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**GENERAL NOTICES • ALGEMENE KENNISGEWINGS**

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**INDEPENDENT COMMUNICATIONS AUTHORITY OF SOUTH AFRICA****NOTICE 683 OF 2018****PURSUANT TO SECTION 4 (1) OF THE ELECTRONIC COMMUNICATIONS ACT 2005,  
(ACT NO. 36 OF 2005)****HEREBY ISSUES A NOTICE REGARDING THE DRAFT IMT ROAD MAP FOR  
CONSULTATION.**

1. The Independent Communications Authority of South Africa ("the Authority"), hereby publishes **the Draft International Mobile Telecommunications (IMT) Roadmap for consultation** in terms of section 2 and 4, read with sections 30, 31(4), and 33 of the Electronic Communications Act (Act No. 36 of 2005).
2. Interested persons are hereby invited to submit written representations, including an electronic version of the representation in Microsoft Word, of their views on the Draft IMT Roadmap by no later than 16h00 on Friday, 18 January 2019.
3. Persons making representations are further invited to indicate whether they are requesting an opportunity to make oral representations, which will not exceed one hour. The public hearings will be held from the 24 to 25 January 2019.
5. Written representations or enquiries may be directed to:

The Independent Communications Authority of South Africa (the Authority)

350 Witch-Hazel Avenue,  
Eco Point Office Park,

Eco Park,  
Centurion,  
Gauteng.

**Attention:**

Mr Manyapelolo Richard Makgotlho

e-mail: [rmakgotlho@icasa.org.za](mailto:rmakgotlho@icasa.org.za)

6. All written representations submitted to the Authority pursuant to this notice shall be made available for inspection by interested persons from 15th of January 2018 at the ICASA Library or website and copies of such representations and documents will be obtainable on payment of a fee.

Where persons making representations require that their representation, or part thereof, be treated confidentially, then an application in terms of section 4D of the ICASA Act, 2000 (Act No. 13 of 2000) must be lodged with the Authority. Such an application must be submitted simultaneously with the representation on the draft regulations and plan. Respondents are requested to separate any confidential material into a clearly marked confidential annexure. If, however, the request for confidentiality is refused, the person making the request will be allowed to withdraw the representation or document in question. The guidelines for confidentiality request are contained in Government Gazette Number 41839 (Notice 849 of 2018).



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**RUBBEN MOHLALOGA**  
**CHAIRPERSON**



# DRAFT IMT ROADMAP 2018

## NOVEMBER 2018

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## 1 About

This document aims to share the findings of the Independent Communications Authority of South Africa (hereafter referred to as “The Authority”) with regards to the roadmap for radio frequency spectrum for International Mobile Telecommunications (IMT).

IMT is as named in ITU-R Resolution 56-1. IMT is the root name and encompasses IMT 2000 (including enhancement) and IMT Advanced (including enhancement).

This document builds on the “draft Frequency Migration Plan” published in Gazette 41854 on August 24th, 2018. The roadmap hereby published by the Authority identifies the bands for IMT deployment and also identifies the migration of a number of current licensees out of (or within) bands identified for IMT services. For bands where costs and benefits of the migration were not straightforward, the Authority conducted feasibility studies to determine the appropriateness of migration, details of which can be found in the appendix to this document.

The Authority’s primary objectives are to ensure spectrum efficiency, universal availability of broadband services as well as a vibrant and competitive telecommunications industry and promote investments.

Subsequently we now need to define a new vision for South Africa that is in line with the international and ITU trends. It is worthwhile to look at RECOMMENDATION ITU-R M.2083-0. This document describe the IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond

This Recommendation defines the framework and overall objectives of the future development of International Mobile Telecommunications (IMT) for 2020 and beyond in light of the roles that IMT could play to better serve the needs of the networked society, for both developed and developing countries, in the future. In this Recommendation, the framework of the future development of IMT for 2020 and beyond, including a broad variety of capabilities associated with envisaged usage scenarios is described in detail. Furthermore, this Recommendation addresses the objectives of the future development of IMT for 2020 and beyond, which includes further enhancement of existing IMT and the development of IMT-2020. It should be noted that this Recommendation is defined considering the development of IMT to date based on Recommendation ITU-R M.1645.

## 2 Executive Summary

### 2.1 Purpose of the IMT Roadmap

The growing demand for mobile broadband in South Africa indicates a need for more mobile broadband bandwidth capacity in general. At the same time, many rural areas do not have access to mobile bandwidth indicating a need for a universal mobile broadband coverage, a need best served by deploying lower frequencies that propagate further.

The International Telecommunication Union (ITU) has identified frequency bands that could be used for International Mobile Telecommunications (IMT), which is mainly intended for mobile broadband. The Radio Frequency Migration Plan 2013 further identified which of these IMT bands (between 450 and 3600 MHz) could be so deployed in South Africa based on the National Radio Frequency Plan (NRFP) 2013 for South Africa. The eventual assignment to IMT is made through a Radio Frequency Spectrum Assignment Plan (RFSAP). The following IMT Radio Frequency Spectrum Assignment Plans (Final) were published:

- Government Gazette No 38640 Notice 270 of 2015 – 450 to 470 MHz (Final)
- Government Gazette No 38640 Notice 271 of 2015 – 703 to 733 MHz and 758 to 788 MHz (Final)
- Government Gazette No 38640 Notice 272 of 2015 – 733 to 758 MHz (Final)
- Government Gazette No 38640 Notice 273 of 2015 – 791 to 821 MHz and 732 to 762 MHz (Final)
- Government Gazette No 38640 Notice 275 of 2015 – 880 to 915 MHz and 925 to 960 MHz (Final)
- Government Gazette No 38640 Notice 276 of 2015 – 2300 to 2400 MHz (Final)
- Government Gazette No 38640 Notice 277 of 2015 – 2500 to 2570 MHz and 2620 to 2690 MHz (Final)
- Government Gazette No 38640 Notice 278 of 2015 – 3400 to 3600 MHz (Final)

The Radio Frequency Migration Plan 2013 has since been replaced by the draft Frequency Migration Plan 2018 and the National Radio Frequency Plan (NRFP) 2013 has been replaced by National Radio Frequency Plan (NRFP) 2018. A key driver for the deployment of IMT bands is the need to ensure that mobile broadband plays its role in meeting the objectives of 'broadband for all' which is encapsulated in the targets of SA Connect published in 2013. A key part of this policy/ document concerns the deployment of the 700 MHz and 800 MHz digital dividend bands that is still being occupied by analogue and digital terrestrial television (DTT). ICASA has taken all steps in their jurisdiction by publishing the Final Radio Frequency Spectrum Assignment Plans to implement IMT in Digital Dividend I and II.



*“The efficient assignment and subsequent use of high demand spectrum to meet this demand is vital and the cost of making this spectrum available is vital and the cost of not doing so is high.”*

The Department of Communications have appointed a team to prioritise DTT implementation in order to release the 700 and 800 MHz spectrum for IMT.

Although IMT essentially means all mobile telecommunications, there is currently a strong focus on Long Term Evolution (LTE) and this is reflected in the document. Where it is necessary to give emphasis to IMT for LTE, the document refers to *broadband* IMT.

For an increasing number of South African consumers and businesses, mobile connectivity is now an everyday necessity. Our desire to get online wherever we are – and at ever-faster speeds – has helped fuel an explosion in mobile data.

IMT2020 is the next generation of mobile technologies and is being designed to provide greater capacity for wireless networks, offer greater reliability, and deliver extremely fast data speeds, enabling innovative new services across different industry sectors.

The first wave of commercial products is expected to be available in 2020. However, initial pre-commercial deployments are already expected to start from 2018.

**Mobile operators have expressed their concerns regarding the availability of IMT2020 spectrum for testing and implementation in South Africa.**

It is worthwhile to look at RECOMMENDATION ITU-R M.2083-0. This document describe the IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond. South Africa need to look in detail into this recommendation of which a copy is included in Appendix H to this document.

**RESOLUTION 238 (WRC-15)**

The following bands, which are already allocated to mobile, will be studied with a view to an IMT-2020 identification: •

- 24.25 – 27.5 GHz •
- 37 – 40.5 GHz •
- 42.5 – 43.5 GHz •
- 45.5 – 47 GHz •
- 47.2 – 50.2 GHz •
- 50.4 – 52.6 GHz •
- 66 – 76 GHz •
- 81 – 86 GHz

The following bands will also be studied, although they do not currently have global mobile allocations: •

- 31.8 – 33.4 GHz •
- 40.5 – 42.5 GHz •
- 47 - 47.2 GHz

### **What services and applications will IMT2020 support?**

IMT2020 technologies are under development, and are likely to include both an evolution of existing and new radio technologies. Potential IMT2020 services and applications can be grouped into three different classes:

- **Enhanced Mobile Broadband.** Together with an evolution of the services already provided by 4G, 5G is expected to provide faster and more reliable mobile broadband, offering a richer experience to consumers;
- **Massive Machine Type Communications.** The Internet-of-Things (IoT) – where gadgets and devices wirelessly connect to the internet and each other – is happening on existing networks. Its technology is being used in everything from smart homes to wearables. IMT2020 should help the evolution of IoT services and applications and improve interaction between different platforms. Possible future applications could include real-time health monitoring of patients; optimisation of street lighting to suit the weather or traffic; environmental monitoring and smart agriculture. Data security and privacy issues will need to be considered given huge amounts of data could be transferred over a public network; and
- **Ultra-Reliable and Low Latency Communications.** IMT2020 networks are being designed to be more reliable and have very low latencies (network delays). This could make them suitable for applications such as connected and driverless cars (cars would use the technology to communicate with each other, other road users and even the road infrastructure), and smart manufacturing (potentially connecting all the various machines involved in the different phases of a production chain). These different services have different requirements in terms of speed, coverage and reliability, which will demand different network solutions (the evolution of existing network and potentially new networks) and different deployment models (including many small cells), an appropriate network infrastructure (which will include both fibre and wireless connectivity to the core network) and access to different spectrum bands.

The conditions for the use of the bands for IMT will be specified in the appropriate Radio Frequency Spectrum Assignment Plans (RFSAPs).

The assignment of IMT frequencies will generally be made through an Invitation to Apply (ITA) in line with Regulation 7 of the Radio Frequency Spectrum Regulations 2011. This process will detail the actual mechanism of assignment (including market-based mechanisms, etc.).

### **Overview**

This IMT Roadmap summarises the ITU perspective on IMT, the Southern African Development Community (SADC) perspective on IMT, the SA Connect targets and the related issue of Universal Service (US) and obligations.

As mentioned before the following IMT Radio Frequency Spectrum Assignment Plans (Final) were published:

- Government Gazette No 38640 Notice 270 of 2015 – 450 to 470 MHz (Final)
- Government Gazette No 38640 Notice 271 of 2015 – 703 to 733 MHz and 758 to 788 MHz (Final)
- Government Gazette No 38640 Notice 272 of 2015 – 733 to 758 MHz (Final)
- Government Gazette No 38640 Notice 273 of 2015 – 791 to 821 MHz and 732 to 762 MHz (Final)
- Government Gazette No 38640 Notice 275 of 2015 – 880 to 915 MHz and 925 to 960 MHz (Final)
- Government Gazette No 38640 Notice 276 of 2015 – 2300 to 2400 MHz (Final)
- Government Gazette No 38640 Notice 277 of 2015 – 2500 to 2570 MHz and 2620 to 2690 MHz (Final)
- Government Gazette No 38640 Notice 278 of 2015 – 3400 to 3600 MHz (Final)

The IMT 850 band is still under discussion in South Africa. On 01 September 2017, in Government Gazette 41082 (Notice 684 of 2017) published the Second draft Radio Frequency Spectrum Assignment Plan for the frequency band 825 to 830 MHz and 870 to 875 MHz for public consultation. The public hearings were held from 06 to 07 September 2018 at the Authority's head office in Block C Auditorium, Pinmil Farm, Sandton.

The IMT Roadmap also gives indicative timelines for the deployment of IMT spectrum to support the targets set by the South Africa Connect (SA Connect) broadband initiative for 2016 and 2020 in terms of ensuring widespread area coverage and adequate bandwidth capacity. It is anticipated that additional spectrum for IMT can be assigned in the short term, however this does not obviate the need for using existing spectrum more efficiently and for operators to 'densify' their networks. The requirement for IMT2020 spectrum places an additional demand for spectrum and therefore additional IMT Spectrum need to be identified. Such spectrum will have to be investigated with a feasibility study to determine the impact of refarming, cost of migration, equipment lifetime and the national need for such frequency spectrum.

Furthermore, the IMT roadmap lists options and recommendations for the deployment of bands designated for IMT usage, potential migration scenarios and timelines, as well as assignments with minimum requirements for coverage and capacity obligations for existing and new bands.

Previously a total bandwidth of 460 MHz was used for IMT in South Africa, mostly for Universal Mobile Telecommunications System (UMTS) and Global System for Mobile Communications (GSM), with LTE deployment. This IMT Roadmap 2014 envisages that an additional 2×133 MHz paired spectrum and 290 MHz unpaired spectrum will be made

available over a given schedule. The most important additional key IMT bands for both coverage (especially rural coverage) and capacity are the IMT700 and IMT800 bands. Unfortunately the IMT700 and IMT800 are still not available for use in South Africa.

## 3 International Telecommunication Union (ITU) and IMT

### 3.1 What is IMT?<sup>1</sup>

According to the ITU, International Mobile Telecommunications (IMT) systems are mobile systems that provide access to a wide range of telecommunication services including advanced mobile services, supported by mobile and fixed networks, which are increasingly packet-based. Key features of IMT include:

- a 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; and
- enhanced peak data rates to support advanced services and applications.

Over the past 25 years, the ITU has developed the IMT system framework of standards for mobile telephony and continues to lead international efforts involving governments and industry players to produce the next generation of standards for global mobile communications.

The term 'IMT' should be the root name that encompasses both IMT-2000 and IMT-Advanced collectively.

#### 3.1.1 IMT 2000

IMT-2000 (International Mobile Telecommunications 2000) is a term coined by the global cellular community to produce a globally-co-ordinated definition of 3G mobile technologies. IMT-2000 networks have been widely deployed since 2000.

According to the ITU, IMT-2000 systems are third generation (3G) mobile systems, which provide access to a wide range of telecommunications services, supported by the fixed telecommunication networks (e.g. PSTN/ISDN/Internet Protocol (IP)), as well as to other services which are specific to mobile users.

The specifications for the initial releases of IMT-2000 are defined in Recommendation ITU R M.1457. The term 'IMT-2000' should also encompass its enhancements and future developments.

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<sup>1</sup> from Recommendation ITU-R M.1645

### 3.1.2 IMT Advanced

The term 'IMT-Advanced' refers to systems, system components and related aspects that include new radio interfaces supporting new capabilities of systems beyond IMT-2000.

ITU has now specified standards for IMT-Advanced. IMT-Advanced provides next-generation global wireless broadband communications using a wide range of packet-based telecommunication services supported by mobile and fixed networks.

It is anticipated that IMT-Advanced will use radio-frequency spectrum much more efficiently making higher data transfers possible on less bandwidth in order to enable mobile networks to face the dramatic increase in data traffic that is expected in the coming years.

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

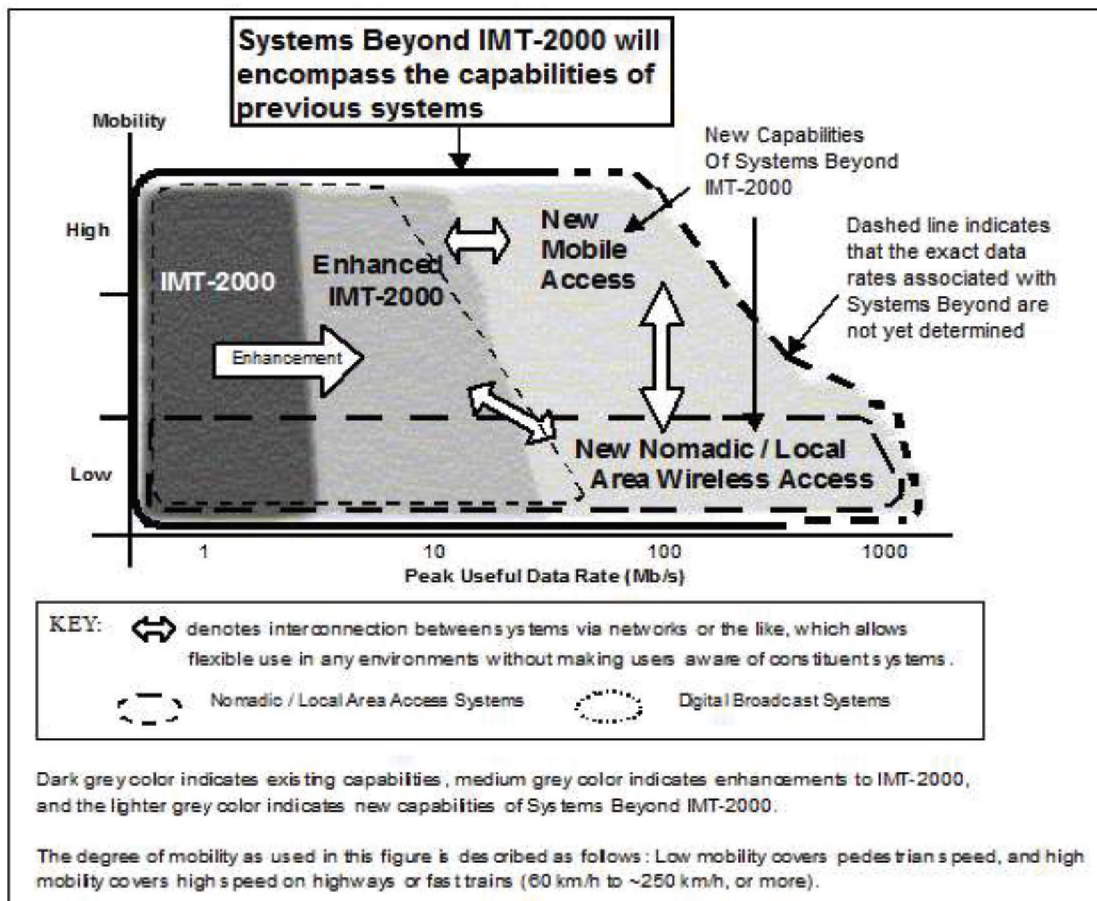


Figure 1: IMT Systems now and in the future (Source: ITU)



### **3.1.3 IMT 2020 Background**

#### **3.1.3.1 IMT evolution**

International Mobile Telecommunications-2000 (IMT-2000) systems provided access to a wide range of telecommunication services, supported by the fixed telecommunication networks (e.g. PSTN/ISDN/IP), and to other services which are specific to mobile users.

Resolution ITU-R 56-2 clarifies the relationship between the terms “IMT-2000” and “IMT-Advanced” and assigns a name to those systems, system components, and related aspects that include new radio interface(s) that support the new capabilities “IMT for 2020 and beyond”: IMT-2020. Resolution ITU-R 56 resolves that the term IMT-2000 encompasses also its enhancements and future developments and the term “IMT-Advanced” encompasses its enhancements and future developments. The term “IMT” is the root name that encompasses IMT-2000, IMT-Advanced, and IMT-2020 collectively.

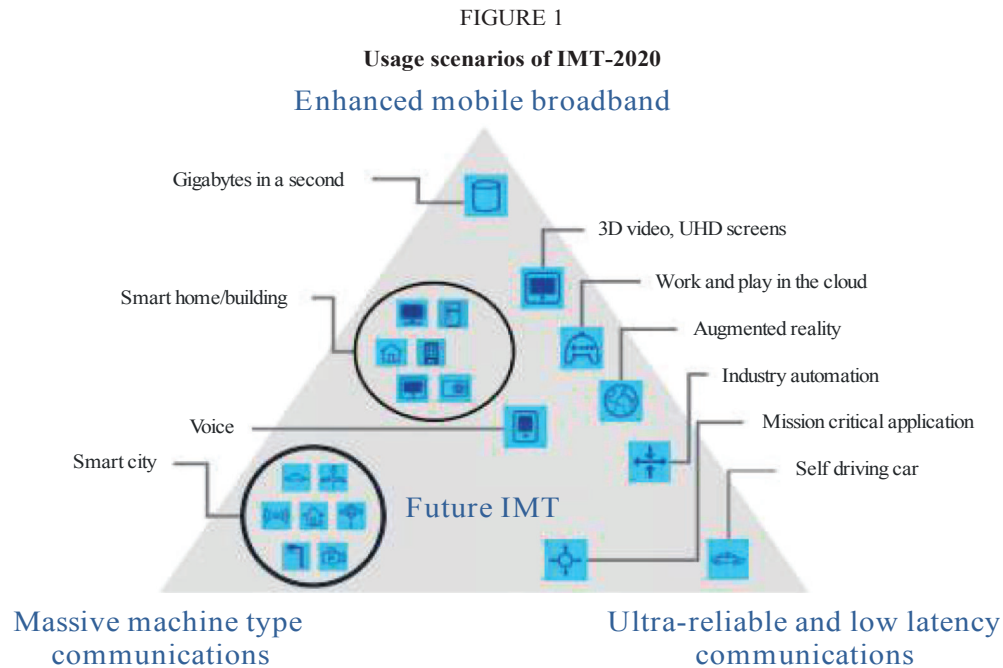
To meet the ever increasing demand for wireless communication (e.g. increased no. of users, higher data rates, video or gaming services which require increased quality of service, etc.), IMT has been, and continues to be, enhanced.

#### **3.1.3.2 Consumer demands**

Consumer demands will shape the future development of IMT. In the future, it is foreseen that new demands, such as more traffic volume, many more devices with diverse service requirements, better quality of user experience (QoE) and better affordability by further reducing costs, etc., will require an increasing number of innovative solutions. In addition, technological advancement and the corresponding user needs will promote innovation and accelerate the delivery of advanced communication applications to consumers. Recommendation ITU-R M.2083 “IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond” describes these potential user and application trends, growth in traffic, technological trends and spectrum implications. Also Reports ITU-R M.2370 “IMT Traffic estimates for the years 2020 to 2030” and ITU-R M.2376 “Technical feasibility of IMT in bands above 6 GHz” detail these expected trends and phenomena for IMT-2020.

IMT-2020 systems will encompass a large number of different features. Depending on the circumstances and the different needs in different countries, future IMT systems should be designed in a modular manner so that not all features have to be implemented in all networks.

In order to fulfil these varied demands, IMT-2020 is envisaged to expand and support diverse usage scenarios and applications that will continue beyond the current IMT. Furthermore, a broad variety of capabilities would be tightly coupled with these intended different usage scenarios and applications for IMT-2020. Figure 1 illustrates some examples of envisioned usage scenarios for IMT-2020 identified in Recommendation ITU-R M.2083.



M.2083-02

### 3.1.3.3 Capabilities of IMT-2020

IMT-2020 systems are mobile systems that include the new capabilities of IMT that go beyond those of IMT-Advanced. IMT-2020 systems support low to high mobility applications and a wide range of data rates in accordance with user and service demands in multiple user environments. IMT-2020 also has capabilities for high quality multimedia applications within a wide range of services and platforms, providing a significant improvement in performance and quality of service.

A broad variety of capabilities, tightly coupled with intended usage scenarios and applications for IMT-2020 is envisioned. Different usage scenarios along with the current and future trends will result in a great diversity/variety of requirements. The key design principles are flexibility and diversity to serve many different use cases and scenarios, for which the capabilities of IMT-2020, described in the following paragraphs, will have different relevance and applicability. In addition, the constraints on network energy consumption and the spectrum resource will need to be considered.

As indicated in Recommendation ITU-R M.2083, the following eight parameters are considered to be key capabilities of IMT-2020:

#### **Peak data rate**

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

#### **User experienced data rate**



Achievable data rate that is available ubiquitously<sup>2</sup> across the coverage area to a mobile user/device (in Mbit/s or Gbit/s).

**Latency**

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

**Mobility**

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

**Connection density**

Total number of connected and/or accessible devices per unit area (per km<sup>2</sup>).

**Energy efficiency**

Energy efficiency has two aspects:

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

**Spectrum efficiency**

Average data throughput per unit of spectrum resource and per cell<sup>3</sup> (bit/s/Hz).

**Area traffic capacity**

Total traffic throughput served per geographic area (in Mbit/s/m<sup>2</sup>).

IMT-2020 is expected to provide a user experience matching, as far as possible, fixed networks. The enhancement will be realized by increased peak and user experienced data rate, enhanced spectrum efficiency, reduced latency and enhanced mobility support.

In addition to the conventional human-to-human or human-to-machine communication, IMT-2020 will realize the Internet of Things by connecting a vast range of smart appliances, machines and other objects without human intervention.

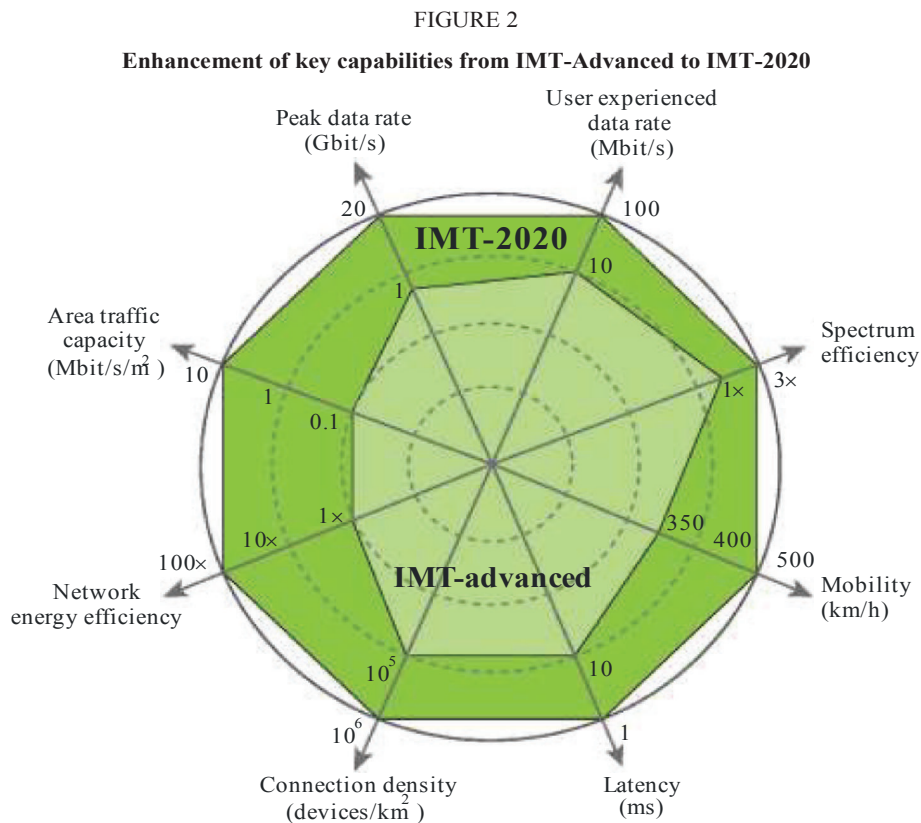
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<sup>2</sup> The term “ubiquitous” is related to the considered target coverage area and is not intended to relate to an entire region or country.

<sup>3</sup> The radio coverage area over which a mobile terminal can maintain a connection with one or more units of radio equipment located within that area. For an individual base station, this is the radio coverage area of the base station or of a subsystem (e.g. sector antenna).

IMT-2020 should be able to provide these capabilities without undue burden on energy consumption, network equipment cost and deployment cost to make future IMT sustainable and affordable.

The key capabilities of IMT-2020 are shown in Fig. 2 (from Recommendation ITU-R M.2083), compared with those of IMT-Advanced.



M.2083-03

The values in the Figure above are targets for research and investigation for IMT-2020 and may be further developed in other ITU-R Recommendations, and may be revised in the light of future studies.

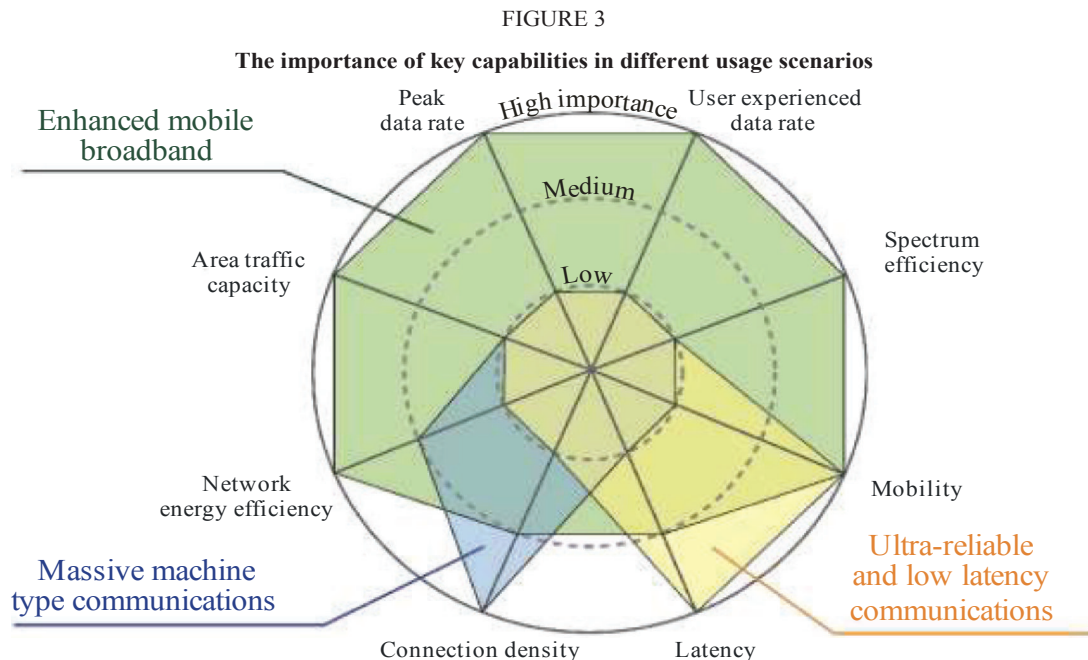
As anticipated above, whilst all key capabilities may to some extent be important for most use cases, the relevance of certain key capabilities may be significantly different, depending on the use cases/scenario. The importance of each key capability for the usage scenarios *enhanced Mobile Broadband*, *ultra-reliable and low latency communication* and *massive machine-type communication* is illustrated in Fig. 3. This is done using an indicative scaling in three steps as “high”, “medium” and “low”.

In the enhanced Mobile Broadband scenario, user experienced data rate, area traffic capacity, peak data rate, mobility, energy efficiency and spectrum efficiency all have high importance, but mobility and the user experienced data rate would not have equal importance simultaneously in all use cases. For example, in hotspots, a higher user

experienced data rate, but a lower mobility, would be required than in wide area coverage case.

In some ultra-reliable and low latency communications scenarios, low latency is of highest importance, e.g. in order to enable the safety critical applications. Examples include traffic safety, traffic efficiency, smart grid, e-health, wireless industry automation, augmented reality, remote tactile control and tele-protection. Such capability would be required in some high mobility cases as well, e.g., in transportation safety, while, e.g. high data rates could be less important.

In the massive machine type communication scenario, high connection density is needed to support tremendous number of devices in the network that e.g. may transmit only occasionally, at low bit rate and with zero/very low mobility. A low cost device with long operational lifetime is vital for this usage scenario.



M.2083-04

Other capabilities may be also required for IMT-2020, which would make future IMT more flexible, reliable, and secure when providing diverse services in the intended usage scenarios:

### **Spectrum and bandwidth flexibility**

Spectrum and bandwidth flexibility refers to the flexibility of the system design to handle different scenarios, and in particular to the capability to operate at different frequency ranges, including higher frequencies and wider channel bandwidths than today.

### **Reliability**

Reliability relates to the capability to provide a given service with a very high level of availability.

### **Resilience**

Resilience is the ability of the network to continue operating correctly during and after a natural or man-made disturbance, such as the loss of mains power.

### **Security and privacy**

Security and privacy refers to several areas such as encryption and integrity protection of user data and signalling, as well as end user privacy preventing unauthorized user tracking, and protection of network against hacking, fraud, denial of service, man in the middle attacks, etc.

### **Operational lifetime**

Operational life time refers to operation time per stored energy capacity. This is particularly important for machine-type devices requiring a very long battery life (e.g. more than 10 years) whose regular maintenance is difficult due to physical or economic reasons.

These capabilities enable IMT-2020 to address evolving user needs. The capabilities of IMT-2020 systems are being continuously enhanced in line with user trends and technology developments.

#### **3.1.3.4 Relationship between existing IMT and IMT-2020**

As indicated in Section 3 above, in order to support emerging new scenarios and applications for 2020 and beyond, it is foreseen that development of IMT-2020 will be required to offer enhanced capabilities. The minimum technical requirements (and corresponding evaluation criteria) to be defined by ITU-R based on these capabilities for IMT-2020 could potentially be met by adding enhancements to existing IMT, incorporating new technology components and functionalities, and/or the development of new radio interface technologies.

Furthermore, IMT-2020 will interwork with and complement existing IMT and its enhancements.

#### **3.1.3.5 Framework of IMT-2020**

The framework and objectives including overall timeframes for the future development of IMT for 2020 and beyond are described in some detail in Recommendation ITU-R M.2083.

### 3.2 Bands designated for IMT

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

The features of IMT enable it to address evolving user needs as the capabilities of IMT systems are being continuously enhanced in line with user trends and technology developments. IMT will operate in the worldwide bands identified in the ITU Radio Regulations (RR).

The table below describes the ITU definition of IMT bands which were mostly addressed by the publication of the Final Radio Frequency Spectrum Assignment Plans.

Band (MHz)	Frequency band	BW <sup>Note1</sup>	RR FN	Channel Plan	WRC Resolution/s
450	450-470 MHz	<20 MHz	5.286AA	(Note 2)	224 (Rev. WRC-12)
700	694-790 MHz	<96 MHz	5.312A	(Note 3)	232 (WRC-12) and 224 (WRC-12)
800	791-821 MHz // 832-862 MHz	2×30 MHz	5.317A	M.1036 (A3) (Note 3)	224 (Rev. WRC-12) and 749 (Rev. WRC-12)
850	824-849 MHz // 869-894 MHz	<2×8 MHz (Note 4)	5.317A	M.1036 (A1)	224 (Rev. WRC-12) and 749 (Rev. WRC-12)
900	880-915 MHz // 925-960 MHz	2×35 MHz	5.317A	M.1036 (A2)	224 (Rev. WRC-12) and 749 (Rev. WRC-12)
1800	1710-1785 MHz // 1805-1880 MHz	2×75 MHz	5.384A	M.1036 (B2)	223 (Rev. WRC-12)
2100	1920-1980 MHz // 2110-2170 MHz	2×60 MHz	5.388	M.1036 (B1)	212 (Rev. WRC-07) and 223 (Rev. WRC-12)
2100 (TDD)	1900-1920 MHz, 2010-2025 MHz	35 MHz (Note 5)	5.388	M.1036 (B1)	212 (Rev. WRC-07) and 223 (Rev. WRC-12)
2300	2300-2400 MHz	100 MHz	5.384A	M.1036 (E1)	223 (Rev. WRC-12) (Note 6)
2600	2500-2690 MHz	2×70 MHz 50 MHz	5.384A	M.1036 (C1)	223 (Rev. WRC-12) (Note 7)
3500	3400-3600 MHz	2×80 MHz (Note 8)	5.430A	M.1036 (F2)	NA

**Table 1: ITU definition of IMT bands**

Table 1 lists all possible IMT frequency bands identified by the ITU, relevant ITU Radio Regulation footnote as well as the applicable ITU-R channel plan. The notes are taken from the (South African) National Radio Frequency Plan 2013 (NRFP-13).

**Note 1:** This column indicates the amount of IMT assignable spectrum; guard bands, centre gaps, etc. are therefore excluded.

**Note 2:** Use of this band will be subject to a feasibility study. Issues to be addressed will include the existing usage, the various channel plan options described in ITU-R M.1036 (section 1) for the band 450-470 MHz, the availability of spectrum in this band, as well as the availability of IMT equipment.

**Note 3:** The World Radiocommunication Conference 2007 (WRC-07) allocated the band 790-862 MHz to all mobile (except aeronautical mobile services) on a primary basis in many countries in ITU Region 1 and designated it for IMT (see 5.316A, 5.316B and 5.317A). WRC-12 resolved to allocate the frequency band 694-790 MHz in ITU Region 1 to the mobile, except aeronautical mobile, service on a co-primary basis with other services to which this band is allocated on a primary basis and to identify it for IMT and ensure that the allocation is effective immediately after WRC-15 (see 5.312A and ITU Resolution 232 (WRC-12)). WRC-15 will specify the technical and regulatory conditions applicable to the mobile service after taking into account ITU-R studies.

Replanning of the broadcasting spectrum to accommodate digital television within the band 470-694 MHz is underway. The band 694-862 MHz will be subject to the outcome of WRC-15 and used exclusively for IMT (mobile services), and planning for this use of the band will be concurrent to the planning of the migration of the broadcasting services. It is intended that the process for the assignment of the band 694-862 MHz for mobile services will take place prior to the end of the dual illumination period. Migration of the broadcasting services from this band will be addressed in accordance with the Terrestrial Broadcast Frequency Plan 2013 (TBFP-13).

Suitable channel plans for the 700 MHz frequency band for IMT systems are being developed by ITU-R WP 5D. The amount of assignable spectrum in this band will depend on the outcome of this exercise. It is important to note that the 700 MHz channel plan adopted in the APT Region (A5) overlaps the 800 MHz channel plan adopted in Europe and Africa (A3).

**Note 4(i):** Whereas the Southern African Development Community (SADC), including South Africa, adopted the 2×30 MHz channel plan in the 800 MHz band (A3), this plan is under review considering the adoption at WRC-12 of the 700 MHz band for IMT (see also Note 3 above).

**Note 4(ii):** Although the international 850 MHz band (also known as CDMA-2000 or GSM850 band plan) has 2×25 MHz total bandwidth, the limited assignable spectrum in South Africa is a result of this band overlapping the GSM 900 MHz band and more importantly due to the use of analogue broadcasting in the UHF band. In South Africa, the use of the 800 MHz band will take precedence over the use of the 850 MHz band; no new assignments will therefore be made according to the 850 MHz channel plan.

**Note 5:** Although the band 1885-1900 MHz is also designated for IMT, the band 1880-1900 MHz is used extensively for Digital Enhanced Telecommunications (DECT) cordless telephone systems. Sharing between IMT and DECT cordless telephones is problematic.



The band 1900-1920 MHz could be used for IMT in future; it is currently used for Fixed Wireless Access (FWA) systems.

**Note 6:** In South Africa, the 2.3 GHz band is allocated to mobile service on a primary basis and is identified for IMT. This band is part of the 2.4 GHz band (2300-2500 MHz) used for FWA systems.

**Note 7:** The 2.6 GHz band (2500-2690 MHz) is available for IMT in accordance with ITU-R Recommendation M.1036 (C1). This channel plan allows for 2×70 MHz (paired) and 50 MHz (unpaired) spectrum.

**Note 8:** The 3.5 GHz band is currently used for FWA systems in South Africa, in particular WiMAX. The channel configuration is based on 2×100 MHz plan with no guard bands or centre gap (Tx-Rx = 100 MHz). When using this band for IMT systems, a new channelling plan is required. ITU-R Recommendation M.1036 (section 6) recommends two options namely: F1 (unpaired, 3400-3600 MHz); and F2 (3410-3490 MHz paired with 3510-3590 MHz). Considering that the current SA plan using Tx-Rx of 100 MHz, option F2 is recommended for SA. Refarming of current licensees may be required to align with this option.

The following IMT bands were assigned by the publications of the Final Radio Frequency Spectrum Assignment Plans.

- IMT 450
- IMT 700
- IMT 800
- IMT 900
- IMT 2300
- IMT 2600
- IMT 3500

The IMT 850 band's is still under discussion and the 2<sup>nd</sup> Draft Radio Frequency Spectrum Assignment Plan was published

The decision on IMT 1800 and IMT 2100 bands has been delayed until a decision and guidance has been given by the ITU.

### 3.3 Issues for WRC 19

ITU Study Group 5D have been working on the following frequency band for IMT use and implementation.

The following bands, which are already allocated to mobile, will be studied with a view to an IMT-2020 identification: •

- 24.25 – 27.5 GHz •
- 37 – 40.5 GHz •

- 42.5 – 43.5 GHz •
- 45.5 – 47 GHz •
- 47.2 – 50.2 GHz •
- 50.4 – 52.6 GHz •
- 66 – 76 GHz •
- 81 – 86 GHz

The following bands will also be studied, although they do not currently have global mobile allocations: •

- 31.8 – 33.4 GHz •
- 40.5 – 42.5 GHz •
- 47 - 47.2 GHz

The above frequency studies are extracted from the ITU resolution below:

#### **RESOLUTION 238 (WRC-15)**

Studies on frequency-related matters for International Mobile Telecommunications identification including possible additional allocations to the mobile services on a primary basis in portion(s) of the frequency range between 24.25 and 86 GHz for the future development of International Mobile Telecommunications for 2020 and beyond

The World Radiocommunication Conference (Geneva, 2015), considering

- a) that International Mobile Telecommunications (IMT) is intended to provide telecommunication services on a worldwide scale, regardless of location and type of network or terminal;
- b) that IMT systems have contributed to global economic and social development;
- c) that IMT systems are now being evolved to provide diverse usage scenarios and applications such as enhanced mobile broadband, massive machine-type communications and ultra-reliable and low-latency communications;
- d) that ultra-low latency and very high bit rate applications of IMT will require larger contiguous blocks of spectrum than those available in frequency bands that are currently identified for use by administrations wishing to implement IMT;
- e) that it may be suitable to examine higher frequency bands for these larger blocks of spectrum;
- f) that there is a need to continually take advantage of technological developments in order to increase the efficient use of spectrum and facilitate spectrum access;



- g) that the properties of higher frequency bands, such as shorter wavelength, would better enable the use of advanced antenna systems including MIMO and beam-forming techniques in supporting enhanced broadband;
- h) that ITU-T has initiated the study of network standardization for IMT for 2020 and beyond;
- i) that adequate and timely availability of spectrum and supporting regulatory provisions is essential to realize the objectives in Recommendation ITU-R M.2083;
- j) that harmonized worldwide bands and harmonized frequency arrangements for IMT are highly desirable in order to achieve global roaming and the benefits of economies of scale;
- k) that identification of frequency bands allocated to mobile service for IMT may change the sharing situation regarding applications of services to which the frequency band is already allocated, and may require additional regulatory actions;
- l) the need to protect existing services and to allow for their continued development when considering frequency bands for possible additional allocations to any service, noting
- a) that Resolution ITU-R 65 addresses the principles for the process of development of IMT for 2020 and beyond, and that Question ITU-R 77-7/5 considers the needs of developing countries in the development and implementation of IMT;
- b) that Question ITU-R 229/5 seeks to address the further development of IMT;
- c) that IMT encompasses both IMT-2000, IMT-Advanced, and IMT-2020 collectively, as described in Resolution ITU-R 56-2;
- d) Recommendation ITU-R M.2083, on the framework and objectives of the future development of IMT for 2020 and beyond;
- e) that Report ITU-R M.2320 addresses future technology trends of terrestrial IMT systems;
- f) Report ITU-R M.2376, on technical feasibility of IMT in the frequency bands above 6 GHz;
- g) that Report ITU-R M.2370 analyses trends impacting future IMT traffic growth beyond the year 2020 and estimates global traffic demands for the period 2020 to 2030;
- h) that there are ongoing studies within ITU-R on the propagation characteristics for mobile systems in higher frequency bands;
- i) the relevance of provisions in Nos. 5.340, 5.516B, 5.547 and 5.553, which may need to be taken into account in studies;
- j) that the FSS allocation in the frequency band 24.65-25.25 GHz was made by WRC-12, recognizing
- a) that there is a lead time between the allocation of frequency bands by world radiocommunication conferences and the deployment of systems in those bands, and that timely availability of wide and contiguous blocks of spectrum is therefore important to support the development of IMT;

b) that frequency bands allocated to passive services on an exclusive basis are not suitable for an allocation to the mobile service;

c) that any identification of frequency bands for IMT should take into account the use of the bands by other services and the evolving needs of these services;

d) that there should be no additional regulatory or technical constraints imposed to services to which the band is currently allocated on a primary basis, resolves to invite ITU-R

1) to conduct and complete in time for WRC-19 the appropriate studies to determine the spectrum needs for the terrestrial component of IMT in the frequency range between 24.25 GHz and 86 GHz, taking into account: – technical and operational characteristics of terrestrial IMT systems that would operate in this frequency range, including the evolution of IMT through advances in technology and spectrally efficient techniques; – the deployment scenarios envisaged for IMT-2020 systems and the related requirements of high data traffic such as in dense urban areas and/or in peak times; – the needs of developing countries; – the time-frame in which spectrum would be needed;

2) to conduct and complete in time for WRC-19 the appropriate sharing and compatibility studies<sup>1</sup>, taking into account the protection of services to which the band is allocated on a primary basis, for the frequency bands:

- 24.25-27.5 GHz
- 37-40.5 GHz,
- 42.5-43.5 GHz,
- 45.5-47 GHz,
- 47.2-50.2 GHz,
- 50.4-52.6 GHz,
- 66-76 GHz and
- 81-86 GHz,

which have allocations to the mobile service on a primary basis; and –

- 31.8-33.4 GHz,
- 40.5-42.5 GHz and
- 47-47.2 GHz,

this may require additional allocations to the mobile service on a primary basis, further resolves

1) to invite CPM19-1 to define the date by which technical and operational characteristics needed for sharing and compatibility studies are to be available, to ensure that studies referred to in

resolves to invite ITU-R can be completed in time for consideration at WRC-19;

2) to invite WRC-19 to consider, based on the results of the above studies, additional spectrum allocations to the mobile service on a primary basis and to consider identification of frequency bands for the terrestrial component of IMT; the bands to be considered being limited to part or all of the bands listed in resolves to invite ITU-R 2, invites administrations to participate actively in these studies by submitting contributions to ITU-R.

1) Including studies with respect to services in adjacent bands, as appropriate.

2) When conducting studies in the band 24.5-27.5 GHz, to take into account the need to ensure the protection of existing earth stations and the deployment of future receiving earth stations under the EESS (space-to-Earth) and SRS (space-to-Earth) allocation in the frequency band 25.5-27 GHz.

## 4 SADC

The Southern African Development Community (SADC) Frequency Allocation Plan (FAP) creates a framework for harmonisation across SADC on the use of the radio frequency spectrum. Countries included in the SADC FAP are Angola, Botswana, Democratic Republic of the Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

The SADC FAP states “Whereas harmonisation is important, this could however take place on various levels namely allocation level, (e.g. mobile service), application level (e.g. cellular mobile) or on technology level (e.g. LTE or mobile WiMAX). Although the ITU spectrum harmonisation is generally limited to the first level, (i.e. radio communication services) it does occasionally also endeavour to harmonise certain applications. A noteworthy example is where a band is ‘identified’ for a specific application such as IMT. Although such identification does not establish any priority in the Radio Regulations, nor does it exclude the use of the particular frequency band for any other application within the same or other allocations, it does signal to the market the potential of harmonising the particular frequency band for the specified application. Within this application various technologies could then be deployed.”

The 2010 SADC FAP was developed taking into account international best practice in the development of Frequency Band Plans and considering the needs of the SADC Members.

ITU Region 1 allocations and footnotes	SADC common allocation/s and relevant ITU footnotes	SADC proposed common sub-allocations / utilisation	Additional information
<b>450-455 MHz</b> FIXED MOBILE 5.286AA 5.209 5.271 5.286 5.286A 5.286B 5.286C 5.286D 5.286E	<b>450-455 MHz</b> FIXED MOBILE 5.286AA 5.286 5.286A	Fixed links (PTP) IMT (450-470 MHz) , PMR and/or PAMR	This band is currently used for a variety of fixed and mobile systems in the various SADC.  This band is also identified for IMT (Res. 224 applies)
<b>455-456 MHz</b> FIXED MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E	<b>455-456 MHz</b> FIXED MOBILE 5.286AA 5.209 5.286A		
<b>456-459 MHz</b> FIXED MOBILE 5.286AA 5.271 5.287 5.288	<b>456-459 MHz</b> FIXED MOBILE 5.286AA 5.287		
<b>459-460 MHz</b> FIXED	<b>459-460 MHz</b> FIXED		

MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E	MOBILE 5.286AA 5.209 5.286A		
<b>460-470 MHz</b> FIXED MOBILE 5.286AA Meteorological satellite (space to Earth) 5.287 5.288 5.289 5.290	<b>460-470 MHz</b> FIXED MOBILE 5.286AA Meteorological satellite (space to Earth) 5.287 5.289		
<b>470-790 MHz</b> BROADCASTING  5.149 5.291A 5.294 5.296 5.300 5.304 5.306 5.311A 5.312 5.312A	<b>694-790MHz</b> BROADCASTING MOBILE except aeronautical mobile service 5.312A SADC 12 5.311A	MOBILE (IMT)	WRC 12 allocated the band to Mobile except aeronautical mobile on a co-primary basis with Broadcasting (WRC-12 Res 232 refers). The band was also identified for IMT. The mobile allocation is effective from 2015, immediately after WRC 15 and shall be subject to technical and regulatory conditions to be stipulated by WRC 15. SADC plans to implement IMT in the band immediately after WRC 15
<b>790-862 MHz</b> MOBILE except aeronautical mobile 5.316B 5.317A <b>BROADCASTING</b> 5.312 5.314 5.315 5.316	<b>790-862 MHz</b> MOBILE except aeronautical mobile 5.316B 5.317A BROADCASTING 5.314 5.315 5.316 5.316A 5.319	MOBILE (IMT)	Band IV/V analogue television to migrate to digital television according to SADC time lines. WRC-07 allocated this band to mobile except aeronautical mobile service and identified it for IMT. This band should be made available for IMT as soon as possible after the migration of analogue television to digital. This band needs to be harmonised in SADC for IMT; channelling plan to be developed for SADC region. Fixed links operating in this band will have to be migrated in order to accommodate IMT.
<b>862-890 MHz</b> FIXED MOBILE except aeronautical mobile	<b>862-890 MHz</b> MOBILE except aeronautical mobile 5.317A	862-876 MHz IMT	The use of this band for IMT in the future to be investigated as part of the development of harmonised IMT channelling arrangements.

<p>5.317A</p> <p>BROADCASTING 5.322</p> <p>5.319 5.323 5.316A</p> <p>5.319</p>	<p>SADC14</p>	<p>876-880 MHz</p> <p>IMT</p> <p>PMR and/or PAMR</p>	<p>This band is paired with 921-925 MHz</p> <p>The use of this band for IMT in the future to be investigated as part of the development of harmonised IMT channelling arrangement.</p>
<p><b>890-942 MHz</b></p> <p>FIXED</p> <p>MOBILE except aeronautical mobile 5.317A</p> <p>BROADCASTING 5.322</p> <p>Radiolocation 5.323</p>	<p><b>890-942 MHz</b></p> <p>MOBILE except aeronautical mobile 5.317A</p>	<p>880-915 MHz</p> <p>IMT</p> <p>915-921 MHz</p> <p>PMR and/or PMR</p> <p>921-925 MHz</p> <p>IMT</p> <p>PMR and/or PAMR</p> <p>925-960 MHz</p> <p>IMT</p>	<p>Paired with 925-960 MHz</p> <p>Paired with 876-880 MHz.</p> <p>Paired with 880-915 MHz</p>
<p><b>942-960 MHz</b></p> <p>FIXED</p> <p>MOBILE except aeronautical mobile 5.317A</p> <p>BROADCASTING 5.322</p> <p>5.323</p>	<p><b>942-960 MHz</b></p> <p>MOBILE except aeronautical mobile 5.317A</p> <p>5.322</p>		
<p><b>1700-1710 MHz</b></p> <p>FIXED</p> <p>METEOROLOGICAL-SATELLITE (space-to-Earth)</p> <p>MOBILE except aeronautical mobile</p> <p>5.289 5.341</p>	<p><b>1700-1710 MHz</b></p> <p>FIXED</p> <p>METEOROLOGICAL-SATELLITE (space-to-Earth)</p> <p>MOBILE except aeronautical mobile</p> <p>5.289 5.341</p>	<p>Fixed links (single frequency)</p>	
<p><b>1710-1930 MHz</b></p> <p>FIXED</p> <p>MOBILE 5.384A 5.388A 5.388B</p> <p>5.149 5.341 5.385 5.386 5.387 5.388</p>	<p><b>1710-1930 MHz</b></p> <p>FIXED</p> <p>MOBILE 5.384A 5.388A 5.388B</p> <p>5.149 5.341 5.385 5.388</p>	<p>1710-1785 MHz IMT</p> <p>1785-1805 MHz BFWA</p> <p>1805-1880 MHz IMT</p> <p>1880-1900 MHz FWA</p> <p>Cordless telephone</p> <p>1900-1920 MHz FWA IMT (terrestrial)</p>	<p>IMT</p> <p>Paired with 1710-1785 MHz.</p>

<b>1930-1979 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>1930-1979 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	1920-1980 MHz IMT (terrestrial)	Paired with 2170-2200MHz The development of satellites for IMT services to be monitored
<b>1970-1980 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>1970-1980 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388		
<b>2010-2025 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>2010-2025 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	IMT terrestrial (2010- 2025 MHz )	TDD
<b>2110-2120 MHz</b> FIXED MOBILE 5.388A5.388B SPACE RESEARCH (deep space) (Earth-to- space) 5.388	<b>2110-2120 MHz</b> MOBILE 5.388A5.388B SPACE RESEARCH (deep space) (Earth-to- space) 5.388	IMT (terrestrial) (2110-2170 MHz)	Paired with 1920-1980 MHz
<b>2120-2160 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>2120-2160 MHz</b> MOBILE 5.388A 5.388B 5.388		
<b>2160-2170 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>2160-2170 MHz</b> MOBILE 5.388A 5.388B 5.388		
<b>2170-2200 MHz</b> FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A 5.388 5.389A 5.389F	<b>2170-2200 MHz</b> MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A 5.388 5.389A 5.389F	IMT (satellite) (2170- 2200 MHz)	Paired with 1980-2010 MHz The development of satellites for IMT services to be monitored.
<b>2 200-2 290 MHz</b> SPACE OPERATION (space-to-Earth) (space- to-space) EARTH EXPLORATION – SATELLITE (space-to- Earth) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (space-to-Earth) (space- to-space) 5.392	<b>2 200-2 290 MHz</b> SPACE OPERATION (space-to-Earth) (space- to-space) EARTH EXPLORATION – SATELLITE (space-to- Earth) (space-to-space) FIXED SPACE RESEARCH (space-to-Earth) (space- to-space) 5.392	Fixed links (2025- 2110 MHz paired with 2200- 2285 MHz)	Radio Frequency channel arrangement according to ITU-RF. 1098.
		BFWA (2 285-2 300 MHz)	
<b>2290-2300 MHz</b>	FIXED	BFWA (2285-2300 MHz)	

FIXED MOBILE except aeronautical mobile SPACE RESEARCH (deep space) (space-to- Earth)	MOBILE except aeronautical mobile SPACE RESEARCH (deep space) (space-to-Earth)		
<b>2300-2450</b> FIXED MOBILE 5.384A Amateur Radiolocation 5.150 5.282 5.395	<b>2300-2450</b> FIXED MOBILE 5.384A Amateur Radiolocation 5.150 5.282	2300-2400 MHz Fixed links PTP/PTMP IMT (TDD) BFWA	Fixed paired with 2400-2500 MHz. This band has been identified for IMT.
<b>2500-2520 MHz</b> FIXED 5.410 MOBILE except aeronautical mobile 5.384A 5.405 5.412	<b>2500-2520 MHz</b> FIXED MOBILE except aeronautical mobile 5.384A	BFWA (2500-2690 MHz) IMT (2500-2690 MHz)	The band 2500-2690 MHz is currently used mainly for BFWA. This band is also allocated to the mobile service and identified for IMT. This band needs to be harmonised in SADC for the IMT channelling plan to be developed.
<b>2520-2655 MHz</b> FIXED 5.410 MOBILE except aeronautical mobile 5.384A BROADCASTING- SATELLITE 5.4135.416 5.339 5.405 5.412 5.417C 5.417D 5.418B 5.418C	<b>2520-2655 MHz</b> FIXED MOBILE except aeronautical mobile 5.384A 5.339		
<b>2655-2670 MHz</b> FIXED 5.410 MOBILE except aeronautical mobile 5.384A BROADCASTING- SATELLITE 5.208B 5.413 5.416 Earth exploration-satellite (passive) Radio astronomy Space research (passive) 5.149 5.412	<b>2655-2670 MHz</b> FIXED MOBILE except aeronautical mobile 5.384A 5.149 5.412		
<b>2670-2690 MHz</b> FIXED 5.410 MOBILE except aeronautical mobile 5.384A Earth exploration-satellite	<b>2670-2690 MHz</b> FIXED MOBILE except aeronautical mobile 5.384A 5.149 5.412		



(passive) Radio astronomy Space research (passive) 5.149 5.412			
<b>3400-3600 MHz</b> FIXED FIXED-SATELLITE (space- to-Earth) Mobile 5.430A Radiolocation 5.431	<b>3400-3600 MHz</b> FIXED MOBILE except aeronautical mobile 5.430A SADC16	BFWA IMT (3400-3600 MHz)	The band 3 400-3 600 MHz is currently used mainly for BFWA. From 17 Nov 2010 this band is also allocated to the mobile service on a primary basis and should be used for IMT in line with WRC-07 decisions.  Because of the expected high usage of BFWA and/or IMT applications in this band, satellite services should be accommodated above  3 600 MHz. This band needs to be harmonised in SADC for the IMT channelling plan to be developed.

Table 2: Table showing SADC Frequency Allocations for IMT Bands

## 5 South Africa

### 5.1 The Electronic Communications Act

A review of the Electronic Communications Act of 2005 contained in the Government Gazette No. 28743, No. 36 of 2005, as well the Electronic Communications Amendment Act of 2014 contained in Government Gazette No. 37536, Act No. 1 of 2014 which together regulate electronic communications in the Republic of South Africa was carried out and the following sections were found to be of particular relevance.

#### 5.1.1 Chapter 1: Introductory provisions

##### *Object of Act*

2. *The primary object of this Act is to provide for the regulation of electronic communications in the Republic in the public interest and for that purpose to:*

- (a) promote and facilitate the convergence of telecommunications, broadcasting, information technologies and other services contemplated in this Act;*
- (b) promote and facilitate the development of interoperable and interconnected electronic networks, ensure the provision of the services contemplated in the Act and to create a technologically-neutral licensing framework;*
- (c) promote the universal provision of electronic communications networks and electronic communications services and connectivity for all;*
- (e) ensure efficient use of the radio frequency spectrum;*
- (f) ensure the provision of a variety of quality electronic communications services at reasonable prices; and*
- (h) promote stability in the ICT sector.*

#### 5.1.2 Chapter 2: Policy and regulations

##### *Ministerial policy and policy directions*

3. *The Minister may make policies on national matters applicable to the ICT sector, consistent with the objectives of this Act and of the relevant legislation in relation to:*

- (a) the radio frequency spectrum;*
- (b) the universal service and access policy; and*
- (c) the Republic's obligations and undertakings under bilateral, multilateral or international treaties and conventions, including technical standards and frequency matters.*

### 5.1.3 Chapter 5: Radio frequency spectrum

#### *Control of radio frequency spectrum*

30 (1) *In carrying out its functions under this Act and the related legislation, the Authority controls, plans, administers and manages the use and licensing of the radio frequency spectrum except as provided for in section 34.*

(2) *In controlling, planning, administering, managing, licensing and assigning the use of the radio frequency spectrum, the Authority must:*

*(a) comply with the applicable standards and requirements of the ITU and its Radio Regulations, as agreed to or adopted by the Republic as well as with the national radio frequency plan contemplated in section 34;*

*(b) take into account modes of transmission and efficient utilisation of the radio frequency spectrum, including allowing shared use of radio frequency spectrum when interference can be eliminated or reduced to acceptable levels as determined by the Authority;*

*(c) give high priority to applications for radio frequency spectrum where the applicant proposes to utilise digital electronic communications facilities for the provision of broadcasting services, electronic communications services, electronic communications network services, and other services licensed in terms of this Act or provided in terms of a licence exemption;*

*(d) plan for the conversion of analogue uses of the radio frequency spectrum to digital, including the migration to digital broadcasting in the Authority's preparation and modification of the radio frequency spectrum plan; and*

*(e) give due regard to the radio frequency spectrum allocated to security services.*

## 5.2 The Frequency Migration Regulations and Plan 2018

### 5.2.1 Principles governing frequency migration

#### 5.2.1.1 Identification of bands which are subject to frequency migration

Bands are identified for radio frequency migration according to the following hierarchy:

- First Level – where the ITU radio regulations / decisions of a World Radio Conference (WRC) require a change in national allocation that will require existing users to be migrated;
- Second Level - where a Regional Radio Conference (RRC) requires a change in national allocation that necessitates existing users to be migrated;
- Third Level – where the SADC FAP requires a change in national allocation that necessitates existing users to be migrated; and
- Fourth Level – a decision is made to change the use of a frequency band at national level and this requires the migration of existing users.

## Process

The process of frequency migration is carried out in a manner consistent with the radio frequency spectrum regulations and the generic process is described in the Frequency Migration Regulation (FMR) 2013.

The key processes are described in the Radio Frequency Spectrum Regulations (RFSR) 2011, and are as follows:

- Preparation of a RFSAP for the particular band or bands; and
- Amendment of a Radio Frequency Spectrum Licence where necessary.

When it has been established that migration is required, then the critical issue is to determine the time frame in a manner consistent with sound radio frequency spectrum management.

In some cases, it is necessary to carry out a feasibility study on the band in question. This is illustrated in the process flow indicated below.

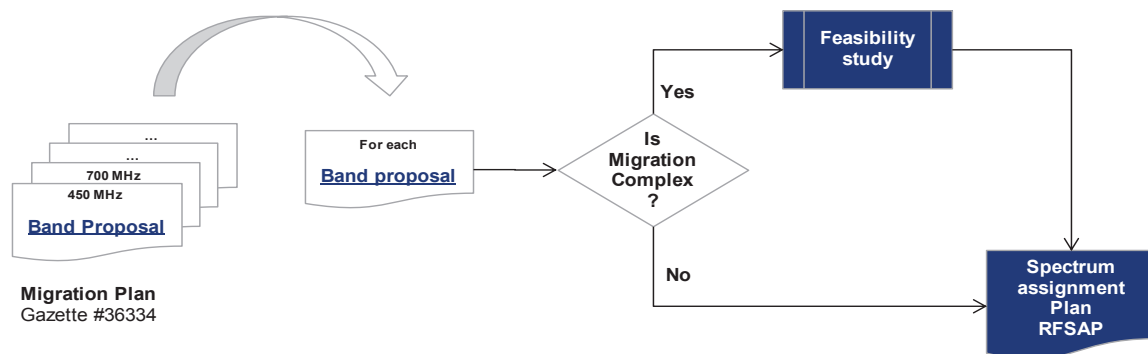


Figure 2: Process for developing an RFSAP

The requirement for a feasibility study is usually, but not necessarily, indicated in the FMP. Where the results of feasibility study indicate a change in the usage of the band in question, a RFSAP will be carried out.

The RFSAP will be subject to a consultation process.

The Frequency Migration Plan does not necessarily identify the destination bands for out-migrating users or uses because the appropriate destination band will vary from user to user, depending on the specific requirements of the user. The spectrum pricing regime is intended to facilitate this process and guide users to the 'optimal' choice.

## Time frame for migration

In principle, the Authority can migrate a user to another location as part of sound radio frequency spectrum management. However, an appropriate time frame should be applied as a matter of standard practice.

In determining the time frame, the following factors are taken into account:

- the duration of the spectrum licence;
- the time frame to migrate existing customers (end-users);

- the economic life of the equipment installed; and
- adequate forward planning.

The forward-looking time frame for a process of spectrum migration is within 5 years from the moment of publication of this FMP unless the Authority states otherwise in a Notice.

### 5.3 South Africa Connect

‘South Africa Connect: Creating Opportunities, Ensuring Inclusion’ which is South Africa’s Broadband Policy was brought into effect in November 2013 by the Department of Communications (DoC). The policy aims to create a seamless information infrastructure, which is accessible to and affordable for South Africans.

The overall goal is to achieve a universal average download speed of 100 Mbps by 2030. The 2020 vision for broadband is to provide 100% of South Africans with broadband services at 2.5% or less of the population’s average monthly income<sup>4</sup>.

The objectives of the National Broadband Policy (NBP) are:

- *affordable broadband available nationally to meet the diverse needs of public and private users, both formal and informal, consumers and citizens;*
- *policy and regulatory conditions that enable public and private sector players to invest and also contribute;*
- *public sector delivery, including e-government services, underpinned by the aggregation of broadband needs;*
- *that all public institutions at the national, provincial and municipal level should benefit from broadband connectivity and this should be extended to the communities they serve;*
- *to establish a framework such that public and private enterprises, formal and informal, are able to fully exploit the efficiencies offered by ubiquitous broadband and its potential for innovation;*
- *the development of a strong national skills base so that South Africa can perform as a proficient, globally-competitive and knowledgeable economy;*
- *a vibrant, creative software industry which produces content and applications which are relevant and meet the needs of the diverse users in the country; and*
- *a literate and skilled society that can effectively access services and content, including public information and public services.*

The Broadband Policy proposed certain targets and timeframes for access to broadband in South Africa.

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<sup>4</sup> 2.5% of average monthly income is approximately R368.28, calculated from an average monthly income of R14731 for all formal and non-agricultural industries. Source: Statistics South Africa: Quarterly Employment Statistics (QES) March 2014

Target	Penetration Measure	Baseline (2013)	By 2016	By 2020	By 2030
Broadband access in Mbps user experience	% of population	33.7% internet access	50% at 5 Mbps	90% at 5Mbps 50% at 100Mbps	100% at 10 Mbps 80% at 100 Mbps
Schools	% schools	25% connected	50% at 10 Mbps	100% at 10Mbps 80% at 100 Mbps	100% at 1Gbps
Health facilities	% of health facilities	13% connected	50% at 10Mbps	100% at 10Mbps 80% at 100Mbps	100% at 1Gbps
Government facilities	% of Government offices		50% at 5Mbps	100% at 10Mbps	100% at 100Mbps

**Table 3: National Broadband Policy Targets**

The issues to be addressed when meeting the current targets are currently low penetration, high prices, and poor quality of service. The broadband Policy requires the Authority to monitor and evaluate set targets and comply with quality of service standards on an ongoing basis and report on them annually. The review of such targets falls within the domain of the Minister.

In Chapter 9 of the Broadband Policy, a gap analysis indicates a number of areas where there is a shortfall between the current status of the broadband ecosystem and the set targets. One of these areas is market structure and regulatory regime and on this issue, the policy states:

*Despite the horizontal licensing regime introduced by the Electronic Communications Act of 2005, the market remains structured around vertically integrated incumbents, who have multiple licences, but continue to compete downstream with multiple service providers. This creates anti-competitive incentives in the market and requires a resource-intensive regulatory regime, where the regulator is constantly required to adjust the behaviour of the incumbents. The wholesale open access regime will also address the structural constraints in the market arising from the dominance of a number of vertically integrated operators. Re-structuring the market to enable greater wholesale access to networks by service providers will go a long way to creating a more competitive services sector, which is likely to enhance quality and drive down prices.*

In terms of the gap in infrastructure reach, the broadband policy highlights that:

*The real gap is in the last-mile local loop infrastructure. In high demand metropolitan areas there is considerable duplication of infrastructure, but outside these areas, ADSL is limited. The delay in releasing spectrum and the cost of building out high-speed, next generation networks to low demand areas, means that the substitution of mobile broadband for ADSL is not as prevalent as it is in metropolitan areas.*

In terms of spectrum, the Broadband Policy identifies the following gap:

*With the increasing reliance on mobile or wireless communications, there is more demand than ever for radio spectrum – the invisible wavelengths or frequencies by which services such as broadcasting and mobile communications can be transmitted.*

*Policy and regulatory bottlenecks associated with spectrum assignment, together with delays in the migration of land analogue broadcasting to digital, have meant that service innovation, increased competition, potential job opportunities and tax revenues have not been realised. The efficient assignment and subsequent use of high demand spectrum to meet this demand is vital and the cost of making this spectrum available is vital and the cost of not doing so is high.*

In terms of Access networks, a gap related to spectrum was also identified and is noted below:

*Extending broadband access is dependent on allocation of high demand spectrum.*

Digital future is also another solution to closing identified gaps and aims to:

*Enable sharing and co-operation on open access network builds and operations through ensuring economies of scale, reducing risk and guaranteeing returns.*

The current status of broadband infrastructure networks with respect to spectrum is outlined in South Africa's Broadband Policy as shown below:

*Spectrum is a scarce but non-depleting resource that has to be managed efficiently in order to optimise its potential to provide broadband access. This is especially pertinent given the dominance of mobile access in South Africa. Fixed wireless access also requires spectrum and represents an alternative to fixed-line networks to provide high capacity broadband especially in rural areas.*

*The immediate priorities with respect to spectrum are:*

- *identification of unused spectrum and its reassignment;*
- *the removal of bottlenecks preventing migration of terrestrial broadcasters from analogue to digital in order to realise the digital dividend;*
- *the re-allocation and assignment of broadband spectrum, taking into consideration job creation, small business development, national empowerment and the promotion of NDP goals;*



- *approval of spectrum-sharing between spectrum licensees and across services by the Authority in support of efficient use of spectrum and where it does not impact negatively on competition;*
- *the enabling of dynamic spectrum allocation; and*
- *ensuring sufficient spectrum for extensive Wi-Fi and other public access technologies and services.*

*It is Government's objective to ensure that access to broadband for all is attained. Therefore, licensing of broadband spectrum should contribute to the realisation of the following public interest policy objectives:*

- *The achievement of universal access to broadband;*
- *Effective and efficient use of high demand spectrum;*
- *Adoption of open access principles;*
- *Safeguard the spectrum commons and spectrum required for public access technologies and services; and*
- *The promotion of broader national development goals of job creation, the development of small and medium-sized businesses and South African-owned and controlled companies, and the broad-based economic empowerment of historically-disadvantaged persons.*

*If required, as part of the strategy to meet national broadband requirements, sufficient spectrum will be set aside for the creation of a national Wireless Open Access Network (WOAN).*

Important policy decisions stemming from the Broadband Policy which affect spectrum are identified and listed below:

Issue	Action
Spectrum delay in allocating broadband spectrum,	ICASA to engage with the New Ministry
Appointment of a Broadband Council	The Minister of Communications appointed a Broadband Council to advise on the implementation of policy and emerging policy issues.

**Table 4: Policy decisions from the broadband policy**

The broadband policy also proposes a roadmap for public and private investment in the next generation broadband network. Part of this roadmap deals with a wireless broadband open access network and is highlighted below:

*The speed of deployment of a wireless network is a fundamental consideration to meet the immediate challenge of meeting the targets of this policy. The Ministerial policy directive will consider as a priority how best to ensure that the release of high demand spectrum fulfils these policy objectives and specifically*



*how best the application of open access principles to the assignment of broadband spectrum will be achieved. The outcome should:*

- *maximize the efficiency with which spectrum is used and minimize the costs of deployment of wireless broadband capacity with national coverage;*
- *provide a neutral, non-discriminatory platform or effectively-regulated, competing platforms providing wholesale access on which competition can take place between multiple service providers at the retail level; and*
- *pool and share existing network assets.*

*Enabling conditions for a national wireless network in the high demand bands are:*

- *access to a portfolio of spectrum that includes adequate and sufficient capacity to be able to provide both capacity and coverage efficiently and economically from dense urban to rural areas;*
- *use of existing facilities wherever possible (e.g. base station locations, fibre links for backhaul and long distance connectivity) to minimize its costs through infrastructure sharing;*
- *cost-based, non-discriminatory access regime for service providers, allowing them to compete fairly in the market and recoup their investments; and*
- *spectrum allocation that is apportioned to ensure the viability of possible new entrants in a fair, competitive environment, whilst encouraging competition and taking account of the broader interests of existing licence holders.*

*Key success factor:*

- *In an environment in which the level of Government's direct financial contributions are constrained, attracting enough investment to deploy the network/s and the use or sharing of existing facilities to minimize the deployment costs;*
- *Realistic coverage targets so the costs do not balloon out of control relative to any conceivable revenue stream;*
- *Pricing incentives to attract users;*
- *Support from the highest levels of Government;*
- *Long term financial horizon for return on investment; and*
- *Assignment of adequate spectrum to ensure the viability of new entrants while advancing industry competitiveness in infrastructure provision.*

#### **5.4 RECOMMENDATION ITU-R M.2083-0.**

This document describe the IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond. South Africa need to look in detail into this recommendation of which a copy is included in Appendix H to this document. **Global Trends for IMT**

## 5.5 Global assignment objectives for IMT

In planning the implementation of IMT, the following objectives are desirable to:

- ensure that frequency arrangements for the implementation of IMT have longevity, yet allow for the evolution of technology;
- facilitate the deployment of IMT, subject to market considerations and facilitate the development and growth of IMT;
- minimise the impact on other systems and services within, and adjacent to, the bands identified for IMT;
- facilitate worldwide roaming of IMT terminals;
- integrate the terrestrial and satellite components of IMT efficiently;
- optimise the efficiency of spectrum utilisation within the bands identified for IMT;
- enable the possibility of competition;
- facilitate the deployment and use of IMT, including fixed and other special applications in developing countries and in sparsely-populated areas;
- accommodate various types of traffic and traffic mixes;
- facilitate the continuing worldwide development of equipment standards;
- facilitate access to services globally within the framework of IMT;
- minimise terminal costs, size and power consumption, where appropriate and consistent with other requirements;
- facilitate the evolution of pre-IMT-2000 systems to any of the IMT terrestrial radio interfaces and to facilitate the ongoing evolution of the IMT systems themselves;
- afford flexibility to administrations, as the identification of several bands for IMT allows administrations to choose the best band or parts of bands for their circumstances;
- facilitate determination, at a national level, of how much spectrum to make available for IMT from within the identified bands;
- facilitate determination of the timing of availability and use of the bands identified for IMT, in order to meet particular user demand and other national considerations;
- facilitate development of transition plans tailored to the evolution of existing systems;
- have the ability, for the identified bands based on national utilisation plans, to be used by all services having allocations in those bands.

The following guiding principles have been applied in determining frequency arrangements:

- harmonisation;
- technical considerations; and
- spectrum efficiency.

## **5.6 IMT and Long Term Evolution (LTE)**

The number of IMT frequency bands has increased significantly in the last several years with the progress of the ITU's IMT spectrum planning.

The potential IMT technologies are LTE, LTE-advanced and WiMAX, with a clear trend towards LTE both from the point of view of the available ecosystem and the choices made by operators.

## **5.7 LTE - paired and unpaired spectrum (FDD and TDD)**

### **5.7.1 FDD and TDD trends**

In the past, the majority of bands were assigned to FDD, with limited TDD spectrum in between the FDD assigned sub-bands or in higher ranges. Recently, the amount of spectrum assigned for TDD has increased, however, on the whole, there is still a gap between TDD and FDD, and there is still relatively little spectrum for TDD in lower frequency bands.

A key requirement for the future is for chipsets and terminals to support multi-band frequencies to meet the requirements of global frequency distribution. At the same time, to achieve economies of scale and global roaming, it will also be required for terminals to support multi-mode, especially LTE FDD and TDD. The technologies for LTE TDD multi-mode, multi-band Smart phones and multi-band LTE TDD dongles and CPEs are maturing and increasingly becoming commercially available.

The majority of assigned spectrum is paired FDD leading to the establishment of a complete and end-to-end industry chain involving widespread participation of global industries and highly matured products including system equipment, chipsets, user devices and test instruments. Currently 288 FDD networks are in commercial operation worldwide, (as compared with 36 TDD networks, although both are steadily increasing).

However, LTE TDD is already a mainstream technology supported by a well-established and fast-growing ecosystem. The number of operators deploying commercial LTE TDD systems, or engaged in trials and studies, is steadily increasing. For example, China Mobile is building the world's largest LTE TDD network.

While a large amount of low and medium frequency spectrum (generally suitable for wide coverage) has been allocated for FDD, the same cannot be said for TDD. There is a general trend for higher downlink provision; therefore the high downlink capacity densities which can be achieved by the larger downlink bandwidth available via TDD bandwidth, favour schemes at higher frequencies resulting in lower coverage cell areas and a consequent larger number of sites. This is the reason why 100 MHz bandwidth in 2300 MHz and 200 MHz bandwidth in 3400-3600 MHz has been allocated to TDD.

The LTE TDD terminal has evolved from a data-only terminal to a mobile terminal. It is expected that during 2014, LTE TDD smart phones will be available commercially on a large scale.

### 5.7.2 Flexible spectrum utilisation

Unpaired spectrum is much easier to release than paired spectrum. This benefit is becoming increasingly important as the globally available supply of spectrum falls, meaning the process of releasing new spectrum can be greatly accelerated by designating it as unpaired TDD.

Capacity benefits of unpaired spectrum are realised in the size of available TDD spectrum bands often allocated in large blocks. From a capacity perspective, this is an advantage over the typical 2×10 MHz configuration found in paired FDD spectrum. The current LTE bandwidth limit is 20 MHz and most equipment could spread power of ~80 W over ~40 MHz bandwidth depending on the frequency range. Therefore, 40 MHz assignments per operator might be cost-efficient, but this would be hard to assign in multi-operator environments. Therefore, it might be advantageous to have one wholesale operator or active Radio Access Network (RAN) sharing involving a number of mobile network operators in TDD spectrum.

In addition, the unpaired TDD spectrum band should not be fragmented with FDD spectrum due to the requirement of a guard band of ~5 MHz between the bands, which is generally taken from the TDD spectrum. Instead of guard bands, the boundary ranges might be used indoors only due to higher penetration losses. Special spectrum assignments for TDD could be used within the duplex gap larger than 15 MHz.

### 5.7.3 High spectral efficiency for adaptive uplink /downlink configuration

The asymmetric nature of TDD brings a number of advantages. One key advantage of this is the flexibility it allows in the adjustment of the downlink and uplink resource ratios. Commonly employed, downlink-to-uplink ratios are 8:1, 3:1, 2:2 and 1:3 and the heavily downlink-oriented configuration fits perfectly with current user behaviour, where streaming and downloads take up a high proportion of downlink resources.

Cisco predicts a dramatic increase in the downlink-centric applications. Based on this prediction, the downlink-centric application will generate more than 90% of the mobile traffic in 2017. Therefore, unpaired spectrum is best suited for the user behaviour of the mobile broadband era.

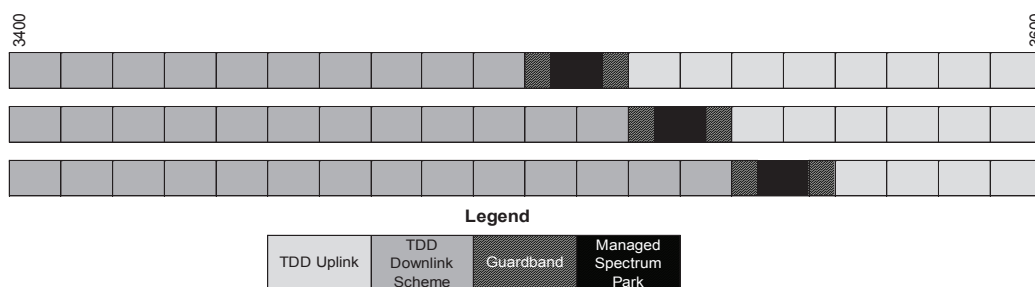
Unpaired LTE is also optimally suited to cover future M2M and 'Internet of Things' demands which will be predominantly uplink-oriented. Also, video uploads from closed-circuit television (CCTV) result in a higher uplink bandwidth capacity requirement which have to be taken into account in specialised schemes.

Due to desensitisation of receivers in case of transmission into neighbouring bands, it is not possible to have different unpaired spectrum configuration schemes in the same band (without guard bands - which are spectrum-inefficient). Therefore, it is expected to have different bands for uplink-oriented and downlink-oriented configurations, e.g., the 450 MHz band, 700 MHz band, 2100 MHz band or 2600 MHz band with reduced bandwidths of maximum 40 MHz for uplink while the 2300 MHz band and 3500 MHz band have 100-200 MHz bandwidths for downlink. In the 3400-3600 MHz bands, there is also a possible differentiation in two sub-bands which might be separated by a 5 MHz guard band.

In South Africa, the Authority is evaluating the concept of managed spectrum parks, which as a whole have to cater for protection with neighbour bands. Three potential solutions exist depending on uplink and downlink requirements within the 3400-3600 MHz band. The downlink schemes suffer from reduced uplink cell coverage required for reverse control channel communications; therefore, downlink should be placed in the lower parts of this band while the uplink schemes are placed in the upper parts of the band. In general, higher demand can be foreseen for downlink; therefore, the spectrum also favours downlink schemes, e.g., 140 MHz for downlink vs. 40 MHz for uplink. Some part of the spectrum might only be used indoors or, with reduced transmission powers, to protect the other unpaired TDD schemes. The minimum guard band of 5 MHz is increased (just as an example) to 20 MHz for any managed spectrum park concept usage (noting that the ultimate location of the guard band would be determined in the event managed spectrum parks are introduced<sup>5</sup>).

The IMT3500 band decision for downlink or uplink configurations could be done later based on the traffic expectations at that time. The Authority intends to assign special uplink or downlink configurations to minimize guard bands. The operators might decide on their individual business cases.

The Block Edge Masks might be investigated in order to allow unsynchronized usage or to minimize the need for guard bands. The managed spectrum park concept should be decided later as well.



**Figure 3: Potential unpaired LTE assignments in 3400-3600 MHz**

*According to downlink or uplink schemes; potential managed spectrum park realisation in the guard band*

**5.7.4 Deployment issues**

One advantage of unpaired over paired spectrum has been that operators have historically been able to pay less for paired spectrum than unpaired spectrum (although this is changing).

<sup>5</sup> Note that beyond the example given here, managed spectrum parks could also be introduced in TDD bands within 2100 MHz.

However, to cover the same area with the same uplink performance, the TDD systems in downlink-oriented configurations need more sites than FDD because the limiting terminal power and the reduced transmission time decrease the coverage in uplink. Therefore, in TDD, a higher number of antennas are used in higher bands for diversity gains or multiple-input and multiple-output (MIMO) usage to compensate uplink performance deficits.

Or to put it another way, for a lower band such as the 450 MHz band good propagation conditions together with uplink-oriented configuration schemes are quite beneficial, so no higher order MIMO or beamforming is needed. In higher bands, such as the 3500 MHz band with poor propagation and downlink-oriented configuration, the cell sizes decrease significantly. Higher order beamforming / MIMO would be more needed, especially due to reduced antenna dimension size. In higher bands, the reduced cell size is generally not an issue, because deployments will be more capacity-oriented and capacity density is higher.

### 5.7.5 Interference suppression

Thanks to uplink and downlink channel reciprocity (ensured by the fact that the same portion of spectrum is used in both link directions); TDD technology has unique co-ordination abilities, such as beamforming, which improves system performance by utilising channel-state information to achieve transmit-array gain. Results show that, across the 3GPP standard in Release 8~10, single-layer, dual-layer and multi-user beamforming can generate a cell throughput gain of 15%. Adoption of beamforming and Coordinated Multi-Points (CoMP), called 'Co-ordinated beamforming' (CBF), can further enhance network performance because interference is mitigated between inter-eNodeBs.

### 5.8 Future system requirements for IMT / LTE & IMT2020 networks

According to the 3GPP, in LTE-Advanced, the focus is on higher capacity. The motivation for further developing LTE towards LTE-Advanced is to provide higher bit-rates in a cost-efficient manner and, fulfil the requirements set by the ITU for IMT Advanced as shown below:

- Increased peak data rate, downlink 3 Gbps, uplink 1.5 Gbps;
- Higher spectral efficiency, from a maximum of 16 bps/Hz in Release 8 (R8) to 30 bps/Hz in Release 10 (R10);
- Increased number of simultaneously-active subscribers;
- Improved performance at cell edges, e.g. for downlink 2x2 MIMO > 2.40 bps/Hz/cell; and
- Enabled Carrier Aggregation (CA), enhanced use of multi-antenna techniques and support for Relay Nodes (RN).

As LTE-Advanced continues to evolve, new CA configurations are added and new features are introduced in upcoming releases of the 3GPP specifications, such as Coordinated Multi Point (CoMP) introduced in Release 11 (R11).

The main reason for introducing CoMP is to improve network performance at cell edges.

IMT2020 standards are not yet finalised and the most advanced services are still in the pre-commercial phase. In fact, we probably won't see any commercial IMT2020 services before at least 2020, so it's impossible to say definitively what speeds will be reachable.

However, they will be significantly ahead of what's currently available with 4G. A minimum expectation for commercial IMT2020 services is for them to be tens of times faster than 4G, which would make even current broadband speeds look sluggish in comparison.

And while the exact speeds are yet to be finalised, early tests are already achieving remarkable results and these give us a good idea of what we can expect when [IMT2020](#) finally launches.

#### DOWNLOAD SPEEDS

The Next Generation Mobile Networks alliance states that for something to be considered IMT2020 it must offer data rates of several tens of megabits per second to tens of thousands of users simultaneously, while a minimum of 1 gigabit per second should be offered to tens of workers on the same office floor.

That's all a little vague, but the signs are promising. Some estimates put download speeds at up to **1000 times faster than 4G**, potentially exceeding 10Gbps. That would enable you to download an entire HD film in less than a second.

Network Type	Download Speeds
3G Network	384Kbps
4G Network	100Mbps
IMT2020 Network	1-10Gbps (theoretical)

Some sources, such as The Korea Times, even reckon IMT2020 networks will be capable of transmitting data at up to 20Gbps. To put that in context, while LTE-A can theoretically achieve speeds of around 300Mbps, you're not likely to get more than around 42Mbps in reality and standard 4G has real world speeds of just around 14Mbps.

Nokia's thoughts are similarly ambitious, with the company suggesting that you'll be able to stream 8K video in 3D over IMT2020.

Some estimates are more conservative though, but even the most conservative estimates put it at several dozen times faster than 4G.

Already IMT2020 trials are taking place, with Verizon in the US for example showing that its technology can achieve download speeds of 30-50 times faster than 4G. That would enable you to download a full movie in around 15 seconds, versus around 6 minutes on 4G.



The IMT2020 Innovation Centre has achieved even higher speeds in test environments, of around 1 terabit per second (1Tbps). That's roughly 65,000 times faster than typical 4G speeds and would enable you to download a file around 100 times larger than a full movie in just 3 seconds.

However, that's unlikely to be replicated in the real world. Indeed, in an actual-use environment (rather than a specially built test site), DOCOMO has recorded speeds in excess of 2Gbps, which is still extremely impressive. Closer to home, EE has begun trialling IMT2020 speeds of 1Gbps.

Ofcom for its part sees IMT2020 as achieving real world speeds of between 10 and 50Gbps, which is insanely fast whichever end of the scale it ends up at. In short, it's clear that it will leave 4G in its dust.

#### UPLOAD SPEEDS

Estimates of upload speeds are so far vaguer than those for IMT2020 download speeds, but the consensus is that you'll be able to upload data at many gigabits per second, possibly up to 10Gbps.

The exact upload speed will of course be tied to the download speed though and whatever download speed is offered uploads will be slower, likely coming in at no more than half the download speed.

#### LATENCY TIME

Network Type	Milliseconds (ms)
3G Network	120ms (actual)
4G Network	45ms (actual)
IMT2020 Network	1ms (theoretical)

Latency is how long it takes the network to respond to a request, which could be you trying to play a song or video or load a website for example. It has to respond before it even starts loading, which can lead to minor but perceptible lag and is especially problematic for online games, as each input has a new response time.

Over 3G those response times are typically around 120 milliseconds and on 4G they're less than half that at between roughly 15 and 60 milliseconds. The theory is that on IMT2020 response times will drop to just 1 millisecond, which will be completely imperceptible.

That will help with all the things we use data for now, but more than that it's necessary for new mobile data uses, such as self-driving cars, which need to respond to inputs and changes in situation immediately.



That will help with all the things we use data for now, but more than that it's necessary for new mobile data uses, such as self-driving cars, which need to respond to inputs and changes in situation immediately.

## 6 Forecasts for South Africa

### 6.1 Forecasts of overall IMT demand

In Report ITU-R M.2290-0 (12/2013) future spectrum requirements are estimated for terrestrial IMT. From this report it is clear that the growth in mobile traffic is expected to increase over the next few years. In order to reflect the increasing traffic demand, new, updated market attributes for the lower user density and higher user density settings are provided.

In ‘Report ITU-R M.2078-0 (2006), Estimated spectrum bandwidth requirements for the future development of IMT-2000 and IMT-Advanced’, the new traffic volumes for the spectrum requirement estimations in 2020 are derived by considering traffic growth ratios from the market studies presented in ‘Report ITU-R M.2243-0 (2011) Assessment of the global mobile broadband deployments and forecasts for International Mobile Telecommunications’. The report relies on several mobile traffic forecasts beyond 2010, provided by different organisations. Most of these forecasts consider mobile traffic in the years 2011-2015, while only one makes projections for the year 2020, anticipating a 33-fold traffic growth ratio in 2020 compared with 2010.

It should be noted that the 2nd-order polynomial function estimates conservative traffic growth, while the 3rd and 4th-order polynomial functions provide more aggressive growth corresponding to approximately 40 to 170-fold and 80 to 240-fold growth ratios, respectively.

The spectrum requirements are distributed and calculated for Radio Access Technology Group 1 (RATG 1) (i.e. pre-IMT, IMT-2000 and its enhancements) and RATG 2 (i.e. IMT-Advanced) for the year 2020.

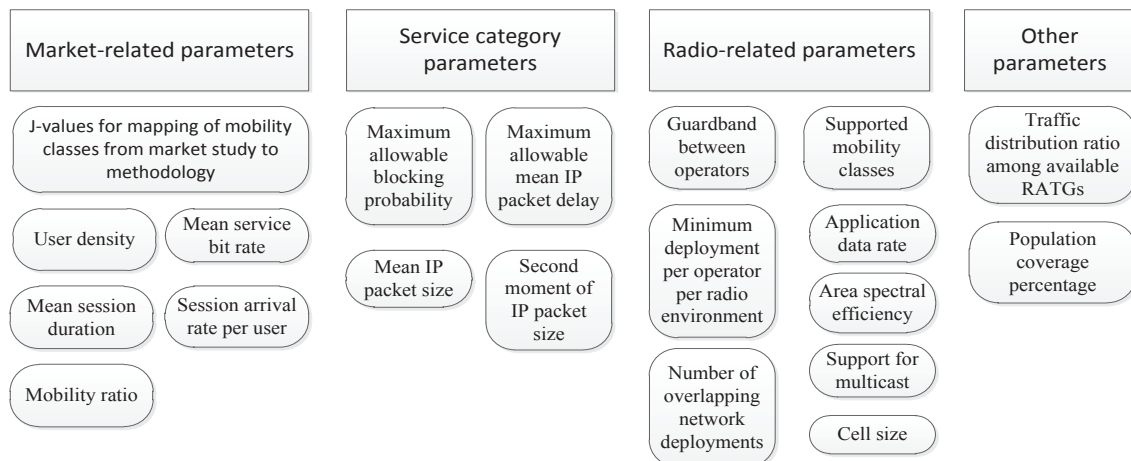


Figure 4: Input parameter overview for IMT spectrum demand estimation

The use of two market settings, lower and higher user density settings, allows for modelling of the differences in markets between different countries. The two settings will

result in two final spectrum requirements for IMT systems and the needs of the different countries could lie between these two extremes.

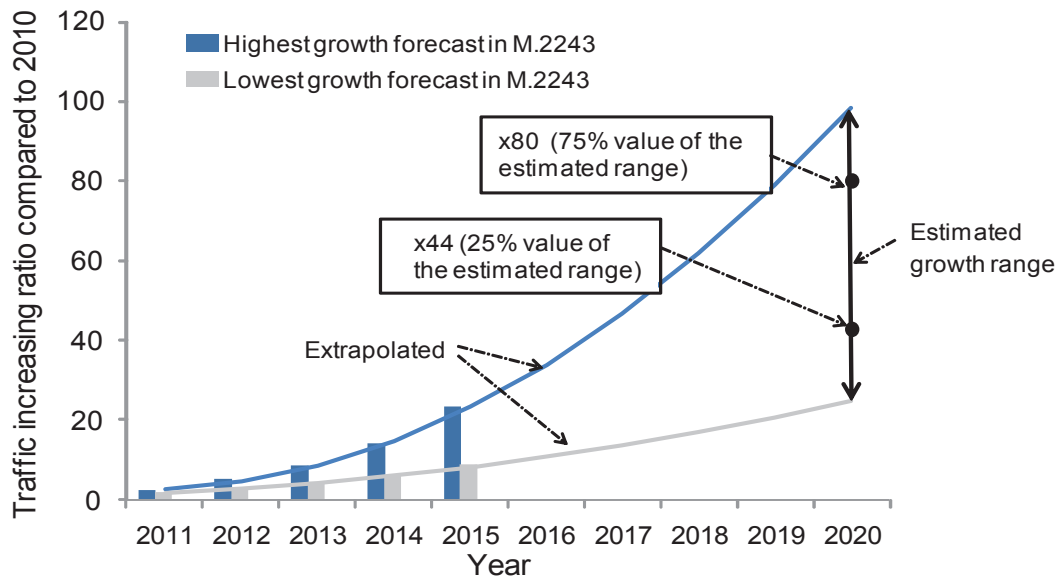


Figure 5: Mobile traffic forecasts toward 2020 by extrapolation (Source: ITU)

Table 5 depicts the Radio Parameters for RATG 1 (pre-IMT2000, IMT2000) whilst Table 6: Radio parameters for RATG 2 (IMT advanced)

In Table 7 the spectral efficiency parameters for RATG1 and RATG 2 (IMT-Advanced) are shown, indicating spectral densities, which generate the capabilities of the networks. Based on these (and further parameters) the overall spectrum demand is estimated and provided in Table 8.

The spectrum efficiency values are to be used only for spectrum requirement estimations given in 'Recommendation ITU-R M.1768-1 (04/13) 'Methodology for calculation of spectrum requirements for the terrestrial component of International Mobile Telecommunications'. These values are based on a full buffer traffic model in accordance with 'Report ITU-R M.2135-1 (2009) Guidelines for evaluation of radio interface technologies for IMT-Advanced'. In practice, such spectrum efficiency values are unlikely to be achieved due to the random nature of traffic, errors caused by radio channel conditions or packet losses. This means, if too high capacity assumptions are used, this will lead to lower spectrum demands. On the contrary, not all applications need 20 Mbps. Therefore, the results given in Table 8 should be used as a general indication of how much spectrum is needed, even if it might be in 2025 instead of 2020.

Parameters	Macro cell	Micro cell	Pico cell	Hot spot
Application data rate (Mbps)	20	40	40	40
Supported mobility classes	Stationary/ pedestrian, low, high	Stationary/ pedestrian, low	Stationary/ pedestrian	Stationary/ pedestrian
Guard band between operators (MHz)	0			
Minimum deployment per operator per radio environment (MHz)	20	20	20	20
Granularity of deployment per operator per radio environment (MHz)	20	20	20	20
Support for multicast	Yes			
Number of overlapping network deployment	1			

Table 5: Radio parameters for RATG 1 (pre-IMT2000, IMT2000):

Parameters	Macro cell	Micro cell	Pico cell	Hot spot
Application data rate (Mbps)	50	100	1 000	1 000
Supported mobility classes	Stationary/ pedestrian, low, high	Stationary/ pedestrian, low	Stationary/ pedestrian	Stationary/ pedestrian
Guard band between operators (MHz)	0			
Support for multicast	Yes			
Minimum deployment per operator per radio environment (MHz)	20	20	120	120
Granularity of deployment per operator per radio environment (MHz)	20	20	20	20
Number of overlapping network deployment	1			

Table 6: Radio parameters for RATG 2 (IMT advanced)

RATG1: Unicast area spectral efficiency (bit/s/Hz/cell)				
Tele density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	2	4	4	4
Suburban	2	4	4	4
Rural	2	4	4	4

RATG2: Unicast area spectral efficiency (bit/s/Hz/cell)				
Tele density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	4	5	5	7.3
Suburban	4	5	5	7.3
Rural	4	5	5	7.3
Dense urban	4	5	5	7.3

Table 7: Spectral efficiency parameters for RATG1 and RATG 2 (IMT advanced)

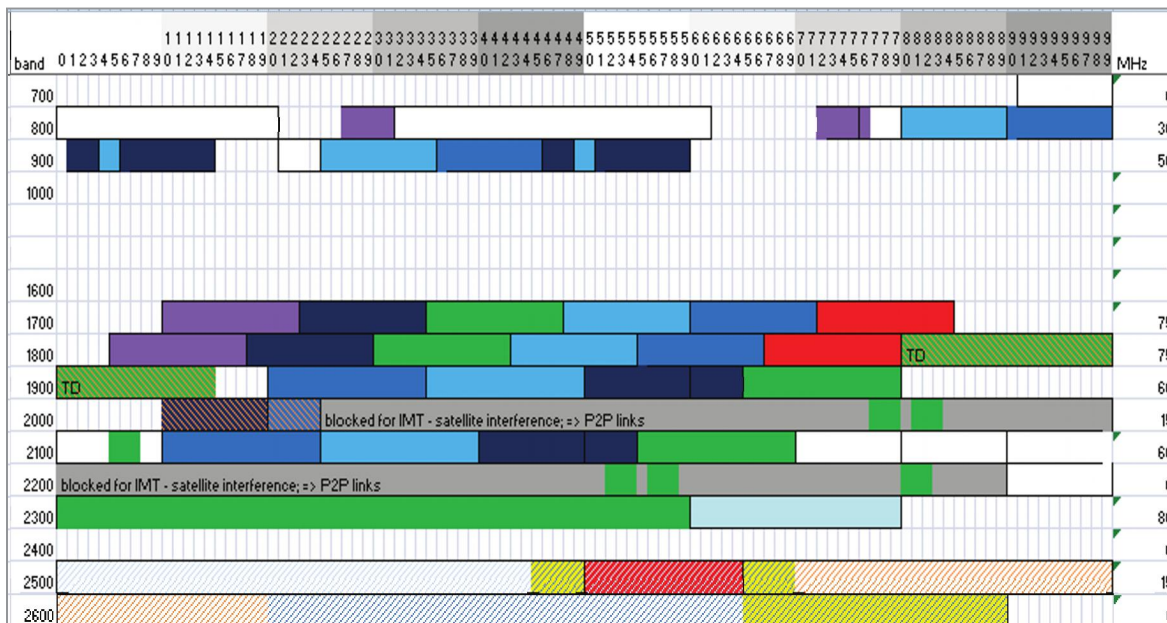
	Total spectrum requirements for RATG 1	Total spectrum requirements for RATG 2	Total spectrum requirements RATGs 1 and 2
Lower user density settings	440 MHz	900 MHz	1 340 MHz
Higher user density settings	540 MHz	1 420 MHz	1 960 MHz

**Table 8: Total spectrum requirements for both RATG 1 (pre-IMT2000, IMT2000) and RATG 2 (IMT advanced) in the year 2020**

In South Africa, 380 MHz are currently used for IMT (including UMTS and LTE) and 80 MHz for GSM. In 2020, more than 1011-1036 MHz could be used for IMT (incl. GSM) depending on the decisions on 700-800 MHz band usage.

This overview includes additional spectrum of 120 MHz in the 694-862 MHz band, 190 MHz in the 2500-2690 MHz band and 200 MHz in the 3400-3600 MHz band. The potential assignments that could be made in the short term within the years 2015-2020 provide for more than the current spectrum usage (510 MHz > 380 MHz) for a traffic ~5 times than today (Figure 5).

Further spectrum beyond 3600 MHz was not considered herein, but might be available for IMT (3600-4200 MHz) or Wi-Fi applications (e.g. within 5100-5900 MHz). As a result, potential gaps between the assumptions within Table 8 could be closed from 2020 onwards with this additional spectrum.



**Figure 6: Current South Africa IMT assignments summarised in Table 9**

IMT spectrum (incl GSM)																	
MHz	400	700	800	900	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	3400	3500	sum
2014	0	0	30	50	75	75	60	15	60	0	80	0	15	0	0	0	<b>460</b>
2020	15	87	69	50	75	75	60	15	60	0	100	15	100	90	100	100	<b>1011</b>

**Table 9: South Africa IMT spectrum assignments**

These figures should not be taken into account in the evaluation of special spectrum use or prioritisation of different bands. 10-15 MHz in 450-470 MHz band does not give sufficient capacity compared to the overall amount of spectrum, but it has enormous benefits in terms of coverage and therefore reduces the level of required capital investment compared to the (rural) rollout of 10-15 MHz in 2600 MHz or 3500 MHz bands. For the SA Connect targets, the 450-470 MHz spectrum may be essential in order to cover a greater population in rural and commercially, less attractive areas. Compared with the 450 MHz band, 55-85% more sites are needed in 700 MHz, and even more in higher bands. It is of no value to compare the deployment costs of a 3500 MHz network in the same rural areas with a 450 MHz network because this scenario is unrealistic. If, in rural areas, the demands increase steadily, (with higher smart phone penetration for example), operators could reuse the existing 450 MHz sites for 700-3500 MHz cells and add some hotspot sites. The coverage improvement reduces with larger separation of the coverage areas, consequently in the case of largely separated populations, each location may need its own base station independent from the band - such deployments would be quite expensive.

### 6.1.1 Forecast of overall M2M demand

Operators are investing in new digital services, such as the 'Internet of Things' (IoT) and M2M, in order to compensate for declining revenue from traditional services. M2M represents a relatively small opportunity in terms of revenue, but one that is growing significantly and which opens up a multitude of new applications and services. Operators have been particularly interested in servicing the demand for M2M solutions and this market is growing.

Connectivity is pivotal, but subject to intense competition. Connectivity underpins M2M and IoT services but it is subject to competition from a large number of players providing fixed and mobile connectivity as well as a growing number of short-range technologies. Operators have recognised this trend and some are positioning themselves in other key areas of the value chain in order to provide an end-to-end service to customers.

- Potential M2M solutions:
- Utilities - metering applications especially in the energy sector;
- Security - alarm and sensor applications;
- Government: surveillance, police and fire fighter response;
- Healthcare - monitoring applications;
- Automotive and transport - connected car applications, fleet tracking;
- Industrial - monitoring applications; and

- Retail - Point-of-Sale (PoS) terminals  
According to one research forecast report<sup>6</sup>, the future worldwide development of M2M application might look like the following:
- At the end of 2013, there were approximately 0.3 billion M2M device connections worldwide
- It is forecast that there will be an increase to 3.4 billion device connections by 2024, indicating a CAGR of 28% over the 10-year period;
- Utilities is both the biggest and the fastest-growing sector in terms of M2M connections; it will account for 59% of all M2M device connections by 2024
- The second fastest growing sector is the automotive and transport sector; and by 2024, overall M2M device connections from this sector are expected to be 26% of the overall device connections
- Security sector solutions are expected to make up 10% of overall M2M device connections by 2024
- The remaining 5% of M2M device connections in 2024 will be accounted for by the healthcare, industrial, retail, financial services and public sectors

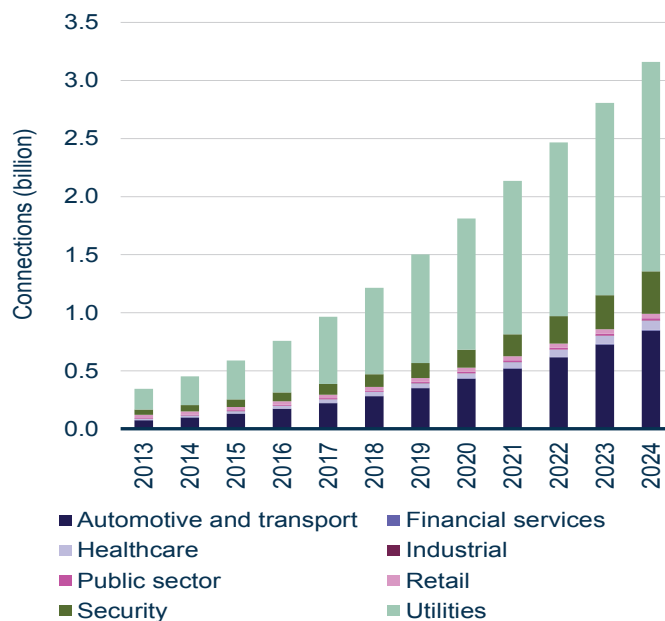


Figure 7: M2M device connections by sector, worldwide, 2013–2024

(Source: Analysis Mason, 2014)

<sup>6</sup> Analysys Mason Research Forecast Report – ‘M2M device connections and revenue: worldwide forecast 2014–2024’ July 2014 – updated from the draft IMT Roadmap based on feedback



## 6.2 IMT Demand for South Africa

The demand for high-speed Internet capabilities, such as those offered by IMT, is growing in South Africa. The targets for download speed outlined in the National Broadband Policy are also a factor that will drive up the demand for IMT.

One area of growth is in the uptake of devices with LTE capabilities. According to the Ovum Small and Medium Enterprise (SME) Insights Survey conducted early in 2013, 51% of South African SMEs provide smart phones to their employees, while 62% supply tablet devices. Regular or feature phones accounted for 31% of responses and dongles or laptops with integrated cellular connectivity accounting for 23%.

Evidently, South African SMEs see the whole range of mobile communications services as important to their businesses but place a particular value on high-end devices.

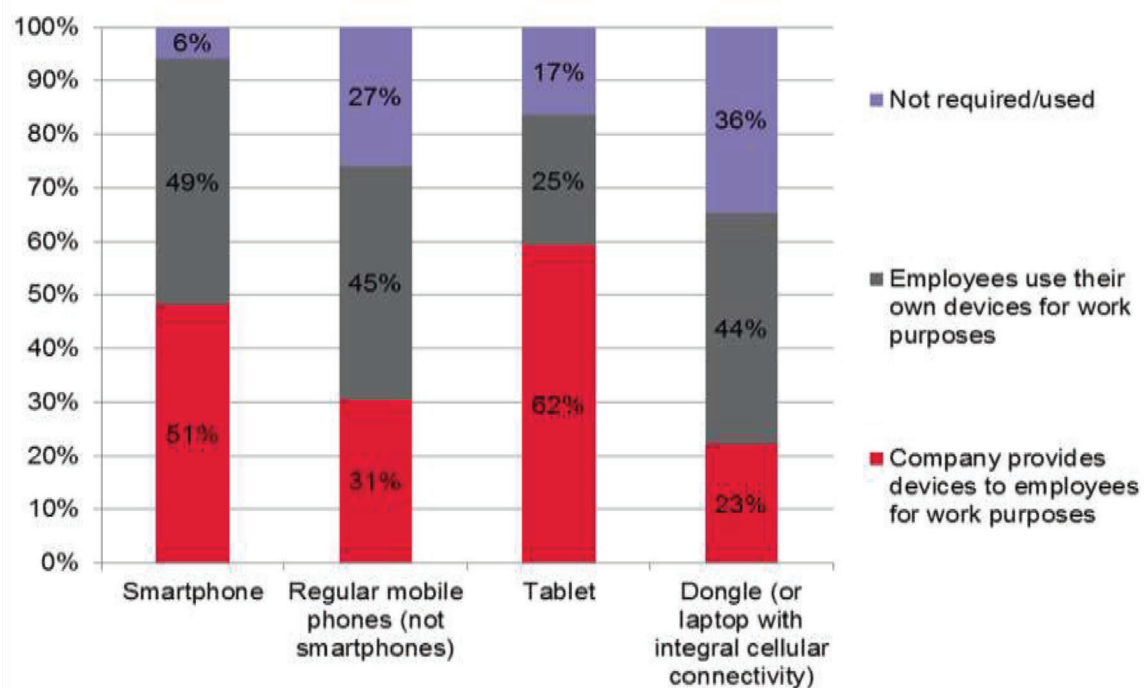


Figure 8: South Africans favour tablets and smart phones

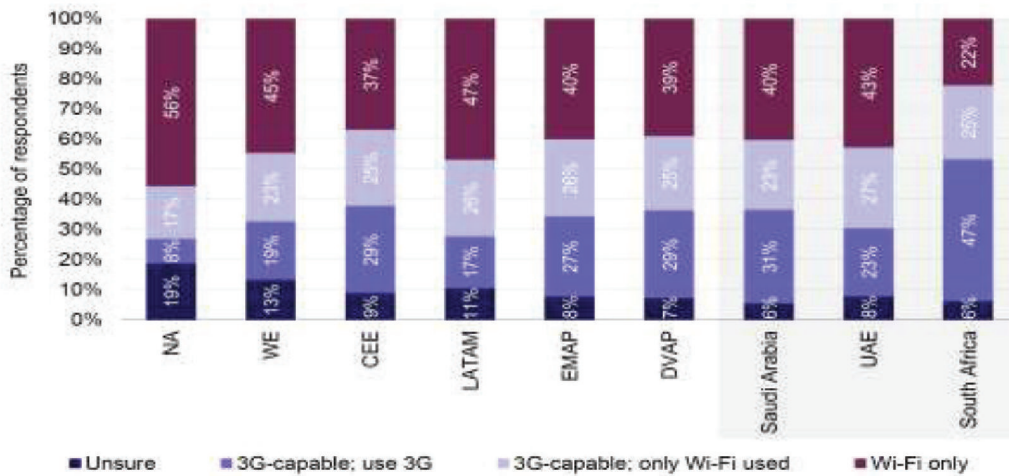
(Source: Ovum)

In a comment article by Analysys Mason (Tablet Survey highlights South Africa's demand for Tablet Cellular connectivity and the impact of 18-24 year old users), South Africa has been proven to be a particularly 'high-mobility' market for tablet users.

According to the survey, only 34% of tablet users in this market use tablets exclusively at home, compared with the 66% who use them partially or exclusively out of the home, while on the move.

Results from the survey also show that the number of tablet users connecting to the cellular network directly from their tablets is already relatively high in South Africa, compared with other countries they surveyed worldwide. Some 47% of South African respondents had a 3G/4G-connectable tablet and used it on the cellular network.





1 Question: "Is your tablet 3G/4G compatible, or is it only able to support Wi-Fi connectivity?" Key: CEE = Central and Eastern Europe; DVAP = Developed Asia-Pacific; EMAP = Emerging Asia-Pacific; LATAM = Latin America; NA = North America; WE = Western Europe.

**Figure 9: Tablet respondents by type of connectivity enabled on their device, by country in MEA and by region**

(Source: Analysys Mason)

A South African telecoms market report by Analysys Mason indicates over 11 million smart phone connections and over 4 million mobile broadband subscribers by the 3<sup>rd</sup> quarter of 2013. This growth in subscribers coincides with a commercial launch of LTE by mobile network operators between late 2012 and early 2013, which again shows the demand for LTE and IMT services is growing.

		2009	2010	2011	2012	September 2013
<b>Mobile</b>	<b>Mobile subscribers (active SIMs)</b>	46 861 000	49 475 000	59 015 000	66 610 000	69 272 000
	Mobile penetration (percentage of population)	91.6 %	95.7 %	113.1 %	126.7 %	131.0 %
	Prepaid subscribers as a percentage of mobile subscribers	83.2 %	81.5 %	82.1 %	82.7 %	82.2 %
	3G subscribers as a percentage of mobile subscribers	10.7 %	14.8 %	20.0 %	25.6 %	28.9 %
	Mobile broadband subscribers (mid and large screen)	1 272 000	2 053 000	2 743 000	3 589 000	4 170 000

Number of smartphone connections	2 049 000	3 345 000	5 969 000	9 138 000	11 184 000
<b>Mobile ARPU (ZAR per month)</b>	146.43	150.61	140.98	126.58	110.46
USD per month	17.66	20.67	19.61	15.52	13.54
<b>Mobile MoU (minutes per month)</b>	64	71	77	74	73

**Table 10: Telecoms KPIs, South Africa, 2009-3Q 2013**

*(Source: Analysys Mason, Economist Intelligence Unit for nominal GDP per capita, 2014)*

ICASA has released its latest State of the ICT Sector in South Africa report, detailing the trends in the country's mobile data sector.

ICASA is responsible for the collection of statistics to monitor and report on the progress of ICT in the country, and monitors aspects such as smartphone adoption and mobile data usage.

"The questionnaires used to collect the relevant information were customised for the three sectors that ICASA regulates, namely telecommunications, broadcasting and postal," said ICASA.

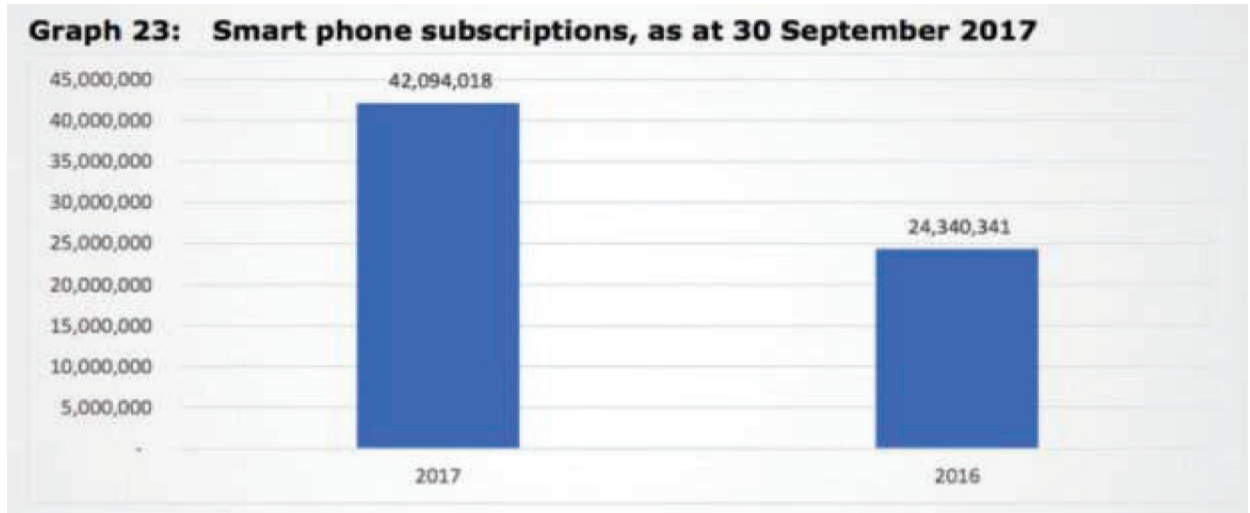
Responses were received from 84 Electronic Communication Services and Electronic Communication Network Services licensees, which was "a significant increase of 82.61%" compared to the previous reporting period.

The report showed that mobile data usage and smartphone adoption are on the rise in South Africa, with a big jump in both categories from 2016 to 2017 – measured at 30 September 2017.

### **Smartphone subscriptions**

ICASA defined a smartphone as a mobile phone with advanced features, Wi-Fi connectivity, web browsing capabilities, a high-resolution touchscreen display, and the ability to use apps.

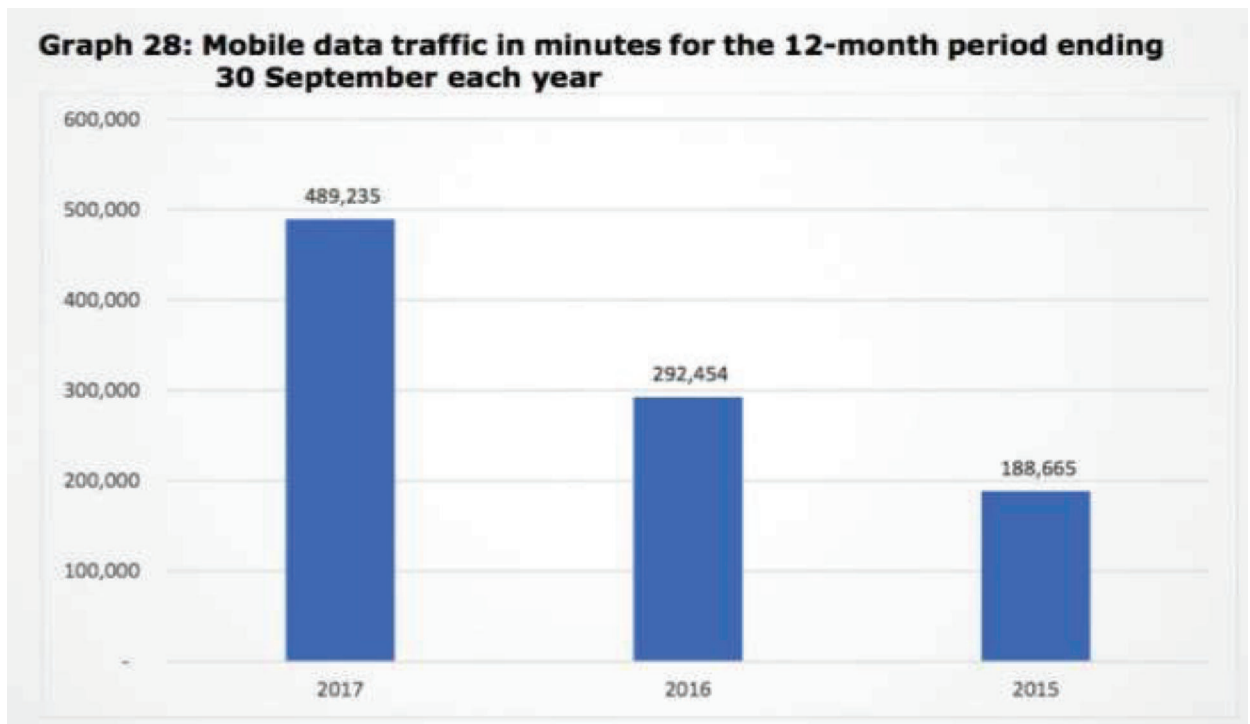
Its data shows that smartphone subscriptions increased by 72.9% from 2016 to 2017, as detailed in the graph below.



### Mobile data traffic

Mobile data traffic also experienced a sharp increase, increasing by 67.3% from 2016 to 2017.

Over the past three years, mobile data traffic increased by 61.0% in South Africa, said ICASA.

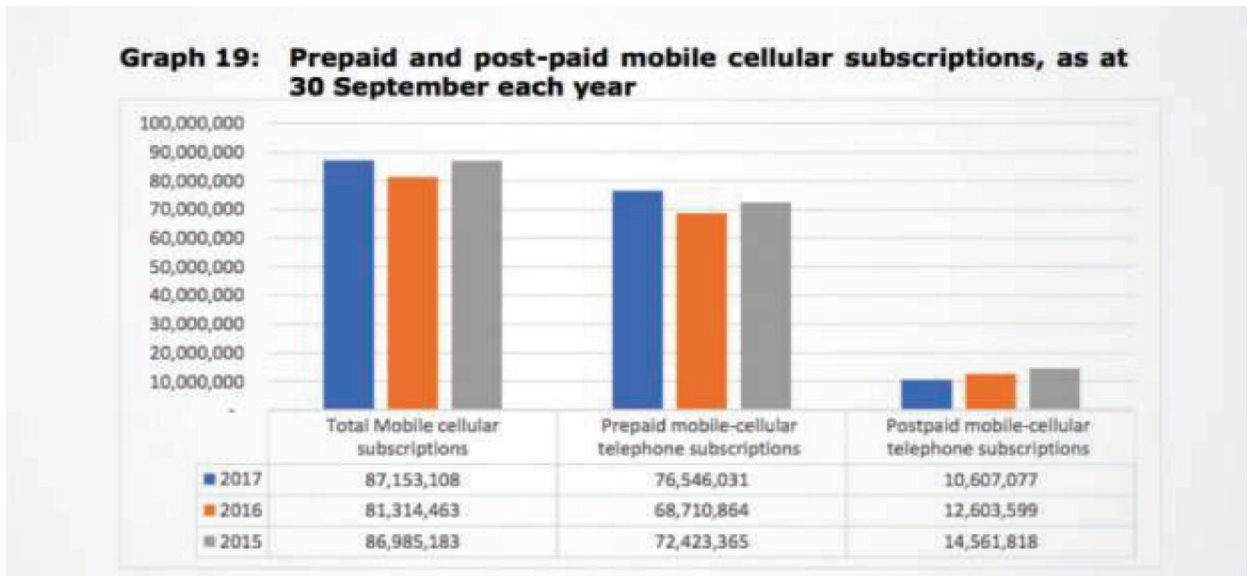


### Cellular subscriptions

Cellular subscriptions in the country were relatively flat overall, reaching just over 87 million as at 30 September 2017.

What is interesting to note is the steady decline in local post-paid mobile users over the past three years.

ICASA added that certain mobile networks count a user as someone who has not deactivated their SIM in a 90-day period – hence the subscriber number being higher than the country’s population.



## 7 IMT Roadmap

The objective of this section is to present the Authority's proposals with regard to radio spectrum plans for broadband services in specific bands.

First, we describe the importance of aligning with IMT in South Africa. Next, we identify the IMT bands targeted in this radio spectrum roadmap. Lastly, we lay out the proposed roadmap for each of the IMT bands considered.

The proposed roadmap for each band is structured to provide useful background information, the options under consideration and, in some cases, the Authority's proposal for the band. For the 450-470 MHz and 876-960 MHz bands, the Authority provides additional feasibility studies for the migrations in the band.

### 7.1 The IMT framework

IMT is the established framework for international alignment of specifications related to mobile technologies. This section presents the IMT specifications used as a basis for the spectrum roadmap and presents the bands considered currently in South Africa.

#### 7.1.1 What is IMT?

In this section, we provide a formal definition of IMT and focus on the most relevant aspect for the roadmap: frequency bands.

According to the ITU, IMT systems are *"mobile systems that provide access to a wide range of telecommunication services including advanced mobile services, supported by mobile and fixed networks, which are increasingly packet-based."*

Further, the ITU states that the key features of "IMT-compliant" technologies include:

- a 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; and
- enhanced peak data rates to support advanced services and applications.

For the purposes of this report, it is assumed that stakeholders are aware that IMT specifications provide guidance on:

- the specifications that compliant technologies must meet in terms of data rate and mobility; and

- the spectrum bands targeted by the IMT specifications for the deployment of IMT-compatible technologies

The latest IMT specifications are IMT-2000 and IMT-Advanced. IMT-2000 defined the capabilities for so-called 'Third Generation' (3G) mobile communications technology. IMT-Advanced promises the next generation mobile network with high data rates, seamless connectivity and mobile communication within heterogeneous networks.

### **7.1.2 The rationale for alignment with IMT in South Africa**

The primary objective of IMT specifications is to provide a basis for harmonisation worldwide and reduce ecosystem fragmentation in several ways:

- In terms of the technological capability, IMT specifications provide a basis for standards development for systems, such as IEEE and 3GPP, to ensure that the technologies meet those requirements. In South Africa, the IMT specifications provide the Authority and the industry with benchmarks regarding the capabilities to be expected from upcoming technologies
- In terms of radio spectrum, IMT specifications provide a predictable basis on which to build a roadmap for the introduction of next-generation technologies. IMT specifications support the Authority in making radio spectrum available in a timely manner for the industry in South Africa.

South Africa stands to gain from adhering to a globally harmonised framework in the following areas:

- Economies of scale for standardised products (terminals and network equipment);
- Interoperability in the form of easy roaming and smooth, cross-border co-ordination;
- Predictability and stability for the mobile communications industry.

It is important to note that the adoption of IMT need not result unconditionally in the displacement of other existing uses of spectrum. In certain cases, radio spectrum sharing with other technologies is feasible. However, it is in South Africa's interest to adopt IMT specifications fully, wherever feasible, and to manage the IMT radio spectrum bands. In any case, the Authority performs feasibility studies in cases where the benefits of allocating spectrum exclusively to IMT services are not straightforward.

South Africa stands to gain from adhering to a globally harmonised framework for radio spectrum usage as is the case with the IMT framework. Spectrum harmonisation ensures:

- economies of scale for standardised products;
- smoother cross-border co-ordination; and
- easy roaming within the region where harmonisation is implemented.

In South Africa, it is important to align with IMT specifications in order to take advantage of worldwide standards, technologies and services.

In general, it is desirable to assign long-term IMT bands, so operators, network solution vendors and terminal manufactures have sufficient time to exploit synergies in harmonised

designs. Globally harmonised frequency arrangements in the bands identified for IMT will reduce the overall cost of IMT networks and terminals by providing economies of scale, and facilitating deployment and cross-border co-ordination, roaming, etc.

### 7.1.3 IMT bands previously identified

The following bands have been identified before by the ITU for use by IMT-compatible standards in the Radio Regulations (RR) "Edition of 2012".<sup>7</sup>

In the rest of this document, IMT designations of spectrum bands are used interchangeably with the actual frequency ranges. For instance, IMT450 refers to the frequency band extending from 450 MHz to 470 MHz.

IMT bands		Paired configuration (FDD)	Unpaired configuration (TDD)
IMT Designation	IMT Range		
IMT450	450-470 MHz	2×5 MHz	15 MHz
IMT700	694-790 (or 806) MHz	2×45 MHz or 2×30 MHz + 2×3 MHz	
IMT750	733-758 MHz		22 MHz (option 3 with 2×6 MHz guard bands) 25 MHz (option 2 with 2×5 MHz guard bands)
IMT800	791-862 MHz	2×30 MHz (reverse uplink-downlink)	
IMT850	825-830// 870-875 MHz <sup>8</sup>	2×5 MHz	
IMT900	880-960 MHz	2×35 MHz	
GSM900-R	876-880// 921-925 MHz	2×4 MHz GSM-R	
IMT1800	1710-1880 MHz	2×75 MHz	
IMT2100	1920-2170 MHz	2×60 MHz	
IMT2300	2300-2400 MHz		100 MHz
IMT2600	2500-2690 MHz	2×70 MHz	50 MHz including 2×5 MHz guard bands
IMT3500	3400-3600 MHz		200 MHz <sup>9</sup>
<b>All IMT</b>		<b>2×355 MHz</b>	<b>370 MHz</b>

**Table 11: IMT roadmap: (summary)**

These bands will be discussed in more detail in the following sections.

The figure below gives an overview of spectrum usage in South Africa in 2025:

\_\_\_\_\_

<sup>7</sup> <http://www.itu.int/pub/R-REG-RR-2012>.

<sup>8</sup> Adjusted to allow coexistence with GSM-R (with no guard band to SRD's)

<sup>9</sup> This may include maximum 20 MHz for a 'managed spectrum park'



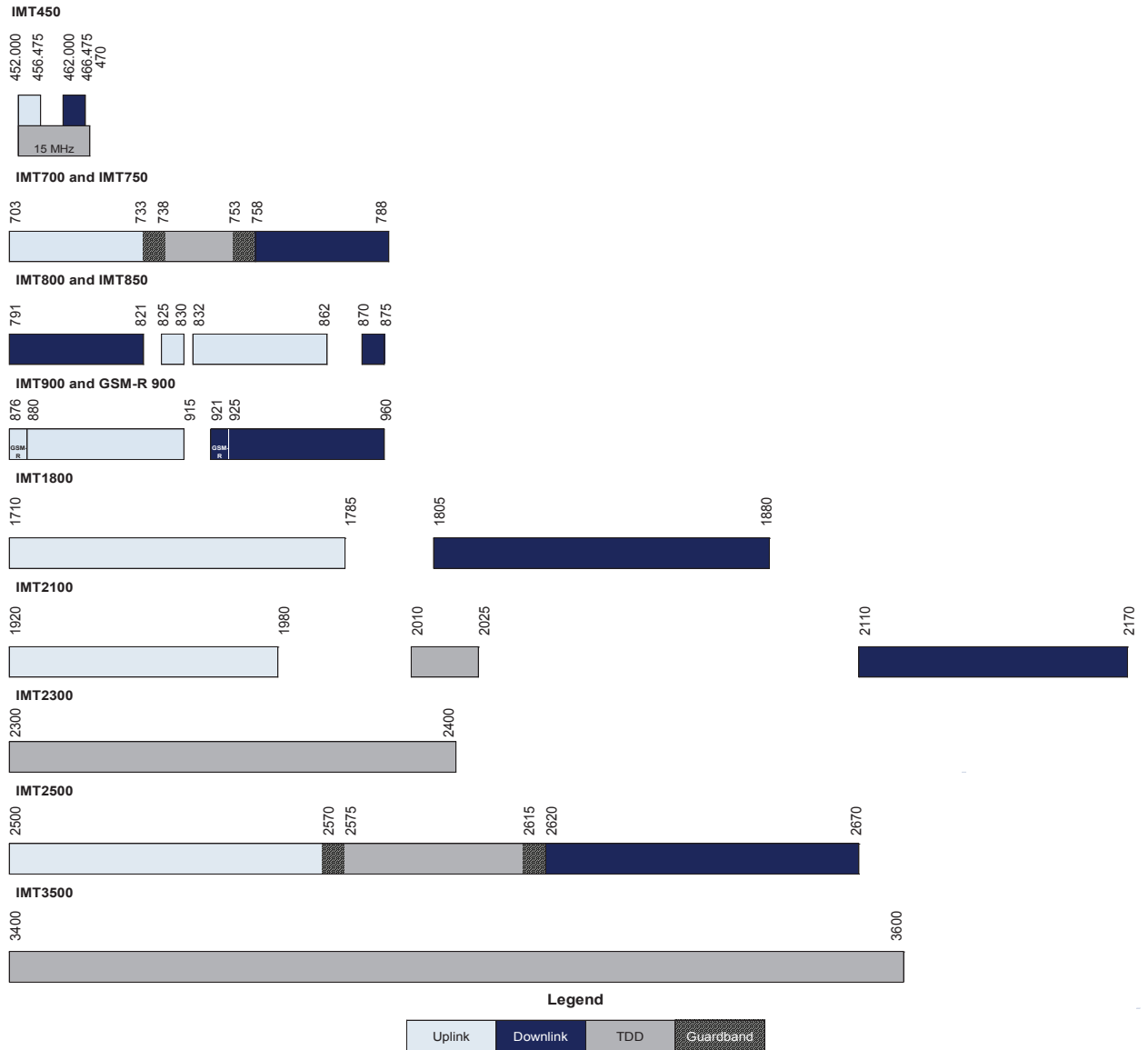


Figure 10: IMT spectrum overview within South Africa in 2025

## 7.2 Guard bands

In order to define the possibilities of any co-existing scenario of IMT with existing technologies and applications, the minimum required guard bands and potential other intelligent interference suppression options have to be investigated properly.

The following summary is based on results of the European Conference of Postal and Telecommunications Administrations (CEPT) Report 41; “Compatibility between LTE and WiMAX operating within the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands) and systems operating in adjacent bands”.

- Introducing LTE and WiMAX to the 900 and 1800 MHz bands should not cause any additional impact on adjacent services. In general, there is no need of an additional



guard band between LTE/WiMAX 900 and GSM-R whatever the channelisation or bandwidth considered for LTE/ WiMAX 900. ECC Report 096 concludes that a carrier separation of 2.8 MHz or more between the UMTS carrier and the nearest GSM-R carrier is sufficient. For LTE/ WiMAX 900, the frequency separation between the nearest GSM-R channel centre frequency and LTE/WiMAX channel edge should be at least 300 kHz.

- The LTE/WiMAX user equipment (UE) transmitting power is relatively limited. By considering that the minimum coupling loss (MCL) between the user equipment and E-GSM-R base station is relatively large compared with the MCL between LTE/WiMAX base station and GSM-R train-mounted mobile stations, and since the user equipment is moving, the interference from LTE/WiMAX user equipment to E-GSM-R mobile stations should not lead to harmful interference. The same holds for PMR/PAMR mobile stations.
- The worst interference case is that from E-GSM-R base station to LTE/WiMAX base station. The utilisation of interference mitigation techniques should be assessed in order to protect the LTE/WiMAX 900 base stations efficiently.
- The interference from Public Mobile Radio (PMR)/Public Access Mobile Radio (PAMR) (CDMA PAMR, Terrestrial Trunked Radio (TETRA)) base stations operating at frequencies above 915 MHz will cause receiver desensitisation of LTE/WiMAX 900 base stations operating below 915 MHz. In order to protect LTE/WiMAX900 base stations, the use of interference-mitigation techniques is necessary:
  - Reduced PMR/PAMR BS transmission power;
  - Spatial separation by co-ordination between operators;
  - External filters applied to the PMR/PAMR base stations; and
  - Sufficient guard band between the 900 MHz mobile allocation and the first PMR/PAMR channel in use. *ECC041 assumed >2 MHz separation between GSM-uplink and CDMA-downlink.*
- It is more likely that a combination of these interference-mitigation techniques should be used in order to ensure the compatibility of LTE/WiMAX 900 operating below 915 MHz and PMR/PAMR (CDMA PAMR, TETRA) operating above 915 MHz.
- LTE/WiMAX base stations to Digital Enhanced Cordless Communications (DECT) base stations / mobile stations: It can be concluded that the interference created by the LTE/WiMAX1800 system would be similar to the interference created by GSM1800. No guard band is therefore required between LTE/WiMAX 1800 and DECT allocations, provided that DECT is able to properly detect interference on the closest DECT carriers.
- The results in ITU-R M.2110 (Table 12 ) indicate that co-existence between CDMA450 base stations and the various fixed and mobile service base stations may be a challenge even with the use of significant filtering to provide the required attenuation. While the separation distance between the two systems is significantly reduced, if a filter at the CDMA450 base station receiver can provide at least 60-70 dB rejection of

the unwanted emissions, the value of the separation distance may be significant to permit co-existence in a few cases. Other possible mitigation measures are available that could be used to decrease the possibility of harmful interference even further, such as the use of guard bands and/or disabling of one or more CDMA450 carriers.

- The same holds for BS to MS interference suppression of 60-80 dB or guard band.

Fixed and mobile systems	CDMA450 base station	
	Separation distance	Separation distance/ filtering
FM	21.45 km	1 km / 60 dB
TETRA	25.6 km	1 km / 60 dB
NMT	49.14 km	1 km / 70 dB
Trunked land mobile systems – analogue FM	43.14 km	1 km / 70 dB
Trunked land mobile systems – digital/C4FM	38.6 km	1 km / 70 dB
Trunked land mobile systems – digital/ BPSK / QPSK/ 8-PSK/ 16-QAM	112 km	3 km / 70 dB

**Table 12: ITU-R M2110: CDMA separation distances (BS-BS case) in 450-470MHz**

- The results of broadcasting systems with CDMA450 (**Table 13**) indicate that broadcasting base stations and CDMA450 base / mobile stations can successfully operate in adjacent spectrum, if the unwanted and spurious emissions from the broadcasting base stations can be reduced. Reducing the unwanted emissions by 60 dB will enable successful sharing between the broadcasting base stations and the CDMA450 base/mobile stations.

Broadcasting system typical transmit power	CDMA450 base station		CDMA450 mobile station	
	Distance	Distance/filtering	Distance	Distance/filtering
2 kW ERP	43.7 km	< 1 km/ 60 dB	20.3 km	< 1 km/ 40 dB
15 kW ERP	59.8 km	1.2 km/ 60 dB	31 km	< 1 km/ 60 dB
1 MW ERP	92 km	3.9 km/ 60 dB	49.9 km	<1 km/ 60 dB

**Table 13: Results of study of interference of broadcasting systems with CDMA 450**

- As seen in Figure 11, in the US-700 MHz band, the guard bands between the narrowband voice system and the broadband LTE system are chosen at 1 MHz each. There was no detailed interference evaluation found so far, therefore, it may be a regulatory definition with special safety margin, which might be reduced with time/experience. Due to improved propagation effects in 450 MHz relative to 700 MHz, any guard band in 700 MHz would have to be larger in 450 MHz. So, 1 MHz guard band is also used in 450 MHz until actual studies may prove lower margins.

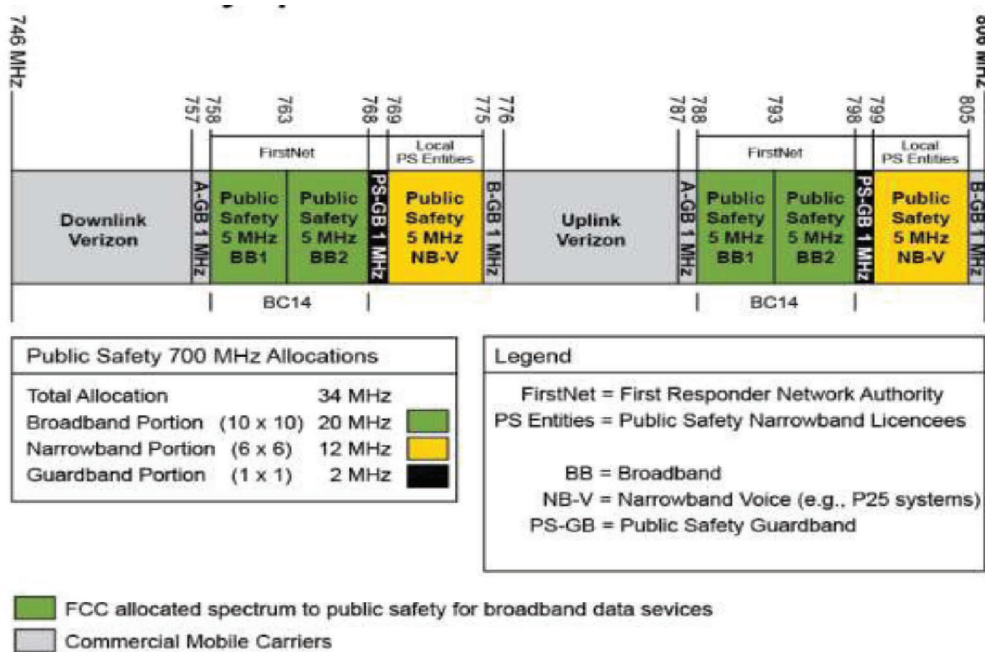


Figure 11: Public safety spectrum allocation in US-700MHz band

Based on the results above, general guard band values can be applied to other bands, which should be considered in the IMT roadmap channelling exercise:

- Guard band between GSM and LTE or UMTS: >300 kHz; and
- Guard band between TETRA, CDMA or other narrowband systems to LTE or UMTS: >1 MHz.

Conclusions

- The Authority’s decision is for Neotel’s assignment to be adjusted to 825-830 MHz paired with 870-875 MHz.
  - The Authority will take the necessary measures to ensure coexistence between CDMA850 and GSM-R, i.e. amend assignments as appropriate and ensure coordination.
- The long term solution is for Neotel to cease using this band for CDMA.
  - Consideration 2 and Consideration 3 indicate a long term solution when CDMA850 has ceased and an (LTE) IMT850 band is deployed. With migration from deployed GSM-R to LTE-R, consideration needs to be made of an intermediate step of 2x3 MHz LTE first to ensure dual illumination and 2x5 MHz LTE in the final step. Further coexistence with GSM-R with about 4 MHz guard band still has to be investigated, but is not expected herein.

*LTE R Considerations*

*In the long term, one future usage of the IMT850-band could be LTE-R with 2×5 MHz along the current GSM-R coverage and beyond. Equipment installed for GSM-R could be prolonged by transferring it to LTE-R (notably when unified SingleRAN equipment has been deployed). Potential coexistence scenarios with GSM-R could be developed and investigated, e.g. 2×1 MHz GSM-R might remain for operational critical voice based services, while the broadband services to the trains would be handled via LTE850.*

*IMT850 for LTE-R would be more favourable than the GSM-R band because of the existing ecosystem for IMT850, while LTE within current GSM-R bands would face the problem that there is less than 2×5 MHz bandwidth and a probable lack of terminals. IMT850 could be implemented in most commercially available terminals which would be an advantage for IMT850 relative to IMT450 until the availability of IMT450-terminals builds up.*

*IMT450 could also be used for LTE-broadband services along the lines to serve customer demands via Wi-Fi-connectivity within the trains. The existing antennas might be reused as IMT450-terminal-antennas.*

*This option could be of relevance to the railway operators.*

### 7.3 1700-2290 MHz band

The key proposals in this band include an extension of the IMT-2100 band, the migration of fixed links into the band and the introduction of fixed broadband where feasible.

First, the various positions of the regulatory or standards bodies such as the ITU, CRASA and the Authority are presented. Next, the action items of the FMP initiated by the Authority are restated. Finally, the Authority presents its proposals for various sub-bands in the 1700-2290 MHz band.

#### 7.3.1 ITU Position on 1700-2290 MHz

According to ITU Recommendation ITU-R M.1036-4 (03/2012), the recommended frequency arrangements for implementation of IMT in the band 1710-2200 MHz are summarised in Table 14.

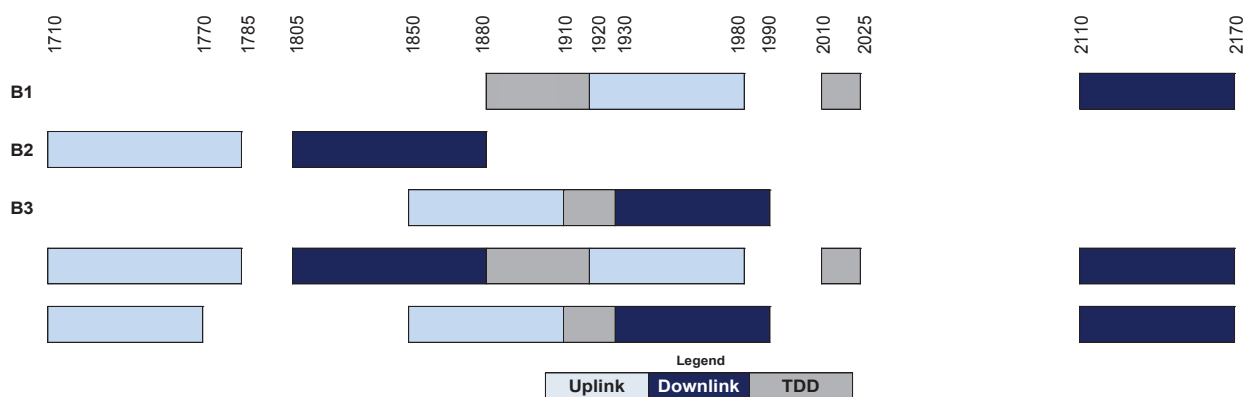


Figure 12: Frequency arrangements in the 1710-2200 MHz band

Frequency arrangements	Paired arrangements				Unpaired 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	1 850-1 910	20	1 930-1 990	80	1 910-1 930
B4 harmonised 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 (harmonised with B3 and parts of B1 and B2)	1 850-1 910 1 710-1 770	20 340	1 930-1 990 2 110-2 170	80 400	1 910-1 930

Table 14: Frequency arrangements in the band 1710-2200 MHz

*NOTE 1 – In the band 1710-2025 MHz and 2110-2200 MHz, three frequency arrangements (B1, B2 and B3) are already deployed by public mobile cellular systems including IMT. Based on these three arrangements, different combinations of arrangements are recommended as described in B4 and B5. The B1 arrangement and the B2 arrangement are fully complementary, whereas the B3 arrangement partly overlaps with the B1 and B2 arrangements.*

*For administrations having implemented the B1 arrangement, the B4 option enables optimisation of the use of spectrum for paired IMT operation.*

*For administrations having implemented the B3 arrangement, the B1 option can be combined with the B2 arrangement. B5 is therefore recommended to optimise the use of the spectrum: B5 enables the use of spectrum to be maximised for IMT in administrations where B3 is implemented and where the band 1770-1850 MHz is not available in the initial phase of deployment of IMT in this frequency band.*

*NOTE 2 – TDD may be introduced in unpaired bands and also under certain conditions in the uplink bands of paired frequency arrangements and/or in the centre gap between paired bands.*

*NOTE 3 – If selectable/variable duplex technology is implemented within terminals as the most efficient way to manage different frequency arrangements, the fact that neighbouring administrations could select B5 will have no impact on the complexity of the terminal. Further studies are necessary.*

### 7.3.2 SADC Position on 1700-2290 MHz

The SADC Frequency Allocation Plan (Table 15) proposes that the 1700-2290 MHz be allocated to Fixed Links (single frequency), IMT, IMT (Terrestrial), IMT (Satellite), FWA and BFWA.

The 1700-2290 MHz band is currently used for a fixed, mobile, mobile-satellite, meteorological-satellite and space operation systems in various SADC countries.

The SADC FAP recognises that frequency channelisation of several key frequency bands must be developed and preferably harmonised throughout the SADC region. The frequency bands used for IMT, Broadband Fixed Wireless Access (BFWA), PtP microwave systems, etc. will be considered. Channelling plans will be added to the SADC band plan in future.

ITU Region 1 allocations and footnotes	SADC common allocation/s and relevant ITU footnotes	SADC proposed common sub-allocations / utilisation	Additional information
<b>1 700-1 710 MHz</b> FIXED METEOROLOGICAL– SATELLITE (space-to-Earth) MOBILE except	<b>1 700-1 710 MHz</b> FIXED METEOROLOGICAL– SATELLITE (space-to-Earth) MOBILE except	Fixed links (single frequency)	

aeronautical mobile 5.289 5.341	aeronautical mobile 5.289 5.341		
<b>1 710-1 930 MHz</b> FIXED MOBILE 5.384A 5.388A 5.388B 5.149 5.341 5.385 5.386 5.387 5.388	<b>1710 – 1930 MHz</b> FIXED MOBILE 5.384A 5.388A 5.388B 5.149 5.341 5.385 5.388	1 710-1 785 MHz IMT	IMT
		1785-1805 MHz BFWA	
		1 805-1 880 MHz IMT	Paired with 1710-1785 MHz.
		1 880-1 900 MHz FWA Cordless telephone	
		1 900-1 920 MHz FWA IMT (terrestrial)	
<b>1930 – 1979 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>1930 – 1979 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	1920-1980 MHz IMT (terrestrial)	Paired with 2170 – 2200MHz The development of satellites for IMT services to be monitored
<b>1970 – 1980 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>1970 – 1980 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388		
<b>2 010-2 025 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>2 010-2 025 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	IMT terrestrial (2010 – 2025 MHz )	TDD
<b>2110 – 2120 MHz</b> FIXED MOBILE 5.388A5.388B SPACE RESEARCH (deep space) (Earth-to- space) 5.388	<b>2110 – 2120 MHz</b> MOBILE 5.388A5.388B SPACE RESEARCH (deep space) (Earth-to- space) 5.388	IMT (terrestrial) (2110- 2170 MHz)	Paired with 1920-1980 MHz
<b>2120 – 2160 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>2120 – 2160 MHz</b> MOBILE 5.388A 5.388B 5.388		
<b>2160 – 2170 MHz</b> FIXED MOBILE 5.388A 5.388B 5.388	<b>2160 – 2170 MHz</b> MOBILE 5.388A 5.388B 5.388		
<b>2 170-2 200 MHz</b> FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A	<b>2 170-2 200 MHz</b> MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A 5.388 5.389A 5.389F	IMT (satellite) (2170- 2200 MHz)	Paired with 1980-2010 MHz The development of satellites for IMT services to be monitored.



5.388 5.389A 5.389F			
<b>2 200-2 290 MHz</b> SPACE OPERATION (space-to-Earth) (space-to-space) EARTH EXPLORATION – SATELLITE (space-to-Earth) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (space-to-Earth) (space-to-space) 5.392	<b>2 200-2 290 MHz</b> SPACE OPERATION (space-to-Earth) (space-to-space) EARTH EXPLORATION – SATELLITE (space-to-Earth) (space-to-space) FIXED SPACE RESEARCH (space-to-Earth) (space-to-space) 5.392	Fixed links (2025-2110 MHz paired with 2200-2285 MHz)  BFWA (2 285-2 300 MHz)	Radio Frequency channel arrangement according to ITU-RF. 1098.

Table 15: SADC Frequency Allocation Plan 1700-2290 MHz

*Footnotes:*

5.384 *Additional allocation: in India, Indonesia and Japan, the band 1700-1710 MHz is also allocated to the space research service (space to Earth) on a primary basis. (WRC-97).*

5.384A *The bands, or portions of the bands, 1710-1885 MHz, 2300-2400 MHz and 2500-2690 MHz, are identified for use by administrations wishing to implement International Mobile Telecommunications (IMT) in accordance with Resolution 223 (Rev.WRC-07). This identification does not preclude the use of these bands by any application of the services to which they are allocated and does not establish priority in the Radio Regulations. (WRC-07)*

5.385 *Additional allocation: the band 1718.8-1722.2 MHz is also allocated to the radio astronomy service on a secondary basis for spectral line observations. (WRC-2000)*

5.386 *Additional allocation: the band 1750-1850 MHz is also allocated to the space operation (Earth-to-space) and space research (Earth-to-space) services in Region 2, in Australia, Guam, India, Indonesia and Japan on a primary basis, subject to agreement obtained under No.9.21, having particular regard to troposcatter systems. (WRC-03)*

5.387 *Additional allocation: in Belarus, Georgia, Kazakhstan, Kyrgyzstan, Romania, Tajikistan and Turkmenistan, the band 1770-1790 MHz is also allocated to the meteorological-satellite service on a primary basis, subject to agreement obtained under No.9.21. (WRC-12)*

5.388A *In Regions 1 and 3, the bands 1885-1980 MHz, 2010-2025 MHz and 2110-2170 MHz and in Region 2, the bands 1885-1980 MHz and 2110-2160 MHz may be used by high altitude platform stations as base stations to provide International Mobile Telecommunications (IMT), in accordance with Resolution 221 (Rev.WRC-07). Their use by IMT applications using high altitude platform stations as base stations does not*



*preclude the use of these bands by any station in the services to which they are allocated and does not establish priority in the Radio Regulations.(WRC-12)*

*5.388B In Algeria, Saudi Arabia, Bahrain, Benin, Burkina Faso, Cameroon, Comoros, Côte d'Ivoire, China, Cuba, Djibouti, Egypt, United Arab Emirates, Eritrea, Ethiopia, Gabon, Ghana, India, Iran (Islamic Republic of), Israel, Jordan, Kenya, Kuwait, Libya, Mali, Morocco, Mauritania, Nigeria, Oman, Uganda, Pakistan, Qatar, the Syrian Arab Republic, Senegal, Singapore, Sudan, South Sudan, Tanzania, Chad, Togo, Tunisia, Yemen, Zambia and Zimbabwe, for the purpose of protecting fixed and mobile services, including IMT mobile stations, in their territories from co-channel interference, a high altitude platform station (HAPS) operating as an IMT base station in neighbouring countries, in the bands referred to in No. 5.388A, shall not exceed a co-channel power flux-density of  $-127 \text{ dB(W/(m}^2 \cdot \text{MHz))}$  at the Earth's surface outside a country's borders unless explicit agreement of the affected administration is provided at the time of the notification of HAPS.(WRC-12)*

*5.389A The use of the bands 1980-2010 MHz and 2170-2200 MHz by the mobile-satellite service is subject to coordination under No. 9.11A and to the provisions of Resolution 716 (Rev.WRC-2000)<sup>10</sup>.(WRC-07)*

*5.389B The use of the band 1980-1990 MHz by the mobile-satellite service shall not cause harmful interference to or constrain the development of the fixed and mobile services in Argentina, Brazil, Canada, Chile, Ecuador, the United States, Honduras, Jamaica, Mexico, Peru, Suriname, Trinidad and Tobago, Uruguay and Venezuela.*

*5.389C The use of the bands 2010-2025 MHz and 2160-2170 MHz in Region 2 by the mobile-satellite service is subject to co-ordination under No.9.11A and to the provisions of Resolution 716 (Rev.WRC-2000)<sup>11</sup>.(WRC-07)*

*5.389E The use of the bands 2010-2025 MHz and 2160-2170 MHz by the mobile-satellite service in Region 2 shall not cause harmful interference to or constrain the development of the fixed and mobile services in Regions 1 and 3.*

*5.389F In Algeria, Benin, Cape Verde, Egypt, Iran (Islamic Republic of), Mali, Syrian Arab Republic and Tunisia, the use of the bands 1 980-2 010 MHz and 2 170-2 200 MHz by the mobile-satellite service shall neither cause harmful interference to the fixed and mobile services, nor hamper the development of those services prior to 1 January 2005, nor shall the former service request protection from the latter services. (WRC-2000)*

*5.391 In making assignments to the mobile service in the bands 2025-2110 MHz and 2200-2290 MHz, administrations shall not introduce high-density mobile systems, as described in Recommendation ITU-R SA.1154, and shall take that*

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<sup>10</sup> Note by the Secretariat: This Resolution was revised by WRC-12.

<sup>11</sup> *Ibid.*

*Recommendation into account for the introduction of any other type of mobile system. (WRC-97)*

5.392 *Administrations are urged to take all practicable measures to ensure that space-to-space transmissions between two or more non-geostationary satellites, in the space research, space operations and Earth exploration-satellite services in the bands 2025-2110 MHz and 2200-2290 MHz, shall not impose any constraints on Earth-to-space, space-to-Earth and other space-to-space transmissions of those services and in those bands between geostationary and non-geostationary satellites.*

### 7.3.3 Radio Frequency Migration Plan for 1700-2290 MHz

With the 1700-2290 MHz band, the objectives of the Radio Frequency Migration Plan are to:

- Retain existing allocations for fixed links and migrate in fixed links from other bands; and
- If co-existence between broadband wireless access and point-to-point services is not possible, then BFWA could be implemented in areas where PtP links are absent.

The table below is the summary of the Authority's Frequency Migration Plan as it relates to the 2025 – 2110 paired with 2200 – 2285 MHz.

Frequency Band (MHz)	Allocation in NRFP 2013 (Applications)	Proposed Utilisation/ Applications	Notes on migration/ usage
2025 – 2110 paired with 2200 – 2285	FIXED (Fixed links)	Fixed Links (DF) BFWA (New ICASA proposal)	Develop RFSAP with consideration to Utilisation of fixed links. Migration of fixed links (DF) from other bands Potential to allocate for BFWA – but only where there is no interference problem with PTP links

**Table 16: SA Frequency Migration Plan 2015-2285 MHz**

CRASA's preferred channel arrangement for the 2 GHz band (2025-2110 MHz paired with 2200-2285 MHz) is the same as the one in Annexure 1 to ITU-R Recommendation F.1098. The 2 GHz band has technical and economic advantages for low capacity digital systems including, for example, provisioning of fixed links operating over long distances. The RF channel arrangement in Annexure 1 of Recommendation ITU-R F.1098 provides for 6 return channels of 14 MHz each. These channels can be further sub-divided into channels of 7 MHz, 3.5 MHz or 1.75 MHz, depending on the system capacity requirements. The centre frequencies for RF channels in the 2 GHz band based on channels of 14 MHz are indicated in the table below.

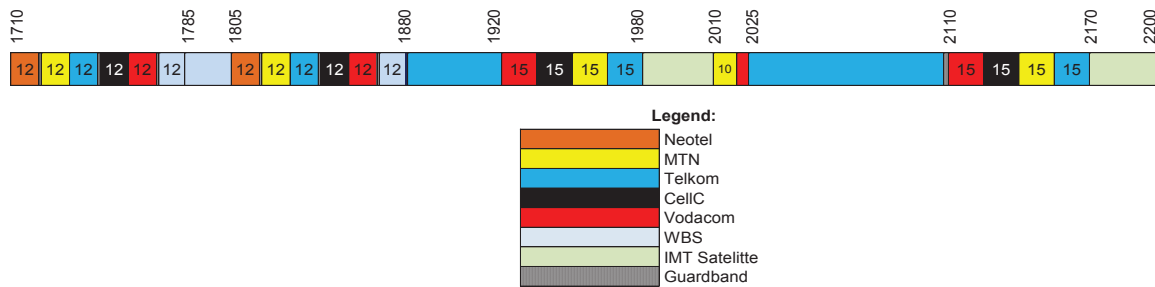
The proposed RF channel centre frequencies for the 2 GHz band (using 14 MHz channels) are:

<b>Channel no.</b>	<b>Centre frequency</b>	<b>Channel no.</b>	<b>Centre frequency</b>
<b>1</b>	2032.5 MHz	<b>1'</b>	2207.5 MHz
<b>2</b>	2046.5 MHz	<b>2'</b>	2221.5 MHz
<b>3</b>	2060.5 MHz	<b>3'</b>	2235.5 MHz
<b>4</b>	2074.5 MHz	<b>4'</b>	2249.5 MHz
<b>5</b>	2088.5 MHz	<b>5'</b>	2263.5 MHz
<b>6</b>	2102.5 MHz	<b>6'</b>	2277.5 MHz

**Table 17: CRASA channelling plan for 2025-2290 MHz**

**7.3.4 Current usage of the 1700-2290 MHz band in South Africa**

The table below summarizes the current assignments in the 1700-2290 MHz band.



**Figure 13: Current assignments with 1700-2200 MHz**

**7.3.4.1 Usage of paired IMT spectrum in the 1700-2290 MHz band**

In South Africa, the IMT1800 FDD spectrum is used for GSM1800 for 2×75 MHz from 1710-1880 MHz for 6 operators with each having 2×12 MHz. There are also 4 operators who already have UMTS 2100 FDD spectrum of 2×15 MHz each.

**7.3.4.2 Usage of unpaired IMT spectrum in the 1700-2290 MHz band**

The TDD bands 2010-2025 are currently assigned to MTN (10 MHz) and Vodacom (5 MHz). The neighbouring band 2025-2100 MHz is sparsely used by PtP-links.

The TDD band from 1880-1920 MHz is in use by Telkom, SAPS and SANDF, e.g. for DECT-systems and fixed links. The guard band of 5 MHz from 1915-1920 MHz is free.

**7.3.5 Proposal for extension of IMT2100**

IMT2100 may be delayed due to reduced availability of terminals. Depending on the traffic requirements for GSM per operator and the increased IMT data demands due to higher IMT-terminal penetration, the opportunity to migrate to broadband IMT (i.e. LTE) may be possible in one or two steps, for example, 2×5 MHz. At later stages, Universal Mobile Telecommunications System (UMTS) will also be migrated to broadband IMT.

The IMT2100 band currently consists of 2×60 MHz of spectrum in 1920-1980 MHz paired with 2110-2170 MHz. The Authority proposes to extend this band by 2x30 MHz at the top end of the current IMT2100 band. This band is currently foreseen as IMT-satellite. The consolidated IMT2100 band would therefore be 1920-2010 MHz paired with 2110-2200 MHz (see figure below).

This extension of the IMT2100 band would push the paired portion of IMT2100 right against the unpaired portion of the band that extends from 2010 MHz to 2025 MHz. A guard band of 5 MHz is typically required between adjacent paired and unpaired IMT bands. Therefore, the first 5 MHz of the 10 MHz assigned to MTN from 2010 MHz to 2015 MHz could be used as a guard band. The band 2015-2025 MHz could remain usable for IMT TDD, but might be reassigned to 10 MHz for one user. MTN and Vodacom might be willing to change unused TDD spectrum for new FDD spectrum. These new TDD bands from 1885-1915 MHz plus guard bands and 2015-2025 MHz might be assigned to a TDD wholesale operator/consortium.

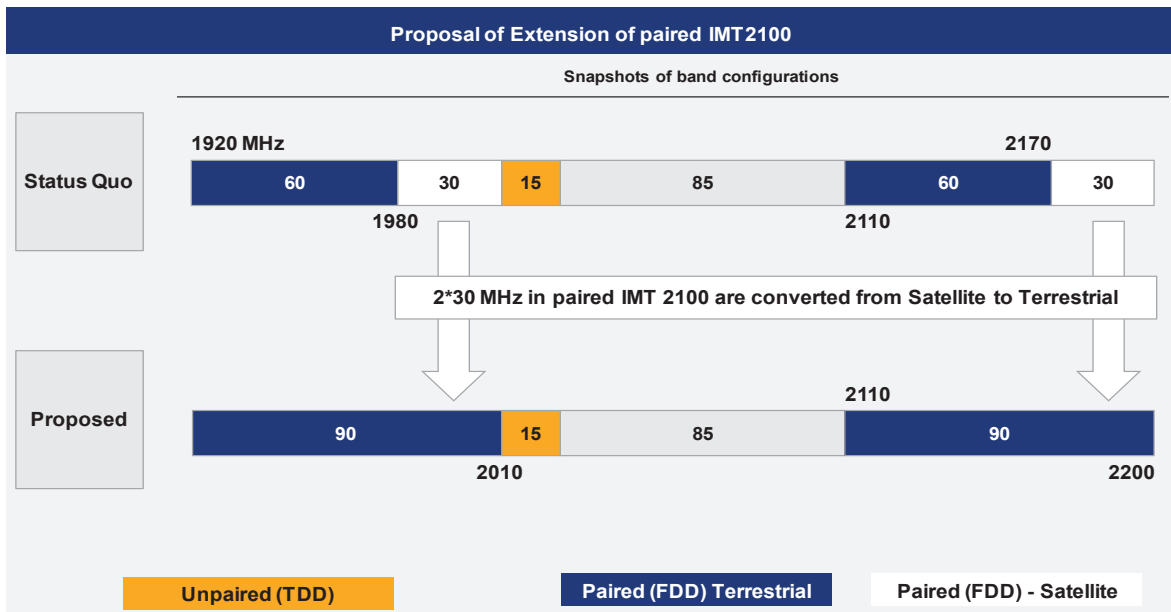


Figure 14: Proposal of Extension of paired IMT2100

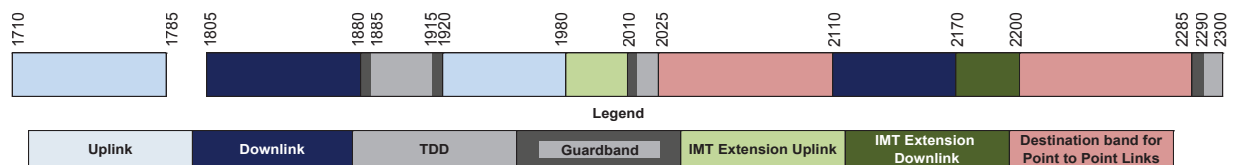


Figure 15: IMT2100-extensions proposal

The 2025-2110 and 2200-2285 bands are not usable for (high-density) IMT-services, so the Authority proposes to use this band for PtP link destination band migrated from lower bands.

2285 – 2290 MHz could be used for a 5 MHz guard band.

The 2290-2300 MHz band is currently unused in South Africa. According to the Frequency Migration Plan an RFSAP should be developed to consider BFWA or BWA. An evaluation may be carried out as to whether IMT-TDD equipment could be developed or tuned to extend IMT-2300 starting from 2290-2400 MHz. In general, the potential interference mitigation measures, between point to point and IMT-TDD at 2025 MHz and at 2285 MHz as well as to IMT FDD at 2110 MHz, have to be considered.

The suggestions concerning 1980-2110 // 2170-2200 MHz are tentative as these bands are not yet identified for terrestrial IMT at international level (and therefore there is no ecosystem). However, these bands might be identified for IMT in the future because of the attractive location near GSM/IMT1800 and UMTS/IMT2100. Digital equipment is

already available (SRAN-concept<sup>12</sup>) and radio equipment, filters and antennas need adaptations.

### **7.3.6 Conclusions**

The response to the consultation on 2290-2300 MHz indicated that while it could be useful to consider the band for IMT, such consideration is not supported at this stage and should wait for a decision at an international level.

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<sup>12</sup> SRAN; single radio access network with separation of RF and digital baseband (BB) offers the use of standardised digital equipment independent from frequency bands. RF-units have to be adapted to specific bands with filters, etc.

## 7.4 IMT2020 Frequencies for Consideration

The following frequency information are extracted from the National Radio Frequency Plan (NRFP) 2018

### 7.4.1 1.427-1.518 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<p><b>1 427-1 429 MHz</b></p> <p>SPACE OPERATION (Earth-to-space) FIXED</p> <p>MOBILE except mobile aeronautical <b>5.341A</b></p> <p>5.338A 5.341</p>	<p><b>1 427-1 429 MHz</b></p> <p>SPACE OPERATION (Earth-to-space) FIXED NF14</p> <p>MOBILE except mobile aeronautical <b>5.341A</b></p> <p>5.338A 5.341</p>	<p><b>1 427-1 452 MHz</b></p> <p>Fixed links (duplex)</p>	<p>Paired with 1 375 – 1 400 MHz in accordance with Recommendation ITU-R F.1242</p> <p>ITU Res. 223 (Rev.WRC-15)</p>
<p><b>1 429-1 452 MHz</b></p> <p>FIXED</p> <p>MOBILE except mobile aeronautical 5.341A</p> <p>5.338A 5.341 5.342</p>	<p><b>1 429-1 452 MHz</b></p> <p>FIXED</p> <p>MOBILE except mobile aeronautical 5.341A</p> <p>5.338A 5.341</p>	<p>1 427-1 452 MHz</p> <p>Fixed links (duplex)</p>	<p>Paired with 1 375 – 1 400 MHz) In accordance with Recommendation ITU-R F.1242</p>
<p><b>1 452-1 492 MHz</b></p> <p>FIXED</p> <p>MOBILE except mobile aeronautical 5.346</p> <p>BROADCASTING</p> <p>BROADCASTING-SATELLITE 5.208B</p>	<p><b>1 452-1 492 MHz</b></p> <p>FIXED NF14</p> <p>MOBILE except mobile aeronautical 5.346</p> <p>BROADCASTING</p> <p>BROADCASTING-SATELLITE 5.208B</p>	<p>)</p>	<p><b>studies called for Resolution 761 (WRC-15)</b> on the “Compatibility of International Mobile Telecommunications and broadcasting-satellite service and take appropriate regulatory and technical studies, with a view to ensuring the compatibility of IMT and BSS (sound) are undertaken within the ITU-R</p>

5.341 5.342 5.345	5.341 5.345 NF12		ITU-R Res. 223 (Rev.WRC-15)  ITU-R Res. 223 (Rev.WRC-15)
<b>1 492-1 518 MHz</b>  FIXED  MOBILE except aeronautical mobile 5.341A	<b>1 492-1 518 MHz</b>  FIXED  MOBILE except aeronautical mobile 5.341A	<b>Fixed Links (1 492 – 1 517 MHz)</b>  <b>Single Frequency Links (1 517 – 1 525 MHz)</b>	<b>Paired with 1 350 – 1 375 MHz</b> In accordance with Recommendation ITU-R F.1242  ITU-R Res. 223 (Rev.WRC-15) <b>(Sharing and Compatibility Studies called for by Resolution 223 (Rev. WRC-15) are underway within the ITU-R)</b>
5.341 5.342	5.341		

**7.4.2 3.3 – 3.6 GHz**

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<b>3 300-3 400 MHz</b>  RADIOLOCATION  5.149 5.429 5.429A 5.429B 5.430	<b>3 300-3 400 MHz</b>  RADIOLOCATION  5.149 5.429A 5.429B	<b>Government Services</b> <b>IMT Res. 223 (Rev.WRC-15)</b>	.  Subject to outcome of the sharing and compatibility studies called for by Resolution 223 (WRC-15) currently underway within the ITU-R, <b>there might be a need to migrate Radars out of this band. This will be addressed through an update of the migration plan.</b>



<p><b>3 400-3 600 MHz</b></p> <p>FIXED FIXED-SATELLITE (space-to-Earth) MOBILE 5.430A</p> <p>Radiolocation</p> <p>5.431</p>	<p><b>3 400-3 600 MHz</b></p> <p>FIXED</p> <p>MOBILE 5.430A NF9</p>	<p><b>IMT3500 TDD (3400 – 3600 MHz)</b></p>	<p><b>International Mobile Telecommunication Roadmap (GG No.38213) 14 November 2014. Radio Frequency Assignment Plan (GG N. 38640) as amended 30 March 2015. Recommendation ITU-R M.1036 The band 3400 -3600 MHz is also used for BFWA in some SADC countries</b></p>
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#### 7.4.3 24.25-27.5 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<p><b>24.25-24.45 GHz</b></p> <p>FIXED</p>	<p><b>24.25-24.45 GHz</b></p> <p>FIXED</p>		<p><b>Temporary fixed links for ENG/OB</b></p>
<p><b>24.45-24.65 GHz</b></p> <p>FIXED</p> <p>INTER-SATELLITE</p>	<p><b>24.45-24.65 GHz</b></p> <p>FIXED NF14</p>	<p><b>Fixed Links (26 GHz) (24.5 – 26.5 GHz)</b></p> <p><b>Fixed links - 26 GHz (24.5-26.5 GHz)</b></p> <p><b>BFWA (24.5- 26.5 GHz)</b></p>	<p><b>Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.</b></p>
<p><b>24.65-24.75 GHz</b></p> <p>FIXED</p>	<p><b>24.65-24.75 GHz</b></p> <p>FIXED NF14</p>	<p><b>Fixed Links (26 GHz) (24.5 – 26.5 GHz)</b></p>	<p><b>Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.</b></p>

FIXED-SATELLITE (Earth-to-space) 5.532B		<b>Fixed links - 26 GHz (24.5-26.5 GHz)</b>	
INTER-SATELLITE		<b>BFWA (24.5-26.5 GHz)</b>	
<b>24.75-25.25 GHz</b>	<b>24.75-25.25 GHz</b>		
FIXED	FIXED NF14	<b>Fixed Links (26 GHz) (24.5 – 26.5 GHz)</b>	<b>Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.</b>
FIXED-SATELLITE (Earth-to-space) 5.532B	FIXED-SATELLITE (Earth-to-space) 5.532B	<b>Fixed links - 26 GHz (24.5-26.5 GHz)</b> <b>BFWA (24.5-26.5 GHz)</b>	
<b>25.25-25.5 GHz</b>	<b>25.25-25.5 GHz</b>		
FIXED	FIXED NF14	<b>Fixed Links (26 GHz) (24.5 – 26.5 GHz)</b>	<b>Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.</b>
INTER-SATELLITE 5.536 MOBILE Standard frequency and time signal-satellite (Earth-to-space)		BFWA (24.5-26.5 GHz)	
<b>25.5-27 GHz</b>	<b>25.5-27 GHz</b>		
EARTH EXPLORATION-SATELLITE (space-to Earth) 5.536B	EARTH EXPLORATION-SATELLITE (space-to Earth) 5.536B	<b>National Polar-Orbiting Operational Environment Satellite System (NPOESS)</b>	<b>Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.</b>
FIXED	FIXED NF14	<b>Fixed Links (26 GHz) (24.5 – 26.5 GHz)</b> BFWA (24.5-26.5 GHz)	
INTER-SATELLITE 5.536 MOBILE SPACE RESEARCH (space-to-Earth) 5.536C Standard frequency and time signal-satellite (Earth-to-space)			

5.536A	5.536A		
<b>27-27.5 GHz</b>  FIXED INTER-SATELLITE 5.536 MOBILE	<b>27-27.5 GHz</b>  FIXED		

## 7.4.4 37-40.5 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<p><b>37-37.5 GHz</b></p> <p>FIXED</p> <p>MOBILE except aeronautical mobile</p> <p>SPACE RESEARCH (space-to-Earth)</p> <p>5.547</p>	<p><b>37-37.5 GHz</b></p> <p>FIXED NF14</p> <p>SPACE RESEARCH (space-to-Earth)</p> <p>5.547</p>	<p><b>Fixed Links (38 GHz) (37.0 – 39.5 GHz)</b></p>	
<p><b>37.5-38 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE (space-to-Earth)</p> <p>MOBILE except aeronautical mobile</p> <p>SPACE RESEARCH (space-to-Earth)</p> <p>Earth exploration-satellite (space-to-Earth)</p> <p>5.547</p>	<p><b>37.5-38 GHz</b></p> <p>FIXED NF14</p> <p>SPACE RESEARCH (space-to-Earth)</p> <p>Earth exploration-satellite (space-to-Earth)</p> <p>5.547</p>	<p><b>Fixed Links (38 GHz) (37.0 – 39.5 GHz)</b></p>	<p><b>The band 37-40 GHz is identified for HDFS; Res.75 applies.</b></p> <p><b>Channelling plan for 38 GHz band in accordance with ITU Rec. F.749 Annex 1.</b></p>
<p><b>38-39.5 GHz</b></p>	<p><b>38-39.5 GHz</b></p>		

<p>FIXED</p> <p>FIXED-SATELLITE (space-to-Earth)</p> <p>MOBILE Earth exploration- satellite (space-to- Earth)</p> <p>5.547</p>	<p>FIXED NF14</p> <p>Earth exploration- satellite (space-to- Earth)</p> <p>5.547</p>	<p><b>Fixed Links (38 GHz) (37.0 – 39.5 GHz)</b></p>	<p><b>Channelling plan for 38 GHz band in accordance with ITU Rec. F.749 Annex 1.</b></p> <p><b>The band 37-40 GHz is identified for HDFSS; Res.75 applies.</b></p>
<p><b>39.5-40 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE (space-to-Earth) 5.516B</p> <p>MOBILE</p> <p>MOBILE- SATELLITE (space-to- Earth)</p> <p>Earth exploration- satellite (space-to- Earth)</p> <p>5.547</p>	<p><b>39.5-40 GHz</b></p> <p>FIXED</p> <p>FIXED- SATELLITE (space- to-Earth) 5.516B</p> <p>Earth exploration- satellite (space-to- Earth)</p> <p>5.547</p>		<p><b>The band 37-40 GHz is identified for HDFSS; Res.75 applies.</b></p> <p><b>The band 39.5-40 GHz is identified for HDFSS; Res.143 applies.</b></p>
<p><b>40-40.5 GHz</b></p> <p>EARTH EXPLORATION- SATELLITE (Earth-to- space)</p> <p>FIXED</p> <p>FIXED-SATELLITE (space-to-Earth) 5.516B</p> <p>MOBILE</p> <p>MOBILE- SATELLITE (space-to- Earth)</p>	<p><b>40-40.5 GHz</b></p> <p>EARTH EXPLORATION- SATELLITE (Earth-to- space)</p> <p>FIXED</p> <p>FIXED- SATELLITE (space- to-Earth) 5.516B</p> <p>MOBILE</p> <p>MOBILE- SATELLITE (space- to-Earth)</p>	<p><b>Government Services</b></p>	<p><b>The band 40-40.5 GHz is identified for HDFSS; Res.143 applies.</b></p>

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SPACE RESEARCH (Earth-to-space) Earth exploration- satellite (space-to- Earth)	SPACE RESEARCH (Earth-to- space) Earth exploration- satellite (space-to- Earth)		
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## 7.4.7 47.2-50.2 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<p><b>47.2-47.5 GHz</b></p> <p>FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE</p> <p>5.552A</p>	<p><b>47.2-47.5 GHz</b></p> <p>FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE</p> <p>5.552A</p>		
<p><b>47.5-47.9 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE (Earth-to-space) 5.552 (space-to-Earth) 5.516B 5.554A MOBILE</p>	<p><b>47.5-47.9 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE (Earth-to-space) 5.552 (space-to-Earth) 5.516B 5.554A MOBILE</p>	<p><b>The band 47.5-47.9 GHz is identified for HDFSS; Res.143 applies.</b></p>	
<p><b>47.9-48.2 GHz</b></p> <p>FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE</p> <p>5.552A</p>	<p><b>47.9-48.2 GHz</b></p> <p>FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE</p> <p>5.552A</p>		
<p><b>48.2-48.54 GHz</b></p> <p>FIXED</p>	<p><b>48.2-48.54 GHz</b></p> <p>FIXED</p>		



<p>FIXED-SATELLITE</p> <p>(Earth-to-space) 5.552</p> <p>(space-to-Earth) 5.516B</p> <p>5.554A 5.555B</p> <p>MOBILE</p>	<p>FIXED-SATELLITE</p> <p>(Earth-to-space) 5.552</p> <p>(space-to-Earth) 5.516B</p> <p>5.554A 5.555B</p> <p>MOBILE</p>		<p><b>The band 48.2-48.54 GHz is identified for HDFSS; Res.143 applies.</b></p>
<p><b>48.54-49.44 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE</p> <p>(Earth-to-space) 5.552</p> <p>MOBILE</p> <p>5.149 5.340 5.555</p>	<p><b>48.54-49.44 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE</p> <p>(Earth-to-space) 5.552</p> <p>MOBILE</p> <p>5.149 5.340 5.555</p>		
<p><b>49.44-50.2 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE</p> <p>(Earth-to-space) 5.338A 5.552</p> <p>(space-to-Earth) 5.516B</p> <p>5.554A 5.555B</p> <p>MOBILE</p>	<p><b>49.44-50.2 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE</p> <p>(Earth-to-space) 5.338A 5.552</p> <p>(space-to-Earth) 5.516B</p> <p>5.554A 5.555B</p> <p>MOBILE</p>		<p><b>The band 49.44-50.2 GHz is identified for HDFSS; Res.143 applies.</b></p>

**7.4.8 50.4-52.6 GHz**

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<b>50.4-51.4 GHz</b>  FIXED  FIXED-SATELLITE (Earth-to-space) 5.338A  MOBILE Mobile-satellite (Earth-to-space)	<b>50.4-51.4 GHz</b>  FIXED  FIXED-SATELLITE (Earth-to-space) 5.338A  MOBILE Mobile-satellite (Earth-to-space)		
<b>51.4-52.6 GHz</b>  FIXED 5.338A MOBILE  5.547 5.556	<b>51.4-52.6 GHz</b>  FIXED 5.338A MOBILE  5.547 5.556		<b>The band 51.4-52.6 GHz is identified for HDFS; Res.75 applies.</b>

## 7.4.9 66-76 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<p><b>66-71 GHz</b></p> <p>INTER-SATELLITE MOBILE 5.553 5.558</p> <p>MOBILE-SATELLITE</p> <p>RADIONAVIGATION</p> <p>RADIONAVIGATION-SATELLITE</p> <p>5.554</p>	<p><b>66-71 GHz</b></p> <p>INTER-SATELLITE MOBILE 5.553 5.558</p> <p>MOBILE-SATELLITE</p> <p>RADIONAVIGATION</p> <p>RADIONAVIGATION-SATELLITE</p> <p>5.554</p>		
<p><b>71-74 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE (space-to-Earth)</p> <p>MOBILE</p> <p>MOBILE-SATELLITE (space-to-Earth)</p>	<p><b>71-74 GHz</b></p> <p>FIXED NF14</p> <p>FIXED-SATELLITE (space-to-Earth)</p> <p>MOBILE</p> <p>MOBILE-SATELLITE (space-to-Earth)</p>	<p><b>Fixed Links (80 GHz) (71 – 76 GHz)</b></p> <p><b>Government use</b></p> <p><b>Fixed links (71-76 GHz)</b></p>	<p><b>Paired with 81 – 86 GHz.</b></p> <p><b>Radio Frequency Spectrum Regulations Amendments (Government Gazette Number 40436, 22 November 2016)</b></p>
<p><b>74-76 GHz</b></p> <p>FIXED</p> <p>FIXED-SATELLITE (space-to-Earth)</p>	<p><b>74-76 GHz</b></p> <p>FIXED NF14</p> <p>FIXED-SATELLITE (space-to-Earth)</p>	<p><b>Fixed Links (80 GHz) (71 – 76 GHz)</b></p>	<p><b>Paired with 81 – 86 GHz.</b></p>

MOBILE	MOBILE		<b>Radio Frequency Spectrum Regulations Amendments (Government Gazette Number 40436, 22 November 2016)</b>
BROADCASTING BROADCASTING-SATELLITE	BROADCASTING BROADCASTING-SATELLITE		
Space research (space-to-Earth)	Space research (space-to-Earth)		
5.561	5.561		

#### 7.4.10 81-86 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<b>81-84 GHz</b>	<b>81-84 GHz</b>		
FIXED 5.338A	FIXED 5.338A NF14	<b>Fixed Links (80 GHz) (81 –86 GHz)</b>	<b>Paired with 71 – 76 GHz.</b>  <b>Radio Frequency Spectrum Regulations Amendments (Government Gazette Number 40436, 22 November 2016)</b>
FIXED-SATELLITE (Earth-to-space)	FIXED-SATELLITE (Earth-to-space)		
MOBILE	MOBILE		
MOBILE-SATELLITE (Earth-to-space)	MOBILE-SATELLITE (Earth-to-space)		
RADIO ASTRONOMY	RADIO ASTRONOMY		
Space research (space-to-Earth)	Space research (space-to-Earth)		
5.149 5.561A	5.149 5.561A		
<b>84-86 GHz</b>	<b>84-86 GHz</b>		

FIXED 5.338A	FIXED 5.338A NF14	<b>Fixed Links (80 GHz) (81 –86 GHz)</b>	<b>Radio Frequency Spectrum Regulations Amendments (Government Gazette Number 40436, 22 November 2016)</b>
FIXED-SATELLITE (Earth-to-space) 5.561B MOBILE RADIO ASTRONOMY	FIXED-SATELLITE (Earth-to-space) 5.561B MOBILE RADIO ASTRONOMY		
5.149	5.149		

which have allocations to the mobile service on a primary basis; and –

#### 7.4.11 31.8-33.4 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<b>31.8-32 GHz</b>  FIXED 5.547A  RADIONAVIGATION  SPACE RESEARCH (deep space) (space-to-Earth)  5.547 5.548	<b>31.8-32 GHz</b>  FIXED 5.547A NF14  RADIONAVIGATION  5.547 5.548	<b>HDFS (31.8 – 33.4 GHz)</b>	Channelling plan for 32 GHz band in accordance with ITU-R Rec. F.1520 Annex 1.  The band 31.8-33.4 GHz is identified for HDFS; Res.75 applies.
<b>32-32.3 GHz</b>	<b>32-32.3 GHz</b>		

<p>FIXED 5.547A</p> <p>RADIONAVIGATION</p> <p>SPACE RESEARCH (deep space) (space-to-Earth)</p> <p>5.547 5.548</p>	<p>FIXED 5.547A NF14</p> <p>RADIONAVIGATION</p> <p>SPACE RESEARCH (deep space) (space-to-Earth)</p> <p>5.547 5.548</p>	<p><b>HDFS (31.8 – 33.4 GHz)</b></p>	<p><b>Channelling plan for 32 GHz band in accordance with ITU-R Rec. F.1520 Annex 1.</b></p> <p><b>The band 31.8-33.4 GHz is identified for HDFS; Res.75 applies.</b></p>
<p><b>32.3-33 GHz</b></p> <p>FIXED 5.547A</p> <p>INTER-SATELLITE</p> <p>RADIONAVIGATION</p> <p>5.547 5.548</p>	<p><b>32.3-33 GHz</b></p> <p>FIXED 5.547A NF14</p> <p>INTER-SATELLITE</p> <p>RADIONAVIGATION</p> <p>5.547 5.548</p>	<p><b>HDFS (31.8 – 33.4 GHz)</b></p>	<p><b>Channelling plan for 32 GHz band in accordance with ITU-R Rec. F.1520 Annex 1.</b></p> <p><b>The band 31.8-33.4 GHz is identified for HDFS; Res.75 applies.</b></p>
<p><b>33-33.4 GHz</b></p> <p>FIXED 5.547A</p> <p>RADIONAVIGATION</p> <p>5.547</p>	<p><b>33-33.4 GHz</b></p> <p>FIXED 5.547A NF14</p> <p>RADIONAVIGATION</p> <p>5.547</p>	<p><b>HDFS (31.8 – 33.4 GHz)</b></p>	<p><b>Channelling plan for 32 GHz band in accordance with ITU-R Rec. F.1520 Annex 1.</b></p> <p><b>The band 31.8-33.4 GHz is identified for HDFS; Res.75 applies.</b></p>

## 7.4.12 40.5-42.5 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
<b>40.5-41 GHz</b>  FIXED <b>FIXED-SATELLITE (space-to-Earth)</b> BROADCASTING BROADCASTING-SATELLITE  Mobile  5.547	<b>40.5-41 GHz</b>  FIXED NF14 <b>FIXED-SATELLITE (space-to-Earth)</b> BROADCASTING BROADCASTING-SATELLITE  Mobile  5.547		<b>BFWA or MWS (40.5-43.5 GHz).</b>  <b>The band 40.5-43.5 GHz is identified for HDFS; Res.75 applies.</b>
<b>41-42.5 GHz</b>  FIXED FIXED-SATELLITE (space-to-Earth) BROADCASTING BROADCASTING-SATELLITE  Mobile  5.547 5.551F 5.551H 5.551I	<b>41-42.5 GHz</b>  FIXED NF14 FIXED-SATELLITE (space-to-Earth) BROADCASTING BROADCASTING-SATELLITE  Mobile  5.547 5.551F 5.551H 5.551I		<b>BFWA or MWS (40.5-43.5 GHz).</b>  <b>The band 40.5-43.5 GHz is identified for HDFS; Res.75 applies.</b>

**7.4.13 47-47.2 GHz**

<b>ITU Region 1 allocations and footnotes</b>	<b>South African allocations and footnotes</b>	<b>Typical Applications</b>	<b>Notes and Comments</b>
<b>47-47.2 GHz</b>  AMATEUR AMATEUR- SATELLITE	<b>47-47.2 GHz</b>  AMATEUR AMATEUR- SATELLITE	<b>Amateur</b>  <b>Amateur</b> <b>satellite</b>	

This may require additional allocations to the mobile service on a primary basis.

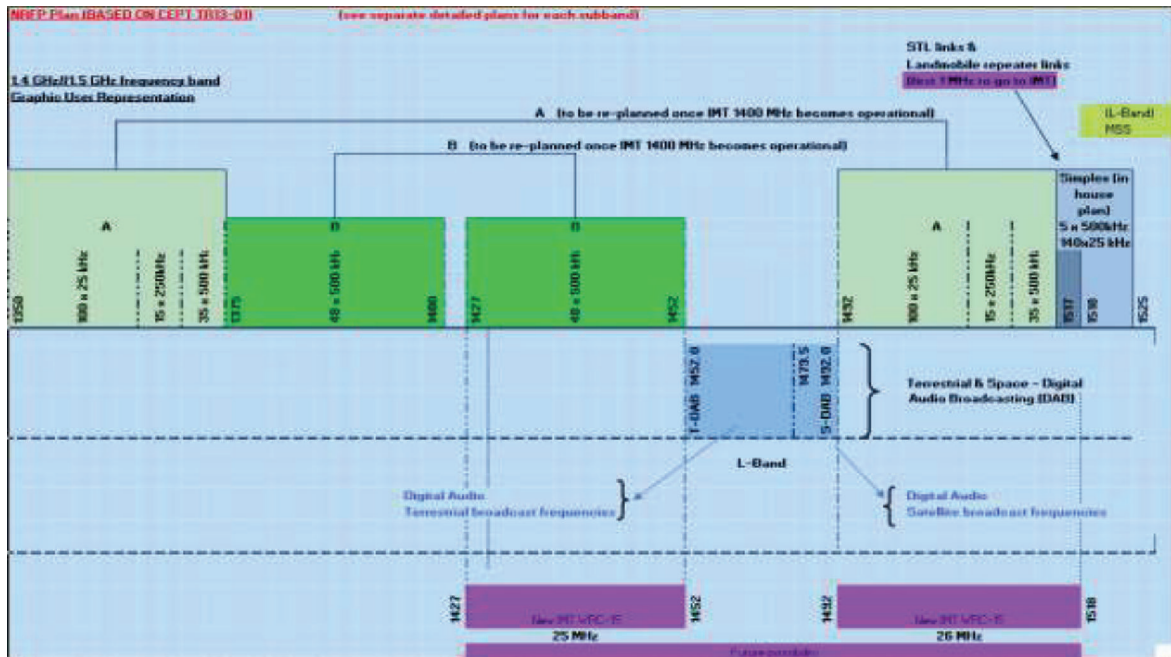


### 7.5 IMT2020 Proposed actions for identified IMT Frequency bands

The sub-sections below provide more information regarding the status and frequency usage in South Africa for the bands identified for IMT2020 implementation.

#### 7.5.1 1.427-1.518 GHz

The picture included below provide information on the band allocations for this band.



The licensees in this band include Telkom, ESKOM, TRANSNET, SAPS, SANDF, Ekurhuleni and National Research Foundation. There are also provision for Terrestrial Digital Audio Broadcasting as well as Satellite Digital Audio Broadcasting. There are currently no licenses issued and operational in this part of the spectrum in South Africa.

More information on the Channel plans and licensee information can be obtained in Appendix B to this document.

A study need to be performed to determine if changes are required to rearrange the band usage

### 7.5.2 3.3 – 3.6 GHz

The following studies are currently being undertaken for the stipulated bands

#### Nigeria, South Africa Zimbabwe & Kenya proposed frequency arrangement for the band 3300-3600 MHz

##### Introduction

The band 3300-3400 MHz is allocated to the Mobile, except aeronautical Service, through various footnotes, and is Identified for IMT in forty-five (45) countries. The identification for IMT was made under the condition that such IMT systems shall not cause interference nor claim protection from the then incumbent primary services of the band. The countries that are on the IMT Identification footnotes cut across the three regions of the ITU, with thirty-three (33) of the countries being in Africa (R1), six (6) in the Americas (R2) and six (6) in Asia (R3). Considering the interest expressed by Administrations, across all the three regions, for this band to be used for IMT, based on its ability to provide the needed capacity for the deployment of IMT services, and considering the band's adjacency to the near-globally harmonised 3400-3600 MHz band, there scope in giving consideration to a channelling arrangement for a contiguous band covering the range 3300-3600 MHz.

##### Proposal

It is hereby proposed that, within the ongoing revision of Recommendation ITU-R. M. 1036, consideration be given to an unpaired (TDD) arrangement covering the range 3300-3600 MHz, as depicted in Table 1 below.

It is further proposed that this option be considered in the compatibility studies called upon by Resolution 223 (Rev WRC-15).

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)	
F6					3300-3600

MHz	3 300	3 600
F4	TDD	
	3 300	3 600

## **Out of block emissions for IMT Base Stations at 3300-3400 MHz in the context of radar systems operating below 3300 MHz**

### **Introduction and background**

The frequency band 3 100-3 300 MHz is allocated, in all three Regions, to the radiolocation service on a primary basis, and earth exploration and space research on a secondary basis.

The frequency band 3 300-3 400 MHz is allocated in all three Regions to the radiolocation service on a primary basis, and in Region 2 and Region 3 is also allocated to the fixed, mobile and amateur service on a secondary basis.

The 3300 – 3400 MHz band was identified for IMT at WRC-15 by a number of countries. Resolution **223 (WRC-15)** calls for compatibility studies to assess the feasibility of:

- co-channel sharing between IMT and Radiolocation systems (including land, maritime and airborne radars) operating in the band 3300 - 3400 MHz; and
- adjacent band sharing between IMT operating in the 3300 – 3400 GHz band and Radiolocation systems deployed in the 3100 – 3300 GHz band.

### **Proposal**

This contribution presents in its attachment a study on the impact of aggregated macro BSs into land based radars B, D and I operating in an adjacent channel. The study assumes that the BS uses beamforming antennas. The results show the probability that the interference from the IMT network exceeds the -6 dB I/N threshold, for a range of values of OOB emissions from at the IMT BSs.

The study shows that for a 1% to 10% exceedance probability, the maximum permitted out of block emissions at the BSs should be in the range -44...-50 dBm/MHz.

The signing Administrations propose that WP5D takes account of the material presented in this contribution as part of its process of revising the working document in consideration of the introduction of 5G IMT systems to 3300-3400 MHz.

## In band coexistence and compatibility studies between IMT-Advanced systems in 3 300-3 400 MHz USING AAS and Radiolocation systems in 3 100-3 400 MHz

### Introduction and background

The frequency band 3 100-3 300 MHz is allocated, in all three Regions, to the radiolocation service on a primary basis, and earth exploration and space research on a secondary basis.

The frequency band 3 300-3 400 MHz is allocated in all three Regions to the radiolocation service on a primary basis, and in Region 2 and Region 3 is also allocated to the fixed, mobile and amateur service on a secondary basis.

The 3300 – 3400 MHz band was identified for IMT at WRC-15 by a number of countries. Resolution **223 (WRC-15)** calls for compatibility studies to assess the feasibility of:

- co-channel sharing between IMT and Radiolocation systems (including land, maritime and airborne radars) operating in the band 3300 - 3400 MHz; and
- adjacent band sharing between IMT operating in the 3300 – 3400 GHz band and Radiolocation systems deployed in the 3100 – 3300 GHz band.

### Proposal

This contribution presents in its attachment a study on the impact of a single macro and micro urban BS into a type D maritime radar operating co-channel. The study is based on a simple MCL analysis, but it assumes that the BS uses beamforming antennas which are modelled statistically. The results show the likelihood that the interference from the BS exceeds the -6 dB I/N threshold, for 20 km, 50 km and 100 km separation distances between the BS and the radar, and for the tropical and equatorial locations agreed by WP5D.

This study shows that compatibility between IMT with AAS and ship based radars is possible. The table below summarises the results.

Probability that the interference from BS into radar is below the – 6dB I/N criterion

	Separation distance (km)	Equatorial P=10%	Equatorial P=20%	Tropical P=10%	Tropical P=20%
Urban Macro	20	58%	58%	58%	58%
	50	80%	80%	80%	93%
	100	86%	93%	93%	98%
Urban Micro	20	92%	92%	92%	92%
	50	95%	95%	95%	99%

**CONTINUES ON PAGE 258 - PART 3**



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The signing administrations propose that the Study in the Attachment is incorporated to the draft report on radar & IMT coexistence in the 3300-3400 MHz

### 7.5.3 24.25-27.5 GHz

This band is currently being utilised and the following entities are licensed in this band:

- Telkom
- Transnet
- Dark Fibre
- MTN
- Vodacom
- Liquid Telecoms (Neotel)
- Multisource (WBS)

Part of the band is also considered for Metro Fibre in Gauteng.

More information on the current licence assignments can be viewed in Appendix C to this document. Study to be performed into the detail current usage of the band and the availability for IMT2020 applications.

### 7.5.4 31.8-33.4 GHz

No licensees are recorded i.e. no licenses have been issued in this band and no channel plans have been developed. It is recommended that a Frequency Spectrum Assignment Plan is developed for this band. There are currently no intention to perform a study before the Frequency Spectrum Assignment Plan is developed.

### 7.5.5 37-40.5 GHz

This band is currently being utilised and there are existing channel plans with spacing or channel width of 3.5 MHz, 7 MHz, 14 MHz and 28 MHz. This band is setup in accordance with ITU-R F.749-1. The Block and Ad Hoc users in this band include the following entities:

- Breedenet
- Comsol Networks
- Cell-C

- Digital Mobile Networks
- Dim Dat
- Drs Bloch Partners Inc.
- Eskom
- Faircape Communications T/A Faircom
- I-Gen
- Infogro
- Infovan
- Internet Solutions
- MTN
- Multisource
- Liquid Telecoms (Neotel)
- Network Embedded Technologies
- Overstrand Municipality
- Rosewell Trading
- SAPS
- Scan RF
- Screamer Communications
- Sentech
- Sishen
- Telkom
- Tenet
- Transnet
- Tswane University of Technology
- Vodacom

It is possible that some of these licensees are not licensed anymore.

The existing channel plans are available in Appendix D to this document.

Study to be performed into the detail current usage of the band and the availability for IMT2020 applications.



**7.5.6 40.5-42.5 GHz**

This band is currently being utilised and there are existing channel plans with spacing or channel width of 7 MHz, 14 MHz, 28 MHz, 56 MHz and 112 MHz. There are no records available from ICASA on licensees in this frequency band.

The existing channel plans are available in Appendix E to this document.

Study to be performed into the detail current usage of the band and the availability for IMT2020 applications.

**7.5.7 45.5-47 GHz**

No licensees are recorded i.e. no licenses have been issued in this band and no channel plans have been developed

It is recommended that that a Frequency Spectrum Assignment Plan is developed for this band. There are currently no intention to perform a study before the Frequency Spectrum Assignment Plan is developed.

**7.5.8 47-47.2 GHz**

No licensees are recorded i.e. no licenses have been issued in this band and no channel plans have been developed

It is recommended that that a Frequency Spectrum Assignment Plan is developed for this band. There are currently no intention to perform a study before the Frequency Spectrum Assignment Plan is developed.

**7.5.9 47.2-50.2 GHz**

No licensees are recorded i.e. no licenses have been issued in this band and no channel plans have been developed

It is recommended that that a Frequency Spectrum Assignment Plan is developed for this band. There are currently no intention to perform a study before the Frequency Spectrum Assignment Plan is developed.

**7.5.10 50.4-52.6 GHz**

No licensees are recorded i.e. no licenses have been issued in this band and no channel Plans have been developed

It is recommended that that a Frequency Spectrum Assignment plan is developed for this band. There are currently no intention to perform a study before the Frequency Spectrum Assignment Plan is developed.

#### **7.5.11 57.0 – 66 GHz**

No licensees are recorded, and no channel plans have been developed. The V-Band has been Gazetted in Government Gazette 40436 dated 22 November 2016 Notice 781 of 2016.

It is recommended that a Frequency Spectrum Assignment plan is developed for this band. There is currently no intention to perform a study before the Frequency Spectrum Assignment Plan is developed.

#### **7.5.12 66-76 GHz (E-Band)**

No licensees are recorded i.e. no licenses have been issued in this band 66 to 71 GHz and no channel plans have been developed. License information and Channel plans are available for the Band 71 to 76 GHz. This frequency band is paired with 81 to 86 GHz.

See Appendix F for more information. .FDD systems are deployed with channel spacing of 250 MHz. Find more information on the self-coordinated Block of frequencies in the E-Band and the ICASA-coordinated Block in Appendix G to this document. See Government Gazette 40815 dated 28 April 2017 Notice 317 of 2017. The entities self-coordinated in this band include:

- Vodacom
- MTN
- Sonic Computers
- EOH
- Fusion Wireless
- Liquid Telecommunications
- Francois Theron Photography
- Others not self-coordinated

It is recommended that a Frequency Spectrum Assignment plan is developed for the band 66 to 71 GHz. Also see Government Gazette 40436 dated 22 November 2016 Notice 781 of 2016.

Study to be performed into the detail current usage of the band and the availability for IMT2020 applications.

#### **7.5.13 81-86 GHz (E-Band)**

The band 81 to 86 GHz is paired with 71 to 76 GHz. See Government Gazette 40815 dated 28 April 2017 Notice 317 of 2017. Find more information on the self-coordinated

Block of frequencies in the E-Band and the ICASA-coordinated Block in Appendix G to this document.

The entities self-coordinated in this band include:

- Vodacom
- MTN
- Sonic Computers
- EOH
- Fusion Wireless
- Liquid Telecommunications
- Francois Theron Photography
- Others not self-coordinated

Also see Government Gazette 40436 dated 22 November 2016 Notice 781 of 2016.

Study to be performed into the detail current usage of the band and the availability for IMT2020 applications.

## 8 IMT Roadmap: Time Frame

### 8.1 Time frame overview

The following was a draft indicative timeline for the deployment of IMT bands and the associated migration timelines, mainly for the 450-470 MHz band. There are some essential conditions for this current draft time plan:

1. The SAPS will finish migration in time and free up their current spectrum by the end of 2014;
2. The broadcasters will complete the DTT process with Analogue Switch Off by mid-2015;
3. Transnet will embark the modernisation from analogue to digital systems;
4. Potential co-existence and other trials for the 450-470 MHz band will be completed by the end of 2016 to enable a decision to be made concerning the options for co-existence; and
5. An overall migration timeframe of 8 years up to 2022 for the 450-470 MHz band is expected to give all players sufficient time for migration.

### 8.2 Calendar of expected activities by year

YEAR	Activities foreseen to take place and deadlines foreseen to occur within the Calendar Year
2014	<ul style="list-style-type: none"> <li>• 380-400 MHz band has already been assigned as PPDR usage band with TETRA as one technological option.</li> <li>• SAPS have already started migration out of 406-420 MHz to TETRA in the 380-387//390-397 MHz band.</li> <li>• The remaining 2x3 MHz in the 380-400 MHz band is available for use by emergency, security, and airport services.</li> <li>• Process of assignment of 700, 800 and 2600 FDD IMT-spectrum starts.</li> </ul>
2015	<ul style="list-style-type: none"> <li>• As per ITU Resolutions 224 WRC07 and 232 WRC12, the DTT process is completed within 470-694 MHz and Analogue Switch Off (ASO) takes place by mid-2015.</li> <li>• Preparation of co-existence trials for 450-470 MHz.</li> <li>• Implementation / rollout of new IMT spectrum (700, 800 and 2600 MHz) starts after ASO.</li> <li>• SAPS finalises network migration frees up spectrum in 406-410//416-420 MHz and 413-416//423-426 MHz. <ul style="list-style-type: none"> <li>• The 406-410//416-420 MHz, 410-413//420-423 MHz and 413-416//423-426 MHz bands free for use for TETRA or PMR networks and services – coordinated by the Authority.</li> </ul> </li> </ul>

2016	<ul style="list-style-type: none"> <li>• Coexistence trials with respect to the 450-470 MHz band will be carried out during 2016 in urban and rural areas. To evaluate guard bands to broadcast channel 21 and TETRA-like narrowband systems (In concordance with potential IMT450-vendors and Transnet).</li> <li>• The 406-410//416-420 MHz and 413-416//423-426 MHz bands potentially deployed as Migration destination bands for TETRA or PMR networks and services,</li> <li>• Other licensees of 450-470 MHz band start migration to: <ul style="list-style-type: none"> <li>• 403-406 MHz (unpaired);</li> <li>• 426-430 MHz (unpaired); or</li> <li>• 440-450<sup>13</sup>MHz bands (paired or unpaired); and</li> <li>• In case of PPDR-use - also to 387-390//397-400 MHz</li> </ul> </li> </ul> <p>migration completed by 2022 (max 7 years).</p> <ul style="list-style-type: none"> <li>• Fixed links (e.g. Telkom) potentially migrated to 2025-2110 MHz band and/or 2200 – 2285 MHz band.</li> <li>• Migration should start in rural areas to clear spectrum for new IMT450 licensees: <ul style="list-style-type: none"> <li>• Phase 1 target: &gt;80% of rural-used licenses is cleared for IMT450 end of 2018 (3 years);</li> <li>• Phase 2: 80% of urban used licenses is cleared for IMT450 end of 2022 (7 years); and</li> <li>• Phase 3: 100% of 450-470 MHz is cleared by end of 2024 (9 years).</li> </ul> </li> </ul>
2017	<p>Depending on co-existence trial results<sup>14</sup>:</p> <ul style="list-style-type: none"> <li>• <b>Co-existence possible:</b> Transnet, SAA or other licensees start migration in co-existence bands within 450-470 MHz, fine tuning of potential splitters, etc.</li> <li>• <b>Migration required:</b> Transnet, SAA and others start migration of operation-relevant services into new destination bands, e.g. TETRA in 410-413//420-423 MHz with spectrum efficient use - target maximum 5 years of migration plus 2 years of dual illumination. <ul style="list-style-type: none"> <li>• Transnet may also opt to migrate to GSM-R<sup>15</sup></li> </ul> </li> </ul>
2018	<ul style="list-style-type: none"> <li>• Present</li> <li>• Potential 2<sup>nd</sup> assignment of TDD IMT spectrum (i.e. IMT750, IMT2600 and IMT3500).</li> <li>• IMT450 licensee starts rollout in 450-470 MHz band in agreed areas (e.g. rural first followed by</li> </ul>

<sup>13</sup> It might be necessary to also clear the 449-450 MHz band to increase IMT-spectrum.

<sup>14</sup> The licensees are at liberty to migrate out of 450-470 MHz earlier, independently from the results of the co-existence trials.

<sup>15</sup> In addition, possibly later to LTE-R in the IMT850 band. It can be anticipated that Transnet (and more probably PRASA) would use a TETRA network for operation and mission critical services and use LTE-R for broadband services. Much of the GSM-R equipment can be reused for LTE-R.

	urban) according to migration Phase 1 where there is no interference to Transnet or other licensees (e.g. reduced power levels); existing licensees remain prioritised.
2020-2022	<ul style="list-style-type: none"> <li>• Target of SA Connect broadband initiative in South Africa is achieved: (ref IMT coverage and capacity obligations in Chapter 0).</li> <li>• Transnet completes migration (deployment) and continues dual illumination phase (in line with Transnet's option 3)</li> </ul>
2024	<ul style="list-style-type: none"> <li>• All licensees have finished spectrum migration or service migration to new operations and shut down all systems in the IMT450 band.</li> <li>• IMT450 licensee reached coverage license obligations.</li> </ul>

### 8.3 Timelines IMT 2020 and beyond

In planning for the development of IMT-2020 as well as future enhancement of the existing IMT, it is important to consider the timelines associated with their realization, which depend on a number of factors:

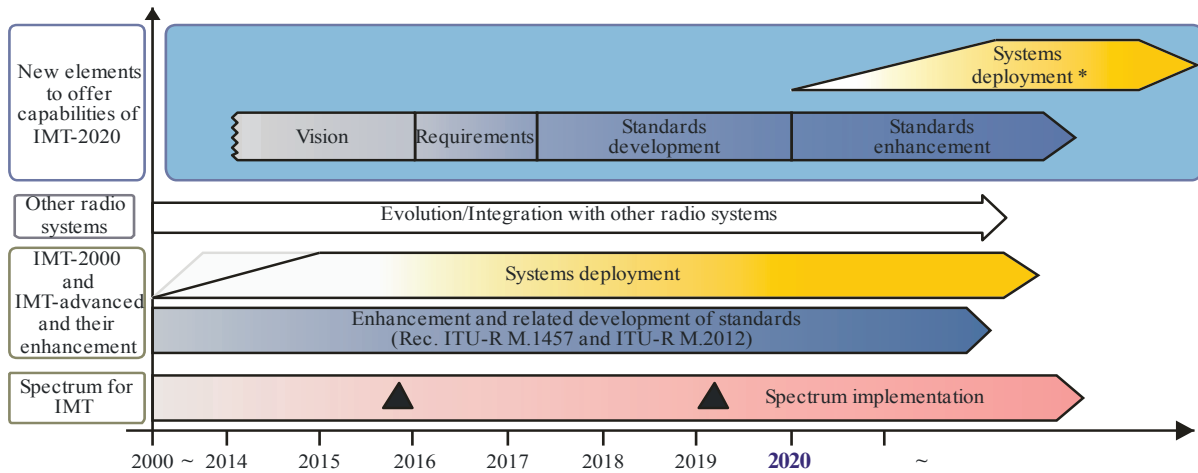
- user trends, requirements and user demand;
- technical capabilities and technology development;
- standards development and their enhancement;
- spectrum matters;
- regulatory considerations;
- system deployment.

All of these factors are interrelated. The first five have been and will continue to be addressed within ITU. System development and deployment relates to the practical aspects of deploying new networks, taking into account the need to minimize additional infrastructure investment and to allow time for customer adoption of the services of a new system. ITU will complete its work for standardization of IMT-2020 no later than the year 2020 to support IMT-2020 deployment by ITU members expected from the year 2020 onwards.

The timelines associated with these different factors are depicted in Fig. 5. When discussing the phases and timelines for IMT-2020, it is important to specify the time at which the standards are completed, when spectrum would be available, and when deployment may start.

FIGURE 5

Phase and expected timelines for IMT-2020



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

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

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

M.2083-05

### 8.3.1 Medium term

In the medium-term (up to about the year 2020) it is envisaged that the future development of IMT-2000 and IMT-Advanced will progress with the ongoing enhancement of the capabilities of the initial deployments, as demanded by the marketplace in addressing user needs and allowed by the status of technical developments. This phase will be dominated by the growth in traffic within the existing IMT spectrum, and the development of IMT-2000 and IMT-Advanced during this time will be distinguished by incremental or evolutionary changes to the existing IMT-2000 and IMT-Advanced radio interface specifications (i.e. Recommendations ITU-R M.1457 for IMT-2000 and ITU-R M.2012 for IMT-Advanced, respectively).

It is envisaged that the bands identified by WRCs will be made available for IMT within this timeframe subject to user demand and other consideration.

### 8.3.2 Long term

The long term (beginning around the year 2020) is associated with the potential introduction of IMT-2020 which could be deployed around the year 2020 in some countries. It is envisaged that IMT-2020 will add enhanced capabilities described in § 5, and they may need additional frequency bands in which to operate.

### 8.4 Workplan, timeline, process and deliverables for the future development of IMT

Working Party 5D has developed a work plan, timeline, process and required deliverables for the future development of IMT, necessary to provide by 2020 timeframe, the expected ITU-R outcome of evolved IMT in support of the next generation of mobile broadband communications systems beyond IMT-Advanced.

Circular Letter(s) are expected to be issued at the appropriate time(s) to announce the invitation to submit formal proposals and other relevant information.

It has been agreed that the well-known process and deliverable formats utilized for both IMT-2000 and IMT-Advanced should be utilized also for IMT-2020 and considered as a “model” for the IMT-2020 deliverables to leverage on the prior work. In WP 5D #20 the process and related deliverables was agreed as shown in Figure 1 and Table 1.

Dates has been decided for RA-19 (21-25 October 2019) and WRC-19 (28 October – 22 November 2019). The WP 5D #32 (July) is the main meeting for year 2019. The WP 5D #33 is to be held in December with a focus on the evaluation process (WG Technology Aspects). If needed there is an opportunity for expert meeting to focus on preparation towards WRC-19 (WG General Aspects and WG Spectrum Aspects) prior to the WP 5D #32 (July).

## Detailed Timeline & Process For IMT-2020 in ITU-R

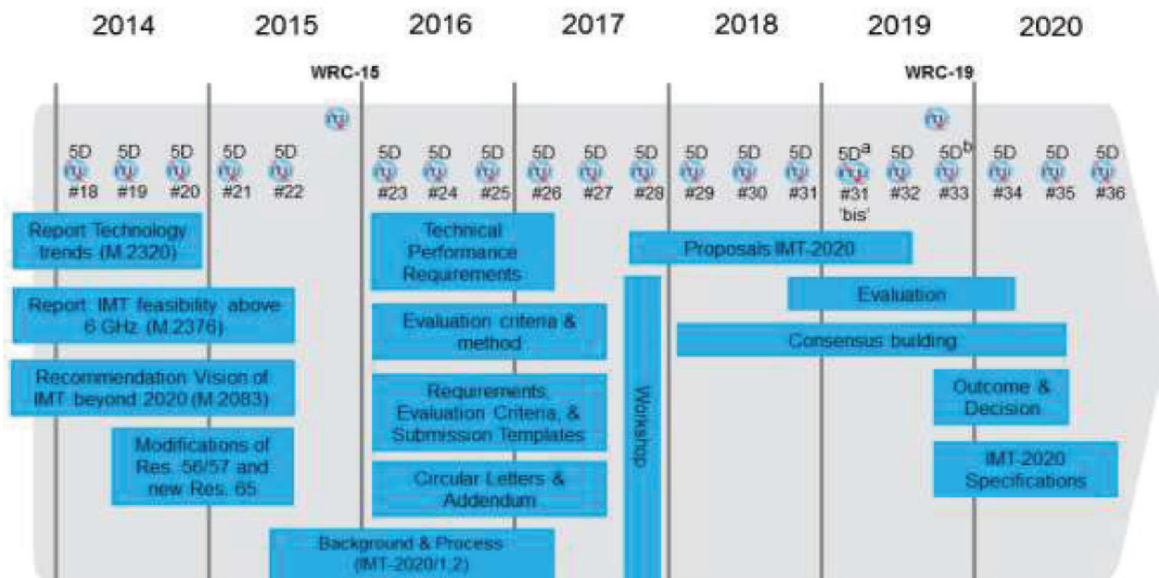




TABLE 11

1 While not expected to change, details may be adjusted if warranted.

Anticipated IMT-2020 related deliverables Item	Proposed IMT-2020 related deliverable	Aspect to be addressed in proposed deliverable	Work start timing	Document completion in WP 5D	IMT-Advanced model document	Responsible WG (and SWG)
1	Doc. IMT-2020/001 IMT-2020 Background”	Background on IMT-2020	Meeting #22 (June 2015)	Meeting #24 (June 2016)	Document IMT-ADV/1 “Background on IMT-Advanced”	WG GEN (SWG CL)
2	Doc. IMT-2020/002 IMT-2020 Process”	The Submission and evaluation process and consensus building for IMT-2020 as well as the “timeline” for IMT-2020	Meeting #22 (June 2015)	Meeting #24 (June 2016)	Document IMT-ADV/2 “Submission and evaluation process and consensus building”	WG TECH (SWG COORD)
3	Draft new Report ITU-R M.[IMT-2020. TECH PERF REQ]	General Technical Performance Requirements expected of a technology to satisfy IMT-2020	Meeting #23 (February 2016)	Meeting #26 (February 2017)	Report ITU-R M.2134 “Requirements related to technical performance for IMT-Advanced radio interface(s)”	WG TECH (SWG RADIO)
4	Draft new Report ITU-R M.[IMT-2020. EVAL]	Evaluation Criteria and Evaluation Methods for IMT-2020 technologies	Meeting #23 (February 2016)	Meeting #27 (June 2017)	Report ITU-R M.2135 “Guidelines for evaluation of radio interface technologies for IMT-Advanced”	WG TECH (SWG EVAL)
5	Draft new Report ITU-R M.[IMT-2020. SUBMISSION]	Specific Requirements of the candidate technology related to submissions, the evaluation criteria and submission templates	Meeting #23 (February 2016)	Meeting #27 (June 2017)	Report ITU-R M.2133 “Requirements, evaluation criteria and submission templates for the development of IMT-Advanced”	WG TECH (SWG COORD)

6	<p><b>Circular Letter IMT-2020</b></p>	<p>The official ITU-R announcement of the IMT-2020 process and the invitation for candidate technology submissions</p>	<p>Meeting #23 (February 2016)</p>	<p>Meeting #36 (October 2020)</p>	<p>Circular Letter 5/LCCE/2 and Addenda <i>“Invitation for submission of proposals for candidate radio interface technologies for the terrestrial components of the radio interface(s) for IMT-Advanced and invitation to participate in their subsequent evaluation”</i> For example, Documents IMT-ADV/4 thru IMT-ADV/9 <i>“Acknowledgement of candidate submission from ..... under step 3 of the IMT-Advanced process (..... technology)”</i></p>	<p>WG GEN (SWG CL)</p>
7	<p><b>Doc. IMT-2020/YYYY Input Submissions Summary</b></p>	<p>Capturing in ITU-R documentation the inputs documents and the initial view of suitability as a valid submission</p>	<p>Meeting #28 (October 2017)</p>	<p>Meeting #32 (July 2019)</p>	<p>WG TECH (SWG COORD)</p>	

## 9 IMT Spectrum and Universal Service Obligations

### 9.1 Objectives of SA Connect

The South Africa Connect broadband policy targets were defined as indicated in Table 18 below:

Target	Penetration measure	Baseline (2013)	By 2016	By 2020	By 2030
Broadband access in Mbps user experience	% of population	33.7% internet access	50% at 5 Mbps	90 % at 5Mbps 50% at 100 Mbps	100% at 10 Mbps 80% at 100 Mbps
Schools	% schools	25% connected	50% at 10 Mbps	100% at 10 Mbps 80% at 100 Mbps	100% at 1 Gbps
Health facilities	% of health facilities	13% connected	50% at 10 Mbps	100% at 10 Mbps 80% at 100 Mbps	100% at 1 Gbps
Government facilities	% of government offices		50% at 5 Mbps	100% at 10 Mbps	100% at 100 Mbps

**Table 18: SA Connect Targets**

Mobile broadband is the critical resource for the provision of broadband for all in South Africa due to the superior roll-out pace possible with wireless and limited reach of fixed access networks with future fibre to the building / home infrastructure unlikely to extend much beyond affluent high-density neighbourhoods in the core urban areas.

### 9.2 Broadband challenge in South Africa

Access to broadband is a necessary condition of economic development in the modern economy. Although attention has been paid to the economic benefits of broadband as calculated by the World Bank, it is probably more accurate to note the converse, that an area that does not have broadband will suffer relative economic decline.

The broadband challenge in all countries is to overcome the specific problems associated with geography and the distribution of population and the manner in which the economic viability of broadband rollout varies from area to area due to the significant differences in financial outlay required and differences in the level of demand (or ability to pay).

A general rule of telecommunications is that, by virtue of geography, it is generally true that the highest revenue customers are the cheapest and easiest to serve as business,

and the rich tend to cluster. The main providers of broadband in South Africa are the mobile customers and it is probably true to say that the mobile providers are fast approaching the point where the economic customers have been captured. In the GSM rollout, a key driver was the need to demonstrate market share and competitive coverage.

Therefore, even when lower frequencies are made available, providers generally consider that rural, underserved areas are uneconomic for the provision of service as income levels are considered to be low. A lack of broadband in a rural area means that those inhabitants will be excluded from participating in the digital economy, exacerbating the disadvantages they have inherited by virtue of their physical address.

In South Africa, the landscape is dominated by a hierarchy of metropolitan areas, with one dominant metropolitan area (Gauteng), three second tier metropolitan areas (Cape Town, Durban and the smaller Port Elizabeth) and then a hierarchy of cities serving sub-regions. The rest of the country is then characterised by two types of economic landscape:

- Areas of low population density characterised by commercial farming areas which towards the west become semi-arid and virtually unpopulated; and
- Areas of relatively high population density characterised by near-subsistence farming with an evenly-dispersed, fairly high density population.

#### **The priority underserved areas**

The map of population density (Figure 16) illustrates this pattern very clearly and equally illustrates the broadband challenge. There are areas of high population density in the north east of the Eastern Cape, substantial areas of Kwa-Zulu Natal and Limpopo and the east of Mpumalanga province which are clearly rural and it is these areas that are generally underserved. As a rough estimate, probably over 80% of the population that is underserved occupies less than 10% of the country's land. The population in these areas is fairly dispersed and it can be contended that it is in these areas that the 700 MHz and 800 MHz bands and potentially the 450-470 MHz band will be required to meet universal service targets<sup>16</sup>. The importance of these bands is that they allow coverage of far wider areas using existing base stations and reducing the number of additional base stations (and subsequently reducing the major cost element).

The licensees assigned to these bands should be subject to strict and enforced coverage targets<sup>17</sup>.

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<sup>16</sup> The Northern Cape and similar areas also provide challenges for coverage, but here the population tends to be more clustered and the problem is more one of backhaul than the frequency used for access.

<sup>17</sup> The value of the digital dividend frequencies to operators probably does lie in the capacity that is made available in areas that already have existing coverage. The value to the nation lies in the potential universal coverage that these bands can provide and the assignment and licensing process should reflect this.

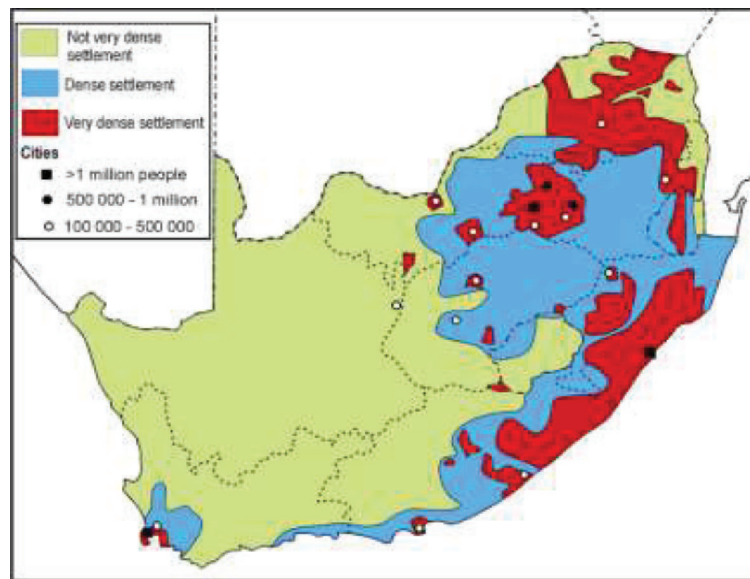


Figure 16: Population densities in South Africa

### 9.3 Considerations for assignment

#### 9.3.1 To link or not to link frequency bands

The Authority has been considering linking low frequencies with high frequencies (for example the 800 MHz band with the 2.6 GHz band). The argument is that this will allow the 2.6 GHz band to be used to provide capacity for 'hotspots' where more capacity is required.

The issue to be considered is what the potential outcomes are if lower frequencies are not linked to higher frequencies:

- A licensee who only has assignments in the lower frequencies may find that the frequencies become congested and capacity cannot be increased in the urban areas which the operator is relying on to make a profit to offset investments; and
- A licensee who only has an assignment in higher bands (such as 2600 MHz or higher) and is not compelled to provide universal service due to the propagation challenges of the band, can simply focus on the urban 'hotspots' (large and small) which generate revenue and by doing so potentially undermine the financial viability of the universal service provider.

These cases are somewhat hypothetical, but do illustrate the issues that need to be considered in effective assignment.

#### 9.3.2 Individual Assignment or Wholesale

The issue of whether the 700 and 800 MHz bands (or even 450-470 MHz band) should be assigned on an individual basis or on a wholesale, open-access basis is beyond the

scope of the present document, however whatever the option that is chosen, obligations should be imposed on the licensee.

#### 9.4 Assignment: Obligations for Licensees

This section illustrates some indicative minimum obligations for licensees of IMT bands in order to achieve universal service targets. However, the details will be aligned with the Broadband policy and contained in the relevant ITA.

Coverage and capacity obligation per IMT band in South Africa:

- 450-470 MHz
  - Coverage obligations for licensee by end of 2025 (mobile terminals assumed):
    - All areas with at least 100 inhabitants to be covered indoor (with indoor penetration assumption of 10 dB) with minimum user data rate of 150 kbps uplink and 300 kbps downlink;
    - All main roads (national and provincial routes) in-car (equal to at least 10 dB penetration assumption) and metropolitan railways<sup>18</sup>(equal to at least 20 dB penetration assumption in carriage).
    - All smaller settlements with less than 100 inhabitants (and more than 20 inhabitants) to be covered outdoor with minimum user data rate of 150 kbps uplink and 300 kbps downlink;
    - Special areas of interest such as tourism areas to be covered outdoor with minimum user data rate in 150 kbps uplink and 300 kbps downlink; and
    - The outdoor obligations could be met by using fixed mobile stations with external high gain antennas and Wi-Fi service distribution. This coverage has to be assigned separately in coverage maps.
  - FDD and TDD: Capacity obligation of minimum uplink and downlink user data rate of 100 kbps for 90% of active users in the cell in the busy hour.
- 700 MHz or 800 MHz (different assignments of 2×5 MHz)
  - Coverage obligations for licensees by end of 2020 (mobile terminals assumed):
    - All centres with at least 1000 inhabitants to be covered indoor (with indoor penetration assumption of 15 dB) with minimum user data rate of 150 kbps uplink and 500 kbps downlink.
  - Capacity obligation of minimum uplink user data rate of 100 kbps for 90% of active users in the cell in the busy hour.
  - Capacity obligation of minimum downlink user data rate of 300 kbps for 90% of active users in the cell in the busy hour.
- 850 MHz (2×5 MHz currently assigned to Neotel, now used for CDMA)

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<sup>18</sup> Transnet (and PRASA) may reuse their existing 450 band antennas to improve in-train broadband coverage via Wi-Fi connectivity for smart terminals.

- Coverage obligations to be defined pending resolution of interference situation with GSM-R.
  - Capacity obligation of minimum uplink user data rate of 100 kbps for 90% of active users in the cell in the busy hour.
  - Capacity obligation of minimum downlink user data rate of 300 kbps for 90% of active users in the cell in the busy hour.
  - Capacity obligations must also be met by current licensees.
- 2300-2400 MHz (different lots of 20 MHz)
    - *Note that 60 MHz are assigned to Telkom and 20 MHz to SMMT, so only 20 MHz is available for new assignments.*
    - TDD: Capacity obligation of minimum uplink and downlink user data rate of 500 kbps for 90% of active users in the cell in the busy hour.
    - Capacity obligations must also be guaranteed by current licensees.
  - 2500-2570 MHz paired with 2620-2690 MHz (different lots of 2×5 MHz) and one TDD licensee for 50 MHz
    - FDD: Capacity obligation of minimum uplink user data rate of 500 kbps for 90% of users in the cell in the busy hour.
    - FDD: Capacity obligation of minimum downlink user data rate of 500 kbps for 90% of active users in the cell in the busy hour.
    - TDD: Capacity obligation of minimum uplink and downlink user data rate of 500 kbps for 90% of active users in the cell in the busy hour.
  - 3400-3600 MHz (different lots of 20 MHz)
    - TDD: Capacity obligation of minimum uplink and downlink user data rate of 500 kbps for 90% of active users in the cell uplink and downlink busy hour.

The minimum service requirements are based on minimum user data rates of current 2G and 3G networks and are intentionally kept low in order to achieve agreement to harmonise minimum service requirements for all bands for all cells. Existing assignments must use these minimum user data rates otherwise there is the risk that operators might implement traffic shifting mechanisms to downgrade users to bands without minimum service requirement obligations. These service requirements will also hold for future assignments in, e.g. 1700-2300 MHz bands.

The minimum service requirements are differentiated with lower requirements in coverage bands below 1 GHz and higher requirements for capacity bands higher than 1 GHz. Therefore, the operators still have the possibility of quality-driven traffic management, while still ensuring a minimum performance in all bands and focusing on higher data rates in higher bands with higher capacity density. This also improves spectral efficiency due to more efficient usage of resources in higher bands.



## 10 Considerations Arising out of IMT Roadmap 2014 & 2018

### 10.1 Considerations IMT Bands for implementation 2014 Roadmap

This process is still ongoing and joins up with the IMT Roadmap 2018. Within this IMT roadmap, the following important recommendations will be highlighted:

#### 450 - 470 band

- The IMT450 band may prove essential for cost-efficient rural coverage for the SA Connect initiative. Potential deployments in IMT700 or IMT800 bands would increase radio access network deployment costs significantly by 55-85% dependent on the target areas and services.
- IMT450 TDD uplink would only slightly reduce coverage and remains the opportunity for uplink-favourable IMT implementation. IMT450 TDD downlink would reduce coverage gain significantly and is not recommended.
- IMT450 has an advantage for IMT TDD due to improved uplink schemes and high uplink demands due to M2M applications. There is the potential for spectrum pairing with higher TDD spectrum bands.
- The IMT450 band might also be attractive to PPDR-supporting services in addition to the SAPS network. 2×5 MHz FDD would be appropriate in this case. TDD is not suggested for PPDR due to reduced coverage characteristics.
- The 450-470 MHz band should be used exclusively for IMT. Potential co-existence scenarios could be deployed dependent on satisfactory trial results:
  - Therefore, the 450-470 MHz band should be used for IMT, for basic broadband coverage in rural areas and potential future services like M2M and connected car application. Both demands will evolve over the following years with the availability of new IMT networks and the availability of devices; and
  - Migration should start as soon as possible dependent on the spectrum vacated by SAPS as one of the targeted destination bands 406-430 MHz,

#### 700 and 800 bands

- IMT700 and IMT800 offer 2×63 MHz (for both ITU Region 1 and ITU Region 3).
- Option 2 and Option 3 (ITU Region 1) offer in addition 10-15 MHz TDD spectrum and are therefore more spectrum-efficient if the TDD band is used;
  - potential channelisation of IMT750 will be decided at WRC-15 and based on WP5D recommendation.



- Option 1 (ITU Region 3) offers a larger ecosystem currently, but ITU Region 3 equipment could also be used in ITU Region 1, at least within the 30 MHz international roaming band.
- In addition, Option 1 (ITU Region 3) would offer 2×10 MHz instead of 2×5 MHz in IMT850 **only if there is no implementation of GSM-R**, but this is not the case for South Africa. Therefore, in this context, the Option 2 and 3 (ITU Region 1) solutions are more advantageous.

#### CDMA and GSM-R

- Neotel's assignment in IMT850 is now 827-832 // 872-877 MHz and overlapping to the GSM-R assignment from 876-880MHz // 921-925 MHz. Neotel has to ensure the migration to 825-830 // 870-875 MHz, which is 1 MHz next to the GSM-R band; therefore the IMT850 licensees need to implement interference mitigation measures (e.g. filters) in areas with GSM-R sites.
- GSM-R is currently deployed by PRASA and it is expected that GSM-R will also have a long term usage. The next possible migration step might be from GSM-R in 877.695-880//921-925 MHz to LTE-R in IMT850 band. GSM-R investment might be optimised in the case of proper usage of SRAN equipment and further upgrades to LTE.

#### 900 band

- The IMT900 migration from GSM to LTE should be possible in 2×5 MHz steps immediately. The additional demands of broadband IMT require spectrum harmonisation to allow licensees to have contiguous assignments. Consolidation will not be initiated until all operators have aligned to Phase 2 (Scenario 3) in order to carry out a one-step migration towards full IMT-usage with 2×5 MHz bands.
- Current guard bands have to be reduced between the operators on mutual agreement to improve spectral efficiency.

#### 1800 and 2100 bands

- Potential migrations of GSM1800 or UMTS2100 bands to broadband IMT1800 or IMT2100 are possible and should be allowed based on operators capacity needs.
- IMT2100 extensions of TDD and FDD spectrum still need to be discussed and agreed at ITU level.

#### 2300 band

- The IMT2300 band is almost fully used. The only free spectrum of 20 MHz could be assigned to WBS to facilitate the clearance of 2550-2565 MHz, which would require new equipment and antennas. There might be a temporary solution for WBS to move their services to 2585-2600 MHz until the new IMT-TDD licensee would need the new spectrum.
  - The 2400-2500 MHz band should be used for ISM applications and DECT-services; In case of interference with 2380-2400 MHz assignments, the ISM-band operator needs to establish a sufficient guard band.

### 2600 band

- IMT2600 should follow the worldwide option 1 with 2×70 MHz FDD and 50 MHz TDD.
- The option could be considered that the IMT TDD spectrum (IMT450, IMT750 and IMT2600) be assigned to one (wholesale) operator to strengthen the TDD ecosystem in South Africa.

### 3500 band

- IMT3500 should be used for 200 MHz for TDD, with special downlink schemes starting from 3400 MHz and uplink schemes ending at 3600 MHz. At least 5 MHz of guard band needs to be used with lower priority. There is a general preference for TDD in higher bands due to the asymmetry of TDD and better decoupling characteristics, especially with the IMT3500 band because of the economy of scale and potential WiMAX to LTE migrations, (which is not relevant for South Africa because FDD is in use now with the tendency of clearing the band by the current licensees).
- If the concept of Managed Spectrum Parks (MSP) is introduced in South Africa, the 5 MHz guard band between downlink and uplink schemes in IMT3500 might be enlarged to 20 MHz for MSP use.

Taking into account all above-mentioned IMT-assignments, the IMT-spectrum bandwidths would increase from 470 MHz to ~1010 MHz.

For all assignments minimum coverage and capacity requirement, thresholds should be introduced to secure capacity demands and meet the targets of SA Connect.

## **10.2 Considerations IMT Roadmap frequency bands for IMT2020 Implementation**

More input required on the time-frame and implementation challenges considering the South African situations, implementation of the bands identified for IMT as well as ITU Region 1 considerations.

See section 8.2 for frequency bands.

## Appendix A Glossary

<b>3G</b>	means 3G or 3rd generation mobile telecommunications is a generation of standards for mobile phones and mobile telecommunication services fulfilling the International Mobile Telecommunications-2000 (IMT-2000) specifications by the ITU
<b>3GPP</b>	means the 3rd Generation Partnership Project (3GPP) which consists of six telecommunications standard development organisations
<b>Act</b>	means the Electronic Communications Act, 2005 (Act No. 36 of 2005);
<b>Amateur</b>	means a person who is interested in the radio technique solely for a private reason and not for financial gain and to whom the Authority has granted an amateur radio station licence and shall mean a natural person and shall not include a juristic person or an association: provided that an amateur radio station licence may be issued to a licensed radio amateur acting on behalf of a duly founded amateur radio association;
<b>APT</b>	means Asia-Pacific Telecommunity which is the focal organisation for ICT in the Asia-Pacific region. The APT has 38 member countries, 4 associate members and 131 affiliate members.
<b>Assignment</b>	means the authorisation given by the authority to a licensee to use a radio frequency or radio frequency channel under specified conditions;
<b>Authority</b>	means ICASA is the Independent Communications Authority of South Africa;
<b>Base station</b>	means a land radio station in the land mobile service for a service with land mobile stations;
<b>BFWA</b>	means Broadband Fixed Wireless Access
<b>BS</b>	means Broadcast Service or Base Station
<b>BTX</b>	means Base Transceiver;
<b>CCTV</b>	means Closed-circuit television
<b>CA</b>	means Carrier Aggregation
<b>CDMA</b>	means Code Division Multiple Access
<b>CEPT</b>	means Conference of European Posts and Telecommunications Authorities;
<b>CoMP</b>	means Co-ordinated Multi Point
<b>DAB</b>	means Digital Audio Broadcasting which is a digital radio technology for broadcasting radio stations
<b>DECT</b>	means Digital Enhanced Cordless Telecommunications 1880 - 1900MHz which is a digital communication standard, primarily used for creating cordless phone systems

<b>DF</b>	means Dual Frequency
<b>DoC</b>	means Department of Communication
<b>DTT</b>	means Digital Terrestrial Television
<b>DTT Mobile</b>	means Digital Terrestrial Television for Mobile services
<b>EIRP</b>	means effective isotropical radiated power;
<b>ERP</b>	means effective radiated power, which is the product of the power supplied to an antenna and its gain relative to a half wave dipole in a given direction;
<b>ECA</b>	means the Electronic Communications ACT of South Africa
<b>EDGE</b>	means Enhanced Data rates for GSM Evolution and is a digital mobile phone technology that allows improved data transmission rates as a backward-compatible extension of GSM
<b>ETSI</b>	means European Telecommunications Standards Institute
<b>FDD</b>	means Frequency Division Duplex
<b>FDMA</b>	means Frequency Division Multiple Access
<b>FMP</b>	means Frequency Migration Plan
<b>FPLMTS</b>	means Future Public Land Mobile Telecommunications System also called IMT-2000
<b>FTBFP 2008</b>	means Final Terrestrial Broadcast Frequency Plan of 2008
<b>FWA</b>	means Fixed Wireless Access
<b>FWBA</b>	means Fixed Wireless Broadband Access
<b>Gbps</b>	means Gigabits per second
<b>GHz</b>	means Gigahertz of Radio Frequency Spectrum;
<b>GSM</b>	means Global System for Mobile Communications,( originally Groupe Spécial Mobile), and is a standard set developed by the European Telecommunications Standards Institute (ETSI) to describe technologies for second generation (2G) digital cellular networks
<b>GSM-R</b>	means GSM for Railways
<b>IEEE</b>	means the Institute of Electrical and Electronics Engineers
<b>IMT</b>	means International Mobile Telecommunications
<b>INMARSAT</b>	means International Maritime Satellite
<b>IoT</b>	means Internet of Things
<b>ISM</b>	means Industrial, Scientific and Medical

<b>ITU</b>	means International Telecommunication Union
<b>ITU RR</b>	means International Telecommunication Union Radio Regulations
<b>kHz</b>	means Kilohertz of Radio Frequency Spectrum
<b>Land mobile service</b>	means a mobile radio-communication service between fixed stations and mobile land stations, or between land mobile stations
<b>LEO</b>	means Low Earth Orbit satellites
<b>LMR</b>	means Land Mobile Radio
<b>Low Power Radio</b>	means radio apparatus, normally hand-held radios used for short range two-way voice communications;
<b>LTE</b>	means Long Term Evolution and is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies
<b>M2M</b>	means Machine to Machine
<b>MFN</b>	means Multiple Frequency Networks
<b>MHz</b>	means Megahertz of Radio Frequency Spectrum;
<b>MIMO</b>	means Multiple-Input and Multiple-Output and is the use of multiple antennas at both the transmitter and receiver to improve communication performance
<b>Mobile station</b>	means a radio station that is intended to be operated while it is in motion or while it is stationary at an unspecified place
<b>Model Control apparatus</b>	means radio apparatus used to control the movement of the model in the air, on land or over or under the water surface
<b>MTX</b>	means Mobile Transceiver
<b>Non-specific Short Range Devices</b>	means radio apparatus used for general telemetry, telecommand, alarms and data applications with a pre-set duty cycle (0.1%: S duty cycle < 100%)
<b>NRFP</b>	means the National Radio Frequency Plan 2013 for South Africa
<b>OB</b>	means Outside Broadcast
<b>PAMR</b>	means Public Access Mobile Radio
<b>PMR</b>	means Public Mobile Radio and is radio apparatus used for short range two-way voice communications;
<b>PPDR</b>	means Public Protection and Disaster Relief as defined in ITU-R Report M.2033.
<b>PRASA</b>	Means Passenger Rail Agency of South Africa
<b>PtM</b>	means Point to Multipoint
<b>PtP</b>	means Point to Point

<b>RATG</b>	means Radio Access Technology Group
<b>Radio trunking</b>	means a technique by means of which free channels out of a group of radio frequency channels allocated to a base station are automatically made available for the establishment of a connection between the stations of a user
<b>Radio-communication</b>	means all electronic communication by means of radio waves;
<b>Relay or repeater station</b>	means a land station in the land mobile service;
<b>RFID</b>	means Radio Frequency IDentification and is a wireless system that uses radio frequency communication to automatically identify, track and manage objects, people or animals. It consist of two main components viz, a tag and a reader which are tuned to the same frequency
<b>RFSAP</b>	means Radio Frequency Spectrum Assignment Plan
<b>RLAN</b>	means Radio Local Access Network and is the high data rate two-way (duplex) wireless data communications network
<b>SABRE</b>	means South African Band Re-planning Exercise
<b>SADC</b>	means Southern African Development Community
<b>SADC FAP</b>	means Southern African Development Community Frequency Allocation Plan 2010
<b>SAPS</b>	means South African Police Service
<b>Self Helps</b>	means repeater stations rebroadcasting television channels to limited areas on a low power basis
<b>Service licence</b>	means a BS, ECS or ECNS licence;
<b>SF</b>	means Single Frequency
<b>SFN</b>	means Single Frequency Network
<b>Ship station</b>	means a mobile station in the maritime mobile service that has been erected
<b>SNG</b>	means Satellite News Gathering
<b>Spread spectrum</b>	means a form of wireless communications in which the frequency of the transmitted signal is deliberately varied, resulting in a much greater bandwidth than the signal would have if its frequency were not varied
<b>SRD</b>	means Short Range Device and is a piece of apparatus which includes a transmitter, and/or a receiver and or parts thereof, used in alarm, telecommand telemetry applications, etc., operating with analogue speech/music or data (analogue and/or digital) or with combined analogue speech/music and data, using any modulation type intended to operate over short distances;

<b>STL or Studio Links</b>	means point to point links in the broadcasting frequency bands used to connect studios to transmitters
<b>STB</b>	means Set Top Box for DVB-T2 reception
<b>T-DAB</b>	means Terrestrial Digital Audio Broadcasting
<b>TDD</b>	means Time Division Duplex
<b>TDMA</b>	means Time Division Multiple Access
<b>Telemetry</b>	means the transmission of remotely measured data
<b>TETRA</b>	means Terrestrial Trunked Radio and is a professional mobile radio [2] and two-way transceiver specification. TETRA was specifically designed for use by government agencies, emergency services, (police forces, fire departments, ambulance) for public safety networks, rail transportation staff for train radios, transport services and the military. TETRA is an ETSI standard.
<b>UE</b>	means user equipment
<b>UHF</b>	means Ultra High Frequency
<b>UMTS</b>	means Universal Mobile Telecommunications System is a third generation mobile cellular technology for networks based on the GSM standard
<b>VHF</b>	means Very High Frequency
<b>Video Surveillance Equipment</b>	means radio apparatus used for security camera purposes to replace the cable between a camera and a monitor
<b>VSAT</b>	means Very Small Aperture Terminal and is a two-way satellite ground station that is smaller than 3 metres in diameter
<b>WAS</b>	means Wireless Access Systems and is end-user radio connections to public or private core networks;
<b>WBS</b>	means Wireless Business Solutions which is a provider of wireless broadband
<b>Wideband Wireless Systems</b>	means radio apparatus that uses spread spectrum techniques and has a high bit rate;
<b>WiMAX</b>	means Worldwide Interoperability for Microwave Access, also known as WirelessMAN which is a wireless broadband standard
<b>WP 5D</b>	means ITU-R Working Party 5D - IMT Systems
<b>WRC 07</b>	means World Radio Conference 2007 held in Geneva
<b>WRC 12</b>	means World Radio Conference 2012 held in Geneva
<b>WRC 15</b>	means the World Radio Conference held in Geneva 2015

<b>WRC 19</b>
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means the World Radio Conference planned to be held in Geneva 2019
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## A.1 Definitions

### A.1.1 ITU Definitions

The standard definitions for spectrum management in the International Telecommunication Union (ITU) Radio regulations (Article 1) are as follows:

**allocation** (of a frequency band): Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space *radiocommunication services* or the *radio astronomy service* under specified conditions. This term shall also be applied to the frequency band concerned. (1.16);

**allotment** (of a radio frequency or radio frequency channel): Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more administrations for a terrestrial or space *radiocommunication service* in one or more identified countries or geographical areas and under specified conditions. (1.17); and

**assignment** (of a radio frequency or radio frequency channel): Authorisation given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions. (1.18).

The ITU does not define spectrum migration as such.

In the Act, the reference to spectrum migration is clearly the migration of users of radio frequency spectrum to other radio frequency bands in accordance with the radio frequency plan. The main focus of the „FREQUENCY MIGRATION PLAN” is on migrating existing users.

Since certain issues of spectrum migration involve usage as opposed to users, it is useful to expand the definition of migration to include not just users but also uses. Therefore the Authority’s definition of radio frequency migration is:

**“Radio Frequency Spectrum Migration”** means the movement of users or uses of radio frequency spectrum from their existing radio frequency spectrum location to another.

### A.1.2 Spectrum re-farming

The term spectrum re-farming is widely used, but like spectrum migration does not have a universal definition and can mean slightly different things in different countries.



The ICT Regulation Toolkit<sup>19</sup> describes spectrum re-farming:

*as a process constituting any basic change in conditions of frequency usage in a given part of radio spectrum (see The ICT Regulation Toolkit)<sup>20</sup>.*

*Such basic changes might be:*

1. *Change of technical conditions for frequency assignments;*
2. *Change of application (particular radiocommunication system using the band); and*
3. *Change of allocation to a different radiocommunication service.*

The term re-farming is used to describe:

- The process where a GSM operator changes the use of all or part of the spectrum used for GSM to UMTS / LTE; especially where the spectrum licence has specified the technology (as GSM) and the operator licence has to be changed<sup>21</sup>.
- The situation where the individual assignments within a band are changed to allow more efficient use to be made of the frequency band (usually due to a change in technology).
- The process of reallocating and reassigning frequency bands where the licence period has expired. This is happening in Europe where the original GSM licences are expiring. For the purposes of the plan therefore, radio frequency spectrum re-farming may be defined as follows:

*"Radio Frequency Spectrum Re-farming" means the process by which the use of a Radio Frequency Spectrum band is changed following a change in allocation, this may include a change in the specified technology and does not necessarily mean that the licensed user has to vacate the frequency.*

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<sup>19</sup>This allows spectrum migration to encompass re-farming of spectrum within assigned bands, other technologies and in-band migration such as the digitalisation of TV broadcast.

<sup>20</sup> The ICT Regulation Toolkit is a joint production of infoDev and the International Telecommunication Union

<sup>21</sup> Even where the licences are not technologically-specific and it could be argued that the change in use from GSM to LTE does not require a regulator to get involved; in order to make efficient use of the spectrum it may be necessary to modify the individual assignments within the band.

# **Appendix B – Additional Information 1.427- 1.518 GHz**

1.4 GHz channel plans TR13-01(A) ITU-R F.1242  
Annex A (new plan)

CEPT Band 1.4 GHz (F.S) Ctr.Freq Ch.Width Separ. Ch.Spac. Ctr.Gap		TR13-01(A) 1.4 GHz (F.S) 1433.5 MHz 25 kHz 142 MHz 100x25 kHz 117 MHz				CEPT Band 1.4 GHz (F.S) 1433.5 MHz Ch.Width Separ. Ch.Spac. Ctr.Gap		TR13-01(A) 1.4 GHz (F.S) 1433.5 MHz 25 kHz 142 MHz 15x250 kHz 117 MHz				CEPT Band 1.4 GHz (F.S) 1433.5 MHz Ch.Width Separ. Ch.Spac. Ctr.Gap		TR13-01(A) 1.4 GHz (F.S) 1433.5 MHz 500 kHz 142 MHz 35x500 kHz 117 MHz		Old plan
Ch.	Go	Retura	Ch.	Go	Retura	Ch.	Go	Retura	Ch.	Go	Retura	Ch.	Go	Retura	channel nu	
1	1350.5125	1492.5125	37	1351.4125	1493.4125	73	1352.3125	1494.3125	9	1355.1250	1497.1250	1	1357.2500	1499.2500	109	
2	1350.5375	1492.5375	38	1351.4375	1493.4375	74	1352.3375	1494.3375	10	1355.3750	1497.3750	2	1357.7500	1499.7500	110	
3	1350.5625	1492.5625	39	1351.4625	1493.4625	75	1352.3625	1494.3625	11	1355.6250	1497.6250	3	1358.2500	1500.2500	111	
4	1350.5875	1492.5875	40	1351.4875	1493.4875	76	1352.3875	1494.3875	12	1355.8750	1497.8750	4	1358.7500	1500.7500	112	
5	1350.6125	1492.6125	41	1351.5125	1493.5125	77	1352.4125	1494.4125	13	1356.1250	1498.1250	5	1359.2500	1501.2500	113	
6	1350.6375	1492.6375	42	1351.5375	1493.5375	78	1352.4375	1494.4375	14	1356.3750	1498.3750	6	1359.7500	1501.7500	114	
7	1350.6625	1492.6625	43	1351.5625	1493.5625	79	1352.4625	1494.4625	15	1356.6250	1498.6250	7	1360.2500	1502.2500	115	
8	1350.6875	1492.6875	44	1351.5875	1493.5875	80	1352.4875	1494.4875				8	1360.7500	1502.7500	116	
9	1350.7125	1492.7125	45	1351.6125	1493.6125	81	1352.5125	1494.5125				9	1361.2500	1503.2500	117	
10	1350.7375	1492.7375	46	1351.6375	1493.6375	82	1352.5375	1494.5375				10	1361.7500	1503.7500	118	
11	1350.7625	1492.7625	47	1351.6625	1493.6625	83	1352.5625	1494.5625				11	1362.2500	1504.2500	119	
12	1350.7875	1492.7875	48	1351.6875	1493.6875	84	1352.5875	1494.5875				12	1362.7500	1504.7500	120	
13	1350.8125	1492.8125	49	1351.7125	1493.7125	85	1352.6125	1494.6125				13	1363.2500	1505.2500	121	
14	1350.8375	1492.8375	50	1351.7375	1493.7375	86	1352.6375	1494.6375				14	1363.7500	1505.7500	122	
15	1350.8625	1492.8625	51	1351.7625	1493.7625	87	1352.6625	1494.6625				15	1364.2500	1506.2500	123	
16	1350.8875	1492.8875	52	1351.7875	1493.7875	88	1352.6875	1494.6875				16	1364.7500	1506.7500	124	
17	1350.9125	1492.9125	53	1351.8125	1493.8125	89	1352.7125	1494.7125				17	1365.2500	1507.2500	125	
18	1350.9375	1492.9375	54	1351.8375	1493.8375	90	1352.7375	1494.7375				18	1365.7500	1507.7500	126	
19	1350.9625	1492.9625	55	1351.8625	1493.8625	91	1352.7625	1494.7625				19	1366.2500	1508.2500	127	
20	1350.9875	1492.9875	56	1351.8875	1493.8875	92	1352.7875	1494.7875				20	1366.7500	1508.7500	128	
21	1351.0125	1493.0125	57	1351.9125	1493.9125	93	1352.8125	1494.8125				21	1367.2500	1509.2500	129	
22	1351.0375	1493.0375	58	1351.9375	1493.9375	94	1352.8375	1494.8375				22	1367.7500	1509.7500	130	
23	1351.0625	1493.0625	59	1351.9625	1493.9625	95	1352.8625	1494.8625				23	1368.2500	1510.2500	131	
24	1351.0875	1493.0875	60	1351.9875	1493.9875	96	1352.8875	1494.8875				24	1368.7500	1510.7500	132	
25	1351.1125	1493.1125	61	1352.0125	1494.0125	97	1352.9125	1494.9125				25	1369.2500	1511.2500	133	
26	1351.1375	1493.1375	62	1352.0375	1494.0375	98	1352.9375	1494.9375				26	1369.7500	1511.7500	134	
27	1351.1625	1493.1625	63	1352.0625	1494.0625	99	1352.9625	1494.9625				27	1370.2500	1512.2500	135	
28	1351.1875	1493.1875	64	1352.0875	1494.0875	100	1352.9875	1494.9875				28	1370.7500	1512.7500	136	
29	1351.2125	1493.2125	65	1352.1125	1494.1125	1	1355.1250	1495.1250				29	1371.2500	1513.2500	137	
30	1351.2375	1493.2375	66	1352.1375	1494.1375	2	1355.3750	1495.3750				30	1371.7500	1513.7500	138	
31	1351.2625	1493.2625	67	1352.1625	1494.1625	3	1355.6250	1495.6250				31	1372.2500	1514.2500	139	
32	1351.2875	1493.2875	68	1352.1875	1494.1875	4	1355.8750	1495.8750				32	1372.7500	1514.7500	140	
33	1351.3125	1493.3125	69	1352.2125	1494.2125	5	1356.1250	1496.1250				33	1373.2500	1515.2500	141	
34	1351.3375	1493.3375	70	1352.2375	1494.2375	6	1356.3750	1496.3750				34	1373.7500	1515.7500	142	
35	1351.3625	1493.3625	71	1352.2625	1494.2625	7	1356.6250	1496.6250				35	1374.2500	1516.2500	143	
36	1351.3875	1493.3875	72	1352.2875	1494.2875	8	1356.8750	1496.8750								
		25 kHz shared					250 kHz shared						500 kHz shared			
		continue Annex B on next sheet					Typical users									
							Eskom									
							Transnet									
							SAPS									
							SANDF									
							Ekurhuleni									
							National Research Foundation									

<b>Annex B (new plan)</b>			
	CEPT TR13-01(B)		
	Band 1.4 GHz (F.S)		
	Ctr.Freq 1413.5 MHz		
	Ch.Width 500 kHz		
	Separ. 52 MHz		
	Ch.Spac. 48x500 kHz		
	Ctr.Gap 27 MHz		
<b>Ch.</b>	<b>Go</b>	<b>Return</b>	
1	1375.7500	1427.7500	
2	1376.2500	1428.2500	
3	1376.7500	1428.7500	
4	1377.2500	1429.2500	
5	1377.7500	1429.7500	
6	1378.2500	1430.2500	
7	1378.7500	1430.7500	
8	1379.2500	1431.2500	
9	1379.7500	1431.7500	
10	1380.2500	1432.2500	Telkom
11	1380.7500	1432.7500	
12	1381.2500	1433.2500	Telkom
13	1381.7500	1433.7500	
14	1382.2500	1434.2500	
15	1382.7500	1434.7500	
16	1383.2500	1435.2500	
17	1383.7500	1435.7500	
18	1384.2500	1436.2500	
19	1384.7500	1436.7500	
20	1385.2500	1437.2500	
21	1385.7500	1437.7500	
22	1386.2500	1438.2500	
23	1386.7500	1438.7500	
24	1387.2500	1439.2500	
25	1387.7500	1439.7500	
26	1388.2500	1440.2500	
27	1388.7500	1440.7500	
28	1389.2500	1441.2500	
29	1389.7500	1441.7500	
30	1390.2500	1442.2500	
31	1390.7500	1442.7500	
32	1391.2500	1443.2500	
33	1391.7500	1443.7500	
34	1392.2500	1444.2500	
35	1392.7500	1444.7500	
36	1393.2500	1445.2500	
37	1393.7500	1445.7500	
38	1394.2500	1446.2500	
39	1394.7500	1446.7500	Telkom
40	1395.2500	1447.2500	Telkom
41	1395.7500	1447.7500	Telkom
42	1396.2500	1448.2500	Telkom
43	1396.7500	1448.7500	Telkom
44	1397.2500	1449.2500	Telkom
45	1397.7500	1449.7500	Telkom
46	1398.2500	1450.2500	Telkom
47	1398.7500	1450.7500	Telkom
48	1399.2500	1451.2500	Telkom

Single (or simplex) frequency channels (shared) [Intended for migration of links < 1 GHz]									
ITU / CEPT		Based on REC ITU-R F.1242							
Band		1.5 GHz (F.S) Simplex							
Ctr.Freq		-							
Ch.Width		7x500 kHz & 140x25 kHz							
Separ.		-							
Ch.Spac.		7x 500 kHz & 140x 25 kHz							
Ctr.Gap		-							
Ck.		Ck.		Ck.		Ck.		Ck.	
1(IMT)	1517.75	37	1521.7375	73	1522.6375	109	1523.5375	145	1524.4375
2(IMT)	1518.25	38	1521.7625	74	1522.6625	110	1523.5625	146	1524.4625
3	1518.75	39	1521.7875	75	1522.6875	111	1523.5875	147	1524.4875
4	1519.25	40	1521.8125	76	1522.7125	112	1523.6125		
5	1519.75	41	1521.8375	77	1522.7375	113	1523.6375		
6	1520.25	42	1521.8625	78	1522.7625	114	1523.6625		
7	1520.75	43	1521.8875	79	1522.7875	115	1523.6875		
8	1521.0125	44	1521.9125	80	1522.8125	116	1523.7125		
9	1521.0375	45	1521.9375	81	1522.8375	117	1523.7375		
10	1521.0625	46	1521.9625	82	1522.8625	118	1523.7625		
11	1521.0875	47	1521.9875	83	1522.8875	119	1523.7875		
12	1521.1125	48	1522.0125	84	1522.9125	120	1523.8125		
13	1521.1375	49	1522.0375	85	1522.9375	121	1523.8375		
14	1521.1625	50	1522.0625	86	1522.9625	122	1523.8625		
15	1521.1875	51	1522.0875	87	1522.9875	123	1523.8875		
16	1521.2125	52	1522.1125	88	1523.0125	124	1523.9125		
17	1521.2375	53	1522.1375	89	1523.0375	125	1523.9375		
18	1521.2625	54	1522.1625	90	1523.0625	126	1523.9625		
19	1521.2875	55	1522.1875	91	1523.0875	127	1523.9875		
20	1521.3125	56	1522.2125	92	1523.1125	128	1524.0125		
21	1521.3375	57	1522.2375	93	1523.1375	129	1524.0375		
22	1521.3625	58	1522.2625	94	1523.1625	130	1524.0625		
23	1521.3875	59	1522.2875	95	1523.1875	131	1524.0875		
24	1521.4125	60	1522.3125	96	1523.2125	132	1524.1125		
25	1521.4375	61	1522.3375	97	1523.2375	133	1524.1375		
26	1521.4625	62	1522.3625	98	1523.2625	134	1524.1625		
27	1521.4875	63	1522.3875	99	1523.2875	135	1524.1875		
28	1521.5125	64	1522.4125	100	1523.3125	136	1524.2125		
29	1521.5375	65	1522.4375	101	1523.3375	137	1524.2375		
30	1521.5625	66	1522.4625	102	1523.3625	138	1524.2625		
31	1521.5875	67	1522.4875	103	1523.3875	139	1524.2875		
32	1521.6125	68	1522.5125	104	1523.4125	140	1524.3125		
33	1521.6375	69	1522.5375	105	1523.4375	141	1524.3375		
34	1521.6625	70	1522.5625	106	1523.4625	142	1524.3625		
35	1521.6875	71	1522.5875	107	1523.4875	143	1524.3875		
36	1521.7125	72	1522.6125	108	1523.5125	144	1524.4125		

## **Appendix C – Additional information on 24.25-27.5 GHz**



# **Appendix D      Additional information for 37- 40.5 GHz**



F.749-1 BAND Ctr-FREQ Ch.Width Separ. Ch.Spac. Ctr. Gap Ch.	A			B			B			F.749-1			C			C			F.749-1			C			BAND Ctr-FREQ Ch.Width Separ. Ch.Spac. Ctr. Gap Ch.				
	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.		
1	37066.0000	38346.0000	1	37072.0000	38532.0000	38	38108.0000	39368.0000	1	37065.0000	38325.0000	38	37583.0000	38843.0000	75	38101.0000	39561.0000	38	37583.0000	38843.0000	75	38101.0000	39561.0000	38	37583.0000	38843.0000	75	38101.0000	39561.0000
2	37142.0000	38402.0000	2	37100.0000	38560.0000	33	38186.0000	39386.0000	2	37079.0000	38339.0000	33	37597.0000	38857.0000	76	38115.0000	39375.0000	33	37597.0000	38857.0000	76	38115.0000	39375.0000	33	37597.0000	38857.0000	76	38115.0000	39375.0000
3	37198.0000	38458.0000	3	37128.0000	38588.0000	40	38164.0000	39424.0000	3	37093.0000	38353.0000	40	37611.0000	38871.0000	77	38129.0000	39389.0000	40	37611.0000	38871.0000	77	38129.0000	39389.0000	40	37611.0000	38871.0000	77	38129.0000	39389.0000
4	37254.0000	38514.0000	4	37155.0000	38616.0000				4	37107.0000	38367.0000	41	37625.0000	38885.0000	78	38143.0000	39403.0000	41	37625.0000	38885.0000	78	38143.0000	39403.0000	41	37625.0000	38885.0000	78	38143.0000	39403.0000
5	37310.0000	38570.0000	5	37184.0000	38644.0000				5	37121.0000	38381.0000	42	37639.0000	38899.0000	79	38157.0000	39417.0000	42	37639.0000	38899.0000	79	38157.0000	39417.0000	42	37639.0000	38899.0000	79	38157.0000	39417.0000
6	37366.0000	38626.0000	6	37212.0000	38672.0000				6	37155.0000	38395.0000	43	37653.0000	38913.0000	80	38171.0000	39431.0000	43	37653.0000	38913.0000	80	38171.0000	39431.0000	43	37653.0000	38913.0000	80	38171.0000	39431.0000
7	37422.0000	38682.0000	7	37240.0000	38700.0000				7	37143.0000	38409.0000	44	37667.0000	38927.0000				44	37667.0000	38927.0000				44	37667.0000	38927.0000			
8	37478.0000	38738.0000	8	37268.0000	38728.0000				8	37163.0000	38423.0000	45	37681.0000	38941.0000				45	37681.0000	38941.0000				45	37681.0000	38941.0000			
9	37534.0000	38794.0000	9	37296.0000	38756.0000				9	37177.0000	38437.0000	46	37695.0000	38955.0000				46	37695.0000	38955.0000				46	37695.0000	38955.0000			
10	37590.0000	38850.0000	10	37324.0000	38784.0000				10	37191.0000	38451.0000	47	37709.0000	38969.0000				47	37709.0000	38969.0000				47	37709.0000	38969.0000			
11	37646.0000	38906.0000	11	37352.0000	38812.0000				11	37205.0000	38465.0000	48	37723.0000	38983.0000				48	37723.0000	38983.0000				48	37723.0000	38983.0000			
12	37702.0000	38962.0000	12	37380.0000	38840.0000				12	37219.0000	38479.0000	49	37737.0000	38997.0000				49	37737.0000	38997.0000				49	37737.0000	38997.0000			
13	37758.0000	39018.0000	13	37408.0000	38868.0000				13	37233.0000	38493.0000	50	37751.0000	39011.0000				50	37751.0000	39011.0000				50	37751.0000	39011.0000			
14	37814.0000	39074.0000	14	37436.0000	38896.0000				14	37247.0000	38507.0000	51	37765.0000	39025.0000				51	37765.0000	39025.0000				51	37765.0000	39025.0000			
15	37870.0000	39130.0000	15	37464.0000	38924.0000				15	37261.0000	38521.0000	52	37779.0000	39039.0000				52	37779.0000	39039.0000				52	37779.0000	39039.0000			
16	37926.0000	39186.0000	16	37492.0000	38952.0000				16	37275.0000	38535.0000	53	37793.0000	39053.0000				53	37793.0000	39053.0000				53	37793.0000	39053.0000			
17	37982.0000	39242.0000	17	37520.0000	38980.0000				17	37289.0000	38549.0000	54	37807.0000	39067.0000				54	37807.0000	39067.0000				54	37807.0000	39067.0000			
18	38038.0000	39298.0000	18	37548.0000	38998.0000				18	37303.0000	38563.0000	55	37821.0000	39081.0000				55	37821.0000	39081.0000				55	37821.0000	39081.0000			
19	38094.0000	39354.0000	19	37576.0000	39006.0000				19	37317.0000	38577.0000	56	37835.0000	39095.0000				56	37835.0000	39095.0000				56	37835.0000	39095.0000			
20	38150.0000	39410.0000	20	37604.0000	39034.0000				20	37331.0000	38591.0000	57	37849.0000	39109.0000				57	37849.0000	39109.0000				57	37849.0000	39109.0000			
			21	37632.0000	39062.0000				21	37345.0000	38605.0000	58	37863.0000	39123.0000				58	37863.0000	39123.0000				58	37863.0000	39123.0000			
			22	37660.0000	39090.0000				22	37359.0000	38619.0000	59	37877.0000	39137.0000				59	37877.0000	39137.0000				59	37877.0000	39137.0000			
			23	37688.0000	39118.0000				23	37373.0000	38633.0000	60	37891.0000	39151.0000				60	37891.0000	39151.0000				60	37891.0000	39151.0000			
			24	37716.0000	39146.0000				24	37387.0000	38647.0000	61	37905.0000	39165.0000				61	37905.0000	39165.0000				61	37905.0000	39165.0000			
			25	37744.0000	39174.0000				25	37401.0000	38661.0000	62	37919.0000	39179.0000				62	37919.0000	39179.0000				62	37919.0000	39179.0000			
			26	37772.0000	39202.0000				26	37415.0000	38675.0000	63	37933.0000	39193.0000				63	37933.0000	39193.0000				63	37933.0000	39193.0000			
			27	37800.0000	39230.0000				27	37429.0000	38689.0000	64	37947.0000	39207.0000				64	37947.0000	39207.0000				64	37947.0000	39207.0000			
			28	37828.0000	39258.0000				28	37443.0000	38703.0000	65	37961.0000	39221.0000				65	37961.0000	39221.0000				65	37961.0000	39221.0000			
			29	37856.0000	39286.0000				29	37457.0000	38717.0000	66	37975.0000	39235.0000				66	37975.0000	39235.0000				66	37975.0000	39235.0000			
			30	37884.0000	39314.0000				30	37471.0000	38731.0000	67	37989.0000	39249.0000				67	37989.0000	39249.0000				67	37989.0000	39249.0000			
			31	37912.0000	39342.0000				31	37485.0000	38745.0000	68	38003.0000	39263.0000				68	38003.0000	39263.0000				68	38003.0000	39263.0000			
			32	37940.0000	39370.0000				32	37499.0000	38759.0000	69	38017.0000	39277.0000				69	38017.0000	39277.0000				69	38017.0000	39277.0000			
			33	37968.0000	39398.0000				33	37513.0000	38773.0000	70	38031.0000	39291.0000				70	38031.0000	39291.0000				70	38031.0000	39291.0000			
			34	37996.0000	39426.0000				34	37527.0000	38787.0000	71	38045.0000	39305.0000				71	38045.0000	39305.0000				71	38045.0000	39305.0000			
			35	38024.0000	39454.0000				35	37541.0000	38801.0000	72	38059.0000	39319.0000				72	38059.0000	39319.0000				72	38059.0000	39319.0000			
			36	38052.0000	39482.0000				36	37555.0000	38815.0000	73	38073.0000	39333.0000				73	38073.0000	39333.0000				73	38073.0000	39333.0000			
			37	38080.0000	39510.0000				37	37569.0000	38829.0000	74	38087.0000	39347.0000				74	38087.0000	39347.0000				74	38087.0000	39347.0000			

F.749-1				F.749-1				F.749-1				F.749-1			
BAND	D			D			D			D			BAND		
38 GHz	38 GHz			38 GHz			38 GHz			38 GHz			38 GHz		
38248.000	38248.000			38248.000			38248.000			38248.000			38248.000		
7 MHz	7 MHz			7 MHz			7 MHz			7 MHz			7 MHz		
1260 MHz	1260 MHz			1260 MHz			1260 MHz			1260 MHz			1260 MHz		
140 MHz	140 MHz			140 MHz			140 MHz			140 MHz			140 MHz		
Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.
1	37061.5000	38321.5000	38	37320.5000	38580.5000	75	37579.5000	38839.5000	152	37838.5000	39098.5000	153	38097.5000	39357.5000	143
2	37066.5000	38326.5000	39	37325.5000	38585.5000	76	37584.5000	38844.5000	153	37843.5000	39103.5000	150	38102.5000	39362.5000	150
3	37071.5000	38331.5000	40	37330.5000	38590.5000	77	37589.5000	38849.5000	154	37848.5000	39108.5000	151	38107.5000	39367.5000	151
4	37076.5000	38336.5000	41	37335.5000	38595.5000	78	37594.5000	38854.5000	155	37853.5000	39113.5000	152	38112.5000	39372.5000	152
5	37081.5000	38341.5000	42	37340.5000	38600.5000	79	37599.5000	38859.5000	156	37858.5000	39118.5000	153	38117.5000	39377.5000	153
6	37086.5000	38346.5000	43	37345.5000	38605.5000	80	37604.5000	38864.5000	157	37863.5000	39123.5000	154	38122.5000	39382.5000	154
7	37091.5000	38351.5000	44	37350.5000	38610.5000	81	37609.5000	38869.5000	158	37868.5000	39128.5000	155	38127.5000	39387.5000	155
8	37096.5000	38356.5000	45	37355.5000	38615.5000	82	37614.5000	38874.5000	159	37873.5000	39133.5000	156	38132.5000	39392.5000	156
9	37101.5000	38361.5000	46	37360.5000	38620.5000	83	37619.5000	38879.5000	160	37878.5000	39138.5000	157	38137.5000	39397.5000	157
10	37106.5000	38366.5000	47	37365.5000	38625.5000	84	37624.5000	38884.5000	161	37883.5000	39143.5000	158	38142.5000	39402.5000	158
11	37111.5000	38371.5000	48	37370.5000	38630.5000	85	37629.5000	38889.5000	162	37888.5000	39148.5000	159	38147.5000	39407.5000	159
12	37116.5000	38376.5000	49	37375.5000	38635.5000	86	37634.5000	38894.5000	163	37893.5000	39153.5000	160	38152.5000	39412.5000	160
13	37121.5000	38381.5000	50	37380.5000	38640.5000	87	37639.5000	38899.5000	164	37898.5000	39158.5000				
14	37126.5000	38386.5000	51	37385.5000	38645.5000	88	37644.5000	38904.5000	165	37903.5000	39163.5000				
15	37131.5000	38391.5000	52	37390.5000	38650.5000	89	37649.5000	38909.5000	166	37908.5000	39168.5000				
16	37136.5000	38396.5000	53	37395.5000	38655.5000	90	37654.5000	38914.5000	167	37913.5000	39173.5000				
17	37141.5000	38401.5000	54	37400.5000	38660.5000	91	37659.5000	38919.5000	168	37918.5000	39178.5000				
18	37146.5000	38406.5000	55	37405.5000	38665.5000	92	37664.5000	38924.5000	169	37923.5000	39183.5000				
19	37151.5000	38411.5000	56	37410.5000	38670.5000	93	37669.5000	38929.5000	170	37928.5000	39188.5000				
20	37156.5000	38416.5000	57	37415.5000	38675.5000	94	37674.5000	38934.5000	171	37933.5000	39193.5000				
21	37161.5000	38421.5000	58	37420.5000	38680.5000	95	37679.5000	38939.5000	172	37938.5000	39198.5000				
22	37166.5000	38426.5000	59	37425.5000	38685.5000	96	37684.5000	38944.5000	173	37943.5000	39203.5000				
23	37171.5000	38431.5000	60	37430.5000	38690.5000	97	37689.5000	38949.5000	174	37948.5000	39208.5000				
24	37176.5000	38436.5000	61	37435.5000	38695.5000	98	37694.5000	38954.5000	175	37953.5000	39213.5000				
25	37181.5000	38441.5000	62	37440.5000	38700.5000	99	37699.5000	38959.5000	176	37958.5000	39218.5000				
26	37186.5000	38446.5000	63	37445.5000	38705.5000	100	37704.5000	38964.5000	177	37963.5000	39223.5000				
27	37191.5000	38451.5000	64	37450.5000	38710.5000	101	37709.5000	38969.5000	178	37968.5000	39228.5000				
28	37196.5000	38456.5000	65	37455.5000	38715.5000	102	37714.5000	38974.5000	179	37973.5000	39233.5000				
29	37201.5000	38461.5000	66	37460.5000	38720.5000	103	37719.5000	38979.5000	180	37978.5000	39238.5000				
30	37206.5000	38466.5000	67	37465.5000	38725.5000	104	37724.5000	38984.5000	181	37983.5000	39243.5000				
31	37211.5000	38471.5000	68	37470.5000	38730.5000	105	37729.5000	38989.5000	182	37988.5000	39248.5000				
32	37216.5000	38476.5000	69	37475.5000	38735.5000	106	37734.5000	38994.5000	183	37993.5000	39253.5000				
33	37221.5000	38481.5000	70	37480.5000	38740.5000	107	37739.5000	38999.5000	184	37998.5000	39258.5000				
34	37226.5000	38486.5000	71	37485.5000	38745.5000	108	37744.5000	39004.5000	185	38003.5000	39263.5000				
35	37231.5000	38491.5000	72	37490.5000	38750.5000	109	37749.5000	39009.5000	186	38008.5000	39268.5000				
36	37236.5000	38496.5000	73	37495.5000	38755.5000	110	37754.5000	39014.5000	187	38013.5000	39273.5000				
37	37241.5000	38501.5000	74	37500.5000	38760.5000	111	37759.5000	39019.5000	188	38018.5000	39278.5000				





# **Appendix E      Additional      Information      40.5- 42.5 GHz**

<b>42 GHz BAND (ITU-R F.2005) or ECC/REC/(01)04</b>						
<b>Sub-band A</b>				<b>Sub-band B</b>		
F ref (MHz)	42000			F ref (MHz)	42000	
Ctr.Freq (MHz)	42000			Ctr.Freq (MHz)	42000	
Separ.	1500 MHz			Separ.	1500 MHz	
Ch.Spac.	112 MHz			Ch.Spac.	56 MHz	
Ctr. Gap	156 MHz			Ctr. Gap	100 MHz	
CH	GO	RETURN		CH	GO	RETURN
1	40606	42106	YC national	1	40578	42078
2	40718	42218	YC national	2	40634	42134
3	40830	42330	space for possible expansion or sharing	3	40690	42190
4	40942	42442		4	40746	42246
5	41054	42554	Liquid Tel national	5	40802	42302
6	41166	42666	Liquid Tel national	6	40858	42358
7	41278	42778		7	40914	42414
8	41390	42890		8	40970	42470
9	41502	43002		9	41026	42526
10	41614	43114		10	41082	42582
11	41726	43226		11	41138	42638
12	41838	43338		12	41194	42694
				13	41250	42750
				14	41306	42806
				15	41362	42862
				16	41418	42918
				17	41474	42974
				18	41530	43030
				19	41586	43086
				20	41642	43142
				21	41698	43198
				22	41754	43254
				23	41810	43310
				24	41866	43366
				25	41922	43422



<b>Sub-band C</b>						
F ref (MHz)	42000					
Ctr.Freq (MHz)	42000					
Separ.	1500 MHz					
Ch.Spac.	28 MHz					
Ctr. Gap	100 MHz					
CH	GO	RETURN		CH	GO	RETURN
1	40564	42064		26	41264	42764
2	40592	42092		27	41292	42792
3	40620	42120		28	41320	42820
4	40648	42148		29	41348	42848
5	40676	42176		30	41376	42876
6	40704	42204		31	41404	42904
7	40732	42232		32	41432	42932
8	40760	42260		33	41460	42960
9	40788	42288		34	41488	42988
10	40816	42316		35	41516	43016
11	40844	42344		36	41544	43044
12	40872	42372		37	41572	43072
13	40900	42400		38	41600	43100
14	40928	42428		39	41628	43128
15	40956	42456		40	41656	43156
16	40984	42484		41	41684	43184
17	41012	42512		42	41712	43212
18	41040	42540		43	41740	43240
19	41068	42568		44	41768	43268
20	41096	42596		45	41796	43296
21	41124	42624		46	41824	43324
22	41152	42652		47	41852	43352
23	41180	42680		48	41880	43380
24	41208	42708		49	41908	43408
25	41236	42736		50	41936	43436



Sub-band E			
F ref (MHz)	42000	GO	RETURN
Chr.Freq (MHz)	42000	GO	RETURN
Separ.	1500 MHz	GO	RETURN
Ch.Spac.	7 MHz	GO	RETURN
Chr. Gap	86 MHz	GO	RETURN
1	40553.5	42053.5	42053.5
2	40560.5	42060.5	42060.5
3	40567.5	42067.5	42067.5
4	40574.5	42074.5	42074.5
5	40581.5	42081.5	42081.5
6	40588.5	42088.5	42088.5
7	40595.5	42095.5	42095.5
8	40602.5	42102.5	42102.5
9	40609.5	42109.5	42109.5
10	40616.5	42116.5	42116.5
11	40623.5	42123.5	42123.5
12	40630.5	42130.5	42130.5
13	40637.5	42137.5	42137.5
14	40644.5	42144.5	42144.5
15	40651.5	42151.5	42151.5
16	40658.5	42158.5	42158.5
17	40665.5	42165.5	42165.5
18	40672.5	42172.5	42172.5
19	40679.5	42179.5	42179.5
20	40686.5	42186.5	42186.5
21	40693.5	42193.5	42193.5
22	40700.5	42200.5	42200.5
23	40707.5	42207.5	42207.5
24	40714.5	42214.5	42214.5
25	40721.5	42221.5	42221.5
26	40728.5	42228.5	42228.5
27	40735.5	42235.5	42235.5
28	40742.5	42242.5	42242.5
29	40749.5	42249.5	42249.5
30	40756.5	42256.5	42256.5
31	40763.5	42263.5	42263.5
32	40770.5	42270.5	42270.5
33	40777.5	42277.5	42277.5
34	40784.5	42284.5	42284.5
35	40791.5	42291.5	42291.5
36	40798.5	42298.5	42298.5
37	40805.5	42305.5	42305.5
38	40812.5	42312.5	42312.5
39	40819.5	42319.5	42319.5
40	40826.5	42326.5	42326.5
41	40833.5	42333.5	42333.5
42	40840.5	42340.5	42340.5
43	40847.5	42347.5	42347.5
44	40854.5	42354.5	42354.5
45	40861.5	42361.5	42361.5
46	40868.5	42368.5	42368.5
47	40875.5	42375.5	42375.5
48	40882.5	42382.5	42382.5
49	40889.5	42389.5	42389.5
50	40896.5	42396.5	42396.5
51	40903.5	42403.5	42403.5
52	40910.5	42410.5	42410.5
53	40917.5	42417.5	42417.5
54	40924.5	42424.5	42424.5
55	40931.5	42431.5	42431.5
56	40938.5	42438.5	42438.5
57	40945.5	42445.5	42445.5
58	40952.5	42452.5	42452.5
59	40959.5	42459.5	42459.5
60	40966.5	42466.5	42466.5
61	40973.5	42473.5	42473.5
62	40980.5	42480.5	42480.5
63	40987.5	42487.5	42487.5
64	40994.5	42494.5	42494.5
65	41001.5	42501.5	42501.5
66	41008.5	42508.5	42508.5
67	41015.5	42515.5	42515.5
68	41022.5	42522.5	42522.5
69	41029.5	42529.5	42529.5
70	41036.5	42536.5	42536.5
71	41043.5	42543.5	42543.5
72	41050.5	42550.5	42550.5
73	41057.5	42557.5	42557.5
74	41064.5	42564.5	42564.5
75	41071.5	42571.5	42571.5
76	41078.5	42578.5	42578.5
77	41085.5	42585.5	42585.5
78	41092.5	42592.5	42592.5
79	41099.5	42599.5	42599.5
80	41106.5	42606.5	42606.5
81	41113.5	42613.5	42613.5
82	41120.5	42620.5	42620.5
83	41127.5	42627.5	42627.5
84	41134.5	42634.5	42634.5
85	41141.5	42641.5	42641.5
86	41148.5	42648.5	42648.5
87	41155.5	42655.5	42655.5
88	41162.5	42662.5	42662.5
89	41169.5	42669.5	42669.5
90	41176.5	42676.5	42676.5
91	41183.5	42683.5	42683.5
92	41190.5	42690.5	42690.5
93	41197.5	42697.5	42697.5
94	41204.5	42704.5	42704.5
95	41211.5	42711.5	42711.5
96	41218.5	42718.5	42718.5
97	41225.5	42725.5	42725.5
98	41232.5	42732.5	42732.5
99	41239.5	42739.5	42739.5
100	41246.5	42746.5	42746.5
101	41253.5	42753.5	42753.5
102	41260.5	42760.5	42760.5
103	41267.5	42767.5	42767.5
104	41274.5	42774.5	42774.5
105	41281.5	42781.5	42781.5
106	41288.5	42788.5	42788.5
107	41295.5	42795.5	42795.5
108	41302.5	42802.5	42802.5
109	41309.5	42809.5	42809.5
110	41316.5	42816.5	42816.5
111	41323.5	42823.5	42823.5
112	41330.5	42830.5	42830.5
113	41337.5	42837.5	42837.5
114	41344.5	42844.5	42844.5
115	41351.5	42851.5	42851.5
116	41358.5	42858.5	42858.5
117	41365.5	42865.5	42865.5
118	41372.5	42872.5	42872.5
119	41379.5	42879.5	42879.5
120	41386.5	42886.5	42886.5



Sub-band E continued													
F ref (MHz)	42000												
Ctr.Freq (MHz)	42000												
Separ.	1500 MHz												
Ch. Spac.	7 MHz												
Ctr. Gap	86 MHz												
CH	GO	RETURN		CH	GO	RETURN		CH	GO	RETURN			
121	41393.5	42893.5		151	41603.5	43103.5		181	41813.5	43313.5			
122	41400.5	42900.5		152	41610.5	43110.5		182	41820.5	43320.5			
123	41407.5	42907.5		153	41617.5	43117.5		183	41827.5	43327.5			
124	41414.5	42914.5		154	41624.5	43124.5		184	41834.5	43334.5			
125	41421.5	42921.5		155	41631.5	43131.5		185	41841.5	43341.5			
126	41428.5	42928.5		156	41638.5	43138.5		186	41848.5	43348.5			
127	41435.5	42935.5		157	41645.5	43145.5		187	41855.5	43355.5			
128	41442.5	42942.5		158	41652.5	43152.5		188	41862.5	43362.5			
129	41449.5	42949.5		159	41659.5	43159.5		189	41869.5	43369.5			
130	41456.5	42956.5		160	41666.5	43166.5		190	41876.5	43376.5			
131	41463.5	42963.5		161	41673.5	43173.5		191	41883.5	43383.5			
132	41470.5	42970.5		162	41680.5	43180.5		192	41890.5	43390.5			
133	41477.5	42977.5		163	41687.5	43187.5		193	41897.5	43397.5			
134	41484.5	42984.5		164	41694.5	43194.5		194	41904.5	43404.5			
135	41491.5	42991.5		165	41701.5	43201.5		195	41911.5	43411.5			
136	41498.5	42998.5		166	41708.5	43208.5		196	41918.5	43418.5			
137	41505.5	43005.5		167	41715.5	43215.5		197	41925.5	43425.5			
138	41512.5	43012.5		168	41722.5	43222.5		198	41932.5	43432.5			
139	41519.5	43019.5		169	41729.5	43229.5		199	41939.5	43439.5			
140	41526.5	43026.5		170	41736.5	43236.5		200	41946.5	43446.5			
141	41533.5	43033.5		171	41743.5	43243.5		201	41953.5	43453.5			
142	41540.5	43040.5		172	41750.5	43250.5		202	41960.5	43460.5			
143	41547.5	43047.5		173	41757.5	43257.5							
144	41554.5	43054.5		174	41764.5	43264.5							
145	41561.5	43061.5		175	41771.5	43271.5							
146	41568.5	43068.5		176	41778.5	43278.5							
147	41575.5	43075.5		177	41785.5	43285.5							
148	41582.5	43082.5		178	41792.5	43292.5							
149	41589.5	43089.5		179	41799.5	43299.5							
150	41596.5	43096.5		180	41806.5	43306.5							

# **Appendix F 66 to 76 GHz and 81 to 86 GHz Additional Information**



# Appendix G E-Band Arrangements

# Channel

**Self Coordinated E-Band**

<b>Channel Number</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
<b>Centre frequency (GHz)</b>	73.500	73.750	74.000	74.250	74.500	74.750	75.000	75.250	75.500	75.750
<b>Centre frequency (GHz)</b>	83.500	83.750	84.000	84.250	84.500	84.750	85.000	85.250	85.500	85.750

**ICASA Coordinated E-Band**

<b>Channel Number</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
<b>Centre frequency (GHz)</b>	71.250	71.500	71.750	72.000	72.250	72.500	72.750	73.000
<b>Centre frequency (GHz)</b>	81.250	81.500	81.750	82.000	82.250	82.500	82.750	83.000



International Telecommunication Union

**Appendix H: RECOMMENDATION ITU-R  
M.2083-0.**

**ITU-R**  
Radiocommunication Sector of ITU

**15**   
1865-2015





International Telecommunication Union

**ITU-R**  
Radiocommunication Sector of ITU

**Recommendation ITU-R M.2083-0**  
(09/2015)

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

**M Series**  
**Mobile, radiodetermination, amateur and related satellite services**



**ITU-R M.2083-0.**

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### **Foreword**

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.



**ITU-R M.2083-0.**

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**11 Policy on Intellectual Property Right (IPR)**

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

**Series of ITU-R Recommendations**(Also available online at <http://www.itu.int/publ/R-REC/en>)

<b>Series</b>	<b>Title</b>
<b>BO</b>	Satellite delivery
<b>BR</b>	Recording for production, archival and play-out; film for television
<b>BS</b>	Broadcasting service (sound)
<b>BT</b>	Broadcasting service (television)
<b>F</b>	Fixed service
<b>M</b>	<b>Mobile, radiodetermination, amateur and related satellite services</b>
<b>P</b>	Radiowave propagation
<b>RA</b>	Radio astronomy
<b>RS</b>	Remote sensing systems
<b>S</b>	Fixed-satellite service
<b>SA</b>	Space applications and meteorology
<b>SF</b>	Frequency sharing and coordination between fixed-satellite and fixed service systems
<b>SM</b>	Spectrum management
<b>SNG</b>	Satellite news gathering
<b>TF</b>	Time signals and frequency standards emissions
<b>V</b>	Vocabulary and related subjects

**Note:** This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

*Electronic Publication*  
Geneva, 2015

**ITU-R M.2083-0.****iv**

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## RECOMMENDATION ITU-R M.2083-0

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

(2015)

**Scope**

This Recommendation defines the framework and overall objectives of the future development of International Mobile Telecommunications (IMT) for 2020 and beyond in light of the roles that IMT could play to better serve the needs of the networked society, for both developed and developing countries, in the future. In this Recommendation, the framework of the future development of IMT for 2020 and beyond, including a broad variety of capabilities associated with envisaged usage scenarios, is described in detail. Furthermore, this Recommendation addresses the objectives of the future development of IMT for 2020 and beyond, which includes further enhancement of existing IMT and the development of IMT-2020. It should be noted that this Recommendation is defined considering the development of IMT to date based on Recommendation ITU-R M.1645.

**Keywords**

IMT, IMT-2020

**Abbreviations/Glossary**

ICT	Information and Communication Technology		
IMT	International Mobile Telecommunications		
IoT	Internet of Things		
M2M	Machine-to-Machine		
MIMO	Multiple Input Multiple Output		
QoE		Quality	of
Experience			
QoS	Quality of Service		
RAT	Radio access technology		
RLAN	Radio Local Area Network		

**Related ITU Recommendations, Reports**

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.2012 – Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced (IMT-Advanced)

Report ITU-R M.2320 – Future technology trends of terrestrial IMT systems

Report ITU-R M.2370 – IMT Traffic estimates for the years 2020 to 2030

Report ITU-R M.2376 – Technical feasibility of IMT in bands above 6 GHz

**ITU-R M.2083-0 6**

Report ITU-R M.2134 – Requirements related to technical performance for IMT-Advanced radio interface(s)

The ITU Radiocommunication Assembly,

*considering*

- a) that ITU has contributed to standardization and harmonized use of IMT, which has provided telecommunication services on a global scale;
- b) that technological advancement and the corresponding user needs will promote innovation and accelerate the delivery of advanced communication applications to consumers;
- c) that Question ITU-R 229/5 addresses further development of the terrestrial component of IMT and the relevant studies under this Question are in progress within ITU-R;
- d) that Recommendation ITU-R M.1645 defines the framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000;
- e) that for global operation and economies of scale, which are key requirements for the success of mobile telecommunication systems, it is desirable to establish a harmonized timeframe for future development of IMT considering technical, operational and spectrum related aspects;
- f) that wireless communication applications are expected to expand into new market segments to facilitate the digital economy, e.g. smart grid, e-health, intelligent transport systems and traffic control, which would bring requirements beyond what can be addressed in today's IMT application areas;
- g) that rapid uptake of smartphones, tablets and innovative mobile applications created by users has resulted in a tremendous increase in the volume of mobile data traffic;
- h) that the number of devices accessing the network are expected to increase due to the emerging applications of Internet of Things (IoT);
- i) that technologies such as beamforming, massive-Multiple Input Multiple Output (MIMO) are easier to implement in higher frequencies due to short wavelength;
- j) that wide contiguous bandwidth would enhance data delivery efficiency and ease the complexity of hardware implementation;
- k) that the cell size is being reduced (e.g. the order of some tens of metres) to provide larger area traffic capacity in dense areas;
- l) that IMT interworks with other radio systems,

*recognizing*

- a) that some administrations had deployed IMT-Advanced systems before global deployment due to the rapid increase of data traffic;

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b) that development of new radio interfaces that support the new capabilities of IMT-2020 is expected along with the enhancement of IMT-2000 and IMT-Advanced systems,

*noting*

that pursuant to Article 44 of the ITU Constitution, Member States shall endeavour to apply the latest technical advances as soon as possible,

*recommends*

that the Annex should be used as the framework and the overall objectives for the future development of IMT for 2020 and beyond.

**Annex**

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## 12 1 Introduction

The socio-technical evolution in the last few decades has been significantly driven by the evolution of mobile communications and has contributed to the economic and social development of both developed and developing countries. Mobile communications has become closely integrated in the daily life of the whole society. It is expected that the socio-technical trends and the evolution of mobile communications systems will remain tightly coupled together and will form a foundation for society in 2020 and beyond.

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

The objective of this Recommendation is to establish the vision for IMT for 2020 and beyond, by describing potential user and application trends, growth in traffic, technological trends and spectrum implications, and by providing guidelines on the framework and the capabilities for IMT for 2020 and beyond.



## **13 2 Observation of trends**

### **13.1 2.1 User and application trends**

Mobile devices play various, continuously evolving roles in everyday life. Future IMT systems should support emerging new use cases, including applications requiring very high data rate communications, a large number of connected devices, and ultra-low latency and high reliability applications. More specific user and application trends are explained in §§ 2.1.1 to 2.1.8.

#### **13.1.1 2.1.1 Supporting very low latency and high reliability human-centric communication**

People expect the experience of instantaneous connectivity wherein applications need to exhibit “flash” behaviour without waiting times: a single click and the response is perceived as instantaneous. Flash behaviour will be a key factor for the success of cloud services and virtual reality and augmented reality applications. The low latency and high reliability communication that supports such behaviour thus becomes an enabler for the future development of new applications, e.g. in health, safety, office, entertainment, and other sectors.

#### **13.1.2 2.1.2 Supporting very low latency and high reliability machine-centric communication**

The reliability and latency in today’s communication systems have been designed with the human user in mind. For future wireless systems, the design of new applications is envisaged based on machine-to-machine (M2M) communication with real-time constraints. Driverless cars, enhanced mobile cloud services, real-time traffic control optimization, emergency and disaster response, smart grid, e-health or efficient industrial communications are examples of where low latency and high reliability can improve quality of life.

#### **13.1.3 2.1.3 Supporting high user density**

Users will expect a satisfactory end-user experience in the presence of a large number of concurrent users, for example in a crowd with a high traffic density per unit area and a large number of handsets and machines/devices per unit area. Examples are audio-visual content to be provided concurrently across an entire cell or infotainment applications in shopping malls, stadiums, open air festivals, or other public events that attract a lot of people. This includes users who use their phone while in unexpected traffic jams, or when travelling in public transportation systems, as well as professionals working in organisations such as police, fire brigades, and ambulances to exploit the public communication networks in crowded environments and machine-centric devices.

#### **13.1.4 2.1.4 Maintaining high quality at high mobility**

A connected society in the years beyond 2020 will need to accommodate a similar user experience for end-users on the move and when they are static e.g. at home or in the office. To offer the “best experience” to highly mobile users and communicating machine

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devices, robust and reliable connectivity solutions are needed as well as the ability to efficiently maintain service quality with mobility.

Maintaining high quality at high mobility will enable successful deployment of applications on user equipment located within a moving platform such as cars or high-speed trains which are being deployed in several countries. Connectivity on mobile platforms may be provided via IMT, Radio Local Area Network (RLAN) or another network on that platform using suitable backhaul.

**13.1.5 2.1.5 Enhanced multimedia services**

It is likely that demand for mobile high-definition multimedia will increase in many areas beyond entertainment, such as medical treatment, safety, and security.

User devices will get enhanced media consumption capabilities, such as Ultra-High Definition display, multi-view High Definition display, mobile 3D projections, immersive video conferencing, and augmented reality and mixed reality display and interface. This will all lead to a demand for significantly higher data rates. Media delivery will be both to individuals and to groups of users.

**13.1.6 2.1.6 Internet of Things**

In the future, every object that can benefit from being connected will be connected through wired or wireless internet technologies. Therefore, the number of connected devices will grow rapidly and is expected to exceed the number of human user devices in the future.

These connected “things” can be smart phones, sensors, actuators, cameras, vehicles, etc., ranging from low-complexity devices to highly complex and advanced devices. A significant number of connected devices are expected to use IMT systems.

As a result, the connected entities are bound to have varying levels of energy consumption, transmission power, latency requirements, cost, and many other indices critical for stable connection.

In addition, as more and more things get connected, various services that utilize the connection capabilities of things will appear. Smart energy distribution grid system, agriculture, healthcare, vehicle-to-vehicle and vehicle-to-road infrastructure communication are generally viewed as potential fields for further growth of the Internet of Things (IoT).

**13.1.7 2.1.7 Convergence of applications**

New applications are increasingly being delivered over IMT, including e-Government, public protection and disaster relief communication, education, linear<sup>22</sup> and on-demand

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<sup>22</sup> A linear audio-visual service refers to the “traditional” way of offering radio or TV services. Listeners and viewers “tune in” to the content organised as a scheduled sequence that may consist of e.g. news, shows, drama or movies on TV or various types of audio content on radio. These sequences of programmes are set up by content providers and cannot be changed by a

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audio-visual content, and e-health. This convergence of applications must take account of the requirements associated with these applications.

**13.1.8 2.1.8 Ultra-accurate positioning applications**

As the accuracy of positioning gets better, location-based service applications that provide improved emergency rescue services, as well as precise ground based navigation service for unmanned vehicles or drones may expand extensively.

**13.2 2.2 Growth in IMT traffic**

There are many drivers influencing the growth of future IMT traffic demand, especially the adoption of devices with enhanced capabilities that require increased bit rates and bandwidth usage. Similar drivers increased traffic in the transition from IMT-2000 to IMT-Advanced.

The main drivers behind the anticipated traffic growth include increased video usage, device proliferation and application uptake. These are expected to evolve over time, and this evolution will differ between countries due to social and economic differences. These drivers and other trends which impact traffic growth are detailed in Report ITU-R M.2370. The Report contains global IMT traffic estimates beyond 2020 from several sources. These estimates anticipate that global IMT traffic will grow in the range of 10-100 times from 2020 to 2030.

Traffic asymmetry aspects for this period are also presented in Report ITU-R M.2370. It is observed that the current average traffic asymmetry ratio of mobile broadband is in favour of the downlink, and this is expected to increase due to growing demand for audio-visual content.

**13.3 2.3 Technology trends**

Report ITU-R M.2320 provides a broad view of future technical aspects of terrestrial IMT systems considering the timeframe 2015-2020 and beyond. It includes information on technical and operational characteristics of IMT systems, including the evolution of IMT through advances in technology and spectrally-efficient techniques, and their deployment. Report ITU-R M.2320 provides more detailed information on the following technical aspects presented in §§ 2.3.1 to 2.3.8. In addition, technologies required to enable higher data rates are explained in § 2.3.9.

**13.3.1 2.3.1 Technologies to enhance the radio interface**

Advanced waveforms, modulation and coding, and multiple access schemes, e.g. filtered OFDM (FOFDM), filter bank multi-carrier modulation (FBMC), pattern division multiple access (PDMA), sparse code multiple access (SCMA), interleave division multiple access

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listener or a viewer. Linear services are not confined to a particular distribution technology. For example, a live stream on the Internet is to be considered as a linear service as well.

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(IDMA) and low density spreading (LDS) may improve the spectral efficiency of the future IMT systems.

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

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

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

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

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

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

**13.3.2 2.3.2 Network technologies**

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

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

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

**13.3.3 2.3.3 Technologies to enhance mobile broadband scenarios**

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

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

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

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

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

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

**13.3.4 2.3.4 Technologies to enhance massive machine type communications**

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

**13.3.5 2.3.5 Technologies to enhance ultra-reliable and low latency communications**

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

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

**13.3.6 2.3.6 Technologies to improve network energy efficiency**

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

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

**13.3.7 2.3.7 Terminal technologies**

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

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

**ITU-R M.2083-0 15****13.3.8 2.3.8 Technologies to enhance privacy and security**

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

**13.3.9 2.3.9 Technologies enabling higher data rates**

In order to achieve higher data rates and improvements in capacity, the following key techniques are needed:

Spectrum:

- Utilization of large blocks of spectrum in higher frequency bands
- Carrier aggregation

Physical Layer:

- Enhanced spectral efficiency by means of e.g. advanced physical layer techniques (modulation, coding) and advances in spatial processing (network MIMO and Massive MIMO), plus exploitation of other novel/alternative ideas.

Network:

- Network densification

**13.4 2.4 Studies on technical feasibility of IMT between 6 and 100 GHz**

The development of IMT for 2020 and beyond is expected to enable new use cases and applications, and addresses rapid traffic growth, for which contiguous and broader channel bandwidths than currently available for IMT systems would be desirable. This suggests the need to consider spectrum resources in higher frequency ranges.

Report ITU-R M.2376 provides information on the technical feasibility of IMT in the frequencies between 6 and 100 GHz. It includes information on potential new IMT radio technologies and system approaches, which could be appropriate for operation in this frequency range.

The Report presents measurement data on propagation in this frequency range in several different environments. Both line-of-sight and non-line-of-sight measurement results for stationary and mobile cases as well as outdoor-to-indoor results have been presented in the report. It also includes performance simulations results for several different deployment scenarios.

The Report describes solutions based on MIMO and beamforming with a large number of antenna elements, which compensate for the increasing propagation loss with frequency; these have become increasingly feasible due to the ability to exploit chip-scale antenna solutions and modular adaptive antenna arrays that do not require an ADC/DAC for each antenna element. The practicality of manufacturing commercial transmitters and receivers at these frequencies is investigated, as evidenced by availability of commercial 60 GHz multi-gigabit wireless systems (MGWS) products and prototyping activities that are already underway at frequencies such as 11, 15, 28, 44, 70 and 80 GHz.



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The potential advantages of using the same spectrum for both access and fronthaul/backhaul, as compared with using two different frequencies for access and fronthaul/backhaul, are described in the Report.

The theoretical assessment, simulations, measurements, technology development and prototyping described in the Report indicate that utilizing the bands between 6 and 100 GHz is feasible for studied IMT deployment scenarios, and could be considered for the development of IMT for 2020 and beyond.

**13.5 2.5 Spectrum implications**

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

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

For future IMT systems in the year 2020 and beyond, contiguous and broader channel bandwidths than available to current IMT systems would be desirable to support continued growth. Therefore, availability of spectrum resources that could support broader, contiguous channel bandwidths in this time frame should be explored. Research efforts must be continued to increase spectrum efficiency and to explore the availability of contiguous broad channels.

Furthermore, if additional spectrum is made available for IMT, the potential implications to the existing uses and users of that spectrum need to be addressed.

**13.5.1 2.5.1 Spectrum harmonization**

As the amount of spectrum required for mobile services increases, it becomes increasingly desirable for existing and newly allocated and identified spectrum to be harmonized. The benefits of spectrum harmonization include: facilitating economies of scale, enabling global roaming, reducing equipment design complexity, preserving battery life, improving spectrum efficiency and potentially reducing cross border interference. Typically, a mobile device contains multiple antennas and associated radio frequency front-ends to enable operation in multiple bands to facilitate roaming. While mobile devices can benefit from common chipsets, variances in frequency arrangements necessitate different components to accommodate these differences, which leads to higher equipment design complexity.

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

**13.5.2 2.5.2 Importance of contiguous and wider spectrum bandwidth**

The proliferation of smart devices (e.g. smartphones, tablets, televisions, etc.) and a wide range of applications requiring a large amount of data traffic have accelerated demand for



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wireless data traffic. Future IMT systems are expected to provide significant improvement to accommodate this rapidly increasing traffic demand. In addition, future IMT systems are expected to provide gigabit-per-second user data rate services. The currently available frequency bands and their bandwidth differ across countries and regions and this leads to many problems associated with device complexity and possible interference issues. Contiguous, broader and harmonized frequency bands, aligned with future technology development, would address these problems and would facilitate achievement of the objectives of future IMT systems.

In particular, bandwidths to support the different usage scenarios in § 4 (e.g. enhanced mobile broadband, ultra-reliable and low-latency communications, and massive machine type communications) would vary. For those scenarios requiring several hundred MHz up to at least 1 GHz, there would be a need to consider wideband contiguous spectrum above 6 GHz.

### 14 3 Evolution of IMT

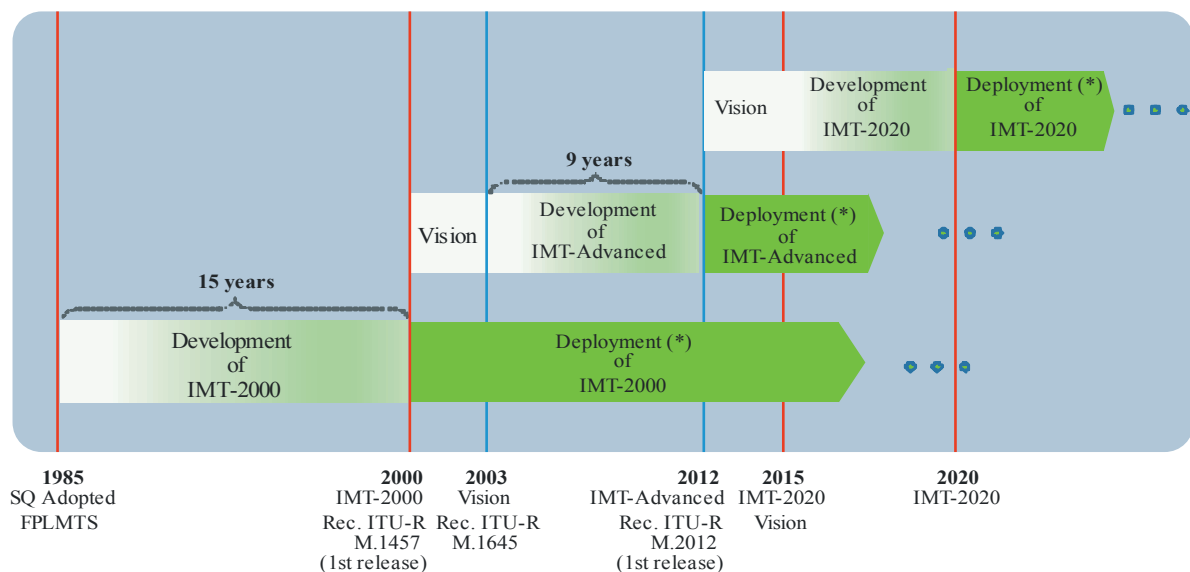
#### 14.1 3.1 How IMT has developed

Following the adoption by International Radio Consultative Committee (CCIR) of the Study Question on the Future Public Land Mobile Telecommunication Systems (FPLMTS) in 1985, it took a total of 15 years for the identification of the radio spectrum in 1992 and development of IMT-2000 specifications (Recommendation ITU-R M.1457). After this development, deployment of IMT-2000 systems started.

The ITU then immediately started to develop the vision Recommendation (Recommendation ITU-R M.1645, June 2003) on Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000. Based on this Recommendation, the ITU has released the Recommendation ITU-R M.2012 in the terrestrial radio interface of IMT-Advanced in 2012. It took nine years for the ITU to develop the second phase of IMT after the completion of the vision recommendation. After this development, deployment of the IMT-Advanced systems started.

FIGURE 1

Overview of timeline for IMT development and deployment



(\*) Deployment timing may vary across countries.

#### 14.2 3.2 Role of IMT for 2020 and beyond

IMT systems serve as a communication tool for people and a facilitator which assists the development of other industry sectors, such as medical science, transportation, and education. Considering the key trends described in § 2, IMT should continue to contribute to the following:

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- **Wireless infrastructure to connect the world:** Broadband connectivity will acquire the same level of importance as access to electricity. IMT will continue to play an important role in this context as it will act as one of the key pillars to enable mobile service delivery and information exchanges. In the future, private and professional users will be provided with a wide variety of applications and services, ranging from infotainment services to new industrial and professional applications.
- **New ICT market:** The development of future IMT systems is expected to promote the emergence of an integrated ICT industry which will constitute a driver for economies around the globe. Some possible areas include: the accumulation, aggregation and analysis of big data; delivering customized networking services for enterprise and social network groups on wireless networks
- **Bridging the Digital Divide:** IMT will continue to help closing the gaps caused by an increasing Digital Divide. Affordable, sustainable and easy-to-deploy mobile and wireless communication systems can support this objective while effectively saving energy and maximizing efficiency.
- **New ways of communication:** IMT will enable sharing of any type of contents anytime, anywhere through any device. Users will generate more content and share this content without being limited by time and location.
- **New forms of education:** IMT can change the method of education by providing easy access to digital textbooks or cloud-based storage of knowledge on the internet, boosting applications such as e-learning, e-health, and e-commerce.
- **Promote Energy Efficiency:** IMT enables energy efficiency across a range of sectors of the economy by supporting machine to machine communication and solutions such as smart grid, teleconferencing, smart logistics and transportation.
- **Social changes:** Broadband networks make it easier to quickly form and share public opinions for a political or social issue through social network service. Opinion formation of a huge number of connected people due to their ability to exchange information anytime anywhere will become a key driver of social changes.
- **New art and culture:** IMT will support people to create works of art or participate in group performances or activities, such as a virtual chorus, flash mob, co-authoring or song writing. Also, people connected to a virtual world are able to form new types of communities and establish their own cultures.

## 15 4 Usage scenarios for IMT for 2020 and beyond

IMT for 2020 and beyond is envisaged to expand and support diverse usage scenarios and applications that will continue beyond the current IMT. Furthermore, a broad variety of capabilities would be tightly coupled with these intended different usage scenarios and applications for IMT for 2020 and beyond. The usage scenarios for IMT for 2020 and beyond include:

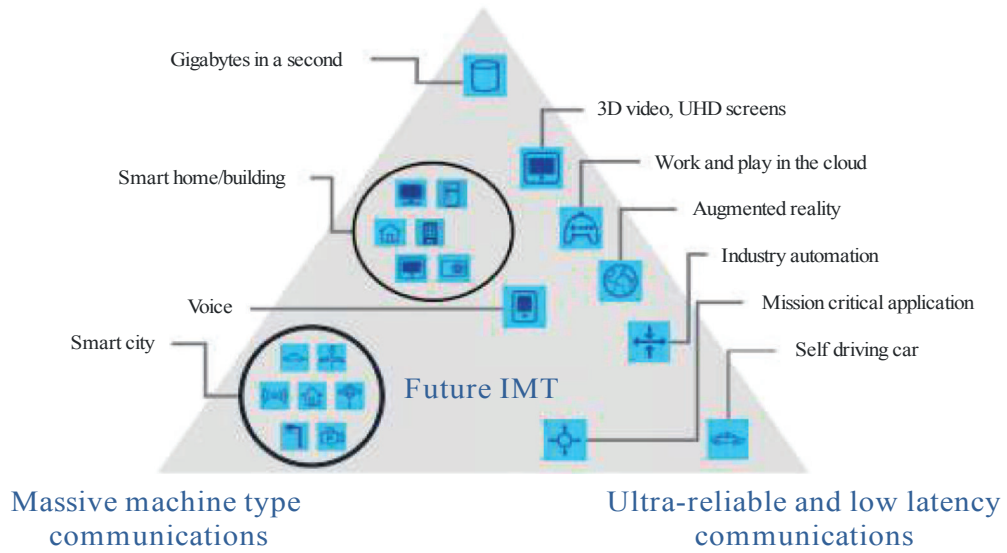
- **Enhanced Mobile Broadband:** Mobile Broadband addresses the human-centric use cases for access to multi-media content, services and data. The demand for mobile broadband will continue to increase, leading to enhanced Mobile Broadband. The enhanced Mobile Broadband usage scenario will come with new application areas and requirements in addition to existing Mobile Broadband applications for improved performance and an increasingly seamless user experience. This usage scenario covers a range of cases, including wide-area coverage and hotspot, which have different requirements. For the hotspot case, i.e. for an area with high user density, very high traffic capacity is needed, while the requirement for mobility is low and user data rate is higher than that of wide area coverage. For the wide area coverage case, seamless coverage and medium to high mobility are desired, with much improved user data rate compared to existing data rates. However the data rate requirement may be relaxed compared to hotspot.
- **Ultra-reliable and low latency communications:** This use case has stringent requirements for capabilities such as throughput, latency and availability. Some examples include wireless control of industrial manufacturing or production processes, remote medical surgery, distribution automation in a smart grid, transportation safety, etc.
- **Massive machine type communications:** This use case is characterized by a very large number of connected devices typically transmitting a relatively low volume of non-delay-sensitive data. Devices are required to be low cost, and have a very long battery life.

Additional use cases are expected to emerge, which are currently not foreseen. For future IMT, flexibility will be necessary to adapt to new use cases that come with a wide range of requirements.

Future IMT systems will encompass a large number of different features. Depending on the circumstances and the different needs in different countries, future IMT systems should be designed in a highly modular manner so that not all features have to be implemented in all networks.

Figure 2 illustrates some examples of envisioned usage scenarios for IMT for 2020 and beyond.

FIGURE 2  
Usage scenarios of IMT for 2020 and beyond  
Enhanced mobile broadband



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## 16 5 Capabilities of IMT-2020

IMT for 2020 and beyond is expected to provide far more enhanced capabilities than those described in Recommendation ITU-R M.1645, and these enhanced capabilities could be regarded as new capabilities of future IMT. As ITU-R will give a new term IMT-2020 to those systems, system components, and related aspects that support these new capabilities, the term IMT-2020 is used in the following sections.

A broad variety of capabilities, tightly coupled with intended usage scenarios and applications for IMT-2020 is envisioned. Different usage scenarios along with the current and future trends will result in a great diversity/variety of requirements. The key design principles are flexibility and diversity to serve many different use cases and scenarios, for which the capabilities of IMT-2020, described in the following paragraphs, will have different relevance and applicability. In addition, the constraints on network energy consumption and the spectrum resource will need to be considered.

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

### **Peak data rate**

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

### **User experienced data rate**

Achievable data rate that is available ubiquitously<sup>23</sup> across the coverage area to a mobile user/device (in Mbit/s or Gbit/s).

### **Latency**

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

### **Mobility**

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

### **Connection density**

Total number of connected and/or accessible devices per unit area (per km<sup>2</sup>).

### **Energy efficiency**

Energy efficiency has two aspects:

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<sup>23</sup> The term “ubiquitous” is related to the considered target coverage area and is not intended to relate to an entire region or country.

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

**Spectrum efficiency**

Average data throughput per unit of spectrum resource and per cell<sup>24</sup> (bit/s/Hz).

**Area traffic capacity**

Total traffic throughput served per geographic area (in Mbit/s/m<sup>2</sup>).

IMT-2020 is expected to provide a user experience matching, as far as possible, fixed networks. The enhancement will be realized by increased peak and user experienced data rate, enhanced spectrum efficiency, reduced latency and enhanced mobility support.

In addition to the conventional human-to-human or human-to-machine communication, IMT-2020 will realize the Internet of Things by connecting a vast range of smart appliances, machines and other objects without human intervention.

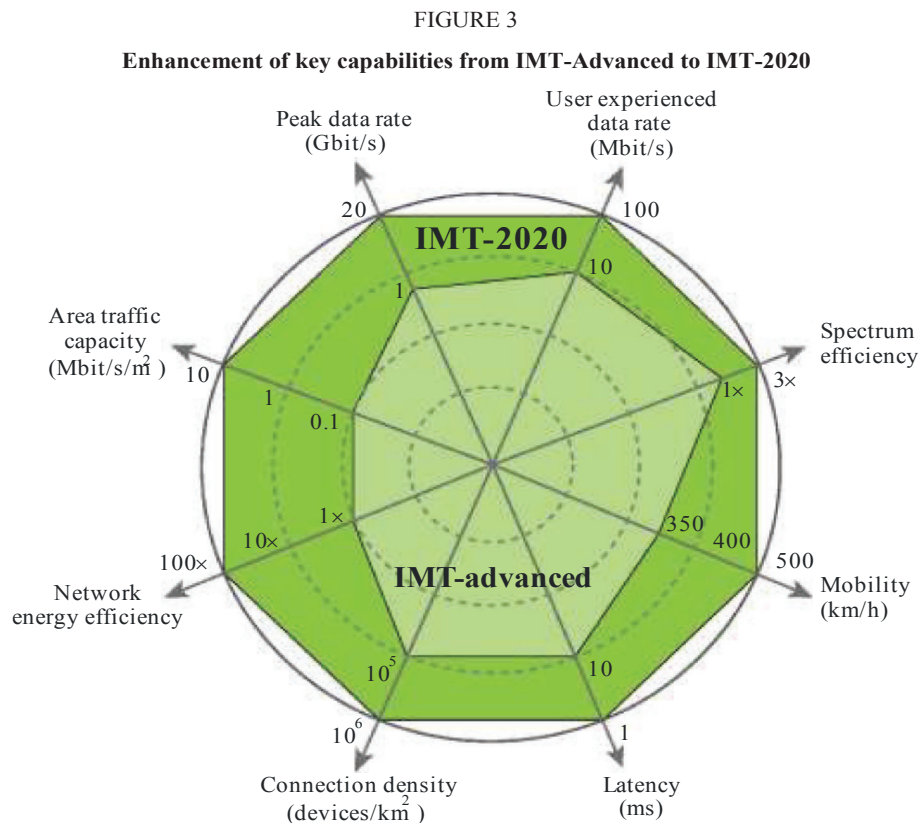
IMT-2020 should be able to provide these capabilities without undue burden on energy consumption, network equipment cost and deployment cost to make future IMT sustainable and affordable.

The key capabilities of IMT-2020 are shown in Fig. 3, compared with those of IMT-Advanced.

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<sup>24</sup> The radio coverage area over which a mobile terminal can maintain a connection with one or more units of radio equipment located within that area. For an individual base station, this is the radio coverage area of the base station or of a subsystem (e.g. sector antenna).





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The values in the Figure above are targets for research and investigation for IMT-2020 and may be further developed in other ITU-R Recommendations, and may be revised in the light of future studies. The targets are further described below.

The peak data rate of IMT-2020 for enhanced Mobile Broadband is expected to reach 10 Gbit/s. However under certain conditions and scenarios IMT-2020 would support up to 20 Gbit/s peak data rate, as shown in Fig. 3. IMT-2020 would support different user experienced data rates covering a variety of environments for enhanced Mobile Broadband. For wide area coverage cases, e.g. in urban and sub-urban areas, a user experienced data rate of 100 Mbit/s is expected to be enabled. In hotspot cases, the user experienced data rate is expected to reach higher values (e.g. 1 Gbit/s indoor).

The spectrum efficiency is expected to be three times higher compared to IMT-Advanced for enhanced Mobile Broadband. The achievable increase in efficiency from IMT-Advanced will vary between scenarios and could be higher in some scenarios (for example five times subject to further research). IMT-2020 is expected to support 10 Mbit/s/m<sup>2</sup> area traffic capacity, for example in hot spots.

The energy consumption for the radio access network of IMT-2020 should not be greater than IMT networks deployed today, while delivering the enhanced capabilities. The network energy efficiency should therefore be improved by a factor at least as great as the envisaged traffic capacity increase of IMT-2020 relative to IMT-Advanced for enhanced Mobile Broadband.

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IMT-2020 would be able to provide 1 ms over-the-air latency, capable of supporting services with very low latency requirements. IMT-2020 is also expected to enable high mobility up to 500 km/h with acceptable QoS. This is envisioned in particular for high speed trains.

Finally, IMT-2020 is expected to support a connection density of up to  $10^6/\text{km}^2$ , for example in massive machine type communication scenarios.

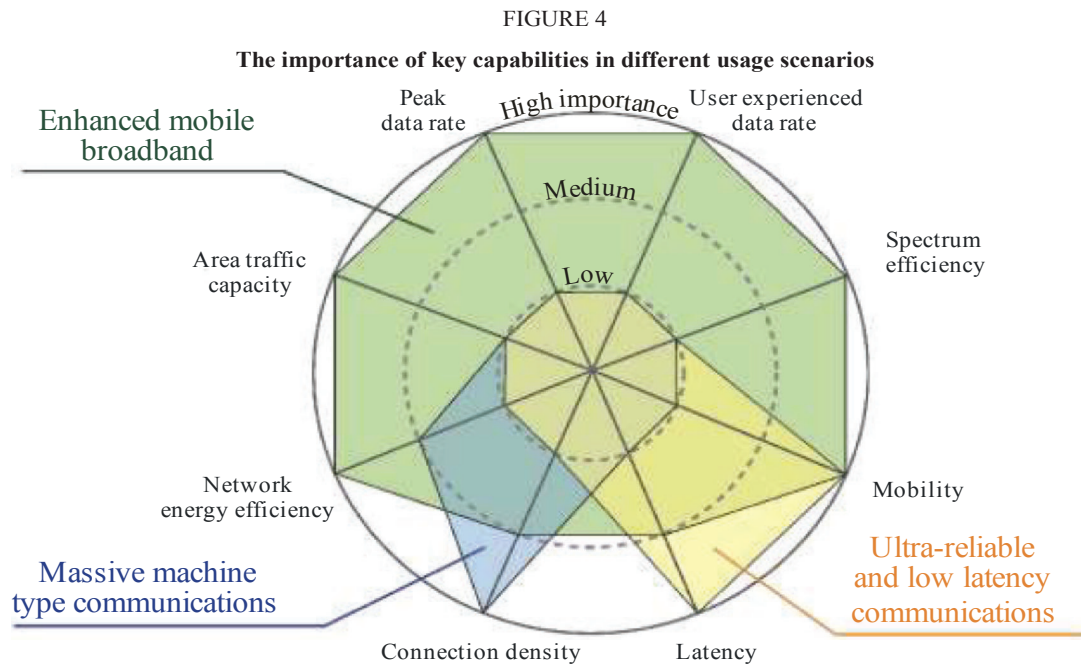
The reference values for IMT-Advanced shown in Fig. 3 for the peak data rate, mobility, spectrum efficiency and latency are extracted from Report ITU-R M.2134. The Report this was published in 2008 and was used for the evaluation of IMT-Advanced candidate radio interfaces described in Recommendation ITU-R M.2012.

As anticipated above, whilst all key capabilities may to some extent be important for most use cases, the relevance of certain key capabilities may be significantly different, depending on the use cases/scenario. The importance of each key capability for the usage scenarios *enhanced Mobile Broadband*, *ultra-reliable and low latency communication* and *massive machine-type communication* is illustrated in Fig. 4. This is done using an indicative scaling in three steps as “high”, “medium” and “low”.

In the enhanced Mobile Broadband scenario, user experienced data rate, area traffic capacity, peak data rate, mobility, energy efficiency and spectrum efficiency all have high importance, but mobility and the user experienced data rate would not have equal importance simultaneously in all use cases. For example, in hotspots, a higher user experienced data rate, but a lower mobility, would be required than in wide area coverage case.

In some ultra-reliable and low latency communications scenarios, low latency is of highest importance, e.g. in order to enable the safety critical applications. Such capability would be required in some high mobility cases as well, e.g. in transportation safety, while, e.g. high data rates could be less important.

In the massive machine type communication scenario, high connection density is needed to support tremendous number of devices in the network that e.g. may transmit only occasionally, at low bit rate and with zero/very low mobility. A low cost device with long operational lifetime is vital for this usage scenario.



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Other capabilities may be also required for IMT-2020, which would make future IMT more flexible, reliable, and secure when providing diverse services in the intended usage scenarios:

### **Spectrum and bandwidth flexibility**

Spectrum and bandwidth flexibility refers to the flexibility of the system design to handle different scenarios, and in particular to the capability to operate at different frequency ranges, including higher frequencies and wider channel bandwidths than today.

### **Reliability**

Reliability relates to the capability to provide a given service with a very high level of availability.

### **Resilience**

Resilience is the ability of the network to continue operating correctly during and after a natural or man-made disturbance, such as the loss of mains power.

### **Security and privacy**

Security and privacy refers to several areas such as encryption and integrity protection of user data and signalling, as well as end user privacy preventing unauthorized user tracking, and protection of network against hacking, fraud, denial of service, man in the middle attacks, etc.

### **Operational lifetime**

Operational life time refers to operation time per stored energy capacity. This is particularly important for machine-type devices requiring a very long battery life (e.g. more

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than 10 years) whose regular maintenance is difficult due to physical or economic reasons.

## 17 6 Framework and objectives

The objective of the development of IMT-2020 is to address the anticipated needs of users of mobile services in the years 2020 and beyond. The goals for the capabilities of IMT-2020 system described in § 5 are only targets for research and investigation and may be further developed in other ITU Recommendations, and may be revised in the light of future studies. This section provides relationships between IMT-2020 and existing IMT/other access systems, timelines and focus areas for further study as framework and objectives for the development of IMT-2020.

### 17.1 6.1 Relationships

#### 17.1.1 6.1.1 Relationship between existing IMT and IMT-2020

In order to support emerging new scenarios and applications for 2020 and beyond, it is foreseen that development of IMT-2020 will be required to offer enhanced capabilities as those described in § 5. The values of these capabilities go beyond those described in Recommendation ITU-R M.1645. The minimum technical requirements (and corresponding evaluation criteria) to be defined by ITU-R based on these capabilities for IMT-2020 could potentially be met by adding enhancements to existing IMT, incorporating new technology components and functionalities, and/or the development of new radio interface technologies.

Furthermore, IMT-2020 will interwork with and complement existing IMT and its enhancements.

#### 17.1.2 6.1.2 Relationship between IMT-2020 and other access systems

Users should be able to access services anywhere, anytime. To achieve this goal, interworking will be necessary among various access technologies, which might include a combination of different fixed, terrestrial and satellite networks. Each component should fulfil its own role, but also should be integrated or interoperable with other components to provide ubiquitous seamless coverage.

IMT-2020 will interwork with other radio systems, such as RLANs, broadband wireless access, broadcast networks, and their possible future enhancements. IMT systems will also closely interwork with other radio systems for users to be optimally and cost-effectively connected.

### 17.2 6.2 Timelines

In planning for the development of IMT-2020 as well as future enhancement of the existing IMT, it is important to consider the timelines associated with their realization, which depend on a number of factors:

- user trends, requirements and user demand;
- technical capabilities and technology development;
- standards development and their enhancement;

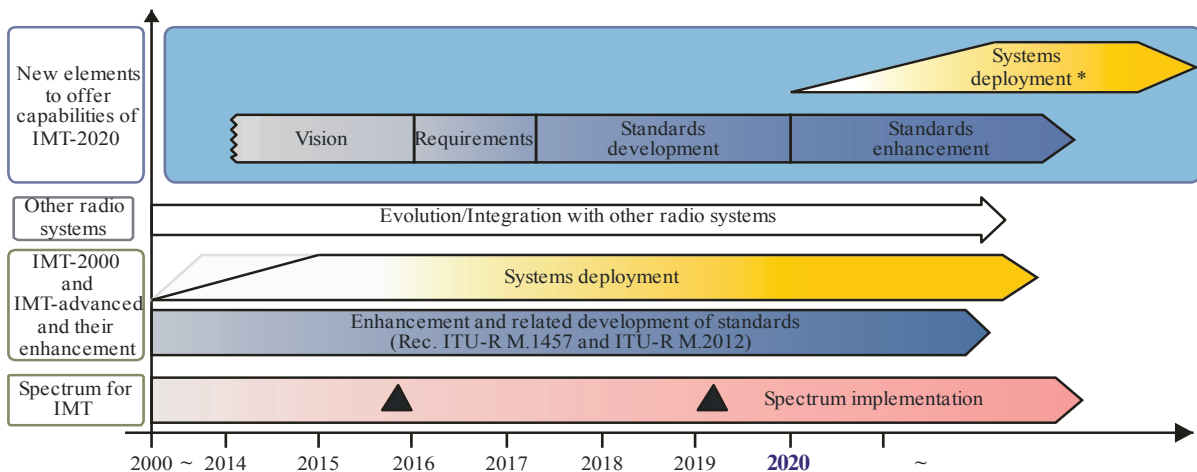
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- spectrum matters;
- regulatory considerations;
- system deployment.

All of these factors are interrelated. The first five have been and will continue to be addressed within ITU. System development and deployment relates to the practical aspects of deploying new networks, taking into account the need to minimize additional infrastructure investment and to allow time for customer adoption of the services of a new system. ITU will complete its work for standardization of IMT-2020 no later than the year 2020 to support IMT-2020 deployment by ITU members expected from the year 2020 onwards.

The timelines associated with these different factors are depicted in Fig. 5. When discussing the phases and timelines for IMT-2020, it is important to specify the time at which the standards are completed, when spectrum would be available, and when deployment may start.

**FIGURE 5  
Phase and expected timelines for IMT-2020**



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

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

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

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**17.2.1 6.2.1 Medium term**

In the medium-term (up to about the year 2020) it is envisaged that the future development of IMT-2000 and IMT-Advanced will progress with the ongoing enhancement of the capabilities of the initial deployments, as demanded by the marketplace in addressing user needs and allowed by the status of technical developments. This phase will be dominated by the growth in traffic within the existing IMT spectrum, and the development of IMT-2000 and IMT-Advanced during this time will be distinguished by

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incremental or evolutionary changes to the existing IMT-2000 and IMT-Advanced radio interface specifications (i.e. Recommendations ITU-R M.1457 for IMT-2000 and ITU-R M.2012 for IMT-Advanced, respectively).

It is envisaged that the bands identified by WRCs will be made available for IMT within this timeframe subject to user demand and other consideration.

**17.2.2 6.2.2 Long term**

The long term (beginning around the year 2020) is associated with the potential introduction of IMT-2020 which could be deployed around the year 2020 in some countries. It is envisaged that IMT-2020 will add enhanced capabilities described in § 5, and they may need additional frequency bands in which to operate.



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The research forums and other external organizations wishing to contribute to the future development of IMT-2020 are encouraged to focus especially in the following key areas:

- a) radio interface(s) and their interoperability;
  - b) access network related issues;
  - c) spectrum related issues;
  - d) traffic characteristics.
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