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NOTICE REGARDING THE FINAL INTERNATIONAL MOBILE TELECOMMUNICATIONS (IMT) ROADMAP 2019

The Independent Communications Authority of South Africa ("the Authority"), hereby publishes **the Final International Mobile Telecommunications (IMT) Roadmap 2019** in terms of section 4(3) (c) of the Independent Communications Authority of South Africa Act, 2000 (Act No. 13 of 2000), as amended read with sections 2, and 30, 31 (4), and 33 of the Electronic Communications Act 2005 (Act No. 36 of 2005), as amended.

DR. K MODIMOENG

ACTING CHAIRPERSON

GENERAL NOTICE

NOTICE ___ OF 2019

INDEPENDENT COMMUNICATIONS AUTHORITY OF SOUTH AFRICA

NOTICE REGARDING THE FINAL INTERNATIONAL MOBILE TELECOMMUNICATIONS (IMT) ROADMAP 2019

1. On 9 November 2018, the Independent Communications Authority of South Africa ("the Authority") published a notice in the Gazette[1] inviting written representations on the Draft International Mobile Telecommunications ("IMT") Roadmap ("the Draft IMT Roadmap") in terms of sections 2 and 4, read with sections 30, 31(4) and 33 of the Electronic Communications Act, 2005 (Act No. 36 of 2005).

2. The Authority received twenty (20) Industry written submissions in relation to the Draft IMT Roadmap, of which Eighteen (18) Industry Oral Representations indicated their intention to make oral submissions.

3. The Authority held public hearings on the Draft IMT Roadmap on Thursday, 31 January 2019 and 01 February 2019 in the Kgotla of Dr Ivy Matsepe-Cassiburri House..

4. The Authority has concluded the consultation process on the Draft IMT Roadmap and has finalised the IMT Roadmap 2019. The IMT Roadmap 2019 substitutes the IMT Roadmap 2014 published in Government Gazette No. 38213 (Notice 1009 of 2014 dated 14 November 2014).
5. A copy of the final IMT Roadmap 2019, is available on the Authority's website (www.icasa.org.za) and at the Authority's head office library (Block C, 350 Witch-Hazel Avenue, Eco Point Office Park Eco Park, Centurion) during office hours (Mon-Fri from 09:00 to 16:30).

6. The Authority's reasons with regard to the IMT Roadmap 2019, will be made available once finalised.

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[1] Government Gazette No. 42021 of 9 November 2018.

IMT Roadmap 2019

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1 PERSPECTIVE

The objective of the IMT Roadmap 2019 is to present the decision of the Independent Communications Authority of South Africa (hereafter referred to as "the Authority / ICASA") in respect of the roadmap for radio frequency spectrum for International Mobile Telecommunications ("IMT").

The IMT Roadmap 2019 substitutes the IMT Roadmap 2014 published in Government Gazette No. 38213 (Notice 1009 of 2014 dated 14 November 2014).

IMT is an acronym developed by the ITU in ITU-R Resolution 56-1. IMT is the root name and encompasses IMT 2000 (including enhancement) and IMT Advanced (including enhancement).[2]

This document amplifies on the "Final Frequency Migration Plan 2014, published in Government Gazette number 38213 (Notice 1009). This roadmap published herewith by the Authority defines the bands identified for IMT deployment and stipulates the forced migration[3] of current licensees either completely out of the identified bands or migration within the existing bands identified for IMT services. For those bands where the migration process was deemed to be complex in respect of cost and benefits for the incumbents, the Authority embarked on feasibility studies[4] to identify solutions to best preserve the interests of the current operators in the bands.

The Authority's primary objective is the assurance of spectrum efficiency, universal availability of broadband services as well as the establishment of a vibrant and competitive telecommunications industry that is attractive for investors in accordance with section 2 (c), (e) and (f) of the Electronic Communications Act, 2005 (Act No. 36 of 20105) ("ECA"), the National Development Plan, Vision 2030 and the Broadband Policy articulated in SA- Connect.

Most importantly the IMT Roadmap 2019 is the process of establishing a renewed vision for South Africa that is completely aligned with international trends and aligned to the ITU Vision on IMT as described in Recommendation ITU-R M.2083-0, which provides the IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond. This Recommendation, ITU-R M.2083-0, defines the framework and overall objectives for the future development of IMT for 2020 and beyond considering the roles that IMT could play to better serve the needs of the networked society, for both developed and developing countries. In this Recommendation, a broad variety of capabilities and applications are foreseen as part of the IMT deployment scenarios as

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[2] IMT 2000 and IMT Advance are generations of IMT progresively leading to IMT2020. The relevance is to ensure that the document complies with the ITU Radio Regulations in force in accordance to ITU-R Resolution 56-1.

[3] Radio Frequency Migration Regulations and Radio Frequency Migration Plan Explanatory Document. (Government Gazette Number 36334 (Notice 352 and 353 of 2014).

[4] Can be found in IMT Roadmap 2014, Government Gazette No. 38213 (Notice No. 1009 of 2014).

described in Recommendation ITU-R.M2083 which the details thereof are highlighted and attached to this document as **APPENDIX F**. Furthermore, the 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 the point of reference for this Recommendation is the development of IMT to date based on Recommendation ITU-R M.1645.

2 OVERVIEW

2.1 Purpose of the IMT Roadmap

The exponential increase in demand for mobile broadband in South Africa compels a need for additional bandwidth capacity. This requirement is further compounded by the fact that many rural areas do not have access to effective mobile bandwidth, emphasising a real requirement for effective universal mobile broadband access in South Africa in general. It is also important to note the advantage of lower frequency bands ("UHF") for this purpose where propagation qualities are significantly better than that of the higher bands. This aspect is particularly important in the process of providing effective coverage in rural areas.

The International Telecommunication Union ("ITU") identified frequency bands that could be used for International Mobile Telecommunications ("IMT"), which is mainly intended for mobile broadband. The National Radio Frequency Plan ("NRFP") 2018, published in Government Gazette Number 41650 (Notice No. 266 of 2018), further identified which of these IMT bands (between 450 MHz and 3600 MHz) could be deployed in South Africa. The NRFP 2018 repealed the National Radio Frequency Plan 2013.

The eventual assignment to IMT is made through a Radio Frequency Spectrum Assignment Plan ("RFSAP"). The IMT Radio Frequency Spectrum Assignment Plans (Final) was published in Government Gazette No 38640 (Notices 270 to 278 of 2015).

The purpose of the Radio Frequency Migration Regulations and Plan is to establish the framework by which the Authority may migrate users of the radio frequency spectrum under the National Radio Frequency Plan of South Africa. The Radio Frequency Migration Plan 2013 has been substituted by the Frequency Migration Plan 2019.

A key driver for the deployment of IMT bands is the need to ensure that mobile broadband meets the objectives of 'broadband for all' which is encapsulated in the targets of the SA Connect (Creating Opportunities, Ensuring Inclusion, South Africa's Broadband Policy) published in Government Gazette No. 37119 (Notice No 953 of 2013).

A key part of this 2019 IMT Roadmap concerns the deployment of the 700 MHz and 800 MHz digital dividend bands that is still being occupied by analogue television and digital terrestrial television ("DTT"). On 30 March 2015, ICASA published the Final Radio Frequency Spectrum Assignment Plans in Government Gazette Number 38640 Notices 271, 272 and 273 to implement IMT in Digital Dividend I and II. This was to give effect to the one of the objectives described in the National Development Plan (NDP), which states that; *"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."*[5]

It is noted that it is South Africa's intention to prioritise the implementation of DTT in order to release the 700 and 800 MHz spectrum for IMT[6].

Although IMT essentially implies all mobile telecommunications, there is currently a strong focus on Long Term Evolution ("LTE") and this is reflected in the IMT Roadmap 2019. In cases where it is necessary to give emphasis to IMT for LTE, the IMT Roadmap 2019t refers to *broadband* IMT.

In various countries these LTE/IMT services have already been introduced in licensing IMT radio frequency spectrum made available through the process of digital migration. The differenct applications are summarised inthe following list:

(a) mobile telephony/broadband internet (LTE/IMT);
(b) broadband access to scarcely populated areas;
(c) services Ancillary to broadcasting, which already coexist with broadcasting;
(d) low power devices (licence exempt or not);
(e) private mobile radio;
(f) military communications;
(g) public protection and disaster relief (PPDR).

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 assisted to 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 is expected to start from 2019 in other countries.

The Mobile Industry expressed their requirements regarding the availability of IMT2020 spectrum for testing and implementation in South Africa in the submissions received on the Draft IMT Roadmap 2018**.**

As indicated above Recommendation ITU-R M.2083-0 describes the IMT2020 Vision. This is the Framework and overall objectives of the future development of IMT for 2020 and beyond. South Africa needs to align with the IMT2020 Vison and form part of the working groups performing studies into the recommendations and studies that feeds into World Radiocommunication Conference, 2019 ("WRC-19"). A copy of REC. ITU-R M.2083-0 is included in **Appendix H**.

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[5] Recommendation ITU-R M.2083-0

[6] SA Connect, page 56 – High demand spectrum.

Future Agenda Items On Spectrum Requirements For IMT In Accordance With Resolusion 238 (WRC-15)

The following bands, which are already allocated to mobile, are being studied by the ITU for possible IMT-2020 identification by WRC-19:

- 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

Which services and applications will IMT2020 support?

IMT 2020 Vision, in Recommendation ITU-R.M.2083, indicates that *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 currently being implemented on existing networks. The technology is being used in everything from smart homes to wearables (an item that can be worn). 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 Radio Frequency Spectrum Assignment Plans (RFSAP) to be published for each band.

The licensing of IMT frequencies will generally be made through an Invitation to Apply (ITA) in line with regulations 6 and 7 of the Radio Frequency Spectrum Regulations 2015, as amended. This process will detail the actual mechanism of assignment (including market-based mechanisms, etc.).

Background on the IMT Roadmap

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 above 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)

Government Gazette No. Notice   of 2019 – 825 to 830 and 870 to 875 MHz (draft)

The final RFSAP is to be published in Government Gazette by 29 March 2019 for 825 to 830 and 870 to 875 MHz[7]

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 2019 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 coverage (especially rural coverage) is the IMT700 and IMT800 bands. Unfortunately, the IMT700 and IMT800 are still not available for use in South Africa.

[7] On 01 September 2017, in Government Gazette 41082 (Notice 684 of 2017), the Authority 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.

3 INTERNATIONAL TELECOMMUNICATION UNION (ITU) IMT GENERATIONS[8]

3.1 IMT[9]

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 release of IMT-2000 are defined in Recommendation

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[8] 1.1 Recommendation ITU-R M.2083-0.

[9] ITU Resolution 56

ITU R M.1457. The term ‘IMT-2000’ should also encompass its enhancements and future developments.

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 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.

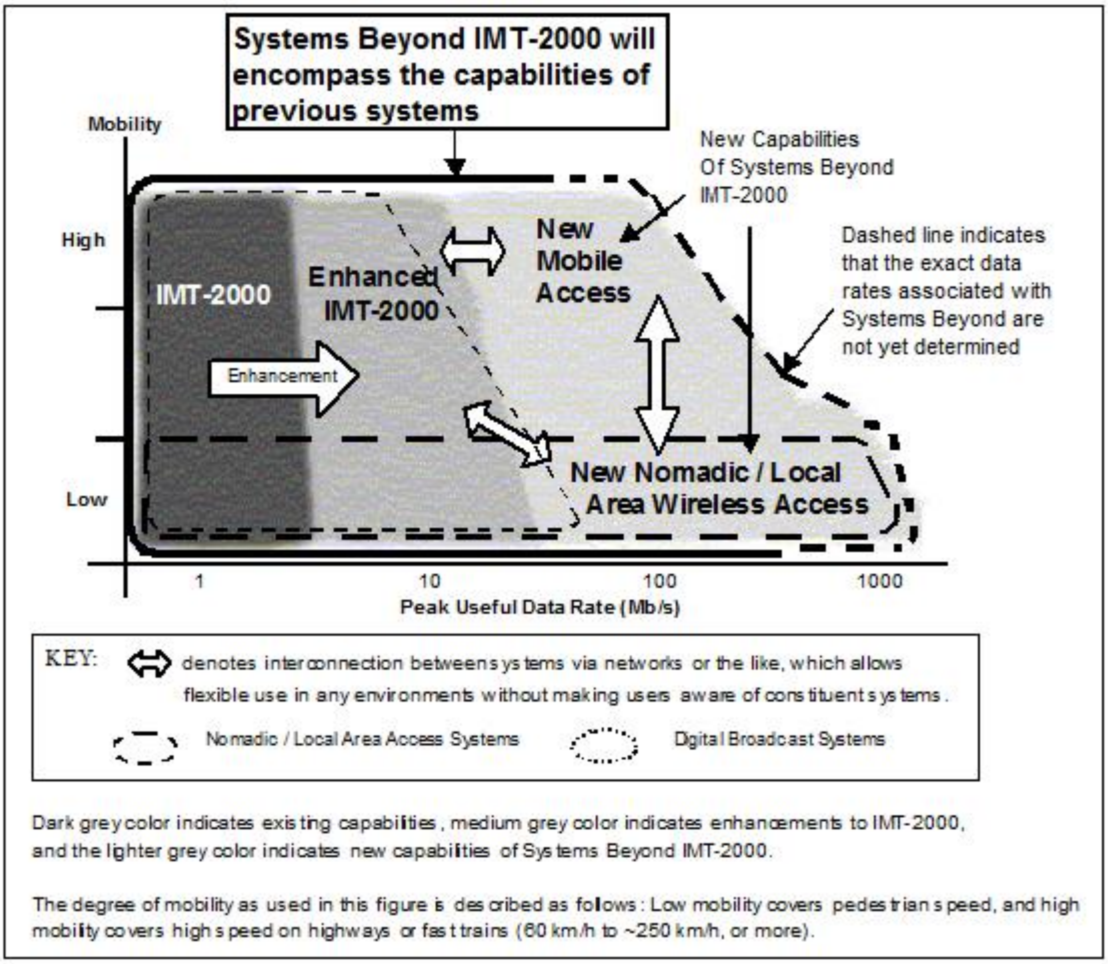


Figure 1: IMT Systems now and in the future (Source: ITU)

3.1.3 IMT 2020 & Beyond

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 ofIMT for 2020 and beyond": IMT-2020. Resolution ITU-R 56 resolves that the term IMT-2000 encompasses its enhancements and future developments and the term "IMT-Advanced" also 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 number 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

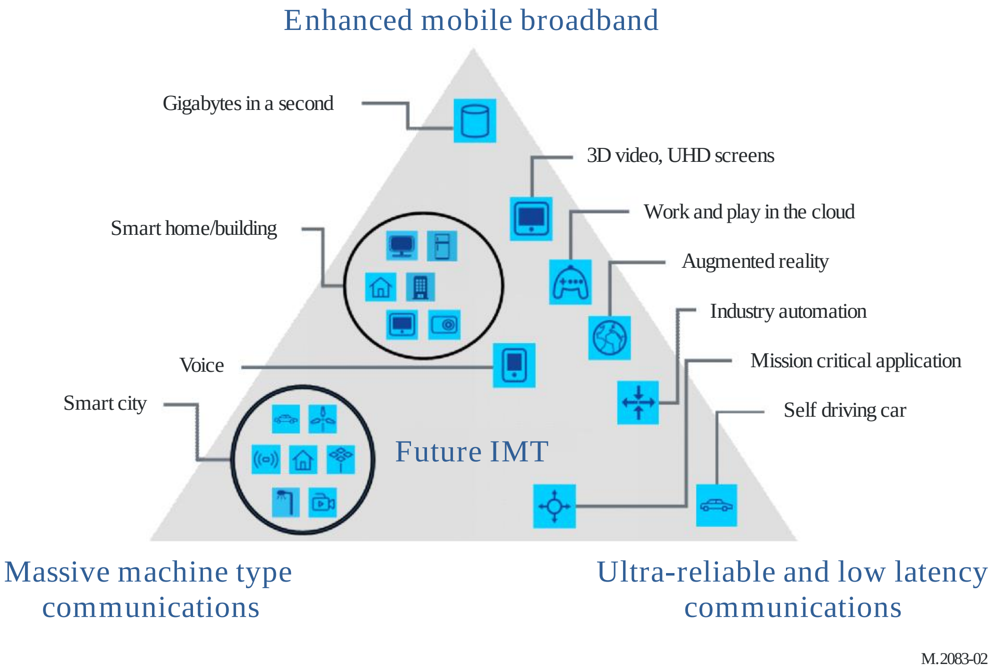
Consumer demands will shape the future development of IMT. In the future, it is foreseen that new demands, such as more traffic volume, many more devices with diverse service requirements, better quality of user experience (QoE) and better affordability by further reducing costs, etc., will require an 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 many 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.

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 2 illustrates some examples of envisioned usage scenarios for IMT-2020 identified in Recommendation ITU-R M.2083.

FIGURE 2

Usage scenarios of IMT-2020



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 key capabilities of IMT-2020:

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

(b) **User experienced data rate:** Achievable data rate that is available ubiquitously[10] across the coverage area to a mobile user/device (in Mbit/s or Gbit/s).

(c) **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).

(d) **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).

(e) **Connection density:** Total number of connected and/or accessible devices per unit area (per km^2).

(f) **Energy efficiency:** Energy efficiency has two aspects-

(i) 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);

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

(g) **Spectrum efficiency:** Average data throughput per unit of spectrum resource and per cell[11] (bit/s/Hz).

(h) **Area traffic capacity:** Total traffic throughput served per geographic area (in $Mbit/s/m^2$).

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 Figure. 3 (from Recommendation ITU-R M.2083), compared with those of IMT-Advanced.

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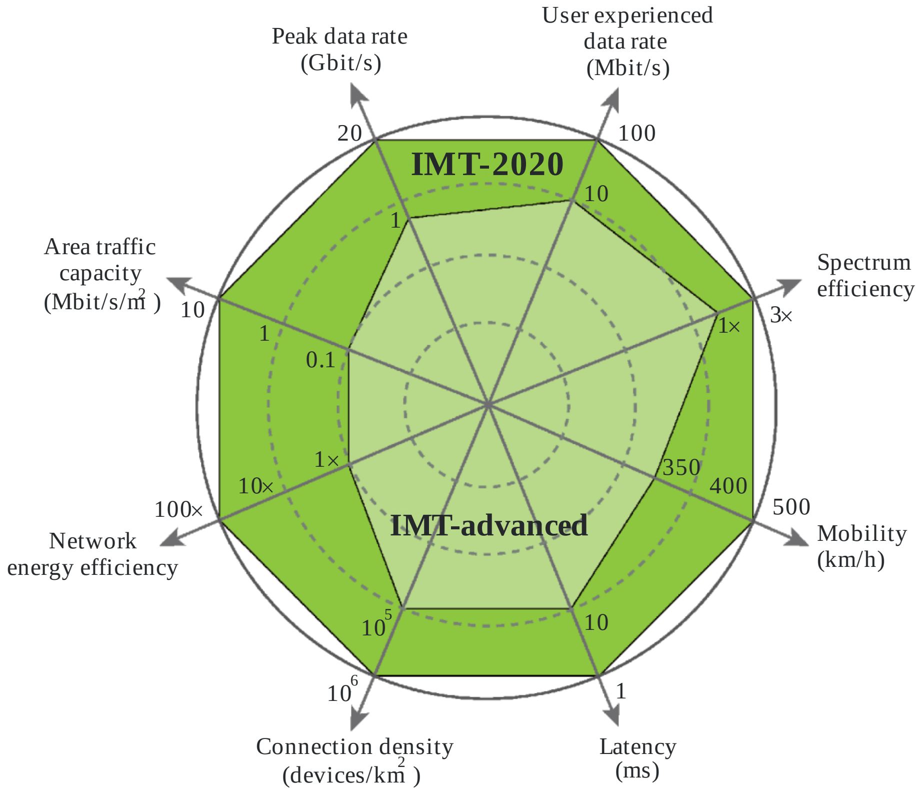
[10] The term "ubiquitous" is related to the considered target coverage area and is not intended to relate to an entire region or country.

[11] 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).

FIGURE 3

Enhancement of key capabilities from IMT-Advanced to IMT-2020



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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.

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 Figure 4. This is done using an indicative scaling in three steps as “high”, “medium” and “low”.

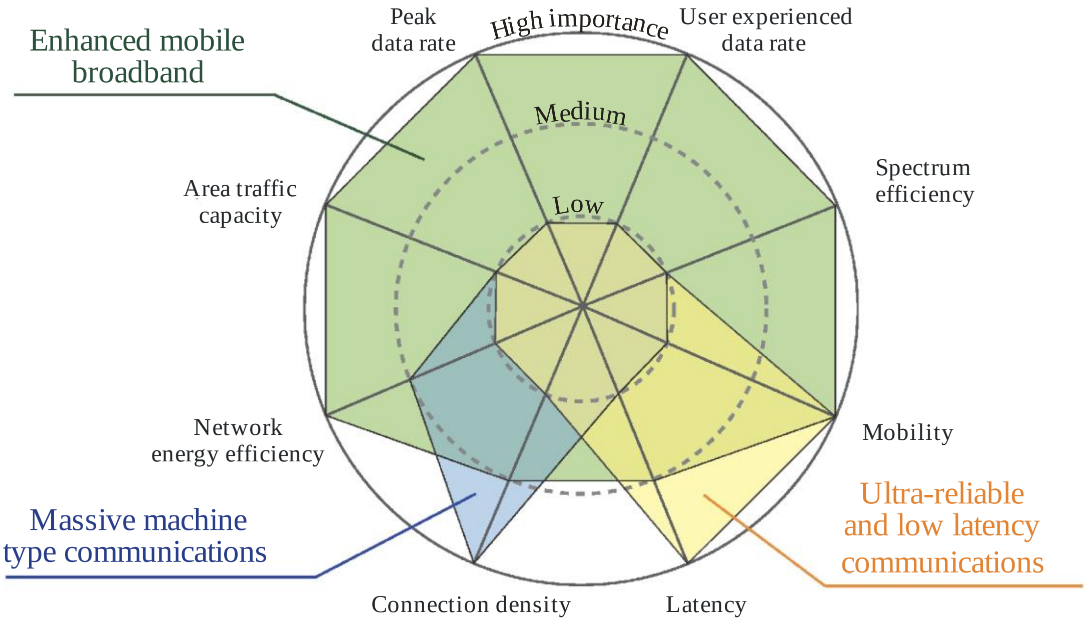
In the enhanced Mobile Broadband scenario, user experienced data rate, area traffic capacity, peak data rate, mobility, energy efficiency and spectrum efficiency all have high importance, but mobility and the user experienced data rate would not have equal importance simultaneously in all use cases.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

FIGURE 4

The importance of key capabilities in different usage scenarios



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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:

Scenario - Spectrum and bandwidth flexibility - Spectrum and bandwidth flexibility refers to the flexibility of the system design to handle different scenarios, and the capability to operate at different frequency ranges, including higher frequencies and wider channel bandwidths than today **:**

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

(b) **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.

(c) **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.

(d) **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 Figure 3 and 4 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 in the National Radio Frequency Plan 2018

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 frequency bands, as extracted from the National Radio Frequency Plan and the details are contained in the Final Radio Frequency Spectrum Assignment Plans 2015.

Band (MHz)	Frequency band	BW Note 1	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)
1500	1427-1518 MHz	80 MHz	5.149, 5.338A, 5.339	Under developmen t. In ITU-R	(Rev, WRC – 15)
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)
3300	3300-3400 MHz	100 MHz	5.429B	Under developmen t. In ITU-R	(Rev, WRC – 15)
3500	3400-3600 MHz	200 MHz (Note 8)	5.430A	M.1036 (F1)	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, as contained in Table 1 above, are taken from the (South African) National Radio Frequency Plan 2018 (NRFP-2018) as per foot note NF9 thereof.

;***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.*

Migration of the broadcasting services from this band has to be addressed in accordance with the Terrestrial Broadcast Frequency Plan 2013 (TBFP-13) as amended in the 2014. The Radio Frequency Spectrum Assignment Plan for DTT Implementation is to be finalised in 2019/2020 financial year.

Suitable channel plans for the 700 MHz frequency band for IMT systems have been developed and is contained in Recommendation ITU-R.M1036-5. The channel arrangement are Frequency Division Duplex (FDD) included as 2 x 30 MHz with duplex gap of 25 MHz.

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 Final International Mobile Telecommunications Roadmap 2014 envisaged a scenario that the Radio Frequency Spectrum Assignment Plans for IMT were to be developed. Subsequent to the publication of the IMT Roadmap 2014 the following IMT RFSAPs were published:

- IMT 450
- IMT 700
- IMT 750
- IMT 800
- IMT 850
- IMT 900
- IMT 2300
- IMT 2600
- IMT 3500

The following Foot Notes ("FN") are an extract from the National Radio Frequency Plan 2018 (NRFP-18). The following FN are applicable to IMT Systems:

NF8A (694 – 862 MHz)

Transitional Arrangements

The Authority resolved the following transitional arrangements for the right of use of spectrum in the frequency range 694 to 862 MHz:

(i) That Broadcasting Spectrum Assignments for the frequency band above 694 MHz, in the affected areas as stipulated in the Terrestrial Broadcasting Frequency Plan (Notice No. 298 of 2013 in Government Gazette No. 36321 and Notice No. 801 of 2014 in Government Gazette 38005 or the latest version), are to be used subject to meeting the conformance requirements in line with the GE06 Plan and are to be phased out during the performance period.

(ii) That broadcast transmissions and services ancillary to broadcasting for the frequency range 694 to 862 MHz is to be systematically switched off.

(iii) That matters related to spectrum management geared at minimising and or preventing harmful interference during the transitional arrangement period, is to be managed by the Authority to achieve systematic implementation and seamless transition.

(iv) That sharing and co-existence in the frequency range 694 to 862 MHz is to be implemented systematically through a Geographic separation of IMT Systems and Broadcasting Services in affected areas in accordance with the Terrestrial Broadcasting

Frequency Plan 2013, Government Gazette 36321, read with the First Update to the Terrestrial Broadcasting Plan 2013 Government Gazette 38005[12] until the end of the migration from Analogue to Digital Terrestrial Television process.

NF9 (IMT Frequency Bands - Terrestrial)

The table below lists all possible IMT frequency bands identified by the ITU, relevant ITU Radio Regulation footnote as well as the applicable ITU-R channel plan.

Band	*Frequency band*		*RR FN*	*Channel Plan*	*WRC Resolution/s*
450 MHz	*450 – 470 MHz*		*5.286AA*	*Recommendation ITU-R M.1036*	*224 (Rev. WRC-15)*
700 MHz	*694 – 790 MHz*		*5.312A and 5.317A*	*Recommendation ITU-R M.1036*	*224 (Rev.WRC-15) and 760 (WRC-15)*
800 MHz	*790 — 862 MHz*		*5.316B and 5.317A*	*Recommendation ITU-R M.1036 (A3)*	*224 (Rev. WRC-15) and 749 (Rev. WRC-15)*
900 MHz	*880 – 915 MHz // 925 – 960 MHz*		*5.317A*	*Recommendation ITU-R M.1036 (A2)*	*224 (Rev. WRC-15) and 749 (Rev. WRC-15)*
1500 MHz	*1 427-1 518 MHz*		*5.341A, 5.346, and 5.346A*	*Recommendation ITU-R M.1036[12]*	223 (Rev. WRC-15), 750 (Rev. WRC-15), and 761 (WRC-15)
1800 MHz	1710 – 1785 MHz // 1805 – 1880 MHz		5.384A	Recommendation ITU-R M.1036 (B2)	223 (Rev. WRC-15)
1900 MHz	*1900 – 1920MHz*		*5.388*	*Recommendation ITU-R M.1036 (B4)*	*Resolution **212 (Rev.WRC-15)***
2100 MHz	1920 – 1980 MHz // 2110 – 2170 MHz		5.388	Recommendation ITU-R M.1036 (B1)	212 (Rev. WRC-07) and 223 (Rev. WRC-12)
2100 MHz (TDD)	1900 – 1920 MHz, 2010 – 2025 MHz		5.388	Recommendation ITU-R M.1036 (B1)	212 (Rev. WRC-07) and 223 (Rev. WRC-12)

[12] Channelling arrangement for 1 427-1 518 MHz is under study at the ITU-R Working Party 5D

2300 MHz	2300 – 2400 MHz		5.384A	Recommendation ITU-R M.1036 (E1)	223 (Rev. WRC-12)
2600 MHz	2500 – 2690 MHz		5.384A	Recommendation ITU-R M.1036 (C1)	223 (Rev. WRC-12)
3500 MHz	3300 – 3400 MHz		5.429B	Recommendation ITU-R M.1036[13]	223 (Rev. WRC-15),
3.5 GHz	3400 – 3600 MHz		5.430A	Recommendation ITU-R M.1036 (F1)	NA

NF10 (876 - 880 // 921 - 925 MHz)

This frequency band is used by GSM-R systems.

NF13 (1980 – 2010 MHz paired with 2170 – 2200 MHz)

These frequency bands are allocated, amongst others, to both the mobile and mobile-satellite services and are also earmarked for the satellite component of IMT. Further, the implementation of IMT in the bands 1885-2025 MHz and 2110-2200 MHz is under study within ITU-R in accordance with Resolution 212 (Rev. WRC-15), See NRFP 18

3.3 **Issues for WRC 19**

The International Telecommunication Union Radiocommunications Sector (ITU-R) have been studying the below frequency bands for IMT use and possible implementation. The studies give an indication of bands which will impact the South African IMT Roadmap in the future and the outcome of WRC-19 agenda items and resolutions.

- 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

[13] Channelling arrangement for 3300 – 3400 MHz is under study at the ITU-R Working Party 5D

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 238 (WRC-15) 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 studies1, 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.

WRC 19 is to discuss 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, based on the Conference Preparatory Meeting 2019 (CPM19-2) Report, contributions from administrations, Ragional Bodies and the Radio Assembly.

4 SADC

The Southern African Development Community (SADC) Frequency Allocation Plan 2016 ("FAP 2016") created a framework for harmonisation across SADC on the use of the radio frequency spectrum for IMT and other purposes. Countries included in the SADC FAP 2016 are Angola, Botswana, Democratic Republic of the Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Eswatini, Tanzania, Zambia and Zimbabwe.

The SADC FAP 2016 states that "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." If no harmonisation of IMT frequency bands takes place within the SADC region it can become problematic considering possible interference between countries especially in the bordering areas.

The SADC FAP 2016 was developed taking into account international best practice in the development of Frequency Band Plans and considering the needs of the SADC Members. The table below is an extract of the SADC FAP 2016;

Table 2: Table showing SADC Frequency Allocations for IMT Bands -

ITU Region 1 allocations and footnotes	SADC common allocation/s and relevant ITU footnotes	SADC proposed common sub-allocations / utilisation	Additional information
450-455 MHz FIXED MOBILE 5.286AA 5.209 5.271 5.286 5.286A 5.286B 5.286C 5.286D 5.286E	**450-455 MHz** 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)
455-456 MHz FIXED MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E	**455-456 MHz** FIXED MOBILE 5.286AA 5.209 5.286A		
456-459 MHz FIXED MOBILE 5.286AA	**456-459 MHz** FIXED MOBILE 5.286AA		

5.271 5.287 5.288	5.287		
459-460 MHz FIXED MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E	**459-460 MHz** FIXED MOBILE 5.286AA 5.209 5.286A		
460-470 MHz FIXED MOBILE 5.286AA Meteorological satellite (space to Earth) 5.287 5.288 5.289 5.290	**460-470 MHz** FIXED MOBILE 5.286AA Meteorological satellite (space to Earth) 5.287 5.289		
470-790 MHz BROADCASTING 5.149 5.291A 5.294 5.296 5.300 5.304 5.306 5.311A 5.312 5.312A	**694-790MHz** 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
790-862 MHz MOBILE except aeronautical mobile 5.316B 5.317A **BROADCASTING** 5.312 5.314 5.315 5.316	**790-862 MHz** 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.
862-890 MHz FIXED	**862-890 MHz** 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.

MOBILE except aeronautical mobile 5.317A BROADCASTING 5.322 5.319 5.323 5.316A 5.319	SADC14	876-880 MHz IMT PMR and/or PAMR	This band is paired with 921-925 MHz The use of this band for IMT in the future to be investigated as part of the development of harmonised IMT channelling arrangement.
		880-915 MHz IMT	Paired with 925-960 MHz
890-942 MHz FIXED MOBILE except aeronautical mobile 5.317A BROADCASTING 5.322 Radiolocation 5.323	**890-942 MHz** MOBILE except aeronautical mobile 5.317A	915-921 MHz PMR and/or PMR	
		921-925 MHz IMT PMR and/or PAMR	Paired with 876-880 MHz.
		925-960 MHz IMT	Paired with 880-915 MHz
942-960 MHz FIXED MOBILE except aeronautical mobile 5.317A BROADCASTING 5.322 5.323	**942-960 MHz** MOBILE except aeronautical mobile 5.317A 5.322		
1427 – 1518 MHz			
1700-1710 MHz FIXED METEOROLOGICAL-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile 5.289 5.341	**1700-1710 MHz** FIXED METEOROLOGICAL-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile 5.289 5.341	Fixed links (single frequency)	
1710-1930 MHz FIXED MOBILE 5.384A 5.388A 5.388B 5.149 5.341 5.385 5.386 5.387 5.388	**1710-1930 MHz** FIXED MOBILE 5.384A 5.388A 5.388B 5.149 5.341 5.385 5.388	1710-1785 MHz IMT	IMT
		1785-1805 MHz BFWA	
		1805-1880 MHz IMT	Paired with 1710-1785 MHz.
		1880-1900 MHz	

		FWA Cordless telephone	
		1900-1920 MHz FWA IMT (terrestrial)	
1930-1979 MHz FIXED MOBILE 5.388A 5.388B 5.388	**1930-1979 MHz** 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
1970-1980 MHz FIXED MOBILE 5.388A 5.388B 5.388	**1970-1980 MHz** FIXED MOBILE 5.388A 5.388B 5.388		
2010-2025 MHz FIXED MOBILE 5.388A 5.388B 5.388	**2010-2025 MHz** FIXED MOBILE 5.388A 5.388B 5.388	IMT terrestrial (2010-2025 MHz)	TDD
2110-2120 MHz FIXED MOBILE 5.388A5.388B SPACE RESEARCH (deep space) (Earth-to-space) 5.388	**2110-2120 MHz** MOBILE 5.388A5.388B SPACE RESEARCH (deep space) (Earth-to-space) 5.388	IMT (terrestrial) (2110-2170 MHz)	Paired with 1920-1980 MHz
2120-2160 MHz FIXED MOBILE 5.388A 5.388B 5.388	**2120-2160 MHz** MOBILE 5.388A 5.388B 5.388		
2160-2170 MHz FIXED MOBILE 5.388A 5.388B 5.388	**2160-2170 MHz** MOBILE 5.388A 5.388B 5.388		
2170-2200 MHz FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A 5.388 5.389A 5.389F	**2170-2200 MHz** 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.
2 200-2 290 MHz SPACE OPERATION (space-to-Earth) (space-to-space)	**2 200-2 290 MHz** SPACE OPERATION (space-to-Earth) (space-to-space)	Fixed links (2025-2110 MHz paired with 2200- 2285 MHz)	Radio Frequency channel arrangement according to ITU-RF. 1098.

EARTH EXPLORATION – SATELLITE (space-to-Earth) (space-to-space) FIXED MOBILE 5.391 SPACE RESEARCH (space-to-Earth) (space-to-space) 5.392	EARTH EXPLORATION – SATELLITE (space-to-Earth) (space-to-space) FIXED SPACE RESEARCH (space-to-Earth) (space-to-space) 5.392	BFWA (2 285-2 300 MHz)	
2290-2300 MHz FIXED MOBILE except aeronautical mobile SPACE RESEARCH (deep space) (space-to-Earth)	FIXED MOBILE except aeronautical mobile SPACE RESEARCH (deep space) (space-to-Earth)	BFWA (2285-2300 MHz)	
2300-2450 FIXED MOBILE 5.384A Amateur Radiolocation 5.150 5.282 5.395	**2300-2450** 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.
2500-2520 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A 5.405 5.412	**2500-2520 MHz** 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.
2520-2655 MHz 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	**2520-2655 MHz** FIXED MOBILE except aeronautical mobile 5.384A 5.339		
2655-2670 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A BROADCASTING-SATELLITE 5.208B 5.413 5.416 Earth	**2655-2670 MHz** FIXED MOBILE except aeronautical mobile 5.384A 5.149 5.412		

exploration-satellite (passive) Radio astronomy Space research (passive) 5.149 5.412			
2670-2690 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A Earth exploration-satellite (passive) Radio astronomy Space research passive) 5.149 5.412	**2670-2690 MHz** FIXED MOBILE except aeronautical mobile 5.384A 5.149 5.412		
3 300-3 400 MHz RADIOLOCATION 5.149 5.429 5.429A 5.429B 5.430	**3 300-3 400 MHz** RADIOLOCATION 5.149 5.429A 5.429B	**IMT Res. 223 (Rev.WRC-15)**	Subject to outcome of the sharing and compatibility studies called for by Resolution 223 (WRC-15) currently underway within the ITU-R, **there might be a need to migrate Radars out of this band. This will be addressed through an update of the migration plan.**
3400-3600 MHz FIXED FIXED-SATELLITE (space- to-Earth) Mobile 5.430A Radiolocation 5.431	**3400-3600 MHz** 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.

5 SOUTH AFRICAN SPECTRUM LEGISLATIVE FRAMEWORK

5.1 The Electronic Communications Act

The Electronic Communications Act, 2005 (Act No. 36 of 2005) ("ECA"), as amended, regulate electronic communications in the Republic of South Africa and the following legislative provisions were found to be of 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.

(*i) promote competition within 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.

Also see section 34 (Radio Frequency Plan) of the ECA.

5.2 The Frequency Migration Regulation and Frequency Migration Plan 2013

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 Radiocommunication Conference (WRC) require a change in national allocation that will require existing users to be migrated;
- Second Level - where a Regional Radiocommunication 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, 2015 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) 2015, 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.

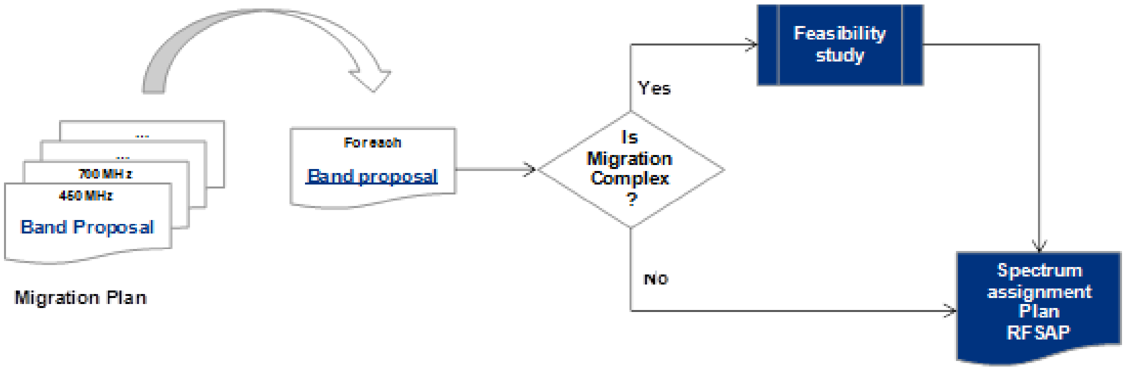

Figure 2: Process for developing an RFSAP

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 considered:

- 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 plays an important role in defining spectrum requirement for government policy directives. South Africa Connect will typically give guidelines on spectrum requirement for the deployment of a new technology to ensure universal service obligations.

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[14].

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;*

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[14] 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

- *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 following targets and timeframes for access to broadband in South Africa:

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 several 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 several 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 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 must be managed efficiently 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).

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 Roadmap describes the IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond. South Africa needs to align with Recommendation ITU-R M.2083-0, of which a copy is included in **Appendix H.**

5.5 Global assignment objectives for IMT

In planning the implementation of IMT, South Africa is to take into consideration the following principles:

- 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, to meet 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)[15]

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

[15] The majority of the information included in this section originates from GSA published documentation

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. LTE TDD smart phones are available commercially on a large scale since 2014.

According to the latest GSA report[16]:

- There are 147 TDD-based LTE networks in operation worldwide
- 219 operators that are investing in TD-LTE networks
- 207 operators in total hold licences to use TDD spectrum for LTE services
- 147 operators in 73 countries have launched TD-LTE networks
- A further 72 operators are either trialling, hold licences to use TDD spectrum, or are actively deploying TD-LTE networks
- Operators are investing in TD-LTE in some form or another in 87 countries

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16 https://gsacom.com/paper/td-lte-snapshot-november-2018/

The figure below, from the GSA, shows TDD licences and launches as of November 2018:

Figure 3: TDD licences and launches (source: GSA)

The majority of submissions received support the use of TDD for new IMT deployment.

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. 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 considered 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 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 if considered at all in future (noting that the ultimate location of the guard band would be determined in the event managed spectrum parks are introduced at all[17]).

The IMT3500 RFSAP was finalised in 2015.

The Block Edge Masks might be investigated to allow unsynchronized usage or to minimize the need for guard bands. The managed spectrum park concept could be decided later as illustrated below:

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[17] Note that beyond the example given here, managed spectrum parks could also be introduced in TDD bands within 2100 MHz. if at all considered in future.

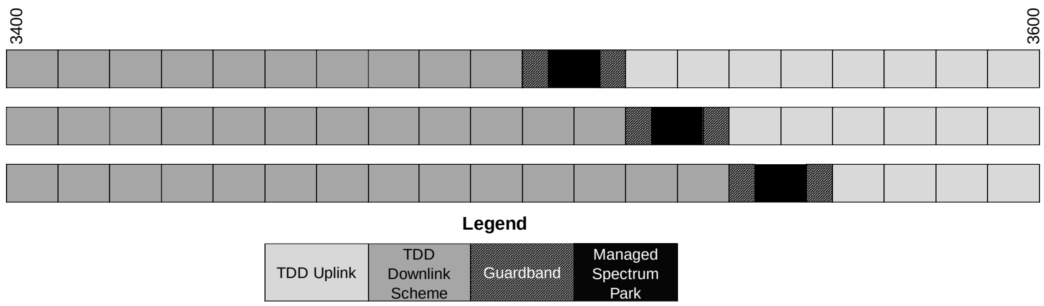


Figure 3: Potential unpaired LTE assignments in 3400-3600 MHz

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).

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.

Put differently, 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 2×2 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.

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. 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:

(a) **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.

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.

(b) **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.

(c) **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.

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.

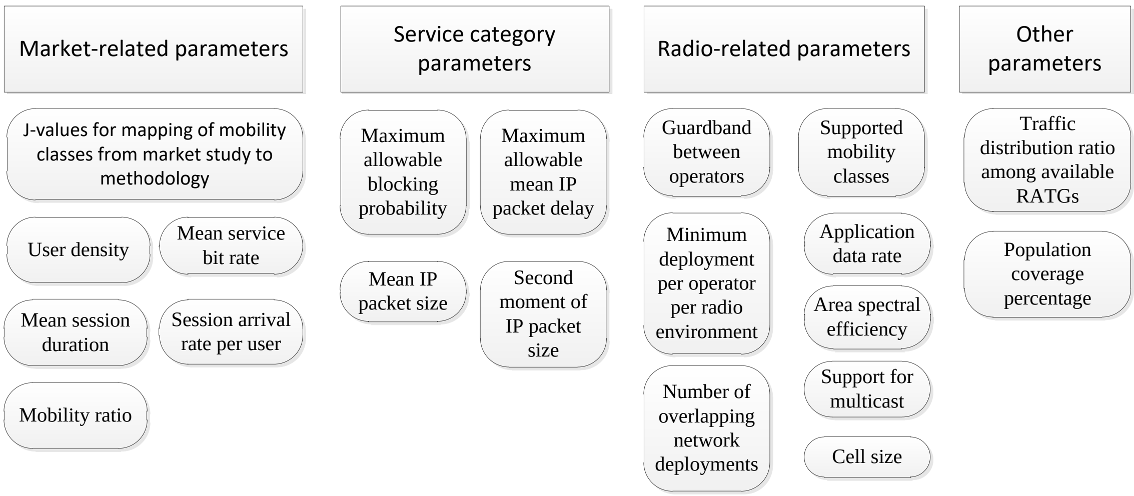


Figure 4: Input parameter overview for IMT spectrum demand estimation

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. The figure below Mobile traffic forecasts toward 2020 by extrapolation;

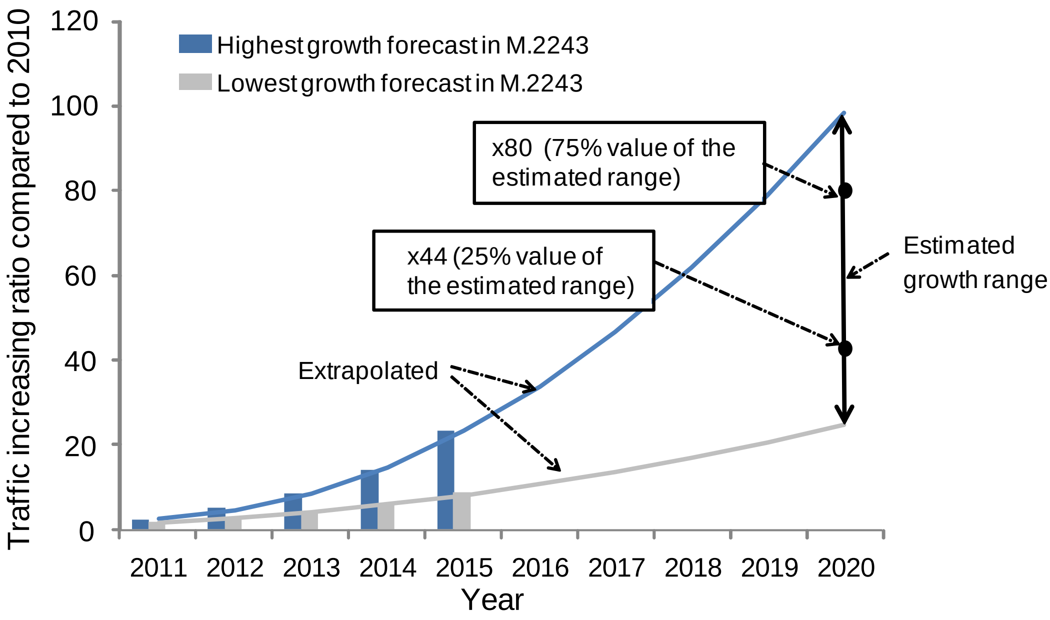


Figure 5: Mobile traffic forecasts toward 2020 by extrapolation *(Source: ITU)*

Table 4 shows the Radio Parameters for RATG 1 (pre-IMT2000, IMT2000) whilst Table 5: Radio parameters for RATG 2 (IMT advanced)

In Table 6 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 7.

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 7 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 4: 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 5: 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 6: 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 7: Total spectrum requirements for both RATG 1 (pre-IMT2000, IMT2000) and RATG 2 (IMT advanced) in the year 2020

In South Africa, 380 MHz is currently used for IMT (including UMTS and LTE) and 80 MHz for GSM. It is anticipated that in 2020, between 1011-1036 MHz could be available for IMT use (incl. GSM) depending on the Authority's decision(s) 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 in the periods 2015-2020 provide for more than the current spectrum usage (510 MHz > 380 MHz) for a traffic ~5 times than that of 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 7 could be closed from 2020 onwards with this additional spectrum.

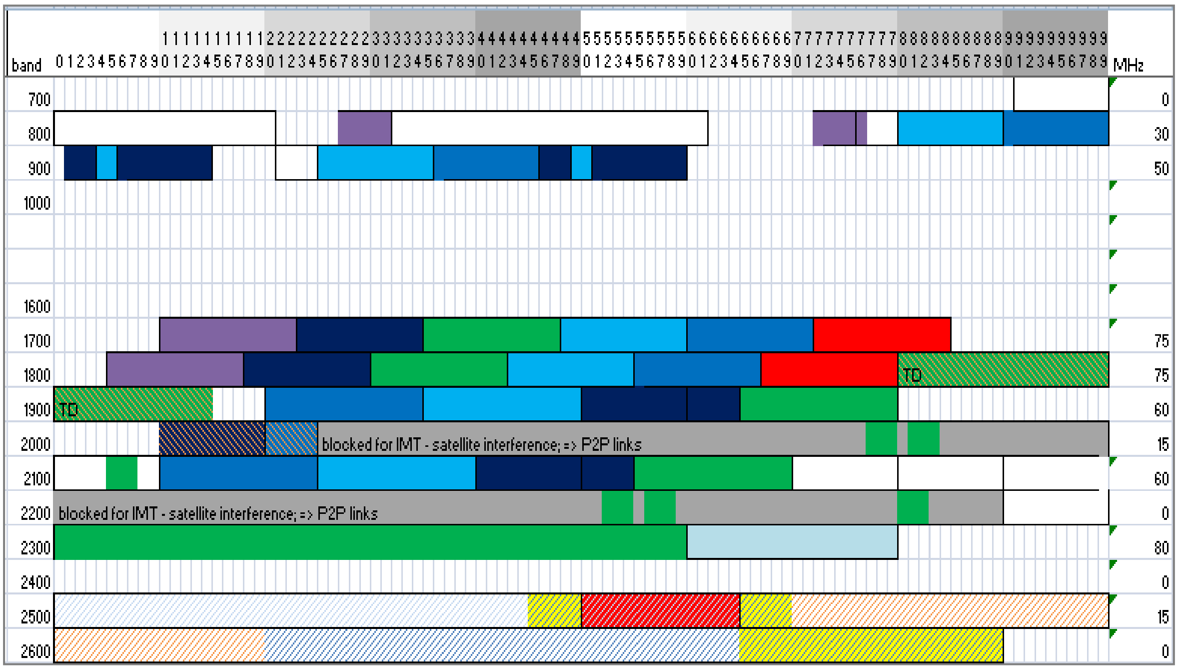
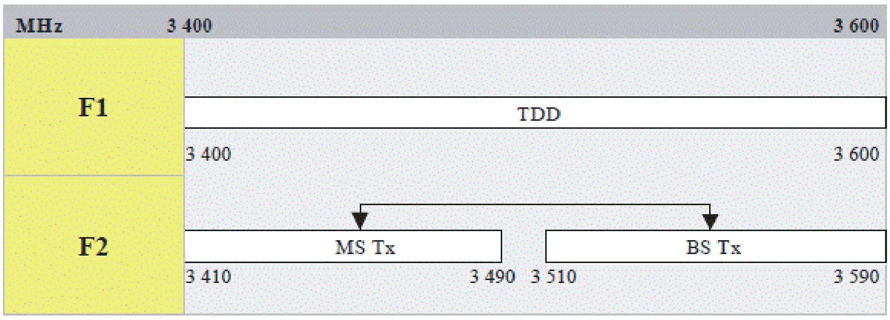


Figure 6: Current South Africa IMT assignments summarised in Table 8



IMT Assignment for 3.6 GHz is included below:

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	**460**
2020	15	87	69	50	75	75	60	15	60	0	100	15	100	90	100	100	**1011**

Table 8: South Africa IMT spectrum assignments

These figures should not be considered 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 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, to compensate for declining revenue from traditional services. M2M represents a relatively small opportunity in terms of revenue, but is one area that is growing significantly, and which opens 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 many 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 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[18], 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.

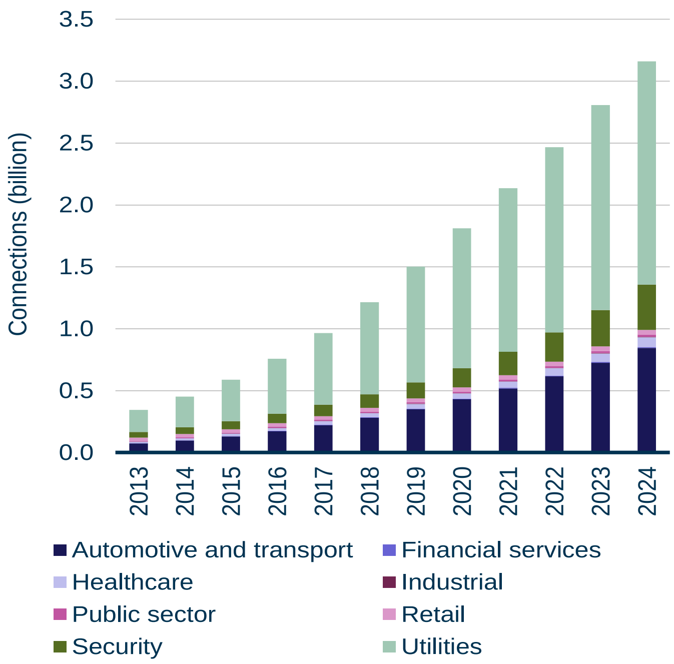


Figure 7: M2M device connections by sector, worldwide, 2013–2024

(Source: Analysis Mason, 2014)

[18] Analysis 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 2020 and Beyond

The expected IMT spectrum demand for 2020 and beyond is described in this paragraph 3.1.3 above and it is based on Rec ITU-R M2083-0.

6.3 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.

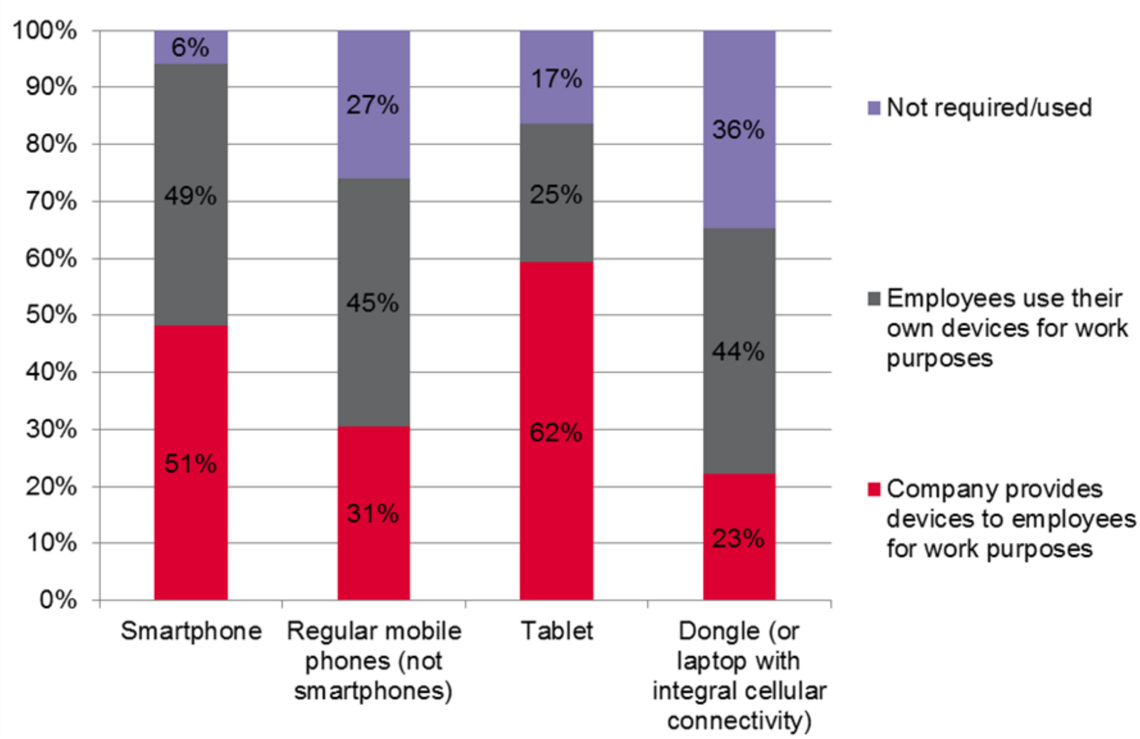


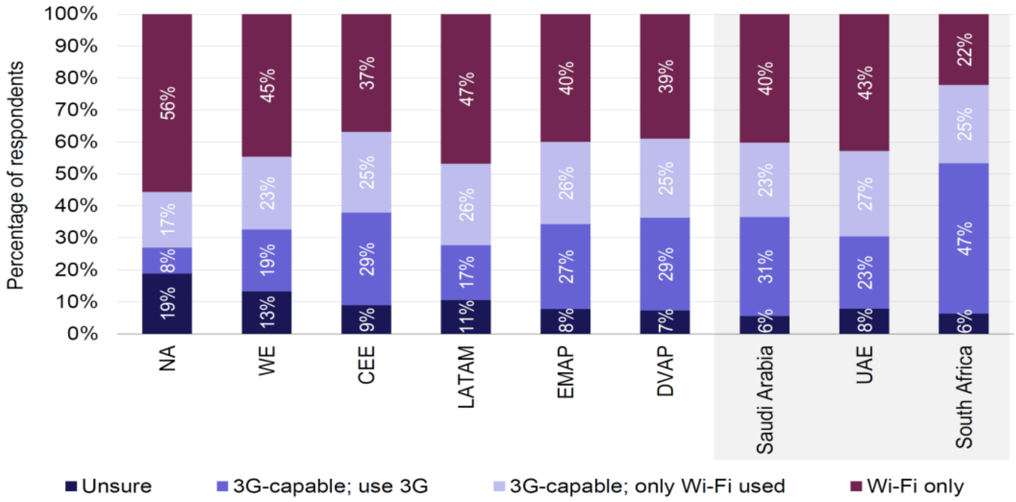
Figure 8: South Africans favour tablets and smart phones

(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 3rd 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
Mobile	**Mobile subscribers (active SIMs)**	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
	Mobile ARPU (ZAR per month)	146.43	150.61	140.98	126.58	110.46
	USD per month	17.66	20.67	19.61	15.52	13.54
	Mobile MoU (minutes per month)	64	71	77	74	73

Table 9: Telecoms KPIs, South Africa, 2009-3Q 2013

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

ICASA released its latest State of the ICT Sector in South Africa report, [19]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. Responses were received

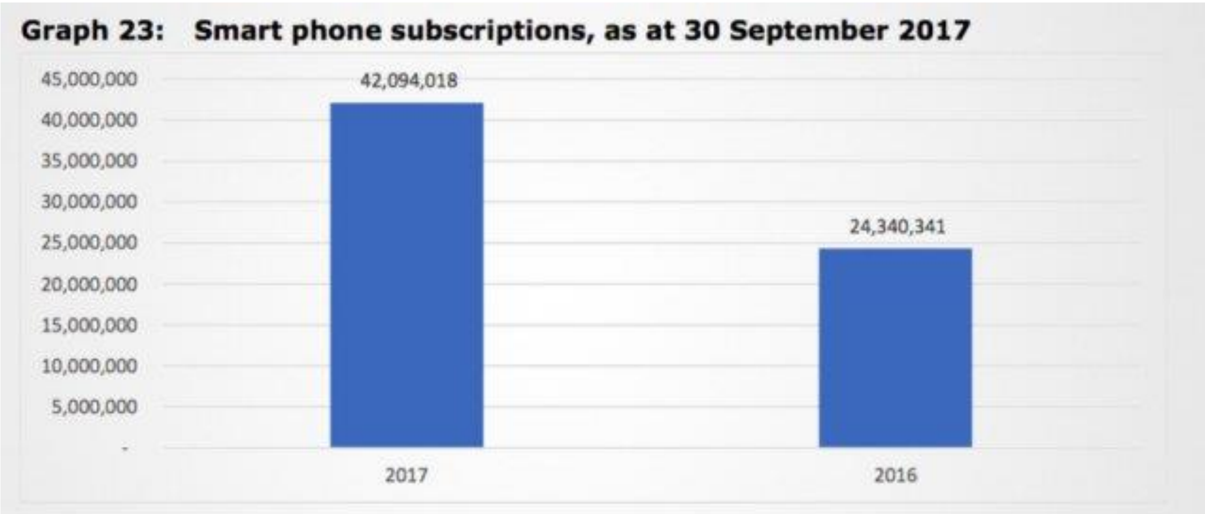
[19] The latest State of the ICT Sector in South Africa report are aviailable on the ICASA Website.

from 84 Electronic Communications Services and Electronic Communications 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

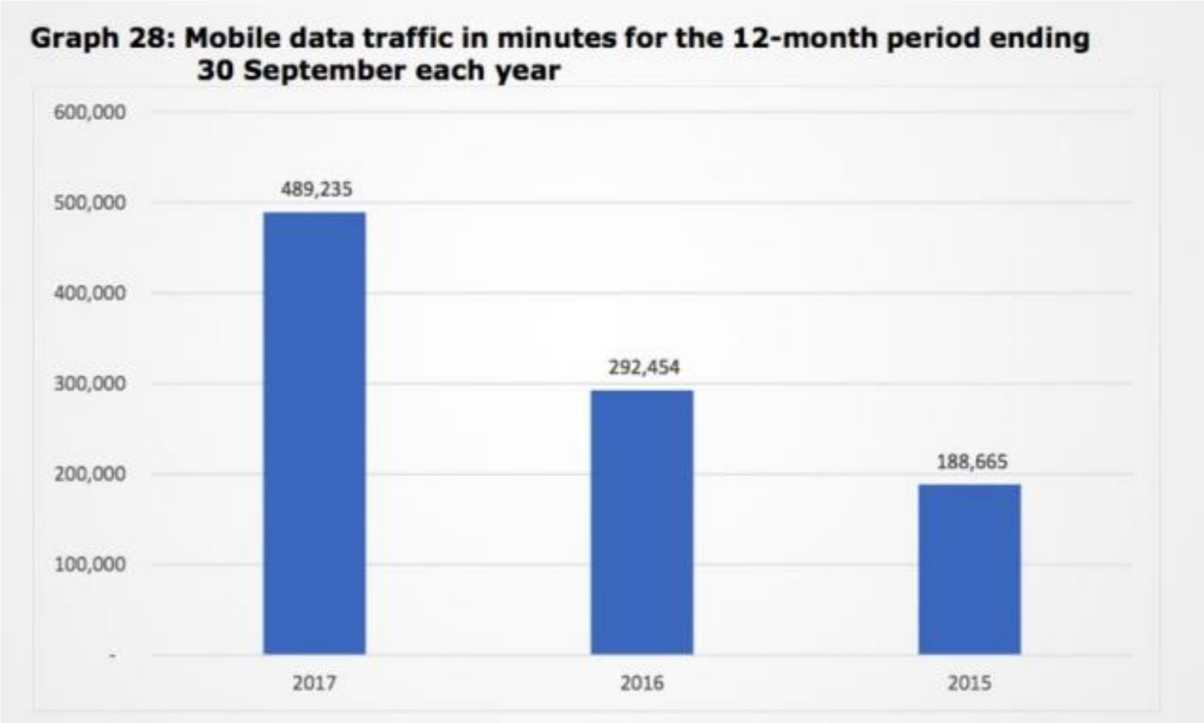
ICASA defined a smartphone as a mobile phone with advanced features, Wi-Fi connectivity, web browsing capabilities, a high-resolution touchscreen display, and the ability to use apps.

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.



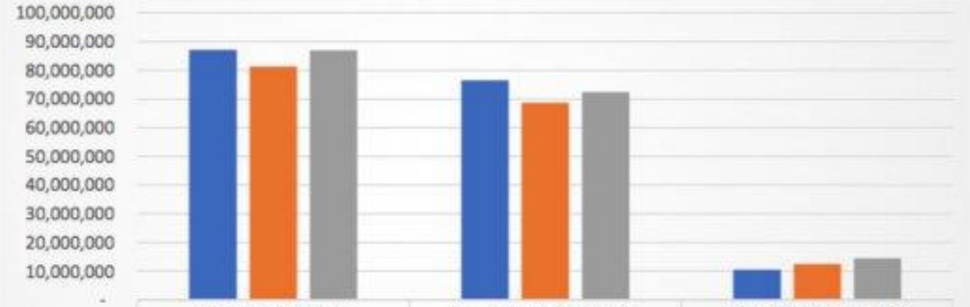
Cellular subscriptions

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.

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.

Graph 19: Prepaid and post-paid mobile cellular subscriptions, as at 30 September each year



	Total Mobile cellular subscriptions	Prepaid mobile-cellular telephone subscriptions	Postpaid mobile-cellular telephone subscriptions
2017	87,153,108	76,546,031	10,607,077
2016	81,314,463	68,710,864	12,603,599
2015	86,985,183	72,423,365	14,561,818

7 IMT ROADMAP

The objective of this section is to provide the long term plan for radio frequency spectrum planning for broadband services in specific bands.

First, the Authority describes 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;
- Smoother cross-border co-ordination; and
- Easy roaming within the region where harmonisation is implemented

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.

In South Africa, it is important to align with IMT specifications 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".[20]

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	D12 - 2×5 MHz (450-455 & 460-465) D13- 2×5 MHz (451-456 & 461-466) D14 - 2×5 MHz (452.5-457.5 & 462.5-467.5)	D8 - 20 MHz (450-470) In accordance with latest revision
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)

[20] http://www.itu.int/pub/R-REG-RR-2012.

			15 MHz (option 1 with 2x5 MHz guard bands)
IMT800	791-862 MHz	2×30 MHz (reverse uplink-downlink)	
IMT850	825-830// 870-875 MHz[21]	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	
IMT1900	1880-1920 MHz		1 x 40 MHz
IMT2100	1920-2170 MHz	2×60 MHz	
IMT2300	2300-2400 MHz		100 MHz
IMT2600	2500-2690 MHz	2×70 MHz (Current arrangement) Current assignment to be revised	50 MHz including 2×5 MHz guard bands
IMT3500	3400-3600 MHz		200 MHz [22]
All IMT		**2×355 MHz**	**370 MHz**

Table 10: IMT roadmap: (summary)

These bands will be discussed in more detail below.

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

[21] Adjusted to allow coexistence with GSM-R (with no guard band to SRD's)

[22] 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

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". The study dealt with the following issues:

- 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 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. 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 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 can properly detect interference on the closest DECT carriers.
- The results in ITU-R M.2110 (Table 11) 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 11: ITU-R M2110: CDMA separation distances (BS-BS case) in 450-470MHz

- The results of broadcasting systems with CDMA450 (Table 12) 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 12: 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.

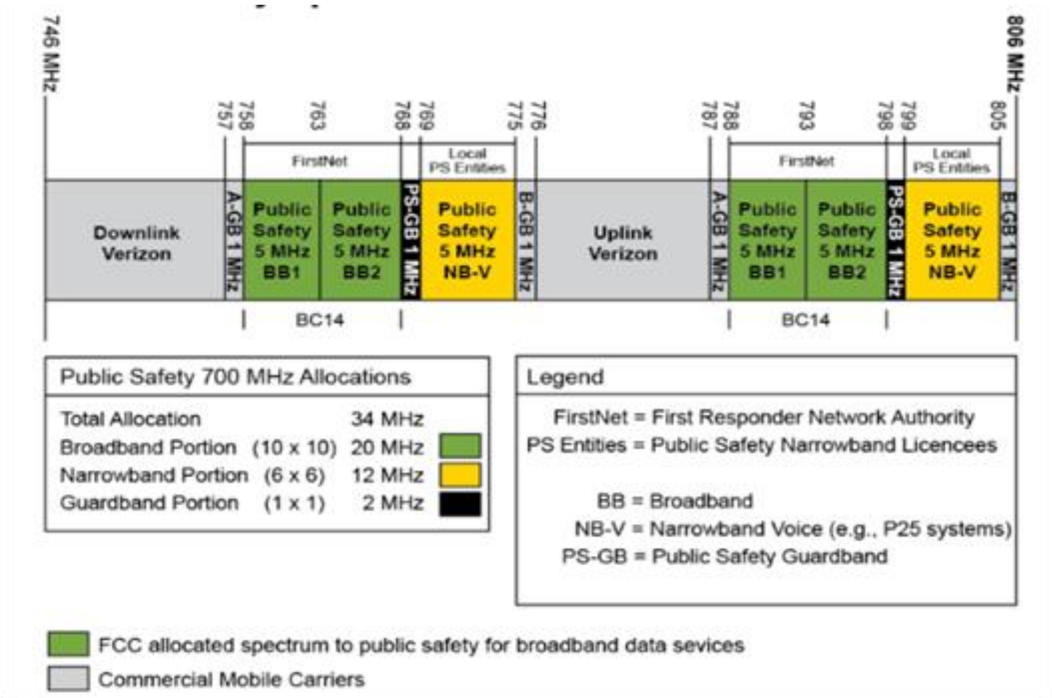


Figure 11: Public safety spectrum allocation in US-700MHz band

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.

<u>Authority's Decision on IMT850</u>

- The Authority's decision is for Liquid Telecom'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 Liquid Telecom 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 2×3 MHz LTE first to ensure dual illumination and 2×5 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.

<u>*LTE R Considerations*</u>

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.1036-5 (10/2015), the recommended frequency arrangements for implementation of IMT in the band 1710-2200 MHz are summarised in

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

Table 13.

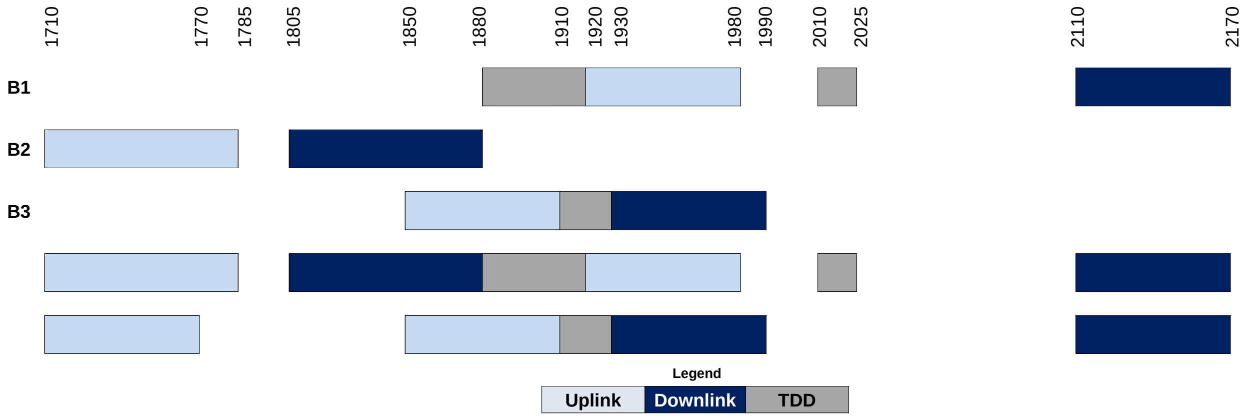


Figure 12: Frequency arrangements in the 1710-2200 MHz band

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

Table 13: Frequency arrangements in the band 1710-2200 MHz

A new” PRELIMINARY DRAFT REVISION OF RECOMMENDATION ITU-R M.1036-5” is under development within the ITU-R.

7.3.2 SADC frequency arrangement on 1700-2290 MHz

The SADC Frequency Allocation Plan (Table 14)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
1 700-1 710 MHz FIXED METEOROLOGICAL–SATELLITE (space-to-Earth)	**1 700-1 710 MHz** FIXED METEOROLOGICAL–SATELLITE (space-to-Earth)	Fixed links (single frequency)	

MOBILE except aeronautical mobile 5.289 5.341	MOBILE except aeronautical mobile 5.289 5.341		
1 710-1 930 MHz FIXED MOBILE 5.384A 5.388A 5.388B 5.149 5.341 5.385 5.386 5.387 5.388	**1710 – 1930 MHz** 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)	
1930 – 1980 MHz FIXED MOBILE 5.388A 5.388B 5.388	**1930 – 1980 MHz** 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
1970 – 1980 MHz FIXED MOBILE 5.388A 5.388B 5.388	**1970 – 1980 MHz** FIXED MOBILE 5.388A 5.388B 5.388		
2 010-2 025 MHz FIXED MOBILE 5.388A 5.388B 5.388	**2 010-2 025 MHz** FIXED MOBILE 5.388A 5.388B 5.388	IMT terrestrial (2010 – 2025 MHz)	TDD
2110 – 2120 MHz FIXED MOBILE 5.388A5.388B SPACE RESEARCH (deep space) (Earth-to-space) 5.388	**2110 – 2120 MHz** MOBILE 5.388A5.388B SPACE RESEARCH (deep space) (Earth-to-space) 5.388	IMT (terrestrial) (2110-2170 MHz)	Paired with 1920-1980 MHz
2120 – 2160 MHz FIXED	**2120 – 2160 MHz**		

MOBILE 5.388A 5.388B 5.388	MOBILE 5.388A 5.388B 5.388		
2160 – 2170 MHz FIXED MOBILE 5.388A 5.388B 5.388	**2160 – 2170 MHz** MOBILE 5.388A 5.388B 5.388		
2 170-2 200 MHz FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A 5.388 5.389A 5.389F	**2 170-2 200 MHz** 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.
2 200-2 290 MHz 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	**2 200-2 290 MHz** 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 14: 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 dB(W/(m^2 *· 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)[23]*.(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)[24]*.(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

[23] Note by the Secretariat: This Resolution was revised by WRC-12.

[24] *Ibid*.

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 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 15: 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:

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

Table 16: CRASA channelling plan for 2025-2290 MHz

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

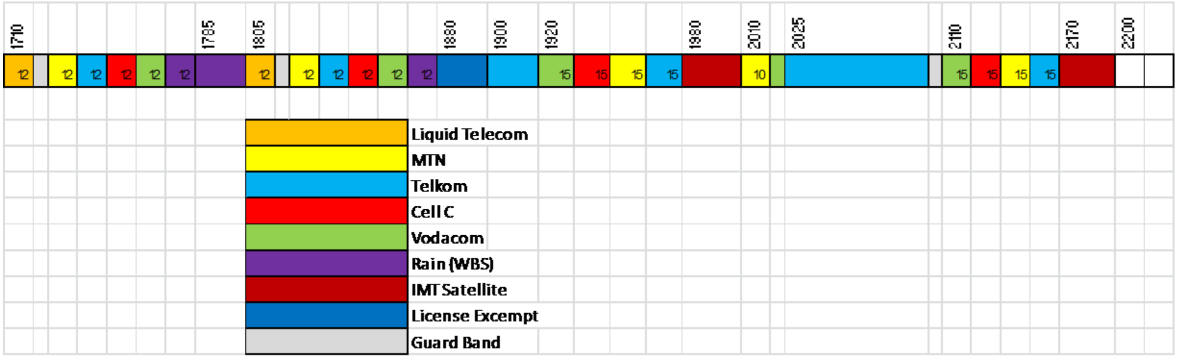


Figure 13: Current assignments with 1700-2200 MHz

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

In South Africa the operators use the IMT1800 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 1880-1900 is license exempt. And used for DECT cordless telephones and DECT WLL, the band 1900 to 1920 MHz is exclusively used by Telkom, for MGW and eMGW FWA-systems. 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.

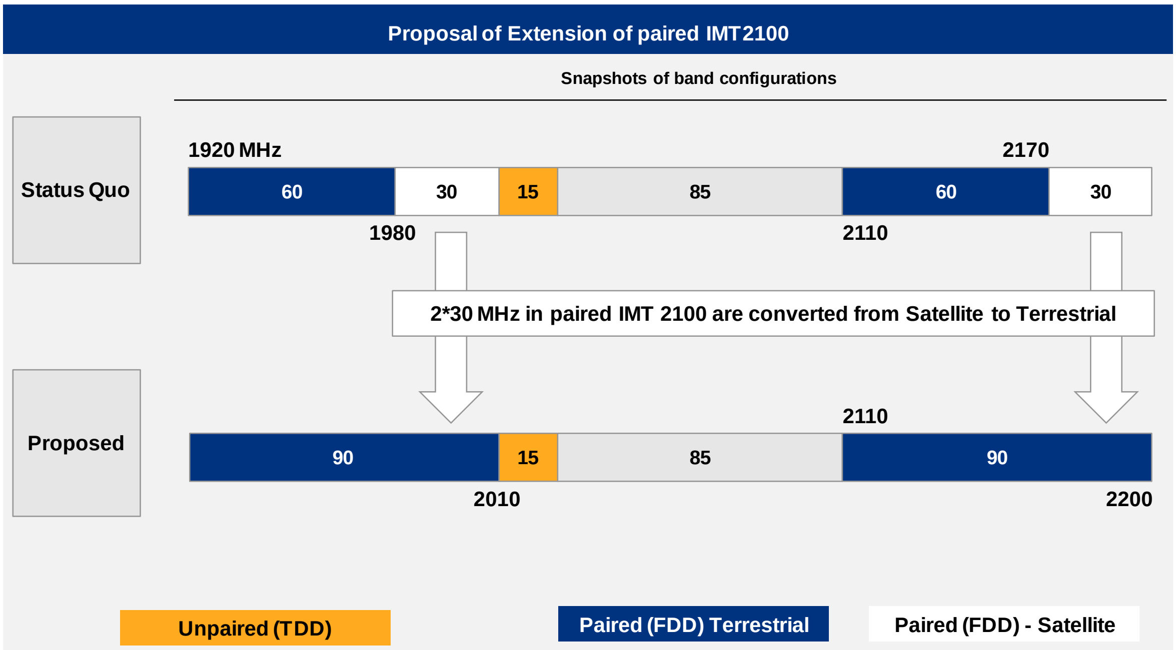


Figure 14: Proposal of Extension of paired IMT2100

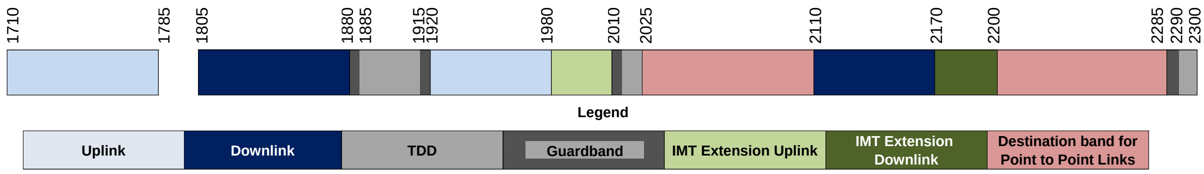


Figure 15: IMT2100-extensions proposal

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. The frequency range 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[25]) and radio equipment, filters and antennas need adaptations.

7.4 IMT2020 Frequencies for Consideration

The majority of the bands included in this section will be discussed at WRC-19 under agenda item 1.13 and the outcome of the conference will provide more clarity the future use of these bands for IMT applications. The only two bands included in this section which have been identified for IMT by WRC-15 are bands 1427 – 1518 MHz and 3.3. to 3.4 GHz. This section provide some information on bands that will be considered for inclusion in future IMT roadmaps.

The following frequency information are extracted from the National Radio Frequency Plan (NRFP) 2018. The frequency ranges from 24.25 to 86 GHz. (Millimeter Wave Band) are currently being study within the ITU-R are due for consideration to enable WRC-19 accordingly.

7.4.1 1.427-1.518 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
1 427-1 429 MHz SPACE OPERATION (Earth-to-space) FIXED MOBILE except aeronautical mobile 5,341A 5.338A 5.341	**1 427-1 429 MHz** SPACE OPERATION (Earth-to-space) FIXED NF14 MOBILE except aeronautical mobile 5,341A 5.338A 5.341	1 427-1 452 MHz Fixed links (duplex)	Paired with 1 375 – 1 400 MHz In accordance with Recommendation ITU-R F.1242 ITU Res. 223 (Rev.WRC-15)
1 429-1 452 MHz FIXED	**1 429-1 452 MHz** FIXED	1 427-1 452 MHz Fixed links (duplex)	Paired with 1 375 – 1 400 MHz) In accordance with

[25] 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.

MOBILE except aeronautical mobile 5.341A 5.338A 5.341 5.342	MOBILE except aeronautical mobile 5.341A 5.338A 5.341		Recommendation ITU-R F.1242
1 452-1 492 MHz FIXED MOBILE except aeronautical mobile 5.346 BROADCASTING BROADCASTING-SATELLITE 5.208B 5.341 5.342 5.345	**1 452-1 492 MHz** FIXED NF14 MOBILE except aeronautical mobile 5.346 BROADCASTING BROADCASTING-SATELLITE 5.208B 5.341 5.345 NF12	)	**studies called for** Resolution **761 (WRC-15)** 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 ITU-R Res. 223 (Rev.WRC-15) ITU-R Res. 223 (Rev.WRC-15)
1 492-1 518 MHz FIXED MOBILE except aeronautical mobile 5.341A	**1 492-1 518 MHz** FIXED MOBILE except aeronautical mobile 5.341A	**Fixed Links (1 492 – 1 517 MHz)** **Single Frequency Links (1 517 – 1 525 MHz)**	**Paired with 1 350 – 1 375 MHz** in accordance with Recommendation ITU-R F.1242 ITU-R Res. 223 (Rev.WRC-15) **(Sharing and Compatibility Studies called for by Resolution 223 (Rev. WRC-15) are**

5.341 5.342	5.341		**underway within the ITU-R)**

7.4.2 2.5 – 2.690 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
2 500-2 520 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A 5.412	**2 500-2 520 MHz** MOBILE except aeronautical mobile 5.384A NF9	**IMT2600 MTX (2500 – 2570 MHz)**	**Paired with 2620 – 2690 MHz** **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**
2 520-2 655 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A BROADCASTING-SATELLITE 5.413 5.416 5.339 5.412 5.418B 5.418C	**2 520-2 655 MHz** MOBILE except aeronautical mobile 5.384A NF9 5.339	**IMT2600 MTX (2500 – 2570 MHz)** **IMT2600 TDD (2570 – 2620 MHz)** **IMT2600 BTX (2620 – 2690 MHz)** **IMT (2500-2690 MHz)**	**Paired with 2620 – 2690 MHz** **Paired with 2500 – 2570 MHz** **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 2 500-2 690 MHz is also used for BFWA in some SADC countries**

2 655-2 670 MHz 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	**2 655-2 670 MHz** MOBILE except aeronautical mobile 5.384A NF9 Radio astronomy 5.149	**IMT2600 BTX (2620 – 2690 MHz);** IMT (2500-2690 MHz)	**Paired with MTX 2500 – 2570 MHz** **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**
2 670-2 690 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A Earth exploration-satellite (passive) Radio astronomy Space research (passive) 5.149 5.412	**2 670-2 690 MHz** MOBILE except aeronautical mobile 5.384A Radio astronomy 5.149	**IMT2600 MTX (2620 – 2690 MHz)**	**Paired with 2500 – 2570 MHz** **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**

7.4.3 2.7 – 2.9 GHz

ITU Region 1 allocations and footnotes	**South African allocations and footnotes**	**Typical Applications**	**Notes and Comments**
2 700-2 900 MHz AERONAUTICAL RADIONAVIGATION 5.337	**2 700-2 900 MHz** AERONAUTICAL RADIONAVIGATION 5.337	Government Services	

Radiolocation 5.423	Radiolocation 5.423		

7.4.4 3.3 – 3.6 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
3 300-3 400 MHz RADIOLOCATION 5.149 5.429 5.429A 5.429B 5.430	**3 300-3 400 MHz** RADIOLOCATION 5.149 5.429A 5.429B	**Government Services** **IMT Res. 223 (Rev.WRC-15)**	. Subject to outcome of the sharing and compatibility studies called for by Resolution 223 (WRC-15) currently underway within the ITU-R**,** there might be a need to migrate Radars out of this band. This will be addressed through an update of the migration plan.
3 400-3 600 MHz FIXED FIXED-SATELLITE (space-to-Earth) MOBILE 5.430A Radiolocation 5.431	**3 400-3 600 MHz** FIXED MOBILE 5.430A NF9	**IMT3500 TDD (3400 – 3600 MHz)**	**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**

7.4.5 24.25 – 27.5 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
24.25-24.45 GHz FIXED	**24.25-24.45 GHz** FIXED		**Temporary fixed links for ENG/OB**
24.45-24.65 GHz FIXED INTER-SATELLITE	**24.45-24.65 GHz** FIXED NF14	**Fixed Links (26 GHz) (24.5 – 26.5 GHz)** **Fixed links - 26 GHz (24.5-26.5 GHz)** **BFWA (24.5-26.5 GHz)**	**Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.**
24.65-24.75 GHz FIXED FIXED-SATELLITE (Earth-to-space) 5.532B INTER-SATELLITE	**24.65-24.75 GHz** FIXED NF14	**Fixed Links (26 GHz) (24.5 – 26.5 GHz)** **Fixed links - 26 GHz (24.5-26.5 GHz)** **BFWA (24.5-26.5 GHz)**	**Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.**
24.75-25.25 GHz FIXED FIXED-SATELLITE (Earth-to-space) 5.532B	**24.75-25.25 GHz** FIXED NF14 FIXED-SATELLITE (Earth-to-space) 5.532B	**Fixed Links (26 GHz) (24.5 – 26.5 GHz)** **Fixed links - 26 GHz (24.5-26.5 GHz)** **BFWA (24.5-26.5 GHz)**	**Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.**

25.25-25.5 GHz FIXED INTER-SATELLITE 5.536 MOBILE Standard frequency and time signal-satellite (Earth-to-space)	**25.25-25.5 GHz** FIXED NF14	**Fixed Links (26 GHz) (24.5 – 26.5 GHz)** BFWA (24.5-26.5 GHz	**Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.**
25.5-27 GHz EARTH EXPLORATION-1SATELLITE (space-to Earth) 5.536B FIXED INTER-SATELLITE 5.536 MOBILE SPACE RESEARCH (space-to-Earth) 5.536C Standard frequency and time signal-satellite (Earth-to-space) 5.536A	**25.5-27 GHz** EARTH EXPLORATION-SATELLITE (space-to Earth) 5.536B FIXED NF14 5.536A	**National Polar-Orbiting Operational Environment Satellite System (NPOESS)** **Fixed Links (26 GHz) (24.5 – 26.5 GHz)** BFWA (24.5-26.5 GHz	**Channelling plan for 26 GHz band in accordance with ITU-R Rec. F.748 Annex 1.**
27-27.5 GHz FIXED INTER-SATELLITE 5.536 MOBILE	**27-27.5 GHz** FIXED		

7.4.6 37 – 40.5 GHz

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

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

FIXED FIXED-SATELLITE (space-to-Earth) 5.516B MOBILE MOBILE-SATELLITE (space-to-Earth) SPACE RESEARCH (Earth-to-space) Earth exploration-satellite (space-to-Earth)	FIXED FIXED-SATELLITE (space-to-Earth) 5.516B MOBILE MOBILE-SATELLITE (space-to-Earth) SPACE RESEARCH (Earth-to-space) Earth exploration-satellite (space-to-Earth)		

7.4.7 42.5 – 43.5 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
42.5-43.5 GHz FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE except aeronautical mobile RADIO ASTRONOMY 5.149 5.547 5.551H	**42.5-43.5 GHz** FIXED NF14 FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE except aeronautical mobile RADIO ASTRONOMY 5.149 5.547 5.551H	**Government Services (43.5-45.5 GHz)**	**BFWA or MWS (40.5-43.5 GHz).** **The band 40.5-43.5 GHz is identified for HDFS; Res.75 applies.**

7.4.8 45.5 – 47 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments

43.5-47 GHz MOBILE 5.553 MOBILE- RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.554	**43.5-47 GHz** MOBILE 5.553 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.554		

7.4.9 47.2 – 50.2 GHz

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

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

(Earth-to-space) 5.338A 5.552 (space-to-Earth) 5.516B 5.554A 5.555B MOBILE	(Earth-to-space) 5.338A 5.552 (space-to-Earth) 5.516B 5.554A 5.555B MOBILE		

7.4.10 50.4 – 52.6 GHz

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

7.4.11 66 – 76 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments

66-71 GHz INTER-SATELLITE MOBILE 5.553 5.558 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE *5.554*	**66-71 GHz** INTER-SATELLITE MOBILE 5.553 5.558 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE *5.554*		
71-74 GHz FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)	**71-74 GHz** FIXED NF14 FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)	**Fixed Links (80 GHz) (71 – 76 GHz)** **Government use** **Fixed links (71-76 GHz)**	**Paired with 81 – 86 GHz.** **Radio Frequency Spectrum Regulations Amendments (Government Gazette Number** 40436, 22 November 2016)
74-76 GHz FIXED FIXED-SATELLITE (space-to-Earth) MOBILE	**74-76 GHz** FIXED NF14 FIXED-SATELLITE (space-to-Earth) MOBILE	**Fixed Links (80 GHz) (71 – 76 GHz)**	**Paired with 81 – 86 GHz.** **Radio Frequency Spectrum Regulations Amendments (Government Gazette Number**

BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth) 5.561	BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth) 5.561		40436, 22 November 2016)

0

7.4.12 81 – 86 GHz

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

Space research (space-to-Earth) 5.149 5.561A	Space research (space-to-Earth) 5.149 5.561A		
84-86 GHz FIXED 5.338A FIXED-SATELLITE (Earth-to-space) 5.561B MOBILE RADIO ASTRONOMY 5.149	**84-86 GHz** FIXED 5.338A NF14 FIXED-SATELLITE (Earth-to-space) 5.561B MOBILE RADIO ASTRONOMY 5.149	**Fixed Links (80 GHz) (81 –86 GHz)**	**Radio Frequency Spectrum Regulations Amendments (Government Gazette Number** 40436, 22 November 2016)

7.4.13 31.8 – 33.4 GHz

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
31.8-32 GHz FIXED 5.547A RADIONAVIGATION SPACE RESEARCH (deep space) (space-to-Earth)	**31.8-32 GHz** FIXED 5.547A NF14 RADIONAVIGATION	**HDFS (31.8 – 33.4 GHz)**	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.

5.547 5.548	5.547 5.548		
32-32.3 GHz FIXED 5.547A RADIONAVIGATION SPACE RESEARCH (deep space) (space-to-Earth) 5.547 5.548	**32-32.3 GHz** FIXED 5.547A NF14 RADIONAVIGATION SPACE RESEARCH (deep space) (space-to-Earth) 5.547 5.548	**HDFS (31.8 – 33.4 GHz)**	**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.**
32.3-33 GHz FIXED 5.547A INTER-SATELLITE RADIONAVIGATION 5.547 5.548	**32.3-33 GHz** FIXED 5.547A NF14 INTER-SATELLITE RADIONAVIGATION 5.547 5.548	**HDFS (31.8 – 33.4 GHz)**	**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.**
33-33.4 GHz	**33-33.4 GHz**		**Channelling plan for 32 GHz band in accordance with ITU-R Rec. F.1520 Annex 1.**

FIXED 5.547A RADIONAVIGATION 5.547	FIXED 5.547A NF14 RADIONAVIGATION 5.547	**HDFS (31.8 – 33.4 GHz)**	**The band 31.8-33.4 GHz is identified for HDFS; Res.75 applies.**

7.4.14 40.5 – 42.5 GHz

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

BROADCASTING-SATELLITE Mobile 5.547 5.551F 5.551H 5.551I	BROADCASTING-SATELLITE 5.547 5.551F 5.551H 5.551I		**BFWA or MWS (40.5-43.5 GHz).** **The band 40.5-43.5 GHz is identified for HDFS; Res.75 applies.**

7.4.15 47 – 47.2 GHz

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

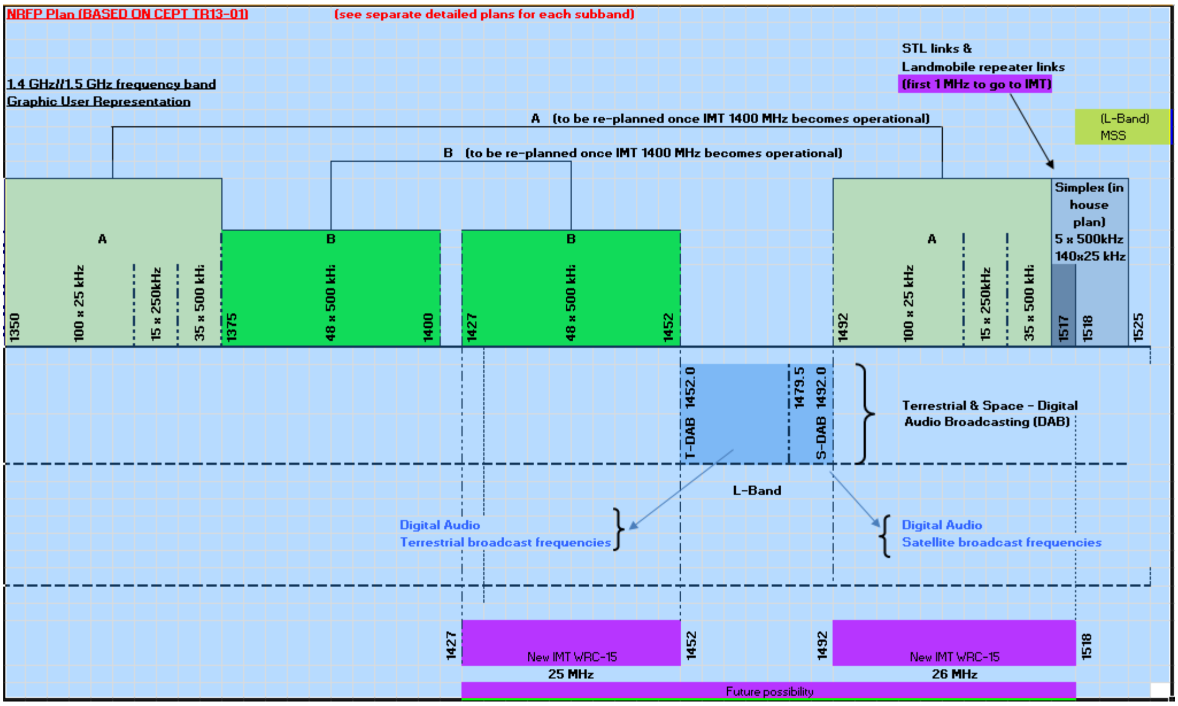
This may require additional allocations to the mobile service on a primary basis.

7.5 IMT2020 Proposed actions for identified IMT Frequency bands

The sub-paragraphs 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 is 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.

During the preparatory meetings leading to WRC-15, there was consensus that the band 1452 – 1492 MHz be supported for an IMT identification since broadcasters are no longer interested in the band. The South African position, sanctioned by Government, at the WRC-15 was based on this position.

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

7.5.2 2.5 – 2.690 GHz

The following have been resolved from studies performed in this band for IMT 2020.

A TDD only plan, in line with 3GPP Band 41, would provide 190 MHz contiguous spectrum and would have several advantages over the arrangement in notice no. 277.

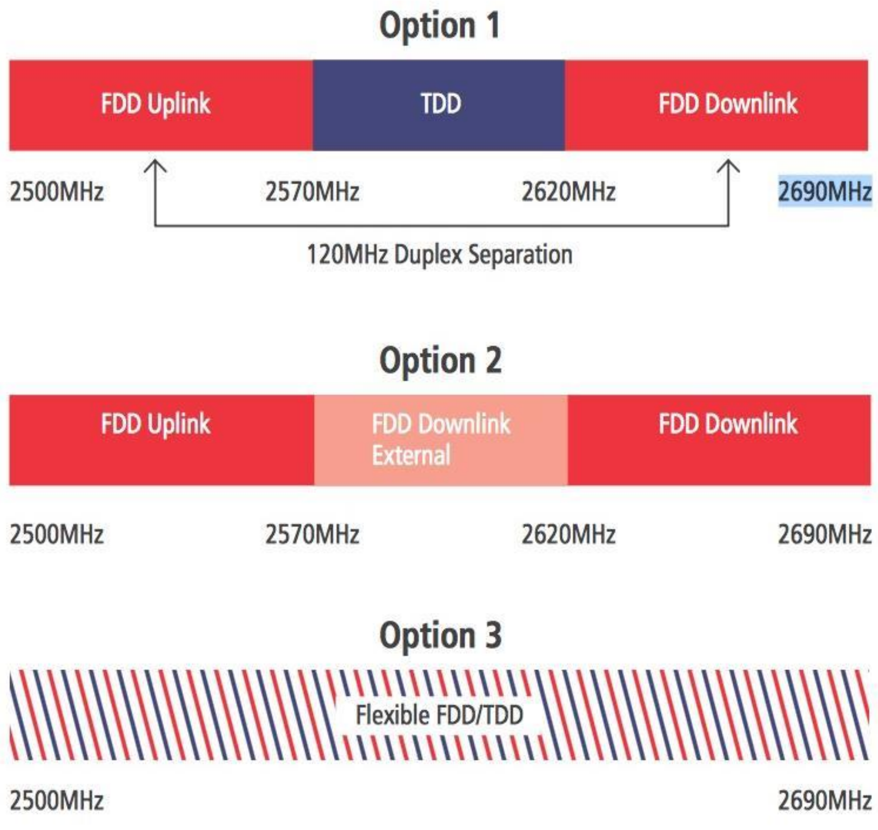
P.S. WPC (Windsor Place Consulting) recently released a whitepaper on the benefits of a TDD band plan over the traditional FDD+TDD band plan on 2.6G, which can also be referenced.

https://www.linkedin.com/pulse/wpc-report-compelling-case-tdd-26-ghz-spectrum-band-scott-w-minehane/

7.5.2.1 Background on the 2.6 GHz spectrum band

The ITU identified the medium frequency spectrum 2500-2690 MHz (or the 2.6 GHz spectrum band) as a global band for IMT, and was formally included in the Radio Regulations in accordance with Resolution 223 (Rev. WRC-15). Importantly, this frequency band is available globally across all three ITU regions.

The ITU, in Recommendation ITU-R M.1036-5 (10/2015) has defined three alternative channel arrangements for the 2.6 GHz band plan, as outlined right.



7.5.2.2 Benefits of the TDD option in today's 4G deployments (1)

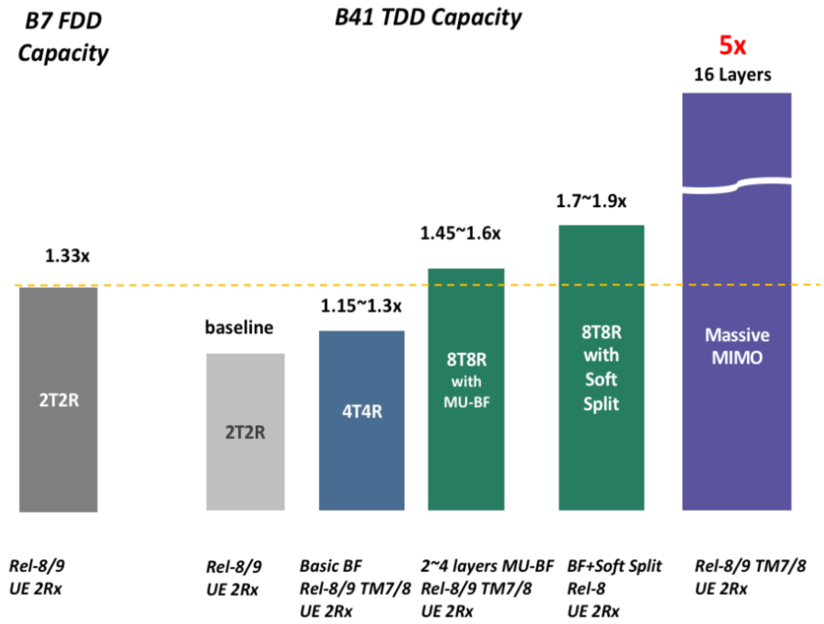
The use of the LTE Band 41 unpaired TDD configuration gives significant benefits over employing the hybrid LTE Bands 7/38 configuration.

Primarily, TDD deployments based on this band plan facilitate the delivery of high quality wireless broadband services at lower cost per MB/GB for MNOs due to:

- Higher throughput performance based on massive MIMO antenna technology
- Lower capex including less need for filers, as no filtering is needed between FDD and TDD services
- Lower opex, due to compact equipment size

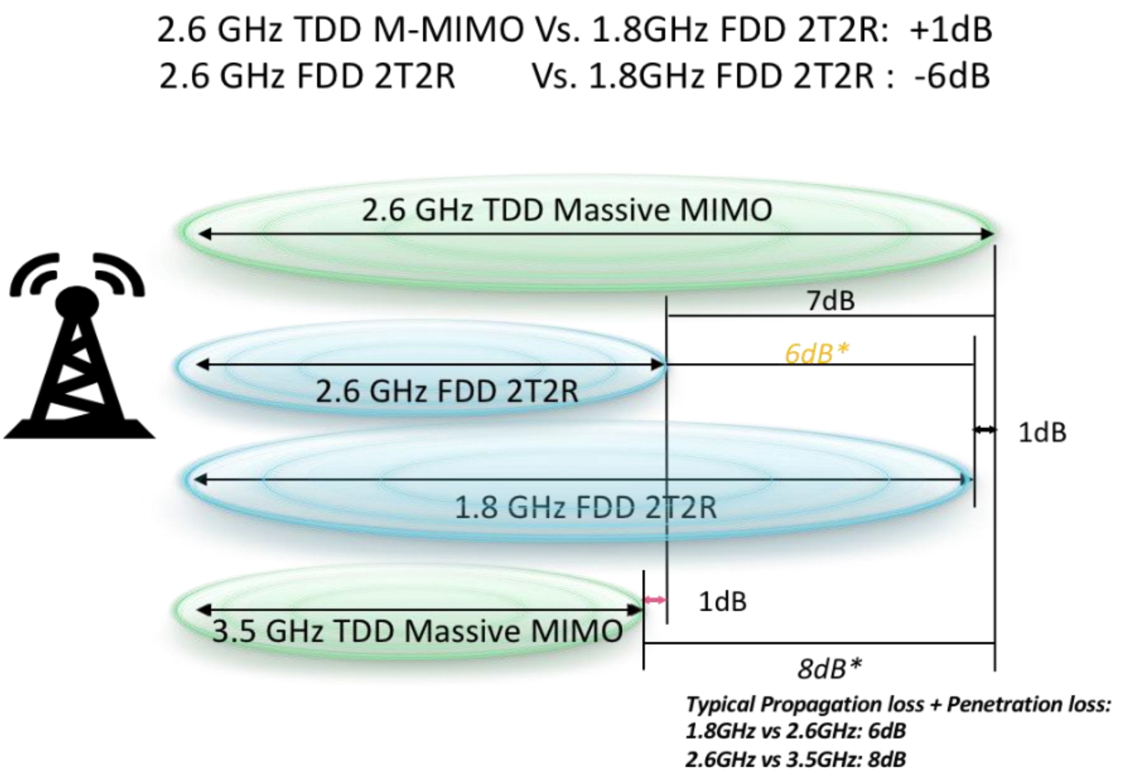
In addition, **LTE Band 41 benefits** include:

- Provides more capacity & increased efficiency
- Advantages in dealing with traffic asymmetry
- Comparable network coverage
- Avoids inter-band interference
- Simplified network operation
- Key global roaming band
- Typically, lower spectrum cost for TDD
- Easier to transition LTE Band 41 to 5G NR.

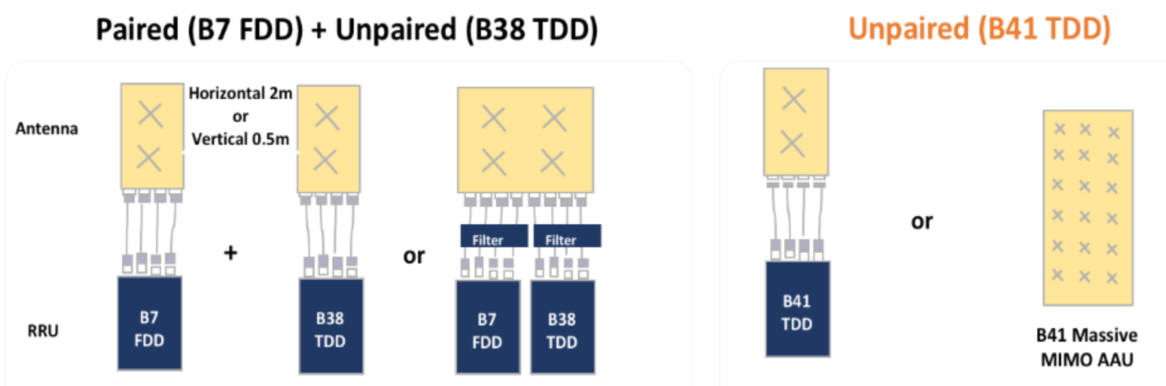


7.5.2.3 Benefits of the TDD option in today's 4G deployments (2)

Coverage of deployments in 2.6 GHz using FDD or TDD technology are very similar. Equipment vendor studies and MNO operator experience with deploying LTE Band 41 with massive MIMO services is that it has comparable coverage to 1.8 GHz coverage using FDD



With Band 41, there is no inter-band interference. If deploy Bands 7/38, it is necessary to allocate two 5 MHz of guard band spectrum between the FDD and TDD allocation, utilise customized filters and have site space isolation.



7.5.2.4 Benefits of the TDD option in today's 4G deployments (3)

Use of TDD in the 2.6 GHz band offers the following benefits for 5G transition:

- **Accurate Beamforming:** Due to uplink and downlink channel reciprocity TDD technology has unique coordination abilities, including Beamforming. Beamforming improves the system performance by utilising channel state information to achieve transmit-array gain.
- **Advanced antenna solutions**: Advanced antenna solutions, like Massive MIMO and Distributed MIMO, utilise TDD's uplink and downlink channel reciprocity to improve performance and capacity. Massive MIMO technology will unleash the powerful capability of the 5G network by taking the advantage of wide bandwidth when available, allowing for the flexible and accurate control of cell coverage radius. LTE Band 41's spectral efficiency of approximately 48 bits/Hz greatly exceeds the 5G requirement of 30 bits/Hz and is almost 3.5 times the spectral efficiency of 14 bits/Hz for LTE Band 7.
- **Smaller Equipment Size:** In particular frequencies, the TDD antenna size is 50 percent smaller than the FDD antenna size. This implies easy deployment, and lower opex will be saved. It may also have advantages in tower space.

Unpaired TDD bands can be made available more easily than paired bands. High performing mobile networks require wide channel bandwidths of say 60-70 MHz or 100 MHz. From a spectrum management perspective, there are challenges making sufficient spectrum and wide channels available.

7.5.2.5 A rapidly growing ecosystem and increasing number of LTE Band 41 Networks

A growing maturity of the ecosystem in LTE Band 41. LTE Band 41 is currently the 3rd most popular of all LTE TDD devices and 11th out of all LTE devices, with at least 2,749 compatible devices.

Increasing number of LTE Band 41 deployments in Asia and globally. The GSA reports 25 commercially launched networks which utilise the 2.6 GHz spectrum band in the LTE Band 41 configuration in over 13 countries with a population over 3.5 billion!

	Country	Operator
1	Angola	Net One
2	Cambodia	Kingtel
3	Cameroon	MTN
4	Canada	Sasktel
5	China	China Mobile
6	China	China Telecom

7	China	China Unicom
8	Ghana	NITA
9	Iraq	Tishknet
10	India	BSNL
11	India	Idea Cellular
12	India	Vodafone
13	Japan	Softbank
14	Japan	UQ Communications
15	Madagascar	Blueline
16	Malawi	TNM
17	Philippines	Smart
18	Philippines	Globe
19	Trinidad & Tobago	TSTT
20	Uganda	MTN
21	USA	Redzone Wireless
22	USA	Rise Broadband
23	USA	Speedconnect
24	USA	Sprint

7.5.3 2.7 – 2.9 GHz

2.7-2.9 GHz would provide important extra mobile capacity, and deployments would be cost effective because existing cell sites could be used. It is primarily used for important civilian and military radars as well as some meteorological radars. However, research shows that the band is not used efficiently so all existing radar requirements could be met in half the band leaving the other half to be used for mobile broadband. Furthermore, the financial benefits of mobile services amount to over 10 times the costs of relocating existing radars into the smaller portion.

The GSMA recommends that the 2.7-2.9 GHz band be allocated to the mobile service and a substantial portion identified for IMT/mobile broadband. It could deliver crucial extra mobile capacity in busy urban areas where data traffic is rising quickly, and deployments would be relatively low-cost because existing 2.6 GHz cell sites could be used. There is also clear evidence that all existing radar requirements could be met in a portion of the band allowing mobile services to occupy the other portion. The band is used for important civil and military radars, which are mainly located at airports, as well as some meteorological radars. However, some countries have no radars at all, in many others there are only one or two, while almost all of the remainder have no more than a few tens of radars operating in the band. Given the small number of radars in most countries, and their use of spectrum at fixed locations, there is a clear opportunity to examine using a portion of the band for mobile services. There is growing interest and support for an IMT identification in the band from various countries in Europe, Africa and Asia. The UK's interest is especially notable because it is one of the heaviest users of radars in the band worldwide yet believes that the spectrum could be used more efficiently. A GSMA study21 using real-world data showed that it is possible to relocate all existing radar requirements in the south-east of England, where radars are most densely used, into the 2.8-2.9 GHz portion of the band thus making the 2.7-2.8 GHz part available for mobile broadband. The study even showed there would still be spare capacity in the 2.8-2.9 GHz portion to support more radars in future. In the past, studies have shown that radar services cannot operate alongside mobile without prohibitively large exclusion zones. However, these conclusions are no longer valid as they were based on less spectrum efficient radar technology and use of the same, rather than adjacent, radio channels for both services.22 There is also a compelling economic argument for allowing mobile services to occupy a portion of the band. Research from Aetha Consulting shows that the estimated financial benefit of using the band for the mobile service in Western Europe would be over 10 times greater than the costs associated with relocating existing radar services.23 Studies in a wide variety of other show similar economic benefits. 24

References

CEPT document CPG-PTD(15)043, "2.7-2.9 GHz band segmentation, radar spectrum efficiency, and compatibility between IMT and radars", April 2015 22 Numerous studies for the ITU show radars can share the 2.7–2.9GHz band using adjacent channels including:- • JTG4567/353-E: Sharing between IMT systems and radars in the 2700–2900 MHz band • JTG4567/541-E: Analysis of required mitigation for IMT systems and radars to share the 2700–2900 MHz band 23 The findings from the study are discussed in JTG4567/193-E: Consideration of the 2.7–2.9 GHz band and economic benefits that would arise from making this band available for IMT 24 The findings of these studies are summarised in a GSMA paper entitled, 'The suitability of an IMT identification in the 2.7-2.9 GHz band at WRC-15' 25 In Africa, the benefits were found to be range from approximately PPP$10 billion to PPP$22 billion, while costs are estimated between PPP $0.3 billion and PPP $1.1 billion. In the Arab States the benefits were found to range from approximately PPP US$5 billion to PPP US$11 billion, while costs are estimated between PPP US$0.1 billion and PPP US$0.6 billion

7.5.4 3.3 – 3.6 GHz

ITU-RWP5D is currently conducting studies in this band and the following studies are also currently being undertaken for the stipulated bands. This is based on the contributions made by some African Countries as indicated below.

7.5.4.1 CONTRIBUTION BY NIGERIA, SOUTH AFRICA, ZIMBABWE & KENYA TO WP5D ON THE FREQUENCY ARRANGEMENTS FOR THE BAND 3300-3600 MHZ

Introduction

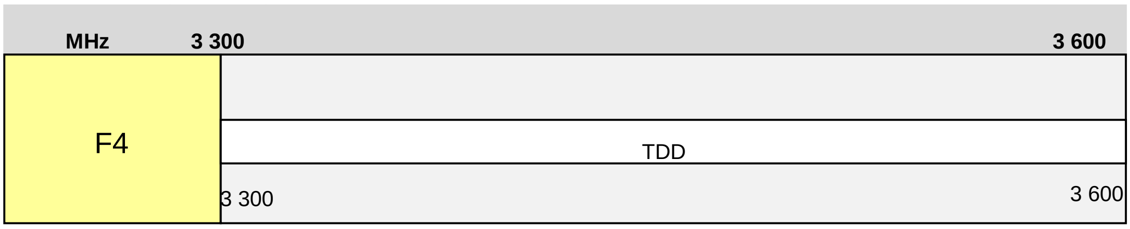
The band 3300-3400 MHz is allocated to the Mobile, except aeronautical Service, through various footnotes, and is Identified for IMT in forty-five (45) countries. The identification for IMT was made under the condition that such IMT systems shall not cause interference nor claim protection from the then 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 considering a channelling arrangement for a contiguous band covering the range 3300-3600 MHz.

Proposal

It was 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



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:

(a) co-channel sharing between IMT and Radiolocation systems (including land, maritime and airborne radars) operating in the band 3300 - 3400 MHz; and

(b) 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.

7.5.4.2 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:

(a) co-channel sharing between IMT and Radiolocation systems (including land, maritime and airborne radars) operating in the band 3300 - 3400 MHz; and

(b) 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%
	100	97%	99%	99%	>99%

Nigeria, South Africa, Zimbabwe & Kenya propose that the Study in the Attachment is incorporated in the draft ITU-R report on radar & IMT coexistence in the 3300-3400 MHz.

7.5.5 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)
- Rain (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.

7.5.6 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 that a Frequency Spectrum Assignment Plan is developed for this band. Feasibility study to be performed. The Frequency Spectrum Assignment Plan is developed.

7.5.7 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
- Rain (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

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

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

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

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

7.5.9 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

If the frequency band is identified by WRC-19 a Radio Frequency Spectrum Assignment Plan will be developed.

7.5.10 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

If the frequency band is identified by WRC-19 a Radio Frequency Spectrum Assignment Plan will be developed.

7.5.11 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

If the frequency band is identified by WRC-19 a Radio Frequency Spectrum Assignment Plan will be developed.

7.5.12 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

If the frequency band is identified by WRC-19 a Radio Frequency Spectrum Assignment Plan will be developed.

7.5.13 57.0 – 66 GHz

The V-Band has been Gazetted.in Government Gazette 40436 dated 22 November 2016 Notice 781 of 2016.

If the frequency band is identified by WRC-19 a Radio Frequency Spectrum Assignment Plan will be developed.

It is noted that this band is not included under WRC-19 agenda item 1.13 and also not considered for IMT during WRC-15.

WRC-19 developments particularly the Agenda Item 1.12: to consider possible global or regional harmonized frequency bands, to the maximum extent possible, for the implementation of evolving Intelligent Transport Systems (ITS) under existing mobile-service allocations, in accordance with Resolution **237 (WRC-15).** The radio frequency band 63 – 64 GHz already allows for ITS applications within the SRD framework. The South African band plan references ITU-R SM.1896, the document in turn references Report ITU-R SM.2153: Technical and operating parameters and spectrum use for short-range radiocommunication devices. Report ITU-R SM.2153 lists the following as applications considered under SRD:

- Telecommand
- Telemetry
- Voice and video
- Equipment for detecting avalanche victims
- Broadband radio local area networks
- Railway applications
- Road transport and traffic telematics
- Equipment for detecting movement and equipment for alert
- Alarms

- Model control
- Inductive applications
- Radio microphones
- RF identification systems
- Ultralow power active medical implant
- Wireless audio applications

Even though the Authority has indicated that no studies will be undertaken regarding the 57 – 66 GHz band, it is important to note that *ITU-R M.2083-0: IMT Vision – Framework and overall objectives of the future* development of *IMT for 2020 and beyond* has acknowledged ITS. The Authority is well aware that ITS applications are categorised under IoT systems.

7.5.14 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 system are deployed with channel spacing of 250 MHz. Find more information on the self-coordinated Block of frequencies in the E-Band and the Authority-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.

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

7.5.15 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.

Feasibility 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 are indicative timelines for the deployment of IMT bands and the associated migration timelines, mainly for the 450-470 MHz band. There are some essential conditions for the time plan:

(a) The SAPS, other Government services, municipalities and emergency services will migrate to the PPDR band as identified in the NRFP 2018. Consideration can be made to develop the RFSAP to include PPDR by 2020.

(b) Transnet has embarking a technology modernisation process from analogue to digital systems;

(c) Potential co-existence and other trials for the 450-470 MHz band was completed by 2017 to enable a decision to be made concerning the options for co-existence;

(d) The IMT450 RFSAP is to be updated to accommodate incumbent by 2019/2020.

(e) 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.

Calendar of expected activities by year

YEAR	**Activities foreseen to take place and deadlines foreseen to occur within the Calendar Year**
2019	• 380-400 MHz band has already been assigned for PPDR with TETRA as one technological option. RFSAP has been developed • SAPS have already started migration out of 406-420 MHz to TETRA in the 380-387//390-397 MHz band. RFSAP has been developed • The remaining 2×3 MHz in the 380-400 MHz band is available for use by emergency, security, and airport services. RFSAP has been developed • Co-existence trials for 450-470 MHz. has been completed • Process for assignment of IMT700, IMT800 and IMT2600 FDD spectrum starts. RFSAP have been developed in 2015.
2021	• As per WRC Resolutions 224 (Rev.WRC-15), WRC Resolution 232 (Rev WRC-12) and WRC Resolution 760 (WRC-15), the DTT process is completed within 470-694 MHz and Analogue Switch Off (ASO) takes place and be completed by 2021 in accordance with the RFSAP under development. • Implementation / rollout of new IMT spectrum in IMT700, IMT800 and IMT2600 starts in parallel with the RFSAP for the band 470 to 694 MHz.

	• SAPS finalises network migration frees up spectrum in 406-410//416-420 MHz and 413-416//423-426 MHz. • 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.

2019 to 2022	• 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,
	• Other licensees of 450-470 MHz band start migration to:
	  • 403-406 MHz (unpaired);
	  • 426-430 MHz (unpaired); or
	  • 440-450[26]MHz bands (paired or unpaired); and
	  • In case of PPDR-use - also to 387-390//397-400 MHz
	migration completed by 2022 (max 3 years).
	• Fixed links (e.g. Telkom) potentially migrated to 2025-2110 MHz band and/or 2200 – 2285 MHz band. RFSAP has been finalised in 2019.
	• Migration should start in rural areas to clear spectrum for new IMT450 licensees:
	  • Phase 1 target: >80% of rural-used licenses is cleared for IMT450 end of 2020 (6 years as of 2014);
	  • Phase 2: 80% of urban used licenses is cleared for IMT450 end of 2021 (7 years as of 2014); and
	  • Phase 3: 100% of 450-470 MHz is cleared by end of 2022 (8 years as of 2014).

2020	Given the co-existence trial results[27]: • **Co-existence possible**: Transnet, SAA or other licensees start migration in co-existence bands within 450-470 MHz, fine tuning of potential splitters, etc. • **Migration required**: 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 3 years of migration including 2 years of dual illumination. • Transnet may also opt to migrate to GSM-R [28]

[26] It might be necessary to also clear the 449-450 MHz band to increase IMT-spectrum.

[27] The licensees are encouraged to migrate out of 450-470 MHz in order to comply with the IMT450 RFSAP., independently from the results of the co-existence trials.

[28] 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.

2021	• Implementation of 2nd assignment of TDD IMT spectrum (i.e. IMT750, IMT2600 and IMT3500). • IMT450 licensee starts rollout in 450-470 MHz band in agreed areas (e.g. rural first followed by 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	• Target of SA Connect broadband initiative in South Africa is achieved: (ref IMT coverage and capacity obligations (see paragraph 9.2) • Transnet completes migration (deployment) and continues dual illumination phase (in line with updated IMT450 RFSAP)
2024	• All licensees have finished spectrum migration or service migration to new operations and shut down all systems in the IMT450 band. • IMT450 licensee reached coverage license obligations.

8.2 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:

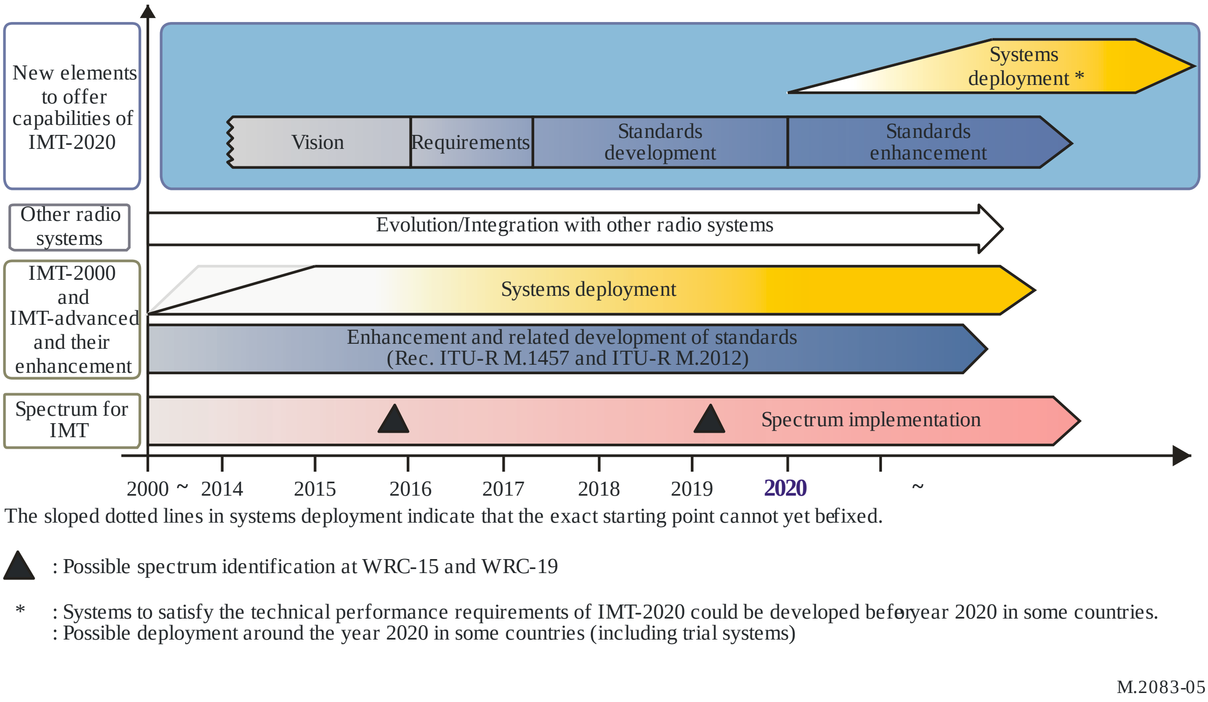
(a) user trends, requirements and user demand;
(b) technical capabilities and technology development;
(c) standards development and their enhancement;
(d) spectrum matters;
(e) regulatory considerations; and
(f) system deployment.

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, considering 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



8.2.1 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 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.

8.2.2 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.

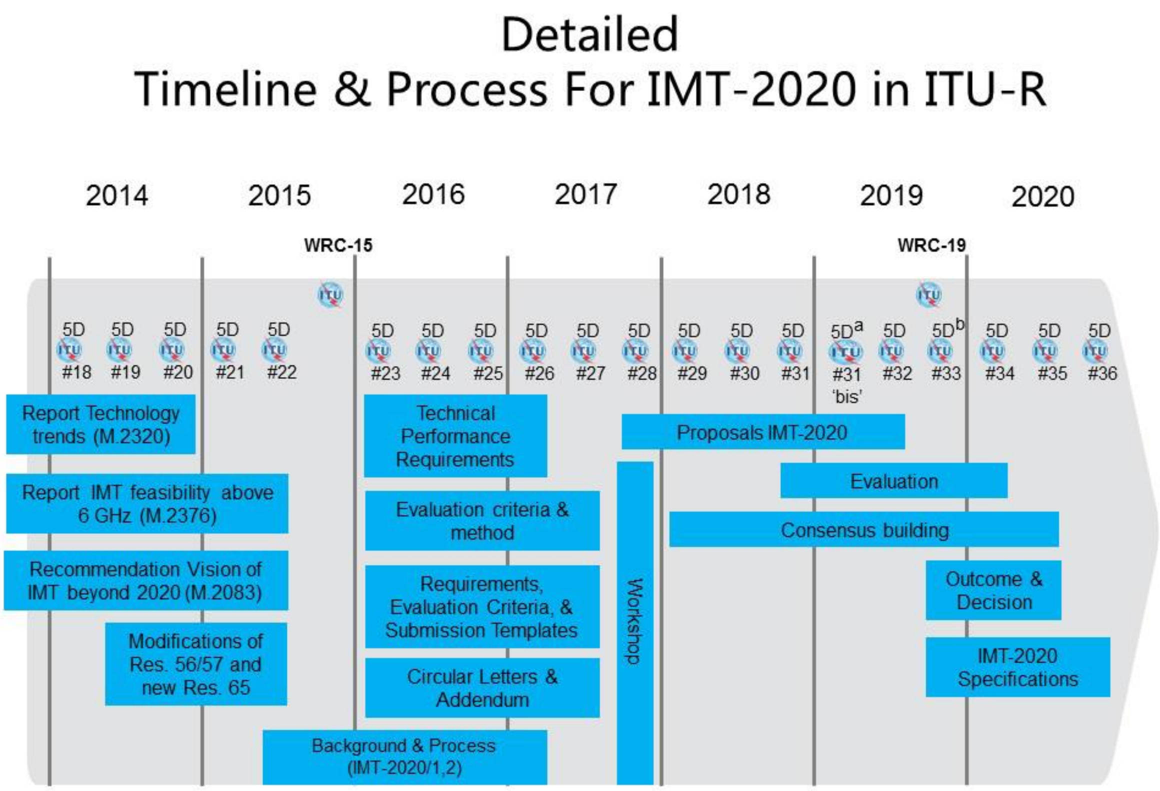
8.3 Workplan, timeline, process and deliverables for the future development of IMT

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).



(a) – five day meeting, (b) – focus meeting on Evaluation (Technology)

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

TABLE 11

GROUP	No.	FROM	TO	PLACE	COMMENTS
WP 5D	23	23 February 16	2 March 16	China	7 working day meeting
WP 5D	24	14 June 16	22 June 16	Geneva	7 working day meeting
WP 5D	25	5 October 16	13 October 16	Geneva	7 working day meeting
WP 5D	26	14 February 17	22 February 17	Geneva	7 working day meeting
WP 5D	27	13 June 17	21 June 17	Canada	7 working day meeting
WP 5D	28	3 October 17	11 October 17	Germany	7 working day meeting, including a one-day workshop
WP 5D	29	31 January 18	7 February 18	Korea	
WP 5D	30	13 June 18	20 June 18	Mexico	
WP 5D	31	9 October 18	16 October 18	[Japan]	(Tuesday to Tuesday)
WP 5D	31*bis*	11 February 19	15 February 19	Geneva	5 working day meeting
CPM19-2	–	18 February 19	28 February 19	Geneva	
WP 5D	32	9 July 19	17 July 19	[Geneva]	7 working day meeting
RA-19	–	21 October 19	25 October 19	[Egypt]	
WRC-19	–	28 October 19	22 November 19	[Egypt]	
WP 5D	33	[9 December] 19	[13 December] 19	[Geneva]	Focus meeting on evaluation (WG Technology Aspects)
WP 5D	34	19 February 20	26 February 20	[TBD]	
WP 5D	35	24 June 20	1 July 20	[TBD]	
WP 5D	36	7 October 20	14 October 20	[TBD]	

9 IMT SPECTRUM AND UNIVERSAL SERVICE OBLIGATIONS

9.1 South Africa's ICT Policy

We have extracted a summary from the South African Integrated ICT White Paper Policy which has a direct impact on the IMT Roadmap 2019 and which will influence licensing of spectrum and obligations of the licensees.

9.1.1 Definition of Open Access:

wholesale access to electronic communications network infrastructure or services that is provided on terms that are reasonable, effective, transparent and non-discriminatory; and at prices that are cost-oriented.

9.1.2 Open Access Policy Objectives

It should enable the creation of efficient, uniform and competitive open access networks that will enable all players to compete on equal terms, thereby enabling multiple downstream competitors to share infrastructure and scarce resources ... encourage service-based competition which will increase consumer choice (of services providers and of services), reduce costs and increase innovation.

9.1.3 Open Access Obligations

9.1.3.1 General Open Access obligations applicable on All networks in South Africa.

Open Access general obligations on all significant networks in South Africa. Intervention: An open access network should satisfy all of the following general obligations: Effective access to the infrastructure Flexibility in providing access to the network, suitable QoS, unbundled services. Transparency in the design of the offering, it's pricing and the terms and conditions of access to the network, billing for services, etc ... Non-discrimination Provision of services on a non-discriminatory manner, not favour services affiliated with its company. Making South Africa a Global Leader in Harnessing

9.1.3.2 Obligations on Vertically Integrated entities

To address potential anticompetitive practices (restrict and/or distort competition) by vertically integrated access providers. Obligations on Vertically Integrated entities as follows: ... Accounting Separation: requires the preparation of separate accounts for each of the different businesses operated by the same entity by identifying and allocating the costs and revenues associated with each business as well as the dealings between them.

9.1.3.3 Obligations on entities with SMP and/or reliant on public resources

To address potential anticompetitive practices by entities with significant market power (dominance) and/or public funded networks Interventions: Place obligations on entities with SMP and/or reliant on public resources as follows:

Cost based pricing: wholesale price regulation (addresses high cost of services) Policy objective:

Define SMP network with SMP: has significant control over the infrastructure in that market, and in some case such infrastructure cannot be duplicated; the regulator, following due process, must make the determination of SMP.

9.1.3.4 Obligations on Designated Open Access Networks

To impose additional Obligations on Designated Open Access Networks (DOAN) so as to achieve national network and population coverage.

- *The DOAN should satisfy all the general open access obligations, and the extent that the OAN is vertically integrated,*
- *It must comply with the requirements for vertically integrated entities.*
- *All designated OANs, by definition, will own essential infrastructure that cannot be duplicated and as such will have to offer cost-based pricing.*

In addition, designated OANs must comply with the following obligations:

- *Network and population coverage obligations: aligned with national targets to achieve national broadband access. Making South Africa a Glob*
- *All networks complying with open access obligations of this policy.*

9.1.4 Further Objectives

The establishment of Open Access Broadband Network (s) in the fixed market;

- *The establishment of an Open Access Wireless Network, which adheres to the open access principles and is dedicated to the provision of wholesale access.*

To promote efficient use of spectrum through addressing: the demand-supply asymmetry of mobile broadband (high demand) spectrum, vertical integration, duplication of networks, competition challenges and high costs of mobile services.

Establish a single national Wholesale-only Wireless OAN private sector-owned and managed network (consortium) participants including: current holders of ECS and ECNS licenses network vendors, infrastructure companies, private equity investors, etc.

Government incentives including access to the spectrum on reasonable terms. No one entity to control the National Wireless Open Access Network

To enable access to existing and future fixed broadband infrastructure of the dominant fixed operator on an open access basis.

- *Policy provides for open access principles on all segments of the network.*
- *Access to the network at cost based pricing.*
- *Noting that Telkom has currently separated its wholesale business from its retail business through the creation of an OpenServe company.*
- *ICASA will impose open access obligations on all licensees.*

9.1.5 Spectrum Policy Changes

Spectrum scarcity: Spectrum is currently a private property of a few and it is an entry barrier to a large majority of telecommunications licensees, who will never be able to have access to it

Market structure: The current market structure forces every entity to build own mobile telecommunications infrastructure, resulting in costly and unnecessary duplications - there is no economic or technical justification of creating numerous mobile broadband networks

The above result in lack of competition, lack of innovation, high cost of communication, and insufficient connectivity in rural areas and underserviced areas.

9.1.6 Goals of the Spectrum Policy

The following goals need to be achieved

- *Facilitate national network deployment, including in rural areas.*
- *Set aside spectrum for wholesale open access*
- *Encourage private sector investment*
- *Encourage all role players to contribute towards the effective management of spectrum*
- *Support the attainment of national broadband targets*
- *Support the provision of government services, emergency services, safety and security and sector-specific operations*
- *Reduce bureaucracy and streamline processes for spectrum assignment where there is no scarcity, for example in the case of government and sector-specific spectrum*

Respond to current and future business models and technological advancements

9.1.7 Policy Principles

Policy principles include the following:

- *Maximization of the efficiency of spectrum used in South Africa*
- *Promotion of infrastructure sharing and nonexclusive utilization*
- *Openness and Transparency*
- *Non-discrimination*
- *Use it or lose it*
- *Predictability*

9.1.8 Spectrum Specific Issues

9.1.8.1 High-Demand Spectrum

Policy issues

Exclusive access of only a few to high-demand spectrum in a vertically integrated market structure. As a consequence, the market is characterized by a lack of competition, a lack of service innovation, relatively high communication costs, and insufficient connectivity in rural areas.

Policy objective

To level the playing fields for competition at services level and ensure that all players are able to benefit from high demand spectrum.

Policy Interventions

All high-demand spectrum shall be assigned on Wholesale Open Access basis, to address scarcity of spectrum and undesirable market structure in Mobile Broadband, Terrestrial Broadcasting and Commercial Land Mobile Radio.

9.1.8.2 Non-commercial Spectrum

Policy issues

Management of non-commercial spectrum is misplaced, resulting in cumbersome and bureaucratic processes and delays and inadequate support.

Policy objective

To improve support and ensure best practices in management of non-commercial spectrum ..

Policy Interventions

Sufficient public services and sector-specific spectrum shall be secured and protected and, as far as it is practically possible, be harmonized internationally and/or regionally –

The Minister may approve sharing of spectrum for public services and sector specific spectrum with other users where practically possible.

Assignment and general management of public services and sector-specific spectrum shall be managed by agencies responsible for the sector, unless a different determination is made by the Minister.

9.1.8.3 Spectrum Management

Policy issues

Inadequate support for all spectrum management activities across diverse services

Policy objective

To ensure long term planning, quality international and regional coordination, support to all economies using spectrum and to ensure centralized coordination of spectrum management

Policy Interventions

Establishment of the Spectrum Management capacity.

9.1.8.4 Spectrum Pricing

Spectrum pricing shall be based on cost recovery model where there is no case for providing incentives or dissuading inefficiency or anti-competitive behaviour. In spectrum pricing a distinction may be made between commercial and non-commercial users.

License fees will, in general, reflect the opportunity cost of spectrum access, in addition to the costs of spectrum management.

Other spectrum pricing frameworks, approved by the Minister, may be used for providing incentives or dissuading inefficiency or anti-competitive behaviour.

9.1.8.5 Spectrum Sharing

Spectrum sharing is encouraged either on a primary or secondary basis while considering spectrum efficiency and operational requirements of services.

Where appropriate, the collective use of spectrum and the shared use of spectrum is encouraged.

9.1.8.6 Unused and Unassigned Spectrum

Assigned spectrum shall not remain unused for a period more than a year, unless a different determination is approved.

All unused spectrum shall be returned to relevant regulatory or sector-specific agencies for immediate re-assignment;

No spectrum shall remain unassigned for more than a year unless it is determined that there is no demand for it; and

All bands that are found to be commercially infeasible, unused or underutilized should be opened for research and development and innovation within a reasonably light-touch regulatory regime, until such time that they are deemed commercially viable.

9.1.8.7 Universal Access

This spectrum policy and the associated licensing and management approaches are designed to meet short, medium and long-term targets for the sector and to meet the needs of consumers in all areas of the country, including rural and remote areas.

The open access approach is fundamentally geared at addressing the universal service and access gaps in the country through extending coverage, reducing duplication and reducing deployment costs. In so doing, it creates a competitive market for ICT services by promoting service based competition – the associated benefits of competition i.e. lower prices, higher quality and greater innovation will follow, for the benefit of consumers.

9.2 Objectives of SA Connect

The South Africa Connect broadband policy targets were defined as indicated in Table 17 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 17: 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.

9.3 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[29]. 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[30].

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[29] 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.

[30] 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 lines in the potential universal coverage that these bands can provide, and the assignment and licensing process should reflect this.

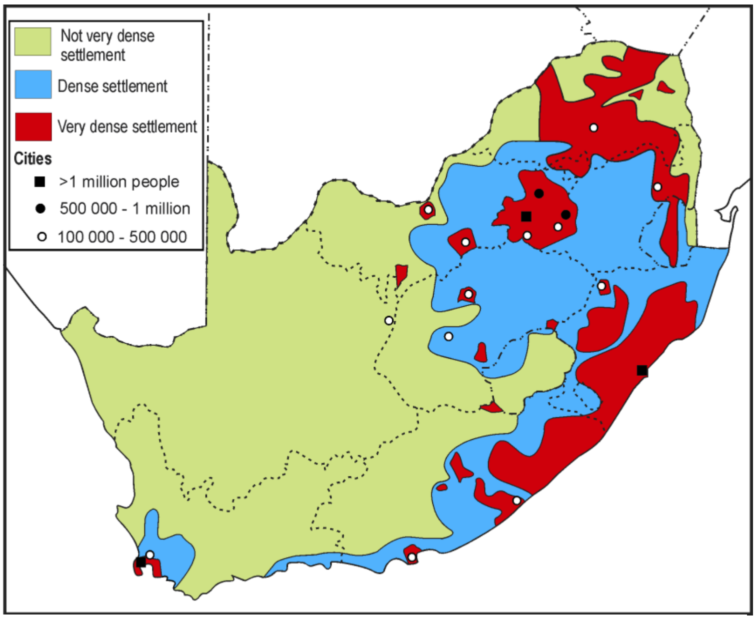

Figure 16: Population densities in South Africa

9.4 Considerations for assignment

9.4.1 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.

9.4.2 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.

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9.5 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[31](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):

[31] Transnet (and PRASA) may reuse their existing 450 band antennas to improve in-train broadband coverage via Wi-Fi connectivity for smart terminals.

    - 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 Liquid Telecom, now used for CDMA)-
  - 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.

9.6 Wireless Open Access Network (WOAN) Spectrum Requirements

9.6.1 Introduction

This document is an abridged report of a study that was commissioned by the Department of Telecommunications and Postal Services ("the department") to determine the amount of spectrum that will be needed by the Wireless Open Access Network (WOAN), as stipulated in the National Integrated ICT Policy White Paper of 2016 [1]. This version was created to ensure that data that was obtained under the non-disclosure agreement is not exposed; it does not change the results of the model and the recommendations emanating from those results. These results were published in Government Gazette No. 41935 Notice 1003 of 27 September 2018.

9.6.2 WOAN Capacity requirement

In line with discussion presented it is recommended that the department consider setting aside only a portion of spectrum in these bands for WOAN and the remaining to other licensees.

The next recommendation focuses on the amount of spectrum required by WOAN to meet the SA connects targets, based on the baseline assumptions as stated. The recommendations based on the results of the model are therefore sensitive to those parameters that were beyond the scope of the study to verify. The projection of the actual number of users that would be served by WOAN in 2020 was beyond the scope of this study; we can therefore recommend a minimum percentage of users to consider based on prior studies. The study was based on the fact that operators that fail to achieve 10-15% market share often struggle to secure EBITDA margins of around 20%, which are typically needed to cover CAPEX investments, interest payments, and tax. SA Connect's recommendation is therefore to consider a minimum of 20% of user population to ensure viability of WOAN.

A third recommendation is that sufficient downlink spectrum in band 20 be set aside for WOAN to lower the cost of deploying the network in rural areas while still delivering sufficient speeds. Band 20 is preferred to band 28 due to it being supported by higher number of devices. In order to afford high-end users of WOAN the benefit of higher broadband speeds through the carrier aggregation feature of LTE advanced, it is further recommended that sufficient spectrum from both band 7 and band 38 be set aside for WOAN.

The most dominant chip manufacturer for high-end devices supports the carrier aggregation of these three bands. The following spectrum combinations should be considered as the minimum:

- 2 x 25 MHz of 800 band (Band 20);
- 2 x 20 MHz of 2600 FDD band (Band 7); and
- 25 MHz of 2600 TDD band (Band 38).

With the downlink-to-uplink ratio of 8:2 split for unpaired Band 38, this would lead to 65 MHz of downlink spectrum for WOAN.

A fourth recommendation is that a detailed market study be undertaken to forecast the market size of WOAN beyond 2020 and up to 2030. This will enable the department to take early decision on the licensing of spectrum for 5G.

A fifth recommendation is experimentation with different spectrum assignment combinations for new mobile broadband spectrum bands to ensure that the emerging broadband needs are catered for and that new technologies, such as 5G are adopted as early as possible. This would include recalculation of WOAN spectrum needs beyond the year 2020 or at any point when the key assumptions change.

A sixth recommendation is a technical study to determine spectral efficiency at five-year intervals as the technology improves. In addition to these recommendations that are directly related to this study, the department needs to consider supporting studies that investigate the deployment models and alternative technologies to cover the 10% of population living in 90% of the land. LTE-Advanced technology, as is the case with the previous generation of 3G and LTE, is well suited to serve densely populated areas.

10 CONSIDERATIONS ARISING OUT OF IMT ROADMAP 2014 & 2019

10.1 Considerations IMT Bands for implementation 2014 Roadmap

The implimentation process envisaged in the IMT Roadmap 2014 will be carried forward in to this Roadmap. Within this IMT roadmap, the following important recommendations are highlighted:

<u>450 - 470 band</u>

- 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 target3g 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.

<u>700 and 800 bands</u>

- 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.

<u>CDMA and GSM-R</u>

- Liquid Telecom's assignment in IMT850 was 827-832 // 872-877 MHz and overlapping to the GSM-R assignment from 876-880MHz // 921-925 MHz. Liquid Telecom 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.

<u>900 band</u>

- 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.

<u>1800 and 2100 bands</u>

- 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.

<u>2300 band</u>

- The IMT2300 band is almost fully used. The only free spectrum of 20 MHz could be assigned to Rain (WBS) to facilitate the clearance of 2550-2565 MHz, which would require new equipment and antennas. There might be a temporary solution for Rain (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.

<u>2600 band</u>

- 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.

<u>3500 band</u>

- 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.

Considering all the 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 paragraph 8.2 for frequency bands.

11 APPENDIX A GLOSSARY

	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
3GPP	means the 3rd Generation Partnership Project (3GPP) which consists of six telecommunications standard development organisations
Act	means the Electronic Communications Act, 2005 (Act No. 36 of 2005);
Amateur	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;
APT	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.
Assignment	means the authorisation given by the authority to a licensee to use a radio frequency or radio frequency channel under specified conditions;
Authority	means ICASA is the Independent Communications Authority of South Africa;
Base station	means a land radio station in the land mobile service for a service with land mobile stations;
BFWA	means Broadband Fixed Wireless Access
BS	means Broadcast Service or Base Station
BTX	means Base Transceiver;
CCTV	means Closed-circuit television
CA	means Carrier Aggregation
CDMA	means Code Division Multiple Access
CEPT	means Conference of European Posts and Telecommunications Authorities;
CoMP	means Co-ordinated Multi Point
DAB	means Digital Audio Broadcasting which is a digital radio technology for broadcasting radio stations

DECT	means Digital Enhanced Cordless Telecommunications 1880 - 1900MHz which is a digital communication standard, primarily used for creating cordless phone systems
DF	means Dual Frequency
DoC	means Department of Communication
DTT	means Digital Terrestrial Television
DTT Mobile	means Digital Terrestrial Television for Mobile services
EIRP	means effective isotropical radiated power;
ERP	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;
ECA	means the Electronic Communications ACT of South Africa
EDGE	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
ETSI	means European Telecommunications Standards Institute
FDD	means Frequency Division Duplex
FDMA	means Frequency Division Multiple Access
FMP	means Frequency Migration Plan
FPLMTS	means Future Public Land Mobile Telecommunications System also called IMT-2000
FTBFP 2008	means Final Terrestrial Broadcast Frequency Plan of 2008
FWA	means Fixed Wireless Access
FWBA	means Fixed Wireless Broadband Access
Gbps	means Gigabits per second
GHz	means Gigahertz of Radio Frequency Spectrum;
GSA	Global mobile Suppliers Association
GSM	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
GSM-R	means GSM for Railways

IEEE	means the Institute of Electrical and Electronics Engineers
IMT	means International Mobile Telecommunications
INMARSAT	means International Maritime Satellite
IoT	means Internet of Things
ISM	means Industrial, Scientific and Medical
ITU	means International Telecommunication Union
ITU RR	means International Telecommunication Union Radio Regulations
kHz	means Kilohertz of Radio Frequency Spectrum
Land mobile service	means a mobile radio-communication service between fixed stations and mobile land stations, or between land mobile stations
LEO	means Low Earth Orbit satellites
LMR	means Land Mobile Radio
Low Power Radio	means radio apparatus, normally hand-held radios used for short range two-way voice communications;
LTE	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
M2M	means Machine to Machine
MFN	means Multiple Frequency Networks
MHz	means Megahertz of Radio Frequency Spectrum;
MIMO	means Multiple-Input and Multiple-Output and is the use of multiple antennas at both the transmitter and receiver to improve communication performance
Mobile station	means a radio station that is intended to be operated while it is in motion or while it is stationary at an unspecified place
Model Control apparatus	means radio apparatus used to control the movement of the model in the air, on land or over or under the water surface
MTX	means Mobile Transceiver
Non-specific Short-Range Devices	means radio apparatus used for general telemetry, telecommand, alarms and data applications with a pre-set duty cycle (0.1%: S duty cycle< 100%)

NRFP	means the National Radio Frequency Plan 2018 for South Africa
OB	means Outside Broadcast
PAMR	means Public Access Mobile Radio
PMR	means Public Mobile Radio and is radio apparatus used for short range two-way voice communications;
PPDR	means Public Protection and Disaster Relief as defined in ITU-R Report M.2033.
PRASA	Means Passenger Rail Agency of South Africa
PtM	means Point to Multipoint
PtP	means Point to Point
RATG	means Radio Access Technology Group
Radio trunking	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
Radio-communication	means all electronic communication by means of radio waves;
Relay or repeater station	means a land station in the land mobile service;
RFID	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 consists of two main components viz, a tag and a reader which are tuned to the same frequency
RFSAP	means Radio Frequency Spectrum Assignment Plan
RLAN	means Radio Local Access Network and is the high data rate two-way (duplex) wireless data communications network
SABRE	means South African Band Re-Planning Exercise
SADC	means Southern African Development Community
SADC FAP	means Southern African Development Community Frequency Allocation Plan 2010
SAPS	means South African Police Service
Self Helps	means repeater stations rebroadcasting television channels to limited areas on a low power basis

Service licence	means a BS, ECS or ECNS licence;
SF	means Single Frequency
SFN	means Single Frequency Network
Ship station	means a mobile station in the maritime mobile service that has been erected
SNG	means Satellite News Gathering
Spread spectrum	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
SRD	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;
STL or Studio Links	means point to point links in the broadcasting frequency bands used to connect studios to transmitters
STB	means Set Top Box for DVB-T2 reception
T-DAB	means Terrestrial Digital Audio Broadcasting
TDD	means Time Division Duplex
TDMA	means Time Division Multiple Access
Telemetry	means the transmission of remotely measured data
TETRA	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.
UE	means user equipment
UHF	means Ultra High Frequency
UMTS	means Universal Mobile Telecommunications System is a third-generation mobile cellular technology for networks based on the GSM standard
VHF	means Very High Frequency
Video Surveillance Equipment	means radio apparatus used for security camera purposes to replace the cable between a camera and a monitor

VSAT	means Very Small Aperture Terminal and is a two-way satellite ground station that is smaller than 3 metres in diameter
WAS	means Wireless Access Systems and is end-user radio connections to public or private core networks;
Rain (WBS)	means Rain which is a provider of wireless broadband
Wideband Wireless Systems	means radio apparatus that uses spread spectrum techniques and has a high bit rate;
WiMAX	means Worldwide Interoperability for Microwave Access, also known as WirelessMAN which is a wireless broadband standard
WP 5D	means ITU-R Working Party 5D - IMT Systems
WRC 07	means World Radio Conference 2007 held in Geneva
WRC 12	means World Radio Conference 2012 held in Geneva
WRC 15	means the World Radio Conference held in Geneva 2015
WRC 19	means the World Radio Conference planned to be held in Geneva 2019

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[32] 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)[33].

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 changed34 .
- 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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[32]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.

[33] The ICT Regulation Toolkit is a joint production of infoDev and the International Telecommunication Union

[34] 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.

12 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	TR13-01(A)	CEPT	TR13-01(A)	CEPT	TR13-01(A)
Band	1.4 GHz (F.S)	Band	1.4 GHz (F.S)	Band	1.4 GHz (F.S)
Ctr.Freq	1433.5 MHz	Ctr.Freq	1433.5 MHz	Ctr.Freq	1433.5 MHz
Ch.Width	25 kHz	Ch.Width	250 kHz	Ch.Width	500 kHz
Separ.	142 MHz	Separ.	142 MHz	Separ.	142 MHz
Ch.Spac.	100x25 kHz	Ch.Spac.	15x250 kHz	Ch.Spac.	35x500 kHz
Ctr.Gap	117 MHz	Ctr.Gap	117 MHz	Ctr.Gap	117 MHz

Ch.	Go	Return		Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return		Old plan channel n	
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	ad hoc
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	ad hoc
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	1353.1250	1495.1250				29	1371.2500	1513.2500		137	ad hoc
30	1351.2375	1493.2375	66	1352.1375	1494.1375	2	1353.3750	1495.3750				30	1371.7500	1513.7500		138	ad hoc
31	1351.2625	1493.2625	67	1352.1625	1494.1625	3	1353.6250	1495.6250				31	1372.2500	1514.2500		139	
32	1351.2875	1493.2875	68	1352.1875	1494.1875	4	1353.8750	1495.8750				32	1372.7500	1514.7500		140	ad hoc
33	1351.3125	1493.3125	69	1352.2125	1494.2125	5	1354.1250	1496.1250				33	1373.2500	1515.2500		141	
34	1351.3375	1493.3375	70	1352.2375	1494.2375	6	1354.3750	1496.3750				34	1373.7500	1515.7500		142	
35	1351.3625	1493.3625	71	1352.2625	1494.2625	7	1354.6250	1496.6250				35	1374.2500	1516.2500		143	
36	1351.3875	1493.3875	72	1352.2875	1494.2875	8	1354.8750	1496.8750									

25 kHz shared | 250 kHz shared | 500 kHz shared

continue Annex B on next sheet

Typical users

- Eskom
- Transnet
- Ekurhuleni
- National Research Foundation

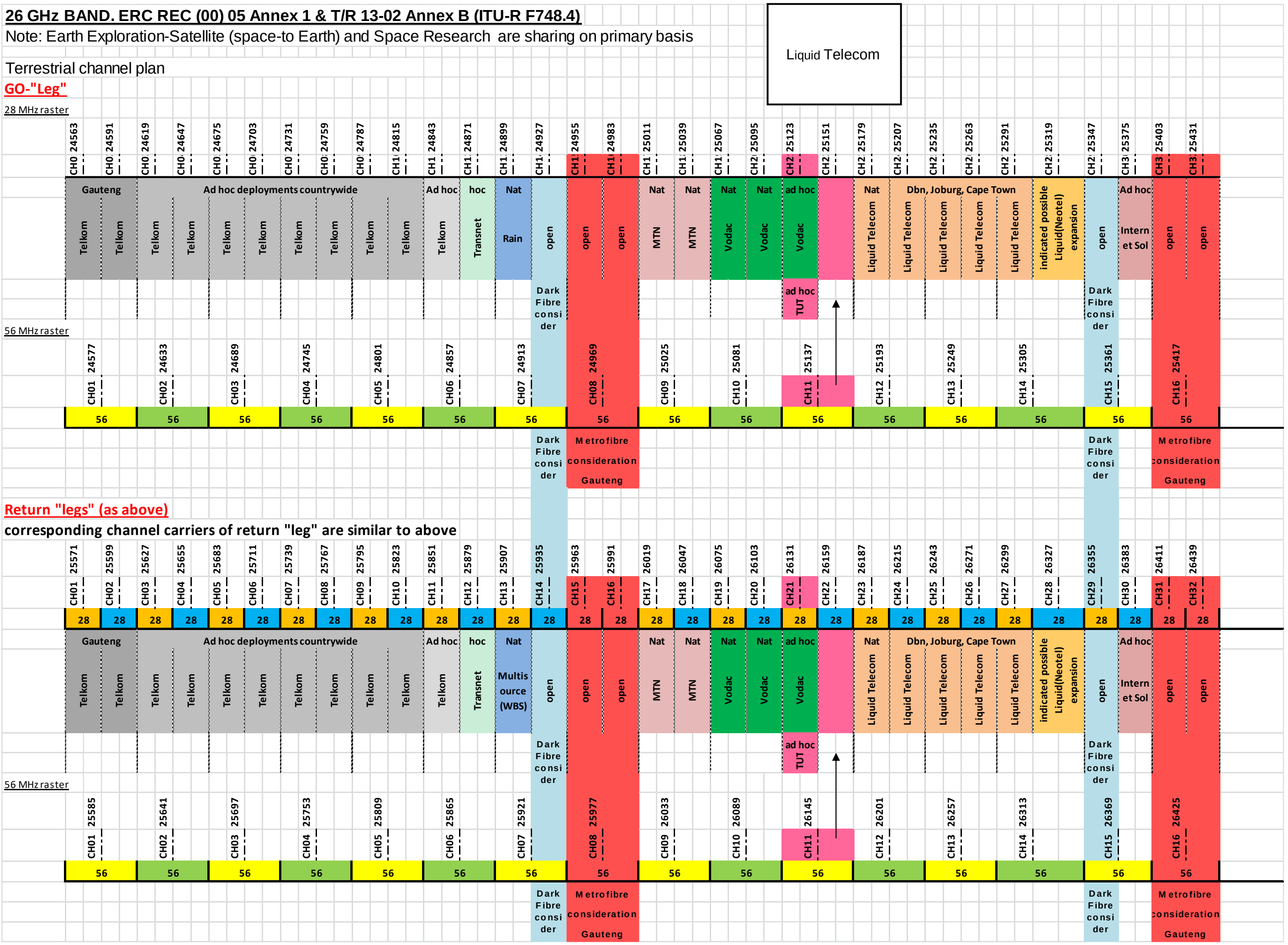
Annex B (new plan)

	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		
Ch.	Go	Return	
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		-						
Ch.		Ch.		Ch.		Ch.		Ch.	
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		

13 APPENDIX C – ADDITIONAL INFORMATION ON 24.25-27.5 GHZ



NB: Neotel Spectrum Licences has been amended to Liquid Telecom

14 APPENDIX D - ADDITIONAL INFORMATION FOR 37-40.5 GHZ

F.749-1	A			B	F.749-1		B			C			F.749-1	C		C		
BAND					38 GHz								38 GHz					BAND
Ctr.FREQ					38248.000								38248.000					Ctr.FREQ
Ch.Width	56 MHz	56 MHz		28 MHz	28 MHz		28 MHz	28 MHz		14 MHz	14 MHz		14 MHz	14 MHz		14 MHz	14 MHz	Ch.Width
Separ.					1260 MHz								1260 MHz					Separ.
Ch.Spac.	56 MHz	56 MHz		28 MHz	28 MHz		28 MHz	28 MHz		14 MHz	14 MHz		14 MHz	14 MHz		14 MHz	14 MHz	Ch.Spac.
Ctr. Gap					140 MHz								140 MHz					Ctr. Gap
Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.	Go	Return	Ch.
1	37086.0000	38346.0000	1	37072.0000	38332.0000	38	38108.0000	39368.0000	1	37065.0000	38325.0000	38	37583.0000	38843.0000	75	38101.0000	39361.0000	75
2	37142.0000	38402.0000	2	37100.0000	38360.0000	39	38136.0000	39396.0000	2	37079.0000	38339.0000	39	37597.0000	38857.0000	76	38115.0000	39375.0000	76
3	37198.0000	38458.0000	3	37128.0000	38388.0000	40	38164.0000	39424.0000	3	37093.0000	38353.0000	40	37611.0000	38871.0000	77	38129.0000	39389.0000	77
4	37254.0000	38514.0000	4	37156.0000	38416.0000				4	37107.0000	38367.0000	41	37625.0000	38885.0000	78	38143.0000	39403.0000	78
5	37310.0000	38570.0000	5	37184.0000	38444.0000				5	37121.0000	38381.0000	42	37639.0000	38899.0000	79	38157.0000	39417.0000	79
6	37366.0000	38626.0000	6	37212.0000	38472.0000				6	37135.0000	38395.0000	43	37653.0000	38913.0000	80	38171.0000	39431.0000	80
7	37422.0000	38682.0000	7	37240.0000	38500.0000				7	37149.0000	38409.0000	44	37667.0000	38927.0000				
8	37478.0000	38738.0000	8	37268.0000	38528.0000				8	37163.0000	38423.0000	45	37681.0000	38941.0000				
9	37534.0000	38794.0000	9	37296.0000	38556.0000				9	37177.0000	38437.0000	46	37695.0000	38955.0000				
10	37590.0000	38850.0000	10	37324.0000	38584.0000				10	37191.0000	38451.0000	47	37709.0000	38969.0000				
11	37646.0000	38906.0000	11	37352.0000	38612.0000				11	37205.0000	38465.0000	48	37723.0000	38983.0000				
12	37702.0000	38962.0000	12	37380.0000	38640.0000				12	37219.0000	38479.0000	49	37737.0000	38997.0000				
13	37758.0000	39018.0000	13	37408.0000	38668.0000				13	37233.0000	38493.0000	50	37751.0000	39011.0000				
14	37814.0000	39074.0000	14	37436.0000	38696.0000				14	37247.0000	38507.0000	51	37765.0000	39025.0000				
15	37870.0000	39130.0000	15	37464.0000	38724.0000				15	37261.0000	38521.0000	52	37779.0000	39039.0000				
16	37926.0000	39186.0000	16	37492.0000	38752.0000				16	37275.0000	38535.0000	53	37793.0000	39053.0000				
17	37982.0000	39242.0000	17	37520.0000	38780.0000				17	37289.0000	38549.0000	54	37807.0000	39067.0000				
18	38038.0000	39298.0000	18	37548.0000	38808.0000				18	37303.0000	38563.0000	55	37821.0000	39081.0000				
19	38094.0000	39354.0000	19	37576.0000	38836.0000				19	37317.0000	38577.0000	56	37835.0000	39095.0000				
20	38150.0000	39410.0000	20	37604.0000	38864.0000				20	37331.0000	38591.0000	57	37849.0000	39109.0000				
			21	37632.0000	38892.0000				21	37345.0000	38605.0000	58	37863.0000	39123.0000				
			22	37660.0000	38920.0000				22	37359.0000	38619.0000	59	37877.0000	39137.0000				
			23	37688.0000	38948.0000				23	37373.0000	38633.0000	60	37891.0000	39151.0000				
			24	37716.0000	38976.0000				24	37387.0000	38647.0000	61	37905.0000	39165.0000				
			25	37744.0000	39004.0000				25	37401.0000	38661.0000	62	37919.0000	39179.0000				
			26	37772.0000	39032.0000				26	37415.0000	38675.0000	63	37933.0000	39193.0000				
			27	37800.0000	39060.0000				27	37429.0000	38689.0000	64	37947.0000	39207.0000				
			28	37828.0000	39088.0000				28	37443.0000	38703.0000	65	37961.0000	39221.0000				
			29	37856.0000	39116.0000				29	37457.0000	38717.0000	66	37975.0000	39235.0000				
			30	37884.0000	39144.0000				30	37471.0000	38731.0000	67	37989.0000	39249.0000				
			31	37912.0000	39172.0000				31	37485.0000	38745.0000	68	38003.0000	39263.0000				
			32	37940.0000	39200.0000				32	37499.0000	38759.0000	69	38017.0000	39277.0000				
			33	37968.0000	39228.0000				33	37513.0000	38773.0000	70	38031.0000	39291.0000				
			34	37996.0000	39256.0000				34	37527.0000	38787.0000	71	38045.0000	39305.0000				
			35	38024.0000	39284.0000				35	37541.0000	38801.0000	72	38059.0000	39319.0000				
			36	38052.0000	39312.0000				36	37555.0000	38815.0000	73	38073.0000	39333.0000				
			37	38080.0000	39340.0000				37	37569.0000	38829.0000	74	38087.0000	39347.0000				

F.749-1					F.749-1						F.749-1				F.749-1
BAND	D			D	38 GHz		D			D	38 GHz		D		BAND
Ctr.FREQ					38248.000						38248.000				Ctr.FREQ
Ch.Width	7 MHz	7 MHz		7 MHz	7 MHz		7 MHz	7 MHz		7 MHz	7 MHz		7 MHz	7 MHz	Ch.Width
Separ.					1260 MHz						1260 MHz				Separ.
Ch.Spac.	7 MHz	7 MHz		7 MHz	7 MHz		7 MHz	7 MHz		7 MHz	7 MHz		7 MHz	7 MHz	Ch.Spac.
Ctr. Gap					140 MHz						140 MHz				Ctr. Gap
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	112	37838.5000	39098.5000	149	38097.5000	39357.5000	149
2	37068.5000	38328.5000	39	37327.5000	38587.5000	76	37586.5000	38846.5000	113	37845.5000	39105.5000	150	38104.5000	39364.5000	150
3	37075.5000	38335.5000	40	37334.5000	38594.5000	77	37593.5000	38853.5000	114	37852.5000	39112.5000	151	38111.5000	39371.5000	151
4	37082.5000	38342.5000	41	37341.5000	38601.5000	78	37600.5000	38860.5000	115	37859.5000	39119.5000	152	38118.5000	39378.5000	152
5	37089.5000	38349.5000	42	37348.5000	38608.5000	79	37607.5000	38867.5000	116	37866.5000	39126.5000	153	38125.5000	39385.5000	153
6	37096.5000	38356.5000	43	37355.5000	38615.5000	80	37614.5000	38874.5000	117	37873.5000	39133.5000	154	38132.5000	39392.5000	154
7	37103.5000	38363.5000	44	37362.5000	38622.5000	81	37621.5000	38881.5000	118	37880.5000	39140.5000	155	38139.5000	39399.5000	155
8	37110.5000	38370.5000	45	37369.5000	38629.5000	82	37628.5000	38888.5000	119	37887.5000	39147.5000	156	38146.5000	39406.5000	156
9	37117.5000	38377.5000	46	37376.5000	38636.5000	83	37635.5000	38895.5000	120	37894.5000	39154.5000	157	38153.5000	39413.5000	157
10	37124.5000	38384.5000	47	37383.5000	38643.5000	84	37642.5000	38902.5000	121	37901.5000	39161.5000	158	38160.5000	39420.5000	158
11	37131.5000	38391.5000	48	37390.5000	38650.5000	85	37649.5000	38909.5000	122	37908.5000	39168.5000	159	38167.5000	39427.5000	159
12	37138.5000	38398.5000	49	37397.5000	38657.5000	86	37656.5000	38916.5000	123	37915.5000	39175.5000	160	38174.5000	39434.5000	160
13	37145.5000	38405.5000	50	37404.5000	38664.5000	87	37663.5000	38923.5000	124	37922.5000	39182.5000				
14	37152.5000	38412.5000	51	37411.5000	38671.5000	88	37670.5000	38930.5000	125	37929.5000	39189.5000				
15	37159.5000	38419.5000	52	37418.5000	38678.5000	89	37677.5000	38937.5000	126	37936.5000	39196.5000				
16	37166.5000	38426.5000	53	37425.5000	38685.5000	90	37684.5000	38944.5000	127	37943.5000	39203.5000				
17	37173.5000	38433.5000	54	37432.5000	38692.5000	91	37691.5000	38951.5000	128	37950.5000	39210.5000				
18	37180.5000	38440.5000	55	37439.5000	38699.5000	92	37698.5000	38958.5000	129	37957.5000	39217.5000				
19	37187.5000	38447.5000	56	37446.5000	38706.5000	93	37705.5000	38965.5000	130	37964.5000	39224.5000				
20	37194.5000	38454.5000	57	37453.5000	38713.5000	94	37712.5000	38972.5000	131	37971.5000	39231.5000				
21	37201.5000	38461.5000	58	37460.5000	38720.5000	95	37719.5000	38979.5000	132	37978.5000	39238.5000				
22	37208.5000	38468.5000	59	37467.5000	38727.5000	96	37726.5000	38986.5000	133	37985.5000	39245.5000				
23	37215.5000	38475.5000	60	37474.5000	38734.5000	97	37733.5000	38993.5000	134	37992.5000	39252.5000				
24	37222.5000	38482.5000	61	37481.5000	38741.5000	98	37740.5000	39000.5000	135	37999.5000	39259.5000				
25	37229.5000	38489.5000	62	37488.5000	38748.5000	99	37747.5000	39007.5000	136	38006.5000	39266.5000				
26	37236.5000	38496.5000	63	37495.5000	38755.5000	100	37754.5000	39014.5000	137	38013.5000	39273.5000				
27	37243.5000	38503.5000	64	37502.5000	38762.5000	101	37761.5000	39021.5000	138	38020.5000	39280.5000				
28	37250.5000	38510.5000	65	37509.5000	38769.5000	102	37768.5000	39028.5000	139	38027.5000	39287.5000				
29	37257.5000	38517.5000	66	37516.5000	38776.5000	103	37775.5000	39035.5000	140	38034.5000	39294.5000				
30	37264.5000	38524.5000	67	37523.5000	38783.5000	104	37782.5000	39042.5000	141	38041.5000	39301.5000				
31	37271.5000	38531.5000	68	37530.5000	38790.5000	105	37789.5000	39049.5000	142	38048.5000	39308.5000				
32	37278.5000	38538.5000	69	37537.5000	38797.5000	106	37796.5000	39056.5000	143	38055.5000	39315.5000				
33	37285.5000	38545.5000	70	37544.5000	38804.5000	107	37803.5000	39063.5000	144	38062.5000	39322.5000				
34	37292.5000	38552.5000	71	37551.5000	38811.5000	108	37810.5000	39070.5000	145	38069.5000	39329.5000				
35	37299.5000	38559.5000	72	37558.5000	38818.5000	109	37817.5000	39077.5000	146	38076.5000	39336.5000				
36	37306.5000	38566.5000	73	37565.5000	38825.5000	110	37824.5000	39084.5000	147	38083.5000	39343.5000				
37	37313.5000	38573.5000	74	37572.5000	38832.5000	111	37831.5000	39091.5000	148	38090.5000	39350.5000				

CCIR/ITU-R								F.749-1												F.749-1							F.749-1
BAND	E			E			E	38 GHz		E			E			E			E	38 GHz		E			E		BAND
Ctr.FREQ								38248.000												38248.000							Ctr.FREQ
Ch.Width	3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz	Ch.Width
Separ.								1260 MHz												1260 MHz							Separ.
Ch.Spac.	3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz		3.5 MHz	3.5 MHz	Ch.Spac.
Ctr. Gap								140 MHz												140 MHz							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	37059.7500	38319.7500	38	37189.2500	38449.2500	75	37318.7500	38578.7500	112	37448.2500	38708.2500	149	37577.7500	38837.7500	186	37707.2500	38967.2500	223	37836.7500	39096.7500	260	37966.2500	39226.2500	297	38095.7500	39355.7500	297
2	37063.2500	38323.2500	39	37192.7500	38452.7500	76	37322.2500	38582.2500	113	37451.7500	38711.7500	150	37581.2500	38841.2500	187	37710.7500	38970.7500	224	37840.2500	39100.2500	261	37969.7500	39229.7500	298	38099.2500	39359.2500	298
3	37066.7500	38326.7500	40	37196.2500	38456.2500	77	37325.7500	38585.7500	114	37455.2500	38715.2500	151	37584.7500	38844.7500	188	37714.2500	38974.2500	225	37843.7500	39103.7500	262	37973.2500	39233.2500	299	38102.7500	39362.7500	299
4	37070.2500	38330.2500	41	37199.7500	38459.7500	78	37329.2500	38589.2500	115	37458.7500	38718.7500	152	37588.2500	38848.2500	189	37717.7500	38977.7500	226	37847.2500	39107.2500	263	37976.7500	39236.7500	300	38106.2500	39366.2500	300
5	37073.7500	38333.7500	42	37203.2500	38463.2500	79	37332.7500	38592.7500	116	37462.2500	38722.2500	153	37591.7500	38851.7500	190	37721.2500	38981.2500	227	37850.7500	39110.7500	264	37980.2500	39240.2500	301	38109.7500	39369.7500	301
6	37077.2500	38337.2500	43	37206.7500	38466.7500	80	37336.2500	38596.2500	117	37465.7500	38725.7500	154	37595.2500	38855.2500	191	37724.7500	38984.7500	228	37854.2500	39114.2500	265	37983.7500	39243.7500	302	38113.2500	39373.2500	302
7	37080.7500	38340.7500	44	37210.2500	38470.2500	81	37339.7500	38599.7500	118	37469.2500	38729.2500	155	37598.7500	38858.7500	192	37728.2500	38988.2500	229	37857.7500	39117.7500	266	37987.2500	39247.2500	303	38116.7500	39376.7500	303
8	37084.2500	38344.2500	45	37213.7500	38473.7500	82	37343.2500	38603.2500	119	37472.7500	38732.7500	156	37602.2500	38862.2500	193	37731.7500	38991.7500	230	37861.2500	39121.2500	267	37990.7500	39250.7500	304	38120.2500	39380.2500	304
9	37087.7500	38347.7500	46	37217.2500	38477.2500	83	37346.7500	38606.7500	120	37476.2500	38736.2500	157	37605.7500	38865.7500	194	37735.2500	38995.2500	231	37864.7500	39124.7500	268	37994.2500	39254.2500	305	38123.7500	39383.7500	305
10	37091.2500	38351.2500	47	37220.7500	38480.7500	84	37350.2500	38610.2500	121	37479.7500	38739.7500	158	37609.2500	38869.2500	195	37738.7500	38998.7500	232	37868.2500	39128.2500	269	37997.7500	39257.7500	306	38127.2500	39387.2500	306
11	37094.7500	38354.7500	48	37224.2500	38484.2500	85	37353.7500	38613.7500	122	37483.2500	38743.2500	159	37612.7500	38872.7500	196	37742.2500	39002.2500	233	37871.7500	39131.7500	270	38001.2500	39261.2500	307	38130.7500	39390.7500	307
12	37098.2500	38358.2500	49	37227.7500	38487.7500	86	37357.2500	38617.2500	123	37486.7500	38746.7500	160	37616.2500	38876.2500	197	37745.7500	39005.7500	234	37875.2500	39135.2500	271	38004.7500	39264.7500	308	38134.2500	39394.2500	308
13	37101.7500	38361.7500	50	37231.2500	38491.2500	87	37360.7500	38620.7500	124	37490.2500	38750.2500	161	37619.7500	38879.7500	198	37749.2500	39009.2500	235	37878.7500	39138.7500	272	38008.2500	39268.2500	309	38137.7500	39397.7500	309
14	37105.2500	38365.2500	51	37234.7500	38494.7500	88	37364.2500	38624.2500	125	37493.7500	38753.7500	162	37623.2500	38883.2500	199	37752.7500	39012.7500	236	37882.2500	39142.2500	273	38011.7500	39271.7500	310	38141.2500	39401.2500	310
15	37108.7500	38368.7500	52	37238.2500	38498.2500	89	37367.7500	38627.7500	126	37497.2500	38757.2500	163	37626.7500	38886.7500	200	37756.2500	39016.2500	237	37885.7500	39145.7500	274	38015.2500	39275.2500	311	38144.7500	39404.7500	311
16	37112.2500	38372.2500	53	37241.7500	38501.7500	90	37371.2500	38631.2500	127	37500.7500	38760.7500	164	37630.2500	38890.2500	201	37759.7500	39019.7500	238	37889.2500	39149.2500	275	38018.7500	39278.7500	312	38148.2500	39408.2500	312
17	37115.7500	38375.7500	54	37245.2500	38505.2500	91	37374.7500	38634.7500	128	37504.2500	38764.2500	165	37633.7500	38893.7500	202	37763.2500	39023.2500	239	37892.7500	39152.7500	276	38022.2500	39282.2500	313	38151.7500	39411.7500	313
18	37119.2500	38379.2500	55	37248.7500	38508.7500	92	37378.2500	38638.2500	129	37507.7500	38767.7500	166	37637.2500	38897.2500	203	37766.7500	39026.7500	240	37896.2500	39156.2500	277	38025.7500	39285.7500	314	38155.2500	39415.2500	314
19	37122.7500	38382.7500	56	37252.2500	38512.2500	93	37381.7500	38641.7500	130	37511.2500	38771.2500	167	37640.7500	38900.7500	204	37770.2500	39030.2500	241	37899.7500	39159.7500	278	38029.2500	39289.2500	315	38158.7500	39418.7500	315
20	37126.2500	38386.2500	57	37255.7500	38515.7500	94	37385.2500	38645.2500	131	37514.7500	38774.7500	168	37644.2500	38904.2500	205	37773.7500	39033.7500	242	37903.2500	39163.2500	279	38032.7500	39292.7500	316	38162.2500	39422.2500	316
21	37129.7500	38389.7500	58	37259.2500	38519.2500	95	37388.7500	38648.7500	132	37518.2500	38778.2500	169	37647.7500	38907.7500	206	37777.2500	39037.2500	243	37906.7500	39166.7500	280	38036.2500	39296.2500	317	38165.7500	39425.7500	317
22	37133.2500	38393.2500	59	37262.7500	38522.7500	96	37392.2500	38652.2500	133	37521.7500	38781.7500	170	37651.2500	38911.2500	207	37780.7500	39040.7500	244	37910.2500	39170.2500	281	38039.7500	39299.7500	318	38169.2500	39429.2500	318
23	37136.7500	38396.7500	60	37266.2500	38526.2500	97	37395.7500	38655.7500	134	37525.2500	38785.2500	171	37654.7500	38914.7500	208	37784.2500	39044.2500	245	37913.7500	39173.7500	282	38043.2500	39303.2500	319	38172.7500	39432.7500	319
24	37140.2500	38400.2500	61	37269.7500	38529.7500	98	37399.2500	38659.2500	135	37528.7500	38788.7500	172	37658.2500	38918.2500	209	37787.7500	39047.7500	246	37917.2500	39177.2500	283	38046.7500	39306.7500	320	38176.2500	39436.2500	320
25	37143.7500	38403.7500	62	37273.2500	38533.2500	99	37402.7500	38662.7500	136	37532.2500	38792.2500	173	37661.7500	38921.7500	210	37791.2500	39051.2500	247	37920.7500	39180.7500	284	38050.2500	39310.2500				
26	37147.2500	38407.2500	63	37276.7500	38536.7500	100	37406.2500	38666.2500	137	37535.7500	38795.7500	174	37665.2500	38925.2500	211	37794.7500	39054.7500	248	37924.2500	39184.2500	285	38053.7500	39313.7500				
27	37150.7500	38410.7500	64	37280.2500	38540.2500	101	37409.7500	38669.7500	138	37539.2500	38799.2500	175	37668.7500	38928.7500	212	37798.2500	39058.2500	249	37927.7500	39187.7500	286	38057.2500	39317.2500				
28	37154.2500	38414.2500	65	37283.7500	38543.7500	102	37413.2500	38673.2500	139	37542.7500	38802.7500	176	37672.2500	38932.2500	213	37801.7500	39061.7500	250	37931.2500	39191.2500	287	38060.7500	39320.7500				
29	37157.7500	38417.7500	66	37287.2500	38547.2500	103	37416.7500	38676.7500	140	37546.2500	38806.2500	177	37675.7500	38935.7500	214	37805.2500	39065.2500	251	37934.7500	39194.7500	288	38064.2500	39324.2500				
30	37161.2500	38421.2500	67	37290.7500	38550.7500	104	37420.2500	38680.2500	141	37549.7500	38809.7500	178	37679.2500	38939.2500	215	37808.7500	39068.7500	252	37938.2500	39198.2500	289	38067.7500	39327.7500				
31	37164.7500	38424.7500	68	37294.2500	38554.2500	105	37423.7500	38683.7500	142	37553.2500	38813.2500	179	37682.7500	38942.7500	216	37812.2500	39072.2500	253	37941.7500	39201.7500	290	38071.2500	39331.2500				
32	37168.2500	38428.2500	69	37297.7500	38557.7500	106	37427.2500	38687.2500	143	37556.7500	38816.7500	180	37686.2500	38946.2500	217	37815.7500	39075.7500	254	37945.2500	39205.2500	291	38074.7500	39334.7500				
33	37171.7500	38431.7500	70	37301.2500	38561.2500	107	37430.7500	38690.7500	144	37560.2500	38820.2500	181	37689.7500	38949.7500	218	37819.2500	39079.2500	255	37948.7500	39208.7500	292	38078.2500	39338.2500				
34	37175.2500	38435.2500	71	37304.7500	38564.7500	108	37434.2500	38694.2500	145	37563.7500	38823.7500	182	37693.2500	38953.2500	219	37822.7500	39082.7500	256	37952.2500	39212.2500	293	38081.7500	39341.7500				
35	37178.7500	38438.7500	72	37308.2500	38568.2500	109	37437.7500	38697.7500	146	37567.2500	38827.2500	183	37696.7500	38956.7500	220	37826.2500	39086.2500	257	37955.7500	39215.7500	294	38085.2500	39345.2500				
36	37182.2500	38442.2500	73	37311.7500	38571.7500	110	37441.2500	38701.2500	147	37570.7500	38830.7500	184	37700.2500	38960.2500	221	37829.7500	39089.7500	258	37959.2500	39219.2500	295	38088.7500	39348.7500				
37	37185.7500	38445.7500	74	37315.2500	38575.2500	111	37444.7500	38704.7500	148	37574.2500	38834.2500	185	37703.7500	38963.7500	222	37833.2500	39093.2500	259	37962.7500	39222.7500	296	38092.2500	39352.2500				

15 APPENDIX E - ADDITIONAL INFORMATION 40.5-42.5 GHZ

42 GHz BAND (ITU-R F.2005) or ECC/REC/(01)04

Sub-band A				Sub-band 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	VC national	1	40578	42078
2	40718	42218	VC national ↓	2	40634	42134
3	40830	42330	space for possible	3	40690	42190
4	40942	42442	expansion or sharing	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

Sub-band C

F ref (MHz)	42000
Ctr.Freq (MHz)	42000
Separ.	1500 MHz
Ch.Spac.	28 MHz
Ctr. Gap	100 MHz

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

Sub-band D

F ref (MHz)	42000	
Ctr.Freq (MHz)	42000	
Separ.	1500 MHz	
Ch.Spac.	14 MHz	
Ctr. Gap	86 MHz	

CH	GO	RETURN
1	40557	42057
2	40571	42071
3	40585	42085
4	40599	42099
5	40613	42113
6	40627	42127
7	40641	42141
8	40655	42155
9	40669	42169
10	40683	42183
11	40697	42197
12	40711	42211
13	40725	42225
14	40739	42239
15	40753	42253
16	40767	42267
17	40781	42281
18	40795	42295
19	40809	42309
20	40823	42323
21	40837	42337
22	40851	42351
23	40865	42365
24	40879	42379
25	40893	42393
26	40907	42407
27	40921	42421
28	40935	42435
29	40949	42449
30	40963	42463

CH	GO	RETURN
31	40977	42477
32	40991	42491
33	41005	42505
34	41019	42519
35	41033	42533
36	41047	42547
37	41061	42561
38	41075	42575
39	41089	42589
40	41103	42603
41	41117	42617
42	41131	42631
43	41145	42645
44	41159	42659
45	41173	42673
46	41187	42687
47	41201	42701
48	41215	42715
49	41229	42729
50	41243	42743
51	41257	42757
52	41271	42771
53	41285	42785
54	41299	42799
55	41313	42813
56	41327	42827
57	41341	42841
58	41355	42855
59	41369	42869
60	41383	42883

CH	GO	RETURN
61	41397	42897
62	41411	42911
63	41425	42925
64	41439	42939
65	41453	42953
66	41467	42967
67	41481	42981
68	41495	42995
69	41509	43009
70	41523	43023
71	41537	43037
72	41551	43051
73	41565	43065
74	41579	43079
75	41593	43093
76	41607	43107
77	41621	43121
78	41635	43135
79	41649	43149
80	41663	43163
81	41677	43177
82	41691	43191
83	41705	43205
84	41719	43219
85	41733	43233
86	41747	43247
87	41761	43261
88	41775	43275
89	41789	43289
90	41803	43303

CH	GO	RETURN
91	41817	43317
92	41831	43331
93	41845	43345
94	41859	43359
95	41873	43373
96	41887	43387
97	41901	43401
98	41915	43415
99	41929	43429
100	41943	43443
101	41957	43457

Sub-band E

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	CH	GO	RETURN
1	40553.5	42053.5	31	40763.5	42263.5	61	40973.5	42473.5	91	41183.5	42683.5
2	40560.5	42060.5	32	40770.5	42270.5	62	40980.5	42480.5	92	41190.5	42690.5
3	40567.5	42067.5	33	40777.5	42277.5	63	40987.5	42487.5	93	41197.5	42697.5
4	40574.5	42074.5	34	40784.5	42284.5	64	40994.5	42494.5	94	41204.5	42704.5
5	40581.5	42081.5	35	40791.5	42291.5	65	41001.5	42501.5	95	41211.5	42711.5
6	40588.5	42088.5	36	40798.5	42298.5	66	41008.5	42508.5	96	41218.5	42718.5
7	40595.5	42095.5	37	40805.5	42305.5	67	41015.5	42515.5	97	41225.5	42725.5
8	40602.5	42102.5	38	40812.5	42312.5	68	41022.5	42522.5	98	41232.5	42732.5
9	40609.5	42109.5	39	40819.5	42319.5	69	41029.5	42529.5	99	41239.5	42739.5
10	40616.5	42116.5	40	40826.5	42326.5	70	41036.5	42536.5	100	41246.5	42746.5
11	40623.5	42123.5	41	40833.5	42333.5	71	41043.5	42543.5	101	41253.5	42753.5
12	40630.5	42130.5	42	40840.5	42340.5	72	41050.5	42550.5	102	41260.5	42760.5
13	40637.5	42137.5	43	40847.5	42347.5	73	41057.5	42557.5	103	41267.5	42767.5
14	40644.5	42144.5	44	40854.5	42354.5	74	41064.5	42564.5	104	41274.5	42774.5
15	40651.5	42151.5	45	40861.5	42361.5	75	41071.5	42571.5	105	41281.5	42781.5
16	40658.5	42158.5	46	40868.5	42368.5	76	41078.5	42578.5	106	41288.5	42788.5
17	40665.5	42165.5	47	40875.5	42375.5	77	41085.5	42585.5	107	41295.5	42795.5
18	40672.5	42172.5	48	40882.5	42382.5	78	41092.5	42592.5	108	41302.5	42802.5
19	40679.5	42179.5	49	40889.5	42389.5	79	41099.5	42599.5	109	41309.5	42809.5
20	40686.5	42186.5	50	40896.5	42396.5	80	41106.5	42606.5	110	41316.5	42816.5
21	40693.5	42193.5	51	40903.5	42403.5	81	41113.5	42613.5	111	41323.5	42823.5
22	40700.5	42200.5	52	40910.5	42410.5	82	41120.5	42620.5	112	41330.5	42830.5
23	40707.5	42207.5	53	40917.5	42417.5	83	41127.5	42627.5	113	41337.5	42837.5
24	40714.5	42214.5	54	40924.5	42424.5	84	41134.5	42634.5	114	41344.5	42844.5
25	40721.5	42221.5	55	40931.5	42431.5	85	41141.5	42641.5	115	41351.5	42851.5
26	40728.5	42228.5	56	40938.5	42438.5	86	41148.5	42648.5	116	41358.5	42858.5
27	40735.5	42235.5	57	40945.5	42445.5	87	41155.5	42655.5	117	41365.5	42865.5
28	40742.5	42242.5	58	40952.5	42452.5	88	41162.5	42662.5	118	41372.5	42872.5
29	40749.5	42249.5	59	40959.5	42459.5	89	41169.5	42669.5	119	41379.5	42879.5
30	40756.5	42256.5	60	40966.5	42466.5	90	41176.5	42676.5	120	41386.5	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
121	41393.5	42893.5
122	41400.5	42900.5
123	41407.5	42907.5
124	41414.5	42914.5
125	41421.5	42921.5
126	41428.5	42928.5
127	41435.5	42935.5
128	41442.5	42942.5
129	41449.5	42949.5
130	41456.5	42956.5
131	41463.5	42963.5
132	41470.5	42970.5
133	41477.5	42977.5
134	41484.5	42984.5
135	41491.5	42991.5
136	41498.5	42998.5
137	41505.5	43005.5
138	41512.5	43012.5
139	41519.5	43019.5
140	41526.5	43026.5
141	41533.5	43033.5
142	41540.5	43040.5
143	41547.5	43047.5
144	41554.5	43054.5
145	41561.5	43061.5
146	41568.5	43068.5
147	41575.5	43075.5
148	41582.5	43082.5
149	41589.5	43089.5
150	41596.5	43096.5

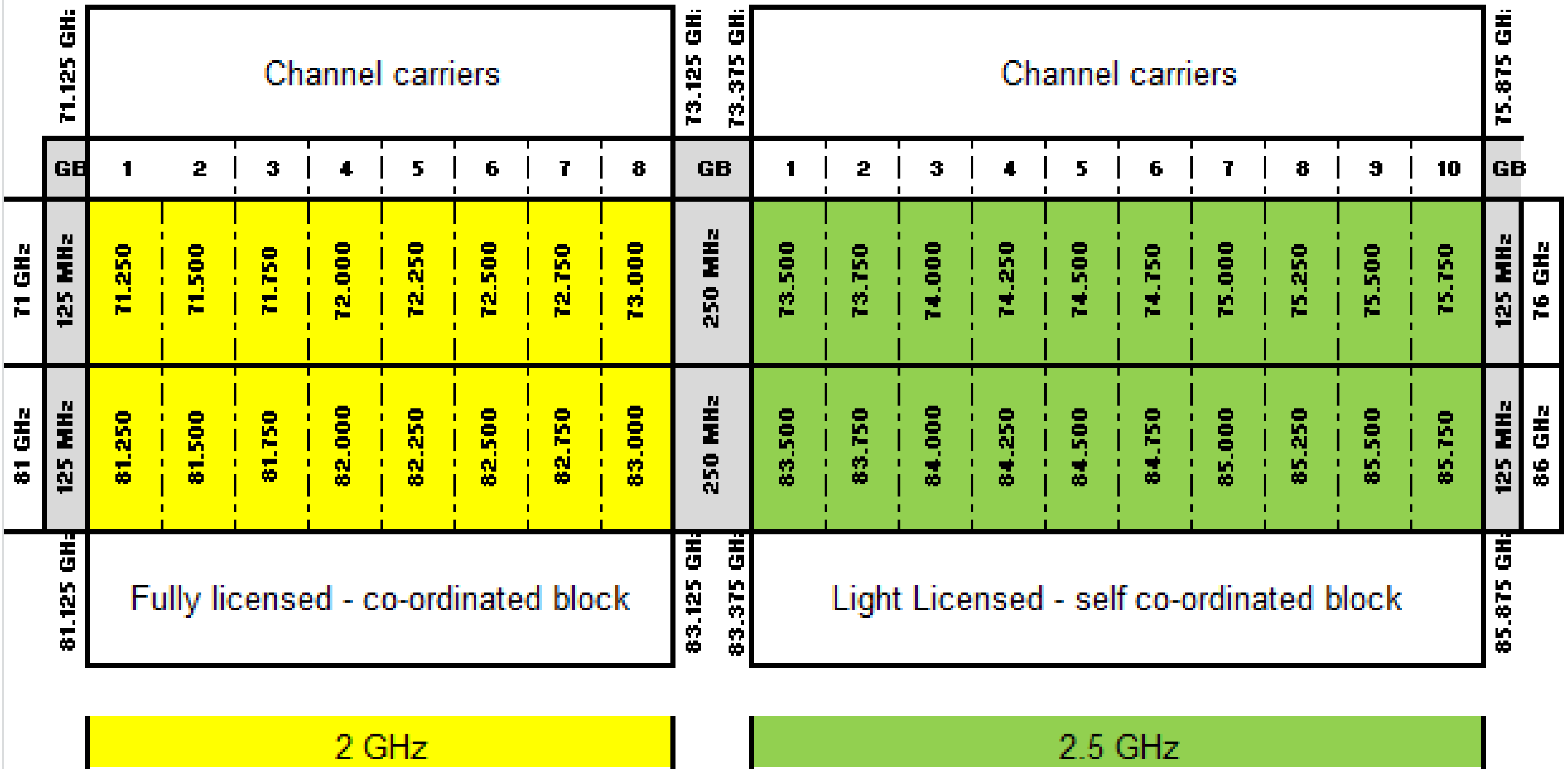
CH	GO	RETURN
151	41603.5	43103.5
152	41610.5	43110.5
153	41617.5	43117.5
154	41624.5	43124.5
155	41631.5	43131.5
156	41638.5	43138.5
157	41645.5	43145.5
158	41652.5	43152.5
159	41659.5	43159.5
160	41666.5	43166.5
161	41673.5	43173.5
162	41680.5	43180.5
163	41687.5	43187.5
164	41694.5	43194.5
165	41701.5	43201.5
166	41708.5	43208.5
167	41715.5	43215.5
168	41722.5	43222.5
169	41729.5	43229.5
170	41736.5	43236.5
171	41743.5	43243.5
172	41750.5	43250.5
173	41757.5	43257.5
174	41764.5	43264.5
175	41771.5	43271.5
176	41778.5	43278.5
177	41785.5	43285.5
178	41792.5	43292.5
179	41799.5	43299.5
180	41806.5	43306.5

CH	GO	RETURN
181	41813.5	43313.5
182	41820.5	43320.5
183	41827.5	43327.5
184	41834.5	43334.5
185	41841.5	43341.5
186	41848.5	43348.5
187	41855.5	43355.5
188	41862.5	43362.5
189	41869.5	43369.5
190	41876.5	43376.5
191	41883.5	43383.5
192	41890.5	43390.5
193	41897.5	43397.5
194	41904.5	43404.5
195	41911.5	43411.5
196	41918.5	43418.5
197	41925.5	43425.5
198	41932.5	43432.5
199	41939.5	43439.5
200	41946.5	43446.5
201	41953.5	43453.5
202	41960.5	43460.5

16 APPENDIX F - 66 TO 76 GHZ AND 81 TO 86 GHZ ADDITIONAL INFORMATION

E-BAND (71 - 81 GHZ paired with 81 - 86 GHz)

250 MHz channel spacing



17 APPENDIX G - E-BAND CHANNEL ARRANGEMENTS

Self-Coordinated E-Band

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

ICASA Coordinated E-Band

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

18 APPENDIX H: RECOMMENDATION ITU-R M.2083-0.

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

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.

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)

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

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

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;

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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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.

2 OBSERVATION OF TRENDS

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.

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.

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.

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.

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 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.

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.

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).

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

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.

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[35] 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 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.

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.

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.

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 (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.

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.

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.

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.

2.3.4 Technologies to enhance massive machine type communications

Future IMT systems are expected to connect many 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.

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.

2.3.6 Technologies to improve network energy efficiency

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.

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.

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.

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

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.

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.

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.

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.

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 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.

3 EVOLUTION OF IMT

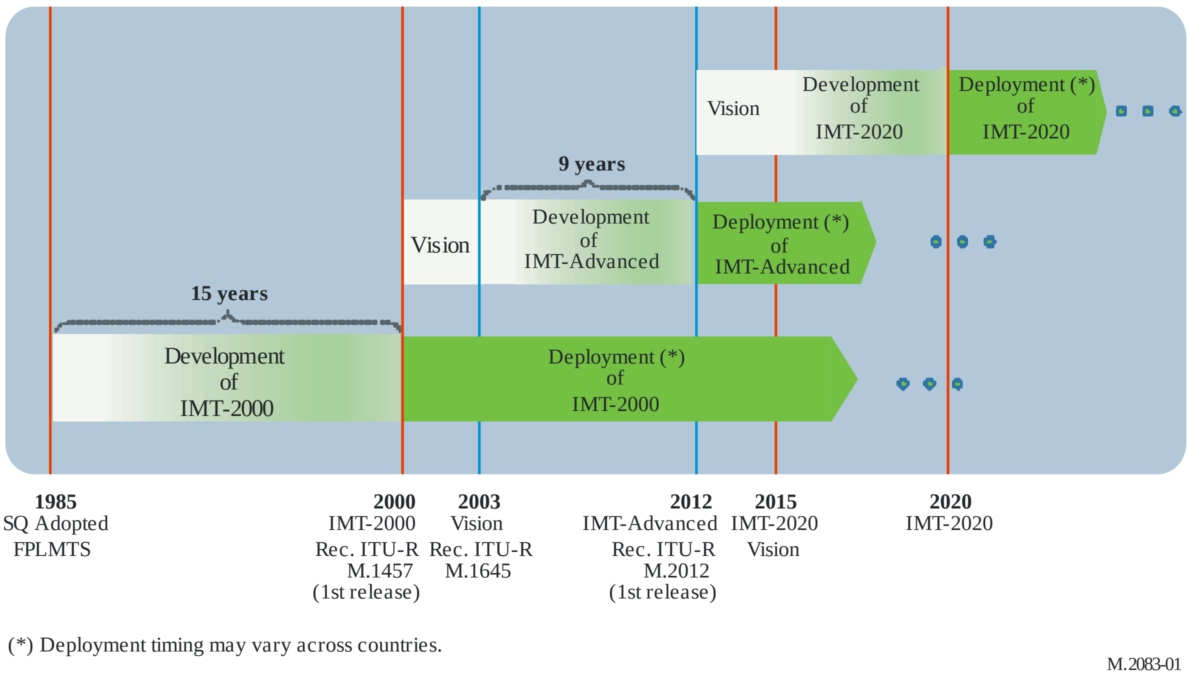
3.1 How IMT has developed

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



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:

– **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.

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.

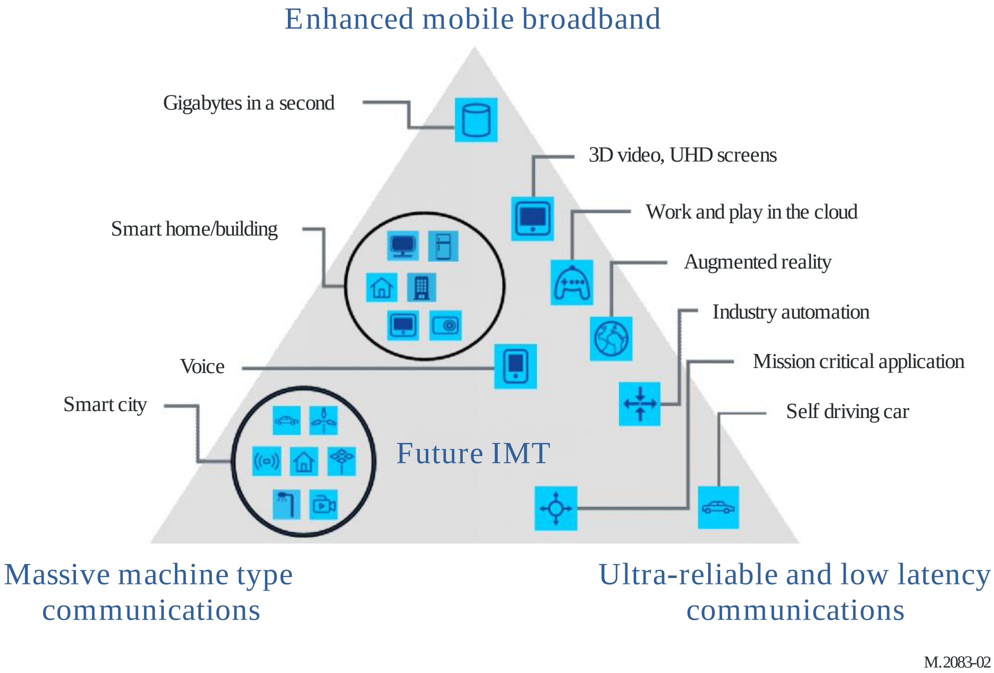
Additional use cases are expected to emerge, which are currently not foreseen. For future IMT, flexibility will be necessary to adapt to new use cases that come with a wide range of requirements.

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



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:

(a) Peak data rate

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

(b) User experienced data rate

Achievable data rate that is available ubiquitously[36] across the coverage area to a mobile user/device (in Mbit/s or Gbit/s).

(c) 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).

(d) 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).

(e) Connection density

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

(f) 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).

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36 The term "ubiquitous" is related to the considered target coverage area and is not intended to relate to an entire region or country.

(g) Spectrum efficiency

Average data throughput per unit of spectrum resource and per cell[37] (bit/s/Hz).

(h) Area traffic capacity

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

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.

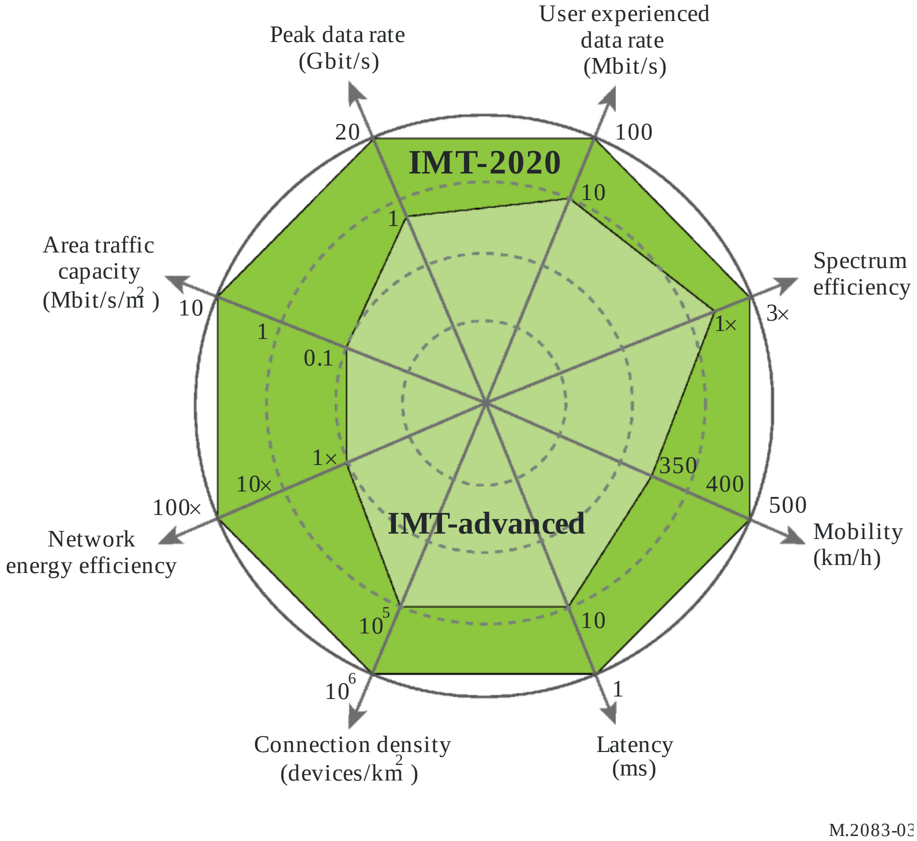
IMT-2020 should be able to provide these capabilities without undue burden on energy consumption, network equipment cost and deployment cost to make future IMT sustainable and affordable.

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

[37] 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).

FIGURE 3

Enhancement of key capabilities from IMT-Advanced to IMT-2020



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^2 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.

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 $10^6/km^2$, 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”.

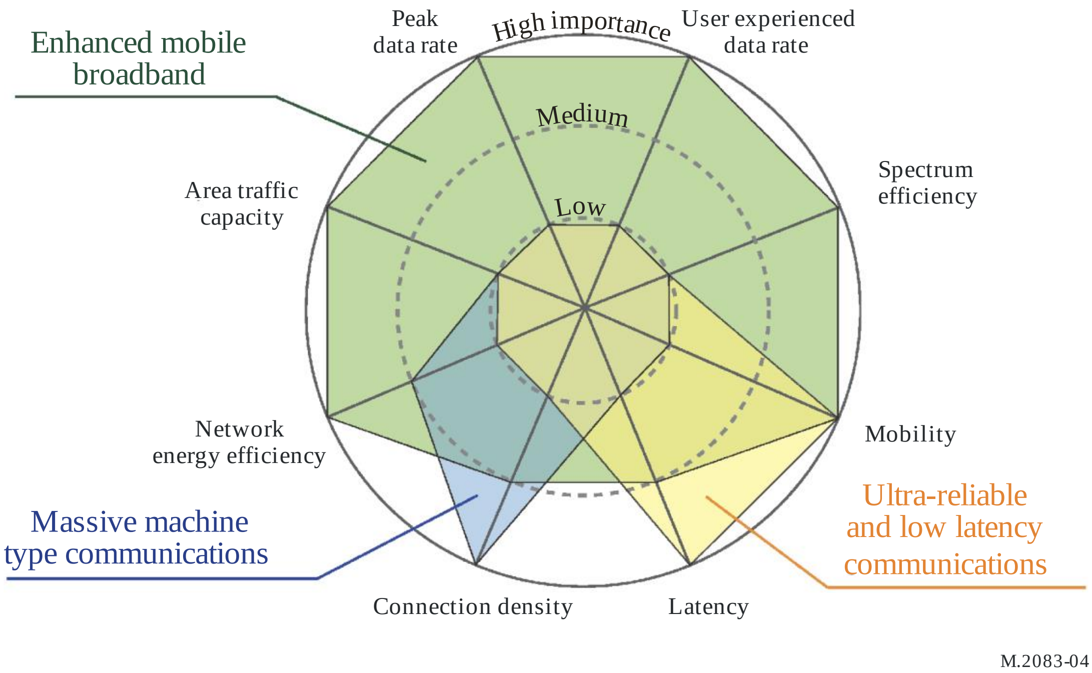
In the enhanced Mobile Broadband scenario, user experienced data rate, area traffic capacity, peak data rate, mobility, energy efficiency and spectrum efficiency all have high importance, but mobility and the user experienced data rate would not have equal importance simultaneously in all use cases.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

FIGURE 4

The importance of key capabilities in different usage scenarios



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.

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.

6.1 Relationships

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.

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.

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:

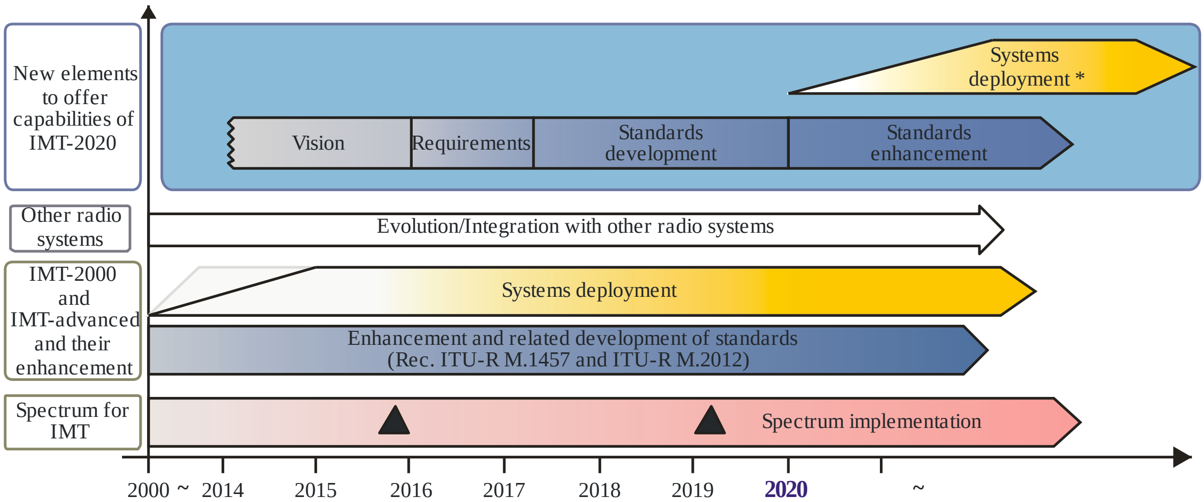
- user trends, requirements and user demand;
- technical capabilities and technology development;
- standards development and their enhancement;
- spectrum matters;
- regulatory considerations;
- system deployment.

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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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 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.

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.

6.3 Focus areas for further study

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.