GTI White Paper

GTI
Global TD-LTE Initiative

FUTURE SPECTRUM WHITE PAPER

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WHITE PAPER

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Executive summary

This white paper summarizes the advantage of TDD technology and the spectrum requirement resulting from the development of IMT and extensive growth in data traffic. It aims to facilitate the TDD technology globalization and unpaired spectrum utilization, including convergence of FDD/TDD, and to drive the unpaired spectrum allocation in future. The potential candidate frequency bands, including both lower and above 6GHz bands, are also presented. To form and propose our GTI position on the future spectrum planning or band allocation for IMT-2020(5G) to ITU to impact on WRC-15 and new agenda item towards WRC-19, this white paper proposes some recommendations and suggestions as follows:

- Over 1GHz spectrum is needed for IMT for 2020 according to ITU studies. Considering the future data traffic growth beyond 2020, we can even foresee larger spectrum needs. To meet the future spectrum requirement, identification of more spectrum for IMT is the solution with highest priority.
- Bands below 6GHz are the core spectrum bands used for IMT today, with C band being a key band for TDD due to the already started ecosystem development and availability of contiguous bandwidth.
- Bands above 6GHz can also be utilized by IMT in order to meet the explosive traffic growth in future, and the candidate frequency ranges to be studied should be kept as wide as possible. A new agenda item considering identification of frequency band(s)within 6-100GHz range for the future development of IMT for 2020 and beyond is highlighted and suggested.
- TDD, as the expected main duplex mode for future technologies, can better fit with the large contiguous bandwidth allocation and more efficiently utilize the spectrum, thus being able to provide high data rate services and cope with the continued data traffic growth.
- Global harmonization of future spectrum should be targeted considering the benefits in economies of scale.

1. Introduction

The spectrum is a scarce non-renewable resource, as well as the core resource for promoting the development of IMT. It is universally acknowledged by the global mobile communication research community that future mobile telecommunication system has the huge demand for globally available supply of spectrum, which attributes it to the extensive growth in mobile data traffic in future mobile communication services. In order to meet ever-increasing demand of the mobile data traffic, on the one hand, it is necessary to find ways of handling future technologies and system architecture evolution; on the other hand, freeing up additional spectrum will also be required to support capacity increases by the next generation system. Nevertheless, increasing the spectrum resource is constantly regarded as a straightforward and effective approach to respond to extensive traffic increase.

TDD based systems have some advantages in future compared to FDD. TDD utilizes unpaired spectrum compared to FDD meaning that TDD can be deployed any single available spectrum band. Another advantage is that TDD allows for adjustment of the downlink and uplink resource and therefore can efficiently respond to traffic asymmetry E.g. For small cell deployments where inter operator co-ordination may be relaxed will allow for dynamic adjustment of uplink and downlink. TDD uses uplink and downlink channel reciprocity, which will help to improve connectivity, especially under the extremely complicated network environment. Moreover, the massive MIMO antenna array technology and ultra dense network deployment can be better supported with TDD. According to the data from 3GPP[1], considering the varies deployment scenarios, it is generally considered that massive MIMO can improve the performance by additional 80% for cell average throughput and 150% for cell edge throughput. In addition, larger bandwidth's for future technologies are likely to be only available with higher frequency bands and for frequency bands with large bandwidths, TDD would be more efficient duplexing mode. Therefore for new high band spectrum that is identified for mobile use, it can be expected TDD will be the main duplexing method. The aggregation of TDD and FDD technology and spectrum provides a route to convergence of these technologies.

The objective of this white paper is to provide a comprehensive introduction about the future spectrum. In order to achieve the IMT traffic requirements in the future, spectrum is considered as the key point. Besides, the results in report ITU-R M.2290 estimates the total global spectrum requirements for IMT to be in the range of 1340 to 1960MHz for the year 2020, and is described in Chapter 2. Chapter 3 addresses some solutions to satisfy the increasing spectrum demands for future services. And the comprehensive descriptions of the potential candidate lower and higher frequency bands are provided at Chapter 4 and 5 respectively. Furthermore, GTI proposals and recommendations for future spectrum are presented in Chapter 6.

2. Spectrum requirement for furture

With the fast advance of the mobile Internet, mobile data traffic has explosively increased. According to the mobile global data traffic estimates summarized in ITU M.2243, global mobile traffic will grow 20-100 times that in 2011 by 2020. Visioning the future year 2030, the global IMT traffic is estimated to grow in the range of 10-100 times from 2020 to 2030 according to ITU report ITU-R M.[IMT.2020BEYOND TRAFFIC].

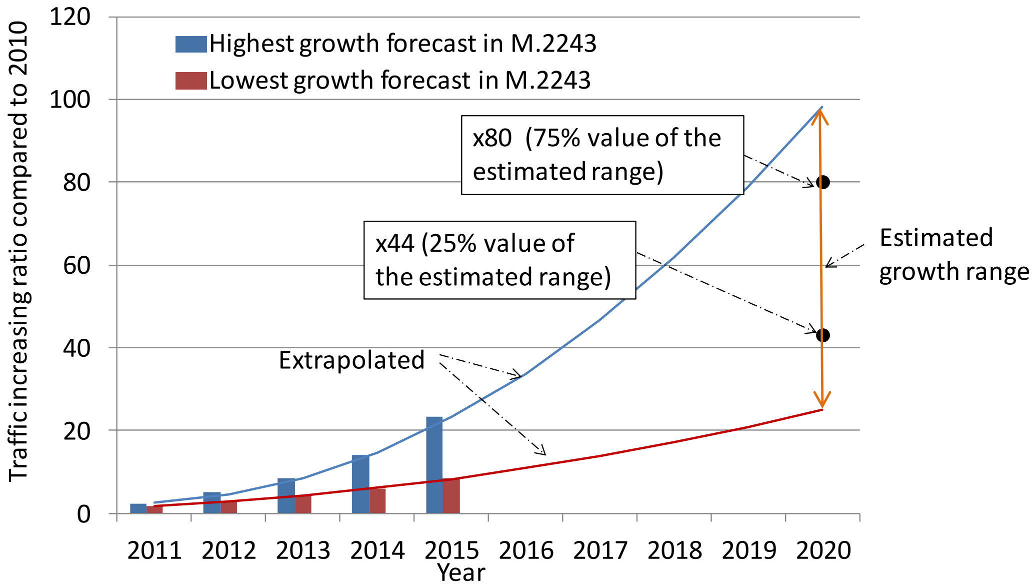

Figure 1 Mobile traffic forecasts toward 2020 by extrapolation

Future traffic demands and higher performance expectations are to be addressed with high spectrum efficiency and heterogeneous networks (HetNet). However, high densification of macro eNodeB deployment to meet the traffic demand will be challenging due to associated CAPEX and OPEX. The quantities of eNBs can't grow without constraint to meet the traffic demands. Even with newer 5G features, spectrum efficiency is only expected to reach 3-5 times higher compared to IMT-A. Traffic demands of 2030 are 200-1000 times that of 2010 and cannot be met with the spectrum already identified for IMT.

In conclusion, in order to meet the 0.1~1Gbps user experienced date rate[2], increased availability of spectrum is considered as the key contributor. Report ITU-R M.2290 provides the results of studies on estimated global spectrum requirements for terrestrial IMT for the year 2020. The estimated total requirements including spectrum already identified for IMT are 1 340 MHz and 1 960 MHz. For future IMT systems in the year 2020 and beyond, contiguous and broader channel bandwidths than available to current IMT systems would be desirable to support high data rates and continued data traffic growth. Therefore, availability of spectrum resources that could support wider, contiguous channel bandwidths in this time frame should be explored. Today, spectrum requirements for the year after 2020 is being estimated by many leading industry organizations, such as the Next Generation Mobile Networks (NGMN), IMT-2020 promotion group in China, GSMA and so on.

3. Solutions for future spectrum challenge

As shown in section 2, the spectrum demand for future IMT development has been increased dramatically due to the dramatic data traffic increase. There is an urgent need to identify new spectrum to ensure future IMT development.

To accommodate the huge gap between the available IMT spectrum and the estimated spectrum demand, new IMT spectrum for mobile use should be identified. The new spectrum should comprise a mixture of coverage and capacity bands to ensure that mobile networks can provide high speed, cost-effective services in rural and metropolitan areas as well as deep inside buildings.

Currently discussions on both low bands and high bands are ongoing in ITU discussions. On the frequency bands below 6GHz, the service conditions, compatibility considerations and the characteristics of spectrum has already had good analysis. The proliferation of smart devices (e.g. smartphones, tablets, televisions, etc.) and a wide range of applications requiring a large amount of data traffic have accelerated demand for wireless data traffic. In particular, wider bandwidth is required to support the different usage scenarios, e.g. enhanced mobile broadband, requiring several hundred MHz up to at least 1 GHz and can only be addressed with wideband contiguous spectrum above 6 GHz.

As the amount of spectrum required for mobile services increases, it becomes increasingly desirable for existing and newly allocated and identified spectrum to be harmonized. The benefits of spectrum harmonization include: facilitating economies of scale, enabling global roaming, reducing equipment design complexity, preserving battery life, improving spectrum efficiency and potentially reducing cross border interference. Therefore, harmonization of spectrum for IMT will lead to commonality of equipment and is desirable for achieving economies of scale and affordability of equipment.

4. Potential candidate lower frequency bands

In addition to the limited spectrum bands already in use, it is anticipated that ITU will identify further new bands for IMT in order to meet the traffic increase mentioned in Chapter 2. It should be emphasized that in general low frequency spectrum (below 6GHz), is absolutely essential for an economical delivery of mobile services and this holds true for existing systems as well as future systems. Therefore, priority must be put on how to make more spectrum in those low bands available, and how to use that spectrum much more efficiently.

Considering the CAPEX and OPEX of operators, bands with good coverage are generally suitable for implementing mobile services. Especially in many developing countries and countries with large areas of low population density, there is a need for cost-effective implementation of IMT. In fact, lower frequency bands, especially < 3 GHz, are most suitable for providing coverage with low cost based on the propagation characteristics.

As for the capacity and performance, the frequency bands from 1GHz to 6GHz, concretely, 3-6GHz, are recommended to be most suitable. With growth in LTE traffic and with migration of WiMAX to LTE by WiMAX operators, operators are experiencing need for additional spectrum for capacity. One of the first of these is spectrum at 3.5GHz. Chipsets, network equipment, and fixed and mobile devices are now available; key operators such as Softbank & KDDI poised already. There are 11 TD-LTE commercial networks already launched in 7 countries. Additionally, over 26 TD-LTE commercial networks are either being deployed or is planned. 3400-3600MHz has been considered to be a global IMT harmonized spectrum band. What's more, many countries and regional bodies have shown their support on 3.5GHz and surrounding spectrum in WRC15 agenda item 1.1 as below in Fig.2. In the future, if other services such as Fixed Satellite Service (FSS) are migrated out of this band to other bands or if can share the frequency bands with mobile services, there is potential for additional 800MHz of spectrum within the frequency range of 3.4 to 4.2GHz, and additionally 600MHz in 4.4 to 5GHz, for mobile services. This is very good for the future development of the wireless market and the interest of the global industry chain. Consequently, C band will be the most promising gold mine in the future.

Frequency Band	APT	ASMG	ATU	CEPT	CITEL	RCC
1 - 470-694/698 MHz	A	A	A	A		A
2 – 1 350-1 400 MHz	A	A	C	A		A
3 – 1 427-1 452 MHz	C	A	C	C	C	A
4 – 1 452-1 492 MHz		C	C	C	C	A
5 – 1 492-1 518 MHz	C	C	C	C	C	A
6 – 1 518-1 525 MHz	A	A		A		A
7 – 1 695-1 710 MHz	A	A	A	A		A
8 – 2 700-2 900 MHz	A	A			A	A
9 – 3 300-3 400 MHz		A		A		A
10 – 3 400-3 600 MHz	A	B&C		B&C	B&C	A
11 – 3 600-3 700 MHz	A	A	A	B&C	A	A
12 – 3 700-3 800 MHz	A	A	A	B&C	A	A
13 – 3 800-4 200 MHz	A	A	A	A	A	A
14 – 4 400-4 500 MHz		A	A	A		C
15 – 4 500-4 800 MHz	A	A	A	A	A	A
16 – 4 800-4 990 MHz		A		A		C
17 – 5 350-5 470 MHz	A	A	A	A	A	A
18 – 5 725-5 850 MHz	A	A	A	A		A
19 – 5 925-6 425 MHz	A	A	A	A	A	C

A/B/C: Method A/B/C used in WRC-15 Oppose Support

Figure 2 Regional positions on WRC15 agenda item 1.1

5. Potential candidate higher frequency bands

Future mobile applications envisaged beyond 2020 can't be efficiently served by current mobile broadband networks. The key design principle for the envisioned future systems is flexibility and diversity in order to serve diverse applications and usage scenarios. The appropriate choices of frequency bands to provide coverage, capacity and performance are necessary and are important for cost effective implementation of future IMT systems taking into account the radio wave propagation characteristics and implementation complexity and cost factors. The frequency bands between 6 and 100 GHz have different characteristics. Lower frequency ranges (below 30GHz) where propagation characteristics may be advantageous and higher spectrum (above 30GHz) ranges where large contiguous bandwidths is available will complement each other and should remain under consideration as new spectrum for mobile access.

Industry and academia are actively researching and developing future IMT technology in a variety of frequency bands above 6GHz. Most importantly, a key objective for the identification of new IMT spectrum above 6 GHz is the potential for global harmonization. Based on the spectrum range from 6GHz to 100GHz, noting that a large number of frequency bands above 6 GHz are already allocated to the mobile services on a (co-) primary basis, and to enable the potential global spectrum harmonization, it’s to firstly consider and study the frequency bands already allocated to the mobile service on a primary basis in three ITU Regions. However, also bands currently not allocated to the mobile service can be suitable for broadband mobile applications and should be excluded without due studies. Recognizing that frequency bands allocated to passive services only are not suitable for identification to IMT because of rigid protection provisions, these bands could therefore be excluded from the frequency bands to be considered.

With these principles, some preliminary recommendations on the frequency ranges for WRC-15 AI 10 consideration from some region research institution are as below:

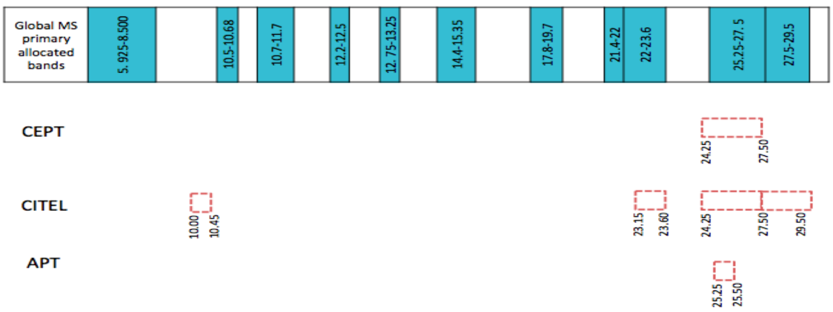

Figure 3. Frequency ranges for WRC-15 AI 10 consideration (<30GHz bands).

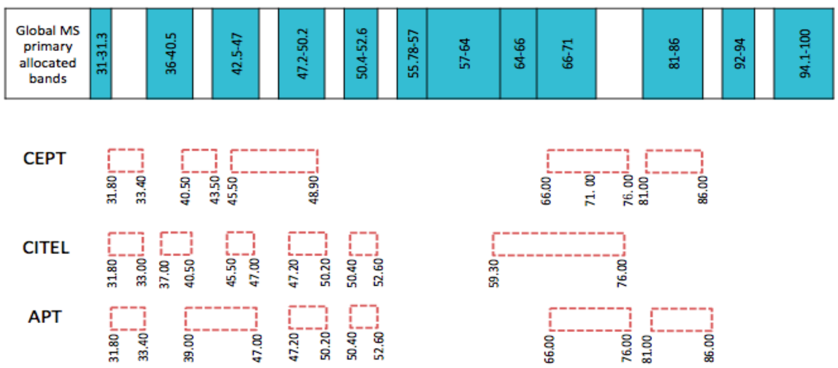

Figure 4. Frequency ranges for WRC-15 AI 10 consideration (>30GHz bands).

During the period between the WRC-15 and WRC-19, the candidate frequency range is suggested to be studied as wide as possible from GTI's view. However, a new agenda item considering identification of frequency band(s) within 6-100GHz range for the future development of IMT for 2020 and beyond is highlighted and suggested.

6. Summary and Recommendations

Seen from the situation of future traffic requirements, solutions for solving spectrum shortage and progress of new candidate bands, it's quite a challenge to satisfy the IMT spectrum demand. Identification of new spectrum for exclusive IMT use is always the most expected way to solve this challenge. The GTI hereby would like to give the following proposals,

- Over 1GHz spectrum is needed for IMT for 2020 according to ITU studies. Considering the future data traffic growth beyond 2020, we can even foresee larger spectrum needs. To meet the spectrum requirement for furture, identification of more spectrum for IMT is the solution with highest priority.
- Bands below 6GHz are the core bands used for IMT today, with C band being a key range due to the already started ecosystem development and availability of contiguous bandwidth.
- Bands above 6GHz can also be utilized by IMT in order to meet the explosive traffic growth in future, and the candidate frequency ranges to be studied should be kept as wide as possible. A new agenda item considering identification of frequency band(s)within 6-100GHz range for the future development of IMT for 2020 and beyond is highlighted and suggested.
- TDD, as the expected main duplex mode for higher frequency bands, can better fit with the large contiguous bandwidth allocation and more efficiently utilize the spectrum, thus being able to provide high data rate services and cope with the continued data traffic growth.

- Global harmonization of future spectrum should be targeted considering the benefits in economies of scale.

7. Terms and Definitions

WRC	World Radiocommunication Conference
3GPP	Third Generation Partnership Project
ITU	International Telecommunication Union
5G	The Fifth Generation Mobile Communication System
CDMA	Code Division Multiple Access
D2D	Device-to-Device
FBMC	Filter Bank Multi-Carrier
FDMA	Frequency Division Multiple Access
F-OFDM	Filtered-Orthogonal Frequency Division Multiplexing
ITU	International Telecommunication Union
LDPC	Low Density Parity Check
MIMO	Multiple-Input Multiple-Output
MUSA	Multi-User Shared Access
NOMA	Non-Orthogonal Multiple Access
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiplex Access
PDMA	Pattern Division Multiple Access
SCMA	Sparse Code Multiple Access
TDMA	Time Division Multiple Access
WLAN	Wireless Local Area Network
mmW	Millimeter wave

MTC	Machine-type communication
RAT	Radio-access technology
TVWS	TV white space
LSA	License shared access
LAA	License assisted access

8. Reference

[1] 3GPP TR 36.897, v13.0.0, 2015.06, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Study on elevation beamforming / Full-Dimension (FD) Multiple Input Multiple Output (MIMO) for LTE (Release 13)

[2] IMT-2020 (5G) Promotion Group WHITE PAPER ON 5G Vision and Requirements V1.0, available at:

http://www.imt-2020.org.cn/en/documents/download/3

[3] R12-WP5D-150610-TD-0625!R1!MSW-E(VISION)