|  |  |
| --- | --- |
| **Radiocommunication Study Groups** |  |
| **19th Meeting of Working Party 5D Halifax, Canada, 18-25 June 2014** |  |
|  |  |
| Attachment 3.2 to Document 5D/726  (Source: Document 5D/TEMP/400) |  |
| **23 June 2014** |
| **English only** |
| Working Party 5D | |
| Working document towards a Handbook on global  trends in IMT – ITU-R M.[IMT.HANDBOOK] | |
|  | |

Sub-Working Group IMT Handbook proposes an expanded table of contents and text for several sections of the working document towards a Handbook on “Global trends in IMT”, ITU-R M.[IMT.HANDBOOK] as provided in the Attachment.

**Attachment**: 1

ATTACHMENT

TABLE OF CONTENTS

Page

[1 Introduction 10](#_Toc391240700)

[1.1 Purpose and scope 10](#_Toc391240701)

[1.2 Background 10](#_Toc391240702)

[1.3 Vocabulary of key terms used in this Handbook 10](#_Toc391240703)

[2 Usage trends and service requirements 11](#_Toc391240704)

[2.1 Introduction 11](#_Toc391240705)

[2.2 Usage trends 11](#_Toc391240706)

[2.2.1 Mobile Internet usage 11](#_Toc391240707)

[2.2.2 Mobile software application offerings (Apps) 12](#_Toc391240708)

[2.2.3 Video traffic 13](#_Toc391240709)

[2.2.4 Social networks on mobile 14](#_Toc391240710)

[2.2.5 Machine-to-machine traffic 15](#_Toc391240711)

[2.2.6 Other drivers of future data traffic 16](#_Toc391240712)

[2.3 Market trends 17](#_Toc391240713)

[2.3.1 Global IMT subscriber information from 2007 to 2013 17](#_Toc391240714)

[2.3.2 Device Type 18](#_Toc391240715)

[2.3.3 Network and user experience improvement 19](#_Toc391240716)

[2.3.4 Policy initiatives to promote mobile broadband 20](#_Toc391240717)

[2.4 Key features of IMT 22](#_Toc391240718)

[2.4.1 Key features of IMT2000 22](#_Toc391240719)

[2.4.2 Key features of IMT Advanced 22](#_Toc391240720)

[2.5 Servicing urban, rural and remote areas 22](#_Toc391240721)

[2.6 Considerations for developing countries 23](#_Toc391240722)

[3 IMT system characteristics, technologies and standards 25](#_Toc391240723)

[3.1 Introduction 25](#_Toc391240724)

[3.2 IMT system concepts and objectives 25](#_Toc391240725)

[3.3 IMT architecture and standards 27](#_Toc391240726)

[3.3.1 IMT Radio Access Network and standards 27](#_Toc391240727)

[3.3.2 IMT Core Network and standards 40](#_Toc391240728)

[3.3.3 IMT standards organizations 40](#_Toc391240729)

[3.4 Techniques to facilitate roaming 41](#_Toc391240730)

[4 IMT spectrum 44](#_Toc391240731)

[4.1 International spectrum identified for IMT 44](#_Toc391240732)

[4.2 Frequency arrangements 44](#_Toc391240733)

[4.3 Methods to estimate frequency spectrum required for IMT 46](#_Toc391240734)

[5 Regulatory issues 46](#_Toc391240735)

[5.1 Institutional aspects and arrangements 46](#_Toc391240736)

[5.2 Transparency and stakeholder involvement 47](#_Toc391240737)

[5.3 Market knowledge 47](#_Toc391240738)

[5.4 Spectrum licensing 47](#_Toc391240739)

[5.4.1 IMT licensing considerations 47](#_Toc391240740)

[5.4.2 IMT licensing principles and methods 48](#_Toc391240741)

[5.5 IMT spectrum clearing (including refarming) guidelines 48](#_Toc391240742)

[5.6 Global circulation of terminals 48](#_Toc391240743)

[5.7 Unwanted emissions 48](#_Toc391240744)

[6 Steps to consider in the deployment of IMT systems 49](#_Toc391240745)

[6.1 Key issues and questions to be considered prior to IMT   
network deployment 49](#_Toc391240746)

[6.2 Demographics and services 49](#_Toc391240747)

[6.3 Evolution and/or migration of existing wireless systems to IMT 49](#_Toc391240748)

[6.4 Choice of technology and spectrum in the identified IMT bands 49](#_Toc391240749)

[6.4.1 Satellite component of IMT 49](#_Toc391240750)

[6.5 Deployment planning 50](#_Toc391240751)

[7 Criteria leading to technology decisions 50](#_Toc391240752)

[7.1 Spectrum implications, Channelization and Bandwidth considerations 50](#_Toc391240753)

[7.2 Importance of multi-mode/multi-band solutions 51](#_Toc391240754)

[7.3 Technology development path 51](#_Toc391240755)

[7.4 Backhaul Considerations 51](#_Toc391240756)

[7.5 Technology Neutrality 51](#_Toc391240757)

[8 Core network evolution scenarios 52](#_Toc391240758)

[Annex A – Abbreviations and acronyms 52](#_Toc391240759)

[Annex B – References 52](#_Toc391240760)

[B.1 Introduction 52](#_Toc391240761)

[B.2 ITU publications 52](#_Toc391240762)

[B.2.1 ITU Recommendations 52](#_Toc391240763)

[B.2.2 ITU Reports 53](#_Toc391240764)

[B.2.3 ITU Handbooks 53](#_Toc391240765)

[B.3 External publications 53](#_Toc391240766)

[B.3.1 Published papers in technical journals 53](#_Toc391240767)

[B.3.2 UMTS Forum Reports 53](#_Toc391240768)

[B.3.3 GSA publications 53](#_Toc391240769)

[Annex C – Applications and services 53](#_Toc391240770)

[C.1 Location based application & services 53](#_Toc391240771)

[C.1.1 Location accuracy techniques 54](#_Toc391240772)

[C.1.1.1 Cell ID 54](#_Toc391240773)

[C.1.1.2 Cell Id +TA/ Cell ID+RTT 54](#_Toc391240774)

[C.1.1.3 E-CID {(Cell Id +TA)/ (Cell ID+RTT) & NMR} 55](#_Toc391240775)

[C.1.1.4 RF Pattern Printing (RFPM) 55](#_Toc391240776)

[C.1.1.5 Uplink time duration of arrival (UTDOA) – Location management   
unit (LMU) 56](#_Toc391240777)

[C.1.1.6 Observed time duration of arrival (O-TDOA) 56](#_Toc391240778)

[C.1.1.7 A-GPS 56](#_Toc391240779)

[C.1.2 Factors impacting location accuracy 56](#_Toc391240780)

[C.1.3 Required features and issues in supporting LBS 56](#_Toc391240781)

[Annex D – Description of the relevant radio and network transport technologies 57](#_Toc391240782)

[Annex E – Description of the IMT radio interfaces and systems 57](#_Toc391240783)

[Annex F – Description of ITU and External Organizations 59](#_Toc391240784)

[Annex G – Examples of business cases 59](#_Toc391240785)

[Annex H – Examples of regulatory policies 59](#_Toc391240786)

[Annex I – Deliverables and ongoing activities of ITU-R on Terrestrial IMT 59](#_Toc391240787)

[I.1 Summary of recent deliverables (Recommendations and Reports)   
of ITU-R WP 5D (since WP 5D #13) 59](#_Toc391240788)

[I.1.1 Report ITU-R M.2117-1 (IMT aspects) “Software-defined radio in the   
land mobile, amateur and amateur-satellite services”, Approved in 2012-11 59](#_Toc391240789)

[I.1.2 Recommendation ITU-R M.1457-11 “Detailed specifications of the   
terrestrial radio interfaces of International Mobile   
Telecommunications-2000 (IMT-2000)”, Approved in 2013-02 60](#_Toc391240790)

[I.1.3 Recommendation ITU-R M.1768-1 “Methodology for calculation   
of spectrum requirements for the terrestrial component of International   
Mobile Telecommunications”, Approved in 2013-04 60](#_Toc391240791)

[i.1.4 “User guide for the imt spectrum requirement estimation tooL”   
in ITU-R WP 5D Web page, Approved in 2013-10 61](#_Toc391240792)

[I.2 Ongoing activities of ITU-R WP 5D 61](#_Toc391240793)

[I.2.1 Draft new Report ITU-R M.[IMT.2020.INPUT] 61](#_Toc391240794)

[I.2.2 Draft new Report ITU-R M.[IMT.ADV PARAM] 62](#_Toc391240795)

[I.2.3 Draft 3rd revision of Report ITU-R M.2039 62](#_Toc391240796)

[I.2.4 Draft revision of Recommendation ITU-R M.2012 62](#_Toc391240797)

[I.2.5 Draft new Report on Applications of IMT technologies to PPDR ITU-R M.[IMT.BROAD.PPDR] 62](#_Toc391240798)

[I.2.6 Draft new Report ITU-R M.[IMT.BEYOND2020 TRAFFIC] 63](#_Toc391240799)

[I.2.7 Draft new Report ITU-R M.[IMT.Small Cell] 63](#_Toc391240800)

[I.2.8 Draft new Report ITU-R M.[IMT.2020.ESTIMATE] 63](#_Toc391240801)

[I.2.9 Draft new Report ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS] 64](#_Toc391240802)

[I.2.10 Draft 12th Revision of Recommendation ITU-R M.1457 64](#_Toc391240803)

[I.2.11 Draft new Report on Resolution 58 for IMT.CRS studies 64](#_Toc391240804)

[I.2.12 Draft new Report ITU-R M.[IMT.ANTENNA] 64](#_Toc391240805)

[I.2.13 Draft new Recommendation ITU-R M.[IMT.VISION] 64](#_Toc391240806)

[I.2.14 Draft new Report ITU-R M.[IMT.ABOVE 6 GHz] 64](#_Toc391240807)

[I.2.15 Draft new Report ITU-R M.[TDD.COEXISTENCE] 64](#_Toc391240808)

[I.2.16 Draft 5th revision of Recommendation ITU-R M.1036 64](#_Toc391240809)

[I.2.17 Draft new Report ITU-R M.[IMT.ARRANGEMENTS] 65](#_Toc391240810)

[I.2.18 Draft 5th revision of Recommendations ITU-R M.1580 and M.1581 65](#_Toc391240811)

[I.2.19 Draft new Recommendations ITU-R M.[IMT.OOBE BS] and   
M.[IMT.OOBE MS] 65](#_Toc391240812)

[I.2.20 Draft new Report ITU-R M.[IMT.vs.IMT.UHF] 65](#_Toc391240813)

[I.2.21 Draft new Report ITU-R M.[IMT.ARCH] 65](#_Toc391240814)

[I.2.22 Draft 2nd revision of Recommendation ITU-R M.2012 65](#_Toc391240815)

[Annex J](#_Toc391240816) [Satellite IMT (and other, related) Recommendations and Reports 67](#_Toc391240817)

# 1 Introduction

This Handbook identifies IMT and provides the general information such as service requirements, application trends, system characteristics, and substantive information on spectrum, regulatory issues, guideline for the evolution and migration, and core network evolution on IMT.

This Handbook also addresses a variety of issues related to the deployment of IMT systems.

## 1.1 Purpose and scope

The purpose and scope of this Handbook is to provide general guidance to ITU Members, network operators and other relevant parties on issues related to the deployment of IMT systems to facilitate decisions on selection of options and strategies for introduction of their IMT‑2000 and IMT‑Advanced networks.

## 1.2 Background

*[Editor’s Note – Insert text here]*

## 1.3 Vocabulary of key terms used in this Handbook

Broadband Commission: The Broadband Commission for Digital Development is composed of the International Telecommunication Union (ITU) and the United Nations Educational, Scientific and Cultural Organization (UNESCO). The Commission embraces a range of different perspectives in a multistakeholder approach to promoting the roll-out of broadband, as well as providing a fresh approach to UN and business engagement.

(e) NodeB: Base Station

Iu: Communication interface between the Radio Network Controller (RNC) and the Core Network Interface (Mobile switching center & Serving GPRS Support Node).

Iub: Physical communication interface between the base station (Node B) and the Radio Network Controller (RNC).

Iur: Communication interface between adjacent Radio Network Controllers (RNCs).

RNC: The Radio Network Controller connects to and co-ordinates base stations (NodeBs).

S1: Interface connecting the base station (eNodeB) to the core network (serving gateway &Mobility Management Entity).

S1-u: Interface connecting the base station (eNodeB) to the serving gateway(S-GW) by means of the user-plane part.

S1-c: Interface connecting the base station (eNodeB) totheMobility Management Entity (MME) by means of the control-plane part.

X2: Interface connecting base stations (eNodeBs) to each other and mainly used to support active-mode mobility.

2G: Second-generation mobile communication technology standards.

3G: Third-generation mobile communication technology standards.

4G: Fourth-generation mobile communication technology standards.

# 2 Usage trends and service requirements

## 2.1 Introduction

In order to understand current trends in IMT, it is important to consider and understand how mobile broadband is being used and for what purposes (including key features of IMT technologies), and any special requirements of developing countries. Together, these topics provide a foundation upon which to build a stronger understanding of the topics discussed in subsequent sections of this handbook. The following sections discuss application trends (such as mobile Internet usage, video traffic, social networks, and machine-to-machine traffic); market trends in traffic and devices; key features of each iteration of IMT technologies; the use of IMT to serve urban, rural and remote areas; and considerations for developing countries, such as barriers to access.

## 2.2 Usage trends

### 2.2.1 Mobile Internet usage

Mobile Internet usage has been growing rapidly on a worldwide basis over the past years. While the state of mobile Internet usage can be measured in several ways, the growth – and projected growth – is perhaps most striking when considering mobile data traffic volumes and data speeds. Ericsson, for example, has quantified the total amount of monthly data traffic at approximately 1,800 petabytes in the third quarter of 2013.[[1]](#footnote-1) Adding some perspective to that figure, the authors noted that the increase in mobile data traffic from the second quarter of 2013 to the third quarter exceeded the total monthly mobile data traffic estimated in the fourth quarter of 2009. In the latest one-year period of Ericsson’s analysis, mobile data traffic grew by approximately 80 percent. In 2013, the analysis noted that the total mobile Internet traffic generated by mobile handsets exceeded that of laptops, tablets and mobile routers for the first time.[[2]](#footnote-2) In another comparison, the GSMA noted that more mobile traffic was generated in 2012 than in all other years combined.[[3]](#footnote-3) Looking ahead, mobile devices are expected to continue to outpace other sources of Internet usage. For example, when considering the sources of IP traffic over the world’s telecommunications networks, Cisco estimated that nearly half will originate with non-PC devices by 2017, up from 26 percent in 2012.[[4]](#footnote-4) Cisco further forecasted that while traffic originating on personal computers (PCs) will grow at a compound annual growth rate (CAGR) of 14 percent, and machine-to-machine (M2M) traffic will grow at 79 percent, tablets and mobile phones will see a growth rate of 104 percent.[[5]](#footnote-5) Globally, Cisco estimated that mobile data traffic will increase 13-fold between 2012 and 2017, at a CAGR of 66 percent, reaching 11.2 exabyte per month by 2017.[[6]](#footnote-6) This rate would be three times faster than fixed traffic over the same period. Smartphone technology and adoption have progressed rapidly in the last several years, providing users with robust, mobile access to broadband services, and comprising the category that will likely make up the bulk of mobile broadband subscriber devices. According to Ericsson’s most recent analysis, smartphones accounted for approximately 55 percent of all mobile handsets sold in the third quarter of 2013, while they made up approximately 40 percent of all handsets sold in all of 2012.[[7]](#footnote-7) The analysis also indicated that there is significant room for additional growth, with only 25‑30 percent of mobile phone subscriptions associated with smartphones. Ericsson predicted that there were 1.9 billion smartphone subscriptions at the end of 2013, but 5.6 billion by the end of 2019. When considering the introduction of LTE technology into smartphones, the growth has been quite rapid. One analysis indicated that while approximately five percent of smartphones were LTE-enabled in July 2011, by August 2013, more than 30 percent could take advantage of LTE networks.[[8]](#footnote-8) Along with the growth in smartphones, the speed of mobile connectivity continues to increase across the world as well as networks and devices implement the latest technologies, such as LTE. Cisco noted that the average mobile network connection speed in 2012 was 526 kbps, but was forecast to grow at a CAGR of 49 percent, and will exceed 3.9 Mbps in 2017. Average smartphone data rates are forecast to triple by 2017, reaching 6.5 Mbps.[[9]](#footnote-9) There is anecdotal evidence to support the idea that usage increases when speed increases, although there may be a delay between the increase in network and device speed and the resultant increased usage, potentially a lag of several years.

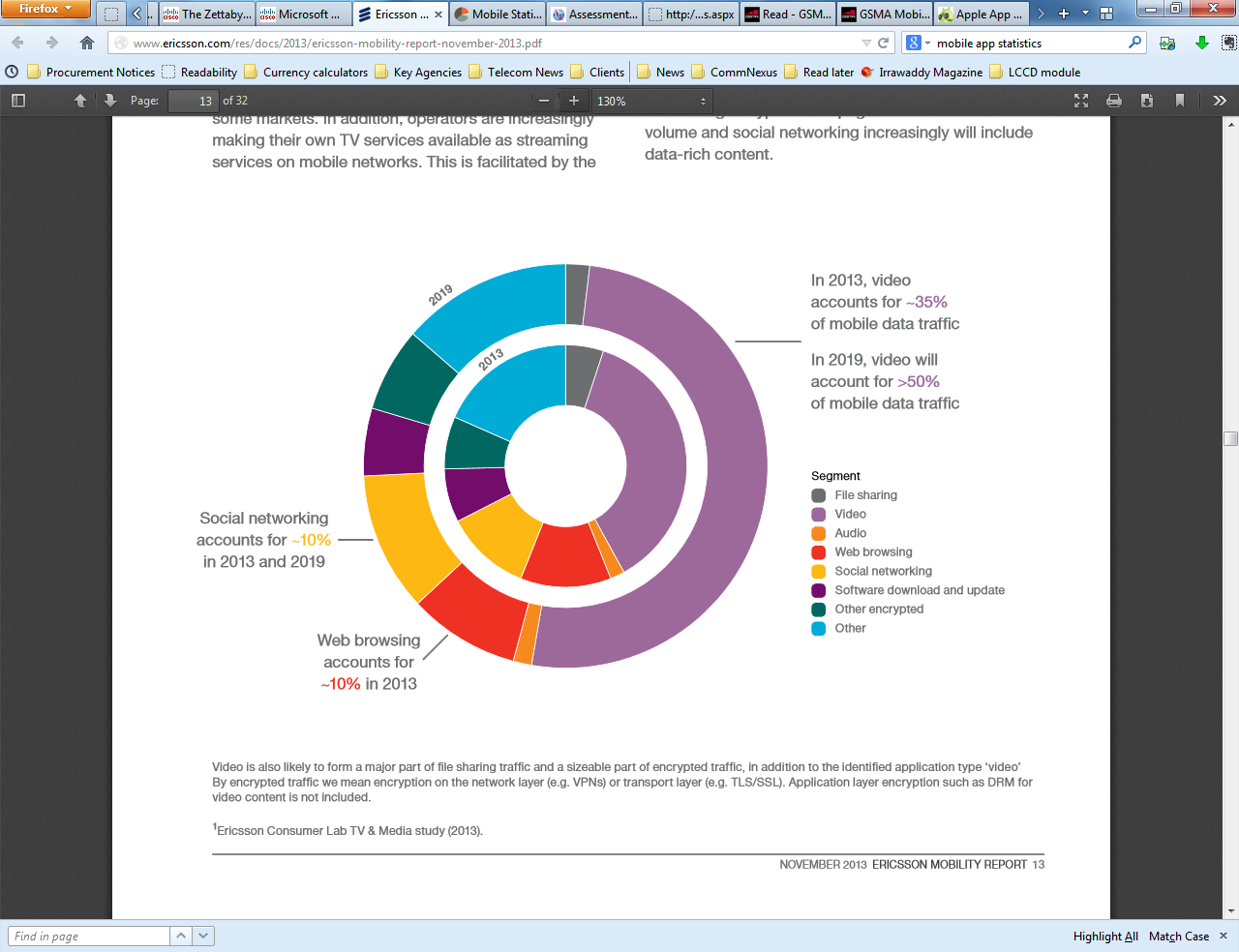
### 2.2.2 Mobile software application offerings (Apps)

A key driver of mobile data usage has been the rapid proliferation of software applications, commonly known as “apps,” for use on smartphones and other mobile devices. Taking into consideration the two largest app ecosystems, there were approximately 900,000 apps available for iOS (the operating system that powers Apple’s iPhone, iPad and iPod devices) and approximately 800,000 apps available for Android (the operating system for a wide range of mobile handsets and tablet devices).[[10]](#footnote-10) There is likely substantial overlap between the ecosystems, with many developers releasing applications for both operating systems in order to reach the largest potential customer bases. Both ecosystems have seen fairly steady growth in recent years, although the rate of growth for Android applications has increased recently. Application download estimates vary widely. ABI Research estimated that there would be a total of 56 billion smartphone apps downloaded in 2013 (including not just iOS and Android, but also Windows Phone and Blackberry), while Portio Research estimated that 82 billion apps would be downloaded worldwide in 2013. Regardless of the exact number, it is worth noting that this mobile app downloads are a relatively new phenomenon, having begun in earnest with the launch of Apple’s App Store in 2008.

Similarly, the number of apps downloaded has increased rapidly. For example in 2010, an estimated five billion iOS apps and 289,000 Android apps were downloaded, as compared to an estimated 48 billion iOS apps and 50 billion Android apps in early 2013. Applications are generally grouped into certain categories, with analysts parsing network traffic to identify the amount of traffic generated by each group, as well as to forecast future traffic patterns. Ericsson’s breakdown of current mobile application traffic percentages and a forecast for traffic in 2019 are presented in Figure 1. In particular, Ericsson expected that video content would continue to drive mobile data usage, representing more than 50 percent of traffic by 2019.

**Figure 1**

Mobile application traffic, 2013 and 2019



*Source: Ericsson*

As mobile network speeds and capacity continue to increase, mobile software applications are expanding to take advantage of both. A GSMA and A.T. Kearny analysis forecasts that mobile data traffic will grow at a CAGR of 66 percent between 2012 and 2017, reaching a monthly rate of 11,156 petabytes.[[11]](#footnote-11) The GSMA analysis predicted that several services will experience CAGR of more than 30 percent over the 2012-2017 period: VoIP (34 percent), gaming (62 percent), M2M (89 percent), file sharing (34 percent), data (55 percent) as well as video (75 percent). The following sections examine some of these important drivers in more detail.

### 2.2.3 Video traffic

As noted in section 2.2.1, mobile data traffic has been growing at a rapid pace, and is expected to continue to do so. The major driver of this growth is expected to be mobile video, which has been predicted to account for more than 7,000 petabytes of monthly data traffic by 2017.[[12]](#footnote-12) Ericsson forecasted that mobile video traffic will increase at an average annual rate of 55 percent through 2019, at which point it would account for more than half of global mobile data traffic.[[13]](#footnote-13)

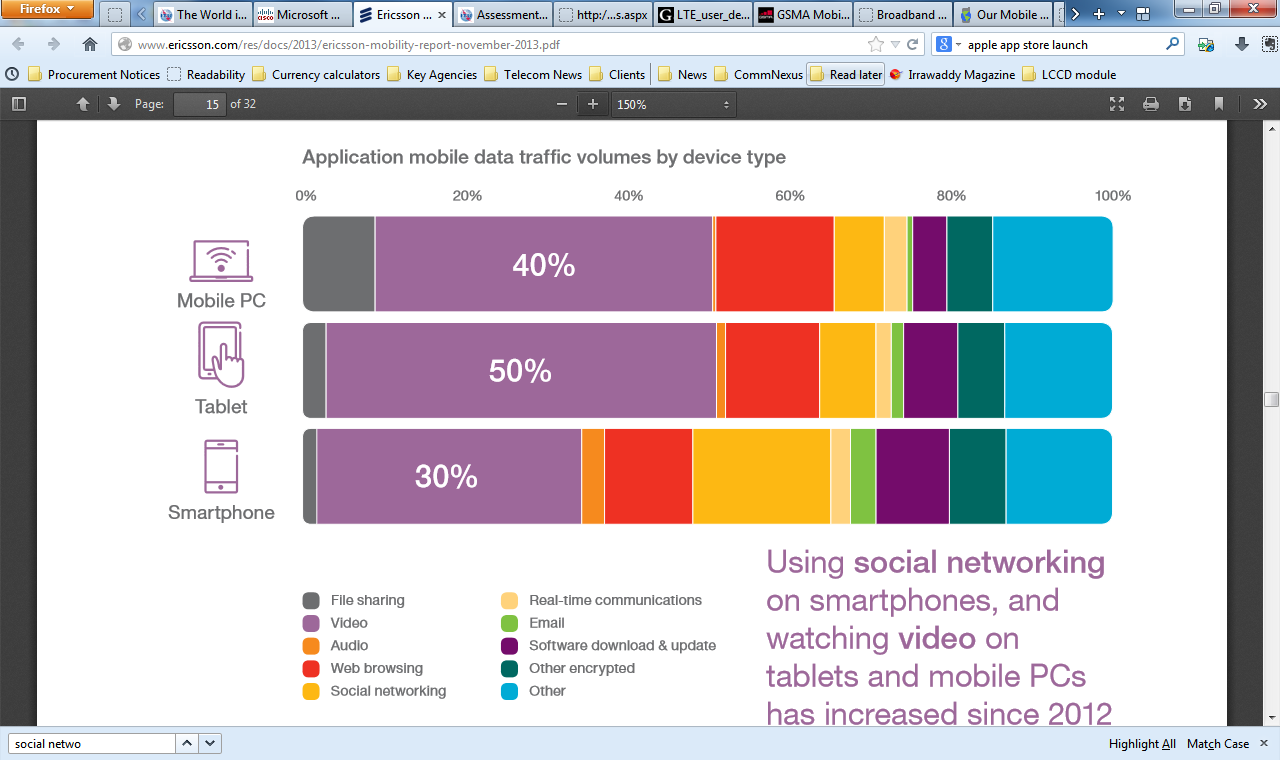
Mobile video is increasingly becoming a mainstream activity among mobile broadband subscribers. As mobile networks deploy technologies, such as HSPA and LTE, that are capable of delivering higher quality content at higher speeds, it has become easier for mobile subscribers to consume content from a wider range of sources. These sources include, but are not limited to, broadcast and cable television networks, YouTube and similar video-sharing services, and content aggregators such as Apples iTunes, Google’s Google Play, Amazon.com, Netflix, Hulu, Youku, iQiyi and others. As of January 2014, Google stated that mobile users made up nearly 40 percent of YouTube’s global “watch time.”[[14]](#footnote-14) As a result, according to one analysis, as many as 41 percent of people between the ages of 65 and 69 stream video content over fixed or mobile networks on at least a weekly basis.[[15]](#footnote-15) One possible development that may drive additional mobile video traffic is gaming. While currently, the data traffic volumes and speed requirements of many single or multi-player games available on mobile devices are relatively low, there is some expectation that this situation will change in the future.[[16]](#footnote-16) As more games adopt elements such as multi-player features, high-definition content and video streaming, gaming may become a more important driver of video traffic.

### 2.2.4 Social networks on mobile

Currently, social networking is estimated to account for approximately 10 percent of total mobile data traffic.[[17]](#footnote-17) Ericsson estimated that this share will remain constant through 2019, although social networking usage increasingly will include more data-rich content, such as photographs and video.[[18]](#footnote-18) When considering how people use their mobile devices, social networking is already the second-largest generator of data traffic volume. Between 2012 and 2013, Ericsson noted an increase in the percentage of social networking traffic on smartphones.[[19]](#footnote-19) Importantly, the use of mobile handsets for social networking far exceeds such use on tablets and laptops, where the percentage of mobile data traffic generated by social networking is below five percent, as shown in Figure 2.

**Figure 2**

Application mobile data traffic volumes by device type (2013)



*Source: Ericsson*

Considering how smartphone users spend time on their devices, Google data from 41 countries indicated that more than half of all smartphone users use social networking at least monthly, and more than 25 percent do so daily.[[20]](#footnote-20) In 27 of those countries, more than 75 percent of smartphone users access social networks at least monthly. An Ericsson analysis showed that social networking is the most popular activity among iOS and Android smartphone users in the United States, accounting for 13.1 hours per month.[[21]](#footnote-21) The next most popular smartphone use in this analysis was entertainment, which was responsible for 8.5 hours of use per month.

### 2.2.5 Machine-to-machine traffic

As mobile network coverage and capacity has expanded, and the cost of embedding connectivity into various types of equipment has declined, the number of Internet-connected devices has grown rapidly. Many of these devices are expected to continuously monitor some sort of situation or status, report information to users, and/or communicate with each other. Depending on the definition used, M2M communications can include a wide range of devices, such as remote sensors, “smart” electricity grids, Internet-connected appliances and automobiles, and manufacturing equipment, just to name a few. According to a 2012 OECD report, some firms using mobile networks to connect Internet-enabled devices already had one million devices under management.[[22]](#footnote-22) OnStar reportedly had more than six million devices under its management at the time, or more than the total number of mobile subscribers in some countries.

There are a wide range of estimates regarding the potential number of Internet-connected devices. One widely cited estimate stated that there may be as many as 50 billion mobile devices connected to the Internet by 2020.[[23]](#footnote-23) Other estimates are much lower. Of course, estimating future connectivity relies on a range of definitions and forecasts that allow for significant variability in methodology. Regardless of the actual number of M2M devices that are put into use, there is widespread agreement that there will be significant growth in the market, which in turn is expected to drive additional traffic across the world’s mobile networks. Cisco estimated that M2M communications will see a CAGR of 82 percent between 2012 and 2017.[[24]](#footnote-24)

### 2.2.6 Other drivers of future data traffic

The demand for mobile cloud services is expected to grow exponentially since the users are increasingly adopting more services that are required to be accessible. The consequence is that the volume of mobile content they generate cumulatively grows. Multimedia services captured on mobile devices will overwhelmingly carry the greatest cloud computing and storage demand and the average size of these media files will grow substantially as camera pixel resolution continues to increase (ARC Chart16 predicts that mobile-generated content will consume 9,400 PB of cloud services by 2015).

It is expected that e-health, e-education and other e-government services will also be accessed by mobile devices, which will contribute to improvements in social welfare.

Furthermore, cloud services are getting a lot of attention since, among other benefits, they save costs for enterprises. These cloud services require guaranteed data communication between the clients and the connected data centers hosting IT servers. As the number of mobile users connecting through the mobile network to the cloud increase, the mobile data traffic will continuously grow.

As mobile software applications advance due to increasing processing power, mobile data traffic is expected to increase[[25]](#footnote-25).

The cloud architecture is a relevant evolution of the provisioning of digital services and applications that has to be considered when planning for the evolution of IMT technologies. Economic underpinnings of all these technological developments is the ability to move data across borders to facilitate a number of key functions such as; communication, information, content, e-commerce, M2M etc. But even more the realities behind the productions of mentioned functions e.g. the presence of global value chains must be recognized. This means that in the B2B market, today’s complex ICT systems that are required to realize these new technologies and functions rely on the ability of companies to develop, produce, integrate, manage and support these systems from multiple territories and hence the ability to collaborate and exchange data across territories is absolutely essential.

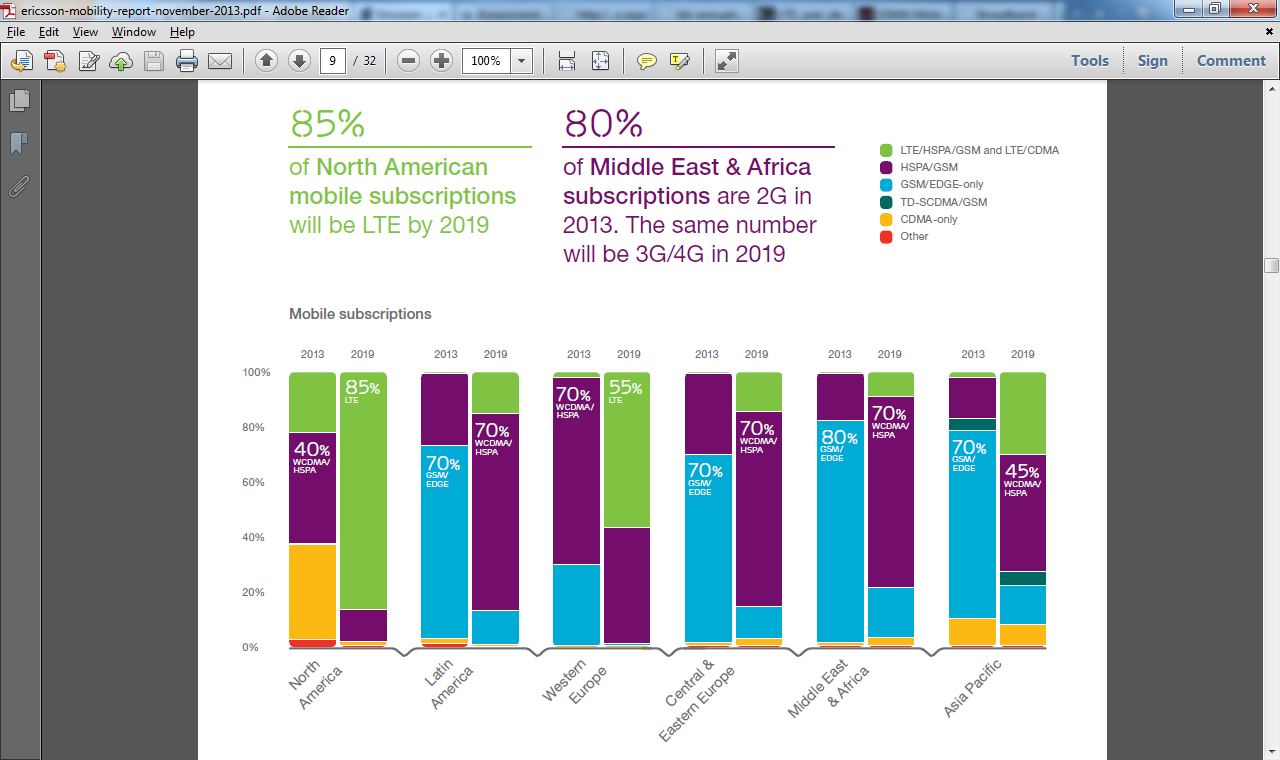
## 2.3 Market trends

### 2.3.1 Global IMT subscriber information from 2007 to 2013

According to the ITU, the number of mobile broadband subscriptions worldwide has surged from 268 million in 2007 to 2.1 billion in 2013.[[26]](#footnote-26) The ITU also noted in 2013 that the number of mobile broadband subscriptions in developing countries had more than doubled since 2011, from 472 million to 1.16 billion, surpassing the number of subscriptions in developed countries.[[27]](#footnote-27) There is still a substantial penetration gap between the developed and developing countries, however. According to the ITU, 75 of every 100 developed country inhabitants have an active mobile broadband subscription, as compared to 20 of every 100 inhabitants in developing countries.[[28]](#footnote-28) As noted by the Broadband Commission in its 2013 Report, *The State of Broadband 2013: Universalizing Broadband*, mobile broadband subscriptions surpassed fixed broadband subscriptions in 2008, and have shown an annual growth rate of approximately 30 percent.[[29]](#footnote-29) That classifies mobile broadband as having, according to the Broadband Commission, the highest growth rate of any ICT, exceeding fixed broadband subscriptions by a ratio of 3:1 (up from 2:1 in 2010). When considering the growth of IMT subscriptions, rapid growth is expected over the next several years. Ericsson data, illustrated in Figure 3, indicated that the majority of subscriptions in North America and Western Europe were already IMT devices in 2013, while IMT devices will comprise the majority of mobile subscriptions in all regions of the world by 2019.[[30]](#footnote-30)

Figure 3

Mobile subscriptions by technology, 2013 and 2019



*Source: Ericsson*

### 2.3.2 Device Type

As mobile broadband connectivity continues to spread and also to increase its capacity and speeds, a growing number of device types have been developed to serve differing user needs. When considering devices supporting LTE, for example, the Global Mobile Suppliers Association (GSA) stated in November 2013 that smartphones comprise the largest LTE device category, including 455 models (including variants developed specifically for certain operators and/or frequencies), or 36 percent of all LTE device types.[[31]](#footnote-31) LTE-capable tablets and personal hotspots are also fast‑growing segments of the device ecosystem.

*Source: Global Mobile Suppliers Association*

According to Ericsson, the market peak for basic or feature mobile phone subscriptions was in 2012. Their analysis estimated that there were 1.9 billion smartphone subscriptions by the end of 2013, and that this figure will increase to 5.6 billion subscriptions by the end of 2019.[[32]](#footnote-32) The growth in smartphone subscriptions was forecast to come primarily as users exchange their basic phones for smartphones in Africa, Asia and the Middle East over the next several years, due in part to the availability of lower-cost devices. Laptops, tablets and mobile router subscriptions will continue to grow as well, from 300 million in 2013 to 800 million in 2019. Ericsson also predicted significant regional differences, with smartphones comprising almost all handsets sold in Western Europe and North America in 2019, compared to 50 percent of handset subscriptions in the Middle East and Africa.[[33]](#footnote-33)

### 2.3.3 Network and user experience improvement

As mobile data traffic demand continues to grow, mobile network operators are spending heavily to upgrade their networks in order to increase their capacity and improve the user experience. One analysis estimated that operators would spend USD8.7 billion on LTE network upgrades alone in 2012, rising to USD24 billion in 2013 and USD36 billion by 2015.[[34]](#footnote-34) One of the most commonly considered measures of user experience is average mobile network speed. According to Cisco, speeds will increase across all regions and all device types between now and 2017.[[35]](#footnote-35) Globally, the average mobile network connection speed in 2012 was 526 kbps. This average will grow at a CAGR of 49 percent, and will exceed 3.9 Mbps in 2017. Smartphone speeds, generally on IMT networks, are currently almost four times higher than the overall average, and are forecast to triple by 2017, reaching 6.5 Mbps. Across all regions, Cisco estimates that average mobile data speeds will increase at a CAGR of at least 36 percent through 2017, with the Middle East and Africa increasing at a CAGR of 68 percent.

IMT technology has become widespread in global mobile networks. With the commercialization of LTE technology in recent years, operators are rapidly moving to upgrade their networks. As of December 2013, there were 244 LTE networks in 92 countries worldwide. Slightly more than a year earlier, there were 113 networks in 51 countries.[[36]](#footnote-36) In October 2011, there were only 35 commercial networks in 21 countries.[[37]](#footnote-37) The LTE deployment trend coincides with a relative slowing in HSPA deployments, as the HSPA upgrade momentum began to level off and operators redirected their capital expenditures toward LTE. As of December 2013, there were 532 HSPA networks in operation, with more than 63 percent of operators having launched HSPA+ networks.[[38]](#footnote-38) A year earlier, there were 482 commercial HSPA networks, with 52 percent of HSPA operators having launched HSPA+, and in 2011 there were 424 commercial networks with 36 percent having launched HSPA.[[39]](#footnote-39)

The evolution of IMT systems has continuously increased the data rates available to mobile broadband users. Technologies have continued to increase peak data speeds with each iteration and new technology.

Advances in technology alone, however, sometimes cannot support the rapid growth rates that are being seen in mobile data use. This is particularly true in urban areas around the world. Thus, operators and regulators worldwide are trying to make additional spectrum available for mobile broadband, particularly by making new bands of spectrum available. For example, the transition from analogue to digital television broadcasting can result in a “digital dividend,” of spectrum that was formerly used for broadcasting but that now can be made available for other uses. Most countries around the world have either started a process to make that spectrum available for mobile broadband or are planning to do so. The majority of such transitions are expected to be completed in the next 10 years.

### 2.3.4 Policy initiatives to promote mobile broadband

Governments and multilateral organizations are taking a variety of approaches to promote mobile broadband such as the development of National Broadband Plan. While each country faces unique challenges to increasing mobile broadband adoption, certain general trends or approaches can be applied in many cases. Mobile broadband initiatives are often developed as subsets of plans intended to increase broadband adoption more generally. As such, policy approaches that may improve mobile broadband adoption may closely track those approaches employed to increase fixed broadband adoption. In other cases, as in many developing countries, mobile broadband is the primary (or only) broadband option available to many individuals and communities. Policy approaches intended to increase mobile broadband supply can include:

* setting concrete, measurable objectives for improving the supply of broadband through infrastructure build-out, including deployment of and upgrades to mobile networks;
* ensuring availability and efficient use of spectrum for mobile services, including flexible spectrum use;
* ensuring competitive, efficient and transparent markets;
* ensuring equitable access to broadband for all; and
* encouraging investment in mobile networks, services and applications;
* one of these approaches is to promote the deployment of mobile networks operating in frequency bands below 1 GHz, as the main solution to facilitate provision of broadband mobile services in unserved areas.

Policy approaches intended to increase demand for mobile broadband can include:

* promoting demand for broadband services and applications;
* considering if there is a need for, and an appropriate mechanism to deliver, subsidies for devices and/or service fees, perhaps through a universal access or universal service program;
* making useful information and services available to mobile device users (e.g., m-government, m-health, m-banking); and
* educating users and potential users on the benefits of mobile broadband-enabled services.

The Broadband Commission, while not focusing on mobile broadband specifically, recently proposed policy approaches intended to improve access to broadband that are applicable to the mobile sector. For example, the Commission’s 2013 report, as part of its goal of universalizing broadband, suggested establishing adequate spectrum policies and reasonable spectrum allocations, as well as ensuring stable legal and regulatory frameworks to foster and incentivize investments, and creating an environment for sustainable competition.[[40]](#footnote-40) In the same discussion, the report noted the importance of establishing a national broadband plan to guide broadband development. Among the other Broadband Commission policy recommendations applicable to mobile services are to focus on making broadband affordable and to improve penetration, which will go hand-in-hand.

The first Broadband Commission report, *A 2010 Leadership Imperative: The Future Built on Broadband*, noted among its recommendations the need for national policy objectives to include the provision of broadband-enabled services and applications for vulnerable, disadvantaged and remote populations, among others.[[41]](#footnote-41) Particularly with respect to remote populations, mobile technology provides a key means – and perhaps the only economically feasible means – by which to reach these groups.

## 2.4 Key features of IMT

### 2.4.1 Key features of IMT2000

Key features of IMT-2000 are:

– high degree of commonality of design worldwide;

– compatibility of services within IMT-2000 and with the fixed networks;

– high quality;

– small terminal for worldwide use;

– worldwide roaming capability;

– capability for multimedia applications, and a wide range of services and terminals.

Recommendation ITU-R M.1457 identifies the IMT-2000 terrestrial radio interface specifications. These radio interfaces support the features and design parameters of IMT-2000, including the above mentioned features, such as capability to ensure worldwide compatibility, international roaming, and access to high-speed data services.

### 2.4.2 Key features of IMT Advanced

Key features of IMT-Advanced are:

– high degree of commonality of functionality worldwide while retaining the flexibility to support a wide range of services and applications in a cost-efficient manner;

– compatibility of services within IMT and with fixed networks;

– capability of interworking with other radio access systems;

– high-quality mobile services;

– user equipment suitable for worldwide use;

– user-friendly applications, services and equipment;

– worldwide roaming capability;

– enhanced peak data rates to support advanced services and applications (100 Mbit/s for high and 1 Gbit/s for low mobility)[[42]](#footnote-42);

These features enable IMT-Advanced to address evolving user needs.

Recommendation ITU-R M.2012 identifies the terrestrial radio interface technologies of IMT‑Advanced and provides the detailed radio interface specifications. These radio interface specifications detail the features and parameters of IMT-Advanced, including the above mentioned features, such as the capability to ensure worldwide compatibility, international roaming, and access to high-speed data services

### 2.5 Servicing urban, rural and remote areas

A number of Mobile Broadband (MBB) systems and applications, based on different standards, are available and the suitability of each depends on usage (fixed vs. nomadic/mobile), and performance and geographic requirements, among others. In countries where wired infrastructure is not well established, MBB systems can be more easily deployed to deliver services to population bases in dense urban environments as well as those in more remote areas. Some users may only require broadband Internet access for short-ranges whereas other users may require broadband access over longer distances. Moreover, these same users may require that their MBB applications be nomadic, mobile, fixed or a combination of all three. In sum, there are a number of multi-access solutions and the choice of which to implement will depend on the interplay of requirements, the use of various technologies to meet these requirements, the availability of spectrum (licensed vs. unlicensed), and the scale of network required for the delivery of MBB applications and services (local vs. metropolitan area networks).”[[43]](#footnote-43)

## 2.6 Considerations for developing countries

The 2013 Annual Broadband Commission Report (Table 3, Source: Inter-American Development Bank) contains a list of special requirements/barriers faced by developing countries and offers examples of strategies to overcome such barriers.

**Barriers to Access and Public Policies to overcome Barriers**

|  |  |  |
| --- | --- | --- |
| **Barrier/obstacle** | **Examples of strategies to overcome the barriers** | |
| 1. Low levels of  purchasing power in  certain rural and  sub-urban areas | • Subsidies to the benefit of end-  users, to ensure broadband adoption, once access is secured  • Discounted offers from operators to end-users  • Telecentres for shared use to kick- start broadband markets  • Public-private partnerships (PPPs) | |
| 2. Limited financial resources available via some USFs | • Policy-makers should work with operators, depending on local needs and government funding, to ensure USF is properly sourced and effective.  • Support (e.g. from international agencies) for ad-hoc projects.  • Priority given to UAS projects based on strict and clear criteria | |
| 3. The low levels of ICT skills of some of the population | • ICT training  • Connecting up educational establishments  • ICT lessons in schools and universities, and  ICT equipment furnished at low or no cost | |
| 4. The lack of basic commodities (water, electricity, etc.) | • Telecentres open to the public where access to commodities is guaranteed  • Wi-Fi access in public spaces where access to commodities is guaranteed | |
| 5. The limited availability  of consumer electronic  equipment | • Distribution of equipment directly, or subsidies for consumer electronic equipment by poor households  • Review import duty regimes to ensure they are effective.  • Equipment approval (supply) policies should not be too onerous or restrictive. | |
| 6. High tax rates on telecom services or equipment | • Targeted tax and import duty reductions on broadband services and devices,  including removal of luxury taxes. | |
| 7. Lack of  infrastructure/ high costs of deployment | • National broadband plan, including roll- out of a mutualized national backbone, as well as in-building infrastructure  • Grants to operators to build out infrastructure  • Sharing of infrastructure and works | |
| 8. Administrative delays in  authorizations to deploy new infrastructure | • Involve relevant agencies and Ministries early  • Streamline licensing procedures  • Eliminate red-tape and delays  • Remove barriers and obstacles to owning land |
| 9. Limited economic growth in  certain areas | • Ongoing subsidy programs on the demand side, following investment on the supply side |
| 10. Limitations  in amount of spectrum available | • Streamline spectrum licensing and re-farming practices  • Implementation of the digital switch-over  • More effective policies for spectrum allocation/assignment |
| 11. Limited availability of relevant  local content | • Subsidies and awards for the development of local content  • Development of e-government services, open government / freedom of information policies. |

In addition, ITU-D Report “Access technology for broadband telecommunications including IMT, for developing countries”[[44]](#footnote-44) provides developing countries with an understanding of the different technologies available for broadband access in urban, rural and remote areas using both wired and wireless technologies for terrestrial and satellite telecommunications, including IMT. The Report covers technical issues involved in deploying broadband access technologies by identifying the factors influencing the effective deployment of such technologies, as well as their applications, with a focus on technologies and standards that are recognized or under study within ITU-R and ITU-T.

# 3 IMT system characteristics, technologies and standards

## 3.1 Introduction

International Mobile Telecommunications (IMT) encompasses both IMT-2000 and IMT-Advanced collectively based on Resolution ITU-R 56.

The capabilities of IMT systems are being continuously enhanced in line with user trends and technology developments.

Recommendations ITU-R M.1457 and ITU-R M.2012 contain, respectively, the detailed specifications of the terrestrial radio interfaces of IMT-2000 and IMT-Advanced.

## 3.2 IMT system concepts and objectives

**IMT system concepts**

IMT-2000, third generation mobile systems started service around the year 2000, and IMT systems provide access by means of one or more radio links to a wide range of telecommunication services including advanced mobile services, supported by fixed networks (e.g. PSTN/Internet), which are increasingly packet-based, and other services specific to mobile users.

It is described in the Recommendation ITU-R M.1645 that the framework of the future development of IMT-2000 and systems beyond IMT-2000 for the radio access network is based on the global user and technology trends, including the needs of developing countries.

International Mobile Telecommunications – Advanced (IMT-Advanced) is a mobile system that includes the new capabilities of IMT that go beyond those of IMT-2000.

The term “IMT‑Advanced” is applied to those systems, system components, and related aspects that include new radio interface(s) that support the new capabilities of systems beyond IMT‑2000[[45]](#footnote-45).

IMT-Advanced systems provide enhanced peak data rates to support advanced services and applications (100 Mbit/s for high and 1 Gbit/s for low mobility were established as targets for research)[[46]](#footnote-46).

IMT-Advanced systems have capabilities for high-quality multimedia applications within wide range of services and platforms, providing a significant improvement in performance and quality of current services, and support low to high mobility applications and a wide range of data rates in accordance with user and service demands in multiple user environments.

The capabilities of IMT-Advanced systems are being continuously enhanced in line with technology developments.

The future development of IMT‑2000 and IMT‑Advanced is foreseen to address the need for higher data rates than those of currently deployed IMT.

The global operation and economy of scale are key requirements for the success of mobile telecommunication systems. It is desirable to agree on a harmonized time-frame for developing common technical, operational and spectrum-related parameters of systems, taking account of relevant IMT‑2000 and other experience.

Maximizing the commonality between IMT‑Advanced air interfaces may lead to reduced complexity and a lower incremental cost of multi-mode terminals.

Objectives

Objectives of IMT-2000 are defined in Recommendation ITU-R M.687 “IMT-2000”, and were finally revised in 1997, including general objectives, technical objectives, and operational objectives. For more details please refer to the original Recommendation.

Objectives on IMT-2000 are also summarized in Recommendation ITU-R M.1645 from the view point of multiple perspectives as in the next table taken from section 4.2.2 of Recommendation ITU‑R M.1645 as follows:

Objectives of IMT-2000 from multiple perspectives

|  |  |
| --- | --- |
| Perspective | Objectives |
| END USER | Ubiquitous mobile access  Easy access to applications and services  Appropriate quality at reasonable cost  Easily understandable user interface  Long equipment and battery life  Large choice of terminals  Enhanced service capabilities  User-friendly billing capabilities |
| CONTENT PROVIDER | Flexible billing capabilities  Ability to adapt content to user requirements depending on terminal, location and user preferences  Access to a very large marketplace through a high similarity of application programming interfaces |
| SERVICE PROVIDER | Fast, open service creation, validation and provisioning  Quality of service (QoS) and security management  Automatic service adaptation as a function of available data rate and type of terminal  Flexible billing capabilities |
| NETWORK OPERATOR | Optimization of resources (spectrum and equipment)  QoS and security management  Ability to provide differentiated services  Flexible network configuration  Reduced cost of terminals and network equipment based on global economies of scale  Smooth transition from IMT-2000 to systems beyond IMT-2000  Maximization of sharing capabilities between IMT-2000 and systems beyond IMT-2000 (sharing of mobile, UMTS subscriber identity module (USIM), network elements, radio sites)  Single authentication (independent of the access network)  Flexible billing capabilities  Access type selection optimizing service delivery |
| MANUFACTURER/ APPLICATION DEVELOPER | Reduced cost of terminals and network equipment based on global economies of scale  Access to a global marketplace  Open physical and logical interfaces between modular and integrated subsystems  Programmable platforms that enable fast and low-cost development |

## 3.3 IMT architecture and standards

Recommendation ITU‑R M.1645 defines the framework and overall objectives of the future development of IMT‑2000 and systems beyond IMT‑2000 for the radio access network based on the global user and technology trends, and the needs of developing countries.

Since the year of 2000, the technical specifications of IMT-2000 have been continually enhanced.

IMT-2000 and IMT-Advanced are defined by a set of interdependent ITU Recommendations which are referred to in this Handbook.

There are a number of other ITU-R Recommendations for IMT (Recommendations ITU-R M.1036, ITU-R M.1580, ITU-R M.1581, ITU-R M.1579, etc.) that provide relevant implementation aspects enabling the most effective and efficient use and deployment of systems – while minimizing the impact on other systems or services in these and in adjacent bands – and facilitating the growth of IMT systems[[47]](#footnote-47).

For more information on ITU-R Recommendations and Reports please refer to Annex B.

### 3.3.1 IMT Radio Access Network and standards

Recommendations ITU-R M.1457 and ITU-R M.2012 provide, respectively, the detailed specifications of the terrestrial radio interfaces of International Mobile Telcommunications-2000 (IMT-2000) and International Mobile Telecommunications-Advanced (IMT-Advanced). These Recommendations provide specific information regarding the air interfaces that are used in the terrestrial IMT networks.

Recommendation ITU-R M.1457 contains overviews and detailed specifications of each of the IMT‑2000 radio interfaces:

– (Section 5.1) IMT-2000 CDMA Direct Spread

– (Section 5.2) IMT-2000 CDMA Multi-Carrier

– (Section 5.3) IMT-2000 CDMA TDD

– (Section 5.4) IMT-2000 TDMA Single-Carrier

– (Section 5.5) IMT-2000 FDMA/TDMA

– (Section 5.6) IMT-2000 OFDMA TDD WMAN.

Recommendation ITU-R M.2012 contains “Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced”. The Recommendation includes both overviews and detailed specifications of the two IMT-Advanced radio interfaces:

– (Annex 1) Specification of the LTE-Advanced radio interface technology.

– (Annex 2) Specification of the WirelessMAN-Advanced radio interface technology.

#### 3.3.1.1 IMT-2000

**3.3.1.1.1 IMT-2000 CDMA Direct Spread**

This section includes CDMA Direct Spread and E-UTRAN.

1) CDMA Direct Spread

The IMT-2000 radio-interface specifications for CDMA Direct Spread technology are developed by a partnership of SDOs[[48]](#footnote-48) (see Note 1). This radio interface is called Universal Terrestrial Radio Access (UTRA) FDD or Wideband CDMA (WCDMA).

The overall architecture of the radio access network is shown in Fig. 4. The architecture of this radio interface consists of a set of radio network subsystems (RNS) connected to the CN through the Iu interface. An RNS consists of a radio network controller (RNC) and one or more entities called Node B. Node B is connected to the RNC through the Iub interface. Each Node B can handle one or more cells. The RNC is responsible for the handover decisions that require signalling to the user equipment (UE). In case macro diversity between different Node Bs is to be supported, the RNC comprises a combining/splitting function to support this. Node B can comprise an optional combining/splitting function to support macro diversity within a Node B. The RNCs of the RNS can be interconnected through the Iur interface. Iu and Iur are logical interfaces, i.e. the Iur interface can be conveyed over a direct physical connection between RNCs or via any suitable transport network.

FIGURE 4

Radio access network architecture   
(Cells are indicated by ellipses)



2) E-UTRAN (Evolved Universal Terrestrial Radio Access Network = LTE)

E–UTRAN has been introduced for the evolution of the radio-access technology towards a high-data-rate, low-latency and packet-optimized radio-access technology.

E-UTRAN supports scalable bandwidth operation below 5 MHz bandwidth options up to 20 MHz in both the uplink and downlink. Harmonization of paired and unpaired operation is highly considered to avoid unnecessary fragmentation of technologies.

The radio access network architecture of E-UTRAN consists of the evolved UTRAN Node Bs (eNBs). eNBs host the functions for radio resource management, IP header compression and encryption of user data stream, etc. eNBs are interconnected with each other and connected to an Evolved Packet Core (EPC).

The E-UTRAN radio access network consists of eNBs, providing the user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the UE. The eNBs are interconnected with each other by means of the X2 interface. The eNBs are also connected by means of the S1 interface to the EPC (Evolved Packet Core), and more specifically to the MME (Mobility Management Entity) by means of the S1--C and to the S-GW (Serving Gateway) by means of the S1-U. The S1 interface supports a many-to-many relation between MMEs/Serving Gateways and eNBs.

The E-UTRAN radio access network architecture is illustrated in Fig. 5.

FIGURE 5

Overall architecture



The eNB hosts the following functions:

– functions for Radio Resource Management: Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic allocation of resources to UEs in both uplink and downlink (scheduling);

– IP header compression and encryption of user data stream;

– selection of an MME at UE attachment;

– routing of User Plane data towards S-GW;

– scheduling and transmission of paging messages (originated from the MME);

– scheduling and transmission of broadcast information (originated from the MME or O&M);

– measurement and measurement reporting configuration for mobility and scheduling.

The MME hosts the following functions:

– NAS signalling;

– NAS signalling security;

– Inter CN node signalling for mobility between 3GPP access networks;

– Idle mode UE Reachability (including control and execution of paging retransmission);

– Tracking Area list management (for UE in idle and active mode);

– PDN GW and Serving GW selection;

– MME selection for handovers with MME change;

– SGSN selection for handovers to 2G or 3G 3GPP access networks;

– Roaming;

– Authentication;

– Bearer management functions including dedicated bearer establishment.

**3.3.1.1.2 IMT-2000 CDMA Multi-Carrier**

The IMT-2000 radio interface specifications for CDMA multi-carrier (MC) technology are developed by a partnership of SDOs [[49]](#footnote-49)(3GPP2, see Note 2). This radio interface is called cdma2000.

**cdma2000 1xRTT and High Rate Packet Data (HRPD) Access Network Architecture**

Figure 6 and Figure 7 below, show the relationship among network components in support of Mobile Station (MS) originations, MS terminations, and direct Base Station (BS) to Base Station (BS) soft/softer handoff oper­at­ions. These two Figures also depict a logical architecture that does not imply any particular physical implementation. The InterWorking Function (IWF) for circuit-oriented data calls is assumed to be located at the circuit-switched MSC (Mobile Switching Center), and the SDU (Selection/Distribution Unit) function is considered to be co-located with the source BSC (Base Station Controller).

FIGURE 6

**Reference Model for Circuit-Switched cdma2000 Access Network Inter­faces**



FIGURE 7

**Reference Model for Packet-based cdma2000 Access Network Inter­faces**



The interfaces defined in Figure 6 and Figure 7 provides:

* bearer (user traffic) connections (A2, A2p, A3 (traffic), A5, A8, and A10);
* a signaling connection between the channel element component of the target BS and the SDU function in the source BS (A3 signaling);
* a direct BS to BS signaling connection (A7);
* a signaling connection between the BS and the circuit-switched MSC (A1);
* a signaling connection between the BS and the MSCe (A1p);
* a signaling connection between the BS and PCF (A9); and
* a signaling connection between a PCF and PDSN pair (A11). A11 signaling messages are also used for passing accounting related and other information from the PCF to the PDSN.

In general, the functions specified on the interfaces are based on the premise that the interfaces carry signaling information that traverses the following logical paths:

* between the BS and MSC only (e.g., BS management information);
* between the MS and the MSC via the BS (e.g., the BS maps air interface messages to the A1 or A1p interface);
* between the BS and other network elements via the MSC;
* between the source BS and the target BS;
* between the BS and the PCF;
* between the PCF and the PDSN; and
* between the MS and the PDSN (e.g., authorization information and Mobile Internet Protocol (MIP) signaling).

**cdma2000 Evolved High Rate Packet Data (eHRPD) Access Network Architecture**

The eHRPD IOS (Interoperability Specification) messaging and call flows are based on the Architecture Reference Model shown in Figure 8[[50]](#footnote-50) (Session Control and Mobility Management in the evolved Access Network) and in Figure 9[[51]](#footnote-51) (Session Control and Mobility Management in the evolved Packet Control Function). In the figures, solid lines indicate signaling and bearer and dashed lines indicate only signaling.

The eHRPD call flows include the E-UTRAN and other 3GPP access entities (S-GW, P-GW, HSS and PCRF). Refer to TS 23.402 [1] for the architecture model and descriptions of these network entities and associated interfaces.

FIGURE 8

**Session Control and Mobility Management in the evolved Access Network**



Figure 9

**Session Control and Mobility Management in the evolved Packet Control Function**



**3.3.1.1.3 IMT-2000 CDMA TDD**

The IMT-2000 radio interface specifications for CDMA TDD technology are developed by a partnership of standards development organizations (SDOs)[[52]](#footnote-52) (see Note 5). This radio interface is called the Universal Terrestrial Radio Access (UTRA) time division duplex (TDD), where three options, called 1.28 Mchip/s TDD [[53]](#footnote-53)(TD-SCDMA – see Note 6), 3.84 Mchip/s TDD and 7.68 Mchip/s TDD can be distinguished. E-UTRAN TDD has been introduced for the evolution of UTRAN TDD towards high data rate, low latency and packet optimized radio access technology.

For the IMT-2000 CDMA TDD RAN overall architecture please refer to Figure 4 described above. For the E-UTRA TDD RAN overall architecture please refer to Figure 5.

**3.3.1.1.4 IMT-2000 TDMA Single-Carrier**

The IMT-2000 TDMA single-carrier radio interface specifications contain two variations depending

on whether a TIA/EIA-41 circuit switched network component or a GSM evolved UMTS circuit

switched network component is used. In either case, a common enhanced GSM General Packet

Radio Service (GPRS) packet switched network component is used.

**Radio interface use with TIA/EIA-41 circuit switched network**

The IMT-2000 radio interface specifications for TDMA single-carrier technology utilizing the TIA/EIA-41 circuit switched network component are developed by TIA TR45.3 with input from the Universal Wireless Communications Consortium. This radio interface is called Universal Wireless Communication-136 (UWC‑136), which is specified by American National Standard TIA/EIA-136. It has been developed with the objective of maximum commonality between TIA/EIA-136 and GSM EDGE GPRS. This radio interface was designed to provide a TIA/EIA-136 (designated as 136)-based radio transmission technology that meets ITU-R's requirements for IMT-2000. It maintains the TDMA community's philosophy of evolution from 1st to 3rd Generation systems while addressing the specific desires and goals of the TDMA community for a 3rd Generation system.

##### Radio interface used with GSM evolved UMTS circuit switched network component

This radio interface provides an evolution path for an additional pre-IMT-2000 technology (GSM/GPRS) to IMT-2000 TDMA Single-Carrier. The IMT-2000 radio interface specifications for TDMA Single-Carrier technology utilizing the GSM evolved UMTS circuit switched network component are developed by 3GPP and transposed by ATIS Wireless Technologies and Systems Committee (WTSC). The circuit switched component uses a common 200 kHz carrier as does the GSM EDGE enhanced GPRS phase 2 packet switched component, as used by 136EHS, to provide high speed data (384 kbit/s). In addition a new dual carrier configuration is supported

**TIA/EIA-41 Circuit Switched Network component**

Figure 10 presents the network elements and the associated reference points that comprise a system utilizing the TIA/EIA-41 circuit switched network component. The primary TIA/EIA-41 network node visible to the serving GPRS support node (SGSN) is the gateway mobile switching center (MSC)/visitor location register (VLR). The interface between the TIA/EIA-41 gateway MSC/VLR and the SGSN is the Gs' interface, which allows the tunnelling of TIA/EIA-136 signalling messages between the MS and the gateway MSC/VLR. The tunnelling of these signalling messages is performed transparently through the SGSN. Between the MS and the SGSN, the signalling messages are transported using the tunnelling of messages (TOM) protocol layer. TOM uses the LLC unacknowledged mode procedures to transport the signalling messages. Between the SGSN and the gateway MSC/VLR, the messages are transported using the BSSAP protocol.

Upon receiving a TIA/EIA-136 signalling message from a MS via the TOM protocol, the SGSN forwards the message to the appropriate gateway MSC/VLR using the BSSAP protocol. Upon receiving a TIA/EIA-136 signalling message from a gateway MSC/VLR via the BSSAP protocol, the SGSN forwards the message to the indicated MS using the TOM protocol.

MS supporting both the TIA/EIA-41 circuit switched network component and packet services (Class B136 MS) perform location updates with the circuit system by tunnelling the registration message to the gateway MSC/VLR. When an incoming call arrives for a given MS, the gateway MSC/VLR associated with the latest registration pages the MS through the SGSN. The page can be a hard page (no Layer 3 information included in the message), in which case, the Gs' interface paging procedures are used by the MSC/VLR and the SGSN. If the circuit page is not for a voice call or, if additional parameters are associated with the page, a Layer 3 page message is tunnelled to the MS by the MSC/VLR. Upon receiving a page, the MS pauses the packet data session and leaves the packet data channel for a suitable DCCH. Broadcast information is provided on the packet control channel to assist the MS with a list of candidate DCCHs. Once on a DCCH, the MS sends a page response. The remaining call setup procedures, such as traffic channel designation, proceed as in a normal page response situation.

figure 10



GSM evolved UMTS Circuit Switched Network component

Figure 11 presents the network elements and the associated reference points that comprise a system utilizing the GSM evolved UMTS circuit switched network component along with the common GSM EDGE enhanced GPRS or EGPRS2 packet switched component.

Since the TDMA-SC network supports a common EDGE 136EHS bearer connected to a core enhanced GPRS backbone network or a GSM EDGE radio access network, along with either circuit switched component, GSM EDGE Release 5, Release 6, Release 7 and Release 8 mobile stations and functions are supported. In addition to the Gs interface, GSM SMS functionality is also supported through the Gd interface[[54]](#footnote-54).

figure 11



**3.3.1.1.5 IMT-2000 FDMA/TDMA**

The IMT-2000 radio interface specifications for FDMA/TDMA technology are defined by a set of ETSI standards. This radio interface is called digital enhanced cordless telecommunications (DECT). This technology provides a comprehensive set of protocols which provide the flexibility to interwork between numerous different applications and networks. Thus a local and/or public network is not part of this specification. Figure 12 illustrates this.

The radio interface covers, in principle, only the air interface between the fixed part (FP) and portable part (PP). The interworking unit (IWU) between a network and the fixed radio termination (FT) is network specific and is not part of the common interface (CI) specification, but the profile specifications define IWUs for various networks. Similarly, the end system (ES)[[55]](#footnote-55), the application(s) in a PP is also excluded. The CI specification contains general end-to-end compatibility requirements e.g. on speech transmission. The IWU and ES are also subject to general attachment requirements for the relevant public network, e.g. the PSTN/ISDN.

Figure 12

The CI structure



For each specific network, local or global, the specific services and features of that network are made available via the air interface to the users of PPs/handsets. Except for cordless capability and mobility, this standard does not offer a specific service; it is transparent to the services provided by the connected network. Thus the CI standard is, and has to be, a tool box with protocols and messages from which a selection is made to access any specific network, and to provide means for market success for simple residential systems as well as for much more complex systems e.g. office ISDN services.

IMT-2000 FDMA/TDMA is very suitable to be used as radio access system to connect to mobile networks. Specifically the access to GSM/UMTS networks has been specified in detail, which allows the provision of GSM/UMTS services via DECT. The multipart TS 101 863 contains the UMTS interworking specification.

##### 3.3.1.1.6 IMT-2000 OFDMA TDD WMAN

The IEEE standard relevant for IMT-2000 OFDMA TDD WMAN, designated as IEEE Std 802.16, is developed and maintained by the IEEE 802.16 Working Group on Broadband Wireless Access. It is published by the IEEE Standards Association (IEEE-SA) of the Institute of Electrical and Electronics Engineers (IEEE).

The radio interface technology specified in IEEE Standard 802.16 is flexible, for use in a wide variety of applications, operating frequencies, and regulatory environments. IEEE 802.16 includes multiple physical layer specifications, one of which is known as WirelessMAN-OFDMA. OFDMA TDD WMAN is a special case of WirelessMAN-OFDMA specifying a particular interoperable radio interface. The component of OFDMA TDD WMAN defined here operates in TDD mode.

The OFDMA TDD WMAN radio interface is designed to carry packet-based traffic, including IP. It is flexible enough to support a variety of higher-layer network architectures for fixed, nomadic, or fully mobile use, with handover support. It can readily support functionality suitable for generic data as well as time-critical voice and multimedia services, broadcast and multicast services, and mandated regulatory services.

The radio interface standard specifies Layers 1 and 2; the specification of the higher network layers is not included. It offers the advantage of flexibility and openness at the interface between Layers 2 and 3 and it supports a variety of network infrastructures. The radio interface is compatible with the network architectures defined in Recommendation ITU-T Q.1701. In particular, a network architecture design to make optimum use of IEEE Standard 802.16 and the OFDMA TDD WMAN radio interface is described in the “WiMAX End to End Network Systems Architecture Stage 2-3”, available from the WiMAX Forum[[56]](#footnote-56).

The protocol layering is illustrated in Figure 13. The MAC comprises three sub-layers. The service-specific convergence sub-layer (CS) provides any transformation or mapping of external network data, received through the CS service access point (SAP), into MAC service data units (SDUs) received by the MAC common part sub-layer (CPS) through the MAC SAP. This includes classifying external network SDUs and associating them to the proper MAC service flow identifier (SFID) and connection identifier (CID). It may also include such functions as payload header suppression (PHS). Multiple CS specifications are provided for interfacing with various protocols. The internal format of the CS payload is unique to the CS, and the MAC CPS is not required to understand the format of or parse any information from the CS payload.

FIGURE 13

OFDMA TDD WMAN protocol layering, showing service access points (SAPs)



The MAC CPS provides the core MAC functionality of system access, bandwidth allocation, connection establishment, and connection maintenance. It receives data from the various CSs, through the MAC SAP, classified to particular MAC connections.

#### 3.3.1.2 IMT-Advanced

#### 3.3.1.2.1 LTE-Advanced

The *LTE-Advanced* radio-access network has a flat architecture with a single type of node, the *eNodeB*, which is responsible for all radio-related functions in one or several cells. The eNodeB is connected to the core network by means of the S1 interface, more specifically to the *serving gateway* (S-GW) by means of the user-plane part, S1-u, and to the *Mobility Management Entity* (MME) by means of the control-plane part, S1-c. One eNodeB can interface to multiple MMEs/ S‑GWs for the purpose of load sharing and redundancy.

The X2 interface, connecting eNodeBs to each other, is mainly used to support active-mode mobility. This interface may also be used for multi-cell *Radio Resource Management* (RRM) functions such as Inter-Cell Interference Coordination (ICIC). The X2 interface is also used to support lossless mobility between neighbouring cells by means of packet forwarding.

Inter-cell interference coordination (ICIC), where neighbour cells exchange information aiding the scheduling in order to reduce interference, is supported for the RITs. ICIC can be used for homogenous deployments with non-overlapping cells of similar transmission power, as well as for heterogeneous deployments where a higher-power cell overlays one or several lower-power nodes. The *LTE-Advanced* Radio-access network interfaces are illustrated in Figure 14.

FIGURE 14

Radio-access network interfaces



#### 3.3.1.2.2 WirelessMAN-Advanced

*[Editor’s Note: Need appropriate reference to WirelessMAN-Advanced Radio Access Network]*

*[Editor’s Note: Based on inputs from IEEE and WiMax Forum]*

### 3.3.2 IMT Core Network and standards

*[Editor’s Note: Based on Recommendations ITU-T Q.1741 (3GPP Core Network Architecture) & Q.1742 (ANSI 41 Core Network Architecture)]*

### 3.3.3 IMT standards organizations

*[Editor’s Note – Need to revisited again: WP 5D Chairman]*

IMT-2000 is a system with global development activity and the IMT-2000 radio interface specifications identified in Recommendation ITU-R M.1457 for IMT-2000 and ITU-R M.2012 for IMT‑Advanced have been developed by the ITU in collaboration with the radio interface technology proponent organizations, global partnership projects and standards development organizations (SDOs).

The ITU has provided the global and overall framework and requirements, and has developed the core global specifications jointly with these organizations. The detailed standardization has been undertaken within the recognized external organization[[57]](#footnote-57) (see Note 9), which operate in concert with the radio interface technology proponent organizations and global partnership projects.

## 3.4 Techniques to facilitate roaming

Roaming is facilitated by:

1) using the frequency bands identified for IMT in the Radio Regulations (RR);

2) following the frequency arrangements in [Recommendation ITU‑R M.1036](http://www.itu.int/rec/R-REC-M.1450/en), “Frequency arrangements for implementation of the Terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR)(03/2012)”, which provides guidance on the selection of transmitting and receiving frequency arrangements for the terrestrial component of IMT;

3) using the 3GPP operating band that are defined in Table 5.5-1 in the technical Specification 3GPP TS 36.101 [2], Table 5.0 in the technical Specification 3GPP TS 25.101[3] and section 5.2 in the technical Specification 3GPP TS 25.102[4]; and

4) using the 3GPP2 operating band defined in Table 1.5-1 in the band class specification 3GPP2 C.S0057 [5].

It should be noted that the technology used by a system and its conformance with the

recommended specifications and standards in Recommendation ITU-R M.1457 define that

system as IMT-2000 regardless of the frequency band of operation as explained in *considering k)*

of Recommendation ITU-R M.1580. So it should be also noted that harmonized frequency

arrangements for the bands identified for IMT are addressed in Recommendation ITU-R M.1036,

which also indicates that some administrations may deploy IMT‑2000 systems in bands other

than those identified to IMT in the RR, as explained in *considering l)* of the same

Recommendation mentioned above.

Table 1 through 3 below, provide information extracted from 3GPP and 3GPP2 operating bands.

Table 1

**E-UTRA operating bands[[58]](#footnote-58)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **E‑UTRA Operating Band** | **Uplink (UL) operating band BS receive UE transmit** | | | **Downlink (DL) operating band BS transmit  UE receive** | | | **Duplex Mode** |
| **FUL\_low – FUL\_high** | | | **FDL\_low – FDL\_high** | | |
| 1 | 1 920 MHz | – | 1 980 MHz | 2 110 MHz | – | 2 170 MHz | FDD |
| 2 | 1 850 MHz | – | 1 910 MHz | 1 930 MHz | – | 1 990 MHz | FDD |
| 3 | 1 710 MHz | – | 1 785 MHz | 1 805 MHz | – | 1 880 MHz | FDD |
| 4 | 1 710 MHz | – | 1 755 MHz | 2 110 MHz | – | 2 155 MHz | FDD |
| 5 | 824 MHz | – | 849 MHz | 869 MHz | – | 894MHz | FDD |
| 6[[59]](#footnote-59) | 830 MHz | – | 840 MHz | 875 MHz | – | 885 MHz | FDD |
| 7 | 2 500 MHz | – | 2 570 MHz | 2 620 MHz | – | 2 690 MHz | FDD |
| 8 | 880 MHz | – | 915 MHz | 925 MHz | – | 960 MHz | FDD |
| 9 | 1 749.9 MHz | – | 1 784.9 MHz | 1 844.9 MHz | – | 1 879.9 MHz | FDD |
| 10 | 1 710 MHz | – | 1 770 MHz | 2 110 MHz | – | 2 170 MHz | FDD |
| 12 | 699 MHz | – | 716 MHz | 729 MHz | – | 746 MHz | FDD |
| 13 | 777 MHz | – | 787 MHz | 746 MHz | – | 756 MHz | FDD |
| 14 | 788 MHz | – | 798 MHz | 758 MHz | – | 768 MHz | FDD |
| 15 | Reserved | | | Reserved | | | FDD |
| 16 | Reserved | | | Reserved | | | FDD |
| 17 | 704 MHz | – | 716 MHz | 734 MHz | – | 746 MHz | FDD |
| 18 | 815 MHz | – | 830 MHz | 860 MHz | – | 875 MHz | FDD |
| 19 | 830 MHz | – | 845 MHz | 875 MHz | – | 890 MHz | FDD |
| 20 | 832 MHz | – | 862 MHz | 791 MHz | – | 821 MHz | FDD |
| 22 | 3 410 MHz | – | 3 490 MHz | 3 510 MHz | – | 3 590 MHz | FDD |
| 23 | 2 000 MHz | – | 2 020 MHz | 2 180 MHz | – | 2 200 MHz | FDD |
| 25 | 1 850 MHz | – | 1 915 MHz | 1 930 MHz | – | 1 995 MHz | FDD |
| 26 | 814 MHz | – | 849 MHz | 859 MHz | – | 894 MHz | FDD |
| 27 | 807 MHz | – | 824 MHz | 852 MHz | – | 869 MHz | FDD |
| 28 | 703 MHz | – | 748 MHz | 758 MHz | – | 803 MHz | FDD |
| 29 | N/A | | | 717 MHz | – | 728 MHz | FDD[[60]](#footnote-60) |
| 30 | 2 305 MHz | – | 2 315 MHz | 2 350 MHz | – | 2 360 MHz | FDD |
| 31 | 452.5 MHz | – | 457.5 MHz | 462.5 MHz | – | 467.5 MHz | FDD |
| ... |  |  |  |  |  |  |  |
| 33 | 1 900 MHz | – | 1 920 MHz | 1 900 MHz | – | 1 920 MHz | TDD |
| 34 | 2 010 MHz | – | 2 025 MHz | 2 010 MHz | – | 2 025 MHz | TDD |
| 35 | 1 850 MHz | – | 1 910 MHz | 1 850 MHz | – | 1 910 MHz | TDD |
| 36 | 1 930 MHz | – | 1 990 MHz | 1 930 MHz | – | 1 990 MHz | TDD |
| 37 | 1 910 MHz | – | 1 930 MHz | 1 910 MHz | – | 1 930 MHz | TDD |
| 38 | 2 570 MHz | – | 2 620 MHz | 2 570 MHz | – | 2 620 MHz | TDD |
| 39 | 1 880 MHz | – | 1 920 MHz | 1 880 MHz | – | 1 920 MHz | TDD |
| 40 | 2 300 MHz | – | 2 400 MHz | 2 300 MHz | – | 2 400 MHz | TDD |
| 41 | 2 496 MHz |  | 2 690 MHz | 2 496 MHz |  | 2 690 MHz | TDD |
| 42 | 3 400 MHz | – | 3 600 MHz | 3 400 MHz | – | 3 600 MHz | TDD |
| 44 | 703 MHz | – | 803 MHz | 703 MHz | – | 803 MHz | TDD |

Table 2

UTRA frequency bands[[61]](#footnote-61)

| **Operating Band** | **UL Frequencies**  **UE transmit, Node B receive** | **DL frequencies**  **UE receive, Node B transmit** |
| --- | --- | --- |
| I | 1920 - 1980 MHz | 2110 -2170 MHz |
| II | 1850 -1910 MHz | 1930 -1990 MHz |
| III | 1710-1785 MHz | 1805-1880 MHz |
| IV | 1710-1755 MHz | 2110-2155 MHz |
| V | 824 - 849 MHz | 869-894 MHz |
| VI | 830-840 MHz | 875-885 MHz |
| VII | 2500-2570 MHz | 2620-2690 MHz |
| VIII | 880 - 915 MHz | 925 - 960 MHz |
| IX | 1749.9-1784.9 MHz | 1844.9-1879.9 MHz |
| X | 1710-1770 MHz | 2110-2170 MHz |
| XII | 699 – 716 MHz | 729 – 746 MHz |
| XIII | 777 - 787 MHz | 746 - 756 MHz |
| XIV | 788 – 798 MHz | 758 – 768 MHz |
| XV | Reserved | Reserved |
| XVI | Reserved | Reserved |
| XVII | Reserved | Reserved |
| XVIII | Reserved | Reserved |
| XIX | 830 – 845MHz | 875 – 890 MHz |
| XX | 832 – 862 MHz | 791 – 821 MHz |
| XXII | 3410 – 3490 MHz | 3510 – 3590 MHz |
| XXV | 1850 – 1915 MHz | 1930 – 1995 MHz |
| XXVI | 814 – 849 MHz | 859 – 894 MHz |
| TDD (Uplink and downlink transmission) | | |
| A (Low) | 1900 - 1920 MHz | |
| A (High) | 2010 - 2025 MHz | |
| B (Low) | 1850 - 1910 MHz: | |
| B (High) | 1930 - 1990 MHz: | |
| C | 1910 - 1930 MHz | |
| D | 2570 - 2620 MHz | |
| E | 2300—2400 MHz | |
| F | 1880 - 1920 MHz | |

Table 3

3GPP2 Band Class[[62]](#footnote-62)

| **Band** | **Uplink Frequencies**  **MS transmit, BTS receive (MHz)** | **Downlink frequencies**  **MS receive, BTS transmit (MHz)** |
| --- | --- | --- |
| 0 | 815 - 849 | 860 - 894 |
| 1 | 1850 - 1910 | 1930 - 1990 |
| 2 | 872 - 915 | 917 - 960 |
| 3 | 887 - 925 | 832 - 870 |
| 4 | 1750 - 1780 | 1840 - 1870 |
| 5 | 410 - 483 | 420 - 493 |
| 6 | 1920 - 1980 | 2110 - 2170 |
| 7 | 776 - 788 | 746 - 758 |
| 8 | 1710 - 1785 | 1805 - 1880 |
| 9 | 880 - 915 | 925 - 960 |
| 10 | 806 - 901 | 851 - 940 |
| 12 | 870 - 876 | 915 - 921 |
| 13 | 2500 - 2570 | 2620 - 2690 |
| 14 | 1850 - 1925 | 1930 - 1995 |
| 15 | 1710 - 1755 | 2110 - 2155 |
| 16 | 2502 - 2568 | 2624 - 2690 |
| 18 | 787 - 799 | 757 - 769 |
| 19 | 698 - 716 | 728 - 746 |
| 21 | 2000 - 2020 | 2180 - 2200 |

# 4 IMT spectrum

## 4.1 International spectrum identified for IMT

A number of frequency bands are identified for IMT in the Radio Regulations (RR) edition 2012. Recommendation ITU-R M.1036 provides guidance on the selection of transmitting and receiving frequency arrangements for the terrestrial component of IMT systems with a view to assisting administrations on spectrum-related technical issues relevant to the implementation and use of the terrestrial component of IMT in the bands identified in the Radio Regulations.

The following bands are identified for IMT in the Radio Regulations (RR) edition 2012, as shown in Table 4. This identification does not preclude the use of these bands by any application of the services to which they are allocated or identified and does not establish priority in the Radio Regulations. It has to be noted that different regulatory provisions apply to each band. The Regional deviations for each band are described in the different footnotes applying in each band, as shown in Table 4.

TABLE 4

|  |  |
| --- | --- |
| **Band  (MHz)** | **Footnotes identifying the band for IMT** |
| 450-470 | 5.286AA |
| 698-960 | 5.313A, 5.317A |
| 1 710-2 025 | 5.384A, 5.388 |
| 2 110-2 200 | 5.388 |
| 2 300-2 400 | 5.384A |
| 2 500-2 690 | 5.384A |
| 3 400-3 600 | 5.430A, 5.432A, 5.432B, 5.433A |

Also, administrations may deploy IMT systems in bands other than those identified in the RR, and administrations may deploy IMT systems only in some or parts of the bands identified for IMT in the RR.

## 4.2 Frequency arrangements

The frequency arrangements for IMT contain in Recommendation ITU-R M.1036 are provided with the intent of enabling the most effective and efficient use of the spectrum to deliver IMT services – while minimizing the impact on other systems or services in these bands – and facilitating the growth of IMT systems.

The recommended frequency arrangements for implementation of IMT in the bands listed in Table 4 are expanded on in Table 5 through 10 based upon Recommendation ITU-R M.1036.

TABLE 5

**Frequency arrangements in the band 450-470 MHz**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Frequency arrangements** | **Paired arrangements** | | | | **Un-paired arrangements (e.g. for TDD) (MHz)** |
| **Mobile station transmitter  (MHz)** | **Centre gap (MHz)** | **Base station transmitter (MHz)** | **Duplex separation (MHz)** |
| D1 | 450.000-454.800 | 5.2 | 460.000-464.800 | 10 | None |
| D2 | 451.325-455.725 | 5.6 | 461.325-465.725 | 10 | None |
| D3 | 452.000-456.475 | 5.525 | 462.000-466.475 | 10 | None |
| D4 | 452.500-457.475 | 5.025 | 462.500-467.475 | 10 | None |
| D5 | 453.000-457.500 | 5.5 | 463.000-467.500 | 10 | None |
| D6 | 455.250-459.975 | 5.275 | 465.250-469.975 | 10 | None |
| D7 | 450.000-457.500 | 5.0 | 462.500-470.000 | 12.5 | None |
| D8 |  |  |  |  | 450-470 TDD |
| D9 | 450.000-455.000 | 10.0 | 465.000-470.000 | 15 | 457.500-462.500 TDD |
| D10 | 451.000-458.000 | 3.0 | 461.000-468.000 | 10 | None |
| D11 | 450.500-457.500 | 3.0 | 460.500-467.500 | 10 | None | |

TABLE 6

**Paired frequency arrangements in the band 698-960 MHz**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Frequency arrangements** | **Paired arrangements** | | | | **Un-paired arrangements (e.g. for TDD) (MHz)** |
| **Mobile station transmitter (MHz)** | **Centre gap (MHz)** | **Base station transmitter (MHz)** | **Duplex separation(MHz)** |
| A1 | 824-849 | 20 | 869-894 | 45 | None |
| A2 | 880-915 | 10 | 925-960 | 45 | None |
| A3 | 832-862 | 11 | 791-821 | 41 | None |
| A4 | 698-716 776-793 | 12 13 | 728-746 746-763 | 30 30 | 716-728 |
| A5 | 703-748 | 10 | 758-803 | 55 | None |
| A6 | None | None | None |  | 698-806 |

TABLE 7

**Frequency arrangements in the band 1 710-2 200 MHz**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Frequency  arrangements** | **Paired arrangements** | | | | **Un-paired arrangements  (e.g. for TDD) (MHz)** |
| **Mobile station transmitter (MHz)** | **Centre gap (MHz)** | **Base station transmitter (MHz)** | **Duplex separation (MHz)** |
| B1 | 1 920-1 980 | 130 | 2 110-2 170 | 190 | 1 880-1 920; 2 010-2 025 |
| B2 | 1 710-1 785 | 20 | 1 805-1 880 | 95 | None |
| B3 | 1 850-1 920 | 10 | 1 930- 2 000 | 80 | 1 920-1 930 |
| B4 (harmonized with  B1 and B2) | 1 710-1 785 1 920-1 980 | 20 130 | 1 805-1 880 2 110-2 170 | 95 190 | 1 880-1 920; 2 010-2 025 |
| B5 (harmonized with B3 and parts of B1 and B2) | 1 850-1 920 1 710-1 780 | 10 340 | 1 930- 2 000  2 110-2 180 | 80 400 | 1 920-1 930 |
| B6 | 1 980-2 010 | 160 | 2 170-2 200 | 190 | None |

TABLE 8

**Frequency arrangements in the band 2 300-2 400 MHz**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Frequency arrangement** | **Paired arrangements** | | | | **Un-paired arrangements  (e.g. for TDD)  (MHz)** |
| **Mobile station transmitter  (MHz)** | **Centre gap (MHz)** | **Base station transmitter  (MHz)** | **Duplex separation (MHz)** |
| E1 |  |  |  |  | 2 300-2 400 TDD |

TABLE 9

**Frequency arrangements in the band 2 500-2 690 MHz   
(not including the satellite component)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Frequency arrangements** | **Paired arrangements** | | | | | **Un-paired arrangements (e.g. for TDD) (MHz)** |
| **Mobile station transmitter  (MHz)** | **Centre gap (MHz)** | **Base station transmitter  (MHz)** | **Duplex separation (MHz)** | **Centre gap usage** |
| C1 | 2 500-2 570 | 50 | 2 620-2 690 | 120 | TDD | 2 570-2 620 TDD |
| C2 | 2 500-2 570 | 50 | 2 620-2 690 | 120 | FDD | 2 570-2 620 FDD DL external |
| C3 | Flexible FDD/TDD | | | | | |

TABLE 10

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Frequency arrangements** | **Paired arrangements** | | | | **Un-paired arrangements  (e.g. for TDD) (MHz)** | |
| **Mobile station transmitter (MHz)** | **Centre gap (MHz)** | **Base station transmitter (MHz)** | **Duplex separation (MHz)** |
| F1 |  |  |  |  | 3 400-3 600 |
| F2 | 3 410-3 490 | 20 | 3 510-3 590 | 100 | None |

Further information can be found in Recommendation ITU-R M.1036 “Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR)”.

## 4.3 Methods to estimate frequency spectrum required for IMT

*[Editor’s Note – Reference to Report ITU-R M.2079 for Input requirement, Recommendation ITU-R M.1768-1 methodology and Report ITU-R M.2290 amount of spectrum needed]. Still need to figure out if this sub-section is at the appropriate place.*

# 5 Regulatory issues

## 5.1 Institutional aspects and arrangements

To facilitate the successful deployment of IMT systems, the policy to make the spectrum available to the market should be clearly stated. In order to guarantee that the spectrum policy is aligned with the country’s main objectives, it is important that telecommunications should figure on country’s main agenda. In this way, regulators and other government institutions will have the necessary support to conduct their activities.

Another important aspect that can foster IMT deployment is related to the institution arrangements for policy delivery. The agency responsible for the spectrum policy should pay close attention to the role of each government agent (national and subnational) as well as other market stakeholders. It is also important to avoid responsibility overlap or gaps in order to facilitate the achievement of goals, diminish tension between institutions, and encourage agreements.

In addition, all stakeholders should have a clear understanding of the decision-making process. This could be accomplished through the development of a code of practice for the decision-making process, enabling both regulators and operators to have a clear understanding of how regulatory decisions are made, and any applicable processes for appealing such decisions.

[Examples of regulatory policies can be found at the Annex H.]

## 5.2 Transparency and stakeholder involvement

In order to ensure that regulatory and policy decisions are made in the best interest of all, an open and public decision-making process should be used. This has two main benefits. First, by using a process that provides for public review and comment of proposed regulations and decisions, policymakers and regulators ensure that the regulatory and policy regime is not developed in a vacuum, and that current and expected future mobile market developments are considered. Policymakers, operators and vendors each have unique insights on the mobile market that, when considered together, have the best chance of developing a mobile sector based on international best practices and up-to-date market and technology intelligence.

Second, an open and public policy development process will lead to greater transparency, a key characteristic of any good decision-making process. By soliciting input from stakeholders and the public at large, and ensuring that industry plays a central role in the development of policies and priorities, regulators have an increased likelihood of crafting a regulatory and policy regime that is supported by most, if not all, interested parties. There are various approaches to including private sector stakeholders in the regulatory process, including standing advisory panels or groups, public consultations, and targeted solicitation of inputs, none of which are mutually exclusive. The close cooperation of regulators and industry is crucial to the development of a robust regulatory regime as well as a successful mobile industry.

## 5.3 Market knowledge

In order to develop good IMT spectrum policy, it is important for regulators and government institutions to know the actual market status and the community needs. To know the needs, the governments can conduct surveys, collect data through public consultations, and other feedback instruments that enable the market and the society to show their opinions and needs. This process can enhance government’s decision making process, improving the effectiveness and quality of the public policies.

Besides, government agencies may also take into account cultural aspects, social conditions, and demographical disparities, since these aspects may influence the development of spectrum policy instruments.

## 5.4 Spectrum licensing

### 5.4.1 IMT licensing considerations

Many considerations may impact IMT licensing conditions including the following:

– Technology requirements

– Coverage/ roll-out obligations

– Timing of license assignments

– Duration of licenses

– Spectrum block size

– Number of operators

– Infrastructure sharing

– Number portability.

### 5.4.2 IMT licensing principles and methods

Many methods of assigning spectrum licenses exist. These methods follow two approaches: 1) non-market based assignments such as comparative process (also known as beauty contests) and lotteries 2) market-based approaches such as auctions. In cases of limited demand for a particular frequency band in a particular geographic area, first-come first served licensing may also be considered. Licensing is a national prerogative and each country must decide what methodology is appropriate for the conditions that exist within its legal, regulatory, and market framework.

Furthermore, transferable and flexible spectrum rights may also be considered when assigning spectrum licenses. According to Report ITU-R SM.2012-1, “economists recommend that spectrum users be allowed to transfer their spectrum rights (whether assigned by auction or some other assignment mechanism) and that spectrum users have a high degree of flexibility in the choice of the consumer services that they provide with their spectrum.”

For more information on spectrum assignment methods, see section 2.3 of Report ITU‑R SM.2012‑1 “Economic aspects for spectrum management”.

## 5.5 IMT spectrum clearing (including refarming) guidelines

Recommendation ITU-R SM.1603-1 “Spectrum redeployment as a method of national spectrum management” gives guidelines for spectrum redeployment issues. This Recommendation defines spectrum redeployment (also known as spectrum refarming) as “a combination of administrative, financial and technical measures aimed at removing users or equipment of the existing frequency assignments either completely or partially from a particular frequency band. The frequency band may then be allocated to the same or different service(s). These measures may be implemented in short, medium or long time-scales.” The Recommendation also provides a guide for national consideration of redeployment issues.

## 5.6 Global circulation of terminals

The global circulation of terminals allows users to carry their personal terminals into a visited country and the ability to use them wherever possible.” Recommendation ITU-R M.1579 establishes the technical basis for global circulation of IMT 2000 terrestrial terminals, based on terminals not causing harmful interference in any country where they circulate. Further information can be found in Recommendation ITU-R M.1579, “Global circulation of IMT-2000 terrestrial terminals”.

## 5.7 Unwanted emissions

*[Editor’s Note – A reference to the equivalent Recommendation for IMT-Advanced ITU-R M.[OOBE] should also be added.]*

Information regarding unwanted emissions can be found in Recommendation ITU-R M.1580 “Generic unwanted emission characteristics of base stations using the terrestrial radio interfaces of IMT-2000” and Recommendation ITU-R M.1581 “Generic unwanted emission characteristics of mobile stations using the terrestrial radio interfaces of IMT-2000”.

# 6 Steps to consider in the deployment of IMT systems

*[Editor’s note: provide general guidelines for the deployment of IMT]*

## 6.1 Key issues and questions to be considered prior to IMT network deployment

## 6.2 Demographics and services

## 6.3 Evolution and/or migration of existing wireless systems to IMT

*[Editor’s Note: Include Guidelines for system evolution and migration (moved from Section 8) and refer to technology section in Section 7]*

## 6.4 Choice of technology and spectrum in the identified IMT bands

*[Editor’s Note – Such as bandwidth requirements, necessary guard bands and FDD/TDD allocations particularly for developing countries]*

*[Editor’s Note: refer to technology section in Section 7]*

### 6.4.1 Satellite component of IMT

IMT consists of both terrestrial component and satellite component radio interfaces. The terrestrial and satellite components are complementary, with the terrestrial component providing coverage over areas of land mass with population density considered to be large enough for economic provision of terrestrially-based systems, and the satellite component providing service elsewhere by a virtually global coverage, especially with strength in providing coverage in the sea, islands, mountainous districts, and sparsely-populated areas. The ubiquitous coverage of IMT can therefore be realized using a combination of satellite and terrestrial radio interfaces.

The satellite component of IMT encompasses both IMT-2000 and IMT-Advanced. The radio interfaces for the satellite component of IMT-2000 are identified in Recommendation ITU-R M.1850-1, including:

– Satellite radio interface A (SRI-A)

– Satellite radio interface B (SRI-B)

– Satellite radio interface D (SRI-D)

– Satellite radio interface E (SRI-E)

– Satellite radio interface F (SRI-F)

– Satellite radio interface G (SRI-G)

– Satellite radio interface H (SRI-H).

The radio interfaces for the satellite component of IMT-Advanced have been developed by ITU-R. Two radio interfaces are identified:

– BMSat

– SAT-OFDM.

For more information on radio interfaces for the satellite component of IMT-Advanced, please refer to Recommendation ITU-R M.2047 “Detailed specifications of the satellite radio interfaces of International Mobile Telecommunications-Advanced (IMT-Advanced)” and to Report ITU-R M.2279 “Outcome of the evaluation, consensus building and decision of the IMT-Advanced satellite process (Steps 4 to 7), including characteristics of IMT-Advanced satellite radio interfaces”.

The bands 1 980 to 2 010 MHz and 2 170 to 2 200 MHz are identified to the satellite component of IMT for return link and forward link, respectively. The specifications of the radio interfaces for the satellite component of IMT could also be adopted by other MSS systems and applied in other bands for MSS.

## 6.5 Deployment planning

A key to supporting the increasing data requirements of IMT systems is the provision of sufficient backhaul capacity to avoid the creation of a bottleneck. Fibre and wireless systems both have roles to play in backhaul of IMT data. Fibre has a greater capacity and typically lower operating expenses, while wireless backhaul is quicker and easier to install, especially in the case where many small cells are being connected. In addition, wireless technologies have the potential to provide lower latencies given the difference in propagation speeds between fibre and wireless.

Although the proportion of data traffic backhauled by fibre is increasing, the absolute number of fixed wireless backhaul links is nevertheless increasing rapidly, particularly systems comprising   
a small number of hops in support of small mobile cells in urban and other high usage areas.

For more detailed information on the design of wireless backhaul systems please refer to the following ITU-R Recommendations:

– Recommendation ITU-R F.746, Radio-frequency arrangements for fixed service systems;

– Recommendation ITU-R F.752, Diversity techniques for point-to-point fixed wireless systems;

– Recommendation ITU-R F.755, Point-to-multipoint systems in the fixed service;

– Recommendation ITU-R F.1093, *Effects of multipath propagation on the design and operation of line-of-sight digital fixed wireless systems*;

– Recommendation ITU-R F.1101, *Characteristics of digital fixed wireless systems below about 17 GHz*;

– Recommendation ITU-R F.1102, *Characteristics of fixed wireless systems operating in frequency bands above about 17 GHz*;

– Recommendation ITU-R F.1668, *Error performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections*; and

– Recommendation ITU-R F.1703, *Availability objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections*.

*Backhaul to be included in this section (based on additional input from ITU-T SG 13)*

For additional information on fixed service backhaul networks for IMT please refer to the working document towards a draft new Report ITU-R F.[FS.IMT/BB].

# 7 Criteria leading to technology decisions

## 7.1 Spectrum implications, Channelization and Bandwidth considerations

[The current availability of frequency bands and amount of bandwidth differs across Member States and regions and this leads to many challenges such as roaming, device complexity, lack of economics of scale, and interference. It is recognized that finding and assigning contiguous, broader and harmonized frequency bands which are aligned with future technology development can reduce these challenges.

Also, pursuing greater harmonization with larger contiguous frequency bands will have support continued introduction of mobile devices with longer battery life while improving spectrum efficiency; and potentially reducing cross border interference.

In addition, fully static spectrum usage strategy cannot make efficient usage of allocated spectrum for certain service due to dynamic change of network load. In time, space, and frequency domain, there exist unused radio resources, i.e. so-called spectrum holes. Flexible spectrum usage can improve the frequency efficiency by spectrum sharing and making use of spectrum holes, which includes the aspects of cognitive radio techniques, authorized spectrum sharing e.g. ASA (Authorized Shared Access)/LSA (Licensed Shared Access) and joint management of multiple RATs.]

## 7.2 Importance of multi-mode/multi-band solutions

The increasing availability of multi-radio mobile devices has fueled a growing trend towards exploiting multiple radio access technologies (RATs), [including IMT and non IMT radio access systems] to address capacity as well as connectivity limitations. Integration of multiple radio access technologies could help seamlessly integrate the new spectrum bands, existing licensed bands, and unlicensed bands to meet capacity and service demands and provide better user experience. Multi-radio networks also offer an opportunity for future IMT systems to support all footprints: wide area networks (WANs), local area networks (LANs), and personal area networks (PANs) in a fashion that is transparent to the end user.

## 7.3 Technology development path

ITU-R WP 5D has a process in place to continually revise Recommendations ITU-R M.1457 and ITU-R M.2012 as several technologies have and will continue to introduce technological advancements to both established and more recent IMT systems. Member States can follow these advancements in many ways including tracking the latest revisions of theserecommendations. Advances in the mobile industry have been significant over the past decade and the ability to introduce these technologies advancements quickly have contributed to the significant growth in mobile broadband data usage.

## 7.4 Backhaul Considerations

In this context backhaul means the aggregate of all the traffic being transported to the core network. As traffic demands for mobile broadband communications increases, backhaul is increasingly becoming an important infrastructure in the IMT network architecture that requires special consideration. Backhaul performance not only affects the data throughput available to users, but also the overall performance of the radio-access network.

High performance backhaul with low latency enables tighter coordination between nodes, which in turn uses available spectrum more efficiently. Networks with large numbers of (small) cell sites require backhaul solutions that can use a selection of physical transmission media, including microwave, fiber and wireless connectivity.

Backhaul solutions should not limit the radio access network, which means that there should be adequate backhaul capacity provision at the network cell sites. In addition, backhaul solutions should have sufficient end-to end performance to meet the desired user quality of experience (QoE) everywhere for the provision of mobile broadband.

## 7.5 Technology Neutrality

[With the rapid changes and developments occurring in the mobile sector, a technology neutral approach in developing policies and regulations for the wireless communications sector will support the continued and robust growth of mobile broadband which will directly benefit the entire community, both the public and private sectors. Policies and regulations that mandate or only address specific technology solutions frequently become impediments for continued growth, limit competition and stifle innovation. ]

*[Editor’s note: Provide some reference]*

# 8 Core network evolution scenarios

*[Editor’s Note: Based on Recommendations ITU-T Q.1741 (3GPP Core Network Architecture) & Q.1742 (ANSI 41 Core Network Architecture)]*

## Annex A – Abbreviations and acronyms

## Annex B – References

## B.1 Introduction

[1]3GPP TS 23.402 V12.4.0 (2014-03), Technical Specification Group Services and System Aspects; Architecture enhancements for non-3GPP accesses

[2] 3GPP TS 36.101 V12.3.0 (2014-03): “Evolved Universal Terrestrial Radio Access (E-

UTRA); User Equipment (UE) radio transmission and reception” (Table 5.5-1)

[3] 3GPP TS 25.101 V12.3.0 (2014-03): “Technical Specification Group Radio Access

Network; User Equipment (UE) radio transmission and reception (FDD)” (Table 5.0)

[4] 3GPP TS 25.102 V11.6.0 (2013-12): “Technical Specification Group Radio Access

Network; User Equipment (UE) radio transmission and reception (TDD)” (Section 5.2)

[5] 3GPP2 C.S0057-E Version 1.0 October 2010: “Band Class Specification for cdma2000 Spread Spectrum Systems Revision E

## B.2 ITU publications

### B.2.1 ITU Recommendations

[*Editor’s note: Including ITU-R, ITU-T, ITU-D]*

Terrestrial IMT (and other, related) Recommendations:

- Recommendation ITU-R M.678, “International Mobile Telecommunications-2000 (IMT‑2000)”.

- Recommendation ITU-R M.819, “International Mobile Telecommunications-2000 (IMT‑2000) for developing countries”.

- [Recommendation ITU‑R M.1036](http://www.itu.int/rec/R-REC-M.1450/en),“Frequency arrangements for implementation of the Terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR)(03/2012)”.

- Recommendation ITU-R M.1224, “Vocabulary of terms for International Mobile Telecommunications (IMT)”.

- [Recommendation ITU-R M.1457](http://www.itu.int/rec/R-REC-M.1457/en), “Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)”.

- [Recommendation ITU-R M.1580](http://www.itu.int/rec/R-REC-M.1580/en), “Generic unwanted emission characteristics of base stations using the terrestrial radio interfaces of IMT 2000”.

- [Recommendation ITU-R M.1581](http://www.itu.int/rec/R-REC-M.1581/en), “Generic unwanted emission characteristics of mobile stations using the terrestrial radio interfaces of IMT 2000”.

- Recommendation ITU-R M.1579, “Global circulation of IMT-2000 terrestrial terminals”.

- Recommendation ITU-R M.1645, “ Framework and overall objectives of the future development of IMT‑2000 and systems beyond IMT-2000”.

- Recommendation ITU-R M.1768, “Methodology for calculation of spectrum requirements for the future development of IMT-2000 and systems beyond IMT-2000”.

- [Recommendation ITU-R M.1801](http://www.itu.int/rec/R-REC-M.1801/en), “Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz”.

- Recommendation ITU-R M.1822, “Framework for services supported by IMT”.

- [Recommendation ITU-R M.1850](http://www.itu.int/rec/R-REC-M.1850/en), “Detailed specifications of the radio interfaces for the satellite component of International Mobile Telecommunications-2000 (IMT-2000)”.

- [Recommendation ITU-R M.2012](http://www.itu.int/rec/R-REC-M.2012/en), “Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced (IMT-Advanced)”.

### B.2.2 ITU Reports

[*Editor’s note: Including ITU-R and other relevant ITU reports]*

Terrestrial IMT (and other, related) Reports:

- Report ITU-R M.2038, “Technology trends (as they relate to IMT-2000 and systems beyond IMT‑2000) ”.

- [Report ITU-R M.2039](http://www.itu.int/pub/R-REP-M/publications.aspx?lang=en&parent=R-REP-M.2039), “Characteristics of terrestrial IMT-2000 systems for frequency sharing/interference analyses”.

- Report ITU-R M.2242, “Cognitive radio systems specific for IMT systems”.

- Report ITU-R M.2243, “Assessment of the global mobile broadband deployments and forecasts for International Mobile Telecommunications”.

- Report ITU-R M.2072, “World mobile telecommunication market forecast”.

- Report ITU-R M.2078, “Estimated spectrum bandwidth requirements for the future development of IMT‑2000 and IMT-Advanced”.

- Report ITU-R M.2079, “Technical and operational information for identifying spectrum for the terrestrial component of future development of IMT-2000 and IMT-Advanced”.

### B.2.3 ITU Handbooks

[*Editor’s note: Including ITU-R and other relevant ITU Handbooks]*

## B.3 External publications

### B.3.1 Published papers in technical journals

### B.3.2 UMTS Forum Reports

### B.3.3 GSA publications

[*Editor’s note: Global mobile Suppliers Association publications]*

## Annex C – Applications and services

### C.1 Location based application & services

Location based application & services helps in determining the geographical position of a mobile phone/device, and delivers the position to the application requesting this information. Location based systems can be broadly divided into: a) network based; b) [handset based].

a) Network based:

Network-based techniques utilize the service provider's network infrastructure to identify the location of the handset. The advantage of network-based techniques   
(from mobile operator's point of view) is that they can be implemented without specific support for LBS from handsets. The accuracy of network-based techniques is dependent on the inter site distance and number of neighboring base station cells.

b) Handset based:

The handset based technique generally uses GPS. In this case location determination calculation is done by the handset, and thus location information is generally more precise.

c) Hybrid positioning systems use a combination of network-based and handset-based technologies for location determination. One example would be Assisted GPS, which uses both GPS and network information to compute the location. Hybrid-based techniques give the best accuracy of the two but inherit the limitations and challenges of network-based and handset-based technologies.

### C.1.1 Location accuracy techniques

The following are the location techniques:

– Cell Id

– Cell Id +TA/ Cell ID+RTT

– Enhanced Cell ID(ECID)

– RF Pattern Matching

– U-TDOA (LMU) based

– O-TDOA

– A-GPS

– Mix of one or more of above.

### C.1.1.1 Cell ID

a) In this positioning mechanism, the serving cell of the target UE is translated to a geographical shape. This is a quick but low accuracy positioning mechanism. For this the positioning entity needs to have a database of CGI (Computer –Generated Imagery) and the corresponding radio coverage.

b) Where can be deployed: Cell ID can be implemented regardless of technology.

c) Salient points:

i) Limited accuracy

ii) No additional major deployment in network

iii) Works in all network technologies (2G, 3G, LTE).

### C.1.1.2 Cell Id +TA/ Cell ID+RTT

a) The TA is based on the existing Timing Advance (TA) parameter. The TA value is known for the serving BTS. To obtain TA values in case the MS is in idle mode a special call, not noticed by the GSM subscriber (no ringing tone), is set up. The cell‑ID of the serving cell and the TA which is received is then used to determine the approximate distance of the UE from the tower.

The Round Trip Time (RTT) measures the distance between the WCDMA/3G-handset and the base station, i.e. with a similar purpose as TA in GSM. Accuracy depends upon various factors such as inter site distance, accuracy of Cell site data bases and stability in RF characteristics of the network. Works with WCDMA / 3G network.

b) Salient points:

i) Cell Id + TA/ Cell Id + RTT positioning method is merely an enhancement of the Cell Id.

ii) The TA parameter is an estimate of the distance (in increments of 550 M) from the mobile terminal to the base station.

iii) The Round Trip Time (RTT) measures the distance between the 3G-handset and the base station, i.e. with a similar purpose as TA in GSM.

iv) Works in all network technologies.

### C.1.1.3 E-CID {(Cell Id +TA)/ (Cell ID+RTT) & NMR}

a) Network Management Reports (NMR) like power measurement can also be used to enhance accuracy of RTT and CGI.

b)Salient points:

i) Medium accuracy around 200 meters in urban areas depending upon inter site distance and number of neighbors.

ii) Works in all network technologies.

### C.1.1.4 RF Pattern Printing (RFPM)

RFPM is a positioning method that uses the RF patterns observed in the region to determine UE location using the NMRs as main inputs RFPM compares “fingerprint” data received from the handsets with the database of radio frequency strength of the same area. This will improve accuracy considerably. Accuracy depends upon various factors such as inter site distance, accuracy of Cell site data bases and stability in RF characteristics of the network. RFPM works with 2G and 3G networks.

a) RF Profiling/Pattern Matching/Fingerprinting- The technology is capable of meeting the 100 m/300 m requirement for network-based solutions in many urban and some dense suburban settings. Accuracy in urban, suburban/rural areas may be achieved depending upon inter site distance and number of neighbors.

b) Works in all network technologies.

c) RF fingerprinting requirements:

i) The method requiresperiodic drive tests and collection of data over the required area. The samples are to be collected at different point of time in a day or adaption of RF patterns data for different RF characteristics in a day.

ii) Large number of samples with the required parameters to be taken.

iii) The drive test for in building and hand held drive test for congested locations (which are non –drivable) should also be done and integrated with the drive test of outdoor to generate RF pattern data.

iv) Incremental drive test or tuning of RF measurement pattern is required in case of change in antenna power, tilt or beam width or when a new base station is installed or any base station stops radiating, the topology changes due to change in Landscape, infrastructure development, terrain etc.

### C.1.1.5 Uplink time duration of arrival (UTDOA) – Location management unit (LMU)

a) This is software and hardware based solution to be installed along with an existing BTS. It will require backend infrastructure to collect process and present the required information.

b) The technology is capable of meeting the 100 m/300 m requirement for network-based solutions. Higher accuracy in urban, suburban/rural areas may be achieved depending upon inter site distance and number of neighbors.

c) Will require additional O&M of LMU hardware.

d) Works in 2G.

e) LMU requirements:

i) At least two neighbors are required.

ii) For synchronization, GPS infrastructure (GPS antenna, cable) is required.

iii) Signaling connectivity between LMU Server and LMUs (located at BTS) is required.

iv) It is an active element which requires connectivity at BTS.

### C.1.1.6 Observed time duration of arrival (O-TDOA)

a) To be deployed for LTE.

b) O-TDOA is a downlink trilateration technique that requires the User Equipment (UE) to detect at least two neighbor eNodeBs.

c) The UE requires O-TDOA software support in order to process the signals from multiple eNodeBs and interact with the E-SMLC/SLP server.

### C.1.1.7 A-GPS

GPS is a satellite based positioning technology. In this UE calculated its location and provides it to the network. A variant of GPS is A-GPS wherein network provides initial assistance data to the UE to reduce the location determination time. GPS based mechanism generally does not work as well indoors or in areas where clear sky is not visible.

a) Salient points:

i) Good accuracy in Sub-urban/ Rural/Remote. In strong signal conditions (e.g., rural environment with user in clear sky conditions), the accuracy can be better than 10 m. In some dense urban or indoors environments, accuracy may degrade to the 50-100 m range.

ii) Only works for users with GPS on their handsets.

iii) GPS enabling is user controlled.

### C.1.2 Factors impacting location accuracy

In all location Accuracy a method except A-GPS, the accuracy is dependent on inter site distance

and number of neighbors of BTSs. Lower the inter site distance the accuracy shall be higher.

Also higher the number of neighbors the accuracy shall be higher.

### C.1.3 Required features and issues in supporting LBS

* + - * 1. Location nodes i.e. GMLC, SMLC and its associated interfaces are required.
        2. The following are the requirements in various network elements for LBS support:

1. BSC/RNC:
   * Lb/Iupc Interface on every BSC/RNC
   * Network features required in each BSC/RNC
   * Unique Point Code/GT/RNCID in all BSC’s/RNC’s across all PLMN’s
   * BSC/RNC Reachability – STP or Direct?
   * Full CGI Value (MCC+MNC+LAC+CI) to be provided by BSC’s
   * Full CGI Value (MCC+MNC+LAC/RNCID+CID) to be provided by RNC’s.
   * Extra Load on BSC/RNC for All Call CDR Requirement.
2. MSC/MME:
   * Lg/SLg& SLs Interface on every MSC/MME
   * Network features required in each MSC/MME.
3. HLR/HSS:
   * Lh/SLh Interface on every HLR/HSS
   * Network features required in each HLR/HSS.
4. BTS/Node B/E-Node B:
   * Intersite Distance Requirement. Accuracy shall increase with lesser inter‑site distance and more number of neighbors for network based solutions.

(c) As the usage of location based services increases, it will have impact on different network elements and signaling etc. for which re-dimensioning of various network elements may be required.

## Annex D – Description of the relevant radio and network transport technologies

*[Editor’s Note: Via References]*

## Annex E – Description of the IMT radio interfaces and systems

*[Editor’s Note: Via References]*

**CDMA Direct Spread**

Figure 15shows the radio interface protocol architecture for the radio access network. On a general level, the protocol architecture is similar to the current ITU-R protocol architecture as described in Recommendation ITU-R M.1035. Layer 2 (L2) is split into the following sub-layers; radio link control (RLC), medium access control (MAC), Packet Data Convergence Protocol (PDCP) and Broadcast/Multicast Control (BMC). Layer 3 (L3) and RLC are divided into control (C-plane) and user (U-plane) planes. In the C-plane, L3 is partitioned into sub-layers where the lowest sub-layer, denoted as radio resource control (RRC), interfaces with L2. The higher-layer signalling such as mobility management (MM) and call control (CC) are assumed to belong to the CN. There are no L3 elements in this radio interface for the U-plane.

Each block in Figure 15 represents an instance of the respective protocol. Service access points (SAPs) for peer-to-peer communication are marked with circles at the interface between sub-layers. The SAP between MAC and the physical layer provides the transport channels. A transport channel is characterized by how the information is transferred over the radio interface (see § 5.1.1.3 “Physical layer” § 5.1.1.3.1 “Transport Channel” of Recommendation ITU-R M.1457 for an overview of the types of transport channels defined). The SAPs between RLC and the MAC sub‑layer provide the logical channels. A logical channel is characterized by the type of information that is transferred over the radio interface. The logical channels are divided into control channels and traffic channels. The different types of logical channels are not further described in this overview. In the C-plane, the interface between RRC and higher L3 sub-layers (CC, MM) is defined by the general control (GC), notification (Nt) and dedicated control (DC) SAPs. These SAPs are not further discussed in this overview.

Also shown in Figure 15 are connections between RRC and MAC as well as RRC and L1 providing local inter-layer control services (including measurement results). An equivalent control interface exists between RRC and the RLC sub-layer. These interfaces allow the RRC to control the configuration of the lower layers. For this purpose separate control SAPs are defined between RRC and each lower layer (RLC, MAC, and L1).

FIGURE 15

Radio interface protocol architecture of the RRC sub layer (L2 and L1)



**IMT-2000 CDMA Multi-Carrier**

As shown in Figure 16, this radio interface has a layered structure that provides a combination of voice, packet data, and circuit data services, according to the ISO/OSI reference model (i.e. Layer 1 – the physical layer, and Layer 2 – the link layer). Layer 2 is further subdivided into the link access control (LAC) sub-layer and the MAC sub-layer. Applications and upper layer protocols corresponding to OSI Layers 3 through 7 utilize the services provided by the LAC services, e.g. signalling services, voice services, data services (packet data and circuit data).

In this radio interface a generalized multimedia service model is supported. This allows any combination of voice, packet data, and circuit data services to be operated. The radio interface also includes a QoS control mechanism to balance the varying QoS requirements of multiple concurrent services (e.g. to support ISDN or RSVP network layer QoS capabilities).

FIGURE 16

General radio interface architecture



## Annex F – Description of ITU and External Organizations

*[Editor’s Note: Via References]*

## Annex G – Examples of business cases

## Annex H – Examples of regulatory policies

## Annex I – Deliverables and ongoing activities of ITU-R on Terrestrial IMT

## I.1 Summary of recent deliverables (Recommendations and Reports) of ITU-R WP 5D (since WP 5D #13)

### I.1.1 Report ITU-R M.2117-1 (IMT aspects) “Software-defined radio in the land mobile, amateur and amateur-satellite services”, Approved in 2012-11

This Report addresses the application and implications of SDR to land mobile systems, including, but not limited to, IMT systems, dispatch systems, intelligent transport systems (ITS), public mobile systems including public protection and disaster relief (PPDR), first and second generation cellular systems including their enhancements, and amateur and amateur-satellite systems. It addresses issues on the characteristics, software download and its security, operational considerations such as spectrum usage and flexibility as well as certification and conformity, and SDR applications to specific land mobile systems.

1st revision of this Report was based on the recent results of ITU-R studies on SDR and CRS. The recent ITU-R study gives clear definitions to SDR and CRS. The contents on cognitive radio system (CRS) and its related technologies were removed from this Report since the topics on CRS are elaborated and well-described in Report ITU-R M.2225. The term “IMT-2000 and systems beyond IMT-2000” was changed to general terminology of “IMT systems”, taking into account the progress of the ITU-R study on IMT-2000 and IMT-Advanced. The SDR applications to ITS, PPDR as well as amateur and amateur-satellite systems were also updated according to the recent advance of the related technologies.

### I.1.2 Recommendation ITU-R M.1457-11 “Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)”, Approved in 2013-02

This Recommendation has been developed based on consideration of the results of a defined evaluation process employed by the ITU-R on IMT-2000 radio proposals that have been submitted in response to a set of defined requirements. Further consideration was given to consensus building, recognizing the need to minimize the number of different radio interfaces and maximize their commonality keeping in mind the end-user needs, while incorporating the best possible performance capabilities in the various IMT-2000 radio operating environments.

The Radiocommunication Assembly recommends that the radio interfaces given in below should be those of the terrestrial component of IMT-2000.

– IMT-2000 CDMA Direct Spread

– IMT-2000 CDMA Multi-Carrier

– IMT-2000 CDMA TDD

– IMT-2000 TDMA Single-Carrier

– IMT-2000 FDMA/TDMA

– IMT-2000 OFDMA TDD WMAN.

Revisions to this Recommendation have been developed jointly by the ITU and the radio interface technology proponent organizations, global partnership projects and standards development organizations. Updates, enhancements and additions to the radio interfaces incorporated in this Recommendation have undergone a defined process of development and review to ensure consistency with the original goals and objectives established for IMT-2000 while acknowledging the obligation to accommodate the changing requirements of the global marketplace.

The main changes of 11th revision of Recommendation ITU-R M.1457 include the addition of enhanced capabilities for some of the radio interfaces, and some consequential changes to the overview sections of the text, as well as to the Global Core Specifications. Also the transposition references have been updated. In addition, section 6 (“Recommendations on unwanted emission limits”) and Annex 1 (“Abbreviations”) were reinserted (they were inadvertently omitted in the previous version of the Recommendation). Also a footnote was added in the Introduction in order to clarify the relation between Recommendation ITU-R M.1457 and Recommendation ITU-R M.2012. Further, a clarifying sentence on the specifications was added at the beginning of each section 5.x.2.

### I.1.3 Recommendation ITU-R M.1768-1 “Methodology for calculation of spectrum requirements for the terrestrial component of International Mobile Telecommunications”, Approved in 2013-04

This Recommendation presents the methodology for calculating the spectrum requirements for the further development of IMT. The methodology accommodates a complex mixture of services from market studies with service categories having different traffic volumes and QoS constraints. The methodology takes into account the time-varying and regionally-varying nature of traffic. The methodology applies a technology neutral approach to handle emerging as well as established systems using the Radio access technique group (RATG) approach with a limited set of radio parameters. The four RATGs considered cover all relevant radio access technologies.

RATG1: Pre-IMT systems, IMT-2000 and its enhancements.

RATG2: IMT-Advanced systems as described in Recommendation ITU-R M.2012.

RATG3: Existing radio LANs and their enhancements.

RATG4: Digital mobile broadcasting systems and their enhancements.

The methodology distributes traffic to different RATGs and radio environments using technical and market related information. For RATG3 and RATG4, no spectrum requirements are calculated. For the traffic distributed to RATG1 and RATG2, the methodology transforms the traffic volumes from market studies into capacity requirements using separate algorithms for packet-switched and circuit switched (reservation based) service categories and takes into account the gain in multiplexing packet services with different QoS characteristics. The methodology transforms capacity requirements into spectrum requirements using spectral efficiency values. The methodology considers practical network deployments to adjust the spectrum requirements and calculates the aggregate spectrum requirements for further development of IMT.

The first revision of this Recommendation includes two changes to the methodology itself and several editorial updates. The changes in the methodology are the following:

− introduction of the granularity concept of spectrum deployment per operator per radio environment for improved increments;

− due to the enhancement of network deployment in IMT-Advanced, the spectrum sharing approach between different radio environments in IMT-Advanced (RATG2) is changed to allow macro cells and micro cells to use the same frequencies. This change may impact the spectrum efficiencies which have to be taken into account in the input parameter values.

### I.1.4 “USER GUIDE FOR THE IMT SPECTRUM REQUIREMENT ESTIMATION TOOL” in ITU-R WP 5D Web page, Approved in 2013-10

The tool for the implementation of the methodology to determine global spectrum requirements for IMT in Recommendation ITU-R M.1768-1 is presented. This methodology and tool could also be used to estimate the total IMT spectrum requirements of a specific country if all the input parameter values are specified (as described in the methodology itself).

## I.2 Ongoing activities of ITU-R WP 5D

### I.2.1 Draft new Report ITU-R M.[IMT.2020.INPUT]

This Report presents the future radio aspect parameters for use with the terrestrial IMT spectrum estimate methodology of Recommendation ITU-R M.1768-1 in conjunction with developing the future spectrum requirement estimate for terrestrial IMT systems, principally focused towards the years 2020 and beyond.

*[Note: SG 5 approved this report at Dec. 2013. This part will be moved to section I.2 if this report is open to public in ITU web page.]*

### I.2.2 Draft new Report ITU-R M.[IMT.ADV PARAM]

IMT systems have been the main method of delivering wide area mobile broadband applications. In order to accommodate increasing amount of mobile traffic and user demand for higher data rates, IMT-Advanced which is evolution of IMT-2000, is planned to be deployed in the world.

Frequency sharing studies and interference analyses involving IMT systems and other systems and services operating in the same or the adjacent bands may need to be undertaken within ITU-R. To perform the necessary sharing studies between IMT systems and systems in other services, characteristics of the terrestrial component of IMT-Advanced systems are needed.

This Report provides the baseline characteristics of terrestrial IMT-Advanced systems for use of sharing and compatibility studies between IMT-Advanced systems and other systems and services.

*[Note: SG 5 approved this report at Dec. 2013. This part will be moved to section I.2 if this report is open to public in ITU web page.]*

### I.2.3 Draft 3rd revision of Report ITU-R M.2039

This draft 3rd revision of Report provides the baseline characteristics of terrestrial IMT‑2000 systems only for use in frequency sharing and interference analysis studies involving IMT‑2000 systems and between IMT‑2000 systems and other systems.

Recommendations ITU-R M.1457, ITU-R M.1580 and ITU-R M.1581 provide standardization information relating to IMT-2000 interfaces.

Parameters for IMT-Advanced interfaces are not addressed in this Report. They are addressed in Report ITU-R M.[IMT-Advanced Parameters].

The characteristics of the IMT-2000 interfaces have been grouped by frequency ranges:

– below 1 GHz,

– between 1 and 3 GHz,

– between 3 and 6 GHz.

### I.2.4 Draft revision of Recommendation ITU-R M.2012

This Recommendation identifies the terrestrial radio interface technologies of International Mobile Telecommunications-Advanced (IMT-Advanced) and provides the detailed radio interface specifications of “LTE-Advanced” and “WirelessMAN-Advanced”. These radio interface specifications detail the features and parameters of IMT-Advanced. The 1st revision of Recommendation ITU-R M.2012 is intended to keep the specified technologies of the terrestrial component of IMT-Advanced up to date. The main changes include the addition of enhanced capabilities for both radio interface technologies in Annexes, and some consequential changes to the overview sections of the text, as well as to the Global Core Specifications. Also the transposition references have been updated.

In addition, a footnote was added in the Introduction in order to clarify the relation between Recommendations ITU-R M.1457 and ITU-R M.2012 and also noting b) is added to refer to the evaluation results on revised RIT/SRIT.

*[Note: This recommendation is in the procedure for simultaneous adoption and approval (PSAA).]*

### I.2.5 Draft new Report on Applications of IMT technologies to PPDR ITU-R M.[IMT.BROAD.PPDR]

This draft new Report has considered how the use of IMT, and LTE in particular, can support current and possible future PPDR applications. The broadband PPDR communication applications are detailed in various ITU-R Resolutions, Recommendations and Reports; and this Report has assessed the LTE system capabilities to support these applications. This Report has also considered the benefits that can be realized when common radio interfaces technical features, and functional capabilities, are employed to address communications needs of public safety agencies. Also, the report describes the features and benefits that make LTE particularly suitable for PPDR applications as compared to traditional PPDR systems.

*[Note: SG 5 approved this report at Dec. 2013. This part will be moved to section I.2 if this report is open to public in ITU web page.]*

### I.2.6 Draft new Report ITU-R M.[IMT.BEYOND2020 TRAFFIC]

This draft new Report will include estimates of IMT (including cellular and Mobile broadband) traffic and estimates of numbers of subscriptions and also including other relevant information impacting traffic estimation. This Report covers a period of 2020-2025, building on the estimates done in Report ITU-R M.2243.

*[Note: At the 17th WP 5D meeting, the identifier was change from M.[IMT.2020 TRAFFIC] to M.[IMT.BEYOND2020 TRAFFIC], dedicated to 2020-2025 time span with a specific title of “IMT traffic and subscription estimation beyond year 2020”.]*

## I.2.7 Draft new Report ITU-R M.[IMT.Small Cell]

The draft new report includes the compatibility study between FSS networks and IMT systems in the band 3 400-3 600 MHz for small cell deployments in the same geographical area and in adjacent geographical areas based on existing allocations/identifications from WRC-07. The impact of other possible types of IMT deployment based upon macro and micro cells, operating in line with the provisions of the Radio Regulations, are not considered by this ITU-R Report, since those are already contained in Report ITU-R M.2109. Mitigation techniques such as resilient and flexible technologies to be used in conjunction with IMT small cell deployments to facilitate protection of FSS networks are also considered in cases where spectrum sharing mechanisms are deemed appropriate.

*[Note:At the 16th WP 5D meeting, it was agreed that there was no need to develop a draft new Report ITU-R M.[IMT.2020.FREQ RANGE]*

## I.2.8 Draft new Report ITU-R M.[IMT.2020.ESTIMATE]

This Report provides results of studies on estimated spectrum requirements for terrestrial IMT. The estimated spectrum requirements are calculated using the methodology defined in Recommendation ITU-R M.1768-1 and the corresponding input parameter values, taking into account recent advances in technologies and the deployments of terrestrial IMT networks as well as recent developments in mobile telecommunication markets.

The total spectrum requirements for both RATG 1 (i.e. pre-IMT, IMT-2000, and its enhancements) and RATG 2 (i.e. IMT-Advanced) in the year 2020 are estimated using the two different settings in order to reflect differences in the markets and deployments and timings of the mobile data growth in different countries. The estimated total spectrum requirements for both the RATGs 1 and 2 are 1 340 MHz and 1 960 MHz for lower user density settings and higher user density settings, respectively.

*[Note: SG 5 approved this report at Dec. 2013. This part will be moved to section I.2 if this report is open to public in ITU web page.]*

## I.2.9 Draft new Report ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS]

This draft new Report provides a broad view of future technical aspects of terrestrial IMT systems related to WRC-15 studies. Also, it provides a view of future IMT technology aspects considering the approximate time frame 2015-2020 and beyond, and provides information on trends of future IMT technology aspects.

## I.2.10 Draft 12th Revision of Recommendation ITU-R M.1457

The 12th revision of Recommendation ITU-R M.1457 is to include latest technology updates to current IMT-2000 terrestrial radio interfaces based on the proposals from relevant External Organizations, and to add new IMT-2000 radio interface technologies if new candidates are proposed, evaluated and agreed to be included as per current process.

## I.2.11 Draft new Report on Resolution 58 for IMT.CRS studies

This draft new Report provides the studies on the implementation and use of cognitive radio systems for the implementation and use of CRS

## I.2.12 Draft new Report ITU-R M.[IMT.ANTENNA]

This draft new Report address on technical and operational aspects of passive and active base station antennas for IMT systems based on Question ITU-R 251/5.

## I.2.13 Draft new Recommendation ITU-R M.[IMT.VISION]

This draft new Recommendation defines what will be the roles of IMT and how could IMT better serve society in the future and the framework and overall objectives of the future development of IMT for 2020 and beyond including the radio access network. The framework will also consider the future development of IMT as described in the Recommendation ITU-R M.1645. The Recommendation recommends the framework and objectives of the future development of IMT for 2020 and beyond.

## I.2.14 Draft new Report ITU-R M.[IMT.ABOVE 6 GHz]

This draft new Report provides information on the study of technical feasibility of IMT in the bands above 6 GHz. Technical feasibility includes information on current IMT or potential IMT radio interface technologies and system approaches appropriate for operation above 6 GHz, on technology enablers such as active and passive components, antenna techniques, deployment architectures, and results of simulations and performance tests.

## I.2.15 Draft new Report ITU-R M.[TDD.COEXISTENCE]

The band 2 300-2 400 MHz was globally identified for IMT at WRC-07 in accordance with the Footnote **5.384A** in the Radio Regulations. The band 2 300-2 400 MHz is being used or is planned to be used for mobile broadband wireless access (BWA) including IMT technologies in a number of countries. This draft new Report will address on the coexistence of two co-located adjacent spectrum blocks in the 2 300-2 400 MHz band in TDD mode in order to maximize benefits from a harmonized use of the band.

## I.2.16 Draft 5th revision of Recommendation ITU-R M.1036

This draft 5th revision of Recommendation provides guidance on the selection of transmitting and receiving frequency arrangements for the terrestrial component of IMT systems as well as the arrangements themselves, with a view to assisting administrations on spectrum-related technical issues relevant to the implementation and use of the terrestrial component of IMT in the bands identified in the RR. The frequency arrangements are recommended from the point of view of enabling the most effective and efficient use of the spectrum to deliver IMT services – while minimizing the impact on other systems or services in these bands – and facilitating the growth of IMT systems.

## I.2.17 Draft new Report ITU-R M.[IMT.ARRANGEMENTS]

This draft new Report provides the harmonized channelling arrangements for IMT adapted to the frequency band below 790 MHz down to around 694 MHz for Region 1, as indicated in Resolution **232 (WRC-12)** “*invites ITU-R* 2”, which directly supports WRC-15 agenda item 1.2, taking into account the existing arrangements in Region 1 in the bands between 790 and 862 MHz as defined in the last version of Recommendation ITU-R M.1036, in order to ensure coexistence with the networks operated in the new allocation and the operational networks in the band 790‑862 MHz.

## I.2.18 Draft 5th revision of Recommendations ITU-R M.1580 and M.1581

ITU-R M.1580-5 provides the generic unwanted emission characteristics of base stations using the terrestrial radio interfaces of IMT-2000. And, M.1581-5 provides the generic unwanted emission characteristics of mobile stations using the terrestrial radio interfaces of IMT-2000, suitable for establishing the technical basis for global circulation of IMT-2000 terminals. Implementation of characteristics of base/mobile stations using the terrestrial radio interfaces of IMT-2000 in any of the bands included in this Recommendation is subject to compliance with the Radio Regulations.

*[Note: This recommendation is in the procedure for simultaneous adoption and approval (PSAA).]*

## I.2.19 Draft new Recommendations ITU-R M.[IMT.OOBE BS] and M.[IMT.OOBE MS]

These drafts new Recommendations provide the “generic unwanted emission characteristics of base/mobile stations using the terrestrial radio interface of IMT-Advanced”.

## I.2.20 Draft new Report ITU-R M.[IMT.vs.IMT.UHF]

The draft new Report focus on the coexistence of the various frequency arrangements for the as currently contained in Recommendation ITU-R M.1036 for the 698-960 MHz frequency range. As a number of these arrangements overlap, coexistence studies are needed for cases where these arrangements are planned to be used within the same or adjacent geographical areas.

## I.2.21 Draft new Report ITU-R M.[IMT.ARCH]

This draft new Report provides studies of the architecture and topology of IMT Networks

## I.2.22 Draft 2nd revision of Recommendation ITU-R M.2012

This draft 2nd revision of Recommendation ITU-R M.2012 is to include the latest technology updates to current IMT-Advanced RIT and SRIT based on the proposals from GCS Proponents, and to add new RIT/SRIT if new candidates are proposed, evaluated and agreed to be included as per current process.

*[Note: The following table provides the schedule of when approval of the planned major deliverables will be achieved following the procedures of WP 5D. According to the schedule, above contents will be updated appropriately.]*

|  |  |  |
| --- | --- | --- |
| **Date** | **Meeting** | **Anticipated Milestones** |
| October 2013 | Switzerland  WP 5D #17 | * Finalize draft new Report ITU-R M.[IMT.ADV PARAM] * Finalize revision of Recommendation ITU-R M.2012 * Finalize draft new Report on Applications of IMT technologies to PPDR M.[IMT.BROAD.PPDR] * Finalize revision of Recommendations ITU-R M.1580/1581 * Finalize draft new Report ITU-R M.[IMT.2020.ESTIMATE] |
| February 2014 | Viet Nam  WP 5D #18 | * Finalize draft new Recommendations ITU-R  M.[IMT-ADV OOBE] * Finalize draft Revision 3 of Recommendation ITU-R M.2039 |
| June 2014 | Canada  WP 5D #19 | * Finalize draft new Report ITU-R M.[IMT.SMALL CELL] * Finalize revision of Recommendation ITU-R M.1579 |
| October 2014 | TBD  WP 5D #20 | * Finalize draft new Report ITU-R  M.[IMT.FUTURE TECHNOLOGY TRENDS] * Finalize revision of Recommendation ITU-R M.1457 * Finalize draft new Report on Res. 58 IMT.CRS studies * Finalize draft new Report ITU-R M.[IMT.ANTENNA] * Finalize M.[IMT.HANDBOOK] * Finalize draft new Report ITU-R M.[IMT.ARCH] * Finalize draft new Report ITU-R M.[TDD.COEXISTENCE] * Finalize draft new Report ITU-R M.[IMT.vs.IMT.UHF] * Finalize draft new Report ITU-R  M.[IMT.BEYOND 2020 TRAFFIC] |
| January 2015 | TBD  WP 5D #21 |  |
| June 2015 | TBD  WP 5D #22 | * Finalize draft new Recommendation ITU-R  M.[IMT VISION] * Finalize draft new Report ITU-R M.[IMT.ABOVE 6 GHz] * Finalize revision of Recommendation ITU-R M.2012-1 |

Annex J

Satellite IMT (and other, related) Recommendations and Reports

– Recommendation ITU-R M.1850-1, “Detailed specifications of the radio interfaces for the satellite component of International Mobile Telecommunications-2000 (IMT‑2000)”.

– Report ITU-R M.2176-1, “Vision and requirements for the satellite radio interface(s) of IMT‑Advanced”.

– Report ITU-R M.2279 “Outcome of the evaluation, consensus building and decision of the IMT-Advanced satellite process (Steps 4 to 7), including characteristics of IMT Advanced satellite radio interfaces”.

– Recommendation ITU-R M.2047 “Detailed specifications of the satellite radio interfaces of International Mobile Telecommunications-Advanced (IMT‑Advanced)”.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 10, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-1)
2. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 11, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-2)
3. GSMA, *The Mobile Economy 2013* (2013) at 22, available at <http://www.gsma.com/mobileeconomy/GSMA%20Mobile%20Economy%202013.pdf>. [↑](#footnote-ref-3)
4. Cisco, *The Zettabyte Era – Trends and Analysis* (2013) at 2, available at <http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/VNI_Hyperconnectivity_WP.pdf>. [↑](#footnote-ref-4)
5. Cisco, *The Zettabyte Era – Trends and Analysis* (2013) at 2, available at <http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/VNI_Hyperconnectivity_WP.pdf>. [↑](#footnote-ref-5)
6. Cisco, *The Zettabyte Era – Trends and Analysis* (2013) at 2, available at <http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/VNI_Hyperconnectivity_WP.pdf>. [↑](#footnote-ref-6)
7. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 4, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-7)
8. Global Mobile Suppliers Association, “LTE: user device segmentation: 2011-2013,” (2013), available at <http://www.gsacom.com/downloads/pdf/LTE_user_device_segmentation_250813.php4>. [↑](#footnote-ref-8)
9. Cisco, *The Zettabyte Era – Trends and Analysis* (2013) at 10, available at <http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/VNI_Hyperconnectivity_WP.pdf>. [↑](#footnote-ref-9)
10. Mobile Statistics, “Total apps available,” available at <http://www.mobilestatistics.com/mobile-statistics/>. [↑](#footnote-ref-10)
11. GSMA, *The Mobile Economy 2013* (2013) at 22, available at <http://www.gsma.com/mobileeconomy/GSMA%20Mobile%20Economy%202013.pdf>. [↑](#footnote-ref-11)
12. GSMA, *The Mobile Economy 2013* (2013) at 22, available at <http://www.gsma.com/mobileeconomy/GSMA%20Mobile%20Economy%202013.pdf>. [↑](#footnote-ref-12)
13. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 13, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-13)
14. YouTube, “Statistics,” available at <http://www.youtube.com/yt/press/statistics.html>, accessed on January 2, 2014. [↑](#footnote-ref-14)
15. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 13, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-15)
16. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 26, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-16)
17. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 13, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-17)
18. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 13, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-18)
19. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 15, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-19)
20. Google, “Our Mobile Planet,” available at <http://www.thinkwithgoogle.com/mobileplanet/en/>. [↑](#footnote-ref-20)
21. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 26, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-21)
22. OECD (2012), “Machine-to-Machine Communications: Connecting Billions of Devices”, OECD Digital Economy Papers, No. 192 at 8, OECD Publishing. <http://dx.doi.org/10.1787/5k9gsh2gp043-en> [↑](#footnote-ref-22)
23. OECD (2012), “Machine-to-Machine Communications: Connecting Billions of Devices”, OECD Digital Economy Papers, No. 192 at 8, OECD Publishing. <http://dx.doi.org/10.1787/5k9gsh2gp043-en>. [↑](#footnote-ref-23)
24. Cisco, *The Zettabyte Era – Trends and Analysis* (2013) at 2, available at <http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/VNI_Hyperconnectivity_WP.pdf>. [↑](#footnote-ref-24)
25. From section 3.10 of Recommendation ITU-R M.2243. [↑](#footnote-ref-25)
26. ITU, “The World in 2013: ICT Facts and Figures,” (2013) at 6, available at <http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2013-e.pdf>. [↑](#footnote-ref-26)
27. ITU, “The World in 2013: ICT Facts and Figures,” (2013) at 6, available at <http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2013-e.pdf>. [↑](#footnote-ref-27)
28. ITU, “The World in 2013: ICT Facts and Figures,” (2013) at 6, available at <http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2013-e.pdf>. [↑](#footnote-ref-28)
29. Broadband Commission, *The State of Broadband 2013: Universalizing Broadband* (2013) at 12, available at <http://www.broadbandcommission.org/Documents/bb-annualreport2013.pdf>. [↑](#footnote-ref-29)
30. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 9, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-30)
31. Global Mobile Suppliers Association, *Report: Status of the LTE Ecosystem* (November 7, 2013) at 2, available at <http://www.gsacom.com/downloads/pdf/GSA_lte_ecosystem_report_071113.php4>. [↑](#footnote-ref-31)
32. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 7, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-32)
33. Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society* (2013) at 7, available at <http://www.ericsson.com/res/docs/2013/ericsson-mobility-report-november-2013.pdf>. [↑](#footnote-ref-33)
34. IHS, LTE Expected to Dominate Wireless Infrastructure Spending by 2013 (January 2012). [↑](#footnote-ref-34)
35. Cisco, *The Zettabyte Era – Trends and Analysis* (2013) at 10, available at <http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/VNI_Hyperconnectivity_WP.pdf>. [↑](#footnote-ref-35)
36. GSA, *Evolution to LTE Report* (November 2, 2012), available at <http://gsacom.com/downloads/pdf/GSA_Evolution_to_LTE_report_011112.php4>. [↑](#footnote-ref-36)
37. GSA, *Evolution to LTE Report rev. 2* (October 12, 2011), available at <http://gsacom.com/downloads/pdf/gsa_evolution_to_lte_report_121011.php4>. [↑](#footnote-ref-37)
38. GSA, “3GPP systems mobile broadband wallchart,” (December 2, 2013), available at <http://gsacom.com/downloads/pdf/3GPP_systems_mobile_broadband_wallchart_111213.php4>. [↑](#footnote-ref-38)
39. GSA, “3GPP systems mobile broadband wallchart,” (November 2012), available at <http://gsacom.com/downloads/pdf/MBB_wallchart_November_2012.php4> and “Mobile Broadband Wallchart: 3GPP Systems,” (November 7, 2011), available at <http://gsacom.com/downloads/pdf/MBB_wallchart_071111.php4>. [↑](#footnote-ref-39)
40. Broadband Commission, *The State of Broadband 2013: Universalizing Broadband* (2013) at 40, available at <http://www.broadbandcommission.org/Documents/bb-annualreport2013.pdf>. [↑](#footnote-ref-40)
41. Broadband Commission, *A 2010 Leadership Imperative: The Future Built on Broadband* (2010) at 57, available at <http://www.broadbandcommission.org/Reports/Report_1.pdf>. [↑](#footnote-ref-41)
42. Data rates sourced from Recommendation ITU-R M.1645. [↑](#footnote-ref-42)
43. LMH-BWA. [↑](#footnote-ref-43)
44. <http://www.itu.int/pub/D-STG-SG02.25-2014> [↑](#footnote-ref-44)
45. As described in Recommendation ITU‑R M.1645, systems beyond IMT‑2000 will encompass the capabilities of previous systems, and the enhancement and future developments of IMT‑2000 that fulfil the criteria in *resolves*2 of Resolution ITU‑R 56 may also be part of IMT‑Advanced. [↑](#footnote-ref-45)
46. Data rates sourced from Recommendation ITU-R M.1645. [↑](#footnote-ref-46)
47. Recommendations ITU-R M.1457 and ITU-R M.2012 are two separate, independent, and self‑contained Recommendations, each one with a specific Scope. Both Recommendations will evolve independently, and there could be some overlap reflected by commonality in content between the two documents. [↑](#footnote-ref-47)
48. NOTE 1 – Currently, these specifications are developed within the third generation partnership project (3GPP) where the participating SDOs are the Association of Radio Industries and Businesses (ARIB), China Communications Standards Association (CCSA), the European Telecommunications Standards Institute (ETSI), Alliance for Telecommunications Industry Solutions (ATIS Committee T1P1), Telecommunications Technology Association (TTA) and Telecommunication Technology Committee (TTC). [↑](#footnote-ref-48)
49. Note 2 – Currently, these specifications are developed within the Third Generation Partnership Project 2 (3GPP2), where the participating SDOs are ARIB, CCSA, TIA, TTA and TTC. [↑](#footnote-ref-49)
50. Note 3: The Interworking Solution (IWS) Function in Figure 8 may be collocated at either the 1x Base Station (BS) or at the HRPD eAN, or may be a standalone entity. When the IWS function is collocated at the 1x BS, the A21 interface is supported between the 1x BS and the HRPD eAN, and the A1/A1p interface is supported between the Mobile Switching Center (MSC) and the 1x BS. When the IWS function is part of the HRPD eAN, the A1/A1p interface between the MSC and the HRPD eAN exists, and the A21 interface is internal to the HRPD eAN. When the IWS is a standalone entity, the A1/A1p interface is supported between the MSC and the IWS, and the A21 interface is supported between the IWS and the HRPD eAN. PDSN and HSGW functions may not be in the same physical entity. [↑](#footnote-ref-50)
51. Note 4: The IWS Function in Figure 9 may be collocated at either the 1x BS or at the HRPD ePCF, or may be a standalone entity. When the IWS function is collocated at the 1x BS, the A21 interface is supported between the 1x BS and the HRPD ePCF, and the A1/A1p interface is supported between the MSC and the 1x BS. When the IWS function is part of the HRPD ePCF, the A1/A1p interface between the MSC and the HRPD ePCF exists, and the A21 interface is internal to the HRPD ePCF. When the IWS is a standalone entity, the A1/A1p interface is supported between the MSC and the IWS, and the A21 interface is supported between the IWS and the HRPD ePCF. PDSN and HSGW functions may not be in the same physical entity. [↑](#footnote-ref-51)
52. Note 5 – Currently, these specifications are developed within the third generation partnership project (3GPP) where the participating SDOs are ARIB, ATIS, CCSA, ETSI, TTA and TTC. [↑](#footnote-ref-52)
53. Note 6 – The same name TD-SCDMA was previously used for one of the original proposals that was further refined following the harmonization process. [↑](#footnote-ref-53)
54. Note 7 – For simplicity, not all network elements of this system are shown in Figure 7 below. [↑](#footnote-ref-54)
55. Note 8 – An ES depends on the application supported in a PP. For a speech telephony application the ES may be a microphone, speaker, keyboard and display. The ES could equally well be a serial computer port, a fax machine or whatever the application requires. [↑](#footnote-ref-55)
56. <http://www.wimaxforum.org/technology/documents/>. [↑](#footnote-ref-56)
57. Note  9 – A “recognized organization” in this context is defined to be a recognized SDO that has legal capacity, a permanent secretariat, a designated representative, and open, fair, and well‑documented working methods. [↑](#footnote-ref-57)
58. Table 5.5-1 from 3GPP TS 36.101[2]; Source: <http://www.3gpp.org/DynaReport/36101.htm> [↑](#footnote-ref-58)
59. Note 10: Band 6 is not applicable. [↑](#footnote-ref-59)
60. Note 11: Restricted to E-UTRA operation when carrier aggregation is configured. The downlink operating band is paired with the uplink operating band (external) of the carrier aggregation configuration that is supporting the configured Pcell. [↑](#footnote-ref-60)
61. Table 5.0 from 3GPP TS 25.101[3] and section 5.2 from 3GPP TS 25.102 [4]; Sources: <http://www.3gpp.org/DynaReport/25101.htm> and <http://www.3gpp.org/DynaReport/25102.htm> [↑](#footnote-ref-61)
62. Based on Table 1.5-1 3GPP2 C.S0057-E [5];Source: <ftp://ftp.3gpp2.org/TSGC/Working/_TSG-C%20Published%20Documents> [↑](#footnote-ref-62)