ASO on the distribution to cable head-ends should be assessed. This may result in compensation claims. However as BBS1 and BBS2 are also distributed by satellite (C-Band) any compensation claims are unlikely.	0
4	Simulcast period for analogue terrestrial services	Broadcast network roll-out monitoring function	Simulcasting costs are the operational expenditure of the ATV network during the simulcast period. As Bhutan has opted for a national ASO this costs can be limited by: 1. Deploying the DTTB sites quicker (it is assumed that as soon as a site is DTTB ready it will be brought into operations and the simulcast period will start) as the last DTTB	+

No	ASO Activity	ASO organisation function	Considerations for Bhutan	Relative costs
			site will determine the end date of the simulcast period; 2. Reducing the simulcast period for the latest DTTB sites.	
5	Managing the ASO process	Broadcast network roll-out monitoring function Market monitoring and research function Consumer communication function Industry communication functions	Assuming all functions (see left column) will be included in the NRT responsibilities and NRT members will be mainly Government entities, the managing efforts and costs can be relatively low. Given the low penetration rate of Internet access and use in Bhutan, communication costs might be relatively high (e.g. printed materials, mobile and more radio and TV broadcasts) DTTB uptake should be monitored closely by carrying out survey periodically. An example monitoring framework can be found in Annex 5: Example tracker board.	+
6	Setting mandatory certification and labelling	Industry liaisons function	These costs could be minimized by: 1. Have suppliers guarantee compliancy and label STBs (before they receive an import license); 2. Stipulating a widely accepted and proven transmission standard (which DVB-T2 is) and CAS system; 3. Implementing a voucher system for a single standard receiver (i.e. set-top-box).	+
7	Cost for resolving any DTTB interference	Contact centre function Customer support function	Interference to cable could occur in Bhutan, given the presence of cable networks and home installations. If interference do take place, costs can be minimized if cable operators are willing to use spectrum not in use by DTTB. That will imply that network operators will have to change their so-called network raster and subscribers have to retune their television sets.	0

TABLE 5: DSO AND ASO COST CATEGORIES

From Table 5, it can be concluded that the main cost element for the Bhutan is likely to be the DTTB network costs and secondly subsidies for STBs.

4.3.2 Public and private revenue sources

A first inventory of possible financial sources have been made by the NRT. A systematic inventory should be made of the possible sources for financing the DSO/ASO costs as included in Table 5. This also serves the purpose of providing evidence that the proposed public-private partnership is the best way forward. The Guidelines provides guidance on sources for funding. Table 6 provides some first considerations on the various sources for Bhutan.

No	Source	Considerations for Bhutan
1	General Taxes	When financing the ASO from general taxes the following should be taken into account: 1. Given the first DTTB coverage target (to match ATV coverage) as stated in the DSO/ASO objectives, a large portion (100% - 36% ATV pop coverage = 64%) of the population will pay towards the DSO/ASO but will not directly benefit from DTTB. This may constitute a political barrier; 2. This is a form of indirect financing of activities (i.e. not through a purpose/specific tax). The DSO/ASO costs and benefits have to be balanced against other national priorities (e.g. building schools or roads). This political process might be long and the DSO/ASO planning should take this into account when deciding to include this source in its financial planning.
2	TV license fees[35]	Introducing the TV license fee can be an option to finance the DSO/ASO process. However in Bhutan such a system is currently absent. Experiences in the past have shown that such fees are heavily debated and people tend to resist such an introduction. This may cause significant political debate. Although law enforcement has shown to be very difficult in the past (as people hide television sets and regular checks were necessary) with a CAS system, in place non-payment can be easily resolved (i.e. non-payers are cut-off). In this system only DTTB viewers would contribute.
3	Spectrum usage/industry levies	The number of licensed spectrum users is relatively low in Bhutan. Hence there seems to be no basis for (additional) spectrum usage levies. Special industry levies for equipment suppliers will be problematic for (inter)national competition rules and policies. Moreover this may work adversely as equipment prices will go up.

[35] This is a system whereby the ownership of a television (or radio) set is taxed (and not the actual usage).

No	Source	Considerations for Bhutan
4	Spectrum auctions or tenders	Spectrum auctions and tenders procedure with substantial upfront payments are rare (although recently Thailand successfully auctioned off broadcast spectrum). However, considering the relatively small television market such an auction would generate little proceeds. Alternatively one could auction off the 'Digital Dividend' spectrum (for example for LTE services). However in the short term spectrum is not scarce in Bhutan, including for mobile/LTE services. Also it should be noted that the revenues/proceeds of this type of auction will become available after ASO. Hence DSO/ASO costs have to be advanced.
5	International organizations/loans (ITU/NGO/World bank, other countries, etc.)	No information available. In the case of international loans (accompanying equipment and service supplies) the ability to pay back should be seriously considered.
6	Public-private partnership (pay-tv service revenues with Government contributions)	The NRT already assessed this as a candidate to be detailed and negotiated further. It should be noted that this model is different from auctioning (which also includes private contributions) as mentioned under item 4. The risk profile is much lower. Costs are incurred in steps and can be actively managed during the deployment. Also the options to share costs can be formulated in a flexible way and/or (re)negotiated during deployment.

TABLE 6: SOURCES FOR FINANCING THE DSO/ASO PROCESS

As Table 6 shows several options are available with their own pros and cons. The NRT should review them systematically. Currently option 6 was assessed to be the most promising and the national association of cable operators was willing to explore the model further.

4.3.3 License terms and conditions

Under the model of the public-private partnership, the spectrum and operating rights have to be assigned to the common multiplex operator and the broadcast rights to the single pay-tv provider (see also Section 4.1). The corresponding license terms and conditions should cover obligations, rights and incentives. Table 7 provides an initial overview of possibilities.

License	Obligations	Rights	Incentives
Spectrum and operating license for MUX operator	• Coverage targets, service levels and pricing as included in the BICMA approved RO	• Exclusive spectrum and operating rights	• A guaranteed (long) period of exclusivity • License fee and/or tax exemptions

License	Obligations	Rights	Incentives
			• Capacity reservations for offering own services
Broadcast license for pay-tv SP	• Providing a BICMA approved service line-up in agreed quality (SD/HD) and with a minimum number of broadcast hours • Providing viewers with assistance for acquiring STBs, DSO/ASO information and installation aid	• Exclusive broadcast rights	• A guaranteed (long) period of exclusivity • License fee and/or tax exemptions • Capacity reservations for extending the pay-tv service offering

TABLE 7: LICENSING OPTIONS

Table 7 just provides an initial overview and any obligations, rights and incentives should be balanced against the cost/financing contributions. Such balancing will take place in the negotiations on the public-private partnership. As the network costs are a key cost element in the DSO/ASO process (see Section 4.3.1) a cost model should be developed that can cater for different scenarios (see also Table 5).

4.4 Frequency plan

The aim of a frequency plan is to:

1. Provide access to the spectrum to current and planned services;
2. Avoid unacceptable interference.

For broadcasting services normally a so-called a-priori plan is made. In such a plan all known and expected (long term) requirements are planned at once. The plan contains only stations that are compatible. In order to cope with unforeseen developments, changes of the plan should be possible, but without significantly affecting the coverage areas. The a-priori plan gives certainty for a long period to the regulator, the network operator(s) and broadcasters that good quality reception levels are maintained in the coverage areas, defined at the moment of licensing.

This section addresses the frequency band to be used for DTTB, the frequency plan related to the transition from analogue TV to DTTB and some attention points for establishing the frequency plan.

4.4.1 Frequency band to be used for DTTB

According to the spectrum plan, in Bhutan VHF Band III (174 to 230 MHz) and UHF Band IV (470 to 610 MHz) are available for broadcasting. In Band III analogue TV is in operation with system B/PAL in 7 MHz channels. Band IV is not used. It is recommended to apply an 8 MHz bandwidth in Band IV, because of the higher multiplex capacity and because this is the most commonly used channel bandwidths in UHF in countries that adopted the DVB-T or DVB-T2 standard.

The ITU Guidelines for transition to digital broadcasting give guidance on selection of the VHF or UHF band for DTTB[36]. The selection table has been reproduced below.

Condition	Band choice	Reason
A. 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
B. 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
C. 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
D. Fixed reception in other cases	Band IV/V	• Limited Band III capacity (in case 7 MHz channel raster) • No need to install Band III receiving antennas • Less interference probability due to abnormal propagation conditions (fading)
E. 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
F. Portable reception	Band IV/V	• Lower man-made noise levels compared to Band III • Easier installation of fill-in transmitters with smaller transmission antennas
[a]) taking into account protection of analogue TV services and T-DAB and T-DMB requirements [b]) 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 bitrate of the system variant used in the transmitters 7 MHz and 8 MHz		

[36] See Section 4.2.4 of Guidelines for the transition from analogue to digital broadcasting, edition January 2014

Condition	Band choice	Reason
channels is higher than the data stream bitrate; inefficient spectrum use in the transmitters with 8 MHz channels may occur due to unused capacity.		

TABLE 8: BAND SELECTION (SOURCE ITU GUIDELINES)

Row D fits best the DSO objectives in Bhutan, because with regard to fixed reception:

1. Conditions A and C are not applicable in Bhutan, because the bandwidth in Band III is 7 MHz;
2. Condition B does not apply because in Bhutan there is no installed base of Band III rooftop antennas;
3. Condition D applies and has the advantage that:
    a. In the long term five multiplexes are required which cannot all be accommodated in Band III. By using UHF only, installation of both VHF and UHF antennas (transmitting and receiving) is avoided;
    b. The UHF band is not used, hence no compatibility problems will occur during the transition from analogue to digital television;
    c. The multiplex capacity in the 8 MHz channels in UHF is 12.5% higher than in the 7 MHz channels in VHF.

With regard to portable reception, in addition to the reason given for fixed reception, condition F applies better than condition E because:

1. The propagation disadvantages of the UHF band are less prominent because in the valleys in many cases the propagation path is short and in line of sight due to the high site heights and relative small coverage areas;
2. Combined band VHF and UHF receiving antennas are avoided by using UHF only.

Taken into account the above mentioned considerations, it is recommended to plan DTTB in UHF only.

4.4.2 Frequency plan related to the transition from analogue TV to DTTB

A frequency plan related to the transition from analogue to digital television plans deals with three stages in the VHF and UHF broadcasting bands[37]:

1. The existing situation with the analogue TV (ATV) plan;
2. The transition period with the ATV plan and DTTB plan and the condition that analogue TV services should be protected by DTTB transmissions;
3. After analogue TV switch-off (ASO) when only digital TV exits.

During the transition period the analogue TV needs to be protected. This means that the analogue coverage areas should not be unacceptably reduced due to interference from digital TV

[37] See also Section 4.2.4 of Guidelines for the transition from analogue to digital broadcasting, edition January 2014

transmissions. Depending on the frequency bands used for ATV and DTTB and the number of analogue TV stations in operation, this requirement limits the number of channels that can be used for digital TV and may also limit the radiated powers of digital transmissions. However, if ATV is planned in VHF only and DTTB is planned in UHF only, analogue TV will not be affected by DTTB and DTTB will not be limited by analogue TV.

Table 9 gives an overview of the planning situations in Bhutan, taking into account the recommendation to plan DTTB in UHF only.

Stages	174 – 230 MHz (Band III)	470 – 862 MHz (Band IV/V)
Existing	• 174 – 230 MHz: ATV	• 470 – 610 MHz: no ATV assignments • > 610 MHz: Mobile
During transition	• 174 – 230 MHz: ATV	• 470 – 610 MHz: DTTB replacing ATV and additional DTTB • > 610 MHz: Mobile
After ASO	• 174 – 230 MHz: DTAB/MTV?	• 470 – 610 MHz: DTTB replacing ATV and additional DTTB • > 610 MHz: Re-allocation of parts of the band to broadcasting?

TABLE 9: NATIONAL TV SPECTRUM SITUATION

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.

The following sections address the frequency plans in the three stages.

1) Existing situation (before DTTB introduction)

The analogue TV plan in Bhutan contains assignments in VHF (Band III) related to operational TV stations and planned TV stations. Further information on the analogue TV plan is also given in Section 2.2.

Attention points regarding the existing analogue TV plan are:

1. Verification of transmitter data. In order to calculate the current analogue TV coverage areas, accurate transmitter station data are needed. The analogue TV station data should be verified and be more detailed (including frequency off-set);
2. Assessment of the current analogue TV coverage areas. According to the DSO objectives the analogue TV coverage should be matched by DTTB. It is therefore necessary to determine the current analogue TV coverage areas in a similar way as for DTTB and taking into account interference from other analogue TV stations.

2) During transition

During the transition period the currently operational analogue TV stations in Band III remain as they are and no new analogue TV stations will be licensed. According to the DSO objectives one DTTB multiplex should be in operation. It is recommended to plan at once also the four multiplexes required after analogue TV switch-off and to establish a channel assignment scheme. By means of such a channel assignment scheme, regular channel assignments to sites will be made which

facilitates planning. It also provides the possibility to group channels in several parts of the band. This would make it possible to use transmitting and receiving antennas more efficiently, as the efficiency of an antenna is wave length dependent and better coverage could be achieved. However, the application of a regular channel scheme may be limited due to international coordination.

The frequency plan for all five multiplexes makes it possible from the start to take account of future frequency assignments in specifying transmission equipment. Also it may avoid future frequency changes.

As according to the recommendation in Section 4.4.1, DTTB is planned in UHF only; compatibility between analogue TV and DTTB is no issue and is not described in this report.

3) After ASO

After analogue TV switch-off, all analogue TV stations should be deleted from the plan. The spectrum used by analogue TV becomes available for new broadcasting services or for other services, for example Digital Terrestrial Audio Broadcasting (DTAB) or mobile TV (MTV).

4.4.3 Attention points for establishing the frequency plan

A number of attention points for establishing the plan are described in this section:

1. Spectrum capacity;
2. Planning and system parameters;
3. Planning process;
4. Compatibility with other services;
5. International coordination;
6. Verification of transmitter data.

1) Spectrum capacity

In the national spectrum plan broadcasting is allocated in the frequency range 470 to 610 MHz; that is channels 21 to 37 plus a guard band of 4 MHz. Hence 17 channels are available for DTTB planning.

The European Broadcasting Union (EBU) estimated that in general 6 to 8 channels are needed to plan a national DTTB coverage in UHF[38]. Further studies in the EBU[39] concluded that by applying large SFNs with the DVB-T2 standard the number of channels could be reduced to four to five per national coverage taking into account that interference from one country into another should be avoided.

In Bhutan the number of channels needed to plan one DTTB multiplex maybe less due to terrain shielding, the relative low ERPs needed to cover small valleys from high sites and only partly coverage of the territory. Furthermore it is noted that in the analogue TV plan in Band III two channels are used to plan one service.

The current broadcasting allocation of 470 to 610 MHz is certainly sufficient to plan the multiplex that required in the period from 2015 to 2018. In Section 4.4.2, item 2, it is recommended to plan all

[38] See EBU Technical Report 015 Defining Spectrum Requirements of Broadcasting in the UHF Band, dated July 2012.

[39] See EBU Technical Report 029 DVB-T2 Single Frequency Networks and spectrum Efficiency, dated October 2014.

five multiplexes at once. Those planning results show the long term spectrum requirement. The Broadcasting allocation in the UHF band may then be reviewed taking into account:

1. The estimated spectrum requirement for five DTTB multiplexes;
2. The results of ITU WRC-2015 regarding the allocation of mobile services in the UHF band.

2) Planning and system parameters

In order to establish the frequency plan that fulfils the DSO objectives and complies with the customer proposition, appropriate planning and system parameters should be adopted. An initial approach towards a set of planning and system parameters is described in Annex 3: System and planning parameters. A summary of this set is included in Table 10.

Characteristics	Initially recommended value
FFT size	32k, extended carriers
Pilot pattern	PP4
Guard interval	1/32 (112 µs)
Modulation and code rate	64-QAM 2/3
Payload	28.5 Mbit/s
C/N (Fixed reception)	16.0 dB
C/N (Portable reception)	17.9 dB
Polarisation	Vertical
Network configuration	MFN

TABLE 10: INITIALLY RECOMMENDED SYSTEM AND PLANNING PARAMETERS

3) Planning process

Before the DTTB planning starts the planning principles and the planning method needs to be described and endorsed by all parties concerned.

With regard to reception of DTTB it should be reminded that, contrary to analogue TV, there is no smooth degradation from good to poor picture quality when the signal to noise ratio or signal to interference ration is decreased below the required value. DTTB should therefore be carefully planned using advanced planning software and detailed terrain and clutter data[40].

[40] The detailed terrain and clutter used in the coverage examples in this Roadmap was provided by courtesy of Progira Communications.

4) Compatibility of DTTB assignments with other services

In the national spectrum plan the frequency range above 610 MHz is allocated to mobile services. As no mobile services are in operation or planned in that frequency range, compatibility between DTTB and mobile on adjacent channels does not need to be taken into account.

If in the future the channels above 48 are allocated to IMT, compatibility between DTTB and IMT needs be investigated taking into account the latest ITU-R recommendations. In case of incompatibilities, it has be decided who is responsible for eliminating the harmful interference.

Interference from DTTB to cable systems may occur if in the cable system the same channels are used as for DTTB broadcasting. Experience in Europe learned that this kind of interference is mainly caused by poor domestic cable installations. Interference was resolved in many cases by applying good quality coax-cable and good quality connectors in the homes. Moreover, sometimes cable operators avoided this kind of interference by not using the channels that are broadcasted in the area served by the cable system.

5) International coordination

An important principle of international coordination of frequencies is that all countries have equitable access to the spectrum. Coordination agreements with neighbouring should be made in on the use of frequencies in border areas. Also transmitter data (in ITU format) should be exchanged which makes it possible to take interference from foreign transmitters into account.

It is important to finalize the international coordination before the licensing procedures start and to incorporate the results in the frequency plan. Otherwise there will be uncertainties about the assignments as changes to licensed DTTB stations may be required once the international coordination is completed.

ITU-BR should be informed about the coordination results (see Article 6.7 of the Radio Regulations) and when a station is brought into operation it should be notified to ITU-BR in accordance to the provision of Article 11 of the Radio Regulations.

6) Verification of transmitter data

In order to calculate the DTTB coverage areas and to perform compatibility calculations, accurate transmitter station data is needed. The data should include:

1. Site name;
2. Geographical coordinates of the site;
3. Altitude of the site above sea level;
4. Height of the transmitting antenna above ground level;
5. Antenna pattern if a given antenna should be used.

The planning process will result in specification of the channel, ERP and antenna pattern (if not prescribed).

4.5 Network architecture

A DTTB network consists of one or more head-ends, the distribution links and the transmitter sites.

This section describes items having an impact on transmission costs and efficient use of frequencies and gives an example of a network lay-out that complies with the DSO objectives and the decisions taken or advised on key topics and choices of the selected functional building blocks.

4.5.1 Items having an impact on transmission costs and efficient use of frequencies

It is up to the network provider to consider the various options of the network architecture and to decide on cost effective and technically sound solutions that comply with the license conditions and the requirements of the service licensees. However, in developing license conditions it should be taken into account that the following items have an impact on transmission costs, efficient use of frequencies and reliability and quality of the service delivery:

1. Local and regional services;
2. Network configuration (SFN or MFN);
3. Statistical multiplexing;
4. Distribution links;
5. Equipment redundancy

1) Local and regional services

Requirements for regional and local services are important design criteria in the network architecture and have an impact on transmission costs. The DSO objectives do not indicate the need for regional of local services, consequently the BBS services as well the services provided by the cable operators are exactly the same at all sites at any time. Under these conditions one head-end at a central location is sufficient where all services are multiplexed and from where the data stream (T2-MI) is distributed to the transmitter sites.

However, if at a later stage regional services at one or more sites are required, the services intended for these sites should be re-multiplexed by taking out one or more of the national services and inserting one or more regional services. In principle three basic network lay-outs could be considered in that case:

1. One main head-end only
   All national and regional services are transported to the main head- end and from there distributed to all transmitter sites;
2. Regional head-end in each region
   National services and regional services are multiplexed at regional head-ends and distributed to the transmitter sites that are part of the regional coverage area;
3. Combination of 1 and 2
   Some regional services are multiplexed at the main head-end and together with the national services distributed to all transmitter sites. Other regional services are coded and (re)multiplexed with national services at regional head-ends.

As the DSO objectives indicate national services only, layout 1 (one main head-end) is shown in the example in Section 4.5.2.

2) Network configuration (SFN or MFN)

In the initial approach towards a set of system and planning parameters described in Annex 3: System and planning parameters, it is assumed that DTTB planning is based on MFNs. However, if at

a later stage it is decided to operate one or more transmitters in SFN (e.g. to cover a town by two sites in order to improve portable indoor reception) it should be taken into account that transmitters belonging to an SFN:

1. Must have the same content at any time;
2. Must be connected to the same T2-Gateway, generating the synchronization information to the transmitters in the SFN.

3) Statistical multiplexing

Efficient use of frequencies is obtained by the application of statistical multiplexing (in short "statmuxing"). In this way a higher bit rate will be automatically allocated to critical scenes and a lower bit rate to less critical scenes. This results in a higher picture quality per SD or HD service. 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. Statistical multiplexing is more efficient with a high number of services and different kind of content per service. Efficiency gains of more than 25% may be reached (see Annex 3: System and planning parameters).

Statistical multiplexing can be applied in different ways, e.g. a group of services in a DVB-T2 Physical Layer Pipe (PLP) could be statistically multiplexed. Also statistical multiplexing could take place between PLPs.

4) Distribution links

In the ITU guidelines[41] several physical means and technologies for distributing signals from the head-end to the transmitters are described including:

1. Satellite links, microwave links, and optical fibre using PHD, SDH, ATM and IP technologies;
2. DVB-S(2) satellite broadcasting transmissions;
3. Off-air reception.

As for analogue television, distribution of the DTTB signals to the transmitters could be provided by DVB-S(2) satellite transmissions. There are several ways to distribute DTTB signals by satellite with different operational and cost aspects. In some cases transcoders and re-multiplexers are needed for all services at all sites, e.g. in case of direct-to-home (DTH) reception. In other cases the received signal can be connected directly to the modulation stage of the transmitter as e.g. the DTTB services are transmitted via the satellite in the T2-MI protocol, which is the DVB-T2 distribution protocol. In the latter case the satellite signal cannot be received with domestic satellite receiving installations or cable TV head-ends. Therefore it should be used in addition to DTH satellite reception, involving doubling of satellite distribution costs for broadcasters.

Off-air reception offers the lowest installation costs[42]. In particular in MFN networks some sites could be fed off-air provided that the received input signal level is sufficiently high. In SFNs the ERP of off-

[41] See Section 4.2.7 of Guidelines for the transition from analogue to digital broadcasting, edition January 2014

[42] See also Section 4.3.3 of Guidelines for the transition from analogue to digital broadcasting, edition January 2014

air fed transmitters is restricted in order to avoid oscillation and depends on the isolation between input and output. The quality and availability of the transmitting signal depends on the quality and availability of the received signal. Application of many off-air fed sites and cascaded off-air fed sites reduces the services availability levels and may not be acceptable for operational reasons.

5) Equipment redundancy

In order to avoid long service interruptions in case of maintenance or equipment failure, critical parts of the transmission chain, including ancillary equipment such as power supply and cooling, should have a certain redundancy[43]. The redundancy could range from use of parallel units in operational equipment to a complete back-up system.

Monitoring the operational status of the transmission chain is essential to make the operators aware of an operational problem and to take actions to resolve the problem.

The ITU Guidelines give the following guidance with regard to redundancy:

1. If several transmitters are used at a site, an n+1 redundancy configuration is often used.
2. 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;
3. In the multiplex centre encoders and multiplexers have often full or n+1 back-up configurations;
4. Monitoring equipment and links should have full redundancy.

The available budget may make it necessary to compromise on back-up facilities; priority may be given to:

1. Parts in the transmission chain that are sensitive to failure based on the experience of the operation of the analogue TV networks;
2. Central parts in the network, such as the head-end;
3. Transmitting stations covering relative large parts of the population.

4.5.2 Example network architecture

The block diagram in Figure 18 shows an example of a network architecture. In order to simplify the figure only three transmitting sites are indicated.

[43] See also Section 4.2.6 of Guidelines for the transition from analogue to digital broadcasting, edition January 2014

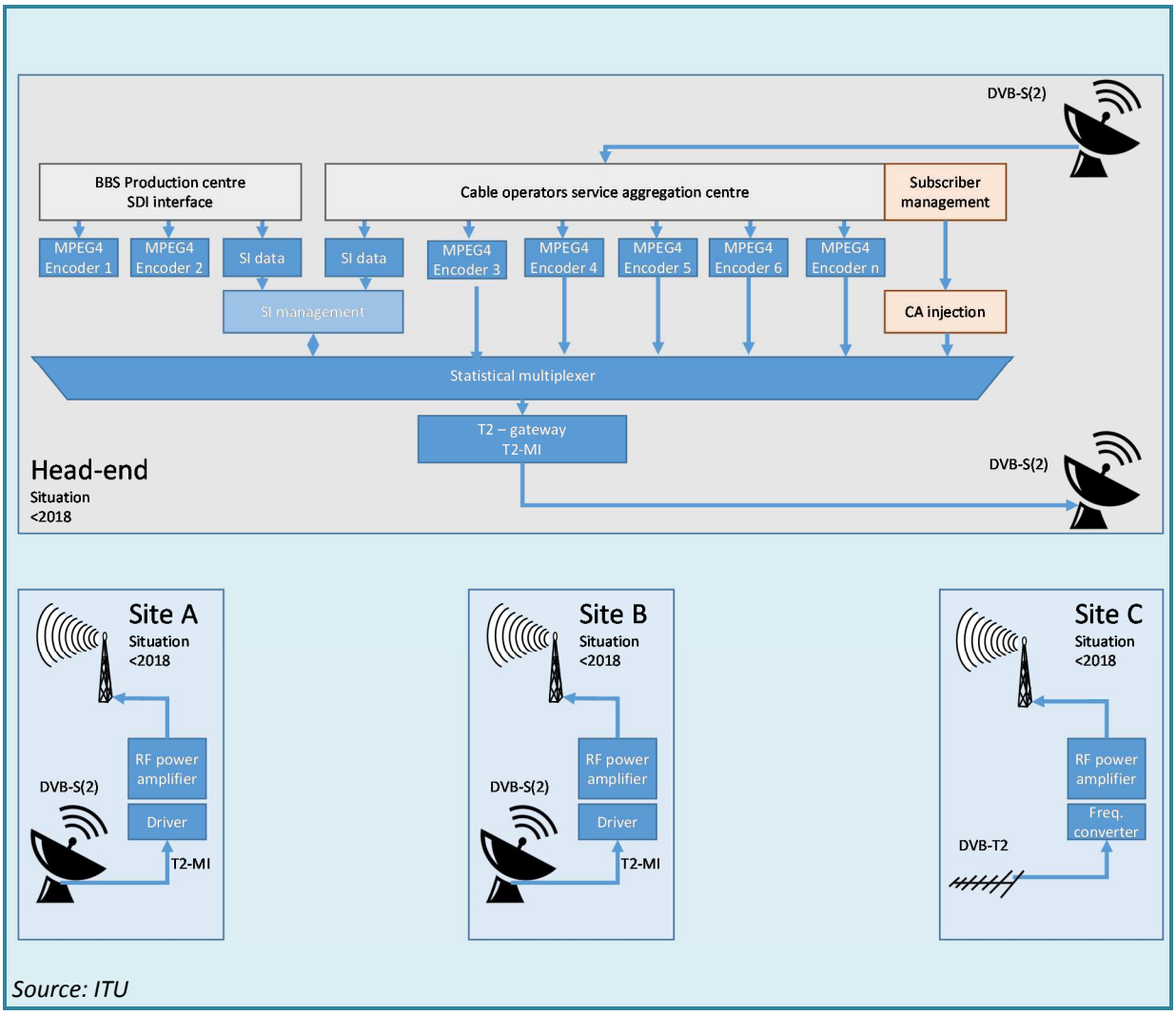
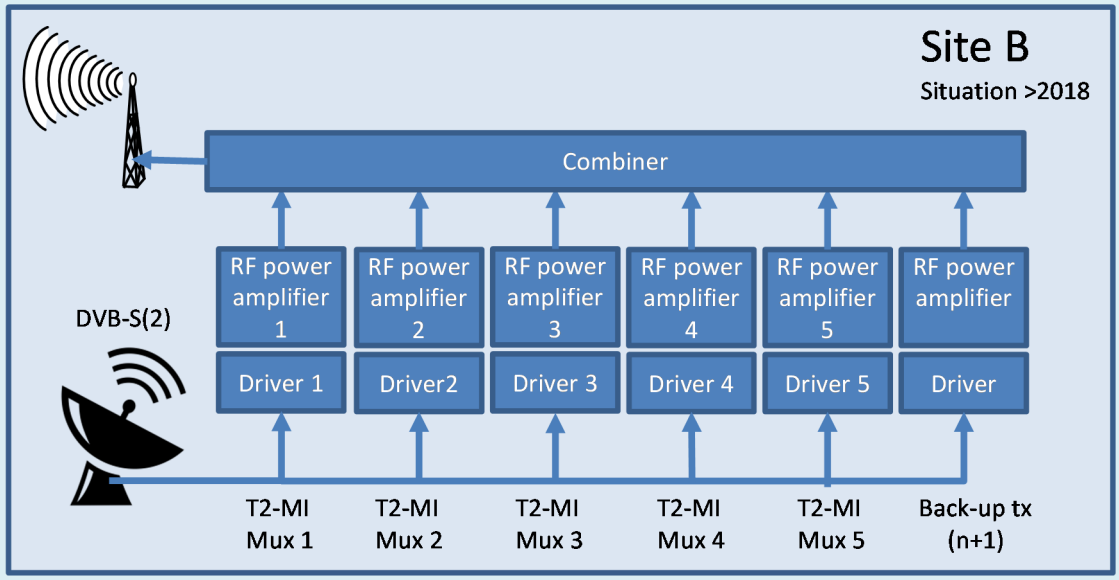


FIGURE 18: EXAMPLE NETWORK ARCHITECTURE

Figure 18 shows the situation before 2018 with one multiplexer and one transmitter per site. After 2018, five multiplexes are expected. The head-end should then be extended with encoders for each of the future SD or HD services and with four additional multiplexers. The transmitting sites will contain five transmitters (one for each multiplex) and the transmitter output will be combined into the antenna. In Figure 19 shows the lay-out of one of the transmitting stations (Site B) after 2018 with five operational transmitters.



Source: ITU

FIGURE 19: LAY-OUT OF SITE B AFTER 2018

The three different parts of the DTTB network are described in the following sections.

1) Head-end

At the head-end the programme streams delivered by BBS and the cable operators are compressed in the MPEG 4 encoders and multiplexed into a data stream (T2-MI) which is distributed to the transmitting stations. Statistical multiplexing is recommended (see Annex 3: System and planning parameters).

The output of the BBS production centre has already a Digital Serial Interface (SDI), which allows transporting uncompressed video from the studio centre to the encoders. SDI links are designed for short distances; therefore the encoders should be located at or close to the BBS production centre.

Because of the interaction between encoders and the statistical multiplexer, normally encoders and multiplexer need to be located close to each other and controlled by the same computer. Some manufactures offer encoders and multiplexers that can be located at different locations. To simplify operations and reduce costs it is assumed that in Bhutan encoders and multiplexer are placed in the same location.

The cable operators will offer a package of services received by DVB-S(2) satellite. As the multiplex bandwidth and modulation of the satellite services is different than the DVB-T2 bandwidth and modulation, the services need to be re-multiplexed. For the same reason as above, it is assumed that the decoders and encoders are placed in the same location as the BBS encoders and the multiplexer. The service package offered by the cable operators will be delivered as pay-tv. Therefore the signals need to be scrambled and Conditional Access (CA) data be inserted. Furthermore a Subscriber Management System is required for managing the billing process and providing authorisations.

At the head-end also the programme related data (SI) for establishing the electronic programme guide (EPG) should be inserted in the data stream.

2) Distribution links

In the example it is assumed that most sites are fed by transmitting the T2-MI data stream via a DVB-S2 satellite link (Site A and Site B in Figure 18) and that some low power sites are fed off-air (Site C in Figure 18).

3) Transmitting station

At the sites fed by satellite, a satellite receiving installation is installed which gives the T2-MI data stream as output. The T2-MI data stream is fed to the transmitter input. The DVB-T2 system parameters are selected at the transmitter.

At sites fed off-air, an UHF receiving antenna and receiver are installed. In the transmitter the received signal is down converted to the intermediate frequency stage (IF) and up-converted to the required transmission frequency.

In Bhutan DTTB will start with one multiplex (one transmitter per site). After 2018 five multiplexes are expected, hence five transmitters per site. It is assumed that in the latter situation a back-up transmitter in n+1 configuration will be installed. To illustrate the short and long term situation, Figure 18 shows the short term situation (one multiplex) and Figure 19 shoes the lay-out of a transmitting site in the long term situation with five transmitters and a back-up transmitter in n+1 configuration.

5. Recommendations

Given the information collected/provided during the Bhutan country visits and the analyses carried out by the experts, the NRT is recommended to carry out the following next steps for a smooth transition to digital television broadcasting and switching off the analogue services:

1. Get the Roadmap report endorsed at either ministerial level and/or political level;
2. After endorsement, acquire a mandate to plan and manage the DSO/ASO process in accordance to the Phases of the Roadmap. As indicated in this Roadmap report, this mandate may come in stages;
3. After being mandated, prepare and take the following decisions first as these decisions are needed to determine the scope and duration of the Roadmap planning:
    a. Finalize and agree the DSO/ASO objectives (see Table 1);
    b. Define and get agreement on the DSO/ASO costs in scope;
    c. Negotiate the public-private partnership on the basis of balancing cost/financing contributions and license terms & conditions (including obligations, rights and incentives);
4. Finalize the licensing model, to include:
    a. Assignment of the spectrum and operating rights to the common multiplex operator. This includes
        i. The drafting of the request for a RO;
        ii. The answering of the request for a RO (and this will take detailed frequency and network planning);
        iii. The approval of the RO;
    b. Assignment of the broadcast rights to the single pay-tv SP;
5. Appoint a full time project manager, form a project management office (PMO) and start drafting an initial detailed DSO/ASO planning (on the basis of this Roadmap report) and determine the progress reporting procedures and structures;
6. Start preparations for separating the network provisioning activities/assets from BBS and arranging for accounting separation.

Glossary of Abbreviations

ASO	Analogue Switch-Off
ATV	Analogue Television
BBS	Bhutan Broadcasting Service
BICMA	Bhutan InfoComm and Media Authority
CA	Conditional Access
CAPEX	Capital Expenditure
CAS	Conditional Access System
DSO	Digital Switch-Over
DTH	Direct To Home
DTTB	Digital Terrestrial Television Broadcasting
DVB-T2	Digital Video Broadcasting-Terrestrial (second generation)
FFB	Functional Building Block
FTA	Free To Air
FX	Fixed (rooftop) reception
HH	Household
IDTV	Integrated Digital Television set
LRIC	Long Run Incremental Costs
MFN	Multi Frequency Network
MIFR	Master International Frequency Register
MoIC	Ministry of Information and Communications (of Bhutan)
MUX	Multiplex or Multiplexer
NO	Network Operator
NRT	National Roadmap Team
OPEX	Operational Expenditure
PBS	Public Broadcasting Service
PI	Portable Indoor reception
PoS	Point of Service
RO	Reference Offer
SFN	Single Frequency Network
SMS	Subscriber Management System
SP	Service Provider
STB	Set-Top-Box
TVHH	Television Household
WACC	Weighted Average Cost of Capital

Annex 1: Preliminary review of the BICM Act

This Annex includes the following sections:

1. Introduction;
2. Preliminary findings.

Introduction

This review of the Bhutan Information, Communications and Media Act 2014 (BICM) was conducted on the basis of the text as included in Word document "BICM ACT-Final Draft 27 Aug2014" and a country visit (see Introduction). No explicit consultation on this matter of the Ministry of Information and Communication (MIC), Bhutan InfoComm and Media Authority (i.e. the National Regulatory Authority - NRA), market parties or other stakeholders took place.

This review is an initial review and focuses on broadcast and multimedia related matters. It merely identifies possible enhancements, additions or omissions and claims not to be comprehensive. Further study should be carried out to confirm these preliminary findings. Also these findings should be tested on the basis of some well selected and formulated regulatory cases.

Assumed is that the BICM has already passed parliament and is enacted as law, any possible changes could (only) be implemented by means of the NRA's authority to issue directions, guidelines or codes of practice. These preliminary findings are explicitly not intended to change or amend the BICM Act proposals.

Preliminary findings

By order of the text of the BICM Act the following findings can be listed:

1. CHAPTER IV: MEDIA COUNCIL

   The BICM Act defines the role of the Media Council, amongst others, as (1) to promote and protect freedom and independence of the media and (2) serve as a standard-setting and dispute resolution body in relation to media content. The Media Council's role could be interpreted as a reactive role, after disputes have arisen. It could be considered that the NRA consults (or asks for advise of) the Media Council when reviewing license applications, especially for assigning content or broadcast rights whereby the appropriateness of the broadcasted or distributed content should be assessed. It was understood that in the current situation (see Section 2.3) the Media Council does not review broadcasting content. It could be considered to include broadcasting services as well. In providing this advice the Media council could test the license applications on the basis of editorial and advertising Code of Conducts. It could be considered that for the services of the Public Service Broadcaster(s) or broadcasters with a Public Service Obligation (BICM no. 225) a separated Code of Conduct or Content charter is drafted as these services are defined as a Universal Service (BICM no. 226), which is more specific on the number of services, content genres, minimum minutes of Bhutan content, advertising and self-promotion minutes;

2. CHAPTER VI: ICT AND MEDIA FACILITIES AND SERVICES

   The BICM defines that the NRA shall define which ICT and Media facilities and services are required to be licensed (BICM no. 131). Also that a person shall not own or operate an ICT

and Media facility and service without a valid license (BICM no. 133). From the further articles in the BICM it is not clear (on the basis of this initial review) which rights are exactly assigned by the license under Chapter VI. Basically three rights can be identified in the domain of broadcasting (a) broadcast or content rights (i.e. the content is approved), (b) spectrum rights (i.e. in case of terrestrial distribution access and usage of parts of the spectrum are approved) and (c) operating rights (i.e. the right to operate and maintain broadcast or ICT network equipment). It seems that content/broadcast rights are assigned under Chapter VI and a part of the operating rights (i.e. the installation) under Chapter VII (Installation of ICT and Media Facilities) and spectrum rights under Chapter VIII (Spectrum and Radio Communications). With this understanding of how these basic rights are assigned it is not clear how this Chapter VI license relates to the Broadcast license under Chapter IX (Broadcasting). The Definitions of the BICM Act do not clarify this matter fully. The essence of broadcasting seems to be content distribution intended for the public at large. It is assumed that the Broadcast license will provide an approval for the content and hence provides a content right and that this forms a separate class of content license/right. This separation should be tested for various new distribution technologies and business models nowadays commonly applied in the converged industries. For example broadcasting of television services over mobile networks or telecom networks or (re)distribution of television services over the Internet (Over the Top – OTT) or terrestrial/cable networks (of satellite/terrestrial TV services). A framework of license types, indicating for which type of service or business what BICM license is required, may help clarifying matters for potential license applicants. Such a framework should consider vested rights and assigned licenses.

Access to Essential Facilities, such as Interconnection and infrastructure sharing, are addressed in the BICM Act (BICM no. 172/8 and 179). To some extend also pricing of these facilities are addressed (“reasonable rates”, BICM no. 177). Disputes over access to Essential Facilities are often about fair pricing and what costs model/margin should be applied. Without having to define what reasonable is, the NRA could be given the power to request for a Reference Offer (RO), see also Section 4.1. In this RO the provider of the Essential Facility has to define the offer in terms of technical performance/service levels as well as pricing. The RO should be transparent and non-discriminatory. Before publication of this RO the NRA should approve this offer.

3. CHAPTER VII: INSTALLATION OF ICT AND MEDIA FACILITIES

The BICM Act provides provisions for a facility provider to acquire an installation permit (BICM no. 191). This permit grants a right from the NRA to access land and attach wires or install (supporting) structures (BICM no. 192), whilst complying with environmental policies and laws and seeking prior agreement with local authorities (BICM no. 193). At the same time the NRA may assign licenses including roll-out or network deployment obligations for service/network providers. These roll-out obligations may be difficult (or even impossible) to meet if local authorities do not agree with providing access to land or structures. Good practice could include that before assigning licenses with these roll-out obligations local authorities are consulted as to stipulate realistic time schedules. Also the NRA could play an active role in helping facility license holders to acquire agreement from local authorities. For

example by providing reports on health/EMC risks of hereinto authorised government bodies or informing the local authorities on the assigned licenses.

It is not clear from the BICM text, whether facility license applicants should comply to standards of professional conduct and proper management, ensuring proper installation of equipment as well as long lasting provisioning of these facilities (e.g. as long as the broadcast license last – Chapter IX). In addition it is not clear whether a facility license applicant should be a holder of a license under Chapter VI or IX. Or reversely, for example if a 'tower' company or real estate owner can apply for a facility license (or stronger, should apply for a facility license).

4. CHAPTER VIII: SPECTRUM AND RADIOCOMMUNICATION

The BICM text identifies NRA's tasks to draft National Spectrum Plans (BICM no. 200) and Frequency Band Plans (for parts of the spectrum, BICM no. 210) and assign spectrum licenses (BICM no. 202). Also the apparatus assignment (i.e. type approval, BICM 203) and the spectrum license exemptions are addressed (BICM no. 213). The assignment instruments are however not addressed at the level of the BICM Act. A range of license assignment instruments is available to NRAs ranging from public tender, first-come-first-served (FCFS), by priority and auction. The latter is often (industry/political) sensitive. Clarity about these instruments could be provided in the National Spectrum Plan or additional Directions/Notifications. The same applies for assigning license under Chapter VI, VII and IX.

In addition the NRA could consider establishing and publishing a National License Register. In this register the public can consult which licenses have been assigned to what party and for what duration, as well as the purpose of these licenses. Also the process of drafting the National Spectrum Plans and Frequency Band Plans could include a requirement for the NRA to consult market parties and any other stakeholders by means of public consultation. This will increase public support for accepting these plans.

5. CHAPTER IX: BROADCASTING

As said under item 2, it is not clear how the Broadcast license relates to a license assigned under Chapter VI.

The BICM Act identifies a Public Service Obligation on broadcasters which can include state funding (BICM no. 225/7). This obligation seems to be purposely defined in this way as to include both the establishment of Public Service Broadcaster(s) as well as private entities having a Public Service Obligation (the latter seems to apply to BBS in the current situation, see Section 2.3). The BICM does not identify a minimum number of services or coverage/audience reach (other than universal access to radio and television services, BICM no. 226). Neither does the BICM stipulate that these Public Services should be available free-to-air (FTA) or must be carried in cable/fixed line networks/service bouquets. Also (minimum) access to spectrum is not provided for. In many countries the Public Service Broadcaster or an entity with a Public Service Obligation has by priority access to spectrum for terrestrial distribution. Without knowing the exact background for the formulation of the Public Service Obligation in the BICM, the NRA could consider further defining these conditions and requirements in additional Definitions/Notifications and/or license terms and

conditions. Without such requirements clarified the introduction or further extension of digital television services should be carefully considered and evaluated on its possibilities and challenges.

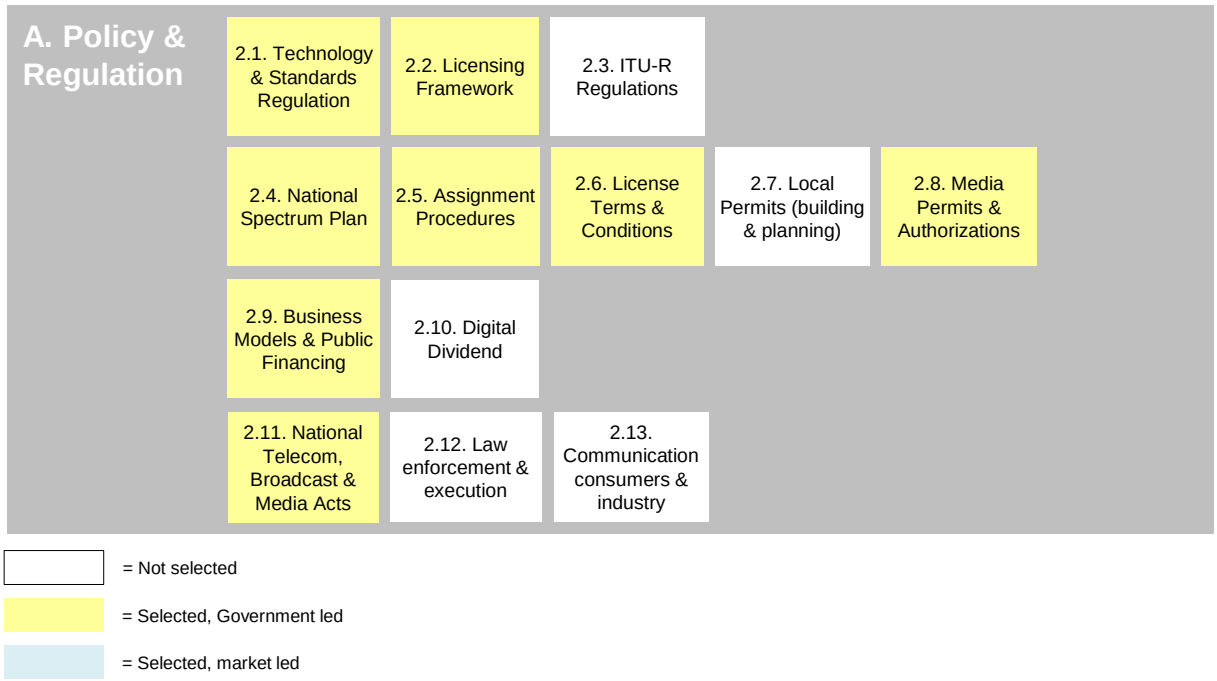
The BICM does not explicitly include provisions for protecting the NRA when assigning licenses under this Act. For example in the license terms and conditions the NRA could include a clause for the licensee's responsibility to pay for content and copyrights (also applicable for a license issued under Chapter VI). The NRA assigning a license doesn't exempt the license holder of its duties. The regulator is explicitly excluded for being responsible for paying any content or copy rights or having provided an approval or authorisation in this matter.

Annex 2: Checklist

In this Annex an inventory is given of the decision already taken and still be considered for the functional building blocks in scope of the Bhutan Roadmap (see Section 3.3). This checklist is structured according to the four layers in the functional framework:

1. Policy and Regulation
2. Analogue Switch-Off (ASO);
3. Market and Business development;
4. DTTB Networks.

Policy and Regulation



[*Replace Figure with selected scope*]

Description	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.
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, licenses and permits to (qualified) market parties in compliance with the relevant Legislation.
Building blocks	2.1 Technology & Standards Regulation 2.2 Licensing Framework 2.3 ITU-R Regulations 2.4 National Spectrum Plan

	2.5 Assignment Procedures 2.6 Licensing Terms & Conditions 2.7 Local Permits (planning & building) 2.8 Media Permits & Authorizations 2.9 Business Models & Public Financing 2.10 Digital Dividend 2.11 National Telecom, Broadcast & Media Acts 2.12 Law enforcement & execution 2.13 Communication to consumers & industry

2.1 Technology & Standards Regulation

Key topics & choices	Status	Decision
2.1.1 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. Has the standard setting been decided?	a	SD for DTTB >2018 HD services (see DSO/ASO objectives) For MTV only capacity is reserved in the future (>2018), see DSO/ASO objectives
2.1.2 Transmission standard: for DTTB platforms e.g. DVB-T2 or ATSC and for MTV platforms ISDB-Tmm or T-DMB. Has the standard setting been decided?	a	DVB-T2
2.1.3 Compression technology: for DTTB platforms MPEG2 or MPEG4 and for MTV platforms e.g. H265 or MPEG-4 AVC or open. Has the standard setting been decided?	a	MPEG4
2.1.4 Conditional Access (CA) system and Digital Rights Management (DRM): interoperability between deployed systems for respectively DTTB and MTV platforms. Has the standard setting been decided?	c	If model B would be selected *and* the MUX operator would carry pay-tv services, a decision still have to be made on the CAS

Key topics & choices	Status	Decision
2.1.5 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 broadcast TV and 3/4G mobile TV networks. Has the standard setting been decided?	a	Will not be regulated, as long as there will be no additional services requiring an API

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.2 Licensing Framework

Key topics & choices	Status	Decision
2.2.1 A licensing framework for any television services comprises the assignment of three sets of rights (a) spectrum (b) broadcast and (c) operating rights. For DTTB and MTV services has the model been decided?	a	See also Annex 1: Preliminary review of the BICM Act
2.2.2 For the extra function of the multiplex operator in the value chain, two basic licensing models can be distinguished for DTTB and MTV services: model A and model B. Has the basic model been decided?	a	Model B
2.2.3 Public Service Broadcasting (PSB) refers to broadcasting intended for the public benefit rather than for purely commercial objectives. In most cases the broadcast content and spectrum rights are specified in a media or broadcast Act. Has the PBS services and spectrum rights been defined yet (and where) for the DTTB and MTV platform?	a	Two slots on the MUX for SD services (BBS1 and BBS2). After 2018 an additional slot will be preserved for an HD services (BBS3) This “PBS must carry” arrangement still needs to embedded in the regulatory rules

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.4 National Spectrum Plan

Key topics & choices	Status	Decision
2.4.1 The context of the national spectrum plan: Is the national spectrum plan, covering the broadcast spectrum, available and is it complete?	a	Yes, UHF band (470-610 MHz = 140 MHz) is allocated for BROADCASTING and this is the band DTTB is planned in. This spectrum is enough for 1 MUX. For the 5 MUX it should be investigated.
2.4.2 Planning current and future DTTB and MTV spectrum use: Has the national spectrum plan/strategic planning process started/completed? (for process see this paragraph)	b	At least 5 MUX will be reserved for DTTB in the long run (>2018) All spectrum for DTTB will be assigned to the MUX operator These spectrum rights will be assigned in batches. For DSO (mid 2018) 1 MUX and depending on DTTB uptake and financial capacity it will be increased up to 5 MUX. Still to be included in the licensing terms and conditions of the MUX operator.
2.4.3 National Spectrum Plan publication and DTTB/MTV introduction: NONE		
2.4.4 General approaches for pricing spectrum usage: (a) One off pricing and/or recurring pricing? (b) Cost based or market based pricing?	c	The current situation is that spectrum utilisation fees are based on assignments. The spectrum access fee is an one-time payment depending on the band allocation (BROADCASTING/MOBILE). With the introduction of DTTB this current system should be reviewed.

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.5 Assignment Procedures

Key topics & choices	Status	Decision
2.5.1 Basic assigned instruments and procedures: What is the preferred assignment instrument (FCFS, auction or public tender) for broadcasting?	a	Public tender for BROADCASTING
2.5.2 Assignment procedures for DTTB and MTV services: What is the selected assignment instrument (FCFS, auction or public tender) for DTTB and MTV?	b	MUX operator will get spectrum and operating rights (the licensing form still to be designed/decided) – this license will be assigned by priority. However a public tender will be initiated to invite private parties to participate in the shareholdings in the MUX operator. BBS as SP doesn't need any new licences as long as it broadcasts BBS1 and BBS2 Private SP (Cable association) will need a new license for broadcasting services nationwide – to be assigned possibly by public tender.

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.6 License Terms & Conditions

Key topics & choices	Status	Decision
2.6.1 Licensing and fair competition rules: Are the license terms and conditions in line with the competition rules (transparent and non-discriminatory)?	c	New licensing forms to be designed/decided: (a) license for the MUX operator and (b) private SPs
2.6.2 Frequency license terms & conditions: have all license terms and conditions been determined and is the list of conditions complete (see list in this paragraph)?	c	See above

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.8 Media Permits & Authorizations

Key topics & choices	Status	Decision
2.8.1 Broadcast licensing framework: the different levels of granting broadcast rights, program or platform level?	c	Private SPs need a broadcast right and this is a new type of license. Also it should be decided if it is per program or bouquet of services
2.8.2 Broadcast licensing requirements: have all license terms and conditions been determined and is the list of conditions complete (see list in this paragraph)?	c	See above

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.9 Business models & public financing

Key topics & choices	Status	Decision
2.9.1 General PSB financing models and sourcing: basic forms already decided, including (a) PSB entity is established by Government, with defined PSB services, fully funded by public sources (either through licensing fees and/or general taxes) (b) A PSB entity is established by Government, with defined PSB services, funded by public sources and (later) partly by commercial income (mostly advertising based) (c) A commercial/private broadcaster was established, fully funded by commercial income (either advertising based and/or subscription based) and has a PSB obligation assigned. (d) Have the different sources for DSO/ASO been selected and is the budget fully financed?	b	BBS is going to be a PSB and is and will be funded by public resources (under the BICMA 2014 Act?) for DTTB distribution The roles and responsibilities of BBS as SP and NO in the DSO/ASO process not detailed yet. For example the simulcast period, the continuation of the DTH service, the communications program, the deployment obligation and service levels. Hence the BBS DSO/ASO budget cannot be defined yet.

Key topics & choices	Status	Decision
2.9.2 DTTB specific financing issues: (a) Financing of digital receivers (b) Financing the impact of free-to-air stipulations(c) In case the PSB service is encrypted content rights can be lowered (d) Financing the simulcast period (e) TV licensing fee system might need revision.	b	Financing the DTTB network deployment and STBs is going to be by a Public-private partnership whereby a pay-tv package is offered. The ratio Public/Private still to be determined, depending on CAPEX levels and terms & conditions of the partnership.

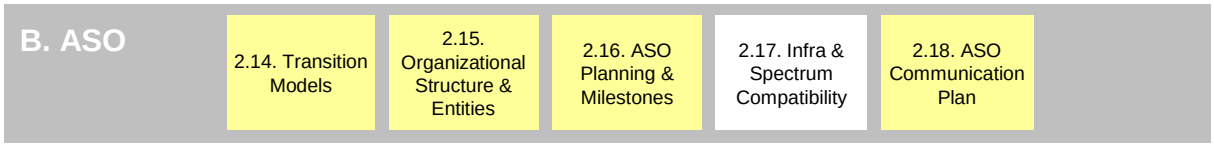
a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.11 National telecom, broadcast & media act

Key topics & choices	Status	Decision
2.11.1 Checking compliancy with existing national, Telecommunications, Broadcast and Media Acts: is the formulated DTTB/MTV policy in line with the Acts?	c	Review of the BICM 2014 Act is needed to check whether the licensing model (model B), PPP and MUX/SP licenses (including terms & conditions) are in compliancy. See also Annex 1: Preliminary review of the BICM Act.
2.11.2 Checking compliancy with other legislation, especially related to cross and foreign ownership and State aid: is the formulated DTTB/MTV policy in line with the Acts?	c	Cross media and foreign ownership (FDI) rules all apply. There are no regulations in place on State Aid.

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

Analogue Switch-Off (ASO)



[*Replace Figure with selected scope*]

Description	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 and integrated digital television set and/or digital recorder).
Objectives	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.
Building blocks	2.14 Transition Models 2.15 Organizational Structure & Enities 2.16 ASO Planning & Milestones 2.17 Infra & Spectrum Compatibility 2.18 ASO Communication Plan

2.14 Transition Models

Key topics & choices	Status	Decision
2.14.1 ASO objectives and hurdles: What are the ASO objectives (To have a universal television service on the DTTB platform, and/or to securing the future of the terrestrial platform)	a	To secure the terrestrial television platform for the future.
2.14.2 ASO factors: What type of ASO process is envisioned, consider the following factors: (a) Required PSB services; (b) The number of	a	2 PSB services in SD and later (>2018) 1 additional HD service depending on uptake of DTTB and financial means.

Key topics & choices	Status	Decision
analogue terrestrial television viewers; (c) Availability of spectrum; (d) DTTB service uptake.		Number of terrestrial television viewers known (relatively small approximately 33 k TVHHs) 470-610 is allocated to BROADCASTING and free. Additional spectrum can be freed up if necessary (470-790 MHz is not in use although 610-870 has different band allocation). Additional spectrum is expected to be needed if 5 MUX are needed. It is expected that the demand for DTTB to be high once offered.
2.14.3 ASO Transition models: Which models is envisioned (a) ASO with simulcast period, with two sub-categories (i) Phased approach to analogue switch-off (ii) National approach to analogue switch-off (b) ASO without simulcast period.	b	Nation switch off with a minimum simulcast period for all TVHH (ATV dependents only) – simulcast period still to be decided.

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.15 Organizational Structure & Enities

Key topics & choices	Status	Decision
2.15.1 ASO success factors: are the success factors in place? (a) Cooperation and coordination across the value chain; (b) Strong leadership; (c) Effective communication strategy; (d) Sufficient financial resources for the ASO organization.	c	A core team has already be formed, but need formalization (with assigned responsibilities and powers).
2.15.2 Organizational ASO structures and entities: ASO organization completed and in place?	c	Not addressed yet.
2.15.3 ASO costs and support: ASO cost analyzed and determined (use table in this section)	b	Decided to provide financial support to the ATV dependent TVHHs. How much is still to be decided and

Key topics & choices	Status	Decision
		depends on the public/private financial viability.

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.16 ASO Planning & Milestones

Key topics & choices	Status	Decision
2.16.1 Outlining the ASO planning: when and where to begin the process and how long the entire operation should last	a	Commencing this year with the policy formulation and ending the process by mid-2018 (i.e. switching off the last ATV site).
2.16.2 Overall ASO planning set-up: including the overall program structure and the key result paths in an ASO plan	c	
2.16.3 ASO planning phases (in a phased approach): the three phases and their key milestones	c	

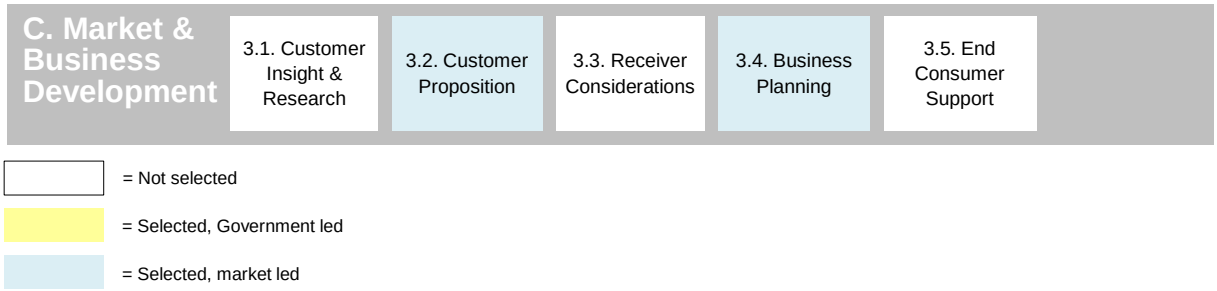
a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

2.18 ASO Communication Plan

Key topics & choices	Status	Decision
2.18.1 Communication strategy: including communication messages (related to the communication stage) and target group(see phased model)	c	
2.18.2 Communication tools: the various communication means to reach the listed target groups	c	

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

Market and Business development



[*Replace Figure with selected scope*]

Description	Layer C deals with key business issues and choices that Service Providers/Broadcasters 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.
Objectives	Commercial parties will seek a DTTB or MTV Service Proposition which fulfil a consumer demand, generating sufficient revenues (either advertising of subscription based). In contrast, Public Service Broadcasters (PSB) normally fulfil 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 advertised based income and some of the topics addressed in this section might also be relevant for PSBs.
Building blocks	3.1 Customer Insight & Research 3.2 Customer Proposition 3.3 Receiver Availability & Considerations 3.4 Business Planning 3.5 End Consumer Support

3.2 Customer Proposition

Key topics & choices	Status	Decision
3.2.1 DTTB competitive advantage and related Service Proposition attributes	b	Competitive advantage is price and more services as compared to respectively DTH and ATV & unserved people.

Key topics & choices	Status	Decision
		Definition of the attributes still to be detailed, including price (one-off and recurring) and number of services, service/content type.
3.2.2 MTV competitive advantage and related Service Proposition attributes	NA	

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

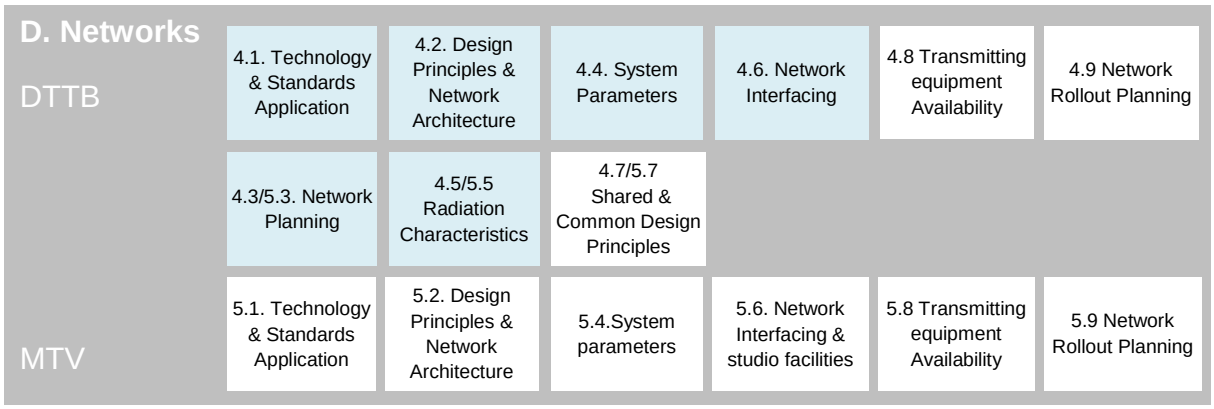
3.4 Business Planning

Brief description	This section will focus on the first two steps for the DTTB and MTV services introductions (a) agreement on business models (b) agreement on business case
Objective	Agreed business model and case as to acquire the necessary funds for the DTTB and/or MTV service launch.

Key topics & choices	Status	Decision
3.4.1 Business models for DTTB services: which model or combination of models is considered (may vary per multiplex)	a	Reservation for 'Must Carry' FTA services and remaining capacity for pay-tv services.
3.4.2 Business models for MTV services.	NA	
3.4.3 Business case examples: what does the first estimated look like for the DTTB and MTV services?	c	Business case still be drafted and negotiated in NRA and national cable association.

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

DTTB Networks



[*Replace Figure with selected scope*]

Description	DTTB networks cover functional building blocks 4.1 to 4.9 (see Figure above). The checklist contains key topics and choices operators face when planning transmitter networks for broadcasting DTTB services. Choices in network architecture, frequency planning, network planning, roll out planning and network operation should be made in such a way that the license 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.
Objectives	Developing DTTB networks in conformity with regulatory framework and formulated business objectives.
Building blocks	4.1 Technology & standards application 4.2 Design principles & network architecture 4.3 Network planning 4.4 System parameters 5.5 Radiation characteristics 4.6 Network interfacing 4.7 Shared & common design principles 4.8 Transmission equipment availability 4.9 Network rollout and planning

4.1 Technology & standards application

Key topics & choices	Status	Decision
4.1.1 Technical tests to evaluate system performance	a	No test to evaluate system performance. Only tests to get familiar with the selected technology
4.1.2 SDTV and HDTV specifications	b	
4.1.3 Selection of DTTB transmission standard	a	DVB-T2
4.1.4 Compression system	a	MPEG4
4.1.5 Encryption system	a	No prescribed system, under the condition that only one MUX operator will be allowed to operate
4.1.6 Additional services	a	There won't be any, at least till mid-2018

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

4.2 Design principles & network architecture

Main topics & choices	Status	Decision
4.2.1 Trade-off between network roll-out speed, network costs and service quality	c	
4.2.2 Main reception mode and defining receiving installations	c	
4.2.3 Services for national, regional, or local coverage	a	Up to 20 SD national services, no regional services.
4.2.4 Frequency plan and network topology	c	
4.2.5 Head- end configuration	c	
4.2.6 Equipment reserve configurations	c	Redundancy level should go up as compared to ATV as the DTTB platform will carry pay-tv services.
4.2.7 Type of distribution network	c	TS-MI over either Satellite or Fibre with microwave links.

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

4.3 Network planning

Key topics & choices	Status	Decision
4.3.1 Service trade-off	c	
4.3.2 SFN or MFN	c	
4.3.3 Fill-in transmitters	c	
4.3.4 GE06 compliance of planned stations, if applicable (Region I only)	NA	
4.3.5 Feed back to business plan and service proposition	c	

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

4.4 System parameters

Key topics & choices	Status	Decision
4.4.1 FFT size	c	
4.4.2 Carrier modulation and code rate	c	
4.4.3 Guard interval	c	

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

4.5 Radiation characteristics

Key topics & choices	Status	Decision
4.5.1 Transmitter power and transmitting antenna gain	c	
4.5.2 Polarization	c	
4.5.3 Use of existing antennas or need for new antennas	a	TX/RX antenna have to be renewed.

a. Already decided
b. Partly decided
c. Not decided yet

d. Revision needed

4.6 Network interfacing

Key topics & choices	Status	Decision
4.6.1 Interfaces with head-end	b	BBS will deliver in SDI (270 Mbit/s). Other feeds still to be investigated
4.6.2 Interfaces between parts in the network	c	
4.6.3 Radio interface between transmitting station and receiving installation	c	
4.6.4 Interfaces between transmitter sites and monitoring system	c	

a. Already decided
b. Partly decided
c. Not decided yet
d. Revision needed

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Annex 3: System and planning parameters

This Annex includes the following sections:

1. Introduction;
2. Technology standards and applications;
3. Design principles and network architecture;
4. Network planning;
5. System parameters.

Introduction

In Bhutan the key competitive advantages of DTTB are price and more services as compared to respectively direct to home satellite (DTH) and analogue TV and providing TV services to yet unserved people. The number of services has been defined as up to twenty SD services in the first multiplex. After 2018 additional multiplexes and HD services are envisaged.

In this Annex an initial approach is given of the specification of a number of system and planning parameters, which comply with the DSO objectives. These initial parameters are used in the examples regarding coverage and transmission capacity given in the Roadmap report. In the frequency planning process in Phase 2/3 of the Roadmap the parameters should be verified against the resulting coverage and spectrum use and adjusted where necessary.

The selection of DTTB system and planning parameters is a trade-off between the potential numbers of viewers (coverage quality), payload of the multiplex (service quality) and transmission costs (number of sites and radiated power)[44]. This so-called service trade-off is illustrated in Figure 20.

[44] See Section 4.3 of ITU report "Guidelines for transition from analogue to digital broadcasting", edition January 2014.

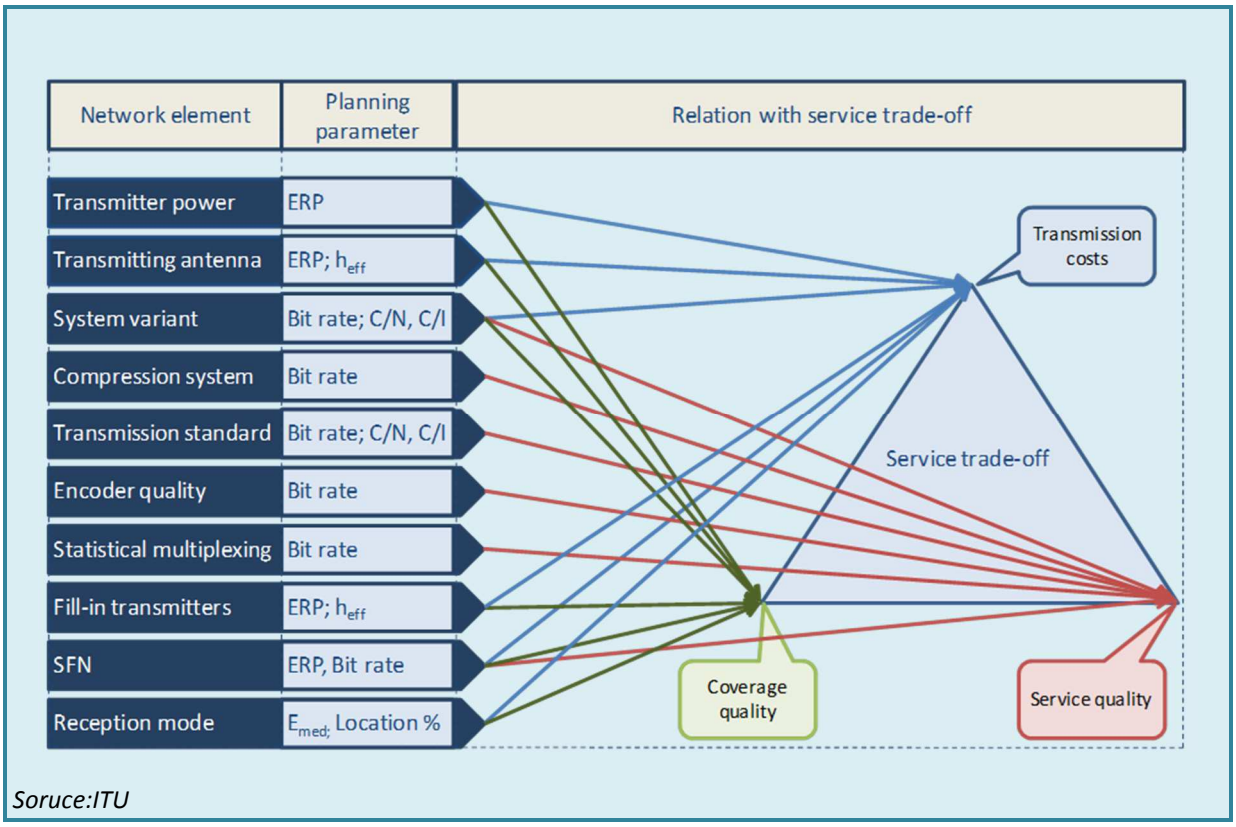


FIGURE 20: SERVICE TRADE-OFF IN PLANNING DTTB STATIONS

In the initial approach it is assumed that the existing 29 analogue TV sites and the envisaged 75 sites will be used for DTTB and the DTTB coverage matches the analogue TV coverage of these analogue TV sites. With this assumption the size of the coverage area has been defined. The following sections deal with system and planning parameter needed to define radiated power and transmission capacity. The system and planning parameters relate to the following functional buildings blocks (see Section 3.3 of the Roadmap report):

- 4.1 Technology standards and applications;
- 4.2 Design principles and network architecture;
- 4.3 Network planning;
- 4.4 System parameters;
- 4.5 Radiation characteristics.

Technology standards and applications[45]

In Bhutan is has been decided to use the DVB-T2 transmission standard with MPEG-4 compression. The system specification assumed for the initial approach is given in Table 11. Also the video and

[45] See also Section 4.1 of ITU report "Guidelines for transition from analogue to digital broadcasting", edition January 2014.

audio bitrates are indicated that are needed for good quality presentation of SDTV and HDTV using state of the art MPEG4 encoders.

Topic	Specification
Transmission standard	DVB-T2
Video compression system	MPEG-4 AVC
Audio compression	MPEG-4 HE AACv2
Video presentation format	SD; after 2018 also HD
Audio	One stereo channel per service
Data services	Service information; no other data services
SDTV video bit rate	1.75 Mbit/s per service
HDTV video bit rate	7 Mbit/s per service
Audio bit rate	96 kbit/s for two-channel stereo
Service information (SI)	0.15 Mbit/s per service

TABLE 11: VIDEO, AUDIO AND DATA SYSTEM SPECIFICATIONS

Design principles and network architecture[46]

This section addresses the planning parameters related to reception mode and head-end configuration.

Reception mode

For analogue TV, planning criteria are specified for fixed (rooftop) reception only in ITU-R recommendations. However, in practise most people in Bhutan receive analogue TV with simple antennas and due to the features of analogue TV, reception quality is poor because of impairments by noise and ghost images.

DTTB offers the possibility of good quality reception with rooftop antennas (fixed reception), but also with simple antennas at indoor or outdoor locations. The latter receiving conditions are called “portable reception”. In order to enable viewers to use low cost and easily to install DTTB antenna installations, portable reception is an attractive DTTB feature, but at a given ERP the size of the coverage is smaller compared to fixed reception. It may not be possible for practical and network

[46] See also Section 4.2 of ITU report “Guidelines for transition from analogue to digital broadcasting”, edition January 2014.

cost reasons to provide portable coverage everywhere in the defined coverage areas. The aim could be to provide portable indoor coverage as far as practically and economically feasible in urban areas.

The parameters for determining the minimum median field strength (Emed) for fixed (FX), portable outdoor (PO) and portable indoor (PI) reception are summarised in Table 12. The figures in Table 12 are taken from Recommendation ITU-R BT.2033, Section 2 of Annex 1, with the exception of four parameters which were adapted to the situation in Bhutan. The four parameters, shown in the blue shade fields, are:

1. The Carrier to Noise ratio (C/N) relates to the set of DVB-T2 system parameters 32k, 64 QAM 3/3, PP4 as described in Section 5 of this Annex;
2. The building penetration loss is taken from Recommendation ITU-R BT.2033, Section 2.2 of Annex 3, and relates to:
    a. Suburban residential building without metallised glass windows;
    b. Room with a window on the exterior wall in an apartment in an urban environment;
3. The standard deviation of the field strength at indoor location is the square root of the sum of the squares of the standard deviation of the field strength at outdoor location (5.5 dB) and the standard deviation of the building penetration loss (for the above mentioned condition 5 dB), resulting in 7.4 dB;
4. The height loss has been calculated using the method given in Recommendation ITU-R P.1546, Section 9 of Annex 5 and related to rural areas.

#	Parameter	DTTB FX	DTTB PO	DTTB PI
1	Noise figure (dB)	6	6	6
2	C/N (dB)	16.0	17.9	17.9
3	Antenna gain minus cable loss (dB)	7	0	0
4	Building penetration loss - mean value (dB)	0	0	7
5	Man-made noise allowance (dB)	0	1	1
6	Field strength standard deviation (dB)	5.5	5.5	7.4
7	Height loss - 10/1.5 m (dB)	0	10.6	10.6
8	Emed; DTTB at 500 MHz (dBµV/m) at reception height (10 m for fixed reception and 1.5 m for the other reception modes)	48.0	57.9	68.1
9	Emed; DTTB at 500 MHz (dBµV/m) at 10 m	48.0	68.5	78.7

TABLE 12: SUMMARY OF PARAMETER FOR DETERMINING THE MINIMUM MEDIAN FIELD STRENGTH (EMED)

Emed specified in item 8 of Table 12 should be used in coverage calculations with “path specific” propagation prediction methods using detailed terrain data. Emed specified in item 9 of Table 12

should be used in coverage calculations with “path general” propagation prediction methods, such as Recommendation ITU-R P.1546.

Item 9 of Table 12 shows that with portable outdoor reception (PO) the Emed and hence the ERP in noise limited conditions is 20 dB (factor 100) higher than with fixed reception (FX) and with portable indoor reception (PI) 30 dB (factor 1000) higher than with fixed reception. Consequently with a given ERP the PI and PO coverage is much smaller than the FX coverage. However, with the high transmitting site heights and in many cases relative small coverage areas in Bhutan, portable reception may be possible for many viewers at reasonable ERPs. In houses where indoor reception is not possible reception could be improved by:

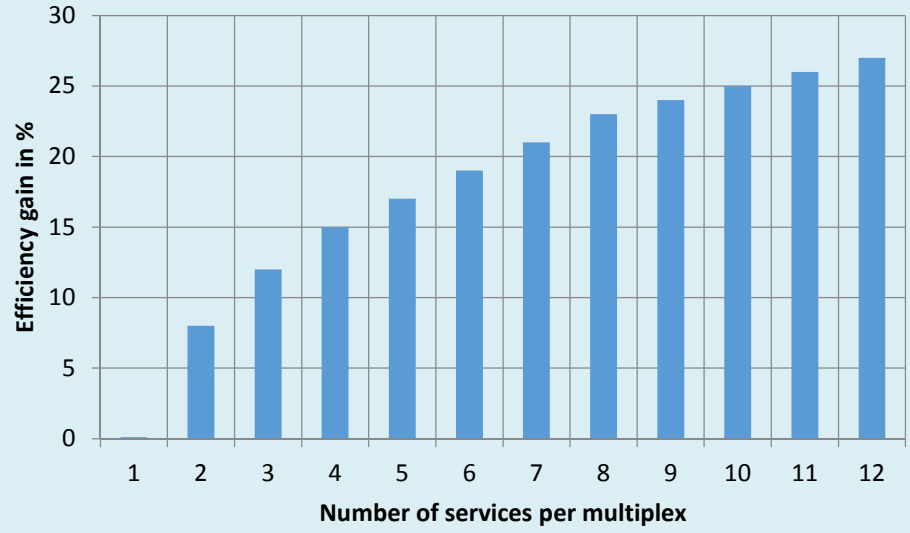
1. Applying an indoor antenna with an integrated low noise amplifier (so-called active indoor antenna);
2. Mounting of a simple antenna outdoors, the higher the better;
3. Applying a small active outdoor antenna;
4. Mounting a directional rooftop antenna;
5. Applying a low noise amplifier at the rooftop antenna.

In the initial approach it is assumed that planning is based on fixed reception and that a considerable number of household are situated fairly close to the transmitter site and have good indoor or outdoor reception (see also Section on ERP in this Annex).

Head-end configuration

Multiplexing takes place in the head-end. Statistical multiplexing (statmux) is widely used. In a statistical multiplexer the bitrate is dynamically allocated to different services depending on the programme content. Compared to a constant bitrate per service, it can provide on average higher picture quality of each service, or instead a higher number of services can be accommodated.

In the initial approach it is assumed that in the head-end statistical multiplexing is applied and that an efficiency gain of up to 27% can be reached depending on the number of services in the multiplex (see Figure 21).



Source: Ofcom - UK

FIGURE 21: EFFICIENCY GAIN OF STATISTICAL MULTIPLEXING

Network planning[47]

This section addresses the planning parameters related to network configuration (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 such as DVB-T2 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 in a single frequency network (SFN). As indicated in the ITU Guidelines for transition to DTTB, in practice, SFNs are mainly used in one or more of the following circumstances:

1. High field strength values are needed over large areas, e.g. for mobile, portable or handheld reception;
2. Fill-in transmitters;
3. No frequencies are available for high and medium power stations or fill-in transmitters in MFN configuration;
4. The related GE06 Plan entry is an allotment.

Conditions 1), 3) and 4) do not apply to Bhutan. A number of low power DTTB transmitters might be operated as fill-in transmitter with off-air reception. However, due to terrain shielding frequencies can be re-used at relative short distance in many cases and spectrum availability is not a pressing

[47] See also Section 4.3 of ITU report "Guidelines for transition from analogue to digital broadcasting", edition January 2014.

issue in the UHF band in Bhutan. For these reason in the initial approach it is assumed that DTTB planning is based on MFNs.

System parameters[48]

The choice of a set of system parameters is a trade-off between payload (net capacity) of the multiplex and the carrier to noise ratio (C/N) required for good reception of the multiplex. The C/N is a factor in determining the minimum median field strength (see Table 12) and is proportionally related to the required EPR in noise limited reception conditions. The major factors in this trade-off are the required number of services, the reception mode and network configuration (MFN or SFN).

The number of services is defined in the DSO objectives (see Table 1); the first multiplex should contain up to twenty SD services and the second multiplex should contain at least three HD services. The content of further multiplexes has not yet been defined. This section will consider the first and second multiplex only.

As indicated in Section 3.1 in this Annex portable reception is important in Bhutan. Therefore a system variant should be selected that facilitates portable reception. Extensive investigations and tests have been carried out in Germany from mid-2009 to mid-2012 to identify the optimal DVB-T2 parameters for portable and mobile reception[49]. The recommended system parameters for portable reception resulting from the investigations in Germany are summarized in Table 13.

#	DVB-T2 parameter	Recommended for portable reception
1	**FFT size**	32k, extended carriers
2	**Pilot pattern**	PP4
3	**Guard interval**	1/32; 1/16; 19/256
4	**Modulation and code rate**	16-QAM 1/2; 16-QAM 3/5; 16-QAM 2/3; 64-QAM 1/2; 64-QAM 3/5; 64-QAM 2/3; 64-QAM 3/4
5	**Rotated constellations**	In theory favourable, but test showed the contrary; therefore not recommended
6	**Time interleaving**	< 10 ms

TABLE 13: RECOMMENDED SYSTEM PARAMETERS FOR PORTABLE RECEPTION

[48] See also Section 4.4 of ITU report "Guidelines for transition from analogue to digital broadcasting", edition January 2014.

[49] See the report of the results of the investigations in Germany: Terrestrik der Zukunft: Zukunft der Terrestrik; Projectbericht DVB-T2 Norddeutschland. Shaker Verlag Aachen, 2012.

In the initial approach it is assumed that DTTB planning is based on MFNs (see Section 4 of this Annex). In MFN only echoes from natural and man-made structures need to be considered and the lowest guard interval mentioned in item 3 of Table 13 of (1/32 corresponding to 112 µs) is sufficient.

To carry up to twenty SD services in a multiplex, a payload of about 30 Mbit/s is needed. From the modulation and code rate combinations mentioned in item 4 of Table 13 and taking into account a guard interval of 1/32 (see above) this payload can be reached with 64-QAM 2/3 and 64-QAM 3/4. The latter provides a 13% higher payload but requires a C/N which is about 2 dB higher. As for cost reasons the radiated power (hence to C/N) should be low, 64-QAM 2/3 fits best with the DSO objectives. Moreover the guard interval of 112 µs allows the use of small SFNs if this would be needed in future.

It could be considered to select a set of parameters providing about 30 Mbit/s with the lowest possible C/N. This would result in 64-QAM 2/3 PP7 and guard interval 1/128 (28 µs). Pilot pattern PP7 requires a slightly lower C/N (0.8 dB) than PP4 and is particularly suited for fixed reception. The guard-interval of 28 µs, allows delayed signals due to reflections with an additional path length of 8.4 km, which may not be sufficient in all situations in the mountainous areas in Bhutan. Because of the advantage of this set of system parameters (a C/N decrease of 0.8 dB) is small and the disadvantage is great (not optimised for portable reception and doubts on the immunity to long delayed multipath signals in the mountainous areas in Bhutan), this set of system parameters is not selected in the initial approach.

The main features of the three sets of system parameters described above are shown in Table 14. The recommended set of parameters for the initial approach is included in the second column.

Characteristics	32k 64-QAM 2/3 PP4	32k 64-QAM 3/4 PP4	32k 64-QAM 2/3 PP7
Guard interval (GI)	1/32 (112 µs)	1/32 (112 µs)	1/128 (28 µs)
Payload	28.5 Mbit/s	32.1 Mbit/s	30.1 Mbit/s
Recommended reception mode	Fixed and portable	Fixed and portable	Fixed
C/N – Fixed reception (Ricean channel[50])	16.0 dB	17.4 dB	15.3 dB
C/N – Portable reception (Rayleigh channel[51])	17.9 dB	19.8 dB	17.2 dB

[50] A Ricean channel is a propagation mode when a dominant wanted signal together with lower level delayed signals are present at the receiver input, taking into account the thermal noise

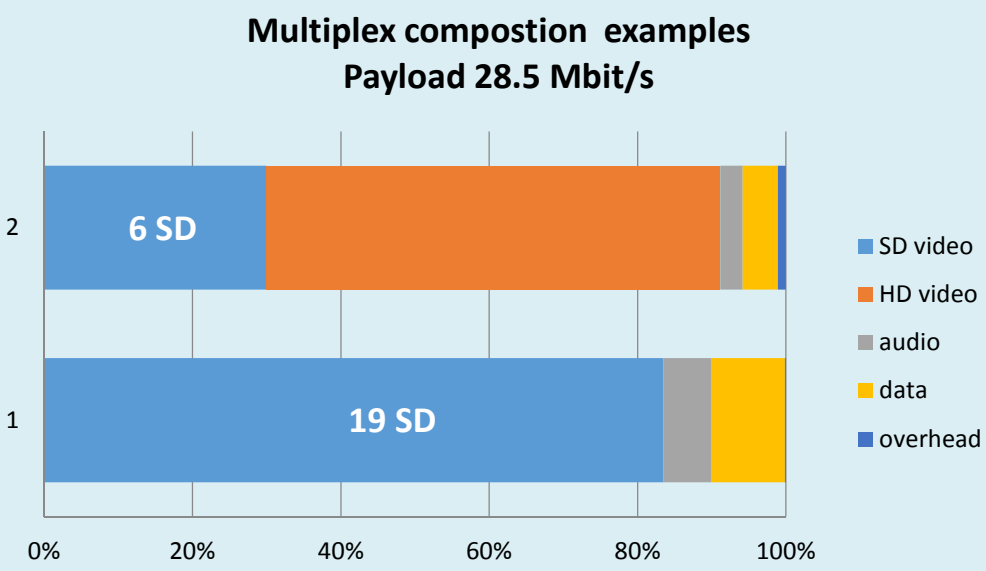
[51] A Rayleigh channel is a propagation mode when several statistically independent signals with different delay times, none of which is dominant, are present at the receiver input, taking into account the thermal noise. Rapid and severe variations of the input signal with locations are observed, caused by multipath propagation

TABLE 14: CHARACTERISTICS OF THE SYSTEM PARAMETERS PROVIDING ABOUT 30 MBIT/S

An example of the multiplex composition with a payload of 28.5 Mbit/s, using statistical multiplexing is shown in Figure 22. In the example two multiplexes are considered:

1. Mux 1, representing the current requirement of up to 20 SD services;
2. Mux 2, representing a future service extension with 3 HD services and a number of SD services.

The purpose of the example is to give an indication of the number of services that can be accommodated in a multiplex in the initial approach of system and planning parameters. The remaining capacity (overhead) is also indicated. In practise the bitrates of the services will be adjusted (slightly higher or lower) to fill the full capacity of the multiplex. However, it should be taken into account that the total bit rate of the services in the multiplex should be somewhat lower than the net bitrate of the set of system parameters for which the transmitters have been adjusted in order to avoid overflow.



Source: ITU

FIGURE 22: EXAMPLES OF MULTIPLEX COMPOSITION

Mux 1 contains just 19 SD services. Actually with the video, audio and data specifications from Section 2 the payload would be exceeded by 0.45 Mbit/s. By reducing the maximum video bitrate by 0.03 Mbit/s to 1.72 Mbit/s (a non-significant reduction) 19 SD services fit into the multiplex. Due to the statmux gain the average video bitrate per service is estimated at 1.25 Mbit/s. The overhead is 0.04 Mbit/s.

Mux 2 contains 6 SD services and 3 HD services. The SD services have the same maximum bitrate as taken in Mux 1. Because of the lower number of services the statmux gain is less and the average

video bitrate per SD service is estimated at 1.42 Mbit/s. The HD services have a maximum bitrate of 7 Mbit/s (according to Section 2). Due to the statmux gain the average bitrate per HD service is estimated at 5.81 Mbit/s. The overhead is 0.32 Mbit/s.

Radiation characteristics[52]

This section addresses the planning parameters related to transmitting antenna patter, radiated power (ERP) and polarisation.

Transmitting antenna pattern

In the initial approach it is assumed that the DTTB sites have non-directional horizontal radiation patterns. In the detailed planning in Phase 3 of the Roadmap the antenna pattern should be verified and where appropriate to be adjusted with the aim to:

1. Avoid spill-over across the border and to direct the radiation to the required areas by applying directional antennas;
2. Provide portable indoor coverage in urban areas with an appropriate directional horizontal radiation pattern, taking into account the ERP adjustment referred to in Section 6.2; noting that directional antennas have higher gain and hence result in a lower transmitter power with a given ERP.

ERP

The required ERP depends on the size of the coverage area (see Introduction of this Annex), the reception mode (see Section Reception mode) and the DVB-T2 system parameters (see Section System parameters). In the initial approach the DTTB ERP is determined to match the analogue TV coverage of the same site with fixed reception.

The ERP of a DTTB station needed to match analogue TV with fixed reception can be calculated with the following formula:

$$ERP_D = ERP_A + (Emed_D - Emin_A) + C_f \qquad (1)$$

Where:

ERP_D	is the ERP of the DTTB station needed to match analogue TV at the same site with fixed reception in dBW;
ERP_A	is the EPR of the analogue station in dBW;
$Emed_D$	is the minimum median field strength for DTTB in dBµV/m with the selected system parameters at a representative channel in the UHF band;

[52] See also Section 4.5 of ITU report "Guidelines for transition from analogue to digital broadcasting", edition January 2014.

$Emin_A$ is the minimum field strength for analogue TV derived from Recommendation ITU-R BT.417 (Emin in the absence of interference other than noise);

C_f is a correction factor in dB for difference in propagation loss between UHF and VHF.

A precise match is not feasible because:

1. $Emed_D$ and $Emin_A$ increase by increasing frequency because of the frequency dependent "effective antenna aperture" (see equations to calculate the minimum median field strength in Appendix 1 to Annex 1 of Recommendation ITU-R BT.2033). In the initial approach a mid-channel in Band III is taken (channel 9) and channel 25 in Band IV.
2. The factor Cf depends on the propagation path. In the situation in Bhutan, with high transmitting antenna site heights and relative small coverage areas, the difference in propagation in Band III and Band IV is negligible in case of line sight. But in the shadow zones behind mountains the losses in Band IV are higher than in Band III. By comparing field strength calculation in Band III and in Band IV at five sites[53] it showed that the in the distance range from 10 km to 20 km the factor Cf is about 4.2 dB.

Under the above mentioned conditions the terms $[(Emed_D - Emin_A) + C_f]$ in equation (1) are -0.8 dB. In the initial approach equation (1) is rounded to: $ERP_D = ERP_A + 0$ dB. Consequently to match analogue TV coverage the DTTB EPP should be the same as the analogue TV ERP.

The radiated power of the analogue TV stations in Bhutan is given in eirp and an analogue TV station has one of the five eirp values indicated in Table 15. After each of the eirp values the analogue TV ERP is given as well as the DTTB ERP (see blue shaded columns) needed to match analogue TV with fixed reception.

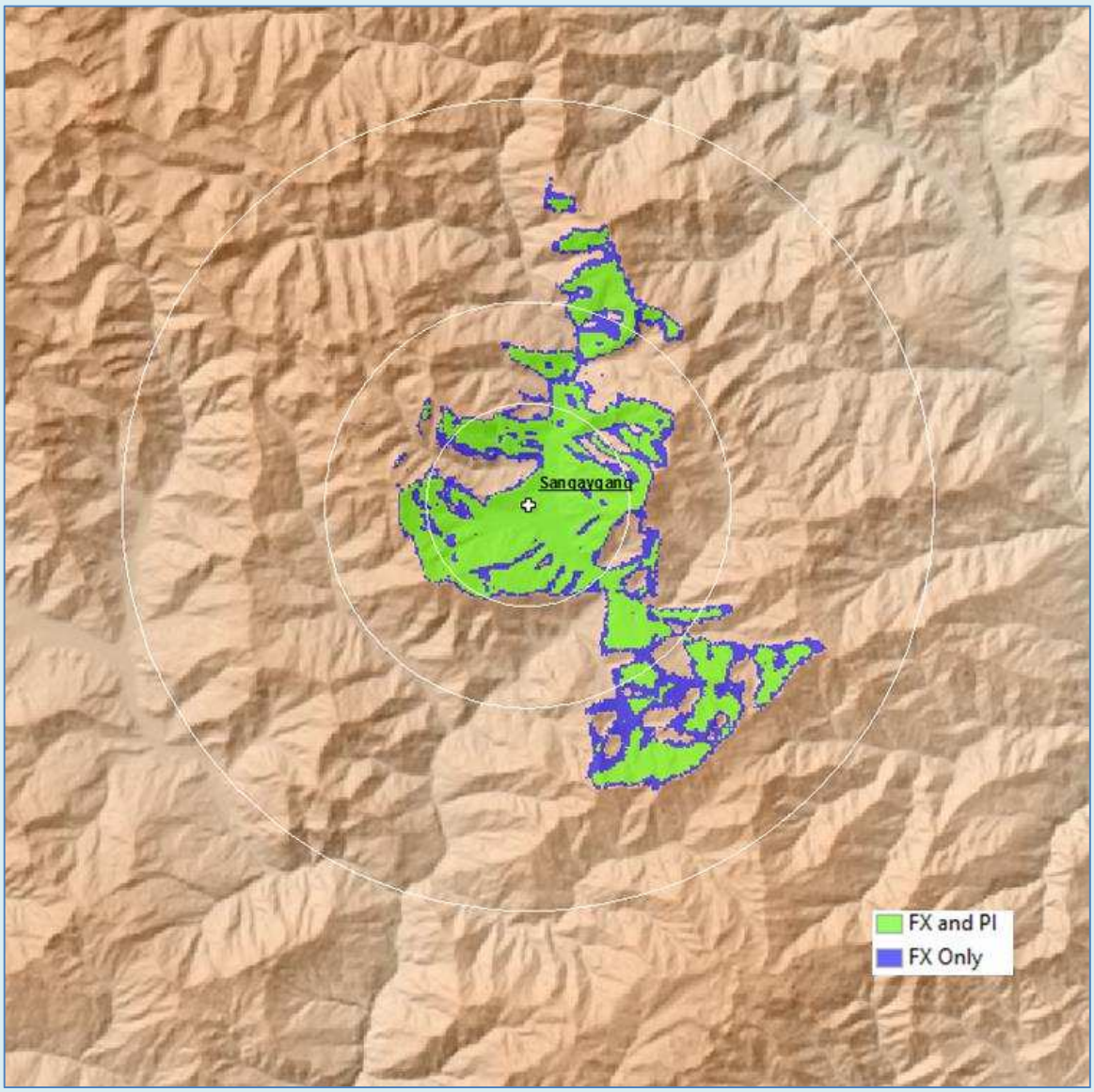
ATV eirp dBW	ATV ERP dBW	ATV ERP kW	DTTB FX ERP dBW	DTTB FX ERP kW
20.89	18.74	0.07	18.74	0.07
23.90	21.75	0.15	21.75	0.15
25.66	23.51	0.22	23.51	0.22
28.67	26.52	0.45	26.52	0.45
33.90	31.75	1.50	31.75	1.50

TABLE 15: DTTB ERP NEEDED TO MATCH ANALOGUE TV WITH FIXED RECEPTION

Figure 23 to Figure 27 show examples of the digital TV coverage with fixed reception matching analogue TV coverage with ERPs according to Table 15, as well as the portable indoor coverage with

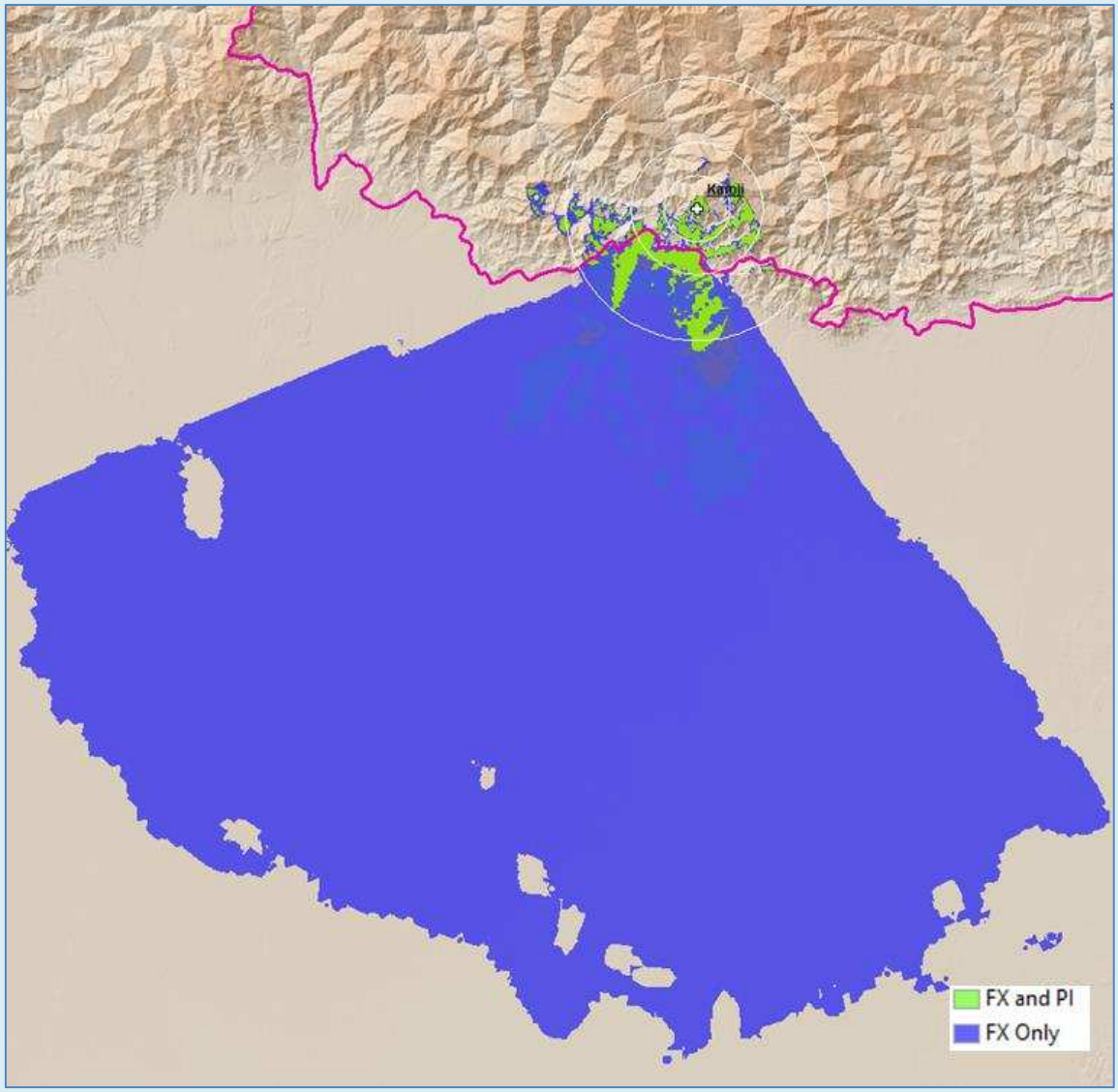
[53] The sites Darjeydangra, Goenkhami, Kamji, Sangaygang and Thrima were used in the test.

this ERP. The figures show that in considerable parts of the urban areas portable indoor coverage is possible, including most of the towns of Thimphu (near site Sangaygang, see Figure 23) and Phuntsholing (near site Kamji, see Figure 24). In order to give an impression on the scale of the maps, circles are shown around each of the sites with radii of 5 km, 10 km and 20 km.



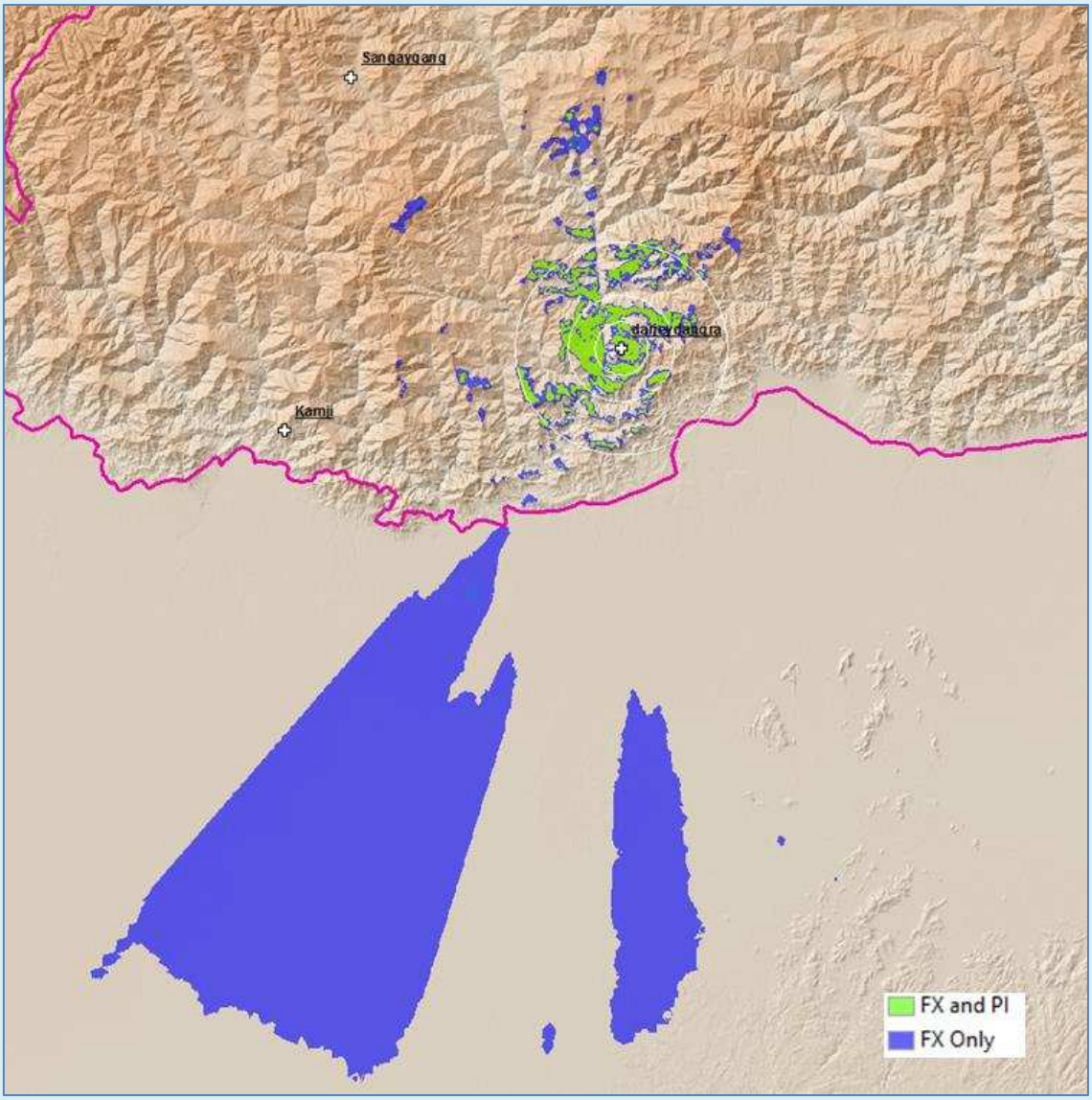
Source: Progira, ITU

FIGURE 23: DTTB COVERAGE OF SITE SANGAYGANG WITH FIXED (FX) AND PORTABLE INDOOR (PI) RECEPTION



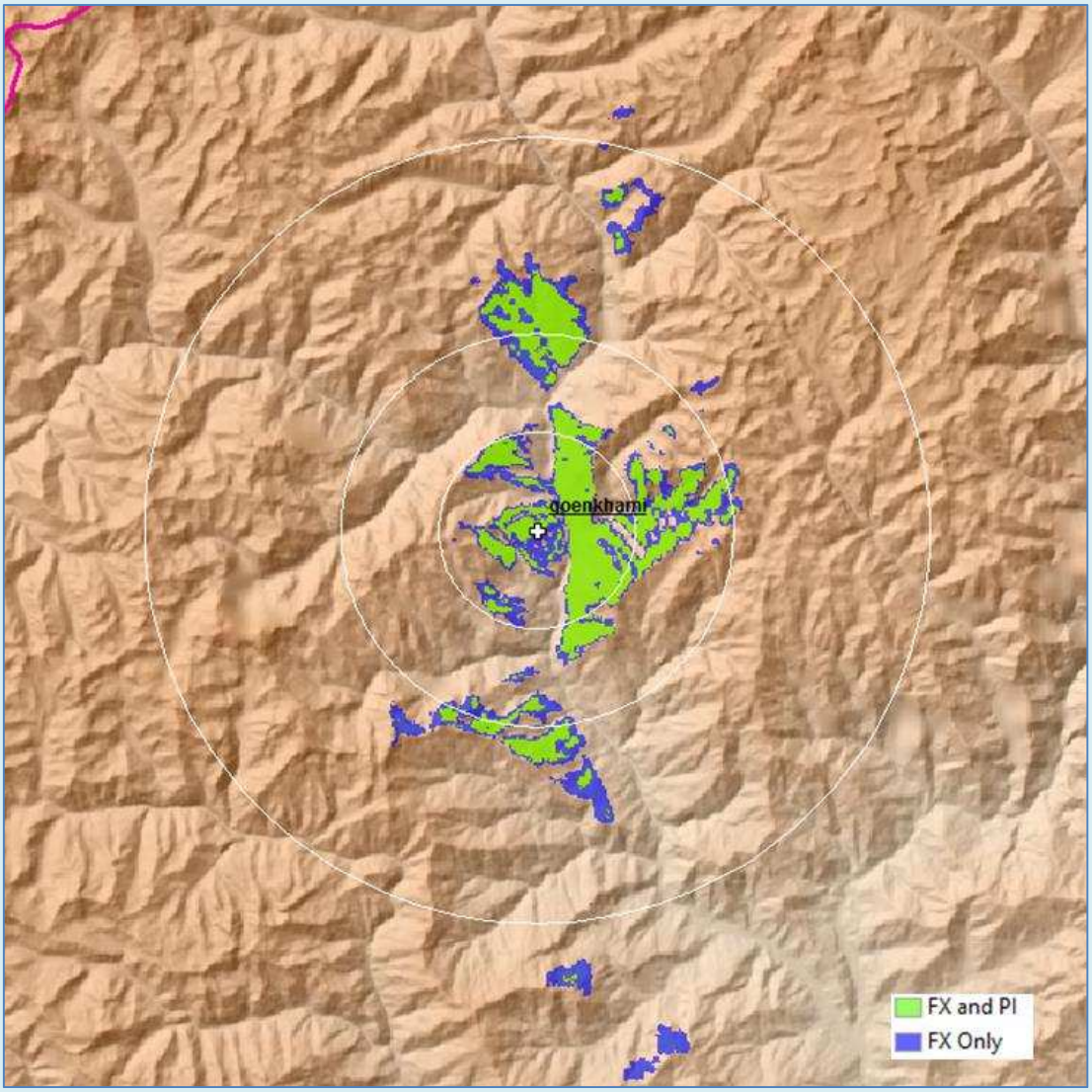
Source: Progira, ITU

FIGURE 24: DTTB COVERAGE OF SITE KAMJI WITH FX AND PI RECEPTION



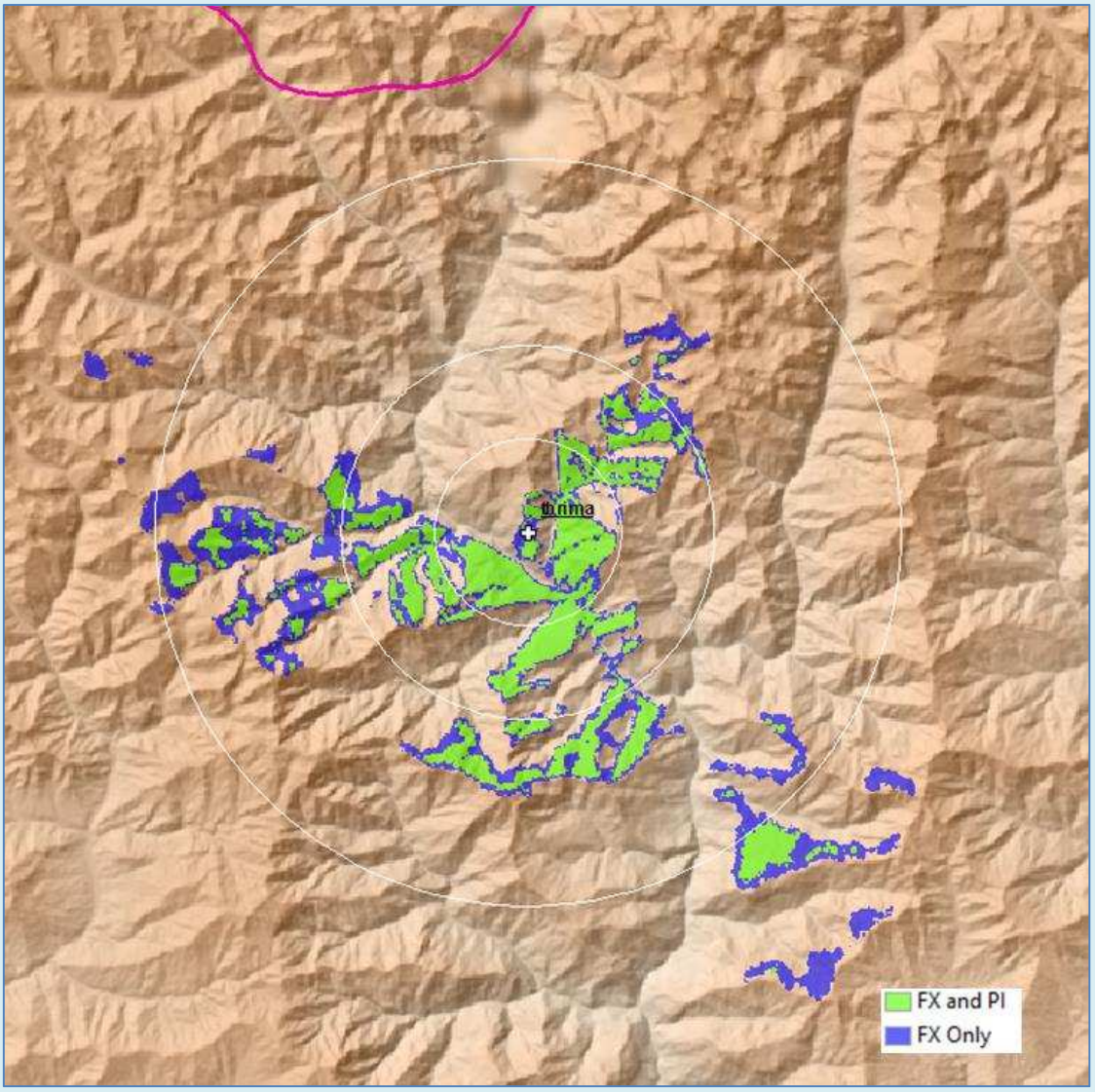
Source: Progira, ITU

FIGURE 25: DTTB COVERAGE OF SITE DARJEYDANGRA WITH FX AND PI RECEPTION



Source: Progira, ITU

FIGURE 26: DTTB COVERAGE OF SITE GOENKHAMI WITH FX AND PI RECEPTION



Source: Progira, ITU

FIGURE 27: DTTB COVERAGE OF SITE THRIMA WITH FX AND PI RECEPTION

In the initial approach the DTTB ERP is taken as indicated in Table 15. In the detailed planning in Phase 3 of the Roadmap ERP should be verified and where appropriate to be adjusted with the aim to:

1. To match to analogue TV coverage with fixed reception;
2. To provide portable indoor coverage in urban areas by increasing the ERP to economically acceptable values, taking into account the antenna diagram adjustment referred to in Section 6.1.

Polarisation

As in indicated in the ITU Guidelines for transition to digital broadcasting, the choice of polarisation is guided by the polarisation of existing transmitting and receiving antennas. Table 16 summarizes the considerations of the polarisation choice, where H is horizontal polarisation and V is vertical polarisation.

#	Transmissions, all combined into one antenna	Use of existing transmitting antenna [a)]	Use of new transmitting antenna	
			Rooftop antennas in use [a)]	Almost no rooftop antennas in use
1	DTTB multiplexes intended for fixed reception	H	H	H
2	DTTB multiplexes also intended for portable or mobile reception	H	H	V
3	Combination of DTTB multiplexes intended for fixed reception and MTV multiplex	H	H [b)]	V
4	Combination of DTTB multiplexes intended for portable or mobile reception and MTV multiplex	H	H [b)]	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.			

TABLE 16: POLARISATION CHOICE

Taking into account that portable reception is important and that there are no existing UHF transmitting antennas and no UHF rooftop antennas, the recommended polarisation is vertical (see blue shaded field in Table 16). Vertically polarised transmitting antennas have also the advantage that for low power transmissions, low cost non-directional dipole antennas can be used.

In the initial approach it is assumed that transmitting antennas are vertically polarised.

Annex 4: More details on Reference Offers

This Annex provides some more details on the system of requiring reference offers (RO) from DTTB multiplex/network operators.

This Annex is structured as follows:

1. Scope of RO;
2. Pricing of RO.

Scope of RO

A NRA stipulates that the network provider has to offer a *minimum service*. The following could be included in the minimum service:

1. Encoding and multiplexing of service feeds, and;
2. The distribution of a DVB-T2 compliant national[54] SD or HD service in calculated coverage areas and covering a minimum population as included in the Network Deployment Plan (i.e. in compliancy with their network roll-out obligation);
3. Not exceeding the maximum permissible powers (and hence interference levels) as included in the Frequency Plan (see also Section 4.4).

A licensed network provider could also provide auxiliary services, such as the supply of studio or service feeds to the national head-end system or to a satellite uplink station. Figure 28 shows an overview of the reference offer' scope, technical interfaces and Point of Service (PoS).

[54] This excludes the requirement for provisioning of regionalised services. A separate reference offer for regionalised DVB-T2 services should be drafted.

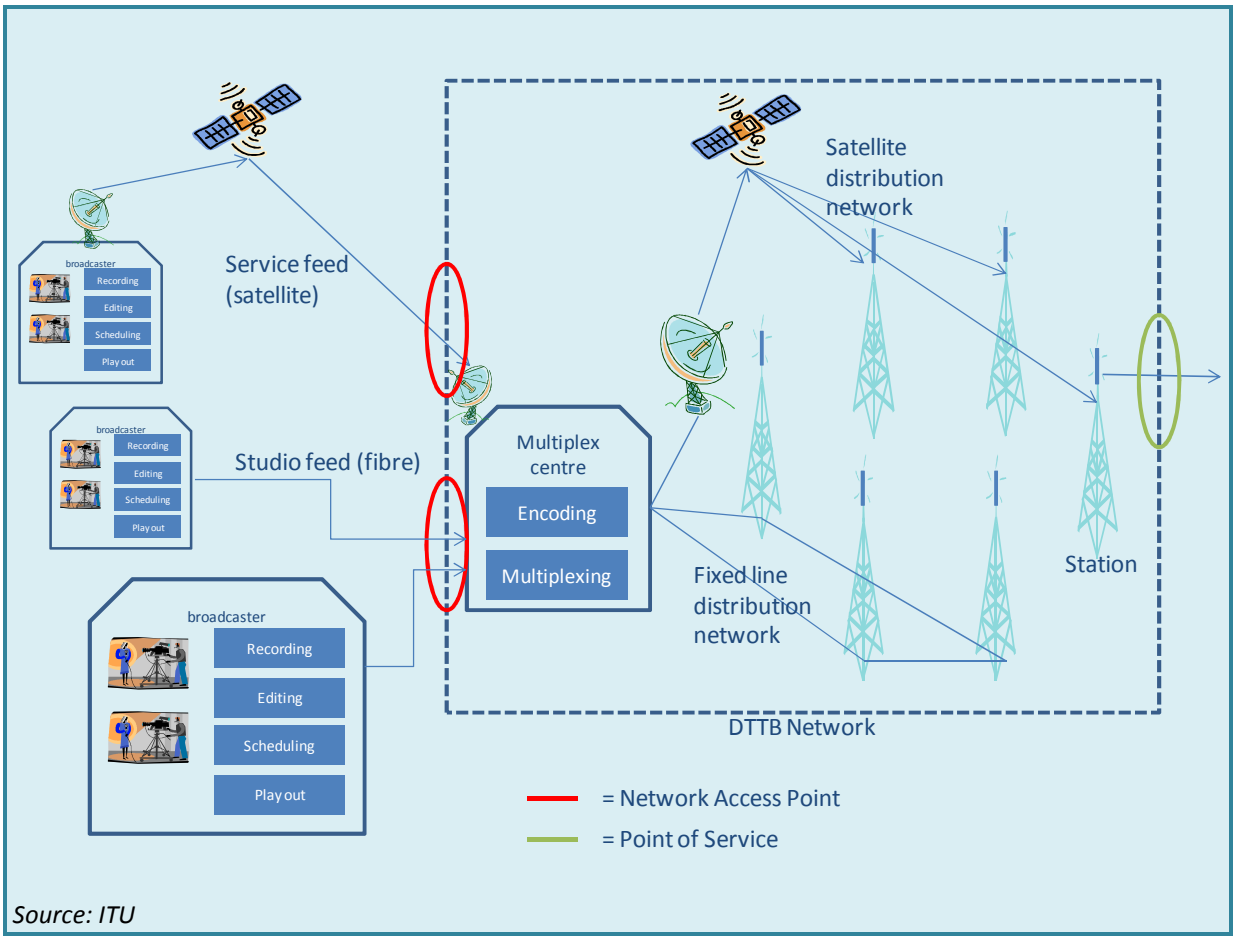


FIGURE 28: SCOPE OF THE RO FOR DTTB NETWORK SERVICES

The network operator has a roll-out obligation to deploy their network in defined stages. In the final stage their network could be near nationwide coverage (see Table 1). The reference offer has to consider this staged deployment. Hence, for the DTTB service delivered at each site the network operator should to include the following:

1. Calculated rooftop and indoor coverage per site (or SFN, if applied), plotted on maps, and in sufficient detail to assess the quality of the coverage areas[55];
2. Calculated rooftop and indoor coverage per site (or SFN, if applied), expressed in number/percentage of households/population;
3. Monthly charge per site per service (Point of Service) allowing for charging distribution fees proportional to the deployment stage.

In the case of two or more network operators some special requirements are necessary in the reference offers as to ensure a coordinated deployment between the multiple network operators. The design, deployment and operations of the sites should be coordinated between the network

[55] The NRA can request the in- and output files from the network operator's planning software tool. It is also noted that the wanted coverage areas are not defined in the case of population target for network coverage. For example only the required population coverage of a whole network is defined (e.g. 90%). Consequently there can be coverage gaps.

operators in such a way that the viewer needs to direct its antenna in one direction while receiving all available services with optimal signal strength.

Also the network operator should provide details on System Software Updates (SSU) it may wish to carry out. SSU should be tested before they are carried out. These SSU procedures have to be described and included in the description of the operational and maintenance procedures of the reference offer. Similarly, the provisioning of service information (i.e. PSI/SI) should be detailed.

Pricing of RO

The pricing structure and pricing model should be defined by the NRA. The costing methodology for calculating the cost of the *minimum service* is commonly based on long run incremental cost (LRIC)[56]. The increment is defined as a DTTB service. The principle of the LRIC model can be defined as the difference between the company cost level with and without the minimum service. Figure 29 illustrates this in the form of a simple formula.

$$LRIC\ of\ the\ minimum\ service = \frac{(\text{Cost of providing the minimum service} - \text{Cost without the minimum service})}{\text{Total number of services in the network/multiplex}}$$

FIGURE 29: LRIC MODEL

The cost of the *minimum service* comprised the following cost elements:

1. Capital expenditure (CAPEX): investment costs in the DTTB network which are directly relevant to the provision of *minimum service* such as encoder, multiplexer, transmitter etc;
2. WACC: reasonable return on capital invested in the DTTB network calculated based on weighted average cost of capital (WACC[57]);
3. Operating expenditure (OPEX): expenses which are directly relevant to the provision of *minimum service* such as operation and maintenance cost;
4. Common cost: costs which are relevant to the business operation but cannot be directly or indirectly allocated to *minimum service* such as general and administration costs, regulatory costs etc[58].

Table 17 includes the assets lives and cost trends that could applied for the various asset categories.

[56] For more details on the application of LRIC models see ITU Regulations Toolkit on www.ictregulationtoolkit.org

[57] For non-public financed entities the WACC is different (higher) from publicly financed entities. Please note that also bank loan interest rates and the risk profiles of the business (and country) drive WACC percentages.

[58] The distribution of common cost to access to the minimum service had to be based on equal proportional mark up (EPMU) method.

Asset category	Life (in yrs)	Price trend (%)
Multiplexer	10	-5%
Transmitters	10	-5%
Tower	20	2%
Antenna system	20	2%
Combiner	10	-5%
TVRO	10	-5%
Site buildings	20	2%
Tools & Instruments	10	-5%
Monitoring system	10	-5%

TABLE 17: ASSET LIVES AND COST TRENDS

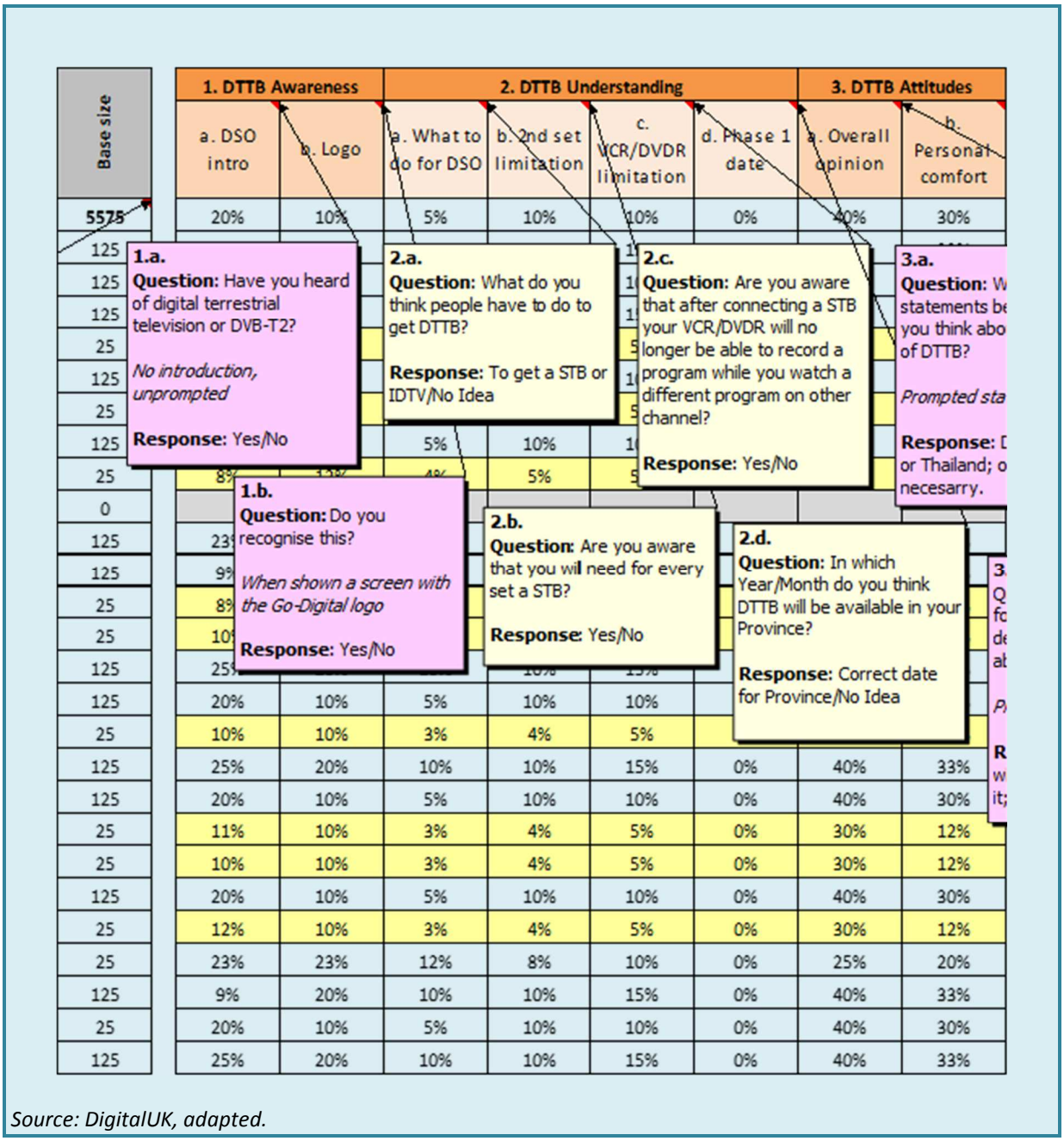
Example reference offers can be found on the Ofcom website (i.e. the NRA of the UK), under reference offers (see www.ofcom.org.uk).

Annex 5: Example tracker board

DSO tracker board is a management tool for planning and monitoring the DSO progress. It can also be used for determining the ASO date. Systematically collected DSO data and regularly communicated DSO tracker boards provide a solid base for determining a national ASO date. Depending on the demographics and the target group details registered in DSO surveys, the tracker board scores can be displayed per administrative area or per target group.

The included example is based on the tracker board as was used by DigitalUK for managing the DSO/ASO process in the UK. The DSO tracker board is designed around the six communications phases (as included in the ITU Guidelines in section 2.18.1).

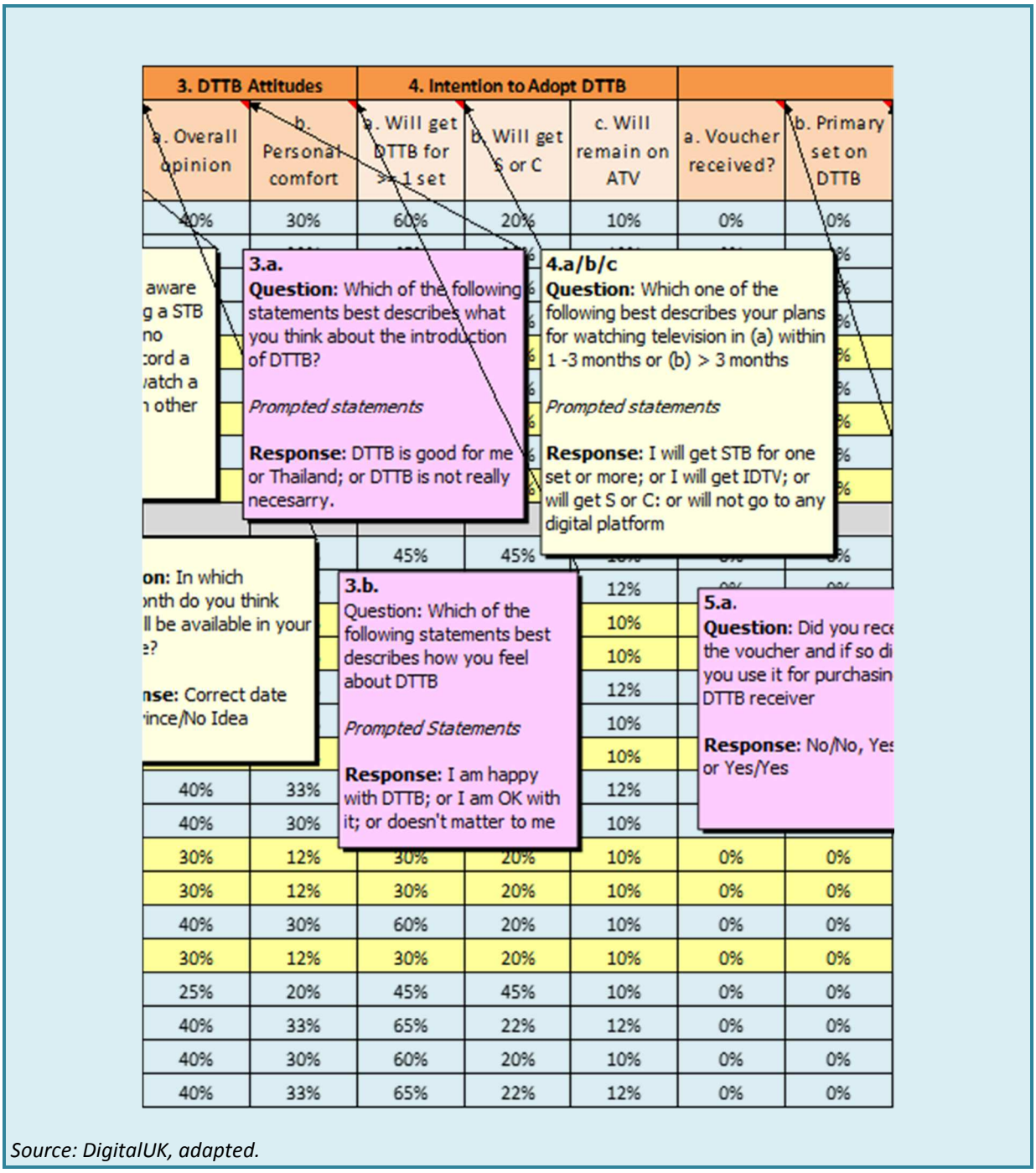
Figure 30 to Figure 32show an overview of the tracker broad.



Base size	1. DTTB Awareness		2. DTTB Understanding				3. DTTB Attitudes	
	a. DSO intro	b. Logo	a. What to do for DSO	b. 2nd set limitation	c. VCR/DVDR limitation	d. Phase 1 date	a. Overall opinion	b. Personal comfort
5575	20%	10%	5%	10%	10%	0%	40%	30%
125								
125								
125								
25								
125								
25								
125			5%	10%	1(			
25	8%		4%	5%	5			
0								
125	23							
125	9%							
25	8%							
25	10							
125	25				10%	15%		
125	20%	10%	5%	10%	10%			
25	10%	10%	3%	4%	5%			
125	25%	20%	10%	10%	15%	0%	40%	33%
125	20%	10%	5%	10%	10%	0%	40%	30%
25	11%	10%	3%	4%	5%	0%	30%	12%
25	10%	10%	3%	4%	5%	0%	30%	12%
125	20%	10%	5%	10%	10%	0%	40%	30%
25	12%	10%	3%	4%	5%	0%	30%	12%
25	23%	23%	12%	8%	10%	0%	25%	20%
125	9%	20%	10%	10%	15%	0%	40%	33%
25	20%	10%	5%	10%	10%	0%	40%	30%
125	25%	20%	10%	10%	15%	0%	40%	33%

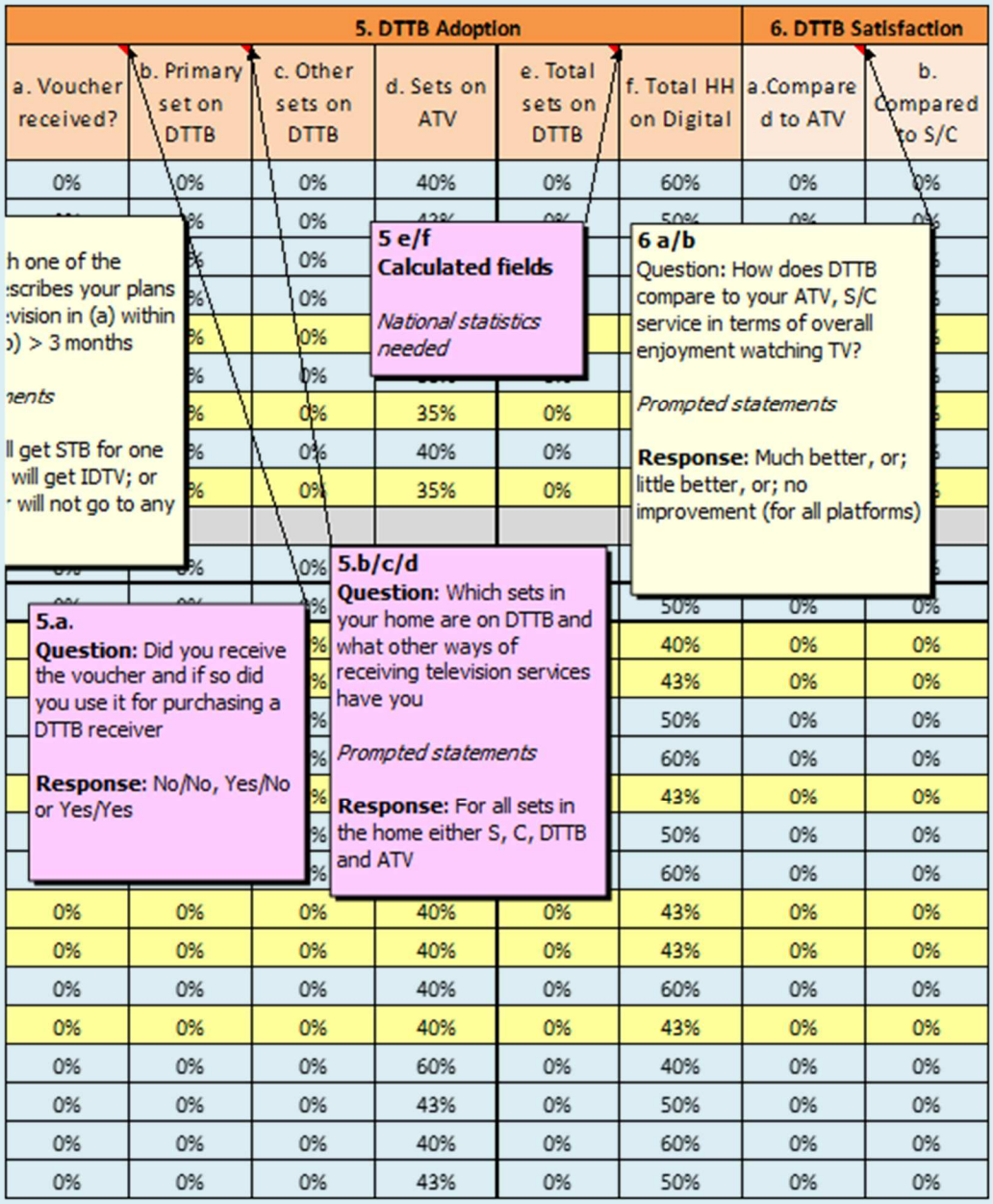
Source: DigitalUK, adapted.

FIGURE 30: PHASE AWARENESS AND UNDERSTANDING



Source: DigitalUK, adapted.

FIGURE 31: PHASE ATTITUDES AND INTENTIONS



Source: DigitalUK, adapted

FIGURE 32: PHASE ADOPTION AND SATISFACTION

Annex 6: Example receiver specifications

The DTTB receiver specifications for Thailand are included in this Annex. The receiver specifications are in two parts. The second part includes an amendment. The two parts are titled as follows:

1. Notification of the National Broadcasting and Telecommunications Commission Re: Technical Standard for Digital Terrestrial Television Receiver (No. 1) B.E. 2555 (2012);
2. Notification of the National Broadcasting and Telecommunications Commission Re: Technical Standard for Digital Terrestrial Television Receiver (No. 2) B.E. 2556 (2013)

Part 1

(UNOFFICIAL TRANSLATION)

Notification of the National Broadcasting and Telecommunications Commission

Re: Technical Standard for Digital Terrestrial Television Receiver

_____

Whereas it is deemed appropriate to set out technical standard for digital terrestrial television receiver in order to ensure that the public are able to use such receiver to view the broadcast digital television programs in an efficient, standardized and quality manner with advanced technology as a way of protecting consumers and contributing to the industry as a whole;

Pursuant to Section 27 (10) and (24) and Section 37 of the Act on Organization to Assign Radio Frequency and to Regulate the Broadcasting and Telecommunications Services B.E. 2553 (2010), which contains certain provisions regarding the restriction of the rights and freedom of an individual as permitted to be done under the law by Article 29, together with Articles 35, 36, 41, 43, 45, 46, 47, 61 and 64 of the Constitution of the Kingdom of Thailand; the National Broadcasting and Telecommunications Commission hereby prescribes the technical standard for digital terrestrial television receiver, as detailed in the Technical Standard No. NBTC BS 4002-2555 appended hereto.

This Notification shall come into force as from the day following the date of its publication in the Government Gazette.

Announced on the 2nd day of November B.E. 2555 (2012)

Colonel

(Natee Sukonrat)

Chairman of the Broadcasting Committee

Officiating for Chairman of the National Broadcasting

and Telecommunications Commission

1. Scope

This Technical Standard specifies the minimum technical specifications for digital terrestrial television receiver, including both receiver with display screen (Integrated Digital Television, iDTV) and receiver without display screen (Set-Top-Box), which are capable of receiving digital television signal in the Second Generation Digital Terrestrial Television Broadcasting System (DVB-T2) in both Standard Definition (SD) format and High Definition (HD) format.

2. General Requirements

2.1 Technical Requirements of Electrical Characteristics and Safety

The receiver shall comply with the electrical characteristics and safety requirements as defined in TIS 1195-2536 [1].

2.2 Technical Requirements of Electromagnetic Compatibility

The receiver shall comply with the electromagnetic compatibility standard as defined in CISPR 13 [2] or TIS 2185-2547 [3].

2.3 Installation and Usage

The receiver shall be supplied with an installation manual and instruction manual, available in both Thai and English languages.

2.4 Remote Control

The receiver shall be supplied with a remote control with tactile marking placed on the number '5' button.

3. Technical Requirements of Connectors and Interfaces

The receiver shall have connectors and interfaces in accordance with the specifications in Table 1.

Table 1: Technical requirements of connectors and interfaces

Type of Connectors	Requirements
RF input connector	Female connector shall be in accordance with IEC 60169-2 [4], with input impedance of 75 ohm. The receiver without display screen (Set-Top-Box) shall support DC power supply of 5V for active antenna, with users being able to set on/off by themselves, and the default shall be set to "off."
RF loop-through	The receiver without display screen shall have the male connector in accordance with IEC 60169-2.
Video and audio connectors	The receiver without display screen (Set-Top-Box) shall have output connectors as follows:

Type of Connectors	Requirements
	1. RCA-phono socket for stereo audio signal output bundled with cable. 2. RCA-phono socket for composite video signal output bundled with cable. 3. HDMI socket with HDCP for digital signal output bundled with cable.

4. RF Tuner and Decoder Requirements

4.1 Radio Frequency Requirements

Radio frequency requirements of RF tuner in the receiver shall comply with the requirements in Table 2.

Table 2: Properties and requirements of RF tuner in the receiver

Properties	Requirements
Frequency range of receiver	470-862 MHz
Bandwidth	8 MHz
Noise Figure (NF)	Not exceeding 6 dB
Receiver sensitivity	Below -78.3 dB for FFT 32K (extended), 256-QAM, code rate 2/3, SISO and pilot pattern PP7
Channel offset	Able to receive carriers within an offset of up to ±125 kHz from the nominal center frequency.

4.2 DVB-T2 Operating Modes

The operation of DVB-T2 receiving and decoding modes shall comply with ETSI EN 302 755 [5] and shall support the minimum requirements in Table 3.

Table 3: Required DVB-T2 operating modes

Parameter	Minimum Requirements
FFT size	1K, 2K, 4K, 8K (normal), 8K (extended), 16K (normal), 16K (extended), 32K (normal), and 32K (extended)
Modulation	QPSK,16-QAM, 64-QAM, and 256-QAM
Code rate	1/2, 3/5, 2/3, 3/4, 4/5, and 5/6

Parameter	Minimum Requirements
Guard interval	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, and 1/4
Pilot pattern	PP1 to PP7
Service type	1. Support both Single PLP (Mode A) and Multiple PLP (Mode B) 2. Support Single Frequency Network (SFN) in accordance with ETSI TS 101 191 [6]

5. Technical Requirements of De-multiplexing and Transport Stream

De-multiplexing and decoding for MPEG-2 transport stream of the receiver shall comply with ETSI TS 101 154 [7] and ISO/IEC 13818-1 [8].

6. Technical Requirements of Video and Audio Signals

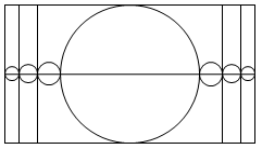
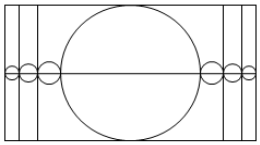
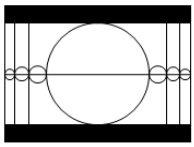
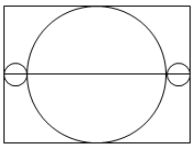
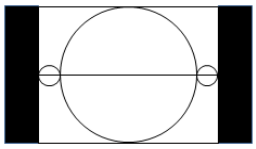
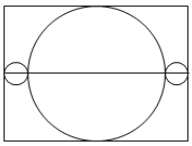
Technical specifications of video and audio signals shall comply with the requirements in Table 4.

Table 4: Video and audio requirements

Characteristics	Required Standards
Video decoder	MPEG-4 AVC/H.264 in accordance with ISO/IEC 14496-10 [9]
Video display	Support High Definition (HD) format with 1920x1080 interlaced (1080i) Frame rate : 25 frames/sec Aspect ratio : 16:9
	Support High Definition (HD) format with 1280x720 progressive (720p) Frame rate : 50 frames/sec Aspect ratio : 16:9
	Support Standard Definition (SD) format with 720x576 interlaced (576i) Frame rate : 25 frames/sec Aspect ratio : 16:9 and 4:3
Audio decoder	Decoding stereo audio signal, MPEG-4 HE AACv2, in accordance with ISO/IEC 14496-3 [10]

The video display shall support display types in accordance with the specification of Active Format Description (AFD) under the ETSI TS 101 154 standard, by supporting at least two types shown in Table 5.

Table 5: Video signal display formats

Input Video Signal				**Output Video Display**	
Source Video Signal		Broadcast Aspect Ratio	AFD Code		
Source Video Aspect Ratio	Source Image from Input Video Signal			16:9	4:3
16:9		16:9	1000		
4:3		4:3	1001		

7. Technical Requirements of Data Processing and Display

7.1 Processor and Memory

The receiver shall have processor and memory that are equal to or better than the following specifications:

1. DDRAM Memory : minimum 64 MB
2. Flash Memory : minimum 8 MB
3. CPU Processor Speed : minimum 300 MHz

7.2 Character Set

The receiver shall support character set as specified in ETSI EN 300 468[11] in Character Code Table 00 – Latin alphabet with Unicode equivalents and Character Code Table 07 - Latin/Thai alphabet with Unicode equivalents.

7.3 On Screen Display (OSD) Language

The receiver shall support Thai and English menu, with the default being set to Thai or the user being able to select language at the first time of use.

7.4 Subtitling System

The receiver shall support the subtitling system in accordance with ETSI EN 300 743 [12] and shall also be able to decode and display in Display Definition Segment (DDS) under such standard.

7.5 Support of Multi-Language Display

The receiver shall support multi-language audio output and subtitling and allow users to choose the primary language of their own, and shall at least support the languages specified in Table 6.

Table 6: Support languages

Language	ISO 639-3 [13] Code
Thai	THA
English	ENG
Original Audio	QAA

7.6 Service and Channel Number

The receiver shall be able to receive all signals in each service area by scanning through frequency range specified in Clause 4.1.

All services shall have a logical channel number (LCN), and the digital terrestrial television channel with original network ID (ONID) of Thailand shall be arranged as the first priority. The channel plan shall cover from number 1 through number 999 and shall be assigned as follows:

1. Number 1 to 799 shall be reserved for domestic channels which have ONID of 0x22FC.
2. Number 800 to 999 shall be reserved for channels which have other ONID.

If the digital terrestrial television network is updated or changed as follows:

1. addition or deletion of multiplexes,
2. change in frequency of multiplex,
3. addition or deletion of television channels,
4. change in channel number, or
5. any other change that affects the television channel,

The receiver shall be fully updated and correctly display television channels.

7.7 Logical Channel Descriptor

The receiver shall support the Logical Channel Descriptor Version 2, which is the information on channel list in service area, as detailed in Table 7.

Table 7: Structure of local channel descriptor

Structure	Bit	Data Type
Logical_channel_v2_descriptor (){		
descriptor_tag	8	Uimsbf

Structure	Bit	Data Type
descriptor_length	8	Uimsbf
for (i=0;i<N;i++){		
channel_list_id	8	Uimsbf
channel_list_name_length	8	Uimsbf
for (i=0;i<N;i++) {		
char	8	Uimsbf
}		
country_code	24	Uimsbf
descriptor_length	8	Uimsbf
for (i=0;i<number_of_services;i++){		
service_id	16	Uimsbf
visible_service_flag	1	Bslbf
reserved_future_use	5	Bslbf
logical_channel_number	10	Uimsbf
}		
}		
}		

Following are parameter descriptions:

Descriptor_tag shall be 0x87 (or 135 in decimal).

Descriptor_length is 8-bit field for specifying the length of descriptor.

Channel_list_id is 8-bit field and is used for specifying a channel list for each service area. Such value shall be unique within the Original Network.

In case more than one list of channels is found when scanning, users shall be able to select their desired list. The receiver shall arrange the channels according to each list.

Channel_list_name_length is 8-bit field and is used for identifying number of bytes that follow this field (name of the channel list) that specifies the number of characters in the name of the channel list. Such name is limited to a maximum of 23 bytes.

Char is 8-bit character. A String of characters is used for describing the name of the channel list. Such information shall be in reference to the character set defined in Character Code Table 00 – Latin alphabet with Unicode equivalent in accordance with ETSI EN 300 468.

Country_code is 24-bit field used for specifying country name in a three-character type in accordance with ISO 3166 [14]. Each character shall be coded into 8 bits in accordance with ISO 8859-1 [15] and shall be inserted respectively in this 24-bit field. This field must be set to "THA."

Service_id is used for specifying service ID on the transport stream.

Visible_service_flag is set to 1 when desiring to display the television channel (visible) and is set to 0 when desiring not to display the television channel (not visible).

Reserved_future_use shall be set to 1. The receiver must ignore this field.

Logic_channel_number is channel number.

7.8 Electronic Program Guide (EPG)

The receiver shall support processing and display of electronic program guide (EPG) from DVB SI EIT p/f Table and DVB SI EIT Schedule in accordance with ETSI EN 300 468. The display must include at least the following data:

1. Current date (day/month/year) and time
2. Start time of present program (now/present) and next program (next/follow)
3. End time of present program (now/present) and next program (next/follow)
4. Logical Channel Number (LCN)
5. Event name and/or title of program
6. Short description
7. Program category

The receiver shall be able to store and display EPG in advance of at least 7 days (24 hours/day).

7.9 Display of Signal Strength and Signal Quality

The receiver shall be able to display the signal strength and signal quality on panel of the receiver or through the display screen.

8. System Software Update (SSU)

The receiver shall support the software update functions as specified in ETSI TS 102 006 [16] and shall at least support simple profile.

9. Conformity of Technical Standard

The receiver shall demonstrate the conformity of technical standard as described in Notification of the National Broadcasting and Telecommunications Commission with respect to conformity assessment of radiocommunication equipment and equipment for broadcasting service. While the said notification has not yet come into force, the Supplier's Declaration of Conformity (SDoC) shall apply, whereby the operator, the producer, the merchandiser or the importer of digital terrestrial television receiver who is responsible for such device shall issue the official confirmation to certify that the receiver complies with the technical standard specified herein.

Glossary

AFD	Active Format Description

AVC	Advanced Video Coding
Bslbf	Bit serial, leftmost bit first
DDS	Display Definition Segment
DVB-T2	Second Generation Digital Terrestrial Television Broadcasting System
EPG	Electronic Program Guide
EIT	Event Information Table
ETSI	European Telecommunication Standards Institute
FFT	Fast Fourier Transform
HDCP	High-Bandwidth Digital Content Protection
HDMI	High-Definition Multimedia Interface
HDTV	High Definition Television
iDTV	Integrated Digital Television
LCN	Logical Channel Number
MPEG	Moving Pictures Expert Group
OSD	On Screen Display
ONID	Original Network ID
PLP	Physical Layer Pipe
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RCA	Radio Corporation of America
RF	Radio Frequency
SD	Standard Definition
SDoC	Supplier's Declaration of Conformity
SDTV	Standard Definition Television
SFN	Single Frequency Network
SI	Service Information
SSU	System Software Update
STB	Set-Top-Box, which is equivalent to a digital terrestrial receiver
Uimsbf	Unsigned integer most significant bit first

References

[1] TIS 1195-2536: Mains Operated Electronic and Related Apparatus for Household and Similar General Use: Safety Requirements

[2] CISPR 13:2009: Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement

[3] TIS 2185-2547: Sound and television broadcast receivers and associated equipment: Radio disturbance limits

[4] IEC 60169-2: Radio-frequency connectors, Part 2: Coaxial unmatched connector

[5] ETSI EN 302 755 v1.3.1 (2012-04): Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)

[6] ETSI TS 101 191 v1.4.1 (2004-06): Digital Video Broadcasting (DVB); DVB mega-frame for Single Frequency Network (SFN) synchronization

[7] ETSI TS 101 154 v1.10.1 (2011-06): Digital Video Broadcasting (DVB); Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream

[8] ISO/IEC 13818-1:2007: Information technology - Generic coding of moving pictures and associated audio information: Systems

[9] ISO/IEC 14496-10:2012: Information technology - Coding of audio-visual objects - Part 10: Advanced video coding

[10] ISO/IEC 14496-3:2009: Information technology - Coding of audio-visual objects - Part 3: Audio

[11] ETSI EN 300 468 v1.13.1 (2012-08): Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems

[12] ETSI EN 300 743 v1.4.1 (2011-10): Digital Video Broadcasting (DVB); Subtitling systems

[13] ISO 639-3: Codes for the representation of names of languages - Part 3: Alpha-3 code for comprehensive coverage of languages

[14] ISO 3166: Codes for the representation of names of countries and their subdivisions

[15] ISO 8859-1: Information technology - 8-bit single-byte coded graphic character sets - Part 1: Latin alphabet No. 1

[16] ETSI TS 102 006 v1.3.2 (2008-07): Digital Video Broadcasting (DVB); Specification for System Software Update in DVB Systems

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Part 2

(UNOFFICIAL TRANSLATION)

Notification of the National Broadcasting and Telecommunications Commission

Re: Technical Standard for Digital Terrestrial Television Receiver

(No. 2) B.E. 2556 (2013)

It deems expedient to adjust the Notification of the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver in order to be appropriate, effective and maximum benefit to the public and to promote the business on the digital terrestrial television.

By virtue of Section 27 Paragraph One (10) and (24), Section 37 of the Act on Organization to Assign Radio Frequency and to Regulate the Broadcasting and Telecommunications Services B.E. 2553 (2010) consisting of some provisions with limitation of exercise of rights and freedom of individual, whereas Section 29 supplementing with Section 35, Section 36, Section 41, Section 43, Section 45, Section 46 Section 47, Section 61 and Section 64 of Constitution of the Kingdom of Thailand allow to do such manners under the enactment of legislation. The National Broadcasting and Telecommunications Commission hereby deems expedient to prescribe the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 additionally as follows:

Section 1: This Notification shall come into force after its date of publication in the Government Gazette.

Section 2: Paragraph 2.1 of the Section 2 related to General Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

"2.1 **General Requirement on the Nature of Electric and Safety**

The digital terrestrial television receiver shall be qualified in relation to the nature of electric and safety according to the Thai Industrial Standard (Mor.Or.Gor.) 1195 [1] or a current version."

Section 3: Paragraph 2.2 of the Section 2 related to General Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

"2.2 **General Requirement on the Electromagnetic Compability**

The general requirement on the electromagnetic compability for the digital terrestrial television receiver shall be in accordance with either standard as follows;

1. CISPR 13 [2] or the current version
2. Thai Industrial Standard (Mor.Or.Gor.) 2185 [3] or a current version
3. EN 55013 [3.1] or a current version."

Section 4: Paragraph 2.4 of the Section 2 related to General Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

"2.4 Remote Control

The digital terrestrial television receiver shall come together with a remote control. It shall have tactile marking over the button No. 5 and the button for audio description. The audio description button may be made in general like the "Audio" button or specifically like the "AD" button.

Section 5: Paragraph 2.5 of the Section 2 related to General Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be added as follow:

"2.5 **General Requirement on Electric Capacity**

The digital terrestrial television receiver both the Set-Top-Box and the Integrated Digital Television (iDTV) shall have electric capacity not exceeding 1 watt in the following modes:

1. OFF Mode means the mode that electric device is connecting with the main power supply and not ready to change in any other modes such as Standby Mode, Network Mode or Active Mode including Normal Mode.
2. Standby Mode means the mode that electric device is connecting with the main power supply and functioning:
   2.1 to change to other modes by way of using the internal or time setting; or
   2.2 constantly in:
      2.2.1 displaying the mode and time on the screen
      2.2.2 activating the sensor

To check the electric capacity, it shall be pursuant to IEC 62301 [17].

In addition, Network Mode means the mode that the electric device is connecting with the main power supply as well as the Internet but it has yet communicated or transferred the information through the Internet.

Active Mode means the mode that the electric device is connecting with the main power supply and activating at least one function (please note that the "on", "in-use" or "normal operation" have similar meaning with this mode).

Section 6: The Table 1 of Section 3 related to the General Requirements on Connectors and Interfaces in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical

Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following table:

Table 1: The Requirements on Connectors and Interfaces

Type of connector	Requirement
RF Input Connector	Female connector shall be in line with the IEC 60169-2 [4] while the input impedance is equal to 75 ohm. In addition, the Set-Top-Box shall supply the direct current in the amount of 5 volt to the active antenna. The user shall be able to turn on/off the current by himself while the starting mode shall be OFF.
RF Loop-through	The Set-Top-Box shall have the male connector according to the IEC 60169-2.
Vision and audio connector and interface	The Set-Top-Box shall have output interfaces as follows; 1. The RCA-phono socket for the stereo audio that comes with cable or other connectors and the cable that enable to convert to the RCA-phono socket; 2. The RCA-phono socket for the composite that comes with cable or other connectors and the cable that enable to convert to the RCA-phono socket; 3. To support the HDMI connection that enables to protect the duplication in the event of digital output and comes with cable.

Section 7: Paragraph 4.2 of the Section 4 related to the RF Tuner and Decider Requirements in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

"4.2 **DVB-T2 Operating Modes**

The method of RF tuner and decoder for the DVB-T2 system shall be in line with the ETSI EN 302 755 v.1.2.1 [5] or a current version of the ETSI EN 302 755. However, it shall support to function according to the Table 3."

Section 8: Paragraph 7.5 of the Section 7 related to General Requirements on Information Evaluation and Display in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be added as follow:

"Moreover, the digital terrestrial television receiver shall support the audio description in a manner of Broadcast Mix according to ETSI TS 101 154 [7]. In this regard, the user shall be able to turn on/off

the audio description by pressing the “Audio” button in general or “AD” button specifically on a remote control.”

Section 9: Paragraph 7.7 of the Section 7 related to General Requirements on Information Evaluation and Display in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following paragraph:

“**7.7 Logical Channel Descriptor**

The digital terrestrial television receiver shall support to function according to the Logical Channel Descriptor version 2 while the Private Data Specifier ID (PDS ID) is equal to 0x0000 22FC. In addition, such Logical Channel Descriptor version 2 is information related to channel arrangement in the service area as detailed in the Table 7.”

Section 10: Paragraph [3.1] in between [3] and Section [4] of the reference in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be added as follow:

“[3.1] EN 55013:2001 Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement”

Section 11: Paragraph [5] of the reference in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be revoked and substituted by the following reference:

“[5] ETSI EN 302 755 v1.2.1 (2011-02): Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)”

Section 12: Paragraph [17] of the reference in the technical standard of the digital terrestrial television receiver NBTC Mor.Sor. 4002-2555 as attached in the National Broadcasting and Telecommunications Commission, Re: Technical Standard for Digital Terrestrial Television Receiver shall be added as follow:

“[17] IEC 62301 Edition 2.0 2011-01: Household electrical appliances – Measurement of standby power”

Announced on the Date of 9 May 2013

Colonel Natee Sukolrath

Chair of the Radio and Television Broadcasting Businesses Commission, Acting on Behalf of Chair of the National Broadcasting and Telecommunications Commission

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