1 IMT sharing and coexistence with other services in the 700 MHz band

This Section addresses the sharing and coexistence of IMT services in the 700 MHz band (i.e. allocated according to frequency arrangements as detailed by the ITU-R and as identified in the ITU-RR) with other primary services in the same band or in adjacent bands.

1.1 IMT frequency arrangements in the 700 MHz band

Table 1 shows the IMT frequency arrangements in the 700 MHz band as included in Recommendation ITU-R M.1036-6. Table 1 shows Frequency Division Duplex (FDD) and Time Division Duplex (TDD) arrangements. It is noted that Administrations may implement a part of each frequency arrangement. The recommended frequency arrangement by the African Union Commission (AUC) is highlighted in grey[10].

Frequency arrangement	Paired arrangements (FDD)				Un-paired arrangements (TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
A4	698-716	12	728-746	30	None
	776-793	13	746-763	30	None
					716-728
A5	703-748	10	758-803	55	None
A6					698-806
A7[11]	703-733	25	758-788	55	None
A8[12]	698-703	50	753-758	55	None
A9[13]	733-736	52	788-791	55	None
A10[14]	External		738-758		None
A11 (harmonized with A7 and A10)	703-733	25	758-788	55	None
	External		738-758		

Table 1: IMT frequency arrangements in the 700 MHz band

From Table 1 the following can be observed and concluded:

1) 8 IMT frequency arrangements are identified in the 700 MHz band;
2) These 8 frequency arrangements range from 698 MHz to 803 MHz;
3) Frequency arrangement A5 corresponds with the APT 700 MHz band plan for IMT;
4) Frequency arrangement A5 (including 3GPP band 28 and 17) is the most commonly applied frequency arrangement in the 700 MHz band around the world[15];

[10] AUC recommendation of 26 December 2016, "Guidelines on the Harmonized use of the Digital Dividend in Africa: Policy, Technical and Regulatory Procedures".
[11] A7 arrangement aligns with the lower duplexer of A5.
[12] A8 arrangement can be implemented alone or in combination with parts of A7.
[13] A9 arrangement aligns with part of the upper duplexer of A5.
[14] For A10 and A11, zero to four frequency blocks of 5 MHz in 738-758 MHz could be used to complement the downlink capacity of a frequency arrangement in this or other bands (i.e. supplemental downlinks).
[15] Source: Halberd Bastion, mobile networks deployment database. See https://halberdbastion.com/intelligence/mobile-networks/.

5) Frequency arrangement A7, the lower duplexer of A5, is also aligned with the lower duplexer of the APT 700 MHz band plan. Hence, resulting in harmonisation across Region 1 and the APT region;
6) Furthermore, the AUC proposes frequency arrangements A8, A9 and A10 as additional options for:
    a. A8 and A9, as options for the allocation of broadband PPDR[16] or as additional capacity for non-PPDR services;
    b. A10, as an option for an additional downlink to the A7 arrangement for non-PPDR services.

1.2 Other services allocated in the 700 MHz band and adjacent bands

The frequency range of 698 MHz to 806 MHz (i.e. the range of the lowest to the highest frequency in Table 1) corresponds with the following (adjacent) parts of the ITFA for Region 1, as depicted in Table 2. Table 2 includes also the footnotes as included in the ITFA. Footnotes not relevant for the African countries or not relevant for the introduction of IMT are between brackets. Footnotes referring to IMT identifications are in blue.

470-694 MHz		
Services:	Footnote number:	Footnote:
BROADCASTING	(5.149)	Administrations are urged to take all practicable steps to protect the radio astronomy service. However, this request applies for the band 608-614 MHz in (Regions 1 and 3) which is 84 MHz apart from the lowest IMT frequency (698 MHz) in Table 1.
	(5.291A)	Additional allocation (to BROACASTING) in the band 470-494 MHz to the radiolocation service on a secondary basis for 8 countries in Europe.
	(5.294)	Additional allocation (to BROACASTING) in the band 470-582 MHz to the fixed service on a secondary basis for the following African countries; Cameroon, Côte d'Ivoire, Egypt, Ethiopia and Chad. However, the additional allocation is very apart from the lowest IMT frequency (see Table 1) and is an allocation on secondary basis which is outside the scope of this report (see Introduction).
	(5.296)	Additional allocation (to BROACASTING) in the band 470-694 MHz to the land mobile service on a secondary basis, intended for applications ancillary to broadcasting and programme-making (SAB/SAP) in most European and African countries. This concerns an additional allocation on secondary basis which is outside the scope of this report (see Introduction)
	(5.300)	Additional allocation (to BROACASTING) in the band 582-790 MHz to the fixed and mobile (except aeronautical mobile) services on a secondary basis in

[16] This is according to the harmonised frequency arrangement for broadband PPDR by the ATU in ITU-R Rec. M.2015-2 (01/2018). It is noted that in this Recommendation also a third option for PPDR (in section 1-1.4) is included by the ATU, however with a selection of A7 to non-PPDR services this PPDR option is not possible.

		the following African countries; Cameroon, Egypt, Libya and Sudan.
	(5.304)	Additional allocation (to BROACASTING) in the band 606-614 MHz to the radio astronomy service on a primary basis in the African Broadcasting Area[17]. However, the upper side of this radio astronomy band (i.e. 614 MHz) sits 84 MHz apart from the lowest IMT frequency (698 MHz) in Table 1.
	(5.306)	Additional allocation (to BROACASTING) in the band 606-614 MHz to the radio astronomy service on a secondary, except in the African Broadcasting Area and Region 3.
	(5.312)	Additional allocation (to BROACASTING) in a number of bands to the aeronautical radionavigation service on a primary basis in a number of European countries.
694-790 MHz		
Services:	Footnote number:	Footnote:
MOBILE except aeronautical mobile BROADCASTING	5.312A	Resolution 760: Given a number of considerations, recognitions and notes, the WRC-19 resolves that Administrations resolving interference between broadcasting and other services should: a. apply the procedures of GE-06 (where applicable) and consider ITU sharing studies; b. resolve adjacent interference within a country as a national matter. Resolve adjacent channel interference between countries by using mutually agreed criteria (see ITU-R BT.1368, ITU-R BT.1895, ITU-R BT.2033 and ITU-R M.2090); c. WRC-19 also invites the ITU-R Sector to pursue further compatibility studies and invites Administrations to contribute. Resolution 224: Given a number of considerations, recognitions and emphasises, the WRC-19 resolves that Administrations should: a. consider the relevant ITU-R Sector studies when implementing IMT; b. protect existing and future broadcasting stations both analogue and digital, except analogue in the GE06 planning area (in the band 470-806/862 MHz), as well as other primary terrestrial services; c. implement IMT stations in line with the procedures contained in the GE06 Agreement[18].

[17] Including all 54 African countries and a number of neighbouring countries in the middle east. For the exact definition see articles 5.10-5.13 in the ITU-RR.

[18] Administrations which deploy stations in the mobile service for which coordination was not required, or without having obtained the prior consent of those administrations that may be affected, shall not cause unacceptable interference to, nor claim protection from, stations of the broadcasting service of administrations operating in conformity with the GE06 Agreement. Those Administration shall also not object to nor prevent the entry into the GE06 plan or recording in the MIFR of additional future broadcasting allotments or assignments.

	5.317A	The frequency bands 694-790 MHz and 790-960 MHz in Region 1, which are allocated to the mobile service on a primary basis, are identified for IMT. For these frequency bands Recommendation ITU-R M.1036-6 provides the frequency arrangements (see Table 1);
	(5.300)	See above
	(5.312)	See above
790-862 MHz		
Services:	Footnotes number:	
FIXED MOBILE except aeronautical mobile BROADCASTING	5.316B	For countries party to the GE06 Agreement, the use of stations of the mobile service is also subject to the successful application of the procedures of that Agreement (see Resolution 224 above).
	5.317A	See above
	(5.312)	See above
	(5.319)	Addition allocation in the band 806-840 and 856-890 MHz to the mobile-satellite (except aeronautical mobile-satellite) service in Belarus, the Russian Federation and Ukraine.

Table 2: ITFA corresponding with the identified IMT frequency arrangements for the 700 MHz band (Region 1)

From Table 2 the following can be observed and concluded:

1) The non-IMT spectrum allocations in the range of 698 MHz to 803 MHz and in the adjacent bands include the following primary services:
    a. MOBILE except aeronautical mobile;
    b. BROADCASTING;
    c. FIXED;
2) Only a limited number of footnotes are relevant for the African countries and the introduction of IMT:
    a. In the band 694-790 MHz (700 MHz band):
        i. 5.312A: Respecting the GE06 Agreement and protecting the incumbent broadcasting services;
        ii. 5.317A: IMT identification;
    b. In the adjacent band 790-862 MHz:
        i. 5.316B: Implementation of IMT stations should comply with GE06;
        ii. 5.317A: IMT identification.

Table 3 provides and overview of the applications and technology standards commonly applied[19] in Region 1 for the *non-IMT* services as included in Table 2.

ITU-RR service	**Application**		**Application examples**	**Technology standard**	**References**
	ITU name	**CEPT name**			
MOBILE except aeronautical mobile 694-790 MHz	Services Ancillary to Broadcasting and Services	Programme Making and Special	Wireless microphones, wireless cameras and	Various, for professional licensed and unlicensed	ETSI

[19] This does not exclude the possibility that country specific applications exist in the band, such as land and maritime military systems, alarms, remote controllers and Radio-frequency identification (RFID).

ITU-RR service	Application		Application examples	Technology standard	References
	ITU name	CEPT name			
790-862 MHz	Ancillary to Programme making (SAB/SAP)	Events (PMSE)[20]	microwave links (for outdoor newsgathering), Assistive Listening Devices (ALD)	(lower power) equipment.	
	Public Protection and Disaster Relief (PPDR)	Public Protection and Disaster Relief (PPDR)[21]	Two-way mission critical narrow- and broadband communication systems with specific requirements. The legacy narrowband systems are also referred to as PMR/PAMR	APCO Project 25	The Association of Public-Safety Communications Officials (APCO)
				DMR	ETSI
				TETRA	ETSI
				(Broadband) LTE/LTE-A[22]	3GPP, ITU
BROADCASTING 470-694 MHz 694-790 MHz 790-862 MHz	Digital Terrestrial Television Broadcasting (DTTB)	Digital Terrestrial Television	Digital Terrestrial Television	DVB-T/DVB-T2	DVB consortium
				ISDB-T	Digital Broadcasting Experts Group (DiBEG)
	Analogue Television (ATV)[23]	Analogue Television	Analogue Terrestrial Television	PAL (G/H)	ITU, ETSI
				SECAM	ETSI
FIXED 790-862 MHz[24]	Fixed and Nomadic Wireless Access (FWA/NWA)	Broadband Wireless Access	Public and private broadband wireless access systems (for at home, shopping	IEEE 802.16 (WiMAX)	IEEE

[20] According to the harmonised European Table of Frequency Allocations and Applications (CEPT/ECC), Radio microphones and ALD are designated in respectively 470-789 MHz (on a tuning range basis) and band 823-832 MHz.

[21] According to ITU-R Rec. M.2015-2, the ATU recommends for broadband PPDR, frequency arrangements A8 and A9. See also footnote 16. According to the harmonised European Table of Frequency Allocations and Applications (CEPT/ECC), Broadband PPDR can be designated in the bands 698-703/753-758 MHz, 703-733/758-788 MHz and 733-736/788-791 MHz.

[22] See ITU Recommendation ITU-R M.2015-2 (01/2018), frequency arrangements for public protection and disaster relief radiocommunication systems in accordance with Resolution 646 (Rev.WRC-15).

[23] According the SADC harmonised Radio Frequency Spectrum Allocation Plan, ATV is to migrate to DTTB in the band 470-694 MHz.

[24] According to the harmonised European Table of Frequency Allocations and Applications (CEPT/ECC), dated March 2019, the band 790-862 MHz is designated to IMT (layer 3 terminology). According to ECC Decision (01)03, IMT falls under Mobile/Fixed Communication Networks (layer 2 terminology), which in turn is part of Fixed (layer 3 terminology).

ITU-RR service	Application		Application examples	Technology standard	References
	ITU name	CEPT name			
			centres, airports, schools, etc.)		
	Point-to-Point (P-P)[25]	Point-to-Point	Backhaul radio links in IMT networks, wireless metropolitan area networks (Wi-MAN) and corporate networks	Various, including proprietary solutions	ETSI
	Point-to-Multipoint (P-MP)[26]	Point-to-Multipoint	As above	As above	ETSI

Table 3: Common applications and technology standards per ITU-RR service for Region 1

From Table 2 and Table 3 the following can be concluded and noted:

1) The following potential incompatibilities could occur between IMT in the 698 MHz-806 MHz (see Table 1) and:
    a. DTTB/ATV in the 470-694 MHz, 694-790 MHz and 790-862 MHz band;
    b. SAP/SAB and PPDR (narrowband PMR/PAMR) in the 694-790 MHz and the 790-862 MHz band;
    c. FWA/NWA, P-P and P-MP in the 790-862 MHz band;
2) The National Table of Frequency Allocations (NTFA) will indicate whether any of the applications in Table 3 are actually assigned and in use in a specific African country. Consequently, such actual use should be considered in assessing the compatibility with an IMT allocation in the 700 MHz band in that African country.

1.3 Sharing/coexistence between IMT and the other services in the 700 MHz band

In spectrum management, terms sharing and coexistence studies are about investigating mechanisms to facilitate the efficient use of spectrum by different services in-band or in adjacent bands, considering the expected deployment of each service as well as the applied technology standards.

Hence, considering Table 1 and Table 3 many sharing and coexistence studies can theoretically be carried out, as the frequency arrangement for IMT (Table 1) and the other services can vary, as well as the applied technology standard for IMT and the other services (Table 3).

In this report only the key IMT sharing and coexistence studies and their results are covered. It is noted that Administrations are advised to interpret these study results with caution as their local situation (including the actual frequency allocations/assignments as reflected in their NTFA, the applied technologies and interference scenario) may differ from the situation as covered in the studies.

[25] This type of applications (P-P and P-MP) are commonly allocated in the higher spectrum bands. For example, in the CEPT countries, P-P and P-MP is used in frequency bands above 1 GHz. See ECC Report 173, Fixed Service in Europe - Current use and future trends post 2016, dated 27 April 2018.
[26] See footnote 25.

1.3.1 Overview of IMT sharing and coexistence studies

When considering the compatibility studies between DTTB and IMT, it is important to note that the introduction of IMT in the so-called *digital dividend* bands[27] takes place in a different order between the ITU Regions. This is due to the process of harmonising the spectrum through the subsequent ITU WRCs:

1) WRC-07 enabled the *first* digital dividend for IMT in the band 790-862 MHz (800 MHz band) in Region 1 and 698-790 MHz (700 MHz band) in Regions 2 and 3;
2) WRC-12 and WRC-15 enabled the *second* digital dividend[28] for IMT in the band 694-790 MHz (700 MHz band) in Region 1 and in the band 610/614-698 MHz (600 MHz) in a few countries in Regions 2 and 3.

This different harmonisation process between the Regions, explains why the first compatibility studies, field trials and service introductions of IMT in the 700 MHz band (and DTTB in the 600 MHz band) took place in Region 2 and 3. Whilst for Region 1 the introduction of IMT started in the 800 MHz band (and DTTB in the 700 MHz band). However, the results of the compatibility studies of having IMT in the 700 MHz (and DTTB in 600 MHz band) or 800 MHz (and DTTB in the 700 MHz band), are mutually relevant[29].

It is noted that currently a debate takes place in Region 1, as part of the preparations for WRC-23, for also reviewing the use of (and allocations) the 600 MHz band (TV channels 38-48). For more details see Section 9.

Table 4 provides an overview of the key IMT sharing and coexistence studies relevant for the 700 MHz band. In Table 4 the second column indicates the compatibility case under consideration in the study, i.e. the compatibility between IMT and an application for the other services (see Table 3).

[27] The digital dividend is the spectrum that becomes available over and above that is required to accommodate the existing analogue television services in a digital form. Part of that available spectrum can be used for additional television services and another part is used for the introduction of IMT services.
[28] The second digital dividend is made possible due to more advanced transmission standards (such as DVB-T2 and ATSC 3.0) and encoding technologies (such as AVC/H.264 and HEVC/H.265), reducing the required spectrum for DTTB.
[29] Noting that different interference scenarios may have been addressed, the key difference is relatively small propagation differences between the 700 and 800 MHz band.

No	Compatibility case	Source	Reference no.	Document title/scope	Key topics/results
1	IMT – other services: – PPDR – DTTB – ARNS (not relevant for Africa, see footnote 5.312 in Table 2)	ITU	Report M.2241-0 (2011)	Compatibility studies in relation to Resolution 224 in the bands 698-806 MHz and 790-862 MHz	• Theoretical compatibility scenarios between IMT systems in 790-862 MHz or 698-806 MHz band and systems of other services operating in the same or adjacent band. • Co-channel: distances to protect IMT-LTE BTS receivers from PPDR BTS transmitters: 170 – 385 km and for protecting PPDR BTS receivers from IMT-LTE BTS transmitters: 170 – 360 km. • Adjacent channel: Separation distance between the ATSC TX and LTE BTS > 15 km, LTE BTS shows no performance degradation.
2	IMT – Fixed services	ITU	Report F.2331-0 (11/2014)	Sharing and compatibility between IMT systems and fixed service systems in the 470-694/698 MHz frequency range	• Theoretical compatibility scenarios between IMT and Fixed Services. Two interference scenarios are considered: IMT base station into FS receiver station and IMT user equipment (UE) into FS receiver station. • Co-channel: required separation distance from 25 to 220 km, depending on the interference scenario and deployment environment. • Adjacent channel: under realistic pointing scenarios, the interference can be mitigated through a combination of geographic separation and frequency separation.
3	IMT - DTTB	ITU	Report BT.2339-0 (11/2014)	Co-channel sharing and compatibility studies between digital terrestrial television	• Theoretical compatibility scenarios between IMT and DTTB in the GE06 planning area[30]. Interference scenario is co-channel

[30] This is relevant as the GE06 Agreement specifies DTTB interference protection values, the so-called trigger values (the calculated medium interference field strength of IMT at the border).

No	Compatibility case	Source	Reference no.	Document title/scope	Key topics/results
				broadcasting and international mobile telecommunication in the frequency band 694-790 MHz in the GE06 planning area	interference with DTTB in the 700 MHz band. • IMT network into DTTB: required separation distance 200 to 1000 km (depending on scenario). • A single IMT base-station will need to be positioned 53 km (for land path) from the DTTB service edge, i.e. from the border of the affected Administration in order not to exceed 23 dB(µV/m), the trigger value.
4	IMT - DTTB	ITU	Report BT.2337-1 (11/2017)	Sharing and compatibility studies between digital terrestrial television broadcasting and terrestrial mobile broadband applications, including IMT, in the frequency band 470-694/698 MHz	• Theoretical compatibility scenarios between IMT and DTTB inside and outside the GE06 planning[31]. • Results for DTTB inside the GE06 planning area, the results of Report BT. 2339-0 (11/2014) are reproduced. • Result for DTTB outside the GE06 planning area not relevant for African countries (but similar in conclusion that sharing is difficult).
5	IMT - DTTB	ITU	Report BT.2301-2 (10/2016)	National field reports on the introduction of IMT in the bands with co-primary allocation to the broadcasting and the mobile services	• National field reports on the introduction of LTE in the 800 MHz Band using the reverse duplex arrangement and DTTB in 700 MHz band. • Germany: Only 10 complaints of interference into the broadcasting service were identified as caused by LTE, due to thorough implemented methodology (i.e. potential interference was checked before IMT base station was approved).

[31] See footnote 30.

No	Compatibility case	Source	Reference no.	Document title/scope	Key topics/results
					• France: LTE 800 MHz BS downlinks interfere fixed roof-top DVB-T reception, despite 1 MHz guardband. Interference is however limited and can be mitigated (applying filters at DTTB RX). • The Netherlands: No reported interference from IMT into DTTB reception with a 1 MHz guardband. • Spain/Portugal: temporarily having DTTB (Spain) and IMT (Portugal) both in 800 MHz resulted in co-channel interference.
6	IMT - DTTB	ACMA	ACMA website[32]	DVB-T in 520-694 MHz (restacked) and LTE in 700 MHz band. DVB-T nationwide (i.e. around main cities) and IMT fully deployed (Optus and Telstra).	• No significant impact on DTTB. Some cases of TV distribution amplifiers being overloaded by LTE BS signals (within 1 km)[33]. • No specific mitigation scheme for LTE 700 MHz interference. Hence no formal reporting. ACMA site provides DTTB viewers mitigation measures, to apply filters and change RX antenna.
7	IMT - ATV	ITU	Report M.1023-1 (1990)	Frequency sharing between the land mobile service and the broadcasting service (television) below 1 GHz	• Theoretical compatibility scenario between mobile and television services. • Television services typically operate with considerably larger radiated powers than mobile services. The total difference of 70 dB in the planning criteria of the two services suggest that sharing will be difficult.

[32] See https://www.acma.gov.au/700-mhz-technical-framework.
[33] See also BT.2296-0 (11/2013), including an example of application of Recommendation ITU-R BT.1895 and Report ITU-R BT.2265 to assess interference to the broadcasting service caused by the impact of IMT systems on existing head amplifiers of collective television distribution systems.

No	Compatibility case	Source	Reference no.	Document title/scope	Key topics/results
8	IMT – SAB/SAP	ITU	Report BT.2338-0 (11/2014)	Services ancillary to broadcasting/services ancillary to programme making spectrum use in Region 1 and the implication of a co-primary allocation for the mobile service in the frequency band 694-790 MHz	• Measurements show that a co-channel and co-location operation between SAB/SAP and IMT is not feasible. • IMT guardbands and duplex gaps, could be used for certain SAB/SAP applications, which can tolerate some levels of interference. Improvement of out-of-band performance of LTE devices can increase the potential utilization for SAB/SAP.

Table 4: Overview of key IMT sharing and coexistence studies relevant for the 700 MHz band

From Table 4 the following can be observed and concluded:

1) Coexistence of the IMT and PPDR[34] services in the same frequency band is in most cases not possible because:
    a. Both applications are often nationwide deployed, and;
    b. As a number of studies showed that the co-channel separation distances for protecting IMT-LTE BTS or PPDR BTS range respectively from 170 to 385 km and from 170 to 360 km (see No 1 in Table 4) ;
    c. Excluding the possibility of geographically separating them;
2) Sharing of the IMT and Fixed services (P-P and P-MP) in the same frequency band requires separation distances ranging 25 to 220 km, depending on the interference scenario and deployment environment. However, under realistic pointing scenarios, the interference can be mitigated through a combination of geographic separation and frequency separation (see No 2 in Table 4);
3) Coexistence of the IMT and DTTB services in the same frequency band is in most cases not possible because:
    a. Both applications are often nationwide deployed, and;
    b. As a number of studies showed that the co-channel separation distances for protecting the DTTB services range from 200 to 1000 km (see No 3 and 4 in Table 4);
    c. Excluding the possibility of geographically separating them;
4) Coexistence of the IMT and DTTB services is possible when the applications are allocated in spectrum adjacent to each other (see No 5 and 6 in Table 4). A number of technical conditions may apply. For example, applying guardbands, reverse IMT duplexing and filtering of IMT BTS/DTTB receivers (for more details see Section 1.3.2);
5) Coexistence of the IMT and ATV services in the same frequency band is not possible for the same reasons as for IMT/DTTB, and in many cases the interference situation is worse because of the higher radiated powers in ATV broadcasting (see No 7 in Table 4);
6) Coexistence of the IMT and SAB/SAP services at the same location is not possible. Sharing scenarios may exist for having certain SAB/SAP applications (i.e. those that can tolerate some levels of interference) in the IMT guardbands and duplex gaps. These possibilities for sharing may increase if the out-of-band performance of LTE devices improves (see No 8 in Table 4).

1.3.2 Technical conditions for IMT sharing and coexistence

As concluded from Table 4, a number of coexistence and sharing options between IMT and the other services have been identified. Table 5 provides an overview of technical conditions under which such options are technically feasible. It is noted that the specific local situation will dictate which and to what extend the listed technical conditions need to be applied.

For the presented technical conditions in Table 5, it is assumed that the radio equipment involved in the interference case, complies with a minimal (least restrictive), and preferably, a harmonised set of technical conditions. Such a set of minimum technical conditions may be checked as part of a type approval procedure for granting the use of radio equipment in the NRA's territory. Also, such a set of

[34] It is noted that PPDR systems can be based on IMT/LTE. For PPDR IMT separate frequency arrangements are included in ITU Recommendation ITU-R M.2015-2 (01/2018).

minimum criteria often include emission limits/spectrum masks and may be complemented with other conditions such as for human safety (EMC)[35].

Finally, the included conditions in Table 5 address the conditions for separating IMT from other non-IMT applications. Conditions for separating frequency blocks between IMT operators (such as guardbands, spectrum masks, radiated power level, etc.) are not addressed.

[35] For example, the CEPT has identified common and minimal (least restrictive) technical conditions for 790 - 862 MHz band for IMT (MFCN) equipment in the European Union. See CEPT Report 30. The included technical conditions are based on Block Edge Mask emission limits. See also ETSI EN 301 908-1 harmonised European standard for IMT cellular networks.

Compatibility case	Option	Interference type/case	Technical conditions	Reference documents	Notes
IMT-DTTB[36]	Coexistence in adjacent bands	IMT in 700 MHz - DTTB in 600 MHz band[37]	Apply (preferably a harmonised) guardband at the IMT lower band edge. For example, for the CEPT area 9 MHz (694-703 MHz) is recommended.	CEPT/ECC Decision (15)01[38]	Consideration should be given to the assumed IMT frequency arrangement. The ECC Decision (15)01 considers A7 (the lower duplexer from A5, see Table 1).
		IMT in 700 MHz - DTTB in 600 MHz band	Reverse the duplex direction (with the mobile terminal transmit within the upper band and base station transmit within the lower band) for example in exceptional cases that a minimum guardband cannot be implemented.	See ITU Rec. ITU-R M.1036-6 See frequency arrangement A4 in Table 1 (or 3GPP band 13)	The AUC harmonised band plan recommends A7 which is not a reversed duplex arrangement[39].
		LTE BTS TX in 700 MHz band into DTTB RX in 600 MHz band (overloading)[40]	Apply a filter at the DTTB receiver. Application is often considered case-by-case (and can be specific to certain geographical areas).	See ITU Rep. BT.2215-7 (04/2018)	Anatel laboratory and field tests[42]

[36] Most documented technical conditions are for DTTB rooftop reception (as this is the applied reception mode in most countries). For indoor reception the necessity to apply certain technical conditions may be different and should be investigated separately.
[37] The interference case of having IMT in the 700 MHz and DTTB in the 800 MHz band is excluded for Region 1, as it assumed that IMT is first introduced in the 800 MHz band (1st Digital Dividend) followed by an introduction in the 700 MHz band (2nd Digital Dividend).
[38] This decision is based and further detailed in CEPT Report 053. CEPT Report 060 reviewed the findings of Report 053 and found no need to revise the channelling arrangement.
[39] See footnote 10.
[40] Overloading (DTTB and IMT/LTE receivers): the receiver begins to lose its ability to discriminate against interfering signals at frequencies differing from that of the wanted signal. In the case of DTTB receivers, overloading means in practice that usually all frequencies are interfered and hence all television services.
[42] Anatel (the NRA of Brazil) compatibility study between LTE and DTTB (ISDB-T) in the 700 MHz Band. Both the laboratory and field test reports are available on the Anatel website: https://www.anatel.gov.br/Portal/verificaDocumentos/documento.asp?numeroPublicacao=311027.

Compatibility case	Option	Interference type/case	Technical conditions	Reference documents	Notes
			Application may also be dependent on the application of other technical conditions: • Repositioning or replacement of the DTTB (rooftop) antenna • Repositioning of the LTE BTS and/or change antenna pattern (includes a critical spectrum mask)[41] • Reduction of ERP of the LTE BTS TX	See ITU Rec. M.2090-0 (10/2015) See ITU Rec. ITU BT.2033-1 (02/2015) See also No 4 and 5 in Table 4	
		LTE BTS TX in 700 MHz band into DTTB RX in 600 MHz band (unwanted emissions)[43]	Apply a filter at LTE-BTS transmitter. Application is often considered case-by-case (and can be specific to certain geographical areas). Application may also be dependent on the application of other technical conditions: • Repositioning or replacement of the DTTB (rooftop) antenna • Repositioning of the LTE BTS and/or antenna pattern (includes a critical spectrum mask)	See ITU Rec. M.2090-0 (10/2015) See ITU Rec. ITU-R SM.1541-6 See ITU Rec. ITU BT.2033-1 (02/2015) See also No 4 and 5 in Table 4	Anatel laboratory and field tests
		DTTB in 600 MHz band into LTE BTS RX in 700 MHz band (overloading)	Apply a filter at LTE-BTS receiver. Application is often considered case-by-case (and can be specific to certain geographical areas). Application may also be dependent on the application of other technical conditions: • Repositioning of the DTTB TX antenna and/or antenna pattern (includes a critical spectrum mask) • Repositioning the LTE BTS and/or antenna pattern	See ITU Rec. ITU-R M.1767 (03/2006) See ITU Rec. ITU-R SM.1541-6 See ITU Rec. ITU-R BT.1206-3 (04/2016)	Anatel laboratory and field tests

[41] In this context a critical spectrum mask is a mask that is more restrictive than the a minimum (least restrictive) spectrum mask conditions.
[43] Unwanted emissions: Consist of spurious emissions and out-of-band emissions.

Compatibility case	Option	Interference type/case	Technical conditions	Reference documents	Notes
			• Reduction of ERP of the DTTB TX antenna		
		DTTB in 600 MHz band into LTE BTS RX in 700 MHz band (unwanted emissions)	Use of critical spectrum mask at DTTB station TX. Application is often considered case-by-case (and can be specific to certain geographical areas). Application may also be dependent on the application of other technical conditions: • Repositioning of the DTTB TX antenna and/or antenna pattern • Repositioning the LTE BTS and/or antenna pattern • Reduction of ERP of the DTTB TX antenna	See ITU Rec. ITU-R BT.1206-3 (04/2016) See ITU Rec. ITU-R M.1767 (03/2006) See ITU Rec. ITU-R SM.1541-6	Anatel laboratory and field tests
		DTTB in 600 MHz band into LTE UE RX in 700 MHz band (overloading)	Reposition or use a more robust IMT UE. The practical and financial application of these technical conditions should be carefully considered.	None	Anatel laboratory and field tests
		DTTB in 600 MHz band into LTE UE RX in 700 MHz band (unwanted emission)	Use of critical spectrum mask at DTTB station TX. Application is often considered case-by-case (and can be specific to certain geographical areas). Application may also be dependent on the application of other technical conditions: • Use of a more robust IMT UE (see also above	See ITU Rec. ITU-R BT.1206-3 (04/2016) See ITU Rec. ITU-R SM.1541-6	Anatel laboratory and field tests

Compatibility case	Option	Interference type/case	Technical conditions	Reference documents	Notes
IMT - ATV	Coexistence in adjacent bands	In principle the same interference cases as for DTTB[44]	Any UHF ATV service cannot claim protection and should not cause harmful interference[45].	GE06 Agreement	The Agreement contains two plans, a digital plan and an analogue plan. The analogue plan expired by 17 June 2015 for the UHF band[46].
IMT – SAB/SAP (i.e. wireless microphones)	Coexistence in adjacent bands	IMT in 700 MHz band and SAB/SAP in 600 MHz	Apply (preferably a harmonised) guardband at the IMT lower band edge. As SAB/SAP often operate in the same band as the broadcasting services (including DTTB). In such a case the guardband size will be determined on the basis of the compatibility between IMT-DTTB. It is noted that SAB/SAP equipment includes unlicensed equipment and hence the NRA does not know the actual use (intensity and locations) of SAB/SAP equipment. For this reason, NRAs have decided to migrate SAB/SAP to other bands to exclude any risks of harmful interference.	See above.	See above.
	Sharing in the same band	IMT in 700 MHz band and SAB/SAP in guardbands and/or multiplexer gap	Set limits to the radiated power (and other specification such as out-of-band and spurious emissions) of SAB/SAP applications in combination with type approval of robust SAB/SAP equipment. A main concern is the unwanted emissions by an LTE UE to a SAB/SAP (PMSE) receiver as SAB/SAP equipment is of low-complexity or has no error correction.	See ETSI EN 300 422 (parts 1 to 4) ITU Rep. ITU-R BT.2338-0 (03/2015)	

Compatibility case	Option	Interference type/case	Technical conditions	Reference documents	Notes
IMT – Fixed services (i.e. P-P and P-MP)	Sharing in the same band	IMT and Fixed services in 700 MHz[47]	Any interference can be mitigated through a combination of geographic separation and frequency separation. This will require a case-by-case approval of any fixed service by the NRA.	ITU Rep. ITU-R F.2331-0 (11/2014)	
IMT - PPDR	Coexistence in adjacent bands	IMT in 700 MHz and PPDR in adjacent band[48]	Apply (preferably a harmonised) guardband at the IMT upper band edge. However, for PPDR systems based on IMT/LTE specific frequency arrangements are identified.	ITU Rec. ITU-R M.2015-2 (01/2018) ITU Rec. ITU-R M.2009-2 (01/2019) ITU Rep. ITU-R M.2291-1 (11/2016)	

Table 5: Technical conditions for IMT sharing and coexistence in the 700 MHz band

[44] For ATV specific interference types may occur, i.e. loss of automatic gain controller and image channel interference. These interference types are deemed unlikely to occur for DTTB as DTTB receivers constantly improve and are well shielded. In ATV frequency planning it is common to check for image channel interference. For DTTB frequency planning it is not common practice to check for image channel interference.
[45] Article 12.8 of the GE06 Agreement allows the continuation of analogue stations on a non-interference and non-protection basis.
[46] Note 7, related to Article 12.6 of the GE06 Agreement lists the countries where the transition period for Band III (VHF band) end on 17 June 2020.
[47] It is noted however that fixed services (P-P/P-MP) are commonly operated in the bands 1 to 3 GHz. See also footnote 24.
[48] It is assumed that PPDR would not be allocated in the 600 MHz band as this band is likely to be used for broadcasting services.

Considering Table 5 the following is observed and noted:

1) The listed technical conditions or measure are often applied in combination with each other, as well as in conjunction with regulatory conditions as outlined in Section 1.3.3. For example, the condition of applying guardbands is set in combination with an obligation for the IMT licensee to resolve any remaining harmful interference by applying filtering of the IMT BTS;
2) Stricter applied technical conditions on the receiver/transceiver equipment may help reducing the guardband sizes (as guardbands for IMT systems should be minimized to avoid wasting spectrum);
3) The specific local situation will dictate which and to what extend the listed technical conditions need to be applied.

1.3.3 Regulatory conditions for IMT sharing and coexistence

National Regulatory Authorities or Administrations may wish to complement the technical conditions under which they grant the IMT spectrum rights (see Section 1.3.2)[49] with specific IMT regulatory conditions (next to the general conditions for assigning spectrum rights[50]). These specific IMT related conditions often arise from the situation that the IMT services are introduced in bands with incumbent services which need to be protected.

Table 6 provides an overview of these IMT specific regulatory conditions.

No	Condition or requirement	Notes	References
1	The IMT licensee(s) has the obligation to arrange for the provisioning of filters for DTTB receivers, for eligible households or all television households.	This can be a general provision in the IMT licence terms and conditions. In case the NRA receives complaints from DTTB households and assess them eligible the IMT licensee has an obligation to provide filters.	See the procedure as applied in the Netherlands (but also in other European countries), see No 5 in Table 4. See also ITU-R Rec SM.1603 (section 4.2.1 and 4.2.2)
2	The IMT licensee(s) has the obligation to apply a critical spectrum mask at certain identified BTS or all BTS.	For example, the BTS can be identified in a frequency assignment procedure in which the IMT licensee has to seek approval from the NRA before the IMT licensee can take the BTS into operation.	See the procedure as applied in Germany, see No 5 in Table 4.
3	The IMT licensee(s) has the obligation to reposition the BTS and/or change the antenna diagram/direction for certain identified BTS or all BTS.	Such a provision will require the IMT licensee to seek approval from the NRA before it can take any BTS in operation. The repositioning or change of the antenna diagram may be determined in	See above.

[49] These spectrum rights may be assigned in a separate spectrum licence or part of network or service licence, dependent on the licensing framework of the different countries.
[50] To comply with the assigned spectrum rights, including the guardbands, assigned spectrum blocks and duplex direction (for example, a reversed duplexing arrangement).

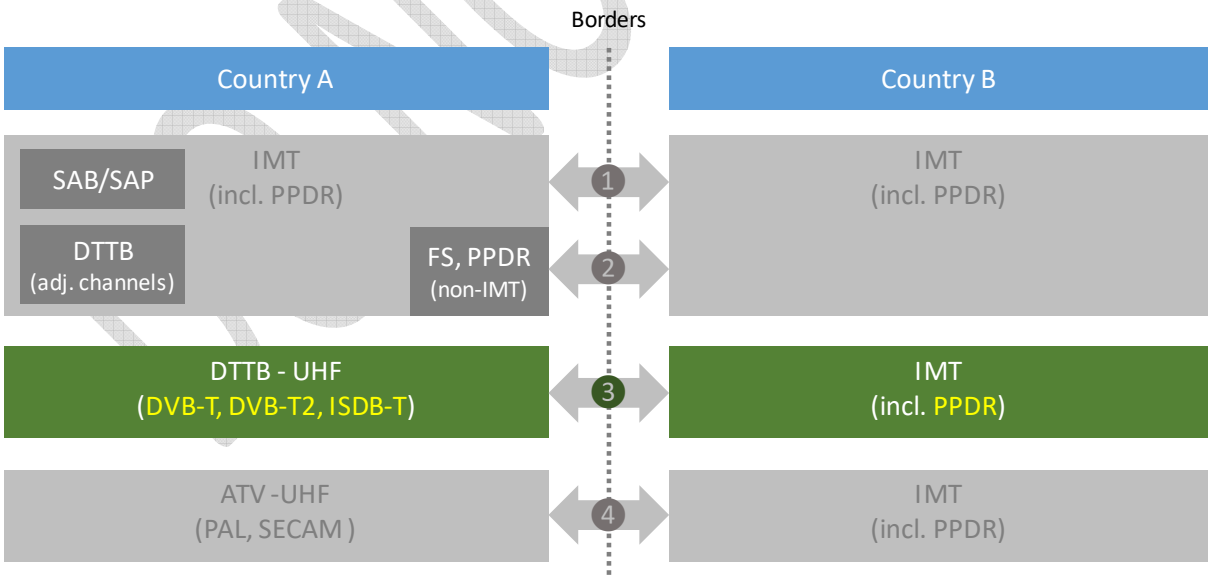
No	Condition or requirement	Notes	References
		consultation with the DTTB (or any other service) licensee (and may require a change of the DTTB network).	
4	The IMT licensee(s) has the obligation to compensate for any incurred costs by the incumbent service. Most commonly applied for DTTB. Here the IMT licensee has to contribute to the costs of re-planning and implementation of the revised DTTB networks, as well as the cost of retuning DTTB receivers and receiving antennas.	In case the DTTB networks had to vacate the band (i.e. refarming). Such an obligation to compensate for incurred costs may also be applied to other services (such as fixed services or SAB/SAP).	See for example the UK, US[51] and other countries (including for example Thailand).
5	The IMT licensee(s) has the obligation to help investigate any complaints about interference of incumbent services (may include DTTB).	Such an obligation may come with the obligation to resolve the interference problem too (see above).	

Table 6: Regulatory conditions specific for IMT licensees

1.3.4 Cross-border coordination aspects for IMT

Cross-border inference cases between countries are a sub-set of the interference cases within a country (as discussed in Section 1.3.1) as, in this frequency band, they mainly cover emissions located closer to the border.

Figure 1 shows a generic overview of the possible cross-border interference cases for the 700 MHz band.



[51] In the US in the 600 MHz incentive auction, the IMT licensee also paid for the relinquishing of the broadcasting spectrum rights and organising the auction (by having a reserve price that would at least cover these costs). See also Section 11.2.3.

Figure 1: Generic overview of possible cross-border interference cases for the 700 MHz band (source: Convergence Consulting Company)

First it is noted that the potential interference case between FS/PPDR (non-IMT) and DTTB is not included in Figure 1. It is assessed that these cases are rare as its assumed that such cases would have been resolved with the introduction of DTTB in the 700 MHz band.

The following interference cases are included in Figure 1:

1) Cross-border cases, number 1 and 2:
    a. Interference case 1: may arise in the final stages when Administrations have adopted IMT and their stations' emissions are within the coordination zone for these services. As a reference the BKO-18[52], HCM[53], HCM4A[54] and the Vienna Agreement[55] provides procedures and parameters for managing possible cross-border interference between IMT services. It is noted that these agreements are based on a system of maximum permissible interference field strengths levels, and if the calculated interference level is higher (trigger value), coordination is needed. It is also noted that the HCM and Vienna Agreement cover both land mobile and fixed services;
    b. Interference case 1: Alternatively, and specifically for cross-border coordination of LTE and NR/5G applications a system of Physical Cell Identity (PCI) can be used. A PCI is an identification of an IMT cell at the physical layer and represents a specific frequency which can be used in cross-border coordination. ECC Rec. (15)01[56] provides guidance for cross-border coordination on the basis of PCI. The recommendation provides the following on cross-border coordination for the band 694-790 MHz:
        i. A system by dividing preferential and non-preferential PCIs between Administrations, on the basis of equitable spectrum access. In other words, Administrations should share PCIs in border areas and have equitable distribution of 504 (LTE) or 1008 (NR/5G) available PCIs, for preferential and non-preferential PCIs;
        ii. Preferential and non-preferential PCIs have different trigger values (expressed in dBµV/m/5 MHz). Coordination is needed if the interfering field strength is higher (Annex 1). The interfering field strength is calculated on the basis of defined propagation models (Annex 2);

[52] Agreement between the Administrations of eight West Africa countries (Burkina Faso, The Gambia, Guinee, Guinee-Bissau, Ivory Coast, Mali, Niger and Senegal) covering 87.5 MHz to 30 GHz and radiocommunication services such as sound broadcasting service, land mobile service and fixed service.
[53] Agreement between the Administrations of Austria, Belgium, the Czech Republic, Germany, France, Hungary, the Netherlands, Croatia, Italy, Liechtenstein, Lithuania, Luxembourg, Poland, Romania, the Slovak Republic, Slovenia and Switzerland on the co-ordination of frequencies between 29.7 MHz and 43.5 GHz for the fixed service and the land mobile service (HCM Agreement), dated 2018.
[54] HCM for Africa (HCM4A). Under PRIDA the HCM4A is updated and support is delivered for adopting and implementing this coordination agreement at a continental level. BKO-18 was derived from HCM4A. For more more information on HCM4A see: https://www.itu.int/en/ITU-D/Projects/ITU-EC-ACP/HIPSSA/Pages/default.aspx.
[55] See ITU-R SM.1049-1, Annex 2, example 3.
[56] ECC Recommendation (15)01, Cross-border coordination for MFCN in the frequency bands 694-790 MHz, 1427-1518 MHz and 3400-3800 MHz, approved 13 February 2015 and latest amendment on 14 February 2020.

iii. A procedure for the exchange of data between the requesting and the affected Administrations (Annex 3);
iv. A detailed system for assigning PCIs to countries. The system is based on a cell colouring system[57] for the CEPT countries. However, African countries can adapt the proposed system for their local situation;

c. Interference cases 2: Fixed Services (FS) and PPDR (not based on IMT but on other applications such as TETRA or APCO Project 25) may be incompatible with IMT. As mentioned before, PPDR systems may be based on IMT (see Table 3), for these PPDR systems separate frequency arrangement have been agreed[58]. Also, Administrations may have agreed shared frequencies for these systems, allowing for cross-border operations. For the cross-border coordination of land mobile services (non-IMT PPDR) also the BKO-18, HCM and Vienna Agreements as mentioned above, can be used as reference. Cross-border coordination of fixed services (P-P) are likely to be incidental and a case-based coordination can be used where any found harmful interference can be mitigated by applying technical measures (see ITU Report F.2331-0 and Table 5);

2) Cross-border case 3. This case entails the possible incompatibilities between IMT and DTTB. The latter including the three different transmission standards applied in Africa. These transmission standards matter as their transmitters have different frequency characteristics, bandwidth and modulation schemes. Consequently, they have different interference potential;
3) Cross-border case 4: This case entails the possible incompatibilities between IMT and ATV services. Again, the latter includes the two different ATV systems which may be still in operation in Africa in the UHF Band. It is noted that in the cross-border coordination between countries, both interference cases number 3 and 4 may need to be addressed, if ASO has not occurred yet[59]. Also, as discussed in Section 1.3.2, any UHF ATV service still in operation cannot claim protection and should not cause harmful interference.

For mitigating any identified interference cases between countries, two basic approaches exist:

1) Case-based coordination;
2) Agreement-based coordination.

Case-based frequency coordination is in principle applied in the absence of bi- or multi-lateral Agreements. Case-based refers to the situation of one country (i.e. Administration) in the need of coordinating a frequency (or a set of frequencies) as it would like to protect this frequency from harmful interference or it expects this frequency to cause harmful interference. Case-based coordination would ultimately result in an agreement on the frequency usage of the frequencies involved in the case.

Bi- or multi-lateral Agreements are agreed well in advance of the actual (detailed) planning and assignment of frequencies. These Agreements include, in varying degrees, the process or method of frequency coordination (such as procedures, data sets, registers, propagation models and planning

[57] A system whereby countries are assigned to groups and each group has a unique colour. On a map the same colour should not touch and should be separated as far possible. The same colour implies the same frequencies and co-channel interference can be best achieved when colours are separated as far as possible.
[58] See ITU-R Recommendation M.2015-2 (01/2018).
[59] According to the PRIDA Explanatory Memorandum, the digital switchover in the 700 MHz and 800 MHz bands is completed in 40% of the 54 countries.

software) and the key applied parameters (such as specified levels of harmful interference, coordination zones and distances).

In Appendix A: Cross-border frequency coordination, more details can be found on case-based and agreement-based coordination.

In the case of cross-border interference case, number 3 and 4 (see Figure 1), the African countries should follow the procedures as included in the GE06 Agreement. This would also be the same for any potential interference case between FS/PPDR (non-IMT) and DTTB-UHF. As said, these cases are not included in Figure 1. It is assessed that these cases are rare as its assumed that such cases would have been resolved with the introduction of DTTB in the 700 MHz band.

The procedures as included in the GE06 Agreement, can be summarised as follows:

1) First, IMT stations should be coordinated by using the existing digital plan entries for that country in the GE06 Agreement (see also Table 2);
2) Secondly, if the IMT stations cannot be coordinated by using the existing digital plan entries, (i.e. in the case when a satisfactory IMT service cannot be obtained by using a plan entry), the involved country could consider modifying the plan entry in accordance with the provisions of Article 4 of GE06. It is important to note that the IMT service shall not cause unacceptable interference to, nor claim protection from, stations of the broadcasting service of administrations operating in conformity with the GE06 Agreement. Also, the Article 4 procedure should be completed in about 2¼ years, if no agreement has been reached within that time, the request for modification lapses.

If a plan entry is used for an alternative application, such as IMT, GE06 Article 5.1.3 allows such an entry under the condition of complying with the spectral power density check. In the spectral power density check, three conditions are verified[60]:

1) The frequency band should be allocated in ITU-RR. Assuming that the IMT application is following one of the frequency arrangements as specified in ITU Rec. M.1036-6, this would be the case;
2) The peak power density in any 4 kHz part of the alternative application should not exceed the spectral power density in the same 4 kHz part of the plan entry (see Figure 2 below);
3) The alternative application should not claim more protection than is provided by the plan entry.

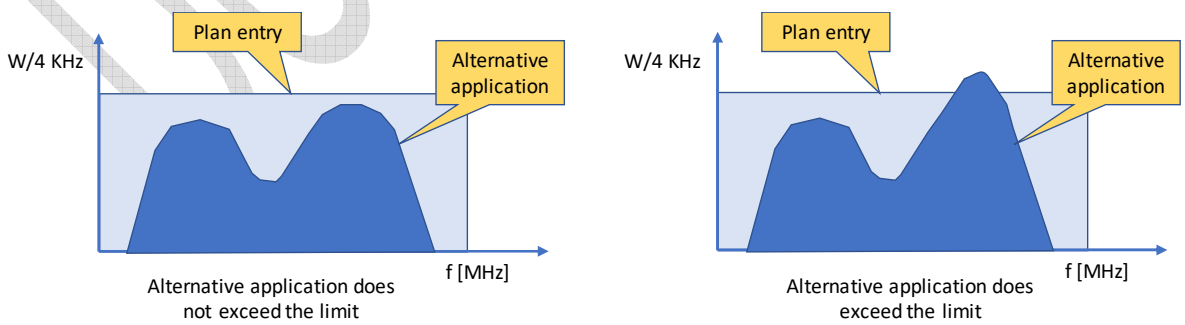


Figure 2: Application of the GE06 spectral power density check (source: ITU)

[60] For more detailed information, see ITU Guideline for the transition from analogue to digital broadcasting, edition 2014, Annex A.

1.4 Best practices and methods for refarming other services in the 700 MHz band

Refarming in the context of this reports means the re-planning of incumbent services deemed not compatible with the introduction of IMT services. In other words, the spectrum needs to be freed-up or cleared for IMT. From Table 4 and Table 5 it can be concluded that the following services or applications may have to be re-planned or reallocated to adjacent or other bands:

1) DTTB;
2) ATV;
3) Wireless microphones (SAB/SAP).

The financial funding of these refarming efforts are addressed in Section 11. It is noted that ITU-R Rec. SM.1603 also covers general approaches to refarming, guidelines for calculating refarming (or redeployment) costs, as well as examples of country experiences with refarming.

1.4.1 Refarming DTTB services

Refarming of DTTB services involves migrating a set of DTTB services, broadcasted on a given set of frequencies, to another set of frequencies which are located in the adjacent band to the IMT services. This process should be well planned as it involves often a large audience of DTTB viewers that should retune their DTTB receivers (including Set-Top-Boxes and Integrated Digital Television sets, respectively STB and IDTVs) at a given date. After retuning, these DTTB viewers should be able to continue enjoying their DTTB services without service interruption.

Refarming of DTTB services may involve the introduction of a new transmission standard (e.g. DVB-T2) and encoding technology (e.g. H.265/HEVC), as to reduce the number of frequencies needed to broadcast the defined set of DTTB services (which may include Ultra High Definition/4K services). Such a transition would require in many cases the replacement of existing DTTB receiver equipment (which may be based on DVB-T and H.264/AVC)[61]. Replacement of broadcasting receiving equipment is also part of the process of refarming ATV services as described in Section 9.

In the following paragraphs the process of refarming DTTB services is described without the necessity of replacing DTTB receiver equipment. Commonly the process involves four parts:

1) Preparations and calculating current coverage, including:
    a. Determining planning criteria and parameters for calculating rooftop (and indoor) reception;
    b. Calculating the reference coverage of the DTTB networks (Reference Plan);
    c. Define and agree planning method for the new frequency plan (including how channels will be restacked/re-shuffled);
    d. Carrying out a schematic channel re-shuffle and verify the coverage and compatibility of this initial new plan;
2) Carrying out a detailed planning in several runs for any missing channels and found incompatibilities, resulting in a Final Plan;
3) Drafting an implementation planning for carrying out the necessary DTTB network changes including:
    a. A compatibility analysis between the Final Plan and Reference Plan;
    b. Determining the retune groups and their order (avoiding any found incompatibilities);

[61] For example, as was the case in the UK when IMT was introduced in the 700 MHz band and also DVB-T2 was introduced. The UK, like many other European countries, initially started DTTB with DVB-T.

   c. Drafting a milestone planning;
   d. Determining the necessary equipment and operational changes (by comparing the Reference Plan and Final Plan);

4) Assessing the costs of the required network changes. This may also include the costs of informing viewers about the necessary equipment retuning and providing installation aid (in case DTTB receiver antennas need to be replaced).

Figure 3 shows an overview of the above described process.

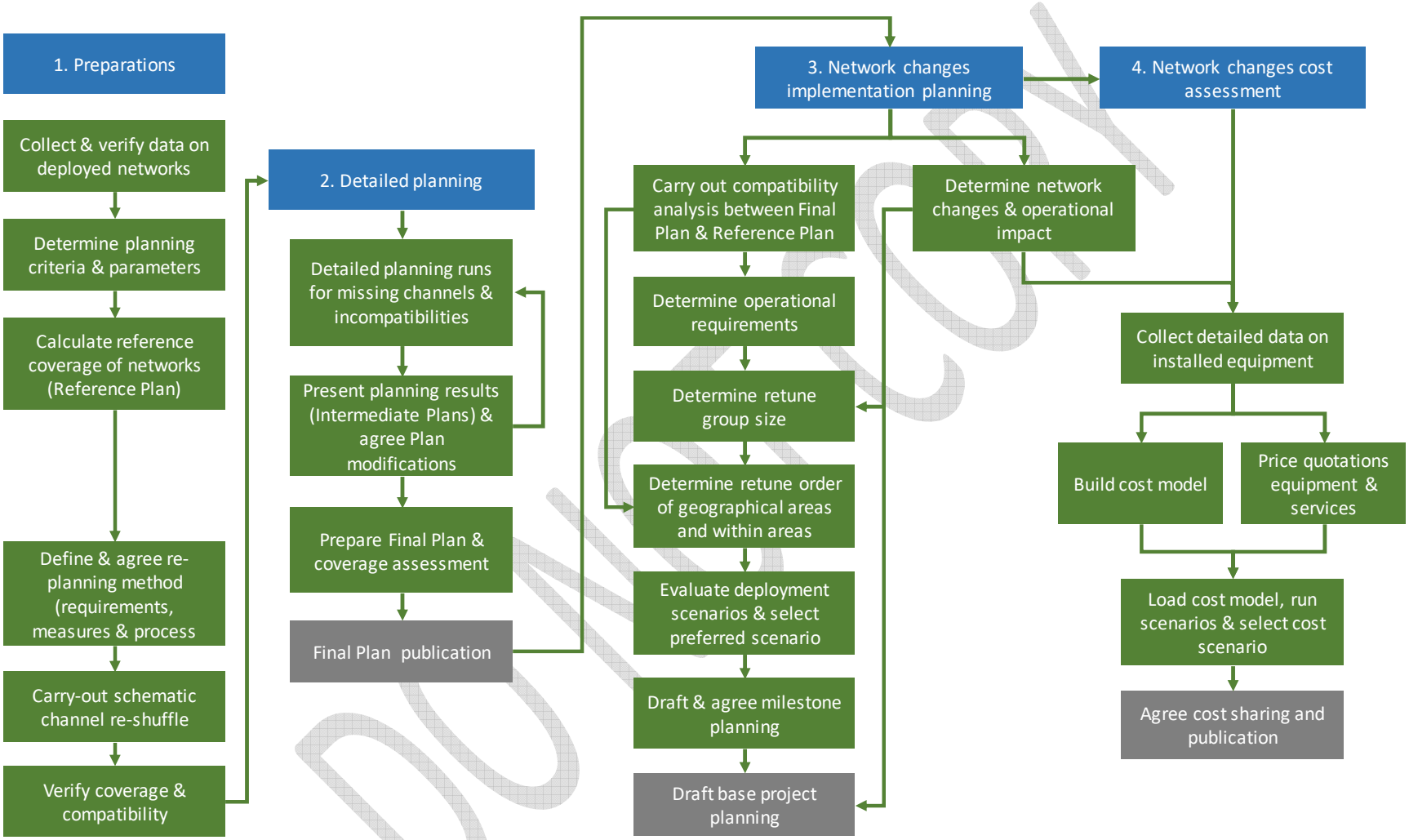


Figure 3: Process of refarming DTTB services (source: Convergence Consulting Company)

For the actual execution of the implementation of the new frequency plan a number of factors can be considered, which are included in the Table 7.

Item	Rationale
Ordering lead time for equipment (e.g. filter sections or transmitter parts)	A longer ordering lead time is better for: – Absorbing delivery eventualities – Preparatory & communications activities – Preparing & agreeing implementation
Lead time between Retune Phase	A longer lead time between Phases is better for: – Absorbing retune eventualities and roll back – Carrying out finalising activities – Less risks of (foreign) expert unavailability – Changing the Retune Calendar for remaining Regions
Number of Retune Phases	A higher number of Phases is better for: – Less strain on the retune capacity of Network Operators and Facility Providers (e.g. tower companies) – Less strain on supplier/expert capacity
Roll-back and mitigation	Roll back and mitigation plan should cover several elements, including: – Checking compatibility of intermediate networks for failed and other sites: If one or more sites failed to retune, new intermediate network configurations may be needed – Finding a compatible insert for failed sites in later Phases: the failed sites in a new network configuration in the Reference Situation, need to be inserted in the remaining Retune Phases. – the Retune Dates of the remaining Retune Phases may need to be changed. A first priority should be to avoid changing the Retune Calendar (current Region and/or next Regions)

Table 7: Key implementation factors

1.4.2 Reframing ATV services

Reframing ATV services is carrying out a process of migrating ATV services to a DTTB platform. In the context of introducing IMT services, this would entail migrating the ATV services to a DTTB platform which is allocated in an adjacent band to the IMT service. The process of migrating ATV services to a DTTB platform includes some unique planning aspects, such as:

1) Simulcasting (i.e. the same TV service is available on the analogue and digital platform for a limited period) and infrastructure availability (as equipment for ATV and DTTB has to be facilitated at the same site and time);
2) Switch-off the ATV services (Analogue Switch-Off – ASO) and informing the ATV viewer;
3) ATV receiving equipment replacement (by DTTB receivers), its costs and viewer support.

An overview of this process and the associated guidelines are provided in Section 9.

1.4.3 Reframing SAB/SAP

Many reframing options can be considered for clearing SAB/SAP usage. Considering the options as shown in Table 4, three basic migration scenarios exist:

1) Migrating all SAB/SAP usage outside the 700 MHz band, for both licensed and unlicensed equipment/low power;

2) Migrating defined SAB/SAP usage (e.g. licensed usage, professional digital equipment which is robust for IMT interference) into the guardbands and multiplexer gaps and the remaining SAB/SAP usage outside the 700 MHz band (e.g. unlicensed usage/low power);
3) Migrating defined SAB/SAP usage (e.g. licensed usage, professional digital equipment) into the guardbands and multiplexer gaps and keeping other defined SAB/SAP usage (e.g. low power equipment in combination with type approval) in the 700 MHz band.

The local situation at hand will demand which of these basic options are most feasible in terms of:

1) Avoiding harmful interference and the extent to which the NRA will be able to mitigate any occurring interference. Factors that could be considered in assessing the associated risks include:
    a. The licensing regime (including the licence conditions, such as technical conditions as discussed in Table 5);
    b. Licence period and terms for (automatic) renewal;
    c. The number of assigned licences for SAB/SAP (which may be recorded in the NTFA or a national frequency register)
    d. Procedure for type approval and registration of SAB/SAP equipment;
    e. Enforcement regulations;
    f. Deployment of SAB/SAP equipment and the ability to retune this equipment to other frequencies;
2) Compatibility with the introduction of IMT and other services in the longer term (e.g. in 5 to 10 years). Factors that could be considered in assessing this long-term compatibility and drafting a long-term scenario include:
    a. The demand for IMT spectrum in the longer term and which bands will be needed to meet this demand;
    b. The applied IMT system (including TDD, FDD, FDD with reversed duplexing, supplemental down links);
    c. The actual and planned frequency assignments for IMT and other services (which may be recorded in the NTFA or a national frequency register);
    d. The (planned) IMT assignment procedure. This may include auction or public tender. Such assignment procedures may have conditions that conditionalize access to new spectrum rights. For example, a combination of different spectrum bands is auctioned at once or spectrum aggregation rules for incumbents are stipulated (e.g. incumbent operators are limited in the number of frequency blocks they can acquire in the auction, depending on the amount of spectrum they may already have in other bands);
3) Options for financing the migration of different SAB/SAP licence holders. Limited financial resources may require longer migration periods. For example, because SAB/SAP licence holders that should relinquish their spectrum rights (before their licence expires) cannot be compensated. Factors that could be considered for assessing the financial resources include:
    a. The (planned) IMT assignment procedure. An IMT licensee may have the obligation to financially contribute in covering the costs for migrating incumbent licence holders (see also Table 6);
    b. The SAP/SAB licence period and renewal clauses;
    c. The number of SAB/SAB licence holders and their equipment (i.e. can the equipment be retuned);

d. The number and type of unlicensed SAB/SAP equipment deployed.

As discussed above, an example of a long-term IMT scenario (across multiple bands) is provided in Figure 4 below. It is noted that the category Short-Range Devices includes Assistive Listening devices (ALD, as part of PSME, see also Table 3), metering devices and active implantable medical devices.

Figure 4: Example long-term scenario for IMT and PMSE or SAB/SAP (source: Ofcom)

For the actual migration of SAB/SAP devices a number of factors can be considered, including:

1) The Final Date by which defined SAB/SAP usage should cease. Different dates may have to be communicated to the users for different SAB/SAP categories (e.g. between licensed and unlicensed equipment users);
2) Early band clearing (before the Final Date). The NRA may have arranged for a procedure whereby IMT licensees (or other licence holders for services such as PPDR) may introduce its services before the Final Date in certain areas. Under such an arrangement the SAB/SAP users in the affected areas will get a notice to vacate the band within a number of days;
3) Modification of SAB/SAP licences. By a general authorisation the NRA can change the licence conditions (which specify the frequency band), allowing these licence holders to operate their equipment in another specified band. By such a general authorisation the SAB/SAP licence holders do not to have file applications to modify their licences;
4) Transition period measures. SAB/SAP users may continue their operations during the transition period under (different) specified criteria. These criteria may include:
    a. High power/licensed SAB/SAP equipment may continue on the basis of the technical conditions set for lower power/unlicensed equipment;
    b. Any (new) SAB/SAP equipment should have type approval (and comply with a set of technical conditions);
    c. SAB/SAP users should not cause harmful interference (to the IMT service or any other primary service) and accept any interference from primary services;
    d. SAP/SAP users need to cease operations, pursuant to the early band clearance rules (see above);
5) Communications and equipment labelling. This includes a communication program targeting the SAB/SAP users and also the public, who may purchase licensed and unlicensed equipment, during the transition period. Labelling should help SAB/SAP users identifying which equipment is permitted to operate in the new frequency bands;
6) Financial compensation schemes and SAB/SAP retuning aid. The inclusion of financial compensation will be dependent on the factors as discussed above.

1.5 Guidelines and recommended actions for the 700 MHz band

The Sections 1.1 to 1.4 cover the spectrum allocations for IMT and other services in the 700 MHz band, the technical and regulatory conditions facilitating the IMT introduction in this band, as well as best practices and methods for refarming the other services, if deemed necessary.

Table 8 provides a comprehensive list of guidelines as included in these Sections.

No	Guideline	Applies to	Ref. Section(s)
1.1	As the frequency arrangement for IMT (Table 1) and frequency allocations for the other services can vary between countries, as well as the applied technology standard for these services (Table 3), Administrations are advised to determine what applications are used in their territory. A market inventory or consultation may be necessary before selecting frequency arrangements. In selecting this frequency arrangement due consideration should be given to the AUC Guidelines on the harmonised use of the digital dividend in Africa.	All applications	Sections 1.1 and 1.2
1.2	Administrations are advised to interpret the sharing and coexistence study results, as included in Section 1.3.1, with caution as their local situation may differ from the situation as covered in the studies. Case-by-case calculation may be needed to determine possibilities for sharing and coexistence of services. For this purpose, a number of ITU Recommendations and Reports are available, as specified in Table 4 and Table 5. Also, a comprehensive list of relevant ITU Recommendations and Reports is provided in Appendix B: ITU Recommendations and Reports	All applications	Sections 1.3.1 and 1.3.2 Appendix B: ITU Recommendations and Reports
1.3	For introducing IMT in the specified frequency bands (see Table 1), Administrations may have to set a range of technical and regulatory conditions. Technical conditions can include the application of guardbands, reverse duplexing, filtering of transmitters/receivers and critical spectrum masks. Regulatory conditions such as an obligation to provide filters to spectrum users, to compensate for migration costs and follow station-approval procedures, are set in combination with the technical conditions.	All applications	Sections 1.3.2 and 1.3.3
1.4	Cross-border coordination may be needed for mitigating co-channel interference for the potential interference cases as included in Figure 1. For resolving interference between IMT and DTTB, the procedures of the GE06 agreement should be followed (as explained in Section 1.3.4). ATV services in the UHF cannot claim protection any longer and should cause harmful interference to other primary services (including IMT). For resolving other interference cases (e.g. between IMT and fixed service) case-by-case coordination may be needed. For resolving IMT-IMT interference the procedures and technical conditions the HCM4A Agreement or ECC Rec. 15/01 may form a good reference.	Cross-border coordination for: GE06 for IMT-DTTB (and DTTB-DTTB) HCM Agreement for IMT-IMT ECC Rec. 15/01 for LTE/NR-LTE/NR	Section 1.3.4 Appendix A: Cross-border frequency coordination

No	Guideline	Applies to	Ref. Section(s)
		coordination cases	
1.5	From Table 4 and Table 5 it was concluded that the following services or applications may have to be re-planned or reallocated to adjacent or other bands: • DTTB and ATV • SAB/SAP	Refarming DTTB, ATV and SAB/SAP	Section 1.4
1.6	Refarming DTTB services involves migrating a set of DTTB services, broadcasted on a given set of frequencies, to another set of frequencies which are located in the adjacent band to the IMT services. This process should be well planned and can include a process as described in Figure 3.	Refarming DTTB	Section 1.4.1
1.7	Refarming ATV services entails the migration of these services to a DTTB platform. This process of migrating ATV services to a DTTB platform includes some unique planning aspects (such simulcasting and ASO). This is separately described in Section 9.	Refarming ATV	Section 1.4.2 See also Section 9
1.8	Refarming of SAB/SAP services can be carried under three basic migration scenarios as provided in Section 1.4.3. For the actual migration of SAB/SAP devices it is recommended that a number of factors is considered, including: • The Final Date by which defined SAB/SAP usage should cease; • Early band clearing (before the Final Date) • Modification of SAB/SAP licences • Transition period measures • Communications and equipment labelling • Financial compensation schemes and SAB/SAP retuning aid	Refarming SAB/SAP	Section 1.4.3

Table 8: Spectrum management guidelines for IMT introduction in the 700 MHz band