SUMMARY REPORT
ON

22nd ITU-R
Study Group 5
Working Party 5D Meeting

10-18 June 2015
San Diego/United States

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On Behalf
MALAYSIAN TECHNICAL STANDARDS FORUM BHD

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1. Abstract

The International Telecommunications Union (ITU) has been leading the development of radio interface standards for mobile communications with the goal of creating a global framework to facilitate interoperability for both customers and network providers. This has required a global effort in the development of requirement sets for the technologies to support this as well as the coordination of frequency bands. The framework of standards for International Mobile Telecommunications (IMT), encompassing IMT-2000 and IMT-Advanced, have led to the global growth of both 3G and 4G technologies and this is set to continue with "IMT-2020" to address 5G network evolution.

WP5D is responsible for the overall system aspects of IMT and has the prime responsibility within ITU-R for issues related to the terrestrial component of IMT, including technical, operational and spectrum related issues to meet the objectives of future IMT systems. It is the lead group for the overall maintenance of existing and the development of new Recommendations on IMT and is responsible for studies related aspects regarding the continued deployment of IMT 2000 and IMT-Advanced including aspects such as convergence impacts, regulatory aspects, etc. It works closely with other Working Parties on issues relevant for IMT systems.

The meetings commenced on the 10th June with an opening Plenary session with all delegates arranged according to country/organization and set the agenda for the remaining sessions. Following this, meetings were held according to Working Group, Sub Working Group (for each Working Group) and Drafting Group (to incorporate contributions into 5D working documents). Under 5D there are 3 Working Groups and one Coordination group as follows:

i. WG General Aspects (WG GEN)

ii. WG Technology Aspects (WG TECH)

iii. WG Spectrum Aspects (WG SPEC)

iv. Ad Hoc Workplan (AH WKPLN)

An overview of the function of each is found in **Appendix 1**

WP 5D structure

High-level scopes for Working Party 5D working and Ad hoc Groups.

The closing plenary session took place on 18th June where all the developments during this round of meetings were agreed upon and the scope of the next cycle of meetings was outlined.

In early 2012, ITU-R embarked on a program to develop "IMT for 2020 and beyond", to scope and drive "5G" research activities emerging around the world. Through the leading role of Working Party 5D, ITU Radiocommunication Sector (ITU-R), has established a timeline towards "IMT-2020" as well as finalizing its "Vision" of the "5G" mobile broadband connected society. This view of the horizon for the future of mobile technology will be a significant input to the agenda for the World Radiocommunication Conference in November 2015, where deliberations on additional spectrum will take place in support of the future growth of IMT.

2. List of Participants

The 22nd meeting of WP 5D was attended by over 112 delegates from 29 countries and 45 delegates from Scientific or Industrial Organizations – please refer to **Appendix 2**.

3. Introduction /Background

The meeting was organized by International Telecommunication Union Radio communication Sector (ITU-R) and hosted by the United States Administration in cooperation with the Alliance for Telecommunications Industry Solutions (ATIS) and a number of private sector companies.

The technology evolution in the last few decades has been significantly driven by the evolution of mobile communications and has contributed to the economic and social development of both developed and developing countries. Mobile communications has become closely integrated in the daily life of a significant number of people across all walks of life. It is expected that the development and evolution of mobile communications systems will remain closely coupled and will form a foundation for society for 2020 and beyond.

In the future, it is expected that new demands from customers, including more traffic volume, many more devices with diverse service requirements, better quality of user experience (QoE) and better affordability by further reducing costs, will require an increasing number of innovative solutions.

The objective of WP 5D is to drive IMT for 2020 and beyond, by exploring potential user and application trends, growth in traffic, technological trends and spectrum implications, and by providing guidelines on the framework and the capabilities for IMT for 2020 and beyond.

4. Agendas/Topics

The ITU-R WP 5D meeting addressed a wide range of topics and activities for IMT-2020. The use of term "IMT-2020" has being adopted for the future development of IMT. The IMT related activities to address the terrestrial IMT technology aspects and enablers and the timeframe across 2015-2020 and beyond for system deployment, including aspects of terrestrial IMT systems related to WRC-15 studies are part of its scope. These activities include new information and deliverables to guide the continuing evolution of terrestrial IMT. At a high level the work is organized in the broad categories related to Working Group on General Aspects, Working Group on Technology Aspects and Working Group on Spectrum Aspect. These Working Groups were further subdivided into Sub-Working Groups and Drafting Groups. The following subsections provide a summary of the key outcomes from this round of meetings for each of the working groups.

4.1. WG General Aspects (WG GEN)

The General Aspects WG worked through four documents from this session. The first was the draft new report, ITU-R M. [IMT.BEYOND 2020 TRAFFIC], which covers traffic and related market demand and users needs towards the years 2020 focusing on terrestrial IMT – including "traffic related" inputs and parameters for use with the terrestrial IMT spectrum estimate methodology. The second was the draft new recommendation, ITU-R M. [IMT VISION], which looks at longer term vision of IMT for 2020 and beyond to drive the future developments for the radio access network. The third was a draft new resolution, ITU-R [IMT.PRINCIPLES], covering the principles for the process of future development of IMT for 2020 and beyond. The final document was a draft new report, ITU R M. [IMT.AV], looking into audio-visual capabilities and applications to be supported by terrestrial IMT systems.

4.2. WG Technology Aspects (WG TECH)

The Technology Aspects WG worked through two main documents from this session. These were the draft new report, ITU-R M. [IMT.ABOVE 6 GHz], exploring the technical feasibility of IMT in bands above 6 GHz and the draft new report, ITU-R M. [IMT.ARCH], covering the architecture and topology of IMT networks.

4.3 WG Spectrum Aspects (WG SPEC)

The Spectrum Aspects WG finalized two main documents from this session. The first was a draft new report ITU-R M. [TDD.COEXISTENCE] which is a study on TDD coexistence in the 2 300-2 400 MHz frequency band. The second was a preliminary draft new study report: Compatibility study between FSS networks and IMT systems in the band 3 400-3 600 MHz for small cell deployments.

There was also a draft revision of recommendation ITU-R M.1036-4, Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR), incorporating contributions received. A new document ITU-R M.[IMT.ARRANGEMENTS], a study of the harmonized channeling arrangements for IMT adapted to the frequency band below 790 MHz down to around 694 MHz for Region 1, was discussed extensively and there were input contributions proposing both the suppression and elevation of the document. It was agreed to carry forward this document for one more meeting, along with all related input and carried-forward documents.

Figure 1 shows a sample schedule for the second day of WP5D meetings (Thursday, 11 June 2015).

Time	**Cortez 1 (100)**	**Cortez 2+3 (100)**	**Hillcrest Ballroom (70)**	**South Park (30)**	**North Park (30)**
Period 0 8:00-9:00	AD HOC WORKPLAN (way forward)				
Period 1 9:00-10:15	DG VISION Trends	SWG OOBE		DG ABOVE 6 GHz	
Period 2 10:45-12:00	DG VISION Capabilities	SWG RADIO ASPECTS	SWG IMT SPECIFICATIONS		SWG IMT-AV
Period 3 14:00-15:15	SWG FREQUENCY ARRANGEMENTS	SWG TRAFFIC	SWG RA-15		
Period 4 15:45-17:00	SWG SHARING DGs	SWG OOBE		DG ABOVE 6 GHz (Summary text for Vision)	
Period 5 17:30-18:45	SWG SHARING DGs	WG TECHNOLOGY ASPECTS (future work)		DG ABOVE 6 GHz	

Figure 1 – WP 5D meeting agenda

5. Findings

5.1 Introduction

The main overview of the key outcomes and expectations of IMT-2020 systems are found in the recommendation ITU-R M. [IMT.VISION], Framework and overall objectives of the future development of IMT for 2020 and beyond. This provides the broad scope of IMT-2020 and looks at it from both a technology perspective and the socio-economic impact on customers.

New demands from customers are anticipated, including significant increases in traffic volume & expected data rates, many more mobile devices coming online with diverse service requirements, a demand for improved quality of user experience (QoE) and better affordability of both devices and services by further reducing costs. To meet these challenges there is a requirement for an increasing number of innovative solutions.

The key focus of IMT-2020 solutions will be on addressing the following areas:

i. Supporting very low latency and high reliability human-centric communication
ii. Supporting very low latency and high reliability machine-centric communication
iii. Supporting high user density
iv. Maintaining high quality at high mobility
v. Enhanced multimedia services
vi. Internet of Things
vii. Convergence of applications

In the following subsections describe the key milestones and drivers for IMT-2020 as identified by the 5D WP.

5.2 Role of IMT for 2020 and beyond

IMT-2020 is a continuation of the IMT process begun by ITU-R in 1985. We have seen that this process has radically altered the usage of mobile technologies where now they are integrated into the daily life of individuals across the world. Figure 1 below shows the ITU-R timeline with an expected commercial deployment of IMT-2020 systems in the year 2020.

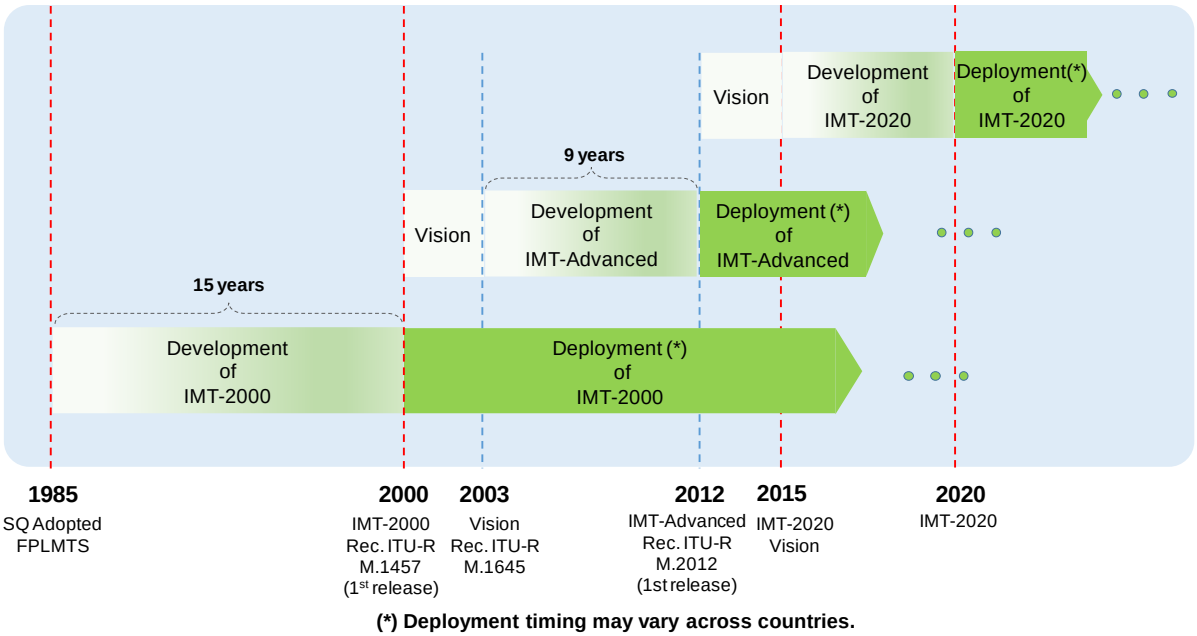


Figure 2 – Overview of timeline for IMT development and deployment

The key goal of IMT systems is to serve as a communication tool for people and a facilitator which assists the development of other industry sectors, for example medical science, transportation, and education. The 5D WP have identified that IMT technologies should contribute as follows:

i. **Wireless infrastructure to connect the world:** broadband connectivity will become as important as access to electricity. IMT will act as one of the key pillars to enable mobile service. In the future, private and professional users will be provided with a wide variety of applications and services, ranging from infotainment services to new industrial and professional applications.

ii. **New ICT market:** promote the emergence of an integrated ICT industry as a driver for global economies. Identified possible areas include: aggregation and analysis of big data; customized networking services for enterprise and social network groups

iii. **Bridging the Digital Divide:** assist in closing the gaps caused by an increasing Digital Divide via affordable, sustainable and easy-to-deploy mobile and wireless communication systems.

iv. **New ways of communication:** sharing of any type of contents anytime, anywhere through any device.

v. **New forms of education:** changing the method of education by providing easy access to digital textbooks or cloud-based storage of knowledge on the internet, boosting applications such as e-learning, e health, and e-commerce.

vi. **Promote Energy Efficiency:** enabling energy efficiency across a range of sectors of the economy by supporting machine to machine communication and solutions such as smart grid, teleconferencing, smart logistics and transportation.

vii. **Social changes:** facilitating the rapid forming and sharing of public opinions for a political or social issue through social network service.

viii. **New art and culture:** supporting people to create works of art or participate in group performances or activities, such as a virtual chorus, flash mob, co-authoring or song writing.

5.3 Usage scenarios for IMT-2020

One of the key aspects of IMT-2020 is looking at a more diverse range of usage scenarios when compared to the current IMT deployments. Some of these identified usage scenarios for IMT for 2020 and beyond include:

i. **Enhanced Mobile Broadband:** new application areas and requirements in addition to existing Mobile Broadband applications for improved performance and an increasingly seamless user experience across both wide-area coverage and hotspot.

ii. **Ultra-reliable and low latency communications:** applications with stringent requirements for throughput, latency and availability. Examples include wireless control of industrial manufacturing or production processes, remote medical surgery, distribution automation in a smart grid, transportation safety, etc.

iii. **Massive machine type communications:** a very large number of connected devices typically transmitting a relatively low volume of non-delay-sensitive data. Devices are required to be low cost, and have a very long battery life.

WP 5D anticipates that additional use cases will emerge, which are currently not foreseen. For future IMT, flexibility will be necessary to adapt to new use cases that come with a wide range of requirements. Therefore future IMT systems should be designed in a highly modular manner so that not all features have to be implemented in all networks. Figure 3 gives some examples of usage scenarios for IMT-2020 and beyond.

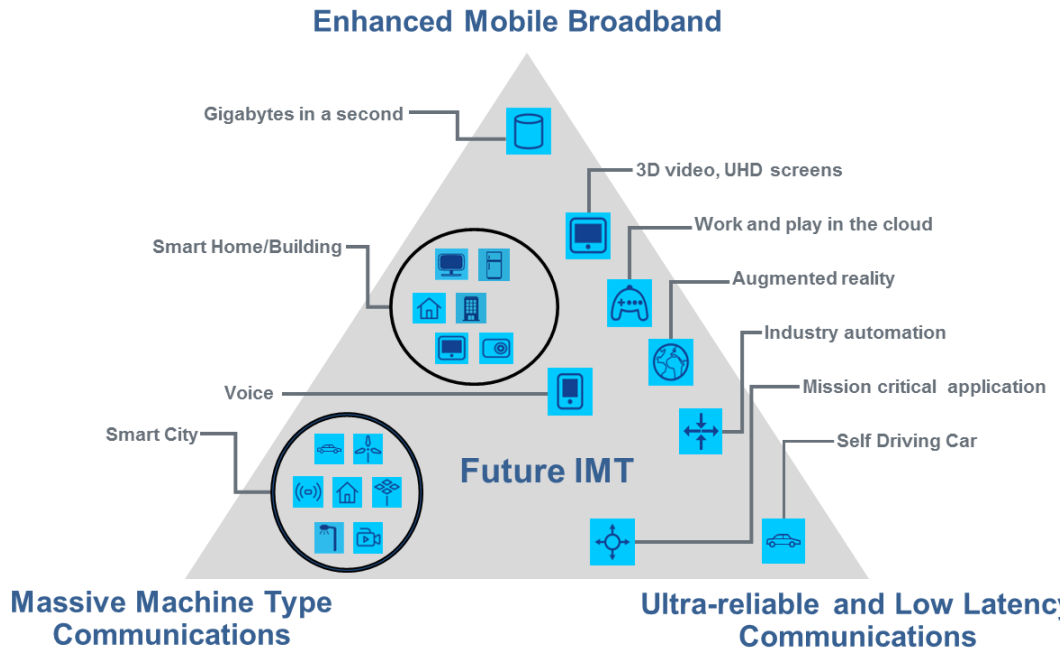


Figure 3 – Usage Scenarios of IMT for 2020 and beyond

5.4 Capabilities of IMT-2020

Previously, ITU-R M.1645 outlined the vision of capabilities for IMT-2000 and beyond. WP 5D expects that IMT-2020 capabilities will be far beyond these. The capabilities are closely linked with usage scenarios and applications. Therefore it is expected that the capabilities will not be achieved simultaneously, but rather depending on usage & application requirements. It is anticipated that IMT-2020 should provide a user experience that is comparable to fixed-line broadband networks. There are eight key parameters considered as the key capabilities of IMT-2020, details as follows:

i. **Peak data rate:** Maximum achievable data rate under ideal conditions per user/device (in Gbit/s). The target is 20Gbit/s.

ii. **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). The target is 100Mbit/s

iii. **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). The target is 1ms.

iv. **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). The target is 500km/h.

v. **Connection density:** Total number of connected and/or accessible devices per unit area (per km^2). Target is 10^6 per km^2.

vi. **Energy efficiency:** Energy efficiency has two aspects:

   a. 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);

   b. on the device side, energy efficiency refers to quantity of information bits per unit of energy consumption of the communication module (in bit/Joule).

   The target is 100x current levels.

vii. **Spectrum efficiency:** Average data throughput per unit of spectrum resource and per cell (bit/s/Hz). The target is 3x current levels.

viii. **Area traffic capacity:** Total traffic throughput served per geographic area (in Mbit/s/m^2). The target is 10 Mbit/s/m^2.

The key capabilities of IMT-2020 are summarized in Figure 4, with a comparison to those of IMT Advanced (shown in light green).

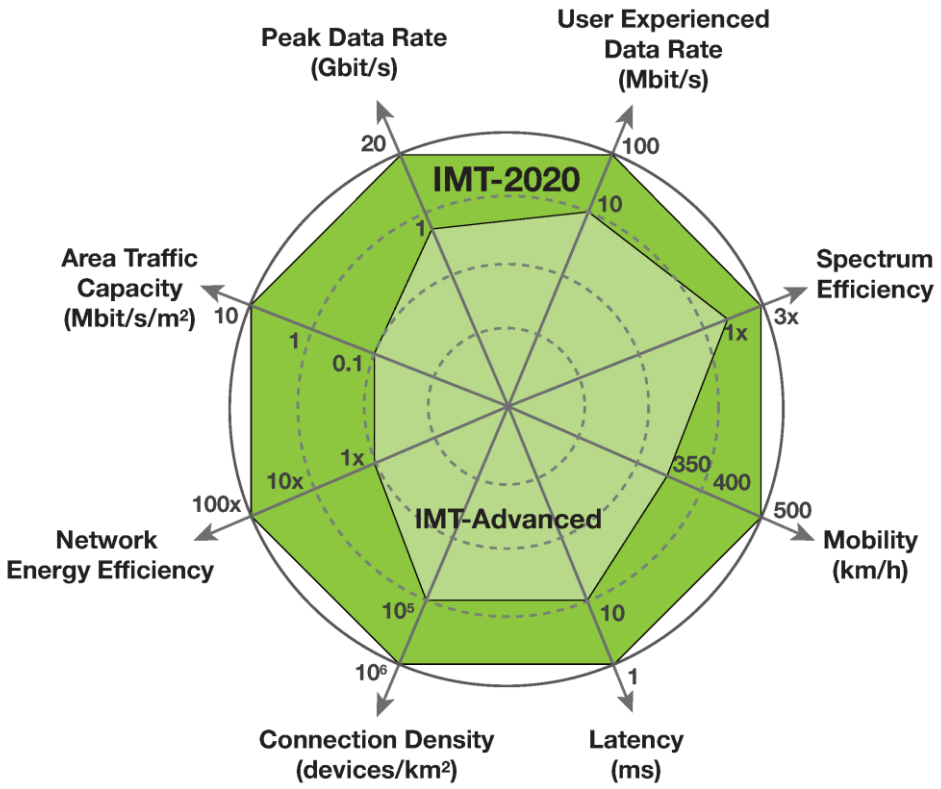


Figure 4 – Enhancement of key capabilities from IMT-Advanced to IMT-2020

As mentioned, it is not expected that these parameters occur simultaneously as requirements differ from application to application. With this in mind, the diagram below, Figure 5, shows the expected parameter requirements in the three broad usage scenarios defined: enhanced mobile broadband, ultra-reliable and low latency communications, and massive machine type communications, ranking the importance of each parameter in terms of high, medium and low.

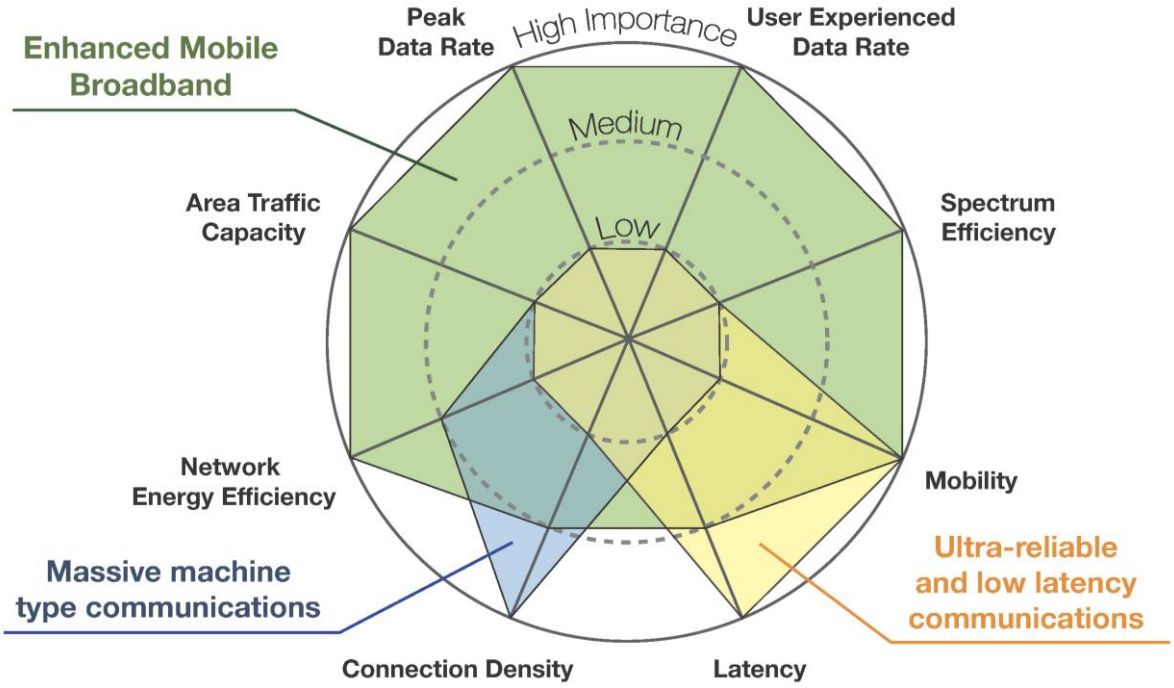


Figure 5 – The importance of key capabilities in different usage scenarios

5.5 IMT at High Frequency Bands (6-100 GHz)

Perhaps one of the most exciting areas and opportunities is the use of frequency bands above 6GHz, including very high frequencies that have never been considered for mobile use previously, potentially up to 100GHz. It is anticipated that these frequency bands will not be used for primary communications, but rather as secondary carriers when the radio propagation conditions are suitable.

The report ITU-R M.[IMT.ABOVE 6 GHz], Technical feasibility of IMT in bands above 6 GHz, provides many interesting studies of these bands and are useful inputs for Malaysian R&D activities in the radio propagation and antenna design areas.

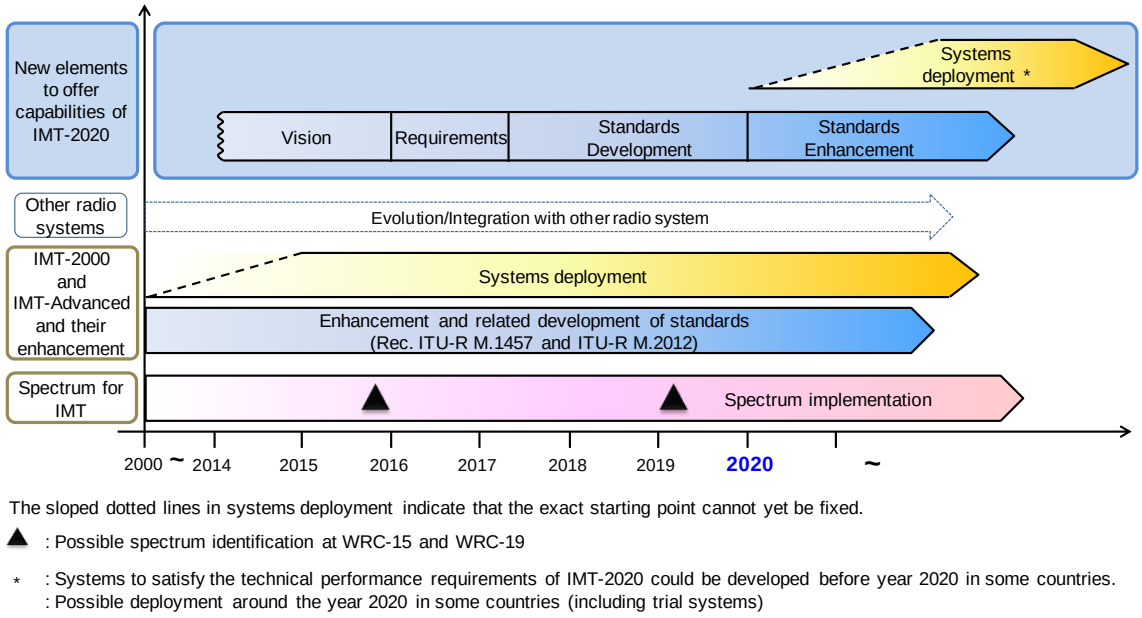
The Report presents measurement data on propagation in this frequency range in several different environments. Both line-of-sight and non-line-of-sight measurement results for stationary and mobile cases as well as outdoor-to-indoor results are presented. It also includes performance simulations results for several different deployment scenarios. The Report describes solutions based on MIMO and beamforming with a large number of antenna elements, which compensate for the increasing propagation loss with frequency; these have become increasingly feasible due to the ability to exploit chip-scale antenna solutions and modular adaptive antenna arrays.

5.6 Timelines

For the development of a timeline for IMT-2020, the following factors have an impact and form part of the consideration of the timeline: user trends & demand, technology

development, standards development, spectrum issues, regulatory considerations and actual system deployment.

The planned timeline for IMT-2020 is shown in Figure 6. The most important parts of this are the time at which the standards are completed (i.e. 2020), when spectrum would be available, and when deployment may start (from 2020 onwards).



The sloped dotted lines in systems deployment indicate that the exact starting point cannot yet be fixed.

▲ : Possible spectrum identification at WRC-15 and WRC-19

* : Systems to satisfy the technical performance requirements of IMT-2020 could be developed before year 2020 in some countries.
: Possible deployment around the year 2020 in some countries (including trial systems)

Figure 6 – Phase and expected timelines for IMT-2020

6 Conclusion

Participation in the ITU-R 5D WP keeps Malaysia updated with the latest developments in IMT and at the forefront of mobile technology. The 5D WP provides a platform where Malaysia can influence the direction of 5G technology at this early stage of its development. Technology related to IMT-2020 is currently in its infancy and there will be many opportunities presented since it is anticipated to be a collection and aggregation of technologies to support the ecosystem. The next phase of 5D WP meetings will begin to chart the requirements for technologies to be considered IMT-2020 in a similar manner to what was done with IMT-2000 and IMT-ADV. Over the course of the development of IMT, there has been a geographical shift in influence from Europe to Asia, and the author saw the significant lobby of Korea and China at the meetings. Much of the development of IMT-2020/5G related technology is at the R&D stage and open to inputs from across the globe. Malaysian institutes of higher learning and industries can take advantage of this to spearhead 5G activities in Malaysia.

The 5G SWG, under the Malaysia IMT Working Group, MTSFB, acts as a focal point for coordination and fostering of collaboration and partnership between academia and industry in 5G R&D activities in Malaysia. As such it is well positioned to contribute to the IMT-2020 specifications and have an influence on its direction.

The author had discussions with the ITU-R 5D WP Chair, Mr. Stephen Blust, and the ITU-R 5D WP Counsellor, Mr. Sergio Buonomo. We have received thanks for our commitment and participation to date and they look forward to this not only continuing but being elevated with greater contributions from Malaysia, where possible.

We look forward to continued MTSFB participation in the next meeting of ITU-R WP 5D, to be held in Geneva in February 2016.

7 Acknowledgement

The author would like to express thanks to both MTSFB and MCMC for supporting and sponsoring the attendance at the ITU-R WP 5D meeting held in San Diego, United States of America from 10th to 18th June 2015.

Appendix 1

WP 5D structure

High-level scopes for Working Party 5D working and Ad hoc Groups

Group	Scope	Chairman
WG GENERAL ASPECTS	- To develop deliverables on services, forecasts, and also convergence of services of fixed and mobile networks which take account the needs of end users, and the demand for IMT capabilities and supported services. This includes aspects regarding the continued deployment of IMT-2000 and the success of IMT-Advanced, other general topics of IMT and overall objectives for the long-term development of IMT. To update the relevant IMT Recommendations/Reports. - To ensure that the requirements and needs of the developing countries are reflected in the work and deliverables of WP 5D in the development of IMT. This includes coordination of work with ITU-D Sector on deployments of IMT systems and transition to IMT system.	K.J. WEE Korea
WG TECHNOLOGY ASPECTS	- To provide the technology related aspects of IMT through development of Recommendations and Reports. To update the relevant IMT-2000 Recommendations. To work on key technology elements of IMT-Advanced including requirements, evaluation, and evolution. To develop liaison with external research and standardization forums, and to coordinate the external and internal activities related to the IMT-Advanced process. - To manage the research topics website and its findings.	H. WANG China
WG SPECTRUM ASPECTS	- To undertake co-existence studies, develop spectrum plans, and channel/frequency arrangements for IMT. This includes spectrum sharing between IMT and other radio services/systems coordinating as appropriate with other Working Parties in ITU-R.	A. JAMIESON New Zealand
AD HOC WORKPLAN	- To coordinate the work of WP 5D to facilitate efficient and timely progress of work items.	H. OHLSEN Sweden

Appendix 2

WP 5D participants

List of Participants

Appendix 3

IMT.VISION

DRAFT NEW RECOMMENDATION ITU-R M. [IMT.VISION]

IMT Vision – "Framework and overall objectives of the future development of IMT for 2020 and beyond"

Appendix 4

IMT above 6 GHz

DRAFT NEW REPORT ITU-R M. [IMT.ABOVE 6 GHz]

Technical feasibility of IMT in bands above 6 GHz

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