FREQUENCY ARRANGEMENT FOR 700 MHZ BAND

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The 694-790 MHz (700 MHz) band was allocated by the 2012 World Radiocommunication Conference (WRC-12) in ITU Region 1 (Europe included), to the mobile service on a co-primary basis with other services to which this band was allocated on the primary basis and identified for the International Mobile Telecommunications (IMT). At the same time, the countries of Region 1 will be able also to continue using these frequencies for their broadcasting services if necessary. This allocation will be effective immediately after 2015 World Radiocommunication Conference (WRC-15). In order to make the best possible use of this frequency band for mobile service, a worldwide harmonized frequency arrangement is to be prepared to allow for large economies of scale and international roaming as well as utilizing the available spectrum in the best possible way, minimizing possible interference between services, facilitating deployment and cross-border coordination. The authors analyze different possible frequency arrangements and conclude on the frequency arrangement most suitable for Europe.

Keywords: *band plan, frequency arrangement, frequency division duplex (FDD), International Mobile Telecommunications (IMT), International Telecommunication Union (ITU), mobile service, spectrum planning.*

1. INTRODUCTION

In response to the ITU administration's proposals made at the World Radio-Communication Conference (WRC-12), Resolution 232 [1] was developed and adopted as to the allocation of the 694-790 MHz frequency band (commonly referred to also as the *second digital dividend*) in ITU Region 1 to the mobile service, except aeronautical mobile service (ITU Radio Regulations, footnote 5.312A) on a co-primary basis with other services to which this band is allocated on the primary basis, identifying it to IMT. The allocation is effective immediately after WRC-15. The identification does not preclude the use of this band by other services or applications to which it is allocated. This band has already been allocated to the mobile service in Regions 2 and 3.

In the framework of WRC-15 Agenda Item 1.2, Resolution 232 (WRC-12) calls for studies on the channelling arrangements, i.e. frequency arrangement (or

band plan) for mobile service adopted for the 700 MHz band. Other tasks include the following: to study coexistence of different channelling arrangements implemented in Region 1 above 790 MHz; to study solutions for accommodating the applications that are ancillary to the broadcasting requirements; to study the compatibility between the mobile service and other services currently allocated in the frequency band 694-790 MHz; and to study the spectrum requirements for the mobile service and broadcasting service in the 700 MHz band in order to determine as early as possible the options for a lower band edge [1].

The ITU-R Joint Task Group 4-5-6-7 was the responsible group for the WRC-15 Agenda Items 1.1 and 1.2 [2]. The frequency arrangements for the use of the 700 MHz band for IMT in Region 1 are studied in ITU-R and also by the European Conference of Postal and Telecommunications Administrations (CEPT). Furthermore, the European Commission has issued a mandate to CEPT to develop harmonized technical conditions for the 694-790 MHz frequency band in the European Union for the provision of wireless broadband and other uses in support of EU spectrum policy objectives [3].

2. FDD AND TDD FREQUENCY ARRANGEMENT

Despite definite benefits provided by the use of both frequency division duplex (FDD) and time division duplex (TDD) modes in the same band, such uses need careful consideration in order to minimize possible interference between the systems [4].

The Long Term Evolution (LTE) as an IMT technology supports both FDD- and TDD-based duplex operation. Both LTE TDD and FDD operational modes of the 3rd Generation Partnership Project (3GPP), Release 8, can effectively be deployed in both the paired and unpaired spectrum. The LTE TDD and FDD modes have been greatly harmonized in the sense that both modes share the same underlying framework, including the radio access Orthogonal Frequency Division Multiple Access (OFDMA) schemes in downlink and Single Carrier Frequency Division Multiple Access (SC-FDMA) in uplink, basic subframe formats, configuration protocols etc.

As a clear indication of harmonization, the TDD mode is included together with the FDD one in the same set of specifications, along with the physical layer where some differences exist only due to the uplink and downlink switching operation. In terms of architecture, there are no differences between FDD and TDD modes, and only minor differences in the Media Access Control (MAC) layer and higher layer protocols relate to the parameters of TDD specific physical layer.

For the bands identified for use by IMT, the systems operating in FDD mode should maintain the conventional duplex direction – i.e. with mobile terminal transmit within the lower band and base station transmit within the upper band. This is because the system performance is generally constrained by the uplink link budget due to the limited transmit power of terminals. In order to facilitate coexistence with adjacent services, in some instances it might be desirable to reverse the duplex direction – with the mobile terminal transmit within the upper band and base station transmit within the lower band.

The duplex separation, the duplexer bandwidth, and the centre gap in an FDD frequency arrangement influence the duplexer performance: separation of the larger

duplex provides better downlink (DL)-uplink (UL) isolation performance (i.e. less self-desensitized); larger duplexer bandwidth reduces the overall duplexer performance, resulting in both worse self-desensitization and higher interference from mobile station (MS) to MS or base station (BS) to BS; a smaller centre gap may lead to higher MS-MS or BS-BS interference.

One of the ways to reduce the duplexer's bandwidth in an FDD system, while keeping a larger duplex separation and total bandwidth, is to use a *dual duplexer*. From the implementation point of view, for a dual duplexer arrangement this is to be done according to Fig. 1 [5].

Fig. 1. Duplexer arrangements in FDD frequency arrangement.

A fixed overlap between duplex arrangement No. 1 and No. 2 enables the use of common equipment to meet the operational requirements of deployments. The overlap size is likely to be the same for all implementations, and this would be decided according to the filter design at band planning. Due to the two adjacent duplex arrangements, the gap between DL and UL blocks can be made smaller than the duplex gap in a single duplexer FDD arrangement. Such a two-duplexer arrangement can be implemented by the standard filter technology, with minimum cost and complexity of equipment. However, the small gap between UL and DL blocks will put additional filtering requirements on the terminals to avoid the MS-MS interference. The BS-BS interference can be handled by additional filtering using conventional technologies [5].

A. Paired frequency arrangement (FDD)

The FDD arrangement requires a paired spectrum. The FDD conventional duplex direction as illustrated in Fig. 2 implies that DL-UL transmission takes place in different sufficiently separated frequency bands. Such transmission can occur simultaneously within a cell. Isolation between these transmissions is achieved using duplexers (transmission and reception filters), and a sufficiently large duplex separation (spacing) in the frequency domain.

Fig. 2. FDD frequency arrangement.

B. Unpaired frequency arrangement (TDD)

In the case of TDD operation as illustrated by Fig. 3 there is a single carrier frequency only, with uplink and downlink transmissions separated in the time domain.

Fig. 3. TDD frequency arrangement.

Like LTE FDD, also LTE TDD supports bandwidths from 1.4 MHz up to 20 MHz; however, depending on the frequency band, the number of supported bandwidths may be smaller than the full range. The maximum achievable data rates are lower than in LTE FDD, since the bandwidth is shared between uplink and downlink.

The implementation of FDD user equipment (UE) requires a duplex filter when simultaneous transmission and reception is ongoing. The complexity of the duplex filter increases when the uplink and downlink frequency bands are closely spaced. In a TDD system the UE does not need such a duplex filter.

The TDD system can be implemented in an unpaired band or in two paired bands separately. In some of the future spectrum allocations it is foreseen that it will be easier to find new unpaired allocations than paired allocations with the duplex separation needed. However, since UL and DL share the same frequency band, the signals in these two transmission directions can interfere with each other (see Fig. 4).

Fig. 4. Interference from uplink to downlink in uncoordinated TDD operation.

Therefore, the use of TDD on the same frequency requires synchronization between sites, i.e. in the LTE TDD mode the transmission of base stations is to be synchronized in the same coverage area to avoid interference [4]. For unsynchronized deployment on the same frequency band the devices connected to the cells with different timing and/or different uplink and downlink allocations may cause blocking for other users.

3. PRINCIPLES APPLIED IN DEVELOPMENT OF THE FREQUENCY ARRANGEMENT FOR THE 700 MHz BAND FOR EUROPE

Considering frequency bands for possible additional allocations to any service it is necessary to protect the existing services. Cellular mobile systems in the three ITU Regions in the bands below 1 GHz operate in various channelling arrangements, and proximity to the bands already identified for IMT may lead to reduced complexity in the equipment design [6].

When developing arrangements for the mobile service adapted to the frequency band below 790 MHz, it is important to carefully consider possible channelling arrangements and harmonize similar ones for Region 1. The following main guiding principles are applied at determination of frequency arrangements: spectrum harmonization, technical aspects, and spectrum efficiency [6]. Allocation to other services in the 700 MHz band should also be taken into account when developing frequency arrangement. The block sizes should be in multiples of 5 MHz, which does not preclude smaller channel bandwidths within a frequency block. Adoption of a single frequency arrangement for Region 1 would be beneficial.

A. Global harmonization of frequency arrangement

The IMT systems are intended to provide telecommunication services on a worldwide scale, regardless of location, network or terminal used. Therefore, for IMT a globally harmonized spectrum and globally harmonized frequency arrangements are desirable.

A minimized number of globally harmonized frequency arrangements in the bands identified for IMT will reduce the overall cost of IMT networks and terminals by providing increased economies of scale, allowing worldwide roaming, and facilitating deployment and cross-border coordination. The development of frequency arrangements for Europe should take into account the progress made within the ITU and at relevant regional organizations, to reach the highest possible level of global harmonization.

B. Spectrum requirements for the mobile service and other services in the 700 MHz band; refinement of the lower edge of mobile service allocation

As a result of the analogue-to-digital transition of terrestrial television broadcasting, many countries from all three ITU regions are planning to make – or have already made – a 694-862 MHz band available (might be partially) for applications in the mobile service. For example, the 790-862 MHz (800 MHz) band was harmonized for use for mobile service in CEPT. Adequate and timely availability of spectrum and supporting regulatory provisions are essential to support future growth of IMT and other mobile broadband systems [6].

The Report ITU-R M.2078 [7] was developed on spectrum estimates for IMT in the preparatory studies for WRC-07 agenda item 1.4. The predicted total spectrum requirement for both low and high user demand scenarios was estimated to be 1280 MHz and 1720 MHz, including the spectrum already in use, or planned to be used, at least until 2020 [8]. Meanwhile, in the framework for preparation of WRC-15 agenda item 1.1 the Report ITU-R M.2290-0 was developed, which estimated total spectrum requirements 1340 MHz and 1960 MHz for lower user density settings and higher user density settings, respectively, for the year 2020 [9].

The 694-790 MHz frequency band represents 30 % of the total remaining UHF broadcasting spectrum. The use of the 700 MHz frequency band by the broadcasting service varies across Region 1 countries. In certain CEPT administrations, the 700 MHz frequency band is intensively used by this service [10]. Some countries

also plan to use the band 470-790 MHz for high definition television (HDTV) and other higher definition modes. Spectrum requirements for the broadcasting service are also studied by ITU study groups [11].

The 700 MHz band is also heavily used in some countries for services ancillary to broadcasting (SAB) and to program making (SAP), especially concerning wireless microphones. The spectrum available for SAB/SAP was also diminished when the 800 MHz band was made available for IMT.

The spectrum to be used for broadband public protection and disaster relief (PPDR) needs to be flexible to fit the individual requirements of CEPT administrations, which consider the options to accommodate 2x10 MHz for broadband PPDR systems within 700 MHz band [12].

CEPT and ITU supports setting 694 MHz as the lower edge of the mobile allocation (needs to be confirmed by WRC-15) [10].

C. Adequate protection of the broadcasting services below 694 MHz

The 470-806/862 MHz frequency band is allocated to the broadcasting service on a primary basis in all three ITU Regions.

To provide compatibility between mobile service in 700 MHz band and broadcasting service below 694 MHz, the IMT uplink band should begin at 703 MHz, thus ensuring a guard band of 9 MHz. The studies discussed at CEPT have shown that the out-of-band emission (OOBE) limit of the LTE mobile user equipment (UE) using a 10 MHz channel bandwidth should be set at -42 dBm/8 MHz below 694 MHz when combined with the suitable channelling arrangements starting at 703 MHz [10].

D. Coexistence with frequency arrangements in the 800 MHz band

The 700 MHz band frequency arrangement should be compatible with the existing European 800 MHz (790-862 MHz) band plan (i.e. the 3rd Generation Partnership Project (3GPP) band 20) in order to provide coexistence of the networks in the new mobile allocation and the operational networks in the 790-862 MHz band.

A number of administrations in Region 1 have licensed the 800 MHz band for IMT based on A3 channelling arrangement of Recommendation ITU-R M.1036-4 (Fig. 5).

790-791	791-796	796-801	801-806	806-811	811-816	816-821	821-832	832-837	837-842	842-847	847-852	852-857	857-862
Guard band	Downlink						Duplex gap	Uplink					
1 MHz	30 MHz (6 blocks of 5 MHz)						11 MHz	30 MHz (6 blocks of 5 MHz)					

Fig. 5. Band plan A3 according to the ITU-R M.1036-4.

In A3, the IMT systems are operating in FDD mode and use a reversed duplex direction, with the mobile terminal transmit within the upper band and the base station transmit within the lower band. Such an arrangement provides better conditions for coexistence with the lower adjacent broadcasting service.

E. Compatibility between the mobile service and other primary services to which the 700 MHz band is allocated, including adjacent bands

Developing the channelling arrangements for mobile service, the allocation to other services in the 700 MHz band should be taken into account. Currently, the 694-790 MHz band is allocated to the following services in Region 1: the broadcasting service on a primary basis; the land mobile service intended for SAB/SAP on a secondary basis (RR footnote 5.296); the fixed and mobile (except aeronautical mobile) services on a secondary basis (RR footnote 5.300); the aeronautical radionavigation service (ARNS) on a primary basis (RR footnote 5.312); the mobile (except aeronautical mobile) service on a primary basis (footnote 5.312A). The use of 620-790 MHz frequency band is allowed for existing assignments to stations of the broadcasting-satellite service (RR footnote 5.311A) [1, 10].

To mitigate the interference with adjacent bands the guard bands should be used for better co-existence with adjacent radiocommunication services.

F. Optimum utilization of spectrum

Spectrum below 1 GHz is of great importance and value, primarily because of its favourable propagation characteristics being generally suitable for implementation of mobile systems including IMT in rural and sparsely populated areas. In developing channelling arrangements, it is necessary to maximize the total usable spectrum in the band by minimizing – to the technically and practically possible extent – the sizes of the guard bands and the duplex gap, to avoid wasting spectrum.

Some countries in Europe have not yet made available spectrum already identified in the RR for IMT for various reasons, including the use of this spectrum by other systems and services. The use of the 700 MHz band by other applications of the mobile service should be decided on national/regional basis.

At developing frequency arrangements, current and future advances in IMT (e.g. multimode/multiband terminals, enhanced filter technology) may facilitate more efficient use and increase the overall utilization of radio spectrum [6].

G. Possible impact of the traffic asymmetry on the frequency arrangement

The IMT radio interfaces currently include two modes of operation: FDD and TDD. Individual subscriber traffic in IMT systems is expected to be dynamically asymmetric, with the direction of asymmetry that can vary rapidly within short (ms) time-frames. The IMT network traffic may change to asymmetric over a longer term. Asymmetry means that the basic amount of traffic in the uplink and the downlink directions may differ [6].

Administrations and operators should consider asymmetric traffic requirements when assigning spectrum or implementing systems. Applications supported by IMT may have various degrees of asymmetry. Report ITU-R M.2072 [13] describes not only download dominant applications such as *e-newspaper*, but also upload dominant applications such as observation e.g. *network-cameras* and upload file transfer. With equal FDD pairing for uplink and downlink, or TDD, varying degrees of traffic asymmetry can be accommodated.

4. THE 700 MHz BAND FREQUENCY ARRANGEMENTS ADOPTED IN OTHER REGIONS

The Recommendation ITU-R M.1036-4 contains frequency arrangements for implementation of the terrestrial component of IMT in the bands identified for IMT in the ITU RR. Currently, for the 700 MHz band the ITU-R M.1036-4 includes frequency arrangements which are – or are planned – to be used in Regions 2 and 3. The frequency arrangement A4 shown in Fig. 6 is (partly) used in some countries of Region 2.

Fig. 6. Frequency arrangement A4 according to the ITU-R M.1036-4.

Frequency arrangement A5 consists of dual duplexers (Fig. 7), and is used or planned to be used in Region 3 and in a number of countries in Region 2.

Fig. 7. Frequency arrangement A5 according to the ITU-R M.1036-4.

A. APT frequency arrangement in the 700 MHz band

The 3GPP band 28, which corresponds to the frequency arrangement A5, is already one of the most harmonized band plans in the world. As first 3GPP band 28 products are becoming available, adoption by CEPT of a 700 MHz band plan based on 3GPP band 28 would bring significant benefits in terms of global harmonization, roaming and costs. With the exception of North America, 3GPP band 28 can become the first global band plan.

The Asia Pacific Telecommunity (APT) band plan is a type of segmentation of the 698–806 MHz band. This segmentation exists in two varieties: FDD and TDD that have been standardized by the 3GPP and recommended by the ITU as corresponding arrangements A5 and A6.

The APT band plan has been designed to enable the most efficient use of available spectrum. Therefore, this plan divides the band into contiguous blocks of frequencies that are as large as possible, taking account of the need to avoid interference with services in other frequency bands. The TDD option A6 shown in Fig. 8 includes 100 MHz of continuous spectrum, while the FDD option A5 comprises two large blocks: one of 45 MHz for uplink transmission in the lower part of the band and the other also of 45 MHz for downlink transmission in its upper part.

Fig. 8. Frequency arrangement A5 according to the ITU-R M.1036-4.

Both FDD and TDD schemes for the 700 MHz band include guard bands of 5 MHz and 3 MHz at their lower and upper edges. The FDD plan also includes a duplex gap of 10 MHz. The 3GPP standards for the APT band plan are summarized in Table 1.

Table 1

3GPP operating bands in 700MHz band

3GPP operating band	Duplex mode	Uplink frequency, MHz	Downlink frequency, MHz
28	FDD	703-748	758-803
44	TDD	703-803	703-803

Currently, the FDD configuration is the one which has been studied most widely and is much more widespread across the world. For this reason, the FDD APT band plan option is generally referred to as the APT band plan.

B. North America (US) band plan in the 700 MHz band

Frequency arrangements of the United States (US) band plan and the APT band plan substantially overlap, thus making them largely incompatible.

The 3GPP has assigned four operating bands for the US band plan, i.e. 3GPP bands 12, 13, 14 and 17, and two bands for the APT band plan, i.e. band 28 for FDD mode and band 44 for TDD mode. There are some differences among the operating bands – such as different channel bandwidths and channel locations within the 700 MHz band. Also duplex separation and guard bands differ from those in the APT band plan.

5. OPTIONS OF 700 MHz BAND FREQUENCY ARRANGEMENTS FOR MOBILE SERVICE IN EUROPE

The full or partial implementation of the existing frequency arrangements in the 700 MHz band should be considered when developing the frequency arrangement for Region 1. Partial implementation of A4 of Recommendation ITU-R M.1036-4 would give a relatively small spectrum, i.e. 2x18MHz paired spectrum for IMT in Region 1. Also, partial implementation of A5 of ITU-R M.1036-4 is not the most optimum from the spectrum utilization point of view for Region 1, but it would allow for 2x30 MHz paired spectrum. However, almost global harmonization coming from partial implementation of A5 may well compensate the less optimal spectrum utilization.

The ITU recommended frequency arrangements for implementation of IMT in the band 698-960 MHz are summarized in Table 2. Due to different usage in the bands 698-960 MHz between three Regions, there is no common solution possible at this time.

Table 2

Recommended frequency arrangements for implementation of IMT in the band 698-960 MHz

Frequency arrangements	Paired arrangements				Unpaired arrangements e.g. for TDD (MHz)
	Mobile station transmitter (MHz)	Duplex gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
A1	824-849	20	869-894	45	None
A2	880-915	10	925-960	45	None
A3	832-862	11	791-821	41	None
A4	698-716 776-793	12 13	728-746 746-763	30 30	716-728
A5	703-748	10	758-803	55	None
A6	None	None	None	None	698-806

A. Option 1 (2 x 30 MHz FDD)

This frequency arrangement is aligned with the lower 2x30 MHz subband of the A5 channelling arrangement of Recommendation ITU-R M.1036-4 presented in Fig. 9. The upper A5 arrangement subband is impossible to use, because this overlaps with the existing A3 channelling arrangement. However, it is envisaged that the majority of terminals supporting the 700 MHz band for Region 1 would include both subbands of the A5 channelling arrangement because of the benefits for global market and economies. This would also facilitate global roaming [14].

Fig. 9. The 2x30 MHz FDD frequency arrangement for IMT implementation in 700 MHz band.

This option makes 2x30 MHz of spectrum available for IMT, i.e. 703-733 MHz for the uplink and 758-788 MHz for the downlink. Adopting this band plan would mean that the new channelling arrangement is harmonized with the lower duplexer of A5 arrangement, i.e. 3GPP band 28. This could result in significant reduction in the network and terminal equipment costs, and would facilitate implementation of global terminals.

Option 1 uses 60 MHz from the total 96 MHz available for use in this band (i.e. 63% of the 700 MHz band). The 9 MHz is maintained as a guard band with the broadcasting service operating in digital terrestrial television (DTT) channel 48 (686-694 MHz).

This channelling arrangement has a duplex separation of 55 MHz with a 25 MHz duplex gap. This larger duplex separation will result in a lower probability of

self-interference between a handset transmitter and its own receiver. The design of the duplex filter is expected to be available at a low cost. In this case, the unutilized spectrum for IMT in the band (694-790) is 36 MHz.

Apart from harmonization, a channelling arrangement based on the lower duplexer part of A5 arrangement enables coexistence with currently deployed IMT systems in Region 1 – i.e. this arrangement will be able to complement A3 arrangement (800 MHz band), which is widely adopted in many European countries, since this option does not overlap with A3 channelling arrangement (Fig. 10) and thus enables using both arrangements together [14].

Fig. 10. Coexistence of 2x30 MHz FDD frequency arrangement and A3 frequency arrangement.

Adoption of the 3GPP band plan 28 lower duplexer (2x30 MHz) by CEPT would send a strong signal for harmonization and international interoperability to the industry. On the contrary, adoption by CEPT of a specific band plan would result in a niche band plan (most likely limited to European use only).

B. Option 2 (2 x 40 MHz FDD)

This option is based on a dual duplexer implementation, e.g. the A5 channelling arrangement. The arrangement shown in Fig. 11 makes 2x40 MHz of spectrum usable for IMT. The overlap with A5 channelling arrangement would allow the roaming of devices between Regions.

Fig. 11. 2x40 MHz FDD frequency arrangement for IMT implementation in the 700 MHz band.

In Option 2 the uplink frequencies are 703-743 MHz and the downlink ones are 751-791 MHz. It has a duplex separation distance of 48 MHz and a duplex gap of only 8 MHz to allow for a 2x40 MHz band plan keeping the same lower edge of A5 arrangement and making use of the spectrum up to 791 MHz (i.e. the lower edge of A3 channelling arrangement). The guard band with digital terrestrial television in the lower part is 9 MHz. Although the combined duplex gap is only 8 MHz, detailed filter analysis has shown that the actual duplex gap in each duplexer would be large enough to allow implementation of the duplexers without desensitization.

This channelling arrangement uses 80 MHz out of 96 MHz for IMT – the ratio similar to that for the 800 MHz band plan (i.e. A3) and the APT 700 MHz band plan (i.e. A5). In this case the unutilized spectrum for IMT in the band is 17 MHz [14].

The duplex separation distance in this option differs from that in A5 channelling arrangement of the ITU-R M.1036-4, and the channelling raster is also different. This requires the definition of a new 3GPP band that would be able to allow roaming among the ITU Regions.

C. Option 3 (2 x 30 MHz FDD with SDL)

This arrangement is harmonized with the lower duplexer of channelling arrangement A5 and does not need extra duplexers. The option of a supplemental downlink (SDL) shown in Fig. 12 promotes a high degree of spectrum use, however a 20 MHz (4x5 MHz) wide block of SDL spectrum overlaps with the FDD uplink of channelling arrangement A5, which contradicts the principle of coexistence with existing channelling arrangements.

Fig. 12. The 2x30 MHz FDD with SDL frequency arrangement for IMT implementation in the 700 MHz band.

By adding a 20 MHz wide block of supplemental downlink spectrum adjacent to the FDD downlink, the harmonization with the A5 channelling arrangement could be retained at the same time as the spectrum utilization and the support for future mobile broadband services is increased. This might be a useful way to implement IMT in the 700 MHz band in Region 1, especially in the areas with limited need of additional spectrum for other applications. Still, It would also be possible to combine this solution with some of the additional applications.

The SDL is defined in ECC Report 188 [15]. A mobile broadband network implementing SDL will use a wider channel for the downlink than for the uplink, by bonding a usual downlink of the paired mobile band – e.g. 800 MHz with a SDL channel from the 700 MHz duplex gap. The SDL was introduced in Release 9 of 3GPP for Evolved High-Speed Packet Access (HSPA+) and it is possible to use it with the Carrier Aggregation (CA) feature for LTE from Release 10 onwards. The SDL uses unpaired spectrum for the downlink communication only.

This option does not overlap with the A3 channelling arrangement and thus the two arrangements could be used together. This former maintains a 9 MHz guard band with the broadcasting service operating in DTT channel 48. Utilization of 20 MHz of duplex gap as SDL will maximize the total amount of spectrum to be used for IMT in the 700 MHz band. Option 3 utilizes 80 MHz out of the total 96 MHz available for IMT, which means providing a high level of utilization. In this case unutilized spectrum for IMT in the band is 16 MHz.

Having SDL in the channelling arrangement is expected to enable CEPT administrations to make a choice and use 83% of 700 MHz band for IMT if needed.

D. Option 4 (TDD frequency arrangement)

This frequency arrangement presumes the 703-790 MHz band to be used for TDD systems. This option utilizes 87 MHz of the total available 96 MHz, meaning that it provides a high level of utilization in the TDD mode. In this case the unutilized spectrum for IMT in the band is 9 MHz.

The SDL (up to 20 MHz) spectrum adjacent to the FDD downlink could also be used for unpaired (TDD) IMT systems.

Impact of using the TDD frequency arrangement on other services in 700 MHz band and adjacent bands needs to be studied further. This arrangement is partly harmonized with the frequency arrangement A6 of Recommendation ITU-R M.1036-4.

E. Option 5 (combined frequency arrangement)

This option presumes combined arrangement 2x5 MHz FDD+2x30 MHz FDD+2x3 MHz FDD+“Y” MHz (DM) (Fig. 13) and makes efficient use of the available spectrum by including subbands suitable for special IMT applications.

Fig. 13. Combined FDD frequency arrangement for IMT implementation in the 700 MHz band.

In this option the 2x30 MHz is presumed for use of IMT mobile broadband. This spectrum is aligned with the lower 2x30 MHz subband of A5 channelling arrangement, which will facilitate implementation of global terminals.

The 2x3 MHz in this option is suitable for IMT narrowband communications, filling the 3 MHz gap between the A5 arrangement upper subband and the A3 arrangement and using a part of the duplex gap. For both uplink and downlink, the duplex direction is the same as the adjacent mobile spectrum, so there is low possibility for interference. This option would support a single 3 MHz LTE carrier. Therefore, this frequency range could be used for machine-to-machine (M2M) applications, e.g. by power and water utilities.

The 2x5 MHz in this option is presumed for use of PPDR. This is below the IMT broadband spectrum, and could be used for PPDR based on LTE system. It might be possible to increase the bandwidth in certain situations – e.g. in geographic areas where the DTT channel 48 is not used. Lower density of PPDR users would significantly reduce the potential interference for DTT reception as compared with the mobile broadband applications [14]. In this case, the guard band to the broadcast channel 48 is 4 MHz.

The “Y” MHz in this option is suitable for use of direct mode, i.e. direct device-to-device communication, which is typically TDD [16]. Parts of unused guard band and duplex gap could be used for audio SAB/SAP applications. This option provides a high level of the band utilization.

6. CONCLUSIONS

Conclusions to be drawn from the results of our analysis are as follows.

The frequency arrangements enable the most effective and efficient use of spectrum for delivering the IMT services, while minimizing the impact on other systems or services in the relevant and adjacent bands and facilitating the development of IMT systems.

The spectrum allocation for mobile service according to the internationally harmonized band plans minimizes the radio interference in border areas, facilitates international roaming and reduces the cost of mobile devices. Spectrum harmonization – being a major objective of the ITU - reduces interference along the national borders when the use of mobile bands are harmonized between countries.

CEPT administrations may implement any of the ITU-R M.1036-4 recommended frequency arrangements, i.e. all of them or part of each recommended frequency arrangement for IMT systems to suit their national conditions taking into account also situation in neighbouring countries. Interference problems may arise if different frequency arrangements with overlaps are implemented by neighbouring countries.

The global spectrum harmonization, the protection of DTT channel 48, the coexistence with other existing services in the 700 MHz band and the adjacent bands, the coexistence with existing arrangements in the 800 MHz band, and the effective spectrum use are key considerations when developing a channel plan for the 700 MHz band in Europe.

Aligning the CEPT band plan with the APT 700 MHz frequency arrangement, i.e. A5 (3GPP band 28), has significant advantages over a standalone European frequency arrangement. Therefore, the 2x30 MHz FDD band plan would be beneficial. This option would allow Europe to enjoy the benefits of being part of a global terminal market, meaning that the consumer equipment prices are lower than on a smaller regional market and that the range of devices supporting this band is as large as possible. Having SDL in the channelling arrangement would enable CEPT administrations to make a choice and to use 83% of 700 MHz band for IMT if needed.

The use of a duplex gap in the frequency arrangement for SDL, direct mode or SAB/SAP could provide improved utilization of mobile broadband spectrum within the range 733-758 MHz. Parts of guard bands and duplex gap could be used for the audio SAB/SAP applications and PPDR if compatibility with existing uses in adjacent bands is provided.

It can be concluded that the preferred harmonized frequency arrangement for 700 MHz band in Europe could be Option 3 and, as a suboption, Option 5.

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FREKVENČU KANĀLU PLĀNS 700 MHZ JOSLAI

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K o p s a v i l k u m s

2012. gada Pasaules Radiosakaru konference (WRC-12) lēma par 694-790 MHz (700 MHz) joslas sadalījumu mobilajam dienestam, izņemot gaisa kuģniecības mobilo, uz primāra pamata, līdzās citiem dienestiem, kuriem šī josla jau ir sadalīta uz

primāriem nosacījumiem (apraides dienestam u.c.), un identificēšanu IMT sistēmām ITU pirmajā reģionā, kurā ietilpst arī Eiropa. Šis sadalījums stāsies spēkā uzreiz pēc WRC-15. 700 MHz joslu mēdz dēvēt arī par „otro ciparu dividendi”.

Lai 700 MHz josla Eiropā tiktu maksimāli efektīvi izmantota mobilajam dienestam, ir nepieciešams izstrādāt 700 MHz joslas kanālu plānu, kas nodrošinātu maksimāli starptautisku joslas harmonizāciju. Starptautiska joslas harmonizācija veicinās mobilo sakaru attīstību, sniegs plašākas viesabonēšanas mobilo sakaru pakalpojumu iespējas, sekmēs pieejamā radiofrekvenču spektra efektīvu izmantošanu, mazinot traucējumu rašanās varbūtību starp dažādiem radiosakaru dienestiem un sistēmām, atvieglos starpvalstu frekvenču koordināciju šai joslai.

Rakstā pētīti 700 MHz frekvenču kanālu plāna izstrādes principi mobilo sakaru sistēmām, analizēti vairāki iespējamie kanālu plāna varianti 700 MHz joslai ar mērķi noteikt piemērotāko frekvenču kanālu plāna variantu izmantošanai Eiropā.

20.12.2014.