2015 ITU World Radiocommunication Conference (WRC-15) Report —Standardization of Mobile Phone Spectrum—

ITU World Radiocommunication Conference was held in Geneva, Switzerland, from the November 2 to 27 in 2015, to deliberate on revisions of the ITU Radio Regulations, under which the international treaty governing the use of the radio-frequency spectrum, procedures for radio station operations and technical standards etc. are prescribed.
This article provides an overview of the conference, its deliberations on matters related to mobile phone spectrum, and their outcomes.

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1. Introduction

The International Telecommunication Union (ITU) defines the international treaty governing the use of the radio-frequency spectrum, procedures relating to radio station operations, and technical standards etc. in the Radio Regulations. The regulations are necessary because radio frequencies are a limited resource, and countries have to use radio frequencies while accommodating each other and maintaining mutual order to prevent interference etc. The countries of the world have ratified the Radio Regulations in international treaties, and make decisions about using radio frequencies domestically based on the provisions in the Radio Regulations.

Revising the Radio Regulations is done by the ITU World Radiocommunication Conference (WRC), which is normally convened once every three to four years. Held over a four-week period from November 2 to 27 in 2015, the World Radiocommunication Conference (WRC-15) entailed deliberations on revising regulations pertaining to radio-frequency spectrum usage.

Identification of the frequency bands for International Mobile Telecommunications (IMT) has been conducted since the introduction of 3G mobile phones, and efforts to identify the frequency bands for IMT in the Radio Regulations are ongoing. Having all nations of the world use the identified bands for IMT is beneficial for standardization of mobile phone spectrum, because these identifications enable mobile phone frequencies to be common and interference to be avoided while conferring advantages with device development and procurement. IMT identifications for the 800/900 MHz, 1.7 GHz, 2 GHz, and 2.5/2.6 GHz frequency bands widely in use with mobile phones around the world are the result of past WRC deliberations.

This article provides an overview

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of WRC-15, and focuses on deliberations pertaining to additional IMT spectrum identification, and the outcomes of those deliberations.

2. WRC-15 Overview

WRC-15 was attended by some 3,800 people from a range of associations such as administrations of 162 of the 193 member states of the ITU and various international organizations. There were 82 attendees from Japan, including attendees from the Ministry of Internal Affairs and Communications, telecommunication operators, vendors and research institutions. Four staff from NTT DOCOMO attended.

Figure 1 shows the WRC-15 conference structure, while a list of agenda items discussed at WRC-15 is shown in **Table 1**. Mr. Daudu of Nigeria was appointed as the Chairman of the Plenary, making it the first time in its history that it has been presided over by a member from the African region. Under the Plenary, there were seven COMmittees (COMs). In addition, under COMs 4 to 6, there were Working Groups (WGs), which were allocated agenda items for consideration in each field of study. Depending on the agenda item, Sub-Working Groups (SWGs) were also set up under Working Groups for more detailed discussions.

3. WRC-15 Agenda Item 1.1 (Additional IMT Spectrum Identification)

This agenda item was set in the 2012 World Radiocommunication Conference (WRC-12) with acceptance that mobile communications traffic would increase, and was widely supported by many countries. After WRC-12, research was carried out by the ITU Radiocommunication Sector (ITU-R), in which 19 frequency bands were cited as candidates, as shown in

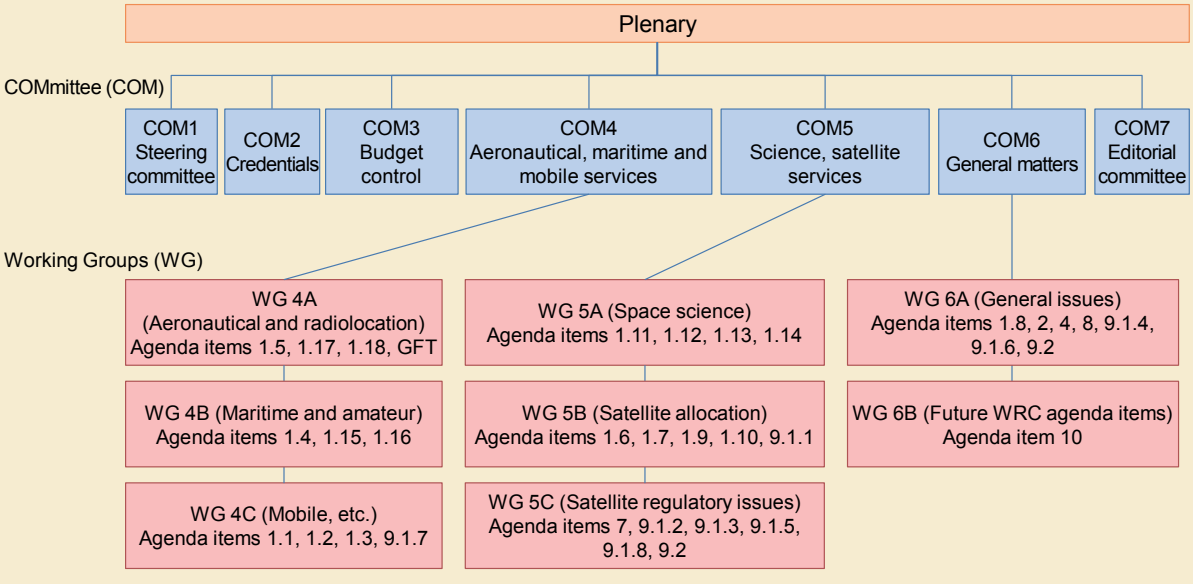

Figure 1 WRC-15 structure

Table 1 WRC-15 agenda items list

Agenda items	Overview
1.1	Additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for IMT
1.2	Use of the frequency band 694 - 790 MHz by the mobile service in Region 1
1.3	Broadband Public Protection and Disaster Relief (PPDR) implementation
1.4	Allocation to the amateur service on a secondary basis within the band 5,250 - 5,450 kHz
1.5	Use of frequency bands allocated to the fixed-satellite service for the control and non-payload communications of Unmanned Aircraft Systems (UAS)
1.6	(1) Additional primary allocation to the fixed-satellite service of 250 MHz in Region 1 within the range between 10 - 17 GHz (2) Additional primary allocation to the fixed-satellite service of 250 MHz in Region 2 and 300 MHz in Region 3 within the range 13 - 17 GHz
1.7	Review of usage of the 5,091 - 5,150 MHz band in the fixed satellite service
1.8	Review of the provisions relating to Earth Stations located on board Vessels (ESVs)
1.9	(1) Allocations to the fixed-satellite service in the frequency bands 7,150 - 7,250 MHz (space-to-Earth) and 8,400 - 8,500 MHz (Earth-to-space) (2) Allocations to the maritime-mobile satellite service in the frequency bands 7,375 - 7,750 MHz and 8,025 - 8,400 MHz
1.10	Spectrum requirements and possible additional spectrum allocations for the mobile-satellite service within the frequency range from 22 GHz to 26 GHz
1.11	Primary allocation for the Earth exploration-satellite service in the 7 - 8 GHz range
1.12	An extension of the current worldwide allocation to the Earth exploration-satellite (active) service within the frequency bands 8,700 - 9,300 MHz and/or 9,900 - 10,500 MHz
1.13	Expansion of communications usage between manned spacecraft
1.14	Review of Coordinated Universal Time (leap second insertion)
1.15	Spectrum demands for on-board communication stations in the maritime mobile service
1.16	Regulatory provisions and spectrum allocations to enable possible new Automatic Identification System (AIS) technology applications and possible new applications to improve maritime radiocommunication
1.17	Support of Wireless Avionics Intra-Communications (WAIC)
1.18	Primary allocation to the radiolocation service for automotive applications in the 77.5 - 78.0 GHz frequency band
2	Examine the revised ITU-R Recommendations incorporated by reference in the Radio Regulations
4	Review of the resolutions and recommendations of previous conferences
7	Review of procedures for frequency assignments pertaining to satellite network
8	Country name deletions from footnotes
9	Report of the Director of the Radiocommunication Bureau
9.1.1	Protection of the systems operating in the mobile-satellite service in the band 406 - 406.1 MHz
9.1.2	Possible reduction of the coordination arc and technical criteria
9.1.3	Use of satellite orbital positions and associated frequency spectrum for international public communications services in developing countries
9.1.4	Updating and rearrangement of the Radio Regulation
9.1.5	Support of existing and future operation of fixed-satellite service earth stations within the band 3,400 - 4,200 MHz, as an aid to the safe operation of aircraft and reliable distribution of meteorological information in some countries in Region 1
9.1.6	Studies towards review of the definitions of fixed service, fixed station and mobile station
9.1.7	Spectrum management guidelines for emergency and disaster relief radiocommunication
9.1.8	Regulatory aspects of nano and pico satellites
9.2	Any difficulties or inconsistencies encountered in the application of the Radio Regulations
9.3	Studies on measures for prescriptions in Resolution 80 (WRC-07 revision)
10	Agenda for future World Radiocommunication Conferences
GFT*	Introduction of global flight tracking (systems for tracking civilian aircraft using satellites)

*An emergency agenda set following the disappearance of the Malaysian Airlines MH370 passenger jet in 2014, not assigned a normal agenda number.

Table 2.

This was also a high-profile agenda item in WRC-15, and was a large scale meeting with full-time participation from some 500 people, even at the SWG level. Dr. Atarashi (one of the authors of this article) was appointed as the chairman to carry out proceedings in this SWG.

Initial SWG discussions were aimed at eliminating candidate frequency bands that had little support, resulting in consensus to remove nine of the 19 bands (the Radio Regulations will not be revised for these frequency bands), which was reported to, and approved by the SWG parent groups. These frequency bands included the 3,800 - 4,200 MHz and 4,500 - 4,800 MHz bands that Japan had been advocating.

Following, regarding the remaining ten frequency bands, discussions on identification of IMT spectrum in the Radio Regulations continued, but as each country expressed different opinions, and agreeable opinions could not be reached, an informal meeting with the Chairman of WRC was held. This informal meeting was held to coordinate opinions for each Region, Region 1 (Europe, Commonwealth of Independent States (CIS), Africa

Table 2 Candidate frequency bands under WRC-15 agenda item 1.1

No.	Frequency bands	Frequency bands supported by Japan	Results of WRC-15 deliberations
1	470 - 694/698 MHz		Refer to Table 3
2	1,350 - 1,400 MHz		No Radio Regulations revision
3	1,427 - 1,452 MHz	Y	Refer to Table 3
4	1,452 - 1,492 MHz	Y	Refer to Table 3
5	1,492 - 1,518 MHz	Y	Refer to Table 3
6	1,518 - 1,525 MHz		No Radio Regulations revision
7	1,695 - 1,710 MHz		No Radio Regulations revision
8	2,700 - 2,900 MHz		No Radio Regulations revision
9	3,300 - 3,400 MHz		Refer to Table 3
10	3,400 - 3,600 MHz	Y	Refer to Table 3
11	3,600 - 3,700 MHz	Y	Refer to Table 3
12	3,700 - 3,800 MHz	Y	No Radio Regulations revision
13	3,800 - 4,200 MHz	Y	No Radio Regulations revision
14	4,400 - 4,500 MHz	Y	No Radio Regulations revision
15	4,500 - 4,800 MHz	Y	No Radio Regulations revision
16	4,800 - 4,990 MHz	Y	Refer to Table 3
17	5,350 - 5,470 MHz*		No Radio Regulations revision
18	5,725 - 5,850 MHz*		No Radio Regulations revision
19	5,925 - 6,425 MHz		No Radio Regulations revision

*Under consideration for additional spectrum for wireless LAN

and Arabia), Region 2 (North and South America) and Region 3 (Asia-Pacific), after which proposals for solutions were submitted for final consensus from each Region. As a result, initiatives to coordinate opinions were entrusted to regional groups rather than on a nation-by-nation basis.

Finally, consensus to revise the Radio Regulations was reached on the night before the final day of WRC-15, based on proposals coordinated by the regional groups. **Table 3** provides a summary of the results of new IMT spectrum identification, including proposed revisions.

3.1 470 - 694/698 MHz

Because these frequency bands are used in countries around the world to broadcast terrestrial television, many countries and regional groups were against identification of the bands for IMT. Nevertheless, with the aim of diverting the 600 MHz band to mobile broadband applications that will cover IMT, there was strong rallying mainly by the US for plans for an incentive auction*1. Finally, consensus was reached to identify the frequency bands for IMT for the North and Central American countries and some countries from the Oceania region (just over ten) after coordination with their surrounding countries.

3.2 1,427 - 1,452 MHz, 1,452 - 1,492 MHz, 1,492 - 1,518 MHz

Many countries supported IMT identification of these frequency bands, including Japan which is already using them for mobile phones, although regulatory methods regarding coexistence with aeronautical mobile telemetry systems*2 and broadcast satellite communications systems in some countries have become an issue.

As a result of discussions, identification for Region 1 1,452 - 1,492 MHz was limited to around 50 countries, although consensus was reached for other Regions for identification as IMT frequency bands. This means that 1,427 - 1,518 MHz is now almost completely recognized internationally as an additional spectrum for mobile phones.

3.3 3,300 - 3,400 MHz

While some countries asserted that this frequency band is suitable for IMT identification because usage with existing systems is limited, countries mainly in Europe expressed the opinion that it is not suitable because of usage with radar.

As a result of discussions, consensus was reached for identification as an IMT frequency band for some countries in the regions of Africa, Central and South America, and Asia (just over 40 countries) with the conditions that IMT radio station usage not interfere with radar, and conversely, protections from interference from radar not be sought.

3.4 3,400 - 3,600 MHz, 3,600 - 3,700 MHz, 3,700 - 3,800 MHz

Since these frequency bands are widely used with satellite communications systems, countries in which these systems constitute important infrastructure have consistently expressed opposition to their IMT identification. In the 2007 World Radiocommunication Conference (WRC-07) also, similar discussions were held on these frequency bands, and as a result, only 3,400 - 3,600 MHz was identified for just over 90 countries in Regions 1 and 3 (including Japan). In WRC-15, discussions followed a similar pattern, and the scope of the identification of 3,400 - 3,600 MHz was expanded in regions as an additional IMT spectrum, meaning that is now almost completely recognized internationally. Regional discussions were as follows.

(1) In Region 1, European countries supported IMT identification of 3,400 - 3,800 MHz, although support from others

*1 **Incentive auction:** A new spectrum auction technique to encourage spectrum diversion that returns some of the auction revenues to the original spectrum license holders.

*2 **Aeronautical mobile telemetry system:** A communication system that transmits data for aircraft meter readings etc, and enables aircraft monitoring and remote control.

Table 3 New IMT frequency band identification at WRC-15

Specified spectra	Region 1 (Europe, CIS, Arab, Africa) 122 countries	Region 2 (North and South America) 35 countries	Region 3 (Asia-Pacific) 36 countries
470 - 694/698 MHz (Section 3.1)	–	• 470 - 608 MHz Identified for 5 countries (US, Canada, Mexico, Bahamas, Barbados) • 614 - 698 MHz Identified for 7 countries (US, Canada, Mexico, Columbia, Bahamas, Barbados, Belize)	• 470 - 698 MHz Identified for 4 countries (Micronesia, Solomon Islands, Tuvalu, Vanuatu) • 610 - 698 MHz Identified for 3 countries (New Zealand, Bangladesh, Maldives)
694/698 - 790 MHz (Chapter 4)	Identified for entire Region (Agenda item 1.2)	Identified for entire Region (Identified in 2007)	Identified for 26 countries (Newly identified for 16 countries. Remaining 10 countries identified in 2007 (including Japan))
1,427 - 1,452 MHz (Section 3.2)	Identified for entire Region	Identified for entire Region	Identified for entire Region
1,452 - 1,492 MHz (Section 3.2)	Identified for 54 countries (Arabic, African countries)	Identified for entire region	Identified for entire Region
1,492 - 1,518 MHz (Section 3.2)	Identified for entire Region	Identified for entire Region	Identified for entire Region
3,300 - 3,400 MHz (Section 3.3)	Identified for 33 countries (African countries)	Identified for 6 countries (Mexico, Columbia, Argentina, Costa Rica, Ecuador, Uruguay)	Identified for 6 countries (Cambodia, India, Laos, Pakistan, Philippines, Vietnam)
3,400 - 3,600 MHz (Section 3.4)	Identified for entire Region	Identified for entire Region	• 3,400 - 3,500 MHz Identified for 11 countries (Newly identified for 2 countries. Remaining 9 countries identified in 2007 (including Japan)) • 3,500 - 3,600 MHz Identified for 10 countries (Newly identified for 2 countries. Remaining 8 countries identified in 2007 (including Japan))
3,600 - 3,700 MHz (Section 3.4)	–	Identified for 4 countries (US, Canada, Columbia, Costa Rica)	–
4,800 - 4,990 MHz (Section 3.5)	–	• 4,800 - 4,900 MHz Identified for 1 country (Uruguay)	Identified for 3 countries (Cambodia, Laos, Vietnam)

countries was limited. While 3,400 - 3,600 MHz was identified for IMT for the entire region, IMT identification above 3,600 MHz was postponed.

(2) In Region 2, 3,400 - 3,600 MHz was identified for IMT for the entire Region, only four countries including the US and Canada consented to IMT identification for the 3,600 - 3,700 MHz band. Also, IMT identification for the frequency band above 3,700 MHz was postponed.

(3) In Region 3, Japan initially aimed for IMT identification for 3,400 - 4,200 MHz, although after determining difficulty in identifying 3,800 MHz and above, this was narrowed down to 3,400 - 3,800 MHz, and supported in partnership with Korea, which supports the

same frequency band. However, the majority of countries advocated for protection of satellite communications systems. As a result of discussions, in Region 3, Australia and the Philippines were added as new countries for identification of 3,400 - 3,600 MHz, although IMT identification above 3,600 MHz was postponed.

3.5 4,400 - 4,500 MHz, 4,800 - 4,990 MHz

These frequency bands are supported for IMT identification by Japan, China, the CIS and some African countries. However, because these spectra are used for radio communications in aircraft etc. in European and some other countries, there were demands that strict conditions be met, such as restricting radio wave intensity so that signals emitted from implemented IMT radio stations stay within national borders, and that signals not exceed a certain level on the high seas. Also, since the effects of interference on aircraft radio altimeters using 4,200 - 4,400 MHz from the adjacent 4,400 - 4,500 MHz spectrum have not been studied, many voiced opposition due to safety concerns.

As a result of discussions, for these frequency bands, 4,800 - 4,900 MHz is only identified for IMT in one country in Region 2, and 4,800 - 4,990 MHz is identified in only three countries in Region 3. IMT identification for 4,400 - 4,500 MHz was postponed.

4. WRC-15 Agenda Item 1.2 (Use of the Frequency Band 694 - 790 MHz by the Mobile Service in Region 1)

This agenda item was set because, in WRC-12, 694 - 790 MHz was identified for IMT in Region 1, and new prescriptions and procedures for its technical and regulatory requirements would be made in WRC-15. As a result of discussions, regarding IMT station operation, official consensus was reached on requirements to protect terrestrial television broadcasting below 694 MHz, and protect radio communications systems for 645 - 862 MHz aeronautical radio navigation mainly used in CIS.

Also in the above WRC-15 agenda item 1.1, consensus was reached to newly identify the 698 - 790 MHz band for IMT in 19 countries in Region 3.

From the above, since IMT identification for Region 2 was already done in WRC-07, 694/698 - 790 MHz is now almost completely recognized internationally as additional mobile phone radio frequencies.

5. WRC-15 Agenda Item 10 (Future WRC Agenda Items)

As well as deliberations on revising the Radio Regulations, WRC also deliberates on selecting agenda items for the next two future WRCs. The following describes future WRC agenda items agreed upon through discussions at WRC-15.

5.1 Additional Identification of IMT Spectrum between 24.25 - 86 GHz (WRC-19 Agenda Item 1.13)

Studies on IMT identification in WRC have so far targeted frequency bands below 6 GHz, including the aforementioned WRC-15 agenda item 1.1. However, technical developments that enable higher frequency use than the conventional mobile phone radio-frequencies are progressing with 5G mobile communications systems. In light of these developments, various countries and regional groups proposed to set an agenda item for IMT identification above 6 GHz for WRC-19.

This quickly led to consensus being reached on setting a new agenda item for IMT identification for WRC-19, and discussions focused on which frequency ranges above 6 GHz should be targeted and the relevant studies

that should be carried out in ITU-R in the lead up to WRC-19. A list of the frequency bands proposed from the regional groups is shown in the upper part of **Figure 2**. In general, the regional proposals take into account the usage of existing radio communications systems (satellite communications, fixed communications etc.), and many of these proposals target the frequency bands above 25 GHz, because they can be secured for future IMT usage.

However, if studies are limited to frequency bands higher than 25 GHz, there are concerns about constraints being added to future development and deployment of the mobile communications systems. Therefore, Japan asserted that studies between the 6 - 20 GHz range should also be included. While there was support for this Japanese proposal from some African and Northern European countries, the majority of opinion was that the 6 - 20 GHz frequency bands could not be secured for future mobile phone use due to their dense use in many countries, hence, consensus was not reached.

Similarly, regarding 27.5 - 29.5 GHz advocated as a new frequency band for 5G mobile communications systems by the USA and Korea, having been originally secured as spectra for satellite communications systems, the majority of opinion was that there is not much potential for the frequency band to be used with mobile phones, hence, consensus was not reached.

In light of the above discussions,

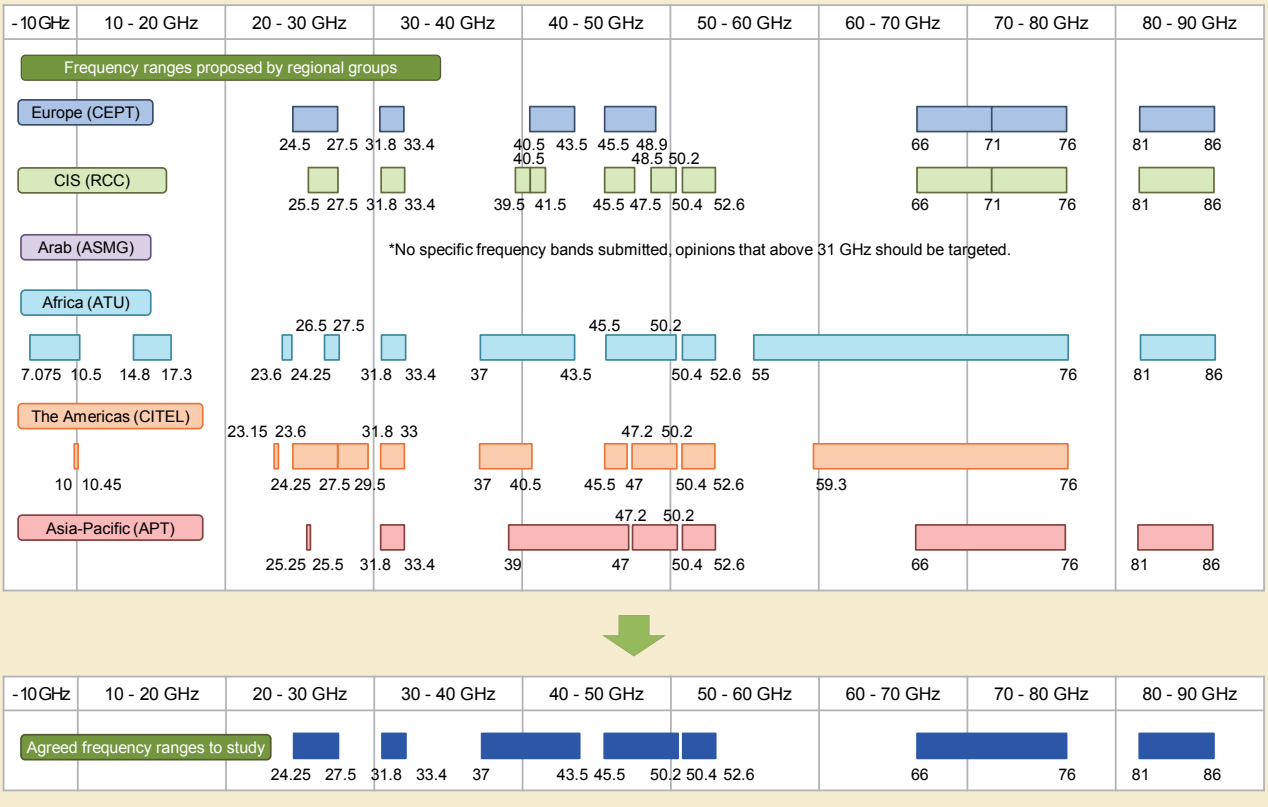

Figure 2 Frequency ranges to study for IMT identification in WRC-19

to identify IMT frequency bands at WRC-19, it was agreed that a number of frequency bands between 24.25 - 86 GHz, shown in the lower part of Fig. 2, should be studied in ITU-R in the lead up to WRC-19.

5.2 Other Future WRC Agenda Items

Other mobile phone and wireless LAN-related agenda items agreed upon for WRC-19 are as follows.

Based on proposals from the USA and others, for spectrum of wide-band radio access systems including wireless LAN, it was agreed that studies be carried out and conclusions reached at WRC-19 for the potential use of the new 5,350 - 5,470 MHz, 5,725 - 5,850 MHz, 5,850 - 5,925 MHz and the existing 5,150 - 5,350 MHz bands with outdoor wireless LAN systems (WRC-19 agenda item 1.16).

Also, based on proposals from the Arabic countries, regarding the Internet of Things (IoT)[*3] concept, it was agreed that wide and narrow-band frequency bands for M2M communications infrastructure be studied in ITU-R, and be studied as required in WRC-19 (one of the issues in WRC-19 agenda item 9.1).

6. Conclusion

This article has provided and overview of WRC-15, and reported on its deliberations regarding additional identification of frequency bands for IMT, and the results of those deliberations. Through the agreements made at WRC-15 to revise the Radio Regulations, the 694/698 - 790 MHz, 1,427 - 1,518 MHz and 3,400 - 3,600 MHz frequency bands already in use or planned for use (partially) with mobile phones, even in Japan, were identified as additional IMT frequency bands, which means these bands are now mostly recognized for mobile phone use internationally. Going forward, the use of these bands in various countries will bring about commonalities with everything from components through to whole radio devices, which will confer benefits such as cost reductions.

In contrast, Japan's advocacy for additional identification of 3,600 - 4,200 MHz and 4,400 - 4,900 MHz as IMT frequency bands was met with opposition from countries focusing on applications other than mobile phones, meaning that only some of those bands were identified for IMT for some countries. This is because usage varies from country to country, and inevitably some candidate frequency band would be difficult to co-exist with incumbent systems between adjacent and peripheral countries, a fact which has made identifying frequency bands for IMT even more difficult. Furthermore, although IMT identification in the Radio Regulations is usually done at the global and regional levels, it was apparent that this WRC was an opportunity to review the positioning and objective of IMT identification, as there were examples of identifications also being made under conditions set down at the level of a few countries.

Heading towards WRC-19, studies on new IMT identification between 24.25 - 86 GHz will proceed. In the week following WRC-15, the 1st session of the Conference Preparatory Meeting for WRC-19 (CPM19-1) was held, in which a new dedicated group was set up in ITU-R. In the group, relevant experts will come together to drive study of spectrum sharing between IMT and existing radio communications systems. At WRC-19, to revisit the original purpose of IMT identification in the Radio Regulations, it will be necessary to further cooperation in technical studies between many of the countries and regions of the world, and deepen mutual understanding about IMT identification in this coming three-year preparatory period. NTT DOCOMO also intends to continue various technical studies for presentation in discussions on identification of new IMT frequency bands.

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*3 **IoT:** A General term for controls and data communications between various "things" connected via the Internet and cloud services.