

# The Future Development of IMT-2000 and Systems Beyond (IMT-Advanced)

—Report from ITU-R World Radiocommunication Conference 2007 (WRC-07)—

*WRC of ITU was held for a four-week period from October 22 to November 16, 2007 in Geneva, Switzerland. This article reports on the main results and views expressed at the conference pertinent to mobile communications.*

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## 1. Introduction

Radio waves used in radio communications are defined by the International Telecommunication Union (ITU) to be electromagnetic waves up to a frequency of 3,000 GHz. The radio spectrum is a limited resource. It must be used rationally, efficiently and economically by the member countries of the ITU in an orderly and mutually accommodating manner. The Radio Regulations (RR), complementing the Constitution and the Convention of the ITU, establishes provisions in the international use of radio frequencies, including the use of frequency bands, the use of geostationary satellite orbits, and other regulatory, operational and technical matters of radio stations. The RR is necessary to avoid harmful interference between radio stations and to facilitate the efficient and effective

operation of all radio communications services. The use of radio waves in mobile communications is also based on the RR.

The World Radiocommunication Conference (WRC) has the responsibility of revising the RR. It is held every three or four years and is attended by concerned group members including governmental agencies and telecommunication carriers registered with the ITU. Each WRC meets for a period of about four weeks, which is the longest period of any radio-related meetings in the ITU. The decisions made at the WRC are used as a basis by each member state of the ITU to determine national policy on spectrum use.

## 2. WRC-07 Geneva Meeting

### 2.1 Overview

The 2007 World Radiocommunication Conference (WRC-07) was

attended by about 2,800 delegates from 164 countries, the largest turnout ever. Japan was represented by about 80 delegates representing the Ministry of Internal Affairs and Communications, telecommunication carriers, and broadcasters. NTT DoCoMo was represented by six delegates in all, four being the authors of this article and the two others being directors Tomohiko Ozaki and Kenji Furukawa of the Network Planning Department.

### 2.2 Main Agenda Items and Conference Structure

**Figure 1** shows the structure of the WRC-07. The agenda items related to the various types of radio communication services were handled by Committee 4 (COM-4) and COM-5, the latter of which was chaired by NTT DoCoMo's Dr. Akira Hashimoto, Managing Director of Wireless Tech-

# Standardization

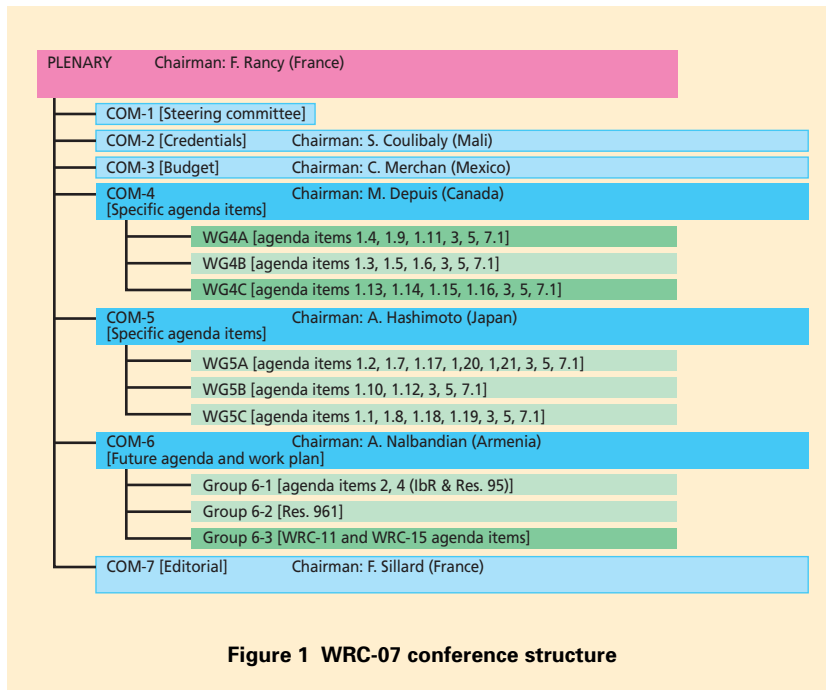


Figure 1 WRC-07 conference structure

nology Standardization Department. Among these agenda items, agenda item 1.4, the ensuring of new spectrum for International Mobile Telecommunications (IMT), the generic term for Third-Generation mobile communication systems (IMT-2000) and Fourth-Generation mobile communication systems (IMT-Advanced), and agenda item 1.9, spectrum sharing in the 2.5 - 2.6 GHz band by space and terrestrial services, were discussed by Working Group 4A (WG4A) of COM-4. In addition, the selection of agenda items to be discussed at the next WRC and the selection of provisional agenda items that should be taken up at other future WRCs were discussed in COM-

6. Each WG consisted of Sub-Working Groups (SWGs) corresponding to specific agenda items. A SWG could consist of ad hoc groups<sup>\*1</sup> and drafting groups<sup>\*2</sup> corresponding to individual study items as the need arose.

### 3. New Radio Spectrum for IMT (agenda item 1.4)

#### 3.1 Background

IMT-2000 technology has begun to spread rapidly throughout the world. There is increasing demand for high-speed data communications, mobile terminals that can be used anywhere in the world, and diversified applications, all of which have their roots in IMT-2000. Against this background, the

ITU Radiocommunication sector (ITU-R) has formulated a vision for a mobile communication system for 2010 and beyond. This vision indicates the need for a new mobile communication system (IMT-Advanced) targeting maximum bit rates of 100 Mbit/s in a mobile environment and 1 Gbit/s in a quasi-stationary environment. Here, frequency bands with wide bandwidths are indispensable for a new mobile radio communication system featuring such high speed data transmission. In addition, the pervasion of IMT-2000 revealed the convenience of using a mobile terminal across national borders making international roaming an indispensable feature for future mobile systems. With these demands in mind, there were increasing calls for new, sufficiently wide frequency bands for mobile communications that could be used on a worldwide basis. In response to these calls, the 2003 WRC (WRC-03) established an agenda item on radio spectrum for IMT-2000 and systems beyond IMT-2000 (WRC-07 agenda item 1.4). In response to WRC-07 agenda items, ITU-R conducted technical studies on spectrum bandwidth requirements for IMT (IMT-2000 and IMT-Advanced) and concluded that the required spectrum bandwidth up to the year 2020 was 1,280 MHz even for countries with

\*1 **ad hoc group:** An interim group that is formed when opinions on a specific issue in the conference must be coordinated and a solution to that issue found.

\*2 **Drafting group:** A group that is formed to prepare documents as a draft on a specific

item and to pass the drafts to higher-level meetings for their consideration.

low user demand and 1,720 MHz for regions with high user demand. These frequency bandwidths include those that are already being used in Second and Third-Generation mobile communication systems. **Table 1** shows specific candidate bands presented by ITU-R and their advantages and disadvantages. Of these, the bands under 1,000 MHz are said to be “coverage bands” mainly for improving the service area of IMT-2000 systems and for eradicating areas in which no IMT-2000 services are provided. At ITU, these are considered to be important bands for solving the digital divide under the slogan “connecting the

unconnected.” The frequency bands above 1,000 MHz are said to be “capacity bands” for accommodating high-capacity multimedia mobile communications. These bands are also considered at ITU to be important bands for the deployment of IMT-Advanced. WRC-07 started discussions on new frequency bands for IMT based on these results of the ITU-R studies.

### 3.2 Summary of Discussions

Similar to the results of the ITU-R study, many countries at WRC-07 expressed their support for identification of both coverage and capacity bands for IMT on a worldwide basis.

However, as a detailed discussion began on which candidate bands should be identified, the trend was for individual countries to advocate different frequency bands in order to protect existing services (broadcasting, fixed satellite, radar, etc.) in their own countries. This made the discussions extremely difficult.

At WRC, regional opinions usually carry weight in forming a conclusion, and there are six regional bodies whose opinions can have a big impact on decisions at WRC. These are the African Telecommunications Union (ATU), Asia-Pacific Telecommunity (APT), Arab Spectrum Management

**Table 1 Candidate bands and their advantages and disadvantages**

Candidate Band (MHz)	Advantages	Disadvantages
410 - 430	<ul style="list-style-type: none"> <li>• Small propagation loss with efficient area coverage</li> <li>• Already allocated to mobile services on a worldwide basis</li> </ul>	<ul style="list-style-type: none"> <li>• Cannot provide a sufficiently wide block of spectrum for IMT</li> <li>• Used by existing land mobile services, including PPDR*<sup>1</sup> in urban areas</li> </ul>
450 - 470	<ul style="list-style-type: none"> <li>• Small propagation loss with efficient area coverage</li> <li>• Already has a primary allocation*<sup>2</sup> to mobile services on a worldwide basis</li> </ul>	<ul style="list-style-type: none"> <li>• Cannot provide a sufficiently wide block of spectrum for IMT</li> <li>• Used by existing land mobile services, including PPDR in urban areas</li> </ul>
470 - 806/862	<ul style="list-style-type: none"> <li>• Can be flexibly used for IMT after the switchover of TV broadcasting to digital</li> <li>• Upper part of the band is close to existing IMT bands</li> <li>• Already allocated to mobile services on a co-primary basis in ITU Region 3</li> </ul>	<ul style="list-style-type: none"> <li>• Has a primary allocation for broadcasting service on a worldwide basis</li> <li>• In Region 1, it is difficult to reach consensus on frequency channel arrangement due to GE-06 plan</li> </ul>
2,300 - 2,400	<ul style="list-style-type: none"> <li>• Close to existing IMT band (2.5 GHz)</li> <li>• Already has a co-primary allocation to fixed and mobile services on a worldwide basis</li> </ul>	<ul style="list-style-type: none"> <li>• Cannot provide a sufficiently wide block of spectrum for broadband IMT</li> <li>• Currently being used or planned for use by other services such as aeronautical telemetry*<sup>3</sup></li> </ul>
2,700 - 2,900	<ul style="list-style-type: none"> <li>• Close to an existing IMT band (2.5 GHz)</li> </ul>	<ul style="list-style-type: none"> <li>• Used by aeronautical and weather radar</li> <li>• Has a primary allocation to aeronautical radionavigation services</li> <li>• No primary allocation to mobile services in any ITU region</li> </ul>
3,400 - 4,200	<ul style="list-style-type: none"> <li>• Can provide a sufficiently wide block of spectrum necessary for broadband IMT</li> <li>• The 3,500 - 4,200 MHz portion of the band is allocated to mobile services on a primary basis in some countries in Regions 2 and 3</li> </ul>	<ul style="list-style-type: none"> <li>• Earth stations for Fixed Satellite Service (FSS) are widely deployed</li> <li>• Part of the band is used by airborne and shipborne radar</li> <li>• The 3,400 - 4,200 MHz band has a primary allocation for fixed and fixed-satellite services in Regions 2 and 3</li> </ul>
4,400 - 4,990	<ul style="list-style-type: none"> <li>• Can provide a sufficiently wide block of spectrum necessary for broadband IMT</li> <li>• Has a primary allocation to mobile service in all ITU regions</li> </ul>	<ul style="list-style-type: none"> <li>• The 4,500 - 4,800 MHz band is a FSS plan for developing countries under Appendix 30B of Radio Regulations</li> </ul>

\* 1 Public Protection and Disaster Relief (PPDR): Communications for public safety and disaster relief/rescue in case of emergency

\* 2 Primary allocation: A form of frequency allocation that gives priority use to the radio service specified

\* 3 Aeronautical telemetry: Communications for reporting information on measurement values onboard or for operation monitoring or remote control of airplanes

## Standardization

Group (ASMG), Conference Européenne des administrations des Postes et des Télécommunications (CEPT), La Comisión Interamericana de Telecomunicaciones (CITEL), and Regional Commonwealth in the field of Communications (RCC). However, with regard to agenda item 1.4 at WRC-07, intra-regional opinions lacked coordination, and for some candidate bands, no unified view could be reached in certain regions. The opinions set forth by individual countries and regions on specific candidate bands are summarized below.

- 450 - 470 MHz band

This band is already being used for IMT-2000 in some countries. Its identification for IMT is supported by Asia and Pacific countries, RCC countries, and North and South American countries but strongly opposed by European countries for the sake of protecting existing services. Japan is also opposed to using this band for IMT from the view of protecting existing services.

- 470 - 806/862 MHz band

Due to the switchover from analog terrestrial broadcasting to digital terrestrial broadcasting, this band has the potential of being used for radio communication services other than broadcasting in the

future. In the United States, it has already been decided internally that a portion of this band will be used for IMT. The United States therefore worked hard and succeeded in obtaining support from other North and South American countries. Based on this support, the United States strongly insisted on the identification of this band for IMT on a global basis. The RCC countries, on the other hand, strongly opposed this view for the reasons that the demand for terrestrial TV broadcasting will still be high even after the switchover to digital broadcasting and that aeronautical radio services in this band must be protected. At the same time, the Asia-Pacific, African and European regions could not reach an agreement due to diverse opinions between broadcasting-oriented and mobile-oriented countries in these regions.

- 2,300 - 2,400 MHz band

The People's Republic of China has already decided to use this band internally for IMT-2000 and the Republic of Korea has decided to use it for Wireless Broadband (WiBro). Consequently, China and Korea together with other Asia-Pacific countries have expressed support for the use of

this band for IMT. African and Middle East countries have also backed the use of this band for IMT, while European countries led by France, Japan and North and South American countries have voiced strong opposition in order to protect existing services in their countries.

- 3,400 - 4,200 MHz band

Various countries and regions advocate the use of this band in whole or in part for mobile communications. Specifically, Europe backs the 3,400 - 3,800 MHz portion for this purpose, South and North African countries the 3,400 - 3,600 MHz portion, Japan and Korea the entire 3,400 - 4,200 MHz band, India, Pakistan and Singapore a part of the band and the Middle East states of Oman, Bahrain and Jordan the entire 3,400 - 4,200 MHz band. This band, however, features low rainfall attenuation in radio-wave propagation. As a result, countries near the equator that strongly advocate the use of this band for stable, fixed satellite communication links as part of their infrastructure (Asia-Pacific countries, central African countries and northern South American countries) have expressed strong opposition to the

identification of this band for mobile communications.

- 4,400 - 4,990 MHz band

Japan and Mongolia have voiced support for this band while many countries have strongly opposed it from the view of protecting existing services.

To break the above discussions, the WRC-07 chairman proposed a compromise in the form of a “fruit basket” plan. Here, considering that the frequency bands desired by each country differ and that agreement on which bands to use couldn’t be reached, the candidate bands advocated by each country (where the different bands favored by each country can be likened to different types of fruit) are all thrown into a basket. The basket is then agreed upon as a package and each country then selects those bands (fruits) that it has judged to be usable from the basket and proceeds to use them.

The 410 - 430 MHz and 2,700 - 2,900 MHz bands that received no support from any country were removed as targets of discussion, so that agreement was at least reached on these two bands. For all other candidate bands, however, there was much discussion as to which bands should be allowed to be entered into the basket, and much confrontation ensued right up to the

last week of the conference.

In particular, debate on use of the 470 - 806/862 MHz band, for which countries placing priority on broadcasting services strongly opposed countries placing priority on mobile communication services, and debate on the use of the 3,400 - 4,200 MHz band, for which countries placing priority on fixed satellite service strongly opposed countries placing priority on mobile communication services, remained in the last week of the WRC.

As for the 470 - 806/862 MHz band, plans for the analog-to-digital switchover of TV broadcasting in ITU Region 1 (Europe, Middle East countries, Africa) are progressing based on the GE-06 plan<sup>\*3</sup>, and countries that advocate the use of this band for broadcasting services were resolutely opposed to its use for IMT until the switchover was completed. As a result, no agreement at all could be reached in Region 1.

The 3,400 - 4,200 MHz band was the last matter to be taken up, and the RCC countries that resolutely opposed the use of this band for IMT eventually compromised allowing for the 3,400 - 3,600 MHz portion of the band to be used. Discussions were subsequently focused on this 3,400 - 3,600 MHz band that had relatively much support. The 3,400 - 3,700 MHz band had been designated as a future-expansion band

for fixed satellite service, which is why compromise on this band was relatively easy compared to that of the 3,700 - 4,200 MHz band on which existing satellite systems have been widely deployed in many countries.

The following bands were eventually identified for IMT, which constitutes a total bandwidth of 428 MHz:

- 1) 3,400 - 3,600 MHz band (200 MHz bandwidth)
- 2) 2,300 - 2,400 MHz band (100 MHz bandwidth)
- 3) 698 - 806 MHz band (108 MHz bandwidth)
- 4) 450 - 470 MHz band (20 MHz bandwidth)

**Figure 2 and 3** show the frequency bands that can now be used for IMT. Each country can use the bands if it wishes to implement IMT. Japan would start implementation of IMT by using bands 1) and 3) first among the above bands.

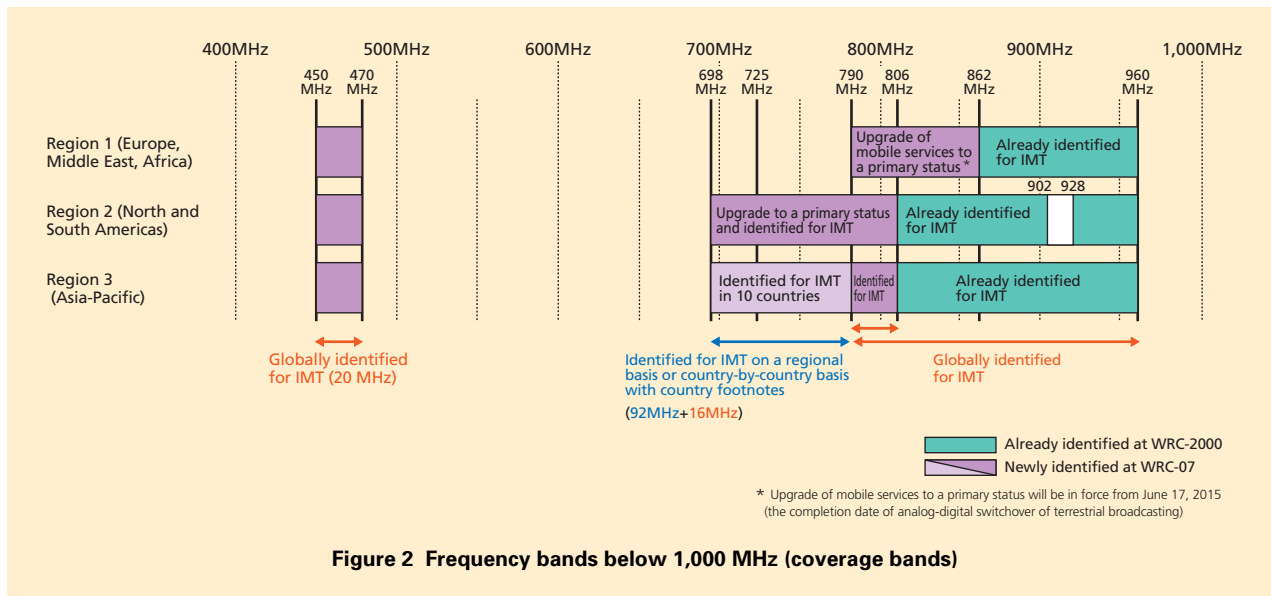
## 4. Use of 2.5 GHz Band for Satellite Communications and Terrestrial Mobile Communications (agenda item 1.9)

### 4.1 Background

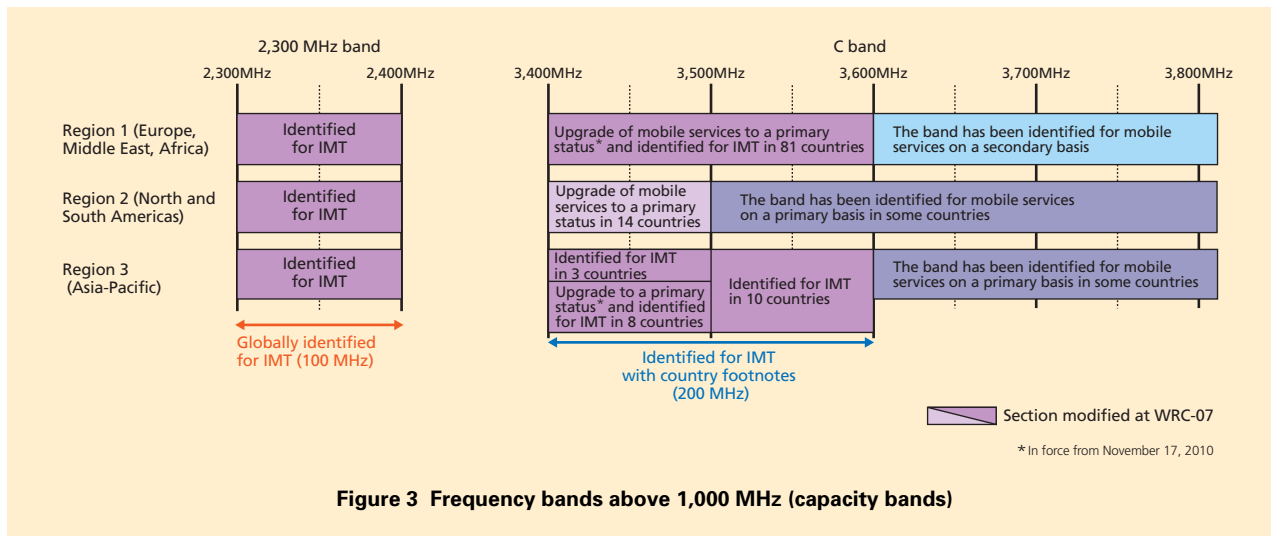
The 2.5 GHz band has come to be used for both satellite communications and terrestrial mobile communications.

<sup>\*3</sup> **GE-06 plan:** A treaty on a plan for analog-to-digital switchover of terrestrial broadcasting concluded in Geneva in 2006.

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**Figure 2 Frequency bands below 1,000 MHz (coverage bands)**



**Figure 3 Frequency bands above 1,000 MHz (capacity bands)**

However, with increase in the demand for spectrum by terrestrial mobile-communication systems, it was decided at WRC-2000 to identify this band for IMT-2000 use. Europe proposed this agenda item at WRC-03 to safeguard the use of this band for IMT-

2000 terrestrial systems by limiting the output power emission by radio stations of satellite communication services.

## 4.2 Summary of Discussions

With regard to agenda item 1.9 on

the prioritized use of the 2.5 GHz band for either satellite communications or terrestrial mobile communications, ITU-R conducted a technical study on limiting output power emission. Judging from the proposals made by individual countries around the world to

WRC-07, it was found that the majority of these proposals called for a priority to be set on the use of terrestrial mobile communications in this band. It was consequently decided that severe power limitations be imposed on satellite communication systems that share this frequency band. Here, however, Japan and India, which are currently operating mobile satellite systems in this band, were excluded from this new stipulation.

## 5. WRC-11 Agenda Items

In addition to discussing revisions to RR, the WRC also decides on agenda items for the next WRC and the one after that. The following four agenda items in relation to mobile communications were set for WRC-11.

- Taking into account the ITU-R studies, take appropriate action with a view to enhancing the international regulatory framework (agenda item 1.2)
- Consider results of sharing studies between mobile services and other services in the 790 - 862 MHz band in Regions 1 and 3 (agenda item 1.17)
- Consider regulatory measures and their relevance in order to enable

the introduction of software-defined radio<sup>\*4</sup> and cognitive radio systems<sup>\*5</sup> (agenda item 1.19)

- Examine the effects of emissions from short-range devices on radiocommunication services (agenda item 1.22)

In comparison with the framework traditionally used by ITU-R for mobile services and fixed services, the boundary between fixed radio and mobile radio is becoming increasingly blurred as reflected by recent technologies of wireless access systems. Agenda item 1.2 seeks to revise this boundary between mobile services and fixed services. Agenda item 1.17 will investigate spectrum sharing in the 790 - 862 MHz band among mobile services, including IMT, broadcast service, and aeronautical mobile service. Discussions will be held on the potential use of this band after the analog-to-digital switchover of TV broadcasting from the viewpoint of spectrum sharing. Agenda item 1.19 has been set based on a proposal from Europe and the Middle East, and it will discuss definitions of cognitive radio systems and software defined radio systems and how to view them within the regulato-

ry framework of the RR. Finally, Agenda item 1.22 will examine the effects of short-range radio devices such as Radio Frequency Identification (RFID) on radiocommunication services.

## 6. Conclusion

This article reported on the discussions at WRC-07 held in Geneva and presented main results relating to mobile communications. The agenda item gathering most attention at this conference was the identification of frequency bands for IMT. A total spectrum bandwidth of 428 MHz has been newly identified for IMT at WRC-07 exceeding the total frequency bandwidth of 333 MHz currently in use for mobile cellular systems in Japan.

In response to these spectrum-identification results from WRC-07, the standardization of IMT-Advanced radio-interface technology will begin led by ITU-R. In the years to come, active participation in and contribution to international standardization in a harmonized manner will be essential to early deployment of IMT-Advanced systems.

\*4 **Software-defined radio:** Radio communication in which the RF operating parameters including, frequency range, modulation type, or output power can be set or altered by software, and/ or the technique by which this is achieved.

\*5 **Cognitive radio system:** Radio communication in which the optimum frequency and communication systems are selected according to the radio wave environment. There is no fixed definition, however, and the definition of "cognitive radio systems" is included in a Question of ITU-R.