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IMT for 2020 and Beyond

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6.1 Introduction

Work on International Mobile Telecommunications (IMT) has been ongoing for nearly three decades in ITU. This has been an open process which has included ITU's Member States, national and regional standards development organizations, equipment manufacturers, network operators, as well as academia and industry forums.

With the development of the IMT-2000 3G mobile systems and the current deployments of the IMT-Advanced 4G systems, this activity has revolutionized the way people communicate around the world. ITU is now working together with these partners in the same open process to develop the standards for IMT-2020.

A vital element in the standardization process has been the identification and global harmonization of frequency bands for the operation of IMT, thereby enabling interoperability, roaming and global economies of scale.

This Chapter outlines the process and timeline for standardizing IMT-2020, and the current status of this work. It also provides a perspective of the key technical requirements and spectrum aspects to address to finalize the standard in 2020.

6.2 Background

The second generation of mobile telephone systems were developed in the late 1980's and initially deployed in the early 1990's. Certainly the transition from the first to the second generation of mobile phones was characterized by the

change from analog to digital communications, but it was also characterized by the growing requirement for these systems to operate on a regional, if not global, basis.

Regional/global operation of these systems was hampered by having multiple incompatible standards as well as different frequency bands and channel arrangements being used in different parts of the world. This in turn had a significant impact on the cost, and hence affordability, of these systems. Recognizing this, the ITU membership established a group of experts to study the requirements of future public land mobile telecommunications systems (FPLMTS).

Studies on FPLMTS were conducted in the CCIR (the former ITU-R) Interim Working Party 8/13, with the first substantive output being a decision by the 1992 World Administrative Radiocommunication Conference to identify specific frequency bands for the operation of FPLMTS. The studies then focussed on developing the set of detailed radio interface specifications for FPLMTS.

ITU-R Task Group 8/1 was established to develop these 3G radio interface specifications, which were finally approved in May 2000 in Recommendation ITU-R M.1457 – “Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)” [1]. The name change from FPLMTS to IMT and the principles and process for the further development of IMT were established by the ITU Radiocommunication Assembly 2000 in ITU-R Resolutions 56 [2] and 57 [3].

ITU-R Working Party 5D was subsequently established to continue the work on IMT. In close collaboration with the relevant national and regional standards development organizations, a yearly update process for IMT-2000 was applied to cater for the evolution and enhancement of the standard. ITU-R Recommendations were also developed to address the implementation aspects of IMT-2000 such as global circulation of terminal equipment, radio frequency channel arrangements and sharing studies between IMT and other radio services. In parallel, successive World Radiocommunication Conferences have periodically identified additional frequency bands for IMT to cater for the rapidly growing demand for mobile communications, particularly mobile broadband data.

At the same time, Working Party 5D initiated work to address the need for a global platform on which to build the next generations of mobile services – fast data access, unified messaging and broadband multimedia: IMT-Advanced. The IMT-Advanced radio interface specifications were finalized in 2012 and are specified in Recommendation ITU-R M.1212 – “Detailed specifications of

the terrestrial radio interfaces of International Mobile Telecommunications Advanced (IMT-Advanced)” [4]. These 4G systems are currently being deployed throughout the world, and it is expected that these systems will continue to evolve and be enhanced in the coming years.

With an eye to the longer term requirements, in 2012 Working Party 5D then commenced studies on the next phase of development: IMT-2020. It is planned to finalize the IMT-2020 specifications in the year 2020.

6.3 IMT-2020 Standardization Process

The process for developing the IMT-2020 radio interface specifications is shown in Figure 6.1 and is similar to the process that was successfully applied in the development of the IMT-2000 and IMT-Advanced standards. It is important to stress that the development of the IMT standards is not carried out by ITU alone. It is a highly collaborative process with substantial input from and coordination with all involved national, regional and international standards development organizations, partnerships and fora.

The first step of the process was to establish the vision for IMT for 2020 and beyond, by describing potential user and application trends, growth in traffic, technological trends and spectrum implications, and by providing guidelines

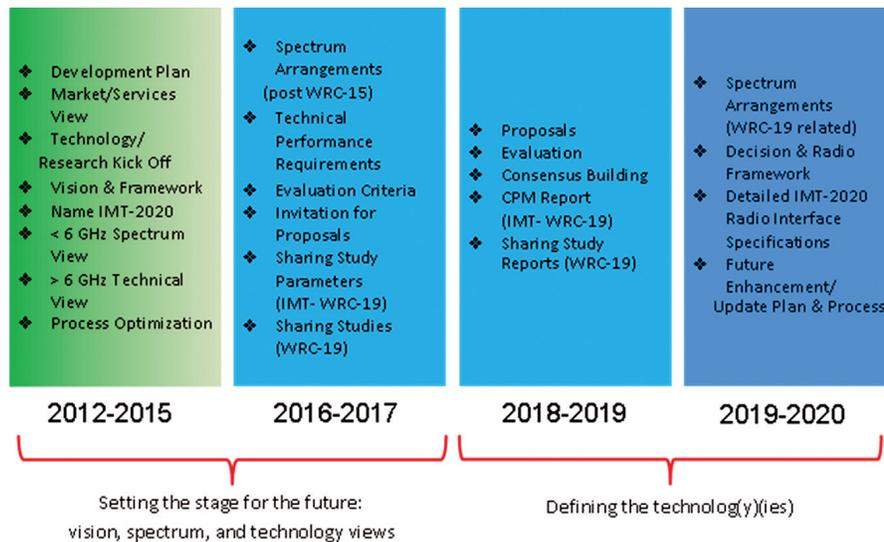


Figure 6.1 The IMT-2020 standardization process.

on the framework and the capabilities for IMT for 2020 and beyond. This work reached a significant milestone with the approval of Recommendation ITU-R M.2083 – “IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond” [5] in September 2015.

The ITU has now issued the invitation for submission of proposals for candidate radio interface technologies for the terrestrial components of the radio interface(s) for IMT-2020 and invitation to participate in their subsequent evaluation in Circular Letter 5/LCCE/59 [6] on 22 March 2016.

The next step, planned for 2016–2017, has now commenced, with studies being undertaken to review how best to make use of the spectrum identified for IMT at world radiocommunication conferences (WRCs), including the recent WRC-15 held in November 2015. It will also be necessary to establish the detailed technical requirements and a set of criteria to support the evaluation of proposals for the radio interfaces for IMT-2020.

The submission of proposals is expected to begin in October 2017 and end by mid-2019. The evaluations against the criteria will then be carried out by independent evaluation groups established for this purpose, and participation in these groups is not limited to ITU members. In the past there has been a very good level of participation in these evaluation activities with the active involvement of Administrations, equipment manufacturers, network operators and academia.

The evaluation reports from the evaluation groups are presented and considered in Working Party 5D and form a basis for developing the consensus on which proposed interfaces should be included in the IMT-2020 standard.

While the 2015 World Radiocommunication Conference made good progress in identifying additional frequency bands and globally harmonized arrangements below 6 GHz for the operation of IMT, it also recognized the potential future requirement for large contiguous blocks of spectrum for this application. Consequently, it called for 11 frequency bands above 24 GHz to be studied by ITU-R as bands that may be identified for future use by IMT at the next World Radiocommunication Conference in 2019 (WRC-19). As a parallel activity, the bands considered as suitable for IMT operation need to be identified and sharing studies associated with the use of these bands need to be conducted in preparation for WRC-19, and these decisions regarding spectrum use will need to be taken into account in developing the final IMT-2020 specifications.

The overall timeline for the standardization of IMT-2020 is presented in Figure 6.2, with final approval of the IMT-2020 specifications expected in around the 3rd quarter of 2020.

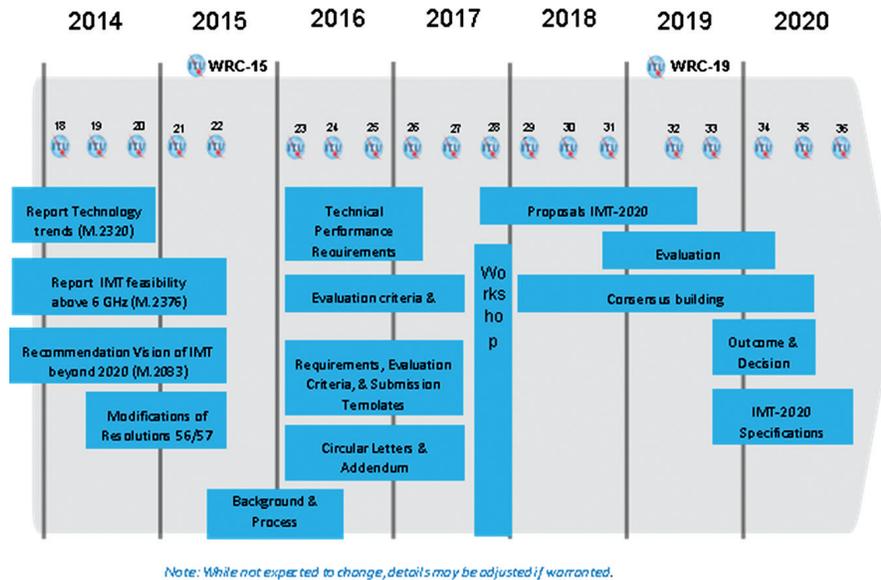


Figure 6.2 Overall timeline for the standardization of IMT-2020.

6.4 Overview of IMT-2020

It is envisaged that IMT-2020 will expand and support diverse usage scenarios and applications that will extend beyond those currently supported by IMT systems. A broad variety of capabilities will need to be tightly coupled with these intended different usage scenarios and applications for IMT-2020.

6.4.1 Usage Scenarios of IMT-2020

Three main usage scenarios for IMT-2020 have been identified in Recommendation ITU-R M.2083, “IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond”, which are enhanced mobile broadband, ultra-reliable and low latency communications, and massive machine-type communications. Additional use cases are expected to emerge, which are currently not foreseen. For future IMT, flexibility will be necessary to adapt to new use cases that come with a widely varying range of requirements.

IMT-2020 will encompass a large number of different features. Depending on the circumstances and the different needs in different countries, future IMT

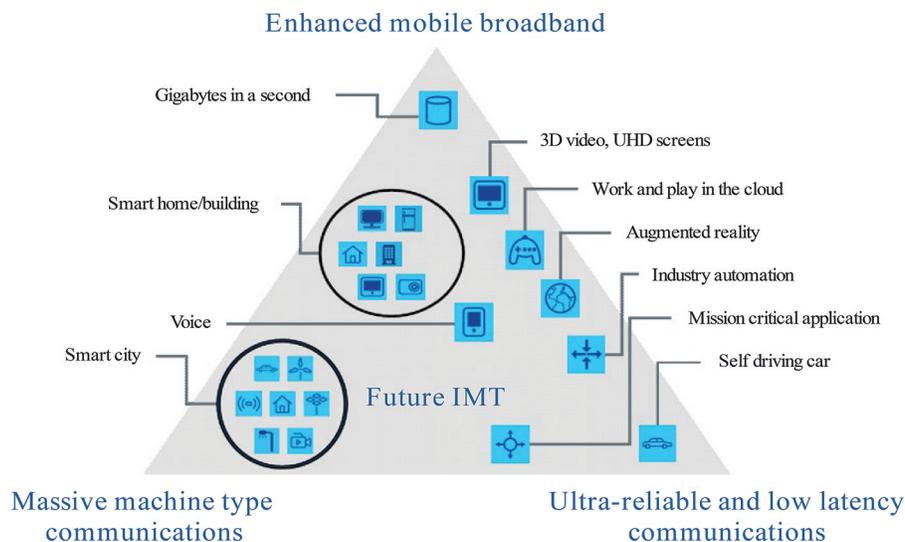


Figure 6.3 Usage scenarios of IMT-2020.

systems should be designed in a highly modular manner so that not all features have to be implemented in all networks.

Figure 6.3 illustrates some examples of envisioned usage scenarios for IMT-2020.

6.4.2 Capabilities of IMT-2020

IMT-2020 systems are mobile systems that include the new capabilities of IMT that go beyond those of IMT-Advanced. IMT-2020 systems will need to support low to high mobility applications and a wide range of data rates in accordance with user and service demands in multiple usage scenarios. IMT-2020 also needs to have capabilities for high quality multimedia applications within a wide range of services and platforms, providing a significant improvement in performance and quality of service. The key design principles of capabilities of IMT-2020 are flexibility and diversity to serve many different use cases and scenarios.

The following eight parameters are considered to be key capabilities of IMT-2020:

Peak data rate

Maximum achievable data rate under ideal conditions per user/device (in Gbit/s).

User experienced data rate

Achievable data rate that is available ubiquitously across the coverage area to a mobile user/device (in Mbit/s or Gbit/s).

Latency

The contribution by the radio network to the time from when the source sends a packet to when the destination receives it (in ms).

Mobility

Maximum speed at which a defined QoS and seamless transfer between radio nodes which may belong to different layers and/or radio access technologies (multi-layer/-RAT) can be achieved (in km/h).

Connection density

Total number of connected and/or accessible devices per unit area (per km²).

Energy efficiency

Energy efficiency has two aspects:

- on the network side, energy efficiency refers to the quantity of information bits transmitted to/received from users, per unit of energy consumption of the radio access network (RAN) (in bit/Joule);
- on the device side, energy efficiency refers to quantity of information bits per unit of energy consumption of the communication module (in bit/Joule).

Spectrum efficiency

Average data throughput per unit of spectrum resource and per cell (bit/s/Hz).

Area traffic capacity

Total traffic throughput served per geographic area (in Mbit/s/m²).

The key capabilities of IMT-2020 are shown in Figure 6.4, compared with those of IMT Advanced.

6.5 Key Technology Enablers

Report ITU-R M.2320 [7] provides a broad view of future technical aspects of terrestrial IMT systems considering the timeframe 2015–2020 and beyond. It includes information on technical and operational characteristics of IMT systems, including the evolution of IMT through advances in technology and

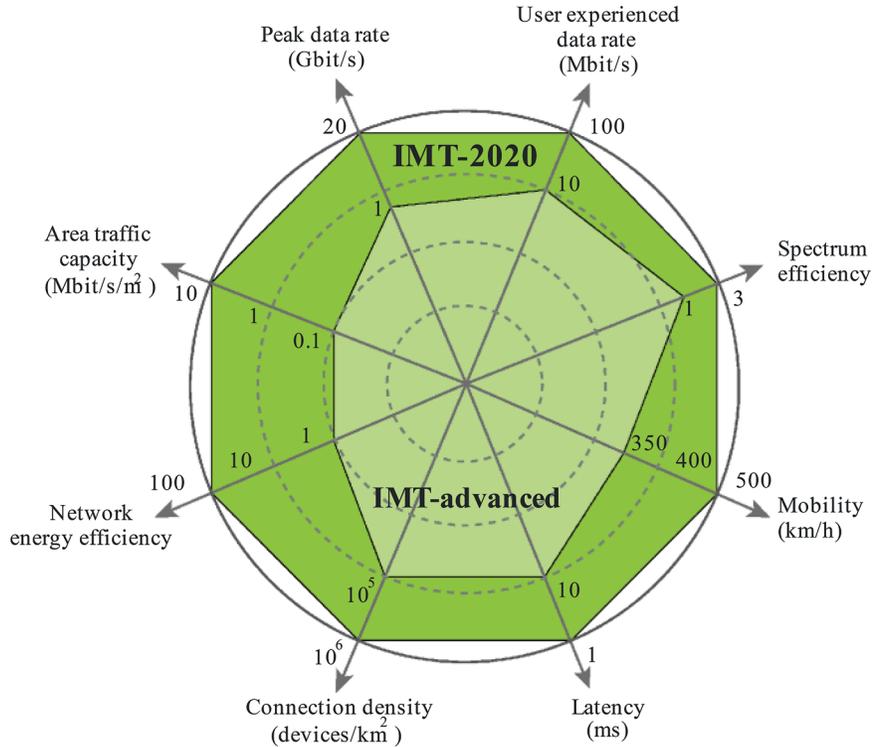


Figure 6.4 Enhancement of key capabilities from IMT-Advanced to IMT-2020.

spectrally-efficient techniques, and their deployment. Key technologies that are expected to influence the development of IMT-2020 are briefly described below.

6.5.1 Technologies to Enhance the Radio Interface

Advanced waveforms, modulation and coding, and multiple access schemes, e.g., filtered OFDM (FOFDM), filter bank multi-carrier modulation (FBMC), pattern division multiple access (PDMA), sparse code multiple access (SCMA), interleave division multiple access (IDMA) and low density spreading (LDS) may improve the spectral efficiency of the future IMT systems.

Advanced antenna technologies such as 3D-beamforming (3D-BF), active antenna system (AAS), massive MIMO and network MIMO will achieve better spectrum efficiency.

In addition, TDD-FDD joint operation, dual connectivity and dynamic TDD can enhance the spectrum flexibility.

Simultaneous transmission and reception on the same frequency with self-interference cancellation could also increase spectrum efficiency.

Other techniques such as flexible backhaul and dynamic radio access configurations can also enable enhancements to the radio interface.

In small cells, higher-order modulation and modifications to the reference-signal structure with reduced overhead may provide performance enhancements due to lower mobility in small cell deployments and potentially higher signal-to-interference ratios compared to the wide-area case.

Flexible spectrum usage, joint management of multiple radio access technologies (RATs) and flexible uplink/downlink resource allocation, can provide technical solutions to address the growing traffic demand in the future and may allow more efficient use of radio resources.

6.5.2 Network Technologies

Future IMT will require more flexible network nodes which are configurable based on the Software-Defined Networking (SDN) architecture and network function virtualization (NFV) for optimal processing the node functions and improving the operational efficiency of network.

Featuring centralized and collaborative system operation, the cloud RAN (C-RAN) encompasses the baseband and higher layer processing resources to form a pool so that these resources can be managed and allocated dynamically on demand, while the radio units and antenna are deployed in a distributed manner.

The radio access network (RAN) architecture should support a wide range of options for inter-cell coordination schemes. The advanced self organizing network (SON) technology is one example solution to enable operators to improve the OPEX efficiency of the multi-RAT and multi-layer network, while satisfying the increasing throughput requirement of subscribers.

6.5.3 Technologies to Enhance Mobile Broadband Scenarios

A relay based multi-hop network can greatly enhance the Quality of Service (QoS) of cell edge users. Small-cell deployment can improve the QoS of users by decreasing the number of users in a cell and user quality of experience can be enhanced.

Dynamic adaptive streaming over HTTP (DASH) enhancement is expected to improve user experience and accommodate more video streaming content in existing infrastructure.

Bandwidth saving and transmission efficiency improvement is an evolving trend for Evolved Multimedia Broadcast and Multicast Service (eMBMS). Dynamic switching between unicast and multicast transmission can be beneficial.

IMT systems currently provide support for RLAN interworking, at the core network level, including seamless as well as non-seamless mobility, and can offload traffic from cellular networks into license-exempt spectrum bands.

Context aware applications may provide more personalized services that ensure high QoE for the end user and proactive adaptation to the changing context.

Proximity-based techniques can provide applications with information whether two devices are in close proximity of each other, as well as enabling direct device-to-device (D2D) communication. Group communication, including push-to-talk type of communication, is highly desirable for public safety applications.

6.5.4 Technologies to Enhance Massive Machine Type Communications

Future IMT systems are expected to connect a large number of M2M devices with a range of performance and operational requirements, with further improvement of low-cost and low complexity device types as well as extension of coverage.

6.5.5 Technologies to Enhance Ultra-reliable and Low Latency Communications

To achieve ultra-low latency, the data and control planes may both require significant enhancements and new technical solutions addressing both the radio interface and network architecture aspects.

It is envisioned that future wireless systems will, to a larger extent, also be used in the context of machine-to-machine communications, for instance in the field of traffic safety, traffic efficiency, smart grid, e-health, wireless industry automation, augmented reality, remote tactile control and tele-protection, requiring high reliability techniques.

6.5.6 Technologies to Improve Network Energy Efficiency

In order to enhance energy efficiency, energy consumption should be considered in the protocol design.

The energy efficiency of a network can be improved by both reducing RF transmit power and saving circuit power. To enhance energy efficiency, the traffic variation characteristic of different users should be well exploited for adaptive resource management. Examples include discontinuous transmission (DTX), base station and antenna muting, and traffic balancing among multiple RATs.

6.5.7 Terminal Technologies

The mobile terminal will become a more human friendly companion as a multi-purpose Information and Communication Technology (ICT) device for personal office and entertainment, and will also evolve from being predominantly a hand-held smart phone to also include wearable smart devices.

Technologies for chip, battery, and display should therefore be further improved.

6.5.8 Technologies to Enhance Privacy and Security

Future IMT systems need to provide robust and secure solutions to counter the threats to security and privacy brought by new radio technologies, new services and new deployment cases.

6.6 Spectrum for IMT Operation

This Section discusses about needs for IMT operation spectrum as well as harmonization, identification and technical issues on spectrum for IMT.

6.6.1 Spectrum Requirements

Report ITU-R M.2290 [8] provides the results of studies on estimated global spectrum requirements for terrestrial IMT in the year 2020. The estimated total requirements include spectrum already identified for IMT plus additional spectrum requirements.

It is noted that no single frequency range satisfies all the criteria required to deploy IMT systems, particularly in countries with diverse geographic and population density; therefore, to meet the capacity and coverage requirements of IMT systems multiple frequency ranges would be needed. It should be noted that there are differences in the markets and deployments and timings of the mobile data growth in different countries.

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 continued growth. Therefore, availability of spectrum resources that could support broader, contiguous channel bandwidths in this time frame should be explored.

6.6.2 Studies on Technical Feasibility of IMT between 6 and 100 GHz

Report ITU-R M.2376 [9] provides information on the technical feasibility of IMT in the frequencies between 6 and 100 GHz. It includes information on potential new IMT radio technologies and system approaches, which could be appropriate for operation in this frequency range. The potential advantages of using the same spectrum for both access and fronthaul/backhaul, as compared with using two different frequencies for access and fronthaul/backhaul, are also described in the Report. The theoretical assessment, simulations, measurements, technology development and prototyping described in the Report indicate that utilizing the bands between 6 and 100 GHz is feasible for studied IMT deployment scenarios, and could be considered for the development of IMT for 2020 and beyond.

6.6.3 Spectrum Harmonization

Where radio systems are to be used globally, it is highly desirable for existing and newly allocated 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.

Mobile devices typically contain multiple antennas and associated radio frequency front-ends to enable operation in multiple bands to facilitate roaming. While mobile devices can benefit from common chipsets, variances in frequency arrangements necessitate different components to accommodate these differences, which leads to higher equipment design complexity.

Consequently, harmonization of spectrum for IMT will lead to simplification and commonality of equipment, which is desirable for achieving economies of scale and affordability of equipment.

6.6.4 Spectrum Identification

As mentioned previously, it was by a decision by the 1992 World Administrative Radiocommunication Conference that the first specific frequency bands for the operation of FPLMTS (now IMT) were identified in the ITU Radio

Regulations, the international treaty governing the use of the radio frequency spectrum and satellite orbits. Identification of a frequency band in the Radio Regulations does not afford any priority for such use with respect to other radio services allocated to that spectrum, but it does provide a clear signal to the national regulators for their spectrum planning, and also provides a degree of confidence for equipment manufacturers and network operators to make the long term investments necessary to develop IMT in these bands.

Since then, successive World Radiocommunication Conferences have periodically identified additional frequency bands for IMT within the range of 450 MHz to 6 GHz to cater for the rapidly growing demand for mobile communications, particularly mobile broadband data.

While the 2015 World Radiocommunication Conference made good progress in identifying additional frequency bands and globally harmonized arrangements below 6 GHz for the operation of IMT, it also recognized a potential future requirement for large contiguous blocks of spectrum at higher frequencies for these systems.

Consequently, it called for 11 frequency bands above 24 GHz to be studied by ITU-R as bands that may be identified for use by IMT at the World Radiocommunication Conference in 2019 (WRC-19). The frequency bands to be studied are shown in Table 6.1 below.

As can be seen, the different bands span from around 24 GHz up to 86 GHz. While some of those bands are already allocated for the operation of mobile services in the Radio Regulations, others would require a mobile service allocation in addition to an identification for operation of IMT systems.

The focus of these studies should be to identify a limited subset of these bands that are recommended to be identified globally for use by IMT. The studies on these bands will be conducted in a Task Group of ITU-R Study Group 5, and the results of the studies will be included in the Conference Preparatory Meeting report to the World Radiocommunication Conference 2019.

Table 6.1 Bands under study for IMT identification by WRC-19

Existing Mobile Allocation	No Global Mobile Allocation
24.25 GHz–27.5 GHz	31.8–33.4 GHz
37–40.5 GHz	40.5–42.5 GHz
42.5–43.5 GHz	
45.5–47 GHz	47–47.2 GHz
47.2–50.2 GHz	
50.4–52.6 GHz	
66–76 GHz	
81–86 GHz	

6.7 Conclusions

The scope of IMT-2020 is much broader than the previous generations of mobile broadband communication systems. We are talking here about not just an enhancement to the traditional mobile broadband scenarios, but extending the application of this technology to use cases involving ultra-reliable and low latency communications, and massive machine-type communications. The ITU's work in developing the specifications for IMT-2020, in close collaboration with the whole gamut of 5G stakeholders, is now well underway, along with the associated spectrum management and spectrum identification aspects.

IMT is the enabler of new trends in communication devices – from the connected car and intelligent transport systems to augmented reality, holography, and wearable devices, and a key enabler to meet social needs in the areas of mobile education, connected health and emergency telecommunications. E-applications are transforming the way we do business and govern our countries, and smart cities are pointing the way to cleaner, safer, more comfortable lives in our urban conglomerates. Certainly, IMT-2020 will be a cornerstone for all of the activities related to attaining the goals in the 2030 Agenda for Sustainable Development.

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About the Author



François Rancy was elected Director of the ITU Radiocommunication Bureau by the ITU Plenipotentiary Conference 2010 (PP-10) in Guadalajara, Mexico. He took office on 1 January 2011. He was confirmed in a second term by the ITU Plenipotentiary Conference 2014 (PP-14) in Busan, Republic of Korea.

François Rancy is an engineer, a graduate of the *École Polytechnique* (1977) and the *École Nationale Supérieure des Télécommunications* (Paris, 1979).

From 1979 to 1997, he worked as systems engineer and subsequently Head of Department in France Télécom's research laboratories, where he was in charge of studies on national and international satellite systems and activities relating to the spectrum and the regulation of satellite systems. As from 1992, his responsibilities expanded to cover the entire radiocommunication sphere.

From 1997 to 2004, he was Director of Spectrum Planning and International Affairs at the National Frequency Agency (ANFR).

From 2004 to 2010, he was Director-General of ANFR, responsible for frequency management in France.

In October 2010, he was elected Director, BR by the ITU Plenipotentiary Conference.

At the international level, he led the coordination of European delegations (CEPT) at WRC-03 and chaired the European Union group on spectrum management policy (RSPG) in 2007. He chaired the ITU-R Special Committee on Regulatory and Procedural Matters from 1997 to 2003, and the World Radiocommunication Conference in 2007.

François Rancy has been awarded the ITU Silver Medal (2007) and the titles of Chevalier de la Légion d'honneur (1998) and Ordre national du mérite (1992).