Government Gazette
Staatskoerant

REPUBLIC OF SOUTH AFRICA
REPUBLIEK VAN SUID-AFRIKA

Vol. 593 Pretoria, 14 November 2014 No. 38213

N.B. The Government Printing Works will not be held responsible for the quality of "Hard Copies" or "Electronic Files" submitted for publication purposes

38213
9771682584003

IMPORTANT NOTICE

The Government Printing Works will not be held responsible for faxed documents not received due to errors on the fax machine or faxes received which are unclear or incomplete. Please be advised that an "OK" slip, received from a fax machine, will not be accepted as proof that documents were received by the GPW for printing. If documents are faxed to the GPW it will be the sender's responsibility to phone and confirm that the documents were received in good order.

Furthermore the Government Printing Works will also not be held responsible for cancellations and amendments which have not been done on original documents received from clients.

CONTENTS • INHOUD

General Notice

NOTICE 1009 OF 2014

INDEPENDENT COMMUNICATIONS AUTHORITY OF SOUTH AFRICA

ICASA

PURSUANT TO SECTION 4 (1) OF THE ELECTRONIC COMMUNICATIONS ACT 2005, (ACT NO. 36 OF 2005)

HEREBY ISSUES A NOTICE REGARDING THE IMT ROAD MAP 2014.

1. The Independent Communications Authority of South Africa ("the Authority"), hereby publishes **the Final International Mobile Telecommunications (IMT) Roadmap 2014** in terms of section 2 and 4, read with sections 30, 31(4), and 33 of the Electronic Communications Act (Act No. 36 of 2005).

Dr SS MNCUBE
CHAIRPERSON

Final (Draft) IMT Roadmap 2014

November 2014

Table of Contents

Table of Figures

Table of Tables

1 About

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

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

This document builds on the "Frequency Migration Plan" published in Gazette 36334 on April 3rd, 2013 and reflects the consultation process initiated on 27th August 2014. The roadmap hereby published by the Authority identifies the bands for IMT deployment and also identifies the migration of a number of current licensees out of (or within) bands identified for IMT services. For bands where costs and benefits of the migration were not straightforward, the Authority conducted feasibility studies to determine the appropriateness of migration, details of which can be found in the appendix to this document.

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

2 Executive Summary

2.1 Purpose of the IMT Roadmap

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

The International Telecommunication Union (ITU) has identified frequency bands that could be used for International Mobile Telecommunications (IMT), which is mainly intended for mobile broadband. The Radio Frequency Migration Plan 2013 further identified which of these IMT bands (between 450 and 3600 MHz) could be so deployed in South Africa based on the National Radio Frequency Plan (NRFP) 2013 for South Africa. The eventual assignment to IMT is made through a Radio Frequency Spectrum Assignment Plan (RFSAP). In addition, for the 450-470 MHz band, a feasibility study was required because of complexities regarding existing users and, for the 880-960 MHz band, a feasibility study was considered necessary because of the complexities of in-band migration / refarming.

A key driver for the deployment of IMT bands is the need to ensure that mobile broadband plays its role in meeting the objectives of 'broadband for all' which is encapsulated in the targets of SA Connect published in 2013. A key part of this policy/ document concerns the deployment of the 700 MHz and 800 MHz digital dividend bands (and potentially the 450-470 MHz Band) to provide universal service. As noted in South Africa (SA) Connect:

> *"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."*

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

The overall purpose of this document is to identify the various options for the deployment of the identified bands for IMT (with feasibility studies for the 450-470 MHz band and 880-960 MHz band), reflect the consultation with stakeholders and state the Authority's intentions (the outlook spans 5-10 years).

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

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

Overview

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

There are two principal components in the analysis of the bands:

- The analysis was broadened to encompass feasibility studies for the 450-470 MHz and 880-960 MHz band. The 450-470 MHz feasibility study looked at the possibility of migrating existing users of the band within a moderate time frame to enable IMT. The 880-960 MHz feasibility study concerned the potential for the in-band migration of existing licensee assignments and band usage towards IMT900 in line with the need for contiguous spectrum while keeping GSM-R and IMT850.
- The need to make optimal use of the digital dividend bands, IMT700 and IMT800. The potential options for the use of these bands are outlined, with reference to the different plans that have been developed for the countries in ITU Region 1 and ITU Region 3[1]. The IMT roadmap aims to identify the optimal option for South Africa in order to achieve the benefits of maximum spectrum efficiency and global harmonisation. This is summarised further below.

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 (depending on the coverage and capacity needs for the SA connect broadband target in 2016).

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.

Currently a total bandwidth of 460 MHz is used for IMT in South Africa, mostly for Universal Mobile Telecommunications System (UMTS) and Global System for Mobile Communications (GSM), with recent LTE deployment. This IMT Roadmap envisages that an additional 2×133 MHz paired spectrum and 290 MHz unpaired spectrum will be made available over a given schedule. The most important additional key IMT bands for both coverage (especially rural coverage) and capacity are the IMT700 and IMT800 bands.

[1] The allocation to Mobile (including IMT) for the 700 MHz band was made at WRC12 and the implementation timelines will be confirmed by WRC15.

2.2 Summary of 450-470 MHz band (Feasibility Study)

The band 450-470 MHz has been identified for IMT usage by the ITU and a feasibility study was indicated by the FMP 2013. A key consideration was the need to identify suitable options for existing users.

Although this band has considerable advantages in terms of propagation, in the short term, there is a very limited 'ecosystem' (i.e. very little equipment and terminals available) and the short term requirements for additional IMT spectrum, especially for rural coverage can be met by new spectrum that will be available in the IMT700 and IMT800 bands. However, it should be pointed out that to support the SA Connect objectives in rural areas, the IMT450 band would be highly advantageous due to significant propagation advantages leading to reduced deployment costs.

There are two alternative modes for use of the 450-470 MHz band for IMT:

1. The deployment of Frequency Division Duplex (FDD) which could be achieved through a paired option - 2×5 MHz FDD:
   - The main purpose of the allocation to IMT is to fulfil the aims of SA Connect with respect to ensuring mobile broadband coverage as the frequency band can ensure coverage in remote rural areas at lower cost than higher frequency bands. The IMT450 network is to be focussed on achieving the SA Connect targets in areas that have no coverage. This can be done either directly via IMT450-capable terminals or indirectly via Wi-Fi connectivity using IMT450-backhaul. Note that IMT450 can also be usefully deployed in all areas due to superior indoor coverage.
   - In addition, one potential use of this band could be for Public Protection and Disaster Relief (PPDR) services[2]. An IMT network for PPDR broadband support might be shared with public mobile services with pre-emption in case of emergency. This could be manifested as PPDR providers (i.e. the security and emergency services) having access as closed user groups on different networks in the wide coverage IMT450 band as well as the other IMT bands (e.g. IMT700 or IMT800) because of their higher capacity.
   - Potential co-existence scenarios in the case of FDD are to be considered by interested parties, according to the IMT Roadmap timelines.
2. The deployment of Time Division Duplex (TDD) could be achieved through an unpaired option - 15 MHz TDD, which is more flexible concerning future extension in digital dividend III bands, as TDD is flexible enough to support either more downlink or more uplink traffic. Therefore, deploying TDD in IMT450 is highly appropriate for uplink-focused services, like Machine-to-Machine (M2M) applications, connected cars and/or smart grid applications, especially in rural areas. TDD in IMT450 could also be

[2] The IMT-based PPDR services would work alongside dedicated Terrestrial Trunked Radio (TETRA) services.

bundled with other TDD bands in higher frequencies[3] to increase flexibility of TDD applications and to build the TDD 'ecosystem' in South Africa which is currently well behind the FDD ecosystem. Some stakeholders responding to the consultation suggested IMT450-TDD for PPDR; however the Authority believes that IMT450-TDD should not be used for downlink-focused services (such as PPDR) due to reduced coverage within the TDD downlink.

In the light of the consultation process and the confirmation that stakeholders are interested in IMT 450, the full migration of all licensees of 450-470 MHz is proposed with a timeframe that will be concluded in 2022. The intention is to afford existing users sufficient time and to ensure that most equipment will have reached near end-of-lifetime before migration is finalised.[4] In order to release spectrum for IMT in the 450 MHz band for the SA Connect initiative, the migration process for rural areas could start in 2015 and existing users should have vacated the band in rural areas by no later than the end of 2018. For urban areas, existing users should have migrated out of the band by the end of 2022. Summary of 700 and 800 MHz Bands

Options for the 700 MHz and 800 MHz bands

For consultation, three Options for the 700 MHz and 800 MHz bands were proposed.

Option 1 is based on that used in ITU Region 3 Asia-Pacific Telecommunity (APT). This option permits 2x45 MHz in the 700 MHz band and has the advantage of a large ecosystem (network equipment and terminals) because the Asia-Pacific ITU Region 3 and large parts of Latin and South America have chosen this option. However, the complexity of the APT-700 capable terminals and equipment is high because they need two overlapping duplexers of 30 MHz bandwidth. In addition to IMT700, in IMT800, 2x18 MHz remains, so in total, 2x63 MHz will be available for IMT.

Option 2 (and Option 3) are with respect to the solution adopted in ITU Region 1 (especially European countries) for the IMT 800 MHz band[5] which permits 2x30 MHz in the 791-862 MHz and which partly overlaps with IMT700 APT channel plan. It is essential to minimize potential interference and ensure border co-ordination between different selections of IMT700.

In Option 2, 2x33 MHz remains available for IMT700. The first 30 MHz of bandwidth fits to the first duplexer of the APT-channelling plan, so the terminals of the APT ecosystem would also be usable in ITU Region 1 and vice versa. These 30 MHz will function as a global international roaming band, which will boost the ecosystem significantly. The

---

[3] This could run by either a retail operator or a wholesale operator.

[4] In addition, migration gives the opportunity to modernise at least the radio frequency (RF) parts of equipment and increase overall spectral efficiency.

[5] This preceded the decision to identify IMT700 at World Radio Conference (WRC) 2012.

additional 2×3 MHz in FDD could only be used by APT terminals with a second duplexer (which is expected to be the case in general).

Therefore, the Option 2 total of 2×30 MHz in IMT800 and 2×33 MHz in IMT700 results in the same Frequency Divisions Duplex (FDD) bandwidth compared with Option 1 with 2×45 MHz and 2×18 MHz.

Option 2 and Option 3 offer the opportunity for 10-15 MHz of unpaired spectrum and 2×5 MHz guard band in the band gap between the FDD blocks. Options 2 and 3 are therefore more spectrum- efficient relative to Option 1, if the TDD band was implemented as well.

The IMT750 TDD band would need additional complexity in terminals that would not be part of the APT FDD ecosystem. Therefore, it is expected that special TDD equipment for IMT450 and IMT750 will be produced, especially considering the background that China has planned to implement the TDD channelling version of ITU Region 3.

Based on the submissions to the consultation:

- Option 2 is supported by industry due to better spectral efficiency and use of the centre gap of 25 MHz.
- In the case of IMT750, South Africa is to take into consideration as appropriate the relevant ITU-R report.

2.3 Summary of 880-960 MHz band (Feasibility Study)

The feasibility study in the 880-960 MHz band involves two issues: the harmonisation of GSM assignments for higher efficiency; and a readiness assessment for the GSM-R bands.

The harmonisation of GSM assignments was considered because the 880-960 MHz GSM band is fragmented, making it technically and financially suboptimal for some licensees to provide broadband services. For instance, over 2 MHz of the 35 MHz available are used for guard bands and two of the licensees are unable to deploy broadband services in the narrow fragments of their assignments. Three scenarios are proposed with benefits of increased spectrum (1.2, 1.8 and 1.8 MHz respectively), and contiguous assignments for all three licensees. The differences between the proposed scenarios include the removal of guard bands and uneven-sized assignments proportionate to the spectrum requirements of each of the licensees. Please refer to Chapter 8.6 for a description of the scenarios.

In the consultation, the potential beneficiaries of consolidation (MTN and Cell C) were supportive of Scenario 1 to be carried out within approximately 2 years, while Vodacom indicated a preference for Scenario 3b in a longer term time frame and Telkom indicated a preference for Scenario 3. MTN and Cell C pointed out that the costs and effort of migration would be significant and complex.

With references to the responses from the consultation, the Authority has decided that a two-phase approach should be adopted as depicted in the Figure below.

- The Authority believes that the present assignments, with excessive capacity occupied by guard bands is inefficient. Therefore, in the short term, i.e. Phase 1, the operators must coordinate on the reduction of guard bands. Alternative examples are given for Phase 1 depending on the level of internal refarming to LTE (or UMTS). Disputes will be resolved as per Section 33. (2) of the Act and read with Regulation 13 of the Radio Frequency Spectrum Regulations 2011.
- The Authority has decided that the long term solution should be as per Phase 2 (Scenario 3 without coupling of the 2×5 MHz to existing operators) and should be achieved by 31st March 2020 at the latest. The 2×5 MHz block will be assigned in a separate process.

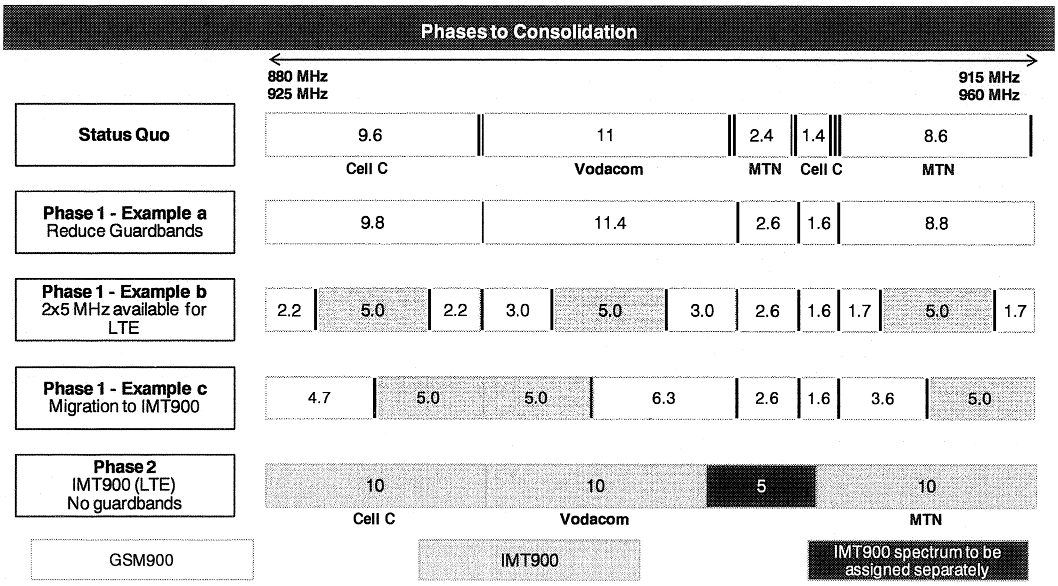


Figure 1: Steps to the harmonisation of the 900 MHz band

Note that Phase 1 (Example b) indicates that currently all operators have at least 2×5 MHz spectrum capable of being refarmed to UMTS900 or LTE900 based on operator`s decision and equipment capability

The principle of removing the guard bands between operators based on mutual agreement and coordination could also be applied to the IMT1800 band.

In the case of refarming to UMTS900 or LTE900, new coverage and capacity obligations for this band may apply to meet SA Connect targets.

GSM-R and CDMA 850

There is an existing overlap of Global System for Mobile Communications-Railways (GSM-R) and Code Division Multiplex Access (CDMA)-850 assigned spectrum making simultaneous deployment difficult.

The initial proposed solution involved a downward shift of the CDMA assignment of Neotel by 3 MHz to clear the overlap of 1 MHz and add 2 MHz of guard band between the GSM-R and CDMA assignments.

In the consultation process, Neotel contended that proposal to shift the assignment by 3 MHz would create problems of interference with the Alarms and SRDs in the 863 MHz to 870 MHz band.

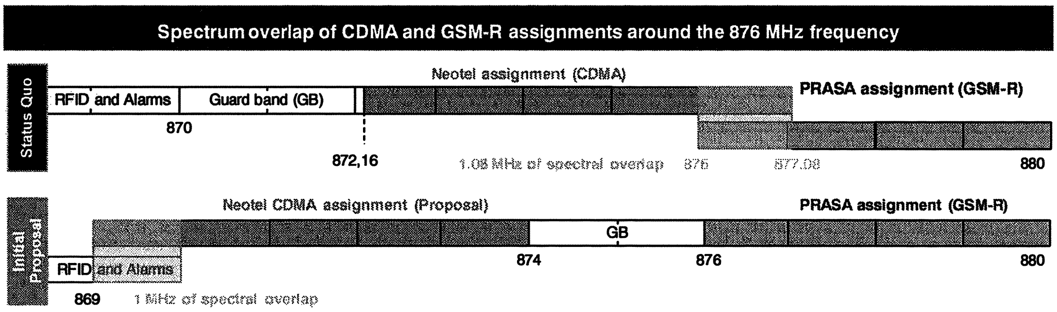


Figure 2: Spectrum overlap of CDMA and GSM-R assignments around 876 MHz

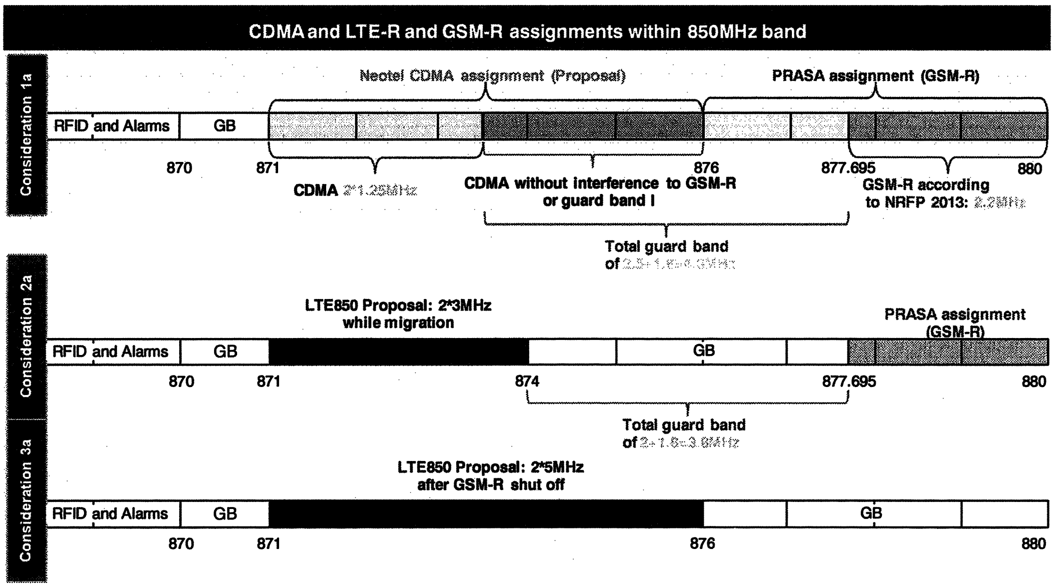


Figure 3: Option a: Migration of CDMA850 band by 1 MHz

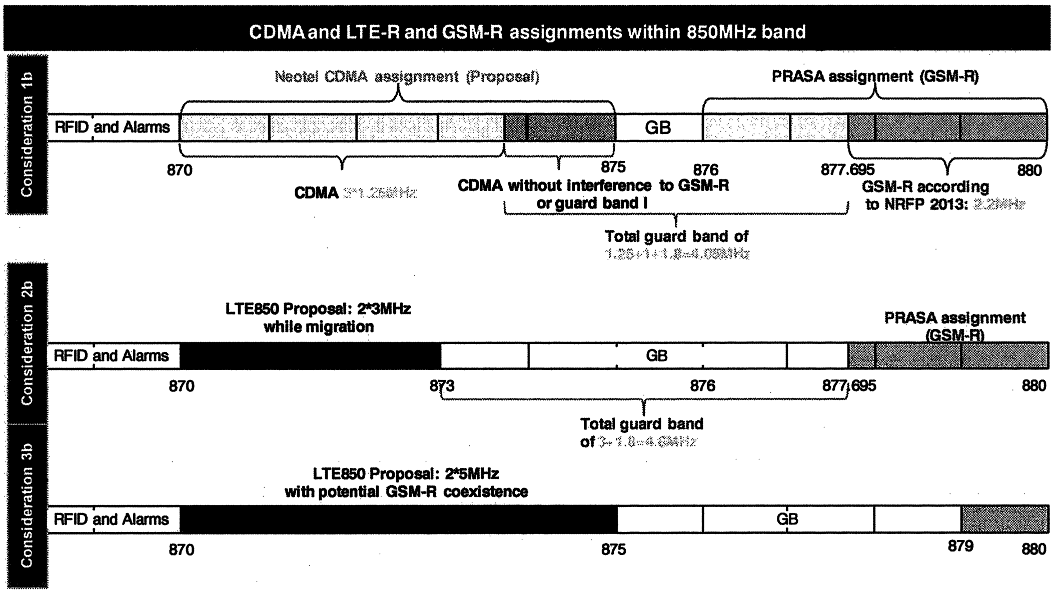


Figure 4: Option b: Migration of CDMA850 band by 2 MHz

There are two possible alternative solutions to the problem identified by Neotel:

- Option a: To have 1 MHz guard band to narrowband systems. The CDMA assignment of Neotel is to be shifted by 1 MHz to 826-831 MHz // 871-876 MHz, this means the downlink remains directly adjacent to the PRASA GSM-R assignment uplink. In order to achieve coexistence *in the same area* a guard band is required in order to have the required base station separation distance. See Consideration 1a in Figure 3 above.
    - One coexistence solution of CDMA850 to GSM-R would be to introduce a guard band of ~4.3 MHz and to reduce the CDMA850 band to 2×2.5 MHz in areas where there will be potential interference to GSM-R. In these areas, reduction to 2×2.5 MHz allows the partial usage of current CDMA850 - at least for voice and wideband packet services. In areas where there is no interference to GSM-R, Neotel may use its existing CDMA850 assignment.
- Option b: To have no guard band to narrowband systems, the CDMA assignment of Neotel is to be shifted by 2 MHz to 825-830 MHz // 870-875 MHz, this means the downlink has a 1 MHz guard band to the PRASA GSM-R assignment uplink. In order to achieve coexistence *in the same area* a guard band is required in order to have the required base station separation distance. See Consideration 1b in Figure 4.
    - The coexistence solution of CDMA850 to GSM-R would be to introduce a guard band of ~4.05 MHz and to reduce the CDMA850 band to 2×3.75 MHz in areas where there will be potential interference to GSM-R. In these areas, reduction to 2×3.75 MHz allows the partial usage of current CDMA850 - at least for voice and wideband packet services. In areas where there is no interference to GSM-R, Neotel may use its existing CDMA850 assignment.

In the National Radio Frequency Plan 2013, the GSM-R assignment was indicated from 877.695 MHz to 880 MHz, which means 2×2.2 MHz use for GSM-R.

Conclusions

- The Authority's decision is for Neotel's assignment to be adjusted to 825-830 MHz paired with 870-875 MHz.
  - The Authority will take the necessary measures to ensure coexistence between CDMA850 and GSM-R, i.e. amend assignments as appropriate and ensure coordination.
- The long term solution is for Neotel to cease using this band for CDMA.
  - Considerations 2 and 3 in Figure 3, and
  - Figure 4 indicates a long term solution when CDMA850 has ceased to be used 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 here.

LTE R Considerations

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

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

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.

2.4 Summary of 2300-2400 MHz band (IMT2300)

IMT2300 is already in use for IMT TDD by Telkom *et al* including some regional operators. The band from 2380-2400 MHz is currently not used[6]. IMT2300 TDD from 2360-2380 MHz (others) and 2380-2400 MHz is to be assigned with mutual alignment to the already assigned licences. In the event that there are different TDD-configurations, a 5 MHz guard band has to be considered within the new assignment.

A guard band of 5 MHz is not required between IMT2300 and the 2400 MHz ISM band. Where there is interference, other Wi-Fi channel settings might be selected appropriately.

In the case of IMT2300, South Africa is to take into consideration as appropriate the relevant ITU-R report.

The Authority has decided that WBS shall migrate to 2380-2400 MHz.

2.5 Summary of 2500-2690 MHz band (IMT2600)

In IMT2600, 2×70 MHz in FDD and 50 MHz in TDD is considered (including 2×5 MHz guard band due to FDD). This was a common stance in the submissions to the consultation.

The Authority has decided the above configuration will be adopted and that WBS should migrate out of this band.

2.6 Summary of 3400-3600 MHz band (IMT3500)

The IMT band from 3400-3600 MHz is currently used by Telkom, Neotel and some of the Universal Service Access Licensees (USALs), and FDD is deployed. Both Telkom and Neotel supported the migration to TDD in the consultation process. The unpaired TDD alternative, which offers 200 MHz, is more attractive in the long term because TDD downlink is better, providing higher frequencies due to downlink schemes and therefore higher capacity-density per coverage area. Therefore, more capacity would be available for IMT TDD with 200 MHz permitted as opposed to 2×80 MHz FDD. In addition, so far IMT3500 is frequently used for WIMAX-TDD by operators - many of whom migrate to LTE. Consequently the ecosystem is favourable for TDD.

In the case of the IMT3500 band, South Africa is to take into consideration, as appropriate, the relevant ITU-R report and traffic expectations. The Authority may assign special uplink or downlink configurations to minimize guard bands. The Block Edge Masks are to be taken into consideration in order to allow unsynchronized usage as well as to minimize the need for guard bands. The managed spectrum park concept will be taken into consideration.

Based on the consultation, IMT3500 may be considered for assignment with a TDD focus and potentially bundled together with other spectrum bands.

[6] This has been determined as a destination band for WBS.

2.7 Summary of migration requirements

In order to make the listed IMT bands available for IMT use, current licensees need to be migrated out in some cases as shown below:

2.7.1 Neotel

Neotel's assignment overlaps the GSM-R spectrum by ~1 MHz and slightly with the IMT800 uplink band at 832 MHz.

Neotel's CDMA850 assignment [7]band should move downwards by 2 MHz to 825-830 MHz // 870-875 MHz, which means the downlink remains with 1 MHz guard band to the GSM-R uplink. Neotel could in this case continue using approximately ~2×3.75 MHz for CDMA850 voice services in areas with GSM-R coverage/sites, and 2×5 MHz in areas without GSM-R sites.

2.7.2 Wireless Business Solutions (WBS)

WBS is using 14 MHz Time Division Synchronous Code Division Multiple Access (TD-SCDMA) in the IMT2600 FDD band and effectively blocks 50 MHz of potential assignments. Therefore WBS should migrate out of this radio frequency band as soon as is practicable. Two options for WBS were indicated for consultation:

1. **Scenario 1: Migration from FDD to TDD band of IMT2600**: This in-band migration within the IMT2600 band may only require retuning of the current base station equipment, while the user terminals would probably remain unaffected; therefore, migration could be achieved within a relatively short time frame. The in-band migration process blocks 25 MHz (50%) of the unpaired IMT2600 spectrum.
2. **Scenario 2: Migration to 2380-2400 MHz band**: This gives WBS significantly more capacity for their current users (from 14 to 20 MHz and improvement of spectral efficiency from 3G to 4G). WBS equipment would need to be modernised, new antennas are probably required, but more energy-efficient technology would be expected to reduce the operational expenditure. LTE TDD terminals are currently available and it is expected that 2-3 years are sufficient for WBS to migrate to the final destination band. WBS would have to migrate by 31st March 2015 from the FDD part to the TDD part as per Phase 0 of Scenario 1. The temporary assignment in the TDD part must be vacated by 31st March 2017.

[7] The CDMA 850 assignment would be the same as any future allocation to IMT850

IMT Roadmap 2014

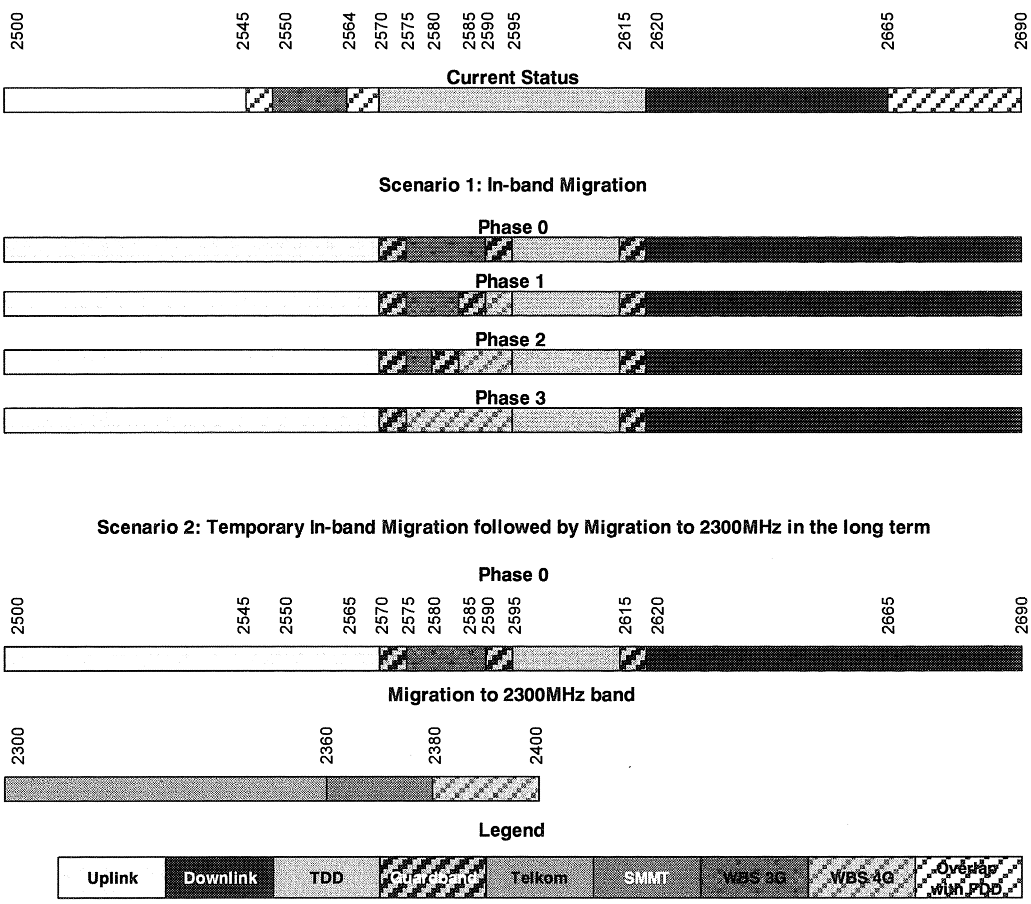


Figure 5: WBS migration scenarios

In Figure 5, the current assignment of WBS in 2550-2565 MHz, could be migrated immediately (Phase 0) to 2575-2590 MHz with two 5 MHz guard bands between the paired and unpaired spectrum. In the case of Scenario 1, in subsequent phases, WBS could migrate their current 3G-users to the unpaired IMT spectrum beginning from 2590-2595 MHz first, then 2585-2595 MHz and finally 2575-2595 MHz. WBS can deploy modernised hardware, but is limited to 5 or 10 MHz in intermediate phases.

In this scenario WBS as well as the other operators in the IMT2600 band deploying services in unpaired spectrum would have the obligation to use:

- The same unpaired downlink scheme to prevent the need for an additional 5 MHz guard bands; and

- The 5 MHz guard band to IMT FDD in a protected mode so as not to interfere with the paired FDD spectrum.

Scenario 2 has the same Phase 0 as Scenario 1, but WBS migrates to 2380-2400 MHz.

The Authority has decided that Scenario 2 should be followed.

3 International Telecommunication Union (ITU) and IMT

3.1 What is IMT? [8]

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

- a high degree of commonality of functionality worldwide while retaining the flexibility to support a wide range of services and applications in a cost efficient manner;
- compatibility of services within IMT and with fixed networks;
- capability of interworking with other radio access systems;
- high-quality mobile services;
- user equipment suitable for worldwide use;
- user-friendly applications, services and equipment;
- worldwide roaming capability; and
- enhanced peak data rates to support advanced services and applications.

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

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

3.1.1 IMT 2000

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

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

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

[8] from Recommendation ITU-R M.1645

3.1.2 IMT Advanced

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

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

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

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

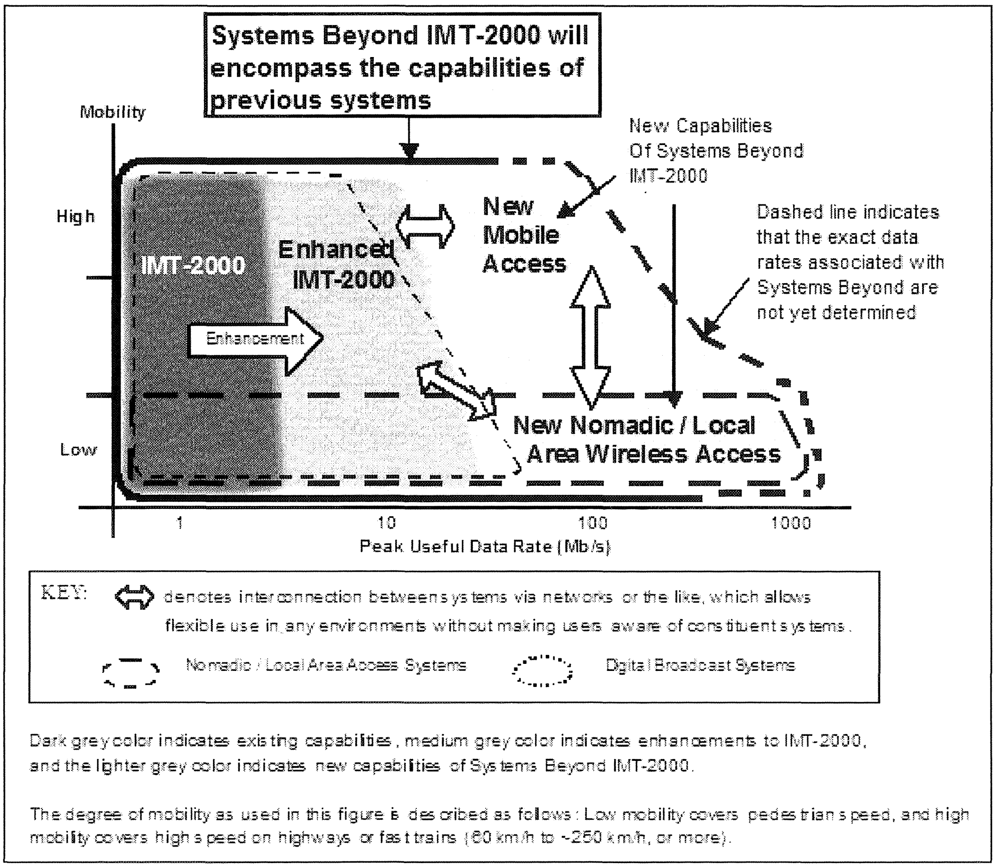


Figure 6: IMT Systems now and in the future *(Source: ITU)*

3.2 Bands designated for IMT

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

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

The table below describes the ITU definition of IMT bands.

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

Table 1: ITU definition of IMT bands

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

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

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

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

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

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

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

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

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

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

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

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

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

3.3 Issues for WRC 15

The place, date and agenda of the World Radiocommunication Conference 2015 (WRC-15) have been set in accordance with Council resolution 1343 of the ITU. The agenda items 1.1 to 1.3 will deal with issues pertaining to spectrum allocation for ITU as noted below:

The Council, noting that Resolution 807 of the World Radiocommunication Conference (Geneva, 2012):

a) resolved to recommend to the Council that a world radiocommunication conference be held in 2015 for a period of four weeks; and

b) recommended its agenda, and invited the Council to finalise the agenda and arrange for the convening of WRC-15, as well as to initiate as soon as possible the necessary consultation with Member States,

resolves

to convene a World Radiocommunication Conference (WRC-15) in Geneva (Switzerland) from 2-27 November 2015, preceded by the Radiocommunication Assembly from 26-30 October 2015, with the following agenda:

1. On the basis of proposals from administrations, taking account of the results of WRC-12 and the Report of the Conference Preparatory Meeting, and with due regard to the requirements of existing and future services in the bands under consideration, to consider and take appropriate action in respect of the following items:

1.1 To consider additional spectrum allocations to the mobile service on a primary basis and identify additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, in accordance with Resolution 233 (WRC-12);

1.2 To examine the results of ITU-R studies, in accordance with Resolution 232 (WRC-12), on the use of the frequency band 694-790 MHz by the mobile, except aeronautical mobile, service in Region 1 and take the appropriate measures; and

1.3 To consider spectrum requirements and possible additional spectrum allocations for the mobile-satellite service in the Earth-to-space and space-to-Earth directions, including the satellite component for broadband applications, including IMT, within the frequency range from 22 GHz to 26 GHz, in accordance with Resolution 234 (WRC-12);

4 SADC

The Southern African Development Community (SADC) Frequency Allocation Plan (FAP) of 2013 creates a framework for harmonisation across SADC on the use of the radio frequency spectrum. Countries included in the SADC FAP are Angola, Botswana, Democratic Republic of the Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

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

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

ITU Region 1 allocations and footnotes	SADC common allocation/s and relevant ITU footnotes	SADC proposed common sub-allocations / utilisation	Additional information
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 5.271 5.287 5.288	**456-459 MHz** FIXED MOBILE 5.286AA 5.287		
459-460 MHz FIXED	**459-460 MHz** FIXED		

MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E	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 MOBILE except aeronautical mobile	**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.

IMT Roadmap 2014

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.
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	880-915 MHz IMT	Paired with 925-960 MHz
		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		
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)	

IMT Roadmap 2014

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) 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)	Radio Frequency channel arrangement according to ITU-RF. 1098.
		BFWA (2 285-2 300 MHz)	
2290-2300 MHz	FIXED	BFWA (2285-2300 MHz)	

FIXED MOBILE except aeronautical mobile SPACE RESEARCH (deep space) (space-to-Earth)	MOBILE except aeronautical mobile SPACE RESEARCH (deep space) (space-to-Earth)		
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 exploration-satellite (passive) Radio astronomy Space research (passive) 5.149 5.412	**2655-2670 MHz** FIXED MOBILE except aeronautical mobile 5.384A 5.149 5.412		
2670-2690 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A Earth exploration-satellite	**2670-2690 MHz** FIXED MOBILE except aeronautical mobile 5.384A 5.149 5.412		

(passive) Radio astronomy Space research passive) 5.149 5.412			
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.

Table 2: Table showing SADC Frequency Allocations for IMT Bands

5 South Africa

5.1 The Electronic Communications Act

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

5.1.1 Chapter 1: Introductory provisions

Object of Act

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

(a) promote and facilitate the convergence of telecommunications, broadcasting, information technologies and other services contemplated in this Act;

(b) promote and facilitate the development of interoperable and interconnected electronic networks, ensure the provision of the services contemplated in the Act and to create a technologically-neutral licensing framework;

(c) promote the universal provision of electronic communications networks and electronic communications services and connectivity for all;

(e) ensure efficient use of the radio frequency spectrum;

(f) ensure the provision of a variety of quality electronic communications services at reasonable prices; and

(h) promote stability in the ICT sector.

5.1.2 Chapter 2: Policy and regulations

Ministerial policy and policy directions

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

(a) the radio frequency spectrum;

(b) the universal service and access policy; and

(c)the Republic's obligations and undertakings under bilateral, multilateral or international treaties and conventions, including technical standards and frequency matters.

5.1.3 Chapter 5: Radio frequency spectrum

Control of radio frequency spectrum

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

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

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

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

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

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

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

5.2 The Frequency Migration Regulations and Plan 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 Radio Conference (WRC) require a change in national allocation that will require existing users to be migrated;
- Second Level - where a Regional Radio Conference (RRC) requires a change in national allocation that necessitates existing users to be migrated;
- Third Level – where the SADC FAP requires a change in national allocation that necessitates existing users to be migrated; and
- Fourth Level – a decision is made to change the use of a frequency band at national level and this requires the migration of existing users.

Process

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

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

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

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

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

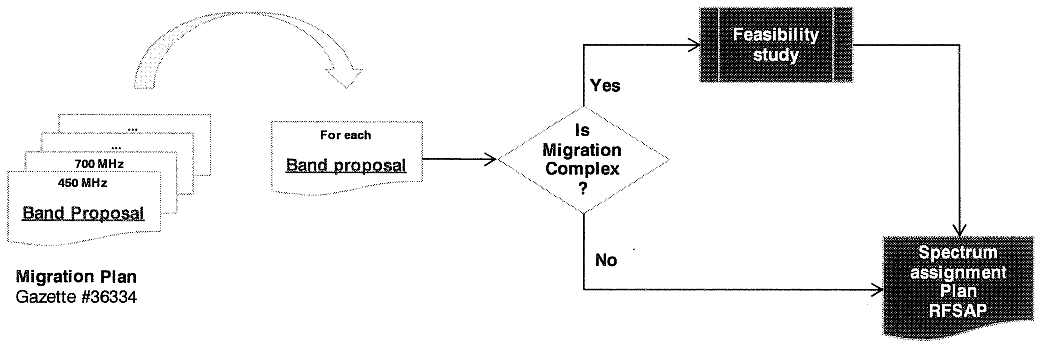


Figure 7: Process for developing an RFSAP

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

The RFSAP will be subject to a consultation process.

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

Time frame for migration

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

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

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

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

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

5.3 South Africa Connect

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

The overall goal is to achieve a universal average download speed of 100 Mbps by 2030. The 2020 vision for broadband is to provide 100% of South Africans with broadband services at 2.5% or less of the population's average monthly income[9].

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

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

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

---

[9] 2.5% of average monthly income is approximately R368.28, calculated from an average monthly income of R14731 for all formal and non-agricultural industries. Source: Statistics South Africa: Quarterly Employment Statistics (QES) March 2014

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

Table 3: National Broadband Policy Targets

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

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

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

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

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

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

> *With the increasing reliance on mobile or wireless communications, there is more demand than ever for radio spectrum – the invisible wavelengths or frequencies by which services such as broadcasting and mobile communications can be transmitted.*
>
> *Policy and regulatory bottlenecks associated with spectrum assignment, together with delays in the migration of land analogue broadcasting to digital, have meant that service innovation, increased competition, potential job opportunities and tax revenues have not been realised. The efficient assignment and subsequent use of high demand spectrum to meet this demand is vital and the cost of making this spectrum available is vital and the cost of not doing so is high.*

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

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

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

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

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

> *Spectrum is a scarce but non-depleting resource that has to be managed efficiently in order to optimise its potential to provide broadband access. This is especially pertinent given the dominance of mobile access in South Africa. Fixed wireless access also requires spectrum and represents an alternative to fixed-line networks to provide high capacity broadband especially in rural areas.*
>
> *The immediate priorities with respect to spectrum are:*
>
> - *identification of unused spectrum and its reassignment;*
> - *the removal of bottlenecks preventing migration of terrestrial broadcasters from analogue to digital in order to realise the digital dividend;*
> - *the re-allocation and assignment of broadband spectrum, taking into consideration job creation, small business development, national empowerment and the promotion of NDP goals;*

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

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

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

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

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

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

Table 4: Policy decisions from the broadband policy

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

The speed of deployment of a wireless network is a fundamental consideration to meet the immediate challenge of meeting the targets of this policy. The Ministerial policy directive will consider as a priority how best to ensure that the release of high demand spectrum fulfils these policy objectives and specifically *how best the application of open access principles to the assignment of broadband spectrum will be achieved. The outcome should:*

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

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

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

Key success factor:

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

6 Global Trends for IMT

6.1 Global assignment objectives for IMT

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

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

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

- harmonisation;

- technical considerations; and
- spectrum efficiency.

6.2 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.

6.3 LTE - paired and unpaired spectrum (FDD and TDD)

6.3.1 FDD and TDD trends

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

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

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

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

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

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

6.3.2 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.

6.3.3 High spectral efficiency for adaptive uplink /downlink configuration

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

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

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

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

In South Africa, the Authority is evaluating the concept of managed spectrum parks, which as a whole have to cater for protection with neighbour bands. Three potential solutions exist depending on uplink and downlink requirements within the 3400-3600 MHz band. The downlink schemes suffer from reduced uplink cell coverage required for reverse control channel communications; therefore, downlink should be placed in the lower parts of this band while the uplink schemes are placed in the upper parts of the band. In general, higher demand can be foreseen for downlink; therefore, the spectrum also favours downlink schemes, e.g., 140 MHz for downlink vs. 40 MHz for uplink. Some part of the spectrum might only be used indoors or, with reduced transmission powers, to protect the other unpaired TDD schemes. The minimum guard band of 5 MHz is increased (just as an example) to 20 MHz for any managed spectrum park concept usage (noting that the ultimate location of the guard band would be determined in the event managed spectrum parks are introduced[10]).

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

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

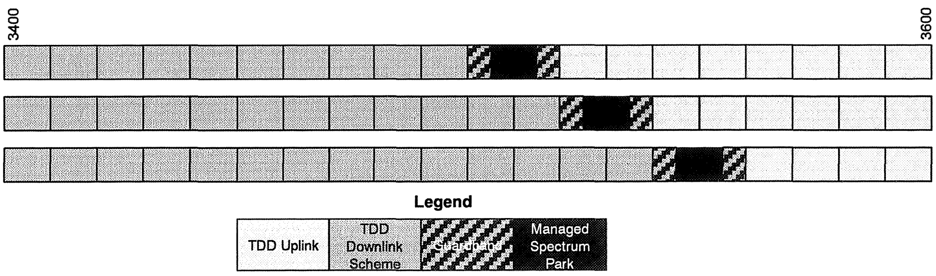


Figure 8: Potential unpaired LTE assignments in 3400-3600 MHz

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

[10] Note that beyond the example given here, managed spectrum parks could also be introduced in TDD bands within 2100 MHz.

6.3.4 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.

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

6.3.5 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.

6.4 Future system requirements for IMT / LTE

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.

7 Forecasts for South Africa

7.1 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.

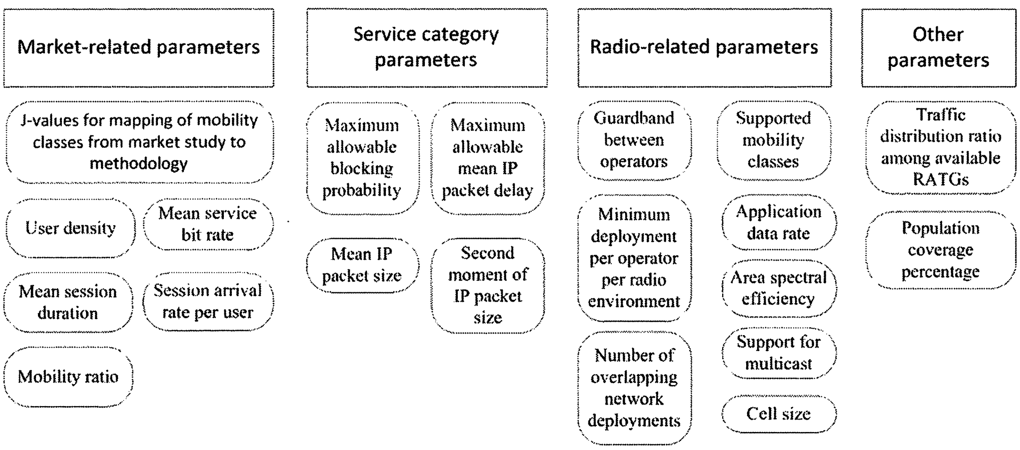


Figure 9: Input parameter overview for IMT spectrum demand estimation

The use of two market settings, lower and higher user density settings, allows for modelling of the differences in markets between different countries. The two settings will result in two final spectrum requirements for IMT systems and the needs of the different countries could lie between these two extremes.

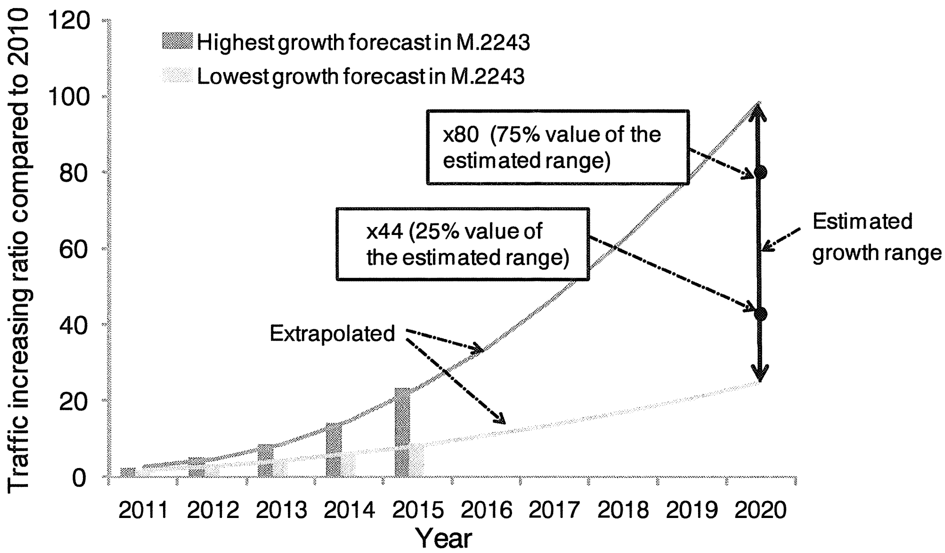


Figure 10: Mobile traffic forecasts toward 2020 by extrapolation *(Source: ITU)*

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

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

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

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

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

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

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

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

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

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

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

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

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

This overview includes additional spectrum of 120 MHz in the 694-862 MHz band, 190 MHz in the 2500-2690 MHz band and 200 MHz in the 3400-3600 MHz band. The potential assignments that could be made in the short term within the years 2015-2020 provide for more than the current spectrum usage (510 MHz > 380 MHz) for a traffic ~5 times than today (Figure 10).

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

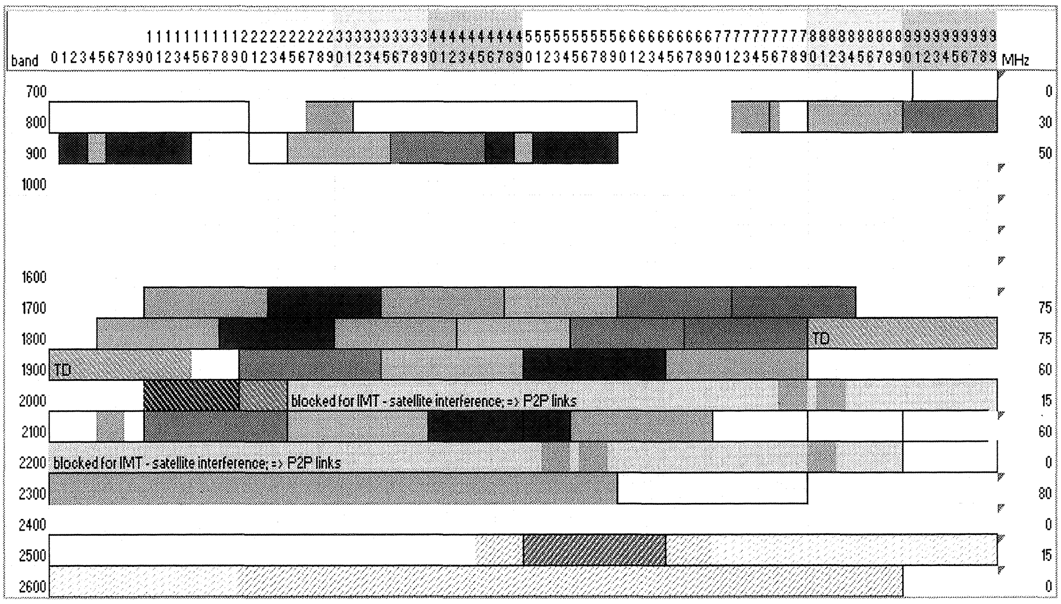


Figure 11: Current South Africa IMT assignments summarised in Table 9

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

Table 9: South Africa IMT spectrum assignments

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

7.1.1 Forecast of overall M2M demand

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

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

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

- Retail - Point-of-Sale (PoS) terminals
  According to one research forecast report[11], 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

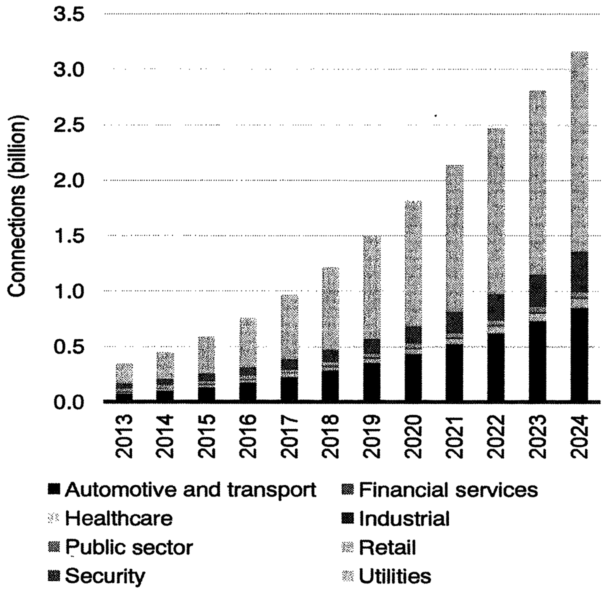


Figure 12: M2M device connections by sector, worldwide, 2013–2024

(Source: Analysys Mason, 2014)

[11] Analysys Mason Research Forecast Report – 'M2M device connections and revenue: worldwide forecast 2014–2024' July 2014 – updated from the draft IMT Roadmap based on feedback

7.2 IMT Demand for South Africa

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

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

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

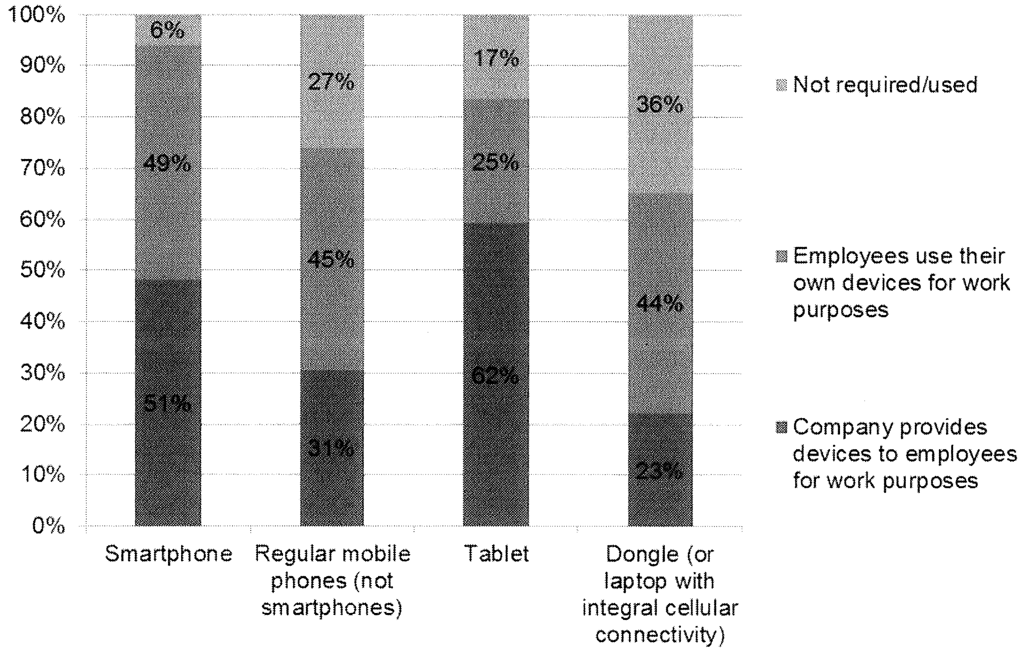


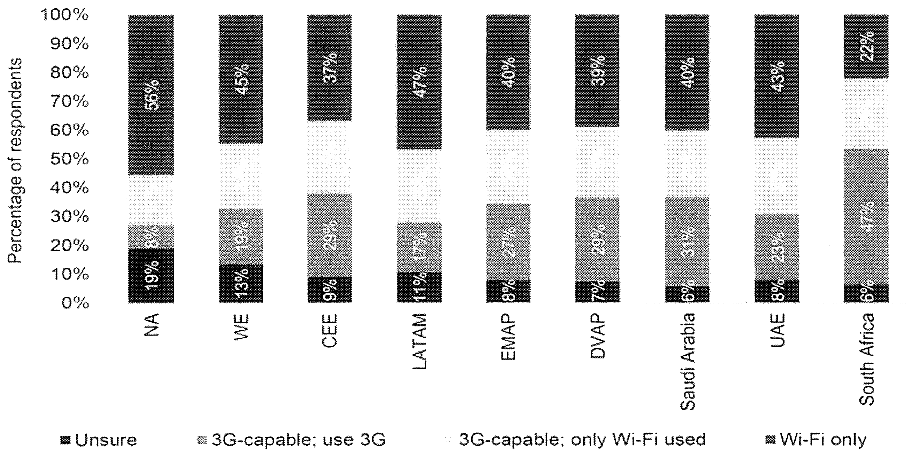
Figure 13: South Africans favour tablets and smart phones

(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 14: 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 10: Telecoms KPIs, South Africa, 2009-3Q 2013

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

8 IMT Roadmap

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

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

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

8.1 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.

8.1.1 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.

8.1.2 The rationale for alignment with IMT in South Africa

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

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

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

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

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

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

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

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

In general, it is desirable to assign long-term IMT bands, so operators, network solution vendors and terminal manufactures have sufficient time to exploit synergies in harmonised designs. Globally harmonised frequency arrangements in the bands identified for IMT will reduce the overall cost of IMT networks and terminals by providing economies of scale, and facilitating deployment and cross-border co-ordination, roaming, etc.

8.1.3 IMT bands considered

The following bands have been identified by the ITU for use by IMT-compatible standards in the Radio Regulations (RR) "Edition of 2012".[12]

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

IMT bands		Paired configuration (FDD)	Unpaired configuration (TDD)
IMT Designation	**IMT Range**		
IMT450	450-470 MHz	2×5 MHz	15 MHz
IMT700	694-790 (or 806) MHz	2×45 MHz or 2×30 MHz + 2×3 MHz	
IMT750	733-758 MHz		22 MHz (option 3 with 2×6 MHz guard bands) 25 MHz (option 2 with 2×5 MHz guard bands)
IMT800	791-862 MHz	2×30 MHz (reverse uplink-downlink)	
IMT850	825-830// 870-875 MHz[13]	2×5 MHz	
IMT900	880-960 MHz	2×35 MHz	
GSM900-R	876-880// 921-925 MHz	2×4 MHz GSM-R	
IMT1800	1710-1880 MHz	2×75 MHz	
IMT2100	1920-2170 MHz	2×60 MHz	
IMT2300	2300-2400 MHz		100 MHz
IMT2600	2500-2690 MHz	2×70 MHz	50 MHz including 2×5 MHz guard bands
IMT3500	3400-3600 MHz		200 MHz [14]
All IMT		**2×355 MHz**	**370 MHz**

Table 11: IMT roadmap: (summary)

These bands will be discussed in more detail in the following sections.
The figure below gives an overview of spectrum usage in South Africa in 2025:

---

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

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

[14] This may include maximum 20 MHz for a 'managed spectrum park'

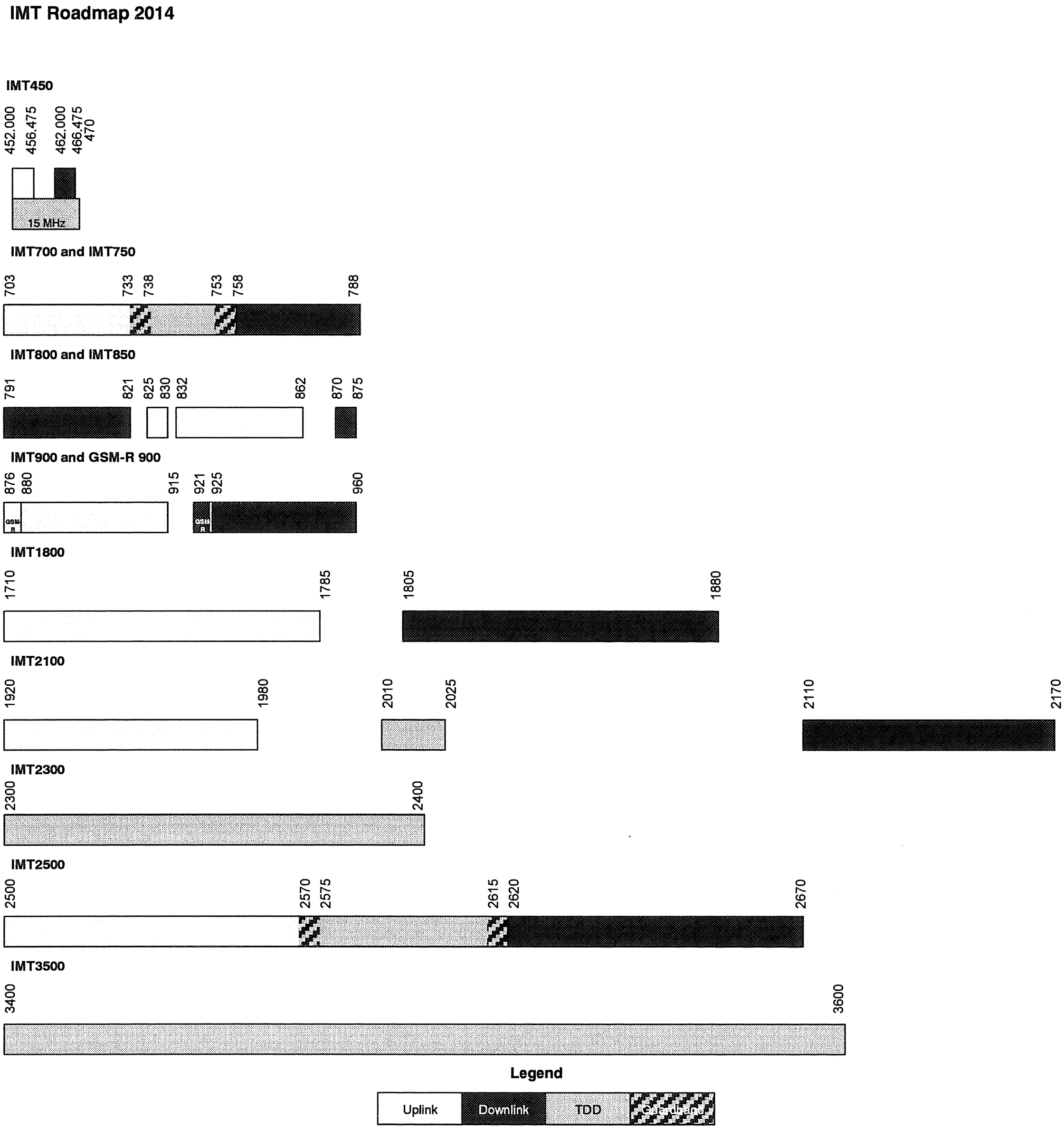


Figure 15: IMT spectrum overview within South Africa in 2025

8.2 Guard bands

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

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

- Introducing LTE and WiMAX to the 900 and 1800 MHz bands should not cause any additional impact on adjacent services. In general, there is no need of an additional guard band between LTE/WiMAX 900 and GSM-R whatever the channelisation or bandwidth considered for LTE/ WiMAX 900. ECC Report 096 concludes that a carrier separation of 2.8 MHz or more between the UMTS carrier and the nearest GSM-R carrier is sufficient. For LTE/ WiMAX 900, the frequency separation between the nearest GSM-R channel centre frequency and LTE/WiMAX channel edge should be at least 300 kHz.

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

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

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

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

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

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

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

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

- As seen in Figure 16, 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.

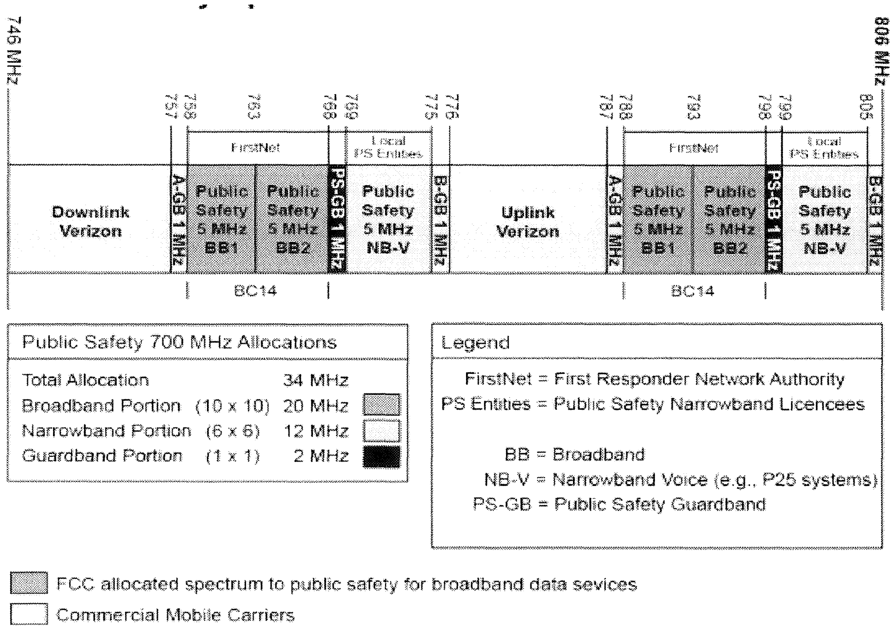


Figure 16: Public safety spectrum allocation in US-700MHz band

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.

8.3 450-470 MHz band

This section presents the Authority's roadmap proposal for the 450-470 MHz band. In the background sub-section, prior activities undertaken by the Authority in the band are presented to provide context for the current proposal. The results of ITU feasibility studies on the co-existence between IMT services in the 450-470 MHz band and services in adjacent bands are then presented. In subsequent sub-sections, the various IMT options for the 450-470 MHz bands are discussed with regard to feasibility, costs and benefits. Finally, the Authority puts forward two main options.

The Authority has conducted an extensive feasibility study for the 450-470 MHz band. This feasibility study includes international and regional standardisation documents, a review of advantages and disadvantages of migrating the current licensees out and a comparative assessment of future usage scenarios for the band. The next sections draw on this feasibility study. For more details on the feasibility study for the 450-470 MHz band, please refer to Appendix A.

8.3.1 Background

The Radio Frequency Migration Plan puts forward a plan to make the 450-470 MHz band available for IMT services (IMT450). This proposal is aligned with plans at the regional level where SADC also seeks to allocate the band for IMT.

The need for more efficient use of the 450-470 MHz band was confirmed by a spectrum audit conducted in the 450-470 MHz band. The spectrum audit showed that less than 20% of the band is actually occupied across South Africa despite the large number of licensees. Additionally, the Authority conducted a feasibility study in the band (see Appendix A) to fully investigate migration scenarios as well as their wider costs and benefits. The outcome of the feasibility study supports the allocation of the band to IMT services.

The following sections present the challenges as well as the options considered by the Authority for the IMT450 band.

8.3.2 Current assignments in the 450-470 MHz band

This section summarises the main assignments in the 450-470 MHz band.

The current usages of the 450-470 MHz band include trunked mobile services, fixed links, paging and emergency services for the most part. Licensees in the band include the railways (i.e. Transnet) and mines, South African Police Service (SAPS), South African Airways (SAA) and a number of private licences (see Figure 17).

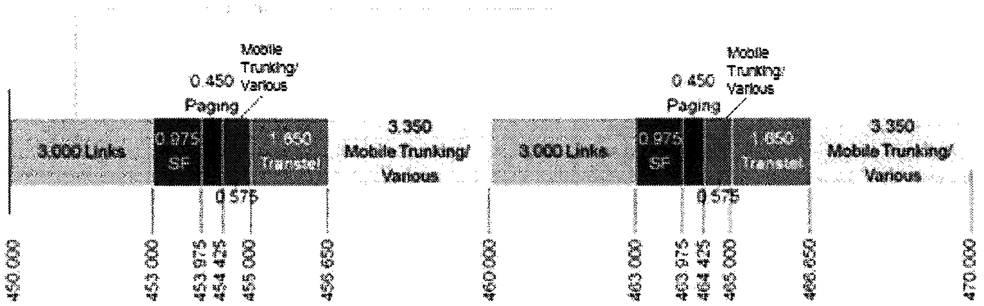


Figure 17: 2012 assignments 450-470 MHz

The SADC FAP-proposed common sub-allocation/utilisation seeks to allocate the 450-470 MHz band for IMT and also Point-to-Point (PtP), PMR and/or PAMR.

8.3.3 Compatibility and interference issues

Unique challenges exist for the co-existence between IMT services in the 450-470 MHz band and other services in adjacent bands (e.g. broadcasting, trunked systems). The ITU has undertaken a feasibility study to assess the challenges involved in the report titled "*ITU-R M.2110: Sharing studies between radiocommunication services and IMT systems operating in the 450-470 MHz.*"

The relevant parts of the results for the purpose of this roadmap are summarised below:

8.3.4 IMT options in 450-470 MHz band

The ITU Recommendation, ITU-R M.1036-4 (03/2012), sets out the following frequency arrangements for the 450-470 MHz band (see Table 14).

Frequency arrangements	Paired arrangements				Unpaired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
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

Table 14: Frequency arrangements in the band 450-470MHz

The following two ITU notes complement the table above:

- Note 1: The number of frequency arrangements given in Table 14 reflects the fact that administrations have had to accommodate incumbent operations, while, for example, maintaining a common uplink/downlink structure (uplink in the lower 10 MHz, downlink in the upper 10 MHz) for FDD arrangements; and
- Note 2: Arrangements D7, D8 and D9 can be implemented by administrations that have the whole 450-470 MHz band available for IMT. Arrangement D8 can also be implemented by administrations which have only a subset of the band available for IMT.

8.3.5 Demand for IMT services in the 450-470 MHz band

The Authority forecasts that the 450-470 MHz band will become increasingly attractive for basic Internet connectivity, upload-heavy and emergency services in South Africa.

The 20 MHz bandwidth provided by the 450-470 MHz is small compared, for instance, with the 60 MHz or more available in higher frequencies. The 450-470 MHz band is also appropriate for services requiring low data rates and capacity.

In addition, in terms of basic internet connectivity using 450-470 MHz targets, two distinct opportunities are emerging: rural broadband and deep-indoor data coverage. With either opportunity, the cost of using higher frequencies is more expensive than that of using the 450-470 MHz band. Rural broadband in the 450-470 MHz is especially attractive for the following reasons:

First, coverage using 450-470 MHz is a more cost-effective coverage option when compared with using 700 MHz or higher frequencies. Therefore, the 450-470 MHz band provides a higher incentive for service providers to offer services in rural areas where purchasing power is lower than in urban areas.

Secondly, the 20 MHz of bandwidth available in the 450-470 MHz are more suitable for low-data rate and low-capacity demand profiles. Indeed, the low population density in rural areas results in low-capacity demand; services used in rural areas are not expected to be as data-heavy as those used in urban areas where low data rates would be problematic.

Thirdly, for deep-indoor coverage, the 450-470 MHz band is better suited when compared with higher bands to provide deep-indoor coverage, whereas higher bands would be too costly to deploy. The 450-470 MHz therefore presents an attractive alternative to ensure that basic data coverage is available in deep, indoor environments.

Fourthly, rural broadband in the 450-470 MHz band supports national development projects such as the "SA Connect" initiative as well as e-Government, e-Health, and e-Learning programmes. Whilst the capacity of 2×5 MHz paired spectrum or 1×20 MHz[15] unpaired spectrum is limited compared with the 700 MHz band with 2×30 MHz or 2×45

[15] Maximum bandwidth to be considered in dependence on interferences with broadcast channel 21 from 470-478 MHz; 1×15 MHz seems realistic.

MHz, or 800 MHz band with 2×30 MHz, and basic services encounter reduced capacity and data rates, they gain improved latency of LTE. Operational benefits are also expected due to harmonised and optimised core hierarchies.

For more quasi-stationary usage with fixed terminals, (and potentially separated outdoor antennas) both technologies could enlarge their coverage significantly. The user penetration could be significantly increased by Wi-Fi offloading of classical smart phones with Wi-Fi-capability and IMT-backhauling. There might be some Mobile Virtual Network Operators (MVNOs) offering hotspot broadband Internet in their restaurants or Wi-Fi Kiosks to low-income groups in areas currently not covered.

Both coverage bands (IMT450 and IMT700), are expected to be embedded in connected car solutions or backhaul technology to other Wi-Fi-capable devices. Potentially larger antenna sizes, due to lower frequency, are more attainable within car or home environments than within small smart phones.

Fifthly, in terms of 'uplink-heavy' services, the distinctive patterns of use of that make the 450-470 MHz band attractive are the low data rates and the symmetrical (or upload-dominated) nature of communications. 'Uplink-heavy' services include M2M communications, messaging, VoIP over IMS and broadcasting uplink. Expected services are uplink-oriented/focussed, and include M2M, messaging, VoIP over IMS, as well as uplink use of broadcasting services. M2M and IoT or smart metering/grid services may need different network parameters optimised for uplink or for small data rate requirements - any congestion due to millions of small-sized messages needs to be prevented.

Potential Wi-Fi-offload-oriented areas should be implemented with a balanced or downlink- favoured TDD-scheme, which would lead to coverage improvements.

Finally, the 450-470 MHz band is also of interest to public protection and disaster recovery services. In addition to the abovementioned usage, 2×5 MHz FDD could be used for public safety agencies, if needed, in addition to the currently implemented systems (TETRA & WiMAX) within 380-400 MHz for SAPS.

8.3.6 Options considered by the Authority

The Authority considers three scenarios for the roadmap of the 450-470 MHz band:

1. **Scenario 1: No allocation of the 450-470 MHz band to IMT** - current licensees in the band stay and no IMT plans are made;
2. **Scenario 2: Allocation of the 450-470 MHz band exclusively to IMT** - all existing licensees in the 450-470 MHz band move to other bands within defined timeframes; and
3. **Scenario 3: Partial allocation of the 450-470 MHz band to IMT** - some parts of the 450-470 MHz band are allocated to IMT services; other parts remain with current allocation. The viability of this scenario is subject to interference trials.

Any geographical split of IMT450 and non-IMT technologies is possible in general, but not recommended due to large separation distances between these technologies. The three scenarios identified are as follows:

8.3.6.1 Scenario 1: No allocation of the 450-470 MHz band to IMT

8.3.6.1.1 Benefits

The main rationale for scenario 1 (no allocation of 450-470 MHz to IMT) is to avoid disrupting the critical services deployed in the 450-470 MHz band. Indeed, the band currently carries radio communications for essential public and private services. Networks for emergency response, rail traffic management and police forces are key critical services in the band. Therefore, scenario 1 avoids all costs and uncertainty that may result from migrating critical services and a large installed base of network equipment and terminals to other bands.

8.3.6.1.2 Costs

Two types of costs arise from not allocating the 450-470 MHz band to IMT - the opportunity cost of foregoing the benefits of IMT in the 450-470 MHz band, as well as the spectral inefficiency of the current fragmentation in the 450-470 MHz band.

The opportunity cost of not allocating the 450-470 MHz band to IMT is presented herein in reference to the next 'best' alternative band for IMT services - the 700 MHz band. If the 450-470 MHz band allocation and use remains as is, IMT services such as basic broadband in rural areas or deep-indoor situations would have to be provided by higher bands such as 700 MHz. The incremental costs of deploying a network in the higher bands can be as much as 100% of the cost of deployment in the 450-470 MHz band. Higher network costs would result in services being less affordable to those least capable of paying for them.

The other type of costs of maintaining the *status quo* is due to the spectral inefficiency of the existing situation in the 450-470 MHz band. Currently, the 450-470 MHz band hosts a large number of licensees and services including fixed links, trunking, and paging services amongst others. For services like trunking, alternatives such as TETRA exist that are more spectrally efficient. For others such as paging, other spectrum bands exist that are in less demand and where these services can be equally deployed.

Finally, it is important to note that the opportunity costs and spectral inefficiency costs of scenario 1 cannot be accurately estimated at this stage. Multiple inputs such as the benefits and costs of spectrum migration (and network modernisation) for current licensees in the band cannot be reliably estimated. Additionally, the overall benefit of rural broadband and deep-indoor data coverage depends on factors other than network costs. Such factors as terminal costs and an ecosystem of relevant value-adding broadband applications, cannot be reliably estimated yet.

It might be possible to estimate the absolute costs of additional IMT sites for 700 MHz or 800 MHz relative to 450 MHz to cover rural or more areas if the real area demands, targeted terminals and the final technology selection are known. The relative costs of a rural-only network within 700 MHz would increase by 55% - 85% relative to 450 MHz. In case of deep-indoor demands in urban areas for M2M, smart metering, etc., the cost will double in the case of 700 MHz.

These additional costs for rural coverage have to be compared with the migration costs of all different licensees in the case of full migration due to exchanges/tuning of potential splitters or antennas and potential exchange of user terminals.

In addition, current congestion due to inefficient spectrum use in this band might lead to other investments in higher bands due to higher capacity needs. These congestion-related costs might not occur if the migration could be combined with modernisation activities which would result in more efficient spectrum use, on the one hand, or synergy effects due to service migration instead of spectrum migration on the other. It is quite difficult to quantify the opportunity to modernise and harmonise licensees` networks with higher spectrum efficiency, lower power consumption, more features and better operation possibilities.

8.3.6.2 Scenario 2: Partial allocation of the band to IMT services

The IMT450 band configurations shown in Figure 50 can be altered to allow other non-IMT technologies to remain in the 450-470 MHz band. However, co-existence issues may arise inside the band in addition to compatibility issues between IMT services in general, and services in adjacent bands.

8.3.6.2.1 Benefits

Allocating part of the 450-470 MHz band to IMT services is a compromise option with two benefits - bringing IMT to the band for cost-effective services, as well as keeping critical public or infrastructure services in the band. The benefits of introducing IMT services in the band depend on the actual services deployed. For instance, benefits accrued from rural broadband would be different from those associated with emergency and public response services.

8.3.6.2.2 Costs

Partial allocation of the 450-470 MHz band to IMT involves clearing some of the current services out of the 450-470 MHz band and into other bands. Costs arise that are associated with the execution and implications of interference assessment trials and spectral inefficiency.

Interference assessment trials are necessary to ascertain interference-free and co-existence of IMT services and non-IMT services in the 450-470 MHz band. These trials are very difficult to conduct in urban areas due to the need to switch off running networks temporarily. In addition, the execution of the trials comes at non-negligible costs. More importantly, should the trials indicate the existence of interference, expensive measures must be taken (e.g. fitting of additional filters to base stations).

Spectral inefficiency costs result from the need for guard bands to avoid interference. Guard bands of 5 MHz or more are typical between IMT and non-IMT spectrum deployed in the same band. However, given that the overall size of the 450-470 MHz is just 20 MHz, such guard bands would considerably limit the usable spectrum for either IMT or non-IMT services.

For partial allocation of IMT and other technologies, co-existence trials/investigations have to be done in advance to ensure that the 1 MHz or 2.5 MHz guard bands will not contribute to delays in use of IMT. These interference trials have not been performed yet and might last for a long time until all technologies of interest are investigated. To perform such trials, at least some parts of the spectrum have to be cleared, especially in urban areas and this would be especially hard to achieve. Also, it may not be sufficient to test co-existence scenarios and guard band requirements in rural areas only.

In any case, IMT and potential co-existence technologies have to be aligned for the specially chosen option of 2×5 MHz FDD. It is not expected that many players would use this band; therefore, the general directive is to migrate all existing licensees out of IMT450. The process could be time-consuming, and lengthy, and would make any IMT usage and potential planning and deployments more and more expensive. Some IMT users might search for alternatives to cover their IMT demands – such options may be more expensive.

Therefore, the costs of investing in new equipment and terminals for most existing licensees remain high, except for those few licensees who might be able to tune any potential splitters to the lower sub-band parts. These licensees would have to invest in modernisation of equipment as well, but these costs would not be due to migration.

8.3.6.3 Scenario 3: Full allocation of the band to IMT services

The full allocation of the 450-470 MHz band to IMT requires the migration of all current users out of the band. This scenario was supported by many stakeholders in their responses to the 2012 consultation on frequency migration. Other stakeholders went further to suggest that the 450-470 MHz band be dedicated to broadband services for public safety.

The following graph describes the out-migrations necessary to allocate the 450-470 MHz for IMT use.

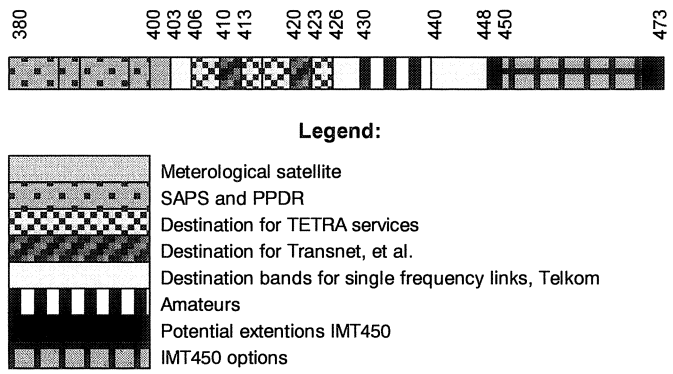


Figure 18: 450-470 MHz potential destination spectrum

Process of Migration to IMT:

- Migration starts in 2016 and is completed in 2022.
- Dual illumination stops in 2022 (for Transnet).

- **SAPS** - free up 406-426 MHz and migrate to 380-400 MHz:
  - SAPS have already started migration in 2010 from 406-410//416-420 and 413-416//423-426 MHz (for R1 billion (est.) with a 5-year migration plan until 2015, with a suggested/potential delay of 1 year until 2016 which will see the end of the dual illumination phase; and
  - Additional 2×3 MHz are still free for potential PPDR licences, e.g., emergency, airports (SAA).
- **Transnet** - free up 450-470 MHz and potentially migrate to 406-426 MHz:
  - Should Transnet decide to migrate from analogue to digital technology, current equipment should be usable until 2019;
  - If Transnet´s data demands increase, then building and operating a LTE450 network might be one possible scenario for Transnet.
  - From 2016 Transnet could start migration towards 410-413//420-423MHz (2×3 MHz).
    - Alternatively there are 2×4 MHz and 2×3 MHz for digital radio trunking (notably TETRA) available in 406-426 MHz.
    - Alternatively, to use GSM-R and / or LTE–Rail.
  - Migration out of the 450-470 MHz band is completed in 9 years, (i.e. 2024) with the end of dual illumination; (the dual illumination phase could be started regionally from 2017 onwards).
- **Other licensees** - migrate from 450-470 MHz to:
  - 403-406 MHz (unpaired);
  - 426-430 MHz (unpaired) ;
  - 440-450 MHz (paired or unpaired), potentially for municipality networks; and
  - In case of PPDR-use also to 387-390//397-400 MHz
- **430-440 MHz** (amateurs) could possibly be used in case of congestion.
- Many municipality networks are in the 440-450 MHz bands. Depending on future demand, a harmonisation might take place.
- In Figure 18 potential extensions to the IMT450-band are marked as well, in order mitigate potential interference with the adjacent bands. These might be reserved in case of extending 2×5 MHz to 2×10 MHz or to minimize interference. Therefore these potential extension bands might be used only in congestion cases - 448-450 MHz and 470-473 MHz (used by broadcasters) until the final IMT option and potential interferences are known.
- Potential **smart grid application** demands for energy companies: depending on selected technology and demand, smart energy services could be handled in IMT450 or in 403-406 MHz and 426-430 MHz.

Migration Objectives	
380-400MHz	**380-400MHz** band is assigned as PPDR usage band with TETRA as one technology. SAPS have already decided for TETRA in 380-387//390-397MHz. Remaining 2*3MHz might be used by emergency, security, or airport services.
400-403MHz	The band from **400-403MHz** is assigned to "METEROLOGICAL AIDS SPACE OPERATION (Space to earth)", but not used in South Africa so far.
403-406MHz	**403-406MHz** could be used for "METEROLOGICAL AIDS, **Fixed, Mobile** except for aeronautical mobile", which offers potential for short range devices (SRD).
406-426MHz	**406-426MHz** could be used for TETRA (2*4MHz) and other PMR (2*3MHz); additional 2*3MHz used for other duplex technologies
426-430MHz	The range from **426-430MHz** is current without any assignment in South Africa.
430-440MHz	The range from **430-440MHz** is reserved for amateur radio. There will be no general change in this band, even if the utilisation is currently low about 1MHz bandwidth. Potential (temporary) use for single links might be discussed.
440-450MHz	The band **440-450MHz** is mainly used by municipalities and security services

Figure 19: Summary of migration of 450-470 MHz and destination bands

8.3.6.3.1 Benefits

The full allocation of the 450-470 MHz band to IMT (scenario 3) will result in increasing the spectrum efficiency in the 450-470 MHz band. Additionally, as a result of the execution of scenario 3, licensees have the opportunity to modernise their networks and gain efficiency and the support of new services.

8.3.6.3.2 Costs

The costs of allocating the 450-470 MHz exclusively to IMT services are located in the incremental expenditure to be incurred by licensees migrating out of the band. In this case, the estimation of the costs of migration are complicated by the fact that many licensees in the band are preparing in parallel to modernise their networks. In fact in some instances migration may be compelled by a need for network modernisation if the destination service is deployed in a different band.

Additional costs related to interference assessment depend on the chosen IMT configuration for the 450-470 MHz band.

8.3.7 Conclusions

The main purpose of this allocation to IMT is to fulfil the aims of SA Connect with respect to mobile broadband coverage as the frequency band can ensure coverage in rural areas at lower cost than high frequency bands. The IMT450 network should be focussed on achieving the SA Connect targets in areas that have no coverage. This can be done either directly via IMT450-capable terminals or indirectly via Wi-Fi routers connected to the IMT450 network. Note that IMT450 can also be usefully deployed in all areas due to superior indoor coverage.

In the light of the consultation process and the confirmation that stakeholders are interested in IMT450, the full migration of all licensees of 450-470 MHz is to take place in line with a time schedule for conclusion in 2022 for all licences. The intention is to provide sufficient time for existing users and to ensure that most equipment will have reached near end-of-lifetime before migration is finalised.[16] In order to release spectrum for IMT in the 450 MHz band for the SA Connect initiative, the migration process for rural areas could start in 2015 and existing users should have vacated the band in rural areas no later than the end of 2018. For urban areas, existing users should have migrated out of the band by the end of 2022.

[16] In addition, migration gives the opportunity to modernise at least the radio frequency (RF) parts of equipment and increase overall spectral efficiency.

8.4 694-876 MHz band

8.4.1 Background

Spectrum bands below 1 GHz are great options for both indoor and outdoor mobile coverage as lower frequencies have better propagation characteristics. The 'digital dividend' spectrum released in the 694-860 MHz as a result of digitisation of broadcasting is being considered for mobile broadband globally. The ITU is considering various options for structuring the 'digital dividend' for IMT services. This section elaborates on the studies undertaken by the Authority and on those concluded by the ITU.

Currently, tension between APT-700 MHz band decision for ITU Region 3 and potential solutions for ITU Region 1 (IMT700) for harmonisation with former band decision within 790-862 MHz (=IMT800) persists. Nevertheless, some countries within South America have adopted APT-700 band, like Mexico, Brazil, in opposition to the US-channelling scheme.

Therefore, some countries of ITU Region 1 (Europe, Asia, Middle East and Africa) have to decide to follow Asia-Pacific channelling schemes of ITU Region 3 or find proper solutions in co-existence with current assignments to achieve maximum harmonisation.

In general, the full unpaired IMT TDD option would lead to the simplest migration and most spectrum-efficient solution: IMT TDD from 702-862 MHz, but this would not be commercially viable until there is a solid ecosystem for TDD in IMT700 and IMT800 bands. However, because Asia-Pacific (except China) has decided on the FDD option, the TDD option may be a more challenging option. IMT800 FDD is well established in Europe because Digital Dividend II is not yet available.

8.4.2 Options considered by the Authority

For the purposes of this analysis, the 700 MHz and 800 MHz bands are considered together. The two bands overlap and spectrum configurations in one affect the possible configurations in the other.

The ITU has considered two, high-level configurations for the 700 MHz band and 800 MHz band.

- **Option 1:** consists of the following combination of spectrum:
    - 2×45 MHz from 703 MHz to 803 MHz with 10 MHz of centre gap;
    - 2×18 MHz from 803 MHz to 862 MHz; and
    - Parts of CDMA/IMT850-spectrum (~2×2-5 MHz)
    - GSM-R and GSM (or their potential IMT900 successors).
- **Option 2:** consists of the following combination of spectrum
    - 2×30 MHz from 703 to 788 MHz (IMT700 plus)
    - 2×30 (or 2×33) MHz IMT800 plus
    - potential IMT-TDD assignments in band gap 733-758 MHz (or other IMT or non-IMT assignments)

- Parts of CDMA/IMT850-spectrum (~2×2-5 MHz)
- GSM-R and GSM (or their potential IMT900 successors).

Note that South Africa is to take into consideration as appropriate the relevant ITU-R report.

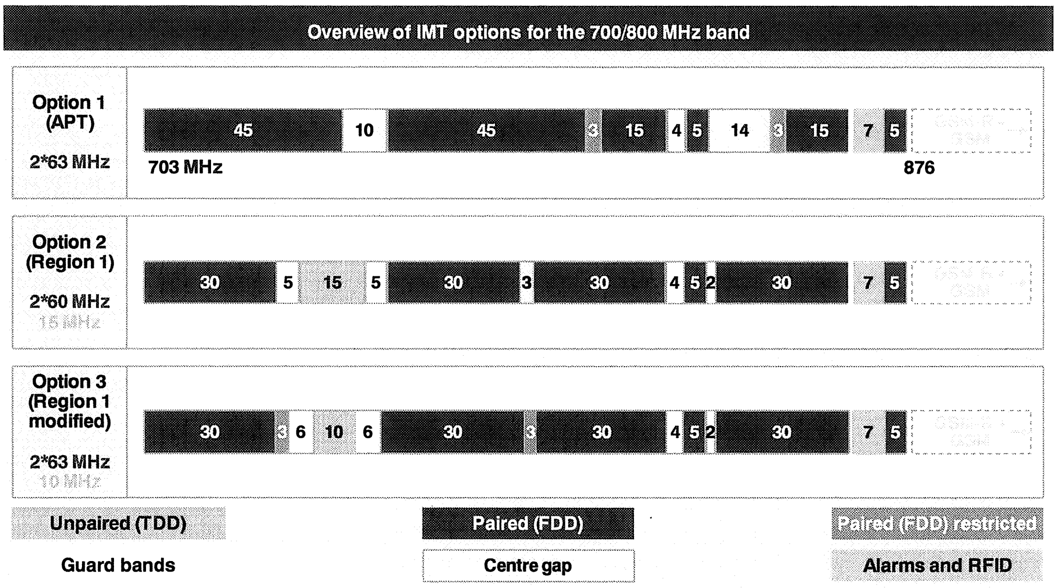


Figure 20: Overview of IMT options for 700/800 MHz

Many countries including most of Asia and Latin America have selected Option 1. At this point, European countries have decided on Option 2. The WRC-15 will decide on which region schemes should be followed:

- **ITU Region 3:** 2×45 MHz IMT700 plus 2×18 MHz IMT800 plus parts of CDMA/IMT850-spectrum (~2×5 MHz) together with GSM-R and GSM (or their potential IMT900 successors);
- **ITU Region 1:** 2×30 MHz IMT700 plus 2×30 (or 2×33) MHz IMT800 plus parts of CDMA/IMT spectrum (~2×5 MHz) plus potential IMT-TDD assignments in band gap 733-758 MHz (or other IMT or non-IMT assignments) together with GSM-R and GSM (or their potential IMT900 successors).

Options 2 and 3 (based on the ITU Region 1 approach), also enable TDD in the spectrum between the FDD blocks (15 MHz TDD for Option 2 and 10 MHz TDD for Option 3). Consequently, Options 2 and 3 are more spectrum-efficient relative to Option 1 (based on the ITU Region 3 approach), if the TDD band is to be implemented as well.

8.4.2.1 Option 1: 2×45 MHz (700 MHz band) + 2×15 MHz (800 MHz band)

This option is the ITU Region 3 channelling solution from 703-803 MHz with two 30 MHz bandwidth duplexers from 703-733 MHZ or 718-748 MHz respectively.

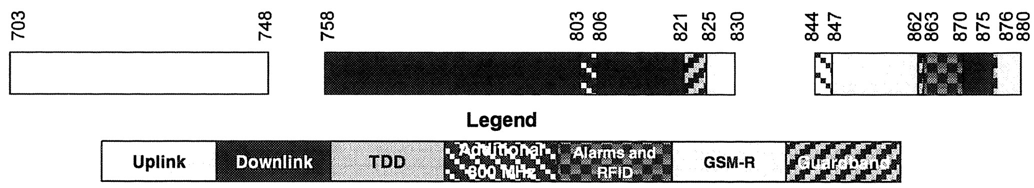


Figure 21: Option 1 in 703-876 MHz

Band	Paired spectrum	Unpaired spectrum
703-803 MHz	2×45 MHz	Not Applicable
803-876 MHz	2×15 MHz (2×3 MHz restricted) (~2×5 MHz IMT850)	Not Applicable

Table 15: Option 1 in 703-876 MHz

- Below are key characteristics of this option: APT (ITU Region 3) might have a better ecosystem in the long term due to larger population in Asia Pacific, South and Latin America and most countries in Africa. But, as already mentioned, the 2×30 MHz FDD band could be used in both regions.
- IMT bands:
  - 2×45 MHz in IMT700;
  - 2×15 MHz in IMT800;
  - 2×5 MHz in IMT850
  - 2×3 MHz in IMT800 in direct junction to IMT700; and
  - 3 MHz bandwidth networks are so far unusual, but possible.
- Solution for SA:
  - Neotel's assignment in IMT850 is currently 827-832 paired with 872-877 MHz and is overlapping with the GSM-R assignment from 876-880 MHz paired with 921-925 MHz. Neotel has to assure the migration to 825-830 paired with 870-875 MHz and needs to implement interference mitigation measures, (e.g. filters) to protect GSM-R; Neotel might use ~2×3.75 MHz for CDMA voice in areas with GSM-R coverage/sites and 2×5 MHz in other areas.

8.4.2.2 Option 2: 2×30 MHz (700 MHz band) + 2×30 MHz (800 MHz band)

The basic option 2 configuration provides the same amount of paired spectrum as option 1. However, the distribution of spectrum between 700 MHz and 800 MHz bands is different from that of Option 1.

This option is where digital dividend I is already deployed from 790-876 MHz in FDD.

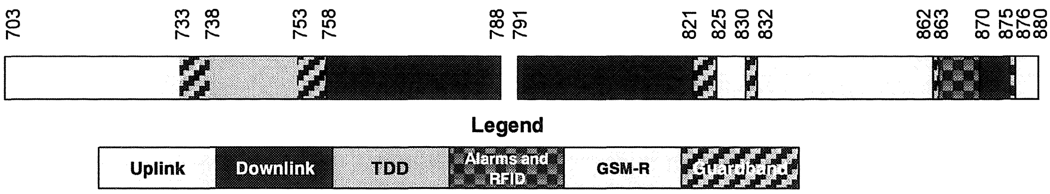


Figure 22: Option 2 in 703-876 MHz

Band	Paired spectrum	Unpaired spectrum
703-788 MHz	2×30 MHz	15 MHz
791-876 MHz	2×30 MHz (~2×5 MHz IMT850)	None

Table 16: Option 2 in 703-876 MHz

- Option 2 is best suited for countries with 3-4 incumbents and gives an opportunity for 3-4 new entrants.
- Solution for SA:
  - 2×30 MHz in IMT700 e.g. 2×2×15 MHz or 3×2×10 MHz expected;
  - 2×30 MHz in IMT800 e.g. 2×2×15 MHz or 3×2×10 MHz expected;
  - 2×5 MHz in IMT850; and
  - 2×30 MHz in IMT900 and 2×5 MHz GSM.
- Radio equipment is either deployed for 700 or 800 band due to double investments in radio equipment. This option is more attractive for different Mobile Network Operator's (MNO's) spectrum demands, e.g. 2×10 MHz and 20 MHz.
- This option also provides the additional benefit of an unpaired band of 15 MHz in the: 738-753 MHz centre gap. It considers the 5 MHz mandatory guard bands between paired and unpaired IMT spectrum, the usable unpaired spectrum with two guard bands of 5 MHz each. Therefore, with this ITU Region 1 option 15-25 MHz TDD capacity would be possible for a new TDD operator.

  Therefore, this ITU Region 1 solution is more spectrum-efficient if the 15-25 MHz is used. Availability of equipment for this TDD band equipment will be secured as China has selected the unpaired configuration in the whole band.
- Neotel's assignment in IMT850 827-832 paired with 872-877 MHz overlaps the GSM-R assignment from 876-880 MHz paired with 921-925 MHz. The Authority proposes to shift the Neotel assignment in the 850 MHz band downward by 2 MHz. Additionally, due to the mission-critical nature of GSM-R services, the Authority proposes that

Neotel will take the necessary measures (e.g. filters) in geographically- overlapping areas to GSM-R deployments to avoid interference with the GSM-R network. Neotel might use ~2×3.75 MHz for CDMA voice in areas with GSM-R coverage/sites and 2×5 MHz in other areas. The Authority proposes that the licensees in adjacent bands to GSM-R, as well as GSM-R operators, proactively co-ordinate network footprints and ongoing changes to their networks.

8.4.2.3 Option 3: Variation of Option 2

Option 3 is a variant of Option 2 that provides more paired spectrum and less unpaired spectrum with a net loss of 1 MHz of useful spectrum over Option 2. The spectrum configurations of Option 3 are summarised in the figure below:

- Instead of 2×30 MHz paired spectrum: 2×33 MHz could be assigned. As in Option 1, an additional 2×3 MHz are available, but of reduced capacity and interest so far.
- These 2×3 MHz are available only to terminals compatible with Option 1 (terminals with a second duplexer).
- Instead of 15 MHz (+10 MHz guard band) unpaired spectrum of Option 2, Option 3 avails 10 MHz (+12 MHz guard band) of unpaired spectrum.

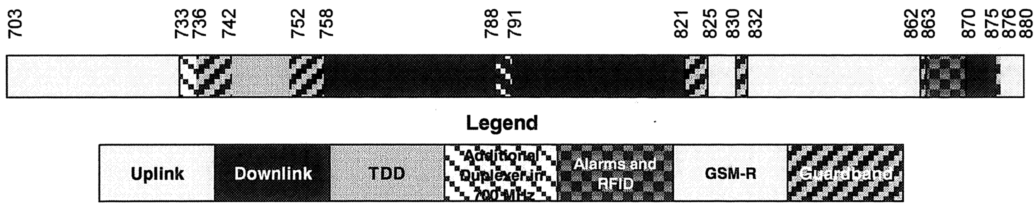


Figure 23: Option 3 703-876 MHz

Band	Paired spectrum	Unpaired spectrum
703-791 MHz	2×30 MHz (2×3 MHz restricted)	10 MHz
791-876 MHz	2×30 MHz (~2×5 MHz IMT850)	None

Table 17: Option 3 in 703-876 MHz

Option 3 is comparable to option 2 in terms of spectrum efficiency, but offers also 2×63 MHz in FDD.

8.4.2.4 Comparative Summary of Options

Band	Option	Paired spectrum	Unpaired spectrum	Note
700/800	1	2×45 MHz + 2×15 MHz + (2×3 MHz restricted)	Not applicable	ITU Region 3
700/800	2	2×30 MHz + 2×30 MHz	15 MHz	ITU Region 1
700/800	3	2×30 MHz + (2×3 MHz restricted) + 2×30 MHz	10 MHz	ITU Region 1

Table 18: Comparative summary of 700 and 800 MHz options

All three options give new FDD spectrum within IMT700 or IMT800 with international well-established ecosystems. Option 2 and 3 have the benefit of being compliant with other ITU Region 1 assignments (minimisation of border interference co-ordination) and also ensures 2×30 MHz of international roaming band in IMT700. If ITU Region 3 adopts option 1, there are also 2×18 MHz and 2×5 MHz available for international roaming. If GSM-R is not implemented (in SA), then ITU Region 3 solution could extend IMT850 2×5 MHz to 2×10 MHz, while ITU Region 1 is limited to 2×(5+3) MHz.

It is expected that the population within ITU Region 3 relative to ITU Region 1 will increase, but this will not influence the ecosystem, because equipment could be used in both regions, at least for the international roaming band of 2×30 MHz. Due to expected TDD selection in China, there would also be a market for IMT TDD-capable equipment and devices in all bands, which make even smaller TDD-assignments of at least 10 MHz for outdoor macro cell[17] use attractive in the long run. There will be all major bands included in the terminals as well as FDD and TDD, so terminals will select the most relevant option using software-defined radio.

In the following figure, the most relevant IMT options are summarised.

[17] >10MHz + 2 guard bands of 5 MHz are needed; the guard spectrum could be used indoor only.

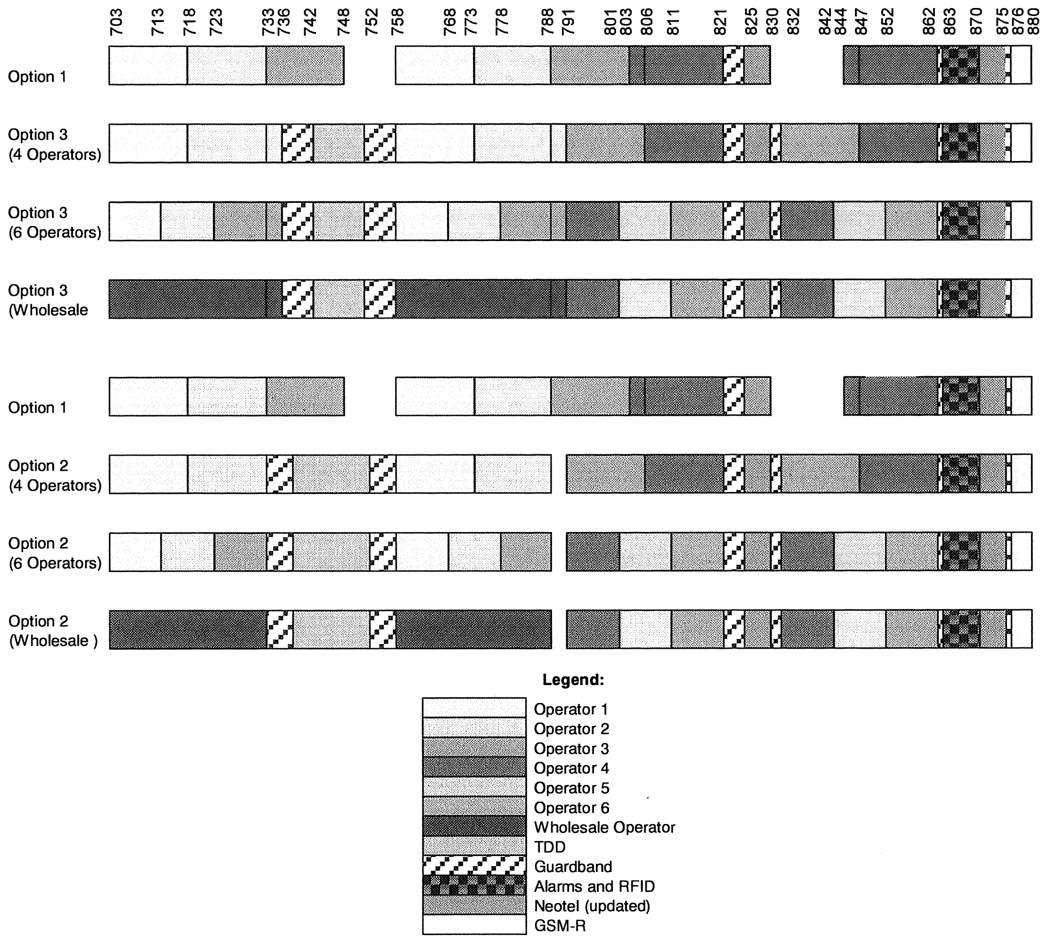


Figure 24: Potential IMT700, 750, 800, solutions

above: Option3 with 2x3 MHz and 10 MHz TDD; below: Option2 with 15 MHz in TDD

8.4.3 Conclusions on 700 and 800 MHz band

Based on the submissions to the consultation:

- Option 2 is supported by industry due to better spectral efficiency and use of the centre gap of 25 MHz.
- Regarding IMT750, South Africa is to take into consideration the ITU-R resolutions and reports as appropriate.

8.4.4 Neotel assignments

Within the feasibility study for 880-960 MHz it was found that Neotel's assignment in IMT850 band is currently 827-832 MHz paired with 872-877 MHz and overlapping the GSM-R allocation in the NRFP (which is from 876-880 MHz paired with 921-925 MHz). The migration of Neotel to the new frequency, by 2 MHz downwards, does not need any new antennas. The new LTE equipment will be able to work within 825-830 // 870-875 MHz. This applies as well to the current CDMA850 equipment.

Due to the lack of a guard band there are likely to be interference issues between the current CDMA equipment (as well as of new LTE technology) with GSM-R equipment:

- ~2 MHz was suggested as a guard band in the draft IMT Road Map for consultation, while now a 1 MHz guard band is suggested, together with reduced use of CDMA-spectrum (use of 2×3.75 MHz instead of 2×5 MHz) and GSM-R assignment (use of 2×2.2 MHz instead of 2×4 MHz).
- For the Final IMT roadmap, it is suggested that ~2×3.75 MHz might be used for CDMA850 voice services in areas with GSM-R sites, while 2×5 MHz could be used in all other areas where there are no GSM-R sites.

If additional filter attenuations are required to prevent interference with GSM-R, this has to be investigated. Technically, this means tuning of current or future equipment to the new band. No changes are expected for the user equipment. There might be some efforts of tuning or adaptations within databases.

In the long term, the further use of this band for LTE-R is expected. The potential coexistence use of reduced GSM-R consisting of ~2×1 MHz might be evaluated as required.

8.5 876-880 MHz (paired with 921-925 MHz)

This section of the document discusses the Authority's proposed solution to the existing spectral overlap between the CDMA850 and GSM-R.

In the rest of this section, mention of the 921-925 MHz band refers to the paired band 876-880 MHz // 921-925 MHz.

8.5.1 Background

The 921-925 MHz band (paired with 876-880 MHz) is currently assigned in its entirety to Passenger Rail Agencies of South Africa (PRASA) as a GSM-R RF licence. The area of operation is restricted to railway lines in metropolitan areas across South Africa. The applicable technical parameters follow the GSM-R standards prescription.

Furthermore, the Authority has assigned this licence on a shared basis and reserves the right to assign the same frequencies to another operator subject to coordination and synchronisation. Other potential users of the band include Transnet and Gautrain for instance.

The entire GSM-R band has been allocated to PRASA. Furthermore, both the lower and upper bands of the GSM-R assignments have close adjacencies:

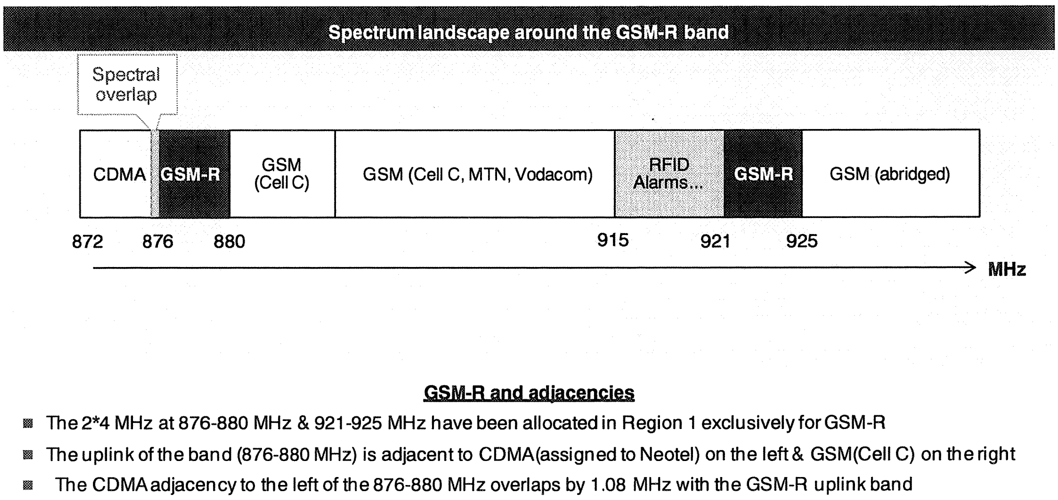


Figure 25: Spectrum landscape around GSM-R

The lower (uplink) GSM-R band is adjacent to the CDMA band (assigned to Neotel) on the left and to the GSM band (specifically the Cell C band) to the right. The upper (downlink) GSM-R band is adjacent to a relatively-empty band (occupied sparsely by RFID and alarm systems) to the left and to a GSM band (specifically the Cell C assignment) to the right.

8.5.2 Challenges in the Band Allocated for GSM-R

The main challenge with the current GSM-R allocation is its potential overlap with another assignment on the 876-880 MHz leg. The following paragraphs present the actual overlap, the obligation of the Authority and the Authority's proposal to resolve the overlap.

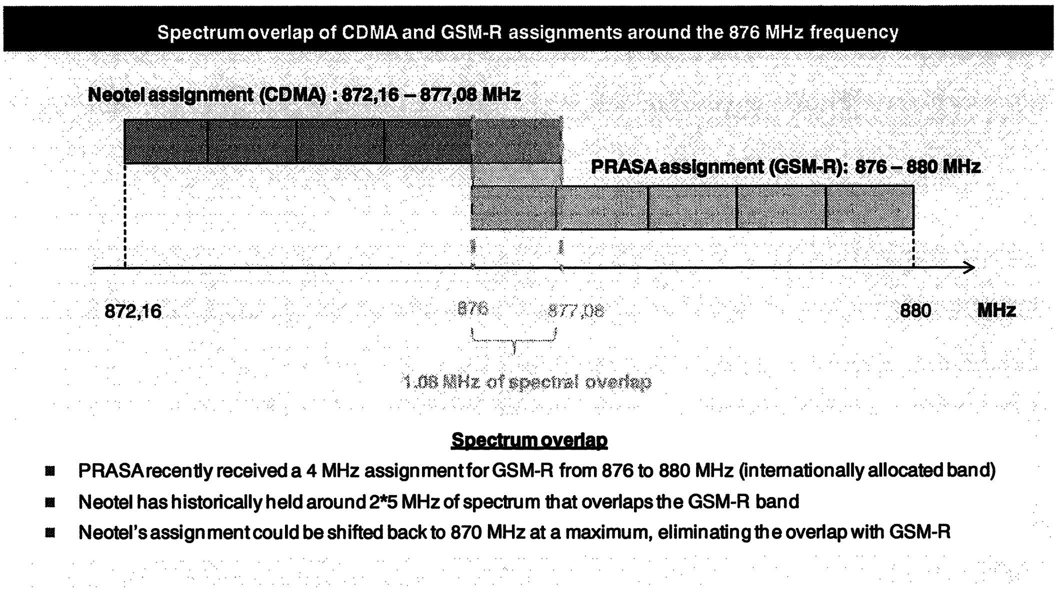


Figure 26: Challenge of spectrum overlap of CDMA and GSM-R assignments

Interference-prevention options vary depending on the exclusive or shared nature of the spectrum.

- Where spectrum is assigned on an exclusive basis, interference is prevented usually through the use of guard bands and strict technical restrictions on emission profiles (spectral masks, EIRP limits).
- If spectrum is assigned on a shared basis however, interference-prevention is commonly achieved through geographical exclusivity. In this case, licensees agree to deploy their systems in different areas at emission levels that ensure interference-free boundaries. In the case of trunking systems, it may also be agreed that all involved parties operate in the same network using different sub-network identifications.

8.5.3 Trends in the 921 - 925 Band

This section describes the directives, guidelines and trends in the 921-925 MHz band on three levels (global, Region 1, SADC) side-by-side with the South Africa dispositions. Furthermore, relevant benchmarks pertaining to GSM-R or the 921-925 MHz band are discussed.

ITU Allocation for Region 1	**SADC Allocation**			**South African Allocation**		
890 – 942 MHz	**890 – 942 MHz**			**890 – 942 MHz**		
FIXED MOBILE except aeronautical mobile	FIXED MOBILE except aeronautical mobile			FIXED MOBILE except aeronautical mobile		
		880 – 915 MHz IMT	Paired with 925 – 960 MHz		IMT 900 MTX (880 – 915 MHz)	Paired with 925 – 960 MHz
		915 – 921 MHz PMR &/or PAMR				
		921 – 925 MHz IMT PMR and /or PAMR	Paired with 876 – 880 MHz		**GSM–R (BTX) (921-925 MHz)**	**Paired with 877.695 – 880 MHz**
		925 – 960 MHz IMT			IMT900 BTX (925 – 960 MHz)	Paired with 880 – 915 MHz
					RFID (including passive tags and vehicle location) (915-921 MHz)	Spectrum Re-allocation for RFID (GG. No 31127, 5 June 2008)
BROADCASTING Radiolocation						

Table 19: Comparison of allocation at ITU, SADC and South Africa Level for 890-942 MHz

GSM-R (GSM Railway) is a customisation of the GSM standard for railway traffic management applications. The GSM-R specifications were finalised in 2000 and the standard is now part of the European Rail Traffic Management System (ERTMS). Over 38 countries have adopted the technology to date. A typical deployment involves a string of base stations along railway lines at intervals of 7 and 15 km for high redundancy and robustness of the network. In addition to GSM, a number of trunking features are built into GSM-R and service quality is designed for mission-critical applications as well as speeds of up to 500 km/h.

8.5.4 Worldwide Trends for GSM-R or 921-925 MHz

GSM-R is standardised for use in either 900 or 1800 MHz bands.

In Europe, GSM-R is deployed by all member states as well as Turkey, Ukraine in the 876-880 MHz (paired with 921-925 MHz band). In Germany, this allocation has been extended by 3 MHz (873-876 MHz) to cater for the extensive and dense network of the railway company (Deutsche Bahn). It is important to note that the 873-876 MHz band was previously in use for trunking services.

In Australia, GSM-R is deployed in the DCS band (1800 MHz). The GSM band was auctioned to allow participation from the railway companies. Other large countries that have adopted GSM-R include China in 2008 (aligned with European bands) and India (in the P-GSM band).

However, it is important to note that most frequency allocation tables do not make explicit allocations to GSM-R. Instead (as in the case of Ofcom), the allocation is to mobile services while a footnote refers to GSM-R operation in the band.

8.5.5 Trends in Africa

To date, according to publically available information, Algeria is the only country in Africa other than South Africa to have deployed a GSM-R network. This deployment started between 2006 and 2008 and is in line with the broader European norms.

8.5.6 Outlook

GSM-R deployment remains highly concentrated in Europe with 35 of the 38 reported deployments in the early 2000's. Large European railway companies including Deutsche Bahn run GSM-R and have not indicated short-term plans of migrating to different technologies. This ensures a stable interest in GSM-R and the strengthening of the GSM-R standard in the band as well as the availability of equipment.

Outside of Europe, a relatively small number of countries have adopted the standard worldwide, suggesting a slow uptake. However, these countries include India and China, the largest emerging economies which have the potential to sway industries.

Most African countries have yet to adopt the standard. A deeper analysis reveals however that the slow adoption in Africa is due to the under-developed and under-funded railways network. As markets continue to grow and infrastructure spending increases in Africa, it is therefore likely to see more GSM-R networks rolled out in the *de facto* Region 1 band of 876 – 880 MHz paired with 921-925 MHz.

In conclusion, GSM-R will likely be a major and growing standard for railways around the world. Since GSM-R is primarily deployed in the 921-925 MHz band, this allocation will remain for the foreseeable future.

It might also be possible to go directly to LTE-R in the IMT850 band. Potential migration from GSM-R to LTE-R could be performed smoothly with Single RAN equipment deployed. Potential coexistence scenarios might be developed with ~2x1 MHz in GSM-R for voice focused services and 2x5 MHz for data demands.

8.5.7 Conclusions

8.5.7.1 Allocation to GSM-R

The Authority confirms the GSM-R allocation in the band 877.695-880 MHz // 921-925 MHz, will amend any assignments in order to comply with the NRFP 2013 and will remove the current overlap between GSM-R and CDMA. Furthermore, given the sensitivity, mission-criticality and nascence of GSM-R, strict non-interference rules must apply to licensees in the adjacent bands.

8.5.7.2 Removal of Spectrum Overlap GSM-R to CDMA 850

There is an overlap of GSM-R and CDMA-850 assigned spectrum making simultaneous deployment difficult.

The initial proposed solution in the draft IMT Roadmap involved a downward shift of the CDMA assignment of Neotel by 3 MHz to clear the overlap of 1 MHz and add 2 MHz of guard band between the GSM-R and CDMA assignments.

In the consultation process, Neotel contended that the proposal to shift the assignment by 3 MHz would create problems of interference with the Alarms and SRDs (permitted on an unlicensed basis) in the 863 MHz to 870 MHz band as indicated in Figure 27.

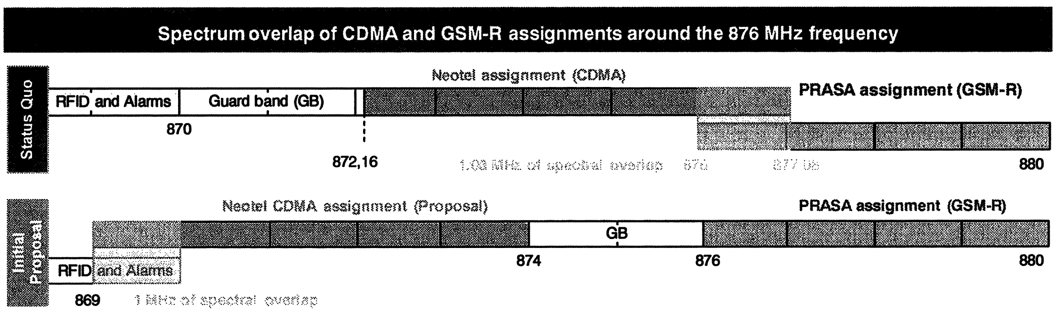


Figure 27: Spectrum overlap of CDMA and GSM-R assignments

Two options have been identified to avoid overlap with the Alarms and SRDs.

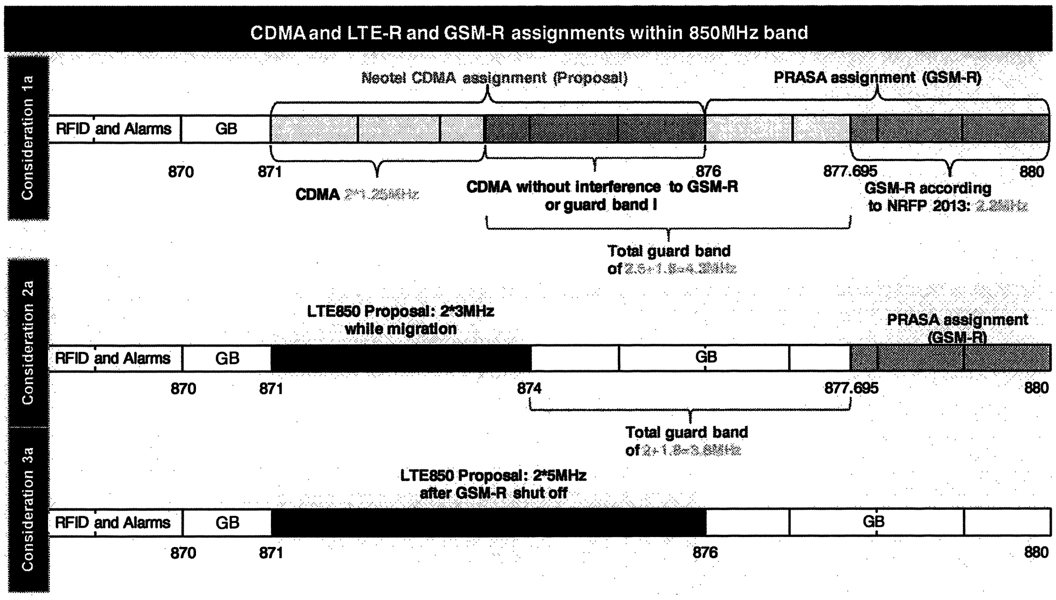


Figure 28: Option a: Migration of CDMA850 band by 1 MHz

Option a: To have 1 MHz guard band to narrowband systems, the CDMA assignment of Neotel is to be shifted by 1 MHz to 826-831 MHz // 871-876 MHz, this means the downlink remains directly adjacent to the GSM-R uplink. In order to achieve coexistence in the same area a guard band is required in order to have the required base station separation distance. This is shown as Consideration 1a in Figure 28 above. One coexistence solution would be to introduce a guard band of ~4.3 MHz and to reduce the CDMA850 band to 2×2.5 MHz in areas where there will be potential interference to GSM-R. In these areas, reduction to 2×2.5 MHz allows the partial usage of current CDMA850 at least for voice and wideband packet services. In areas where there is no interference to GSM-R, Neotel may use its existing CDMA850 assignment.

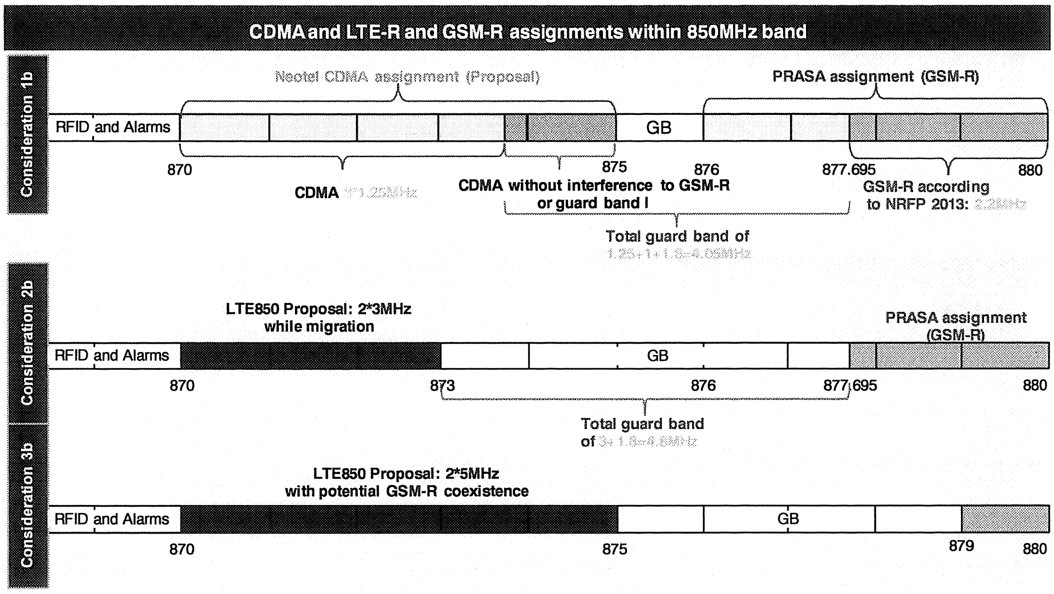


Figure 29: Option b: Migration of CDMA850 band by 2 MHz

Option b: To have 1 MHz guard band between CDMA and GSM-R systems, the CDMA assignment of Neotel is to be shifted by 2MHz to 825-830MHz // 870-875 MHz, this means the downlink remains with 1 MHz guard band adjacent to the GSM-R uplink and zero guard band to the alarms. In order to achieve coexistence in the same area a guard band is required between CDMA and GSM-R in order to achieve the required base station separation distance. This is in Consideration 1b in Figure 29 above. One coexistence solution would be to introduce a guard band of ~4.05 MHz and to reduce the CDMA850 band to 2×3.75 MHz in areas where there will be potential interference to GSM-R. In these areas, reduction to 2×3.75 MHz allows the partial usage of current CDMA850 at least for voice and wideband packet services. In areas where there is no interference to GSM-R, Neotel may use its existing CDMA850 assignment.

In the National Radio Frequency Plan 2013, the GSM-R assignment was defined from 877.695MHz to 880MHz, which means 2×2.2 MHz use for GSM-R. Therefore the license to PRASA has to be adapted accordingly.

The long term solution would be for Neotel to cease using this band for CDMA.

Consideration 2 and Consideration 3 in Figure 28 and Figure 29 indicate a long term solution when CDMA850 has ceased and an (LTE) IMT850 band is deployed. While migrating from deployed GSM-R to LTE-R, there could be 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.

Conclusions

- The Authority's decision is for Neotel's assignment to be adjusted to 825-830 MHz paired with 870-875 MHz.
    - The Authority will take the necessary measures to ensure coexistence between CDMA850 and GSM-R, i.e. amend assignments as appropriate and ensure coordination.
- The long term solution is for Neotel to cease using this band for CDMA.
    - Consideration 2 and Consideration 3 in Figure 28 and Figure 29 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.

LTE R Considerations

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

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

8.6 880-915 MHz band paired with 925-960 MHz

This section presents the in-band harmonisation options developed by the Authority following the frequency migration plan put forth in April 2013.

The actual migration of the GSM 900 band to broadband IMT is not dealt with in this document because significant GSM spectrum is still used for 2G. However, the in-band harmonisation options presented in this document assist licensees to deploy broadband IMT services in the GSM band.

8.6.1 Background

The Authority initiated the in-band migration of the 880-960 MHz band according to its mandate as laid out in the 'Process for Radio Frequency Migration' draft regulations S 4 (e). The mandate states that: "*The Authority shall initiate a process of radio frequency migration in the following circumstances: where the authority has determined that a change in a radio frequency spectrum licence holder's assignment within a radio frequency band is required to enable more efficient use of the radio frequency spectrum (in-band migration).*"

Further, the "Radio frequency migration regulation and plan" (Gazette 36334) states for the 880-915 MHz band that:

"A Radio Frequency Spectrum Assignment Plan (RFSAP) will be developed regarding the Mobile (890 – 915 MHz paired with 925 – 935 MHz) bands with respect to harmonisation including in-band migration."

The Authority's objective to carry out an in-band migration (harmonisation) of the current GSM assignments is premised on the need to achieve contiguous assignments for each of the three cellular carriers while increasing spectrum efficiency (fewer guard bands).

8.6.2 Options considered by the Authority

Based on an extensive benchmarking on the GSM900 band and best practices around the world, the Authority proposes three options for in-band harmonisation in the GSM900 band.

These proposals are summarised in the chart below.

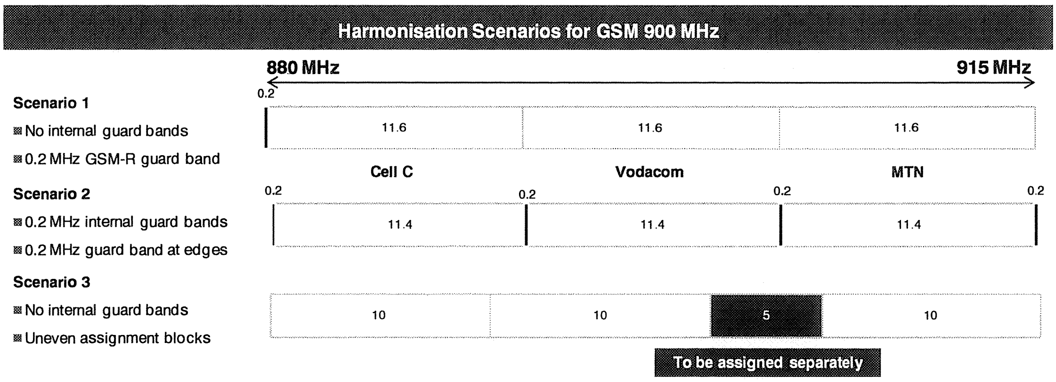


Figure 30: Harmonisation scenarios for GSM 900 MHz

The next sections explain these scenarios in detail.

8.6.2.1 Scenario 1: Equal 5 MHz+ blocks without guard bands

This scenario involves the assignment of equal shares of spectrum to licensees and the elimination of internal guard bands. Additionally, the left-edge guard band is expanded to a full GSM channel (0.2 MHz) and the right-edge guard band is removed.

As indicated earlier the primary drivers for this scenario are contiguity and spectral efficiency involving the three current licensees in this band.(As compared to the current distribution of spectrum in the band, the benefits of the current assignment arrangement are as follows:

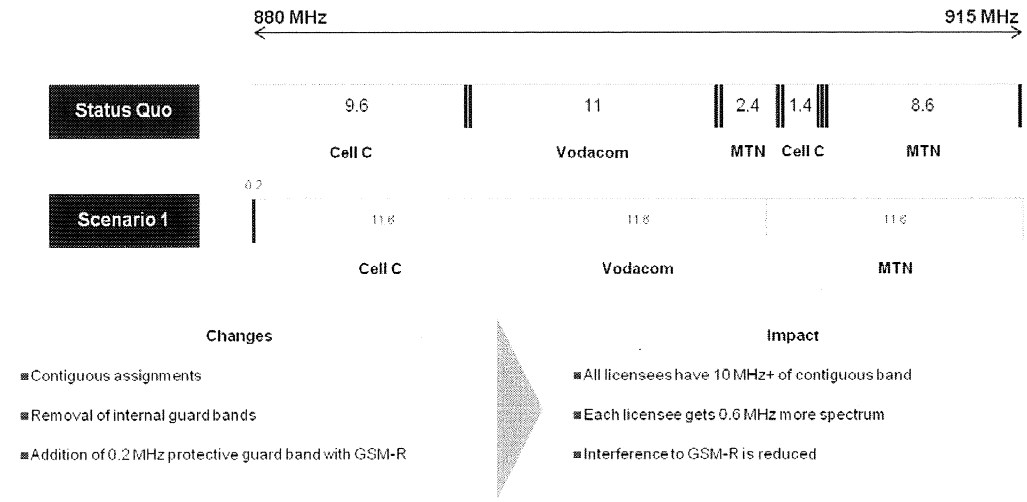


Figure 31: Status quo vs. scenario 1 (880-915 MHz harmonisation)

This scenario, like all others achieves the essential objective of contiguity. As a result, each licensee can now deploy either GSM or any of the other common technologies (3G or LTE). However, the scenario is still based on GSM channelisation (0.2 MHz) as evidenced by the GSM-R guard band of 0.2 MHz on the left-edge of the 880-915 MHz band.

The key feature of this scenario is the complete removal of internal guard bands. This removal saves 1.8 MHz in one step: 1.4 MHz contiguity gain and 0.4 MHz internal guard band gain. Removing guard bands is a paradigm shift that benefits licensees with more spectrum and empowers them to co-ordinate interference issues among themselves. Given the use of interference-resistant technologies such as frequency-hopping in GSM, rigid measures such as guard bands are less and less relevant to protect licensees in the same band from mutual interference.

Additionally, the 0.2 MHz remaining from the three-way division of the band has been assigned to the left edge of the band (before the GSM-R allocation). The goal of this guard band is to provide spectral protection for the GSM-R band. It is important to note that guard bands are still very useful between different service classes and especially with GSM-R. Many GSM-R services are mission-critical and faults carry enormous safety and financial risks; therefore explicit measures such as guard bands are justified whenever feasible to add another layer of protection to deployments.

8.6.2.2 Scenario 2: Equal 5 MHz+ blocks with guard bands

In this scenario, licensees receive equal shares of spectrum and guard bands are maintained both between licensees within the band and at the two edges of the band. This scenario is the most conservative, contiguous arrangement assuming only 0.2 MHz of guard band.

The primary drivers for this scenario are also contiguity and spectral efficiency with the assumption of three players (the *status quo* in South Africa).

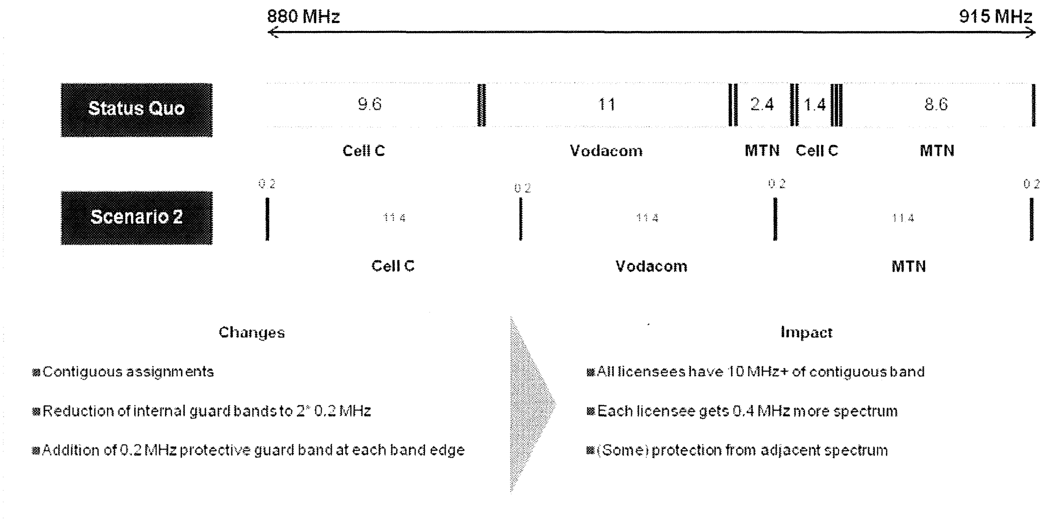


Figure 32: Status quo vs. scenario 2 (880-915 MHz harmonisation)

In summary, the objective of contiguity is achieved and all players gain 0.4 MHz more spectrum while explicit guard bands increase protection from mutual interference. Channelisation of 0.2 MHz is still based on GSM.

The key difference between this option and scenario 1 is that guard bands are maintained between players. While removing guard bands favours increased spectrum and soft interference management, it can be argued that maintaining guard bands supports interference prevention.

In addition to an increased guard band with GSM-R, this approach also adds a guard band on the right edge of the 880-915 MHz band. A variation of scenario 2 is to increase the guard band with GSM-R by shifting the right-edge guard band to the left-edge. Such a measure is a preventive move for the protection of mission-critical GSM-R services. A final decision about the merit of this variation of scenario 2 would best be made after interference analysis on GSM-R taking into account the density of deployments immediately to the right of 915 MHz.

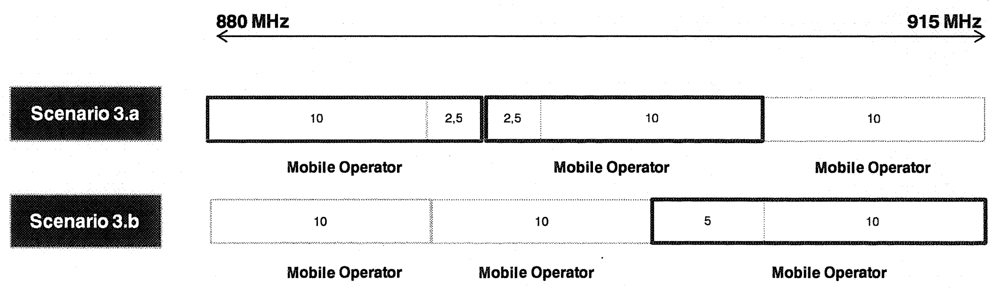
8.6.2.3 Scenario 3: Differentiated × 5 MHz blocks without guard bands

This scenario consists of four contiguous blocks (3×10 MHz + 1×5 MHz) and no internal or external guard bands to be assigned to existing players on a differentiated need basis.

The key features are a new channelisation based around 5 MHz and the option of either catering for unequal assignments among the existing three licensees based on need, or facilitating a new licensee in this band.

The primary drivers of this scenario include a focus on broadband as well as differentiated assignments (uneven spectrum assignments to licensees based on such factors as market share and geographic differentiation). There are precedents to this in many countries including France and Pakistan.

The assignment is intended primarily to accommodate broadband services. UMTS and LTE (the two major 3G and 4G technologies) are realistically deployed in bands of 5, 10, 15 or 20 MHz. The snapshot below illustrates this scenario.



Notes on scenarios 3.a and 3.b

- The spectral positions of "mobile operators" indicated above are purely hypothetical and may not be interpreted based on current assignments
- Scenarios 3.a and 3.b involves 1 or 2 of the licensees giving up spectrum for the benefit of 1 or 2 others
- Decision about what licensee gets the 5 MHz to be made using 'need-based' criteria such as market share, traffic volume

Figure 33: Scenarios for differentiated assignments (880-915 MHz)

The 5 MHz block assignment can also be used for differentiated assignments in a way that is compatible with both GSM and IMT. That is, each existing player has enough spectrum to deploy either or both GSM and 3G/4G in the same band (with 10 MHz assignments) while the Authority has the flexibility to assign the extra 5 MHz on an 'incremental-need' basis. In other terms, the Authority can assign extra spectrum to a licensee with a demonstrable need (in a given geographical region for a given period upon which the need is re-evaluated). The rationale behind 'need-based' primary assignments is that beyond a certain minimum amount of spectrum required for basic operation of a network, incremental assignments must recognise the actual need for spectrum. It is common practice among regulators to allocate uneven amounts of spectrum to licensees. Such decisions may result from the history of assignments or be based on factors such as market share, penetration or revenues.

8.6.3 Costs and benefits

Cost-benefit Analysis of the Migration Scenarios for the Cellular Spectrum

Stakeholders	Impact items	Scenarios			
		0*	1	2	3
Licensees	Amount of spectrum held (MHz)	**11**	**11.6**	**11.4**	**10 or 12.5**
Licensees	Cost of migration	NC	Low	Low	Low
End users / Licensees	Quality of existing service	Baseline	Best	Better	High
End users / Licensees	Affordability of existing services	Baseline	Baseline	Baseline	Better/Best
End users / Licensees	Availability of broadband services	Baseline	High	High	High
ICASA	Revenue from spectrum management	Baseline	More	More	More

Costs and benefits of various migration scenarios

- Scenario 1 provide the best overall benefits to the end users in a 3-player cellular scenario
- Scenario 1 is easier and faster to implement given that operator buy-in exists.

**0: Current spectrum distribution*

Figure 34: Cost benefit analysis of migration scenarios for the cellular spectrum

For more details on the rationale behind the summary table, please refer to the feasibility study for the 880-960 MHz band in Appendix B.

8.6.4 Conclusions

In the consultation, the potential beneficiaries of consolidation (MTN and Cell C) were supportive of Scenario 1 to be carried out within approximately 2 years, while Vodacom indicated a preference for Scenario 3b in a longer term time frame and Telkom indicated a preference for Scenario 3. MTN and Cell C pointed out that the costs and effort of migration would be significant and complex.

With references to the responses from the consultation, the Authority has decided that a two phase approach should be adopted as depicted in the Figure below.

- Phase 1 is the short term. Should the operators come to mutual agreement and coordination on the removal of guard bands, this should be done. Alternative examples are given for Phase 1 depending on the level of internal refarming to LTE (or UMTS).
- The Authority has decided that the long term solution should be as per Phase 2 (Scenario 3 without coupling of the 2×5 MHz to existing operators) and should be achieved by 31st March 2020 at the latest. The 2×5 MHz block will be assigned in a separate process.

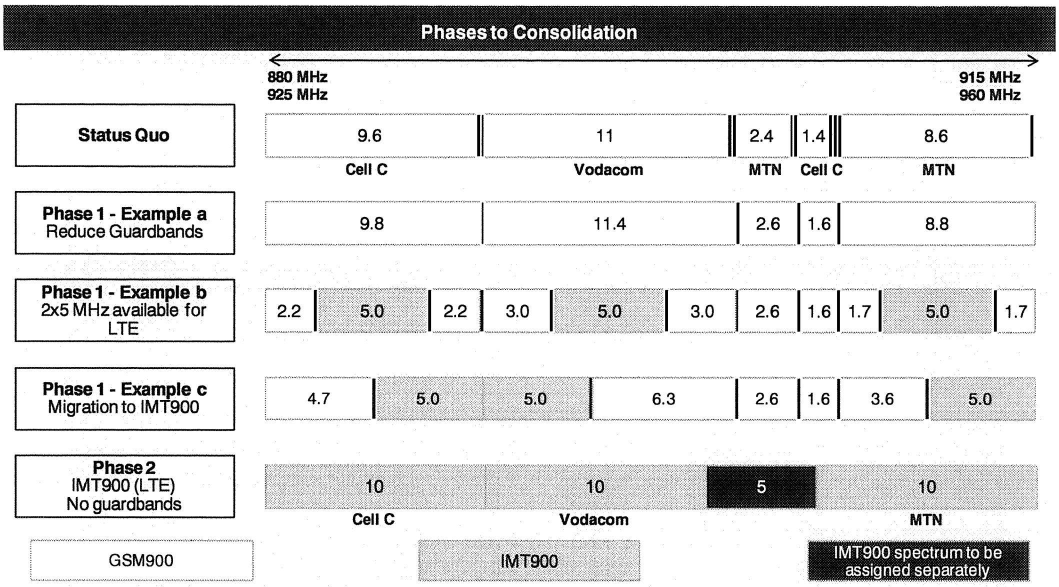


Figure 35: Steps to the harmonisation of the 900 MHz band

Note that Phase 1 (Example b) indicates that currently all operators have at least 2×5 MHz spectrum capable of being refarmed to UMTS900 or LTE900 based on operator's decision and equipment capability

The principle of removing the guard bands between operators based on mutual agreement and coordination could also be applied to the IMT1800 band.

In the case of refarming to UMTS900 or LTE900, new coverage and capacity obligations for this band may apply to meet SA Connect targets.

8.7 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.

8.7.1 ITU Position on 1700-2290 MHz

According to ITU Recommendation ITU-R M.1036-4 (03/2012), the recommended frequency arrangements for implementation of IMT in the band 1710-2200 MHz are summarised in Table 20.

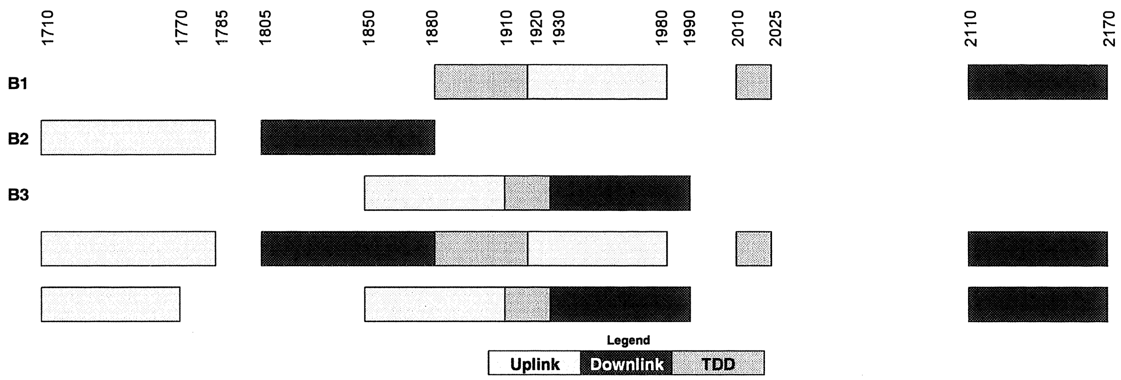


Figure 36: Frequency arrangements in the 1710-2200 MHz band

Frequency arrange ments	Paired arrangements				Unpaired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
B1	1 920-1 980	130	2 110-2 170	190	1 880-1 920; 2 010-2 025
B2	1 710-1 785	20	1 805-1 880	95	None
B3	1 850-1 910	20	1 930-1 990	80	1 910-1 930
B4 harmonised with B1 and B2)	1 710-1 785 1 920-1 980	20 130	1 805-1 880 2 110-2 170	95 190	1 880-1 920; 2 010-2 025
B5 (harmonised with B3 and parts of B1 and B2)	1 850-1 910 1 710-1 770	20 340	1 930-1 990 2 110-2 170	80 400	1 910-1 930

Table 20: Frequency arrangements in the band 1710-2200 MHz

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

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

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

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

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

8.7.2 SADC Position on 1700-2290 MHz

The SADC Frequency Allocation Plan (Table 21)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) MOBILE except	**1 700-1 710 MHz** FIXED METEOROLOGICAL–SATELLITE (space-to-Earth) MOBILE except	Fixed links (single frequency)	

IMT Roadmap 2014

aeronautical mobile 5.289 5.341	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 – 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		
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 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		
2 170-2 200 MHz FIXED MOBILE MOBILE-SATELLITE (space-to-Earth) 5.351A	**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.

5.388 5.389A 5.389F			
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)	Radio Frequency channel arrangement according to ITU-RF. 1098.
		BFWA (2 285-2 300 MHz)	

Table 21: 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)[18].(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)[19].(WRC-07)

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

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

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

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

[19] *Ibid*.

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

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

8.7.3 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 22: 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 23: CRASA channelling plan for 2025-2290 MHz

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

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

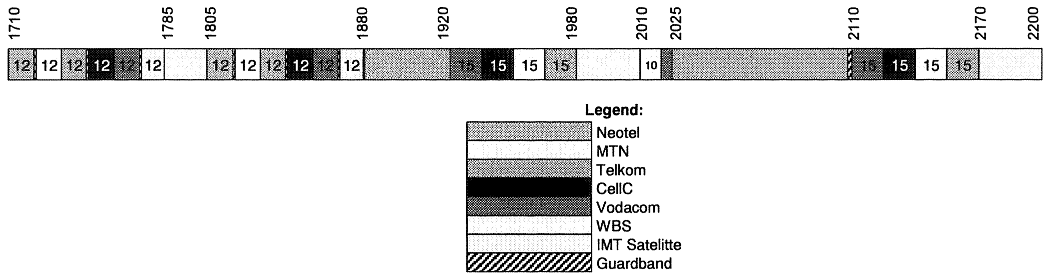


Figure 37: Current assignments with 1700-2200 MHz

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

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

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

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

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

8.7.5 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.

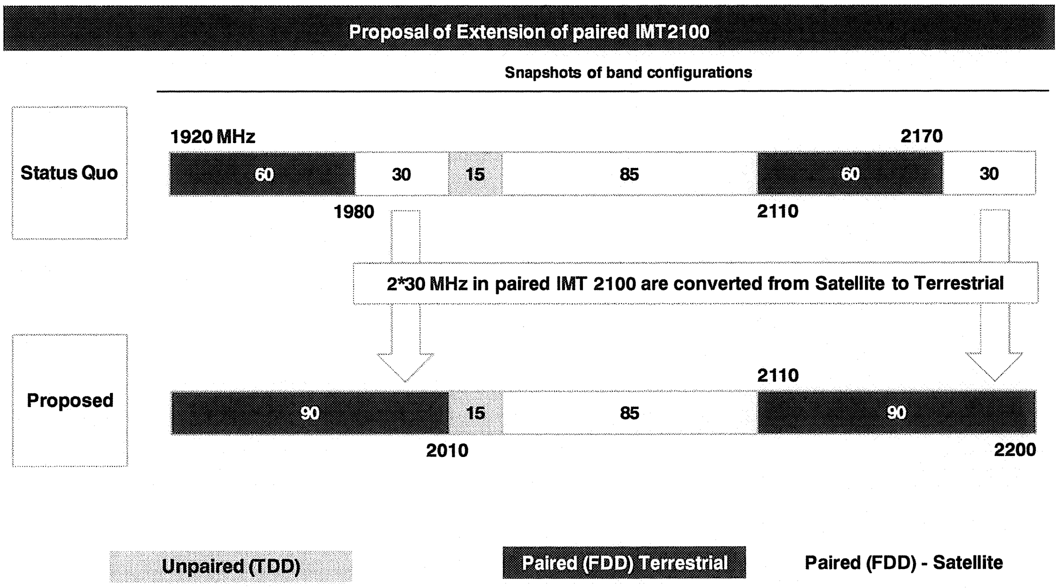


Figure 38: Proposal of Extension of paired IMT2100

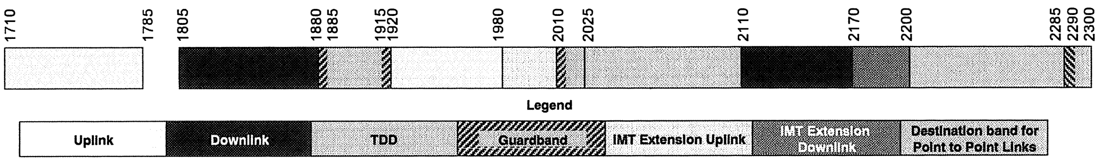


Figure 39: IMT2100-extensions proposal

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

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

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

The suggestions concerning 1980-2110 // 2170-2200 MHz are tentative as these bands are not yet identified for terrestrial IMT at international level (and therefore there is no ecosystem). However, these bands might be identified for IMT in the future because of the attractive location near GSM/IMT1800 and UMTS/IMT2100. Digital equipment is already available (SRAN-concept[20]) and radio equipment, filters and antennas need adaptations.

8.7.6 Conclusions

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

[20] 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.

8.8 2300-2400 MHz band

IMT2300 is already in use for IMT TDD by Telkom *et al* including some regional operators. The band from 2380-2400 MHz is currently not used[21]. IMT2300 TDD from 2360-2380 MHz (others) and 2380-2400 MHz is to be assigned with mutual alignment to the already assigned licences. In the case of different TDD configurations, a 5 MHz guard band has to be considered within the new assignment.

A guard band of 5 MHz is not required between IMT2300 and the 2400MHz ISM band. In case of interference, other Wi-Fi-channel settings might be selected appropriately.

In the case of IMT2300, South Africa is to take into consideration, as appropriate, the relevant ITU-R report.

8.8.1 ITU Position on 2300-2400 MHz

ITU Recommendation ITU-R M.1036-4 (03/2012) states the following. The recommended frequency arrangements for implementation of IMT in the band 2300-2400 MHz are summarised in Table 24.

Frequency arrange ments	**Paired arrangements**				**Unpaired arrangements (e.g. for TDD) (MHz)**
	Mobile station transmitter (MHz)	**Centre gap (MHz)**	**Base station transmitter (MHz)**	**Duplex separation (MHz)**	
E1					2 300-2 400 TDD

Table 24; Frequency arrangements in the band 2300-2400 MHz

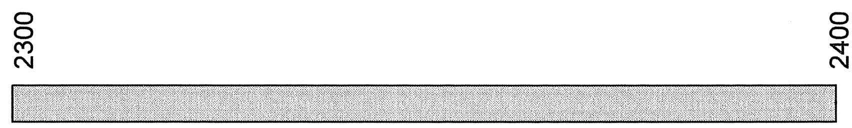


Figure 40: Frequency arrangements in the band 2300 – 2400 MHz: 100 MHz (unpaired)

8.8.2 SADC Position on 2300-2400 MHz

The SADC Frequency Allocation Plan proposes that 2300-2400 MHz be allocated to Fixed Links, IMT (TDD), PtP/PtMP and Broadband Fixed Wireless Access (BFWA).

The 2300-2400 MHz band is currently used for fixed and mobile systems in various SADC countries.

The SADC FAP recognises that frequency channelisation of several key frequency bands must be developed and preferably harmonised throughout SADC. The frequency bands used for IMT, BFWA, PtP microwave systems, etc. will be considered. Channelling plans will be added to the SADC Band Plan in future.

---

[21] This has been determined as a destination band for WBS.

ITU Region 1 allocations and footnotes	SADC common allocation/s and relevant ITU footnotes	SADC proposed common sub-allocations / utilisation	Additional information
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.

Table 25: SADC Frequency Allocation Plan 2300-2450 MHz

8.8.3 National Radio Frequency Plan on 2300-2400 MHz

The National Radio Frequency Plan for 2300-2400 MHz is shown in Table 26.

ITU Region 1 allocation and footnotes	South African Allocation and footnotes	Typical Applications	Comments
2300 -2450 MHz	**2300-2450 MHz**		
FIXED	FIXED	FWA (PTP/PTMP)(2307-2387 MHz) Outside Broadcast Links	PAIRED with 2401-2481 MHz 28 MHz channels OB links. Frequency co-ordination with other systems operating in the band is mandatory on a case by case basis. Primary basis: 2377 MHz and 2471 MHz. Secondary basis: 2321 MHz, 2349 MHz, 2415 MHz and 2443 MHz.
MOBILE 5.384A	MOBILE 5.384A NF9	FWA(PTP/PTMP) (2401-2481 MHz	Paired with 2307-2387MHz
		IMT2300 TDD(2300-2400 MHz)	
		WLAN, FDDA and model ctrl. (2400 – 2483.5 MHz)	Radio Frequency Spectrum Regulations (Annex B)(GG. No. 34172, 31 March 2011)
		Non-specific SRDs and low power video surveillance (2400 -2483 MHz)	
		RFID (2400-2483.5 MHz)	Spectrum re-allocation to RFID(GG. No. 31127, 5 June 2008)
Amateur	Amateur		
Radiolocation		ISM applications (2400-2500 MHz)	
5.150 5.282 5.395	5.150 5.282		

Table 26: National Radio Frequency Plan on 2300-2400 MHz

Footnotes:

5.384A The bands, or portions of the bands, 1 710-1 885 MHz, 2 300-2 400 MHz and 2 500-2 690 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).*

8.8.4 Radio Frequency Migration Plan for 2300-2400 MHz

The Radio Frequency Migration Plan concerning 2300-2400 MHz is shown below.

Frequency Band (MHz)	Allocation in NRFP 2013 (applications)	Proposed utilisation/ applications	Notes on migration/ usage
2300-2450	FIXED MOBILE Amateur (Fixed links (2307 – 2387 MHz) paired with (2401 – 2481 MHz) (Several outside broadcasting links) (ISM band (2400 – 2500 MHz))	IMT (Terrestrial) 2300 – 2400 MHz as per SADC FAP proposed common sub-allocation/ utilisation	Feasibility Study to be carried out with consideration of: ■ Use for IMT. ■ Migration of fixed links and OB links.

Table 27: Radio frequency migration plan for 2300-2400 MHz

8.8.5 Typical usage of 2300-2400 MHz

Large bandwidths are available with medium propagation loss and penetration loss in 2300 MHz. TDD-band 40 is currently used for WiMAX, but with a general worldwide trend to LTE.

In South Africa, the operator Telkom Mobile (formerly 8ta) holds 60 MHz of 2.3 GHz unpaired spectrum (band 40. Telkom TDD-LTE service was commercially launched alongside new data tariffs on April 21, 2013. SMMT holds an additional 20MHz within 2300MHz.

Other examples for TDD-LTE in 2300 MHz: India, Saudi Arabia, Thailand (1WSO), Indonesia, Philippines, Malaysia, Singapore.

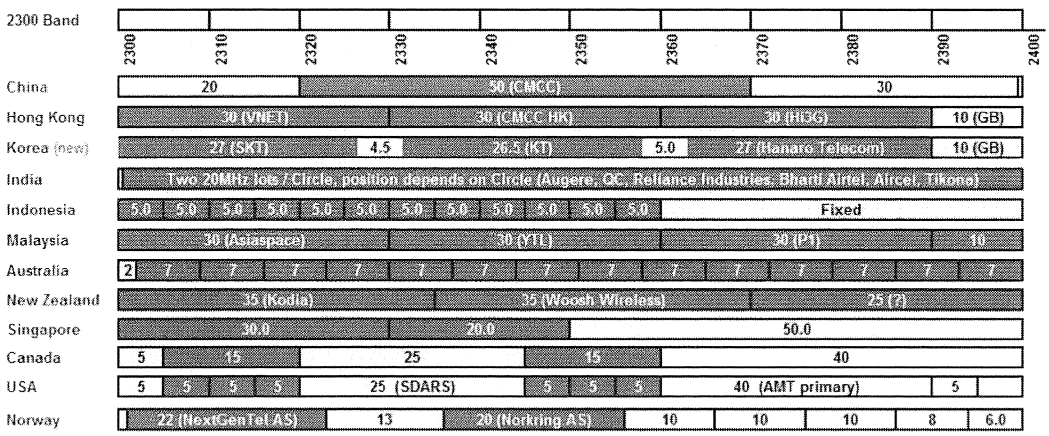


Figure 41: IMT TDD assignments within 2300-2400 MHz worldwide

Contiguous TDD spectrum allocation in large blocks is beneficial for improved mobile broadband experience and enlarging the global market scale. 100 MHz bandwidth of unpaired spectrum from 2300 to 2400 MHz was identified for IMT at the World Radiocommunication Conference 2007 (WRC-07).

Since synchronised TDD networks lead to best spectrum utilisation and the corresponding solutions are mature, the synchronised operation among multiple TDD-LTE networks is recommended for TDD co-existence.

8.8.6 Options for the 2300-2400 MHz

The current spectrum in SA is widely used by Telkom (60 MHz) and SMMT (20 MHz). The remaining spectrum (2380-2400 MHz) could potentially be assigned to WBS in the event of spectrum clearance of 2500-2565 MHz band, where WBS has 14 MHz in TDD-SCDMA. However, this option would require new antennas and filters, and consequently impose additional costs to the technology migration from TDD-SCDMA to IMT-TDD. WBS commenced with TDD-SCDMA in 2005 and announced in 2011 to migrate to LTE-TDD.

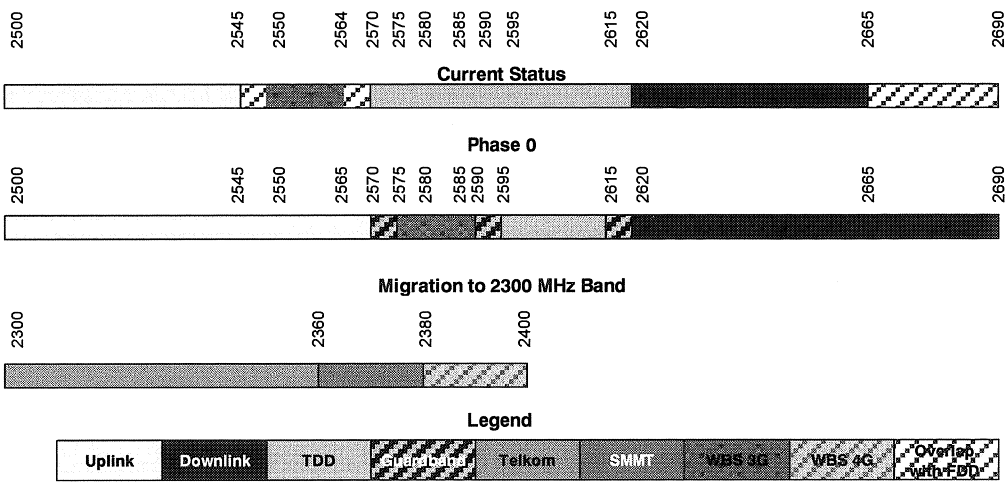


Figure 42: WBS migration issue out of IMT2600 band

A migration of WBS is essential for the use of the IMT2600 band, otherwise 2×25 MHz of valuable could remain idle because the first 15 MHz in the downlink are unusable and the second 2×5 MHz in uplink and downlink are needed as guard band to TDD-SCDMA.

The migration to 2380-2400 MHz yields 6 MHz more spectrum to WBS and results in increased capacity brought about improved spectral efficiency. In addition, modernised equipment reduces OPEX costs due to increased energy-efficiency.

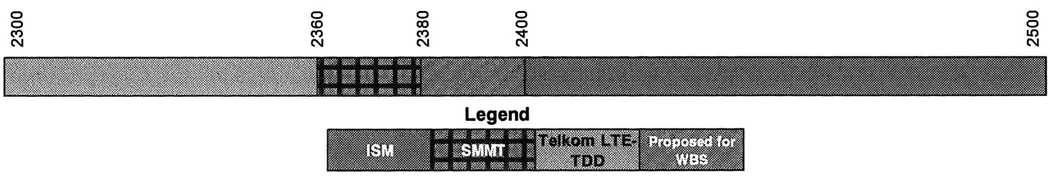


Figure 43: 2300 - 2500 MHz usage in South Africa

If 2380-2400 MHz is not used as a destination band by WBS, others might be interested in this part of the band.

Consultation responses suggested a 5-10 MHz to the 2400 MHz guard band. However, new licensees must follow the already implemented TDD-scheme, or need to include a 5 MHz guard band within their 10 MHz or 20 MHz assignment. There is no need to reserve any guard band to the 2400 MHz. In cases of interference with ISM-Wi-Fi, another Wi-Fi-channel might be selected, or the guard band will be taken from 2400-2405 MHz.

The 2400-2500 MHz band is given as a' typical application' in the NRFP to be used for ISM applications.

8.9 2500-2690 MHz band

8.9.1 ITU Position on 2500-2690 MHz

The recommended frequency arrangements for implementation of IMT in the band 2500-2690 MHz as per ITU Recommendation ITU-R M.1036-4 (03/2012) are summarised in Table 28.

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

Table 28: Frequency arrangements in the band 2500-2690 MHz

NOTE 1 – In C1, in order to facilitate deployment of FDD equipment, any guard bands required to ensure adjacent band compatibility at the 2570 MHz and 2620 MHz boundaries will be decided on, on a national basis and will be taken within the band 2570-2620 MHz as well as kept to the minimum necessary, as per the ITU-R M.2045 Report.

NOTE 2 – In C3, administrations can use the band solely for FDD or TDD or some combination of TDD and FDD. Administrations can use any FDD duplex spacing or FDD duplex direction. However, when administrations choose to deploy mixed FDD/TDD channels with a fixed duplex separation for FDD, the duplex separation and duplex direction as shown in C1 are preferred.

The frequency arrangements are also depicted in Figure 32 below.

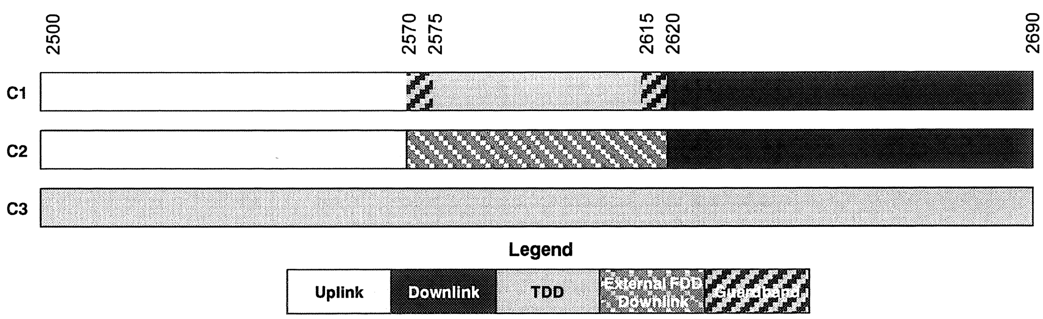


Figure 44: Frequency arrangements in the band 2500 – 2690 MHz

8.9.2 SADC Position on 2500-2690 MHz

The SADC Frequency Allocation Plan (Table 29) proposes that the 2500-2690 MHz be allocated to IMT and BFWA. The 2500-2690 MHz band is currently used for mainly BFWA systems in various SADC countries and is also allocated to mobile services identified for IMT.

The SADC FAP recognises that frequency channelisation of several key frequency bands must be developed and preferably harmonised throughout SADC. 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
2 500-2 520 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	**2 500-2 520 MHz** FIXED MOBILE except aeronautical mobile 5.384A	BFWA (2500-2690 MHz) IMT (2500-2690 MHz)	The band 2 500-2 690 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 IMT channelling plan to be developed.
2 520-2 655 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	**2 520-2 655 MHz** FIXED MOBILE except aeronautical mobile 5.384A 5.339		
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** FIXED MOBILE except aeronautical mobile 5.384A 5.149 5.412		
2 670-2 690 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A	**2 670-2 690 MHz** FIXED MOBILE except aeronautical mobile 5.384A 5.149 5.412		

Earth exploration-satellite (passive) Radio astronomy Space research (passive) 5.149 5.412			

Table 29: SADC Frequency Allocation Plan

8.9.3 National Radio Frequency Plan on 2500-2690 MHz

ITU Region 1 allocation and footnotes	South African Allocation and footnotes	Typical Applications	Comments
2500-2520 MHz FIXED MOBILE except aeronautical mobile 5.384A 5.412	**2500-2520 MHz** MOBILE except aeronautical mobile 5.384A NF9	IMT2600 MTX (2500-2570 MHz)	PAIRED with 2620-2690 MHz
2520-2655 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A BROADCASTING SATELLITE 5.413 5.416 5.339 5.412 5.417C 5.417D 5.418B 5.418C	**2520-2655 MHz** MOBILE except aeronautical mobile 5.384A NF9 5.339	IMT2600 MTX (2500-2570 MHz) IMT2600 TDD (2570-2620 MHz) IMT2600 BTX (2600-2690 MHz)	PAIRED with 2620-2690 MHz PAIRED with 2500-2570 MHz
2655-2670 MHz FIXED 5.410 MOBILE except aeronautical mobile 5.384A BROADCASTING SATELLITE 5.20B 5.413 5.146 Earth exploration-satellite (passive) Radio astronomy Space research (passive) 5.149 5.412	**2655-2670 MHz** MOBILE except aeronautical mobile 5.384A NF9 Radio Astronomy 5.149	IMT2600 BTX (2600-2690 MHz)	PAIRED with 2500-2570 MHz
2655-2670 MHz FIXED 5.410 MOBILE except	**2655-2670 MHz** MOBILE except	IMT2600 MTX (2500-2570	PAIRED with 2500-2570 MHz

aeronautical mobile 5.384A Earth exploration-satellite (passive) Radio astronomy Space research (passive) 5.149 5.412	aeronautical mobile 5.384A Radio Astronomy 5.149	MHz)	
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** MOBILE except aeronautical mobile 5.384A Radio astronomy 5.149	IMT2600 MTX (2620 – 2690 MHz)	Paired with 2500 – 2570 MHz

Table 30: National Radio Frequency Plan for 2500-2690 MHz

Footnotes:

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)

8.9.4 Radio Frequency Migration Plan for 2500-2690 MHz

Frequency Band (MHz)	Allocation in NRFP 2013 (Applications)	Proposed Utilisation/ Applications	Notes on migration/ usage
2500 – 2690	2500-2520 MHz MOBILE except aeronautical mobile	Mobile IMT (as per SADC FAP proposed common sub-allocation/ utilisation)	Develop RFSAP with consideration to: ▪ Current re-planning efforts within the 2.6 GHz band. ▪ The allocation of this band to Mobile IMT.
		2520-2655 MHz MOBILE except aeronautical mobile	
		2655-2690 MHz MOBILE except aeronautical mobile Radio astronomy	

Table 31: Radio Frequency Migration Plan for 2500-2690 MHz

8.9.5 Options for 2500-2690 MHz

With respect to the ITU plan:

- Option C2 requires the identification of an FDD downlink assignment external to the 2.6 GHz band. Since this downlink has not yet been identified, this option is not recommended.
- Option C1 is chosen by most operators worldwide. The allocation of this band to Mobile IMT is as follows:
  - IMT-FDD 2500-2570 // 2620-2690 MHz: 2×70 MHz for;
    - 7×2×10 MHz for max 7 operators; or
    - 2×2×20 MHz and 3×2×10 MHz for 5 operators; or
  - 2×2×20 MHz and 2×2×15 MHz for 4 operators. [22]Guard bands for less prioritised usage from 2570-2575 MHz and 2615-2620 MHz in TDD band due to improved spectrum efficiency compared to guard bands in FDD band;
  - IMT-TDD 2575-2615 MHz - 40 MHz macro cell within 2570-2620 MHz;
  - 50 MHz for indoor usage should be assigned to one operator or at least with the obligation to all licensees to use the same TDD downlink scheme; and
  - The FDD-part of the IMT2600 band might be assigned to 4 to 7 MNOs from 2×10 MHz up to 2×20 MHz according to their demands.

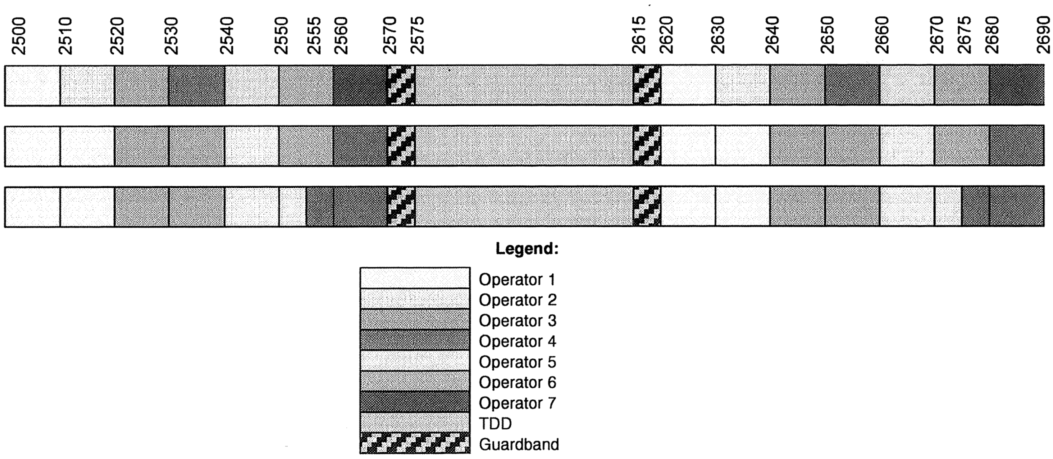


Figure 45: Frequency allocation examples of 2500-2690 MHz

[22] Telkom suggested an additional 3×2×20 MHz and 2×10 MHz for 5 operators (in the response to the consultation).

8.9.6 WBS Migration

Currently WBS is licensed for 2550-2565 MHz. They use 14 MHz TDD-SCDMA technology. WBS started TDD-SCDMA in 2005 and announced the migration to LTE-TDD in 2011.

The migration of WBS out of this band is essential for the use of the IMT2600 band, otherwise 2×25 MHz could not be used because:

- 15 MHz in the downlink are not usable for IMT; and
- 2×5 MHz in uplink and downlink are needed as guard band to TDD-SCDMA.

A possible migration into 2380-2400 MHz adds 6 MHz to WBS's current assignment and the opportunity to modernise equipment to IMT-TDD with significantly higher spectral efficiency. The migration might take place in 2 phases:

- Immediately to 2575-2590 MHz - a temporary move from the FDD-part to the TDD-part until the TDD-band will be used by the new licensees; and
- Migration to 2380-2400 MHz.

The temporary in-band migration is expected as a minimum cost solution for WBS if its base stations and terminals operate in this part of the band as well, but it is still a temporary solution. An analysis of the currently-used modem technical description of Navini Networks (Table 32 below) suggests that the modems would work in the TDD-part of 2600, but no terminal would be available for this technology in 2380-2400 MHz.

Modem	Model	Frequency range	Operating band
2.3 GHz LMX	2305-2360 LMX E	2.305-2.360 GHz	WCS
2.4 GHz LMX	2400-2483 LMX E	2.400-2.483 GHz	ISM
2.5-2.6 GHz LMX	2.5-2.6 LMX E	2.500-2.686 GHz	EBS-BRS
3.4 GHz LMX	3410-3525 LMX E	3.410-3.525 GHz	WLL
3.5 GHz LMX	3475-3600 LMX E	3.475-3.600 GHz	WLL

Table 32: Terminals for operation in 2600 MHz band

The migration to 2380-2400 MHz would consequently escalate costs to the technology migration from TDD-SCDMA to IMT-TDD, as new antennas and filters will be necessary.

Conclusion

As WBS is using 14 MHz Time Division Synchronous Code Division Multiple Access (TD-SCDMA) in the IMT2600 FDD band and this effectively blocks 50 MHz of potential assignments, WBS should nevertheless migrate out of this radio frequency band as soon as is practicable. Two options for WBS were indicated for consultation:

1. **Scenario 1: Migration from FDD to TDD band of IMT2600**: This in-band migration within the IMT2600 band may only require retuning of the current base station equipment, while the user terminals would probably remain unaffected; therefore, migration could be achieved within a relatively short time frame. The in-band migration process blocks 25 MHz (50%) of the unpaired IMT2600 spectrum.

2. **Scenario 2: Migration to 2380-2400 MHz band**: This gives WBS significantly more capacity for their current users (from 14 to 20 MHz and improvement of spectral efficiency from 3G to 4G). WBS equipment would need to be modernised, new antennas are probably required, but more energy-efficient technology would be expected to reduce the operational expenditure. LTE TDD terminals are currently available and it is expected that 2-3 years are sufficient for WBS to migrate to the final destination band. WBS would have to migrate by 31st March 2015 from the FDD part to the TDD part as per Phase 0 of Scenario 1. The temporary assignment in the TDD part must then be vacated by 31st March 2017.

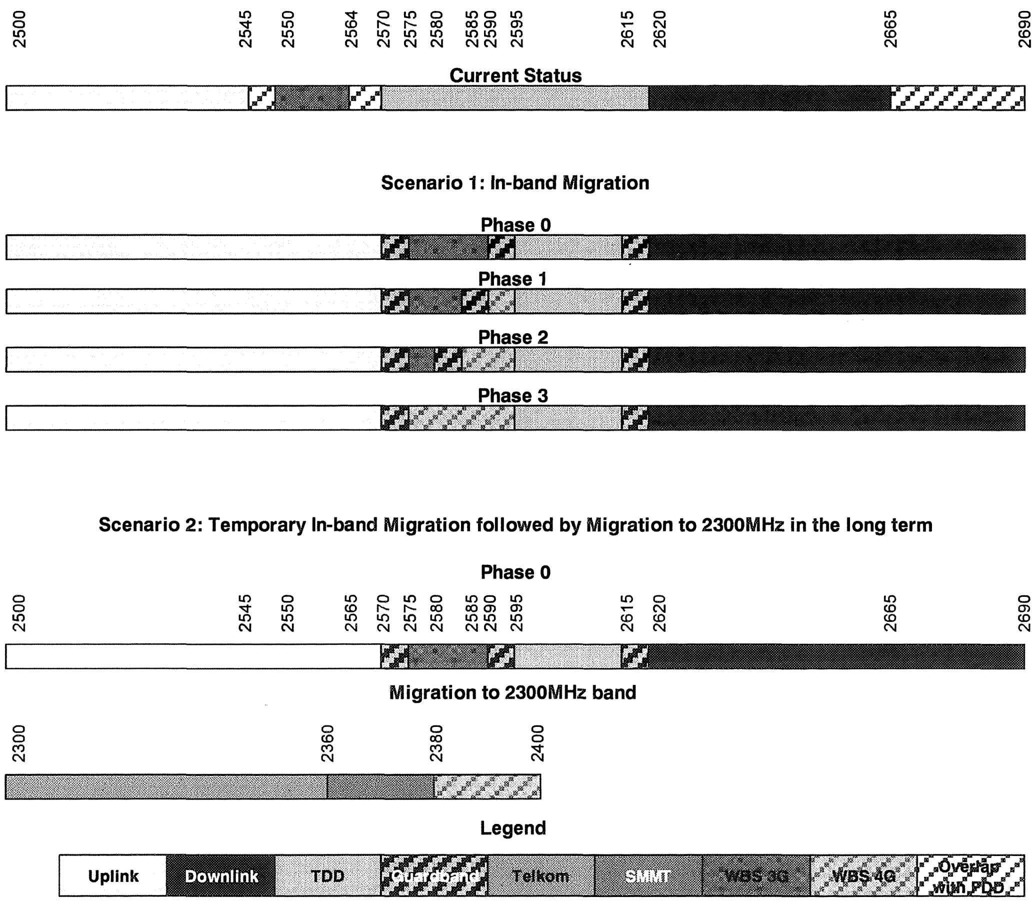


Figure 46: WBS migration scenarios

In Figure 46, the current assignment of WBS in 2550-2565 MHz, could be migrated immediately (Phase 0) to 2575-2590 MHz with two 5 MHz guard bands between the paired and unpaired spectrum. In the case of Scenario 1, in subsequent phases, WBS could migrate their current 3G-users to the unpaired IMT spectrum beginning from 2590-2595 MHz first, then 2585-2595 MHz and finally 2575-2595 MHz. WBS can deploy modernised hardware, but is limited to 5 or 10 MHz in intermediate phases.

In this scenario WBS as well as the other operators in the IMT2600 deploying services in unpaired spectrum would have the obligation to use:

- The same unpaired downlink scheme to prevent the need for an additional 5 MHz guard bands; and
- The 5 MHz guard band to IMT FDD in a protected mode so as not to interfere with the paired FDD spectrum.

Scenario 2 has the same Phase 0 as Scenario 1, but WBS migrates to 2380-2400 MHz.

The Authority has decided that Scenario 2 should be followed.

8.10 3400-3600 MHz band

8.10.1 ITU Position on 3400-3600 MHz

ITU Recommendation ITU-R M.1036-4 (03/2012) states the following. The recommended frequency arrangements for implementation of IMT in the band 3400-3600 MHz are summarised below:

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

Table 33: Frequency arrangements in the band 3400-3600 MHz

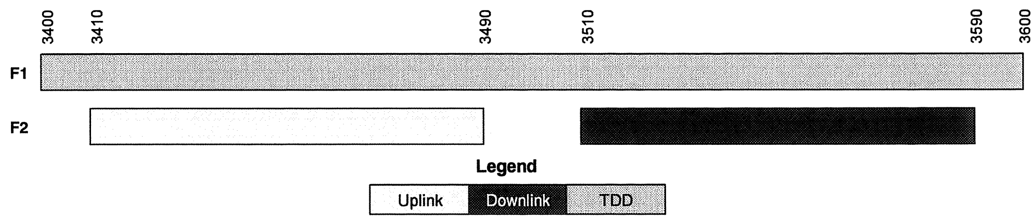


Figure 47: Frequency arrangements for 3400-3600 MHz

8.10.2 SADC Position on 3400-3600 MHz

The SADC Frequency Allocation Plan proposes that the 3400-3600 MHz be allocated to IMT and BFWA.

The 3400-3600 MHz band is currently used mainly for BFWA systems in various SADC countries and, as from 17 November 2010, is also allocated to mobile services identified for IMT.

The SADC FAP recognises that frequency channelisation of several key frequency bands must be developed and preferably harmonised throughout SADC. The frequency bands used for IMT, 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
3 400-3 600 MHz FIXED FIXED-SATELLITE (space-to-Earth) Mobile 5.430A	**3 400-3 600 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

Radiolocation 5.431			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 IMT; channelling plan to be developed.

Table 34: SADC position on 3400-3600MHz

8.10.3 National Radio Frequency Plan on 3400-3600 MHz

ITU Region 1 allocation and footnotes	South African Allocation and footnotes	Typical Applications	Comments
3400 – 3600MHz	**3400-3600MHz**		
FIXED	FIXED	FWA (3400-3600 MHz)	
FIXED SATELLITE (space to Earth)	MOBILE	IMT3500 (3410-3490 MHz)	PAIRED with 3510-3590 MHz
Mobile 5.430A	5.430A, NF9	IMT3500(3510-3590 MHz)	PAIRED with 3410-3490 MHz
Radiolocation			
5.431			

Table 35: National Radio Frequency Plan for 3400-3600 MHz

Relevant Footnotes:

5.430A Different category of service: in Albania, Algeria, Germany, Andorra, Saudi Arabia, Austria, Azerbaijan, Bahrain, Belgium, Benin, Bosnia and Herzegovina, Botswana, Bulgaria, Burkina Faso, Cameroon, Cyprus, Vatican, Congo (Rep. of the), Côte d'Ivoire, Croatia, Denmark, Egypt, Spain, Estonia, Finland, France and French overseas departments and communities in Region 1, Gabon, Georgia, Greece, Guinea, Hungary, Ireland, Iceland, Israel, Italy, Jordan, Kuwait, Lesotho, Latvia, The Former Yugoslav Republic of Macedonia, Liechtenstein, Lithuania, Malawi, Mali, Malta, Morocco, Mauritania, Moldova, Monaco, Mongolia, Montenegro, Mozambique, Namibia, Niger, Norway, Oman, Netherlands, Poland, Portugal, Qatar, the Syrian Arab Republic, the Dem. Rep. of the Congo, Slovakia, Czech Rep., Romania, United Kingdom, San Marino, Senegal, Serbia, Sierra Leone, Slovenia, South Africa, Sweden, Switzerland, Swaziland, Chad, Togo, Tunisia, Turkey, Ukraine, Zambia and Zimbabwe, the band 3 400-3 600 MHz is allocated to the mobile, except aeronautical mobile, service on a primary basis subject to agreement obtained under No. 9.21 with other administrations and is identified for International Mobile Telecommunications (IMT). This identification does not preclude the use of this band by any application of the services to which it is allocated and does not establish priority in the Radio

Regulations. At the stage of co-ordination the provisions of Nos. 9.17 and 9.18 also apply. Before an administration brings into use a (base or mobile) station of the mobile service in this band, it shall ensure that the power flux-density (pfd) produced at 3 m above ground does not exceed −154.5 dB(W/(m^2• 4 kHz)) for more than 20% of time at the border of the territory of any other administration. This limit may be exceeded on the territory of any country whose administration has so agreed. In order to ensure that the pfd limit at the border of the territory of any other administration is met, the calculations and verification shall be made, taking into account all relevant information, with the mutual agreement of both administrations (the administration responsible for the terrestrial station and the administration responsible for the earth station), with the assistance of the Bureau if so requested. In case of disagreement, the calculation and verification of the pfd shall be made by the Bureau, taking into account the information referred to above. Stations of the mobile service in the band 3 400-3 600 MHz shall not claim more protection from space stations than that provided in Table 21 4 of the Radio Regulations (Edition of 2004). This allocation is effective from 17 November 2010. (WRC 12)

8.10.4 Radio Frequency Migration Plan for 3400-3600 MHz

Frequency band (MHz)	Allocation in NRFP 2013 (applications)	Proposed utilisation/ applications	Notes on migration/ usage
3400 – 3600	FIXED MOBILE except aeronautical mobile	Mobile IMT (as per SADC FAP proposed common sub-allocation/ utilisation)	Develop RFSAP with consideration to: ■ Allocate for mobile service on a primary basis and use for Mobile IMT. This would also result in a harmonised Mobile IMT band across the entire SADC region. ■ Migrate existing users out of the band.

Table 36: Radio Frequency Migration Plan for 3400-3600 MHz

The Authority intends to develop a Radio Frequency Spectrum Assignment Plan (RFSAP) with consideration to:

- allocating mobile service on a primary basis for use of Mobile IMT; this would also result in a harmonised Mobile IMT band across the entire SADC region;
- migrating existing users out of the band;
- considering the concerns of Inmarsat regarding BFWA interference with earth stations.

8.10.5 Options for the 3400-3600 MHz band

- This band is assigned in South Africa, 2×28 MHz is used by Telkom and assigned to Neotel (but minor utilisation) and to USALs;
- This band has a very large bandwidth, high propagation loss and penetration loss.

- Trials demonstrated a seamless TDD-LTE option over existing WiMAX infrastructure, offering a smooth migration path from WiMAX to TDD-LTE;
- Potential usage in South Africa:
  - Full IMT-TDD usage with larger TDD downlink schemes in the lower part of the band and reduced smaller part with TDD uplink schemes in the higher part due to reduced coverage degradation of uplink schemes, therefore almost comparable coverage areas;
  - It could be decided based on traffic and asymmetry requirements which option might be chosen finally;
  - Between TDD downlink and TDD uplink schemes at least 5 MHz are needed;
  - The Authority might introduce the Managed Spectrum Park (MSP) concept later. In this concept, the operators have to exercise special care to minimise interferences. This MSP concept could be attractive for about 20 MHz in TDD; and
  - Alternatively, this guard band could be used for indoor DECT systems.

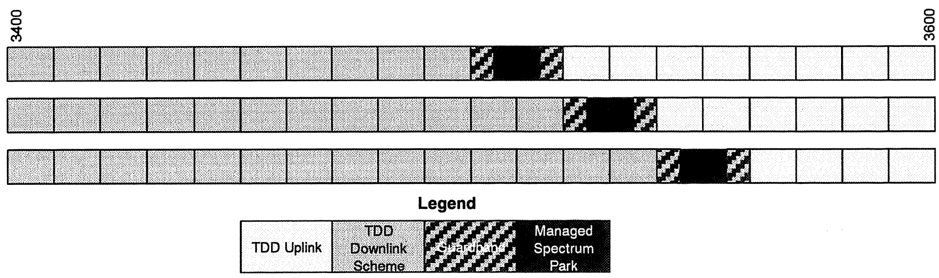


Figure 48: Potential LTE-TDD-assignments in 3400-3600 MHz

Conclusions

In the case of the IMT3500 band, South Africa is to take into consideration, as appropriate, the relevant ITU-R report and traffic expectations at that time. The Authority may assign special uplink or downlink configurations to minimize guard bands. The Block Edge Masks are to be taken into consideration in order to allow unsynchronized usage as well as to minimize the need for guard bands. The managed spectrum park concept is to be taken into consideration.

Based on the consultation, IMT3500 may be considered for assignment with a TDD focus and potentially bundled together with other spectrum bands.

9 IMT Roadmap: Time Frame

9.1 Time frame overview

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

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

9.2 Calendar of expected activities by year

YEAR	Activities foreseen to take place and deadlines foreseen to occur within the Calendar Year
2014	Current • 380-400 MHz band has already been assigned as PPDR usage band with TETRA as one technological option. • SAPS have already started migration out of 406-420 MHz to TETRA in the 380-387//390-397 MHz band. • The remaining 2×3 MHz in the 380-400 MHz band is available for use by emergency, security, and airport services. Foreseen • Process of assignment of 700, 800 and 2600 FDD IMT-spectrum starts.
2015	• As per ITU Resolutions 224 WRC07 and 232 WRC12, the DTT process is completed within 470-694 MHz and Analogue Switch Off (ASO) takes place by mid-2015. • Preparation of co-existence trials for 450-470 MHz. • Implementation / rollout of new IMT spectrum (700, 800 and 2600 MHz) starts after ASO. • 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.

2016	• Coexistence trials with respect to the 450-470 MHz band will be carried out during 2016 in urban and rural areas. To evaluate guard bands to broadcast channel 21 and TETRA-like narrowband systems (In concordance with potential IMT450-vendors and Transnet).
	• 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[23]MHz bands (paired or unpaired); and
	  ◦ In case of PPDR-use - also to 387-390//397-400 MHz
	migration completed by 2022 (max 7 years).
	• Fixed links (e.g. Telkom) potentially migrated to 2025-2110 MHz band and/or 2200 – 2285 MHz band.
	• 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 2018 (3 years);
	  ◦ Phase 2: 80% of urban used licenses is cleared for IMT450 end of 2022 (7 years); and
	  ◦ Phase 3: 100% of 450-470 MHz is cleared by end of 2024 (9 years).

2017	Depending on co-existence trial results[24]: • **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 5 years of migration plus 2 years of dual illumination. ◦ Transnet may also opt to migrate to GSM-R [25]
2018	• Potential 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

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

[24] The licensees are at liberty to migrate out of 450-470 MHz earlier, independently from the results of the co-existence trials.

[25] And possibly later to LTE-R in the IMT850 band. It can be anticipated that Transnet (and more probably PRASA) would use a TETRA network for operation and mission critical services and use LTE-R for broadband services. Much of the GSM-R equipment can be reused for LTE-R.

	urban) according to migration Phase 1 where there is no interference to Transnet or other licensees (e.g. reduced power levels); existing licensees remain prioritised.
2020-2022	• Target of SA Connect broadband initiative in South Africa is achieved: (ref IMT coverage and capacity obligations in Chapter 10). • Transnet completes migration (deployment) and continues dual illumination phase (in line with Transnet`s option 3
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.

10 IMT Spectrum and Universal Service Obligations

10.1 Objectives of SA Connect

The South Africa Connect broadband policy targets are as indicated in Table 37 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 37: 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.

10.2 Broadband challenge in South Africa

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

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

A general rule of telecommunications is that, by virtue of geography, it is generally true that the highest revenue customers are the cheapest and easiest to serve as business, and the rich tend to cluster. The main providers of broadband in South Africa are the mobile customers and it is probably true to say that the mobile providers are fast approaching the point where the economic customers have been captured. In the GSM rollout, a key driver was the need to demonstrate market share and competitive coverage.

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

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

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

The priority underserved areas

The map of population density (Figure 49) 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[26]. 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[27].

---

[26] 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.

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

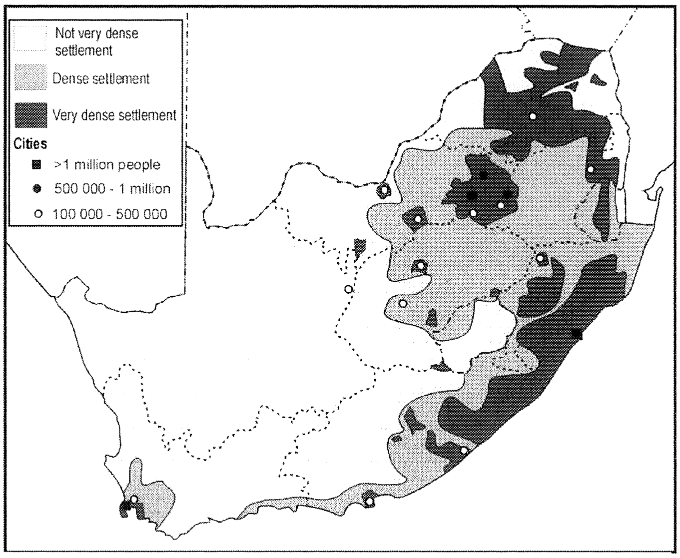


Figure 49: Population densities in South Africa

10.3 Considerations for assignment

10.3.1 To link or not to link frequency bands

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

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

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

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

10.3.2 Individual Assignment or Wholesale

The issue of whether the 700 and 800 MHz bands (or even 450-470 MHz band) should be assigned on an individual basis or on a wholesale, open-access basis is beyond the scope of the present document, however whatever the option that is chosen, obligations should be imposed on the licensee.

10.4 Assignment: Obligations for Licensees

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

Coverage and capacity obligation per IMT band in South Africa:

- 450-470 MHz
  - Coverage obligations for licensee by end of 2025 (mobile terminals assumed):
    - All areas with at least 100 inhabitants to be covered indoor (with indoor penetration assumption of 10 dB) with minimum user data rate of 150 kbps uplink and 300 kbps downlink;
    - All main roads (national and provincial routes) in-car (equal to at least 10 dB penetration assumption) and metropolitan railways[28](equal to at least 20 dB penetration assumption in carriage).
    - All smaller settlements with less than 100 inhabitants (and more than 20 inhabitants) to be covered outdoor with minimum user data rate of 150 kbps uplink and 300 kbps downlink;
    - Special areas of interest such as tourism areas to be covered outdoor with minimum user data rate in 150 kbps uplink and 300 kbps downlink; and
    - The outdoor obligations could be met by using fixed mobile stations with external high gain antennas and Wi-Fi service distribution. This coverage has to be assigned separately in coverage maps.
  - FDD and TDD: Capacity obligation of minimum uplink and downlink user data rate of 100 kbps for 90% of active users in the cell in the busy hour.
- 700 MHz or 800 MHz (different assignments of 2×5 MHz)
  - Coverage obligations for licensees by end of 2020 (mobile terminals assumed):
    - All centres with at least 1000 inhabitants to be covered indoor (with indoor penetration assumption of 15 dB) with minimum user data rate of 150 kbps uplink and 500 kbps downlink.
  - Capacity obligation of minimum uplink user data rate of 100 kbps for 90% of active users in the cell in the busy hour.
  - Capacity obligation of minimum downlink user data rate of 300 kbps for 90% of active users in the cell in the busy hour.
- 850 MHz (2×5 MHz currently assigned to Neotel, now used for CDMA)

---

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

- Coverage obligations to be defined pending resolution of interference situation with GSM-R.
- Capacity obligation of minimum uplink user data rate of 100 kbps for 90% of active users in the cell in the busy hour.
- Capacity obligation of minimum downlink user data rate of 300 kbps for 90% of active users in the cell in the busy hour.
- Capacity obligations must also be met by current licensees.

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

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

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

11 Considerations Arising out of IMT Roadmap

Within this IMT roadmap, the following important recommendations will be highlighted:

450 - 470 band

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

700 and 800 bands

- IMT700 and IMT800 offer 2×63 MHz (for both ITU Region 1 and ITU Region 3).
- Option 2 and Option 3 (ITU Region 1) offer in addition 10-15 MHz TDD spectrum and are therefore more spectrum-efficient if the TDD band is used;
    - potential channelisation of IMT750 will be decided at WRC-15 and based on WP5D recommendation.
- Option 1 (ITU Region 3) offers a larger ecosystem currently, but ITU Region 3 equipment could also be used in ITU Region 1, at least within the 30 MHz international roaming band.
- In addition, Option 1 (ITU Region 3) would offer 2×10 MHz instead of 2×5 MHz in IMT850 **only if there is no implementation of GSM-R**, but this is not the case for South Africa. Therefore, in this context, the Option 2 and 3 (ITU Region 1) solutions are more advantageous.

CDMA and GSM-R

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

900 band

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

1800 and 2100 bands

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

2300 band

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

2600 band

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

3500 band

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

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

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

Appendix A Feasibility Study for IMT in 450-470 MHz

A feasibility study concerning the 450-470 MHz band based on the Frequency Band Migration Regulation and Plan contained in the Government Gazette No. 36334, Notice No. 352 of 3rd April 2013.

A.1 Introduction

A.1.1 ITU Position on 450-470 MHz

3GPP completed the standardisation process of the 450 MHz band in September 2013. The ITU Recommendation ITU-R M.1036-4 (03/2012) states the following: The recommended frequency arrangements for implementation of IMT in the band 450-470 MHz are summarised in Table 38.

Frequency arrange ments	Paired arrangements				Unpaired 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

Table 38: Frequency arrangements in the band 450-470 MHz

Notes to Table 38

NOTE 1 – The number of frequency arrangements given in Table 2 reflects the fact that administrations have had to accommodate incumbent operations, while, for example, maintaining a common uplink/downlink structure (uplink in the lower 10 MHz, downlink in the upper 10 MHz) for FDD arrangements.

NOTE 2 – Arrangements D7, D8 and D9 can be implemented by administrations that have the whole 450-470 MHz band available for IMT. Arrangement D8 can also be implemented by administrations having only a subset of the band available for IMT.

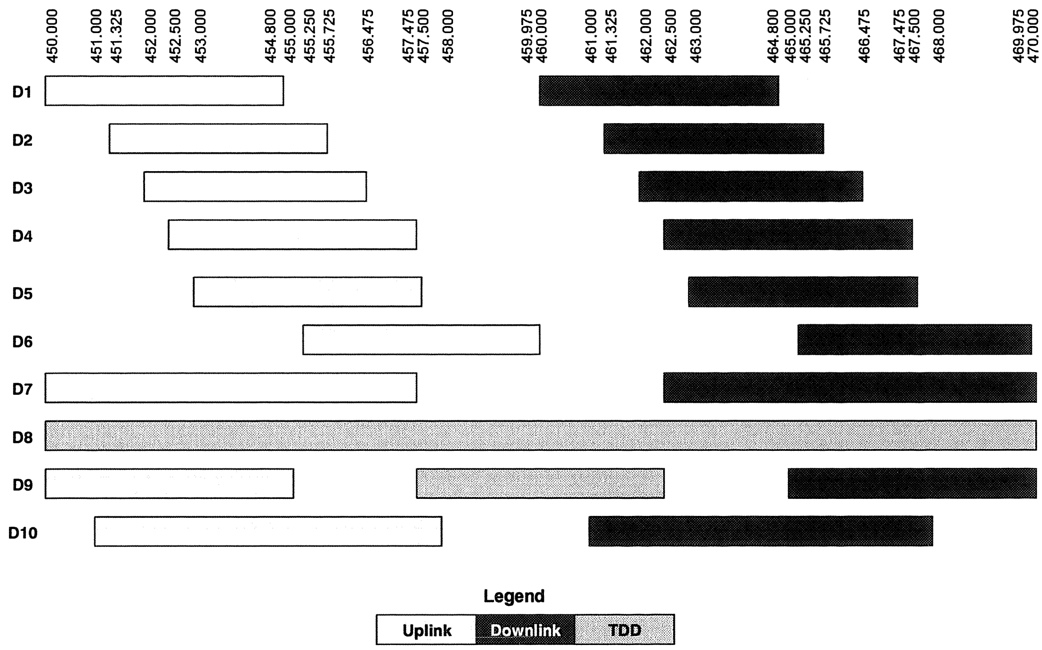


Figure 50: IMT-options for 450-470 MHz

- In the case of LTE FDD usage in the IMT450-470 band, a bandwidth of 5 or 10 MHz is standardised. If this does not change with LTE-Advanced, some of the options might not be spectrum-efficient, e.g., option D7 or D10 would waste 2×(2-2.5 MHz).
- Options D1-D6 are valid options with different pros and cons using about 50% of the spectrum, probably less due to established guard bands. It has to be evaluated if guard bands are needed and how large they have to be introduced. At least for TETRA-like systems 1 MHz guard band is required as shown in US-700 band plan for TETRA and LTE. The guard band to channel 21 (470-478 MHz) is a major selection criterion for the possible IMT450 options.
- Option D8 is a full TDD solution. It is expected that some guard band close to broadcasters might be necessary. So, 15 MHz for IMT usage are assumed so far in 451-466 MHz. In some regions, 10 MHz (e.g. 455-465 MHz) might be used outdoor and indoor, while the remaining 10 MHz might be used partly for indoor only due to better separation. Option D8 gives the opportunity to extend IMT450 into digital dividend III.

The tight FDD duplex gap creates an effect known as self-defence whereby false signals from the transmitter are caught up by the receiver thus degrading the system's performance. This duplex gap is the smallest under analysis at 3GPP, making FDD at 450 MHz the most challenging band ever considered. Ways are available to tackle this problem, but at the expense of increased terminal complexity. User terminals constitute the most critical piece of equipment in a cellular network, as constraints on their cost, size and weight are more stringent than the constraints on base stations. The 450-470 MHz capable terminals could evolve steadily with the user demand, starting with larger fixed CPEs with 450 MHz external (or additional outdoor) antennas or embedded in cars and Wi-Fi capability to support the classical smart phones (Wi-Fi offload). In a second wave, multimode smart phones or tablets might arise which offer direct access to the IMT450 network also in real mobile situations. For the large number of M2M devices, which have to be small and cheap, the desensitisation issue is not a problem because they are transmitting most of the time, which favours TDD instead of FDD. M2M devices should be small in general, but for 450 MHz, the required antenna should be larger and may cause concerns for some applications.

A.1.2 SADC FAP on 450-470 MHz

The SADC Frequency Allocation Plan (Table 39) proposes that the 450-470 MHz band be allocated to Fixed Links (PtP), IMT, PMR and/or PAMR. There is no preference given for IMT over other services.

The 450-470 MHz band is currently used for a variety of fixed and mobile systems in various SADC countries.

The SADC FAP recognises that frequency channelisation of several key frequency bands must be developed and preferably harmonised throughout SADC. 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
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 5.271 5.287 5.288	**456-459 MHz** FIXED MOBILE 5.286AA, 5.287		
459-460 MHz FIXED MOBILE 5.286AA,	**459-460 MHz** FIXED MOBILE 5.286AA 5.209 5.286A		

5.209 5.271 5.286A, 5.286B 5.286C 5.286E			
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		

Table 39: 450-470MHz SADC Frequency Allocation Plan

A.1.3 National Radio Frequency Plan

On review of the National Radio Frequency Spectrum Plan contained in Government Gazette No. 36336, Vol. 576, 2013 (which incorporates the decisions made at World Radiocommunications Conferences, up to and including WRC-2 which was concluded in Geneva in February 2012), the following allocations for the 450-470 MHz band were noted:

ITU Region 1 allocations and footnote	South African allocations and footnotes	Typical Applications	Comments
450-455 MHz FIXED MOBILE 5.286AA, 5.209, 5.271, 5.286, 5.286A, 5.286B, 5.286C,5.286D, 5.286E	**400-455 MHz** FIXED MOBILE 5.286AA, NF9 5.209, 5.286, 5.286A	Fixed links (450-453 MHz) Single Frequency Mobile (453-454 MHz) Paging (454-454.425 MHz) Trunked Mobile BTX (454.425-460 MHz) IMT 450(450-470 MHz)	Paired with 460-463 MHz Government Services Paired with 464.425-470 MHz
455-456 MHz FIXED MOBILE 5.286AA 5.209, 5.271, 5.286A,	**455-456 MHz** FIXED MOBILE (5.286AA, NF9	Trunked Mobile BTX (454.425-460 MHz) IMT 450(450-470 MHz) Government Services	Paired with 464.425-470 MHz

IMT Roadmap 2014

5.286B, 5.286C, 5.286E	5.209, 5.286A		
456-459 MHz FIXED MOBILE 5.286AA 5.271, 5.287, 5.288	**456-459 MHz** FIXED MOBILE 5.286AA, NF9 5.287	Trunked Mobile BTX (454.425-460 MHz) IMT 450(450-470 MHz) Government Services	Paired with 464.425-470 MHz
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, NF9 5.209, 5.271, 5.286A	Trunked Mobile BTX (454.425 - 460 MHz) IMT 450(450-470 MHz) Government Services	Paired with 464.425-470 MHz
460-470 MHz FIXED MOBILE 5.286AA	**460-470 MHz** FIXED MOBILE 5.286AA, NF9	Fixed links (460-463 MHz) Single Frequency Mobile (463.025-463.975 MHz), Low Power Mobile Radio(463.975 MHz, 464.125 MHz, 464.175 MHz, 464.325 MHz, 464.375 MHz) Single Frequency Mobile (464.375-464.425 MHz) Trunked Mobile MTX (464-470 MHz) IMT 450(450-470 MHz); Security Systems (464.5375 MHz) Non specific SRDs (464.5-	Paired with 450-453 MHz; Radio Frequency Spectrum Regulations Annex B GG No 34172, 31 March 2011) Paired with 454.425-460 MHz

Meteorological satellite (space to Earth) 5.287, 5.288, 5.289, 5.290	2.287, 5.289	464.5875 MHz) Government Services	Radio Frequency Spectrum Regulations (Annex B (GG. No 34172, 31 March 2011)

Table 40: 450-470MHz allocations in the NRFP

A.1.4 Radio Frequency Migration Plan for 450-470 MHz

Frequency Band (MHz)	Allocation in NRFP 2013 (applications)	Proposed utilisation/ applications	Notes on migration/ usage
450-470 MHz	FIXED MOBILE (Trunked Mobile Railways, Mines etc.)	Has been identified for Mobile (IMT) as per WRC-07 (Res. 224)	Feasibility Study to be carried out on this band.

Table 41: 450-470 MHz migration plan

450-470 MHz band is currently used for, amongst other uses, Trunked Mobile with several users including the railways (i.e. Transnet) and mines (Figure 51). The SADC FAP-proposed, common sub-allocation/utilisation seeks to allocate this spectrum for Mobile IMT and also PTP, PMR and/or PAMR.

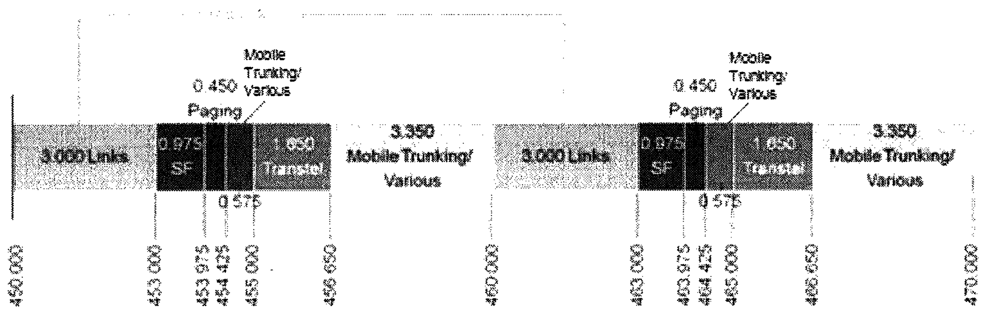


Figure 51: 2012 assignments 450-470 MHz

A.1.5 Constraints

IMT450 is currently less prioritised than DTT in 470-698 MHz, therefore potential guard bands have to be within 450-470 MHz. DTT DSO (digital switch over) is expected to be finalised by the end of 2015. Then interference trials should identify the minimum required guard band. For potential options, 2×5 MHz for FDD or 15 MHz for TDD is assumed. In some regions, some cells might reduce transmitting powers, or are only applicable indoor due to better isolation.

A.1.6 Demand for IMT in the 450-470 MHz band

The IMT450 band is especially needed for improved data coverage in deep-indoor environments and in rural areas to support data connectivity initiatives (e.g. e-Government, e-Health, e-Learning, etc.). The capacity of 2×5 MHz FDD or 1×20 MHz[29] in TDD is limited compared with the 700 MHz band with 2×30 MHz or 2×45 MHz, or 800 MHz band with 2×30 MHz. Therefore, basic services are in focus with reduced capacity and data rate requirements, but improved latency of LTE. In addition operational benefits are expected due to harmonised and optimised core hierarchies.

For more quasi-stationary usage with fixed terminals (and potentially separated outdoor antennas) both technologies could enlarge their coverage significantly. The user penetration could be significantly increased by Wi-Fi offloading of classical smart phones with Wi-Fi capability and IMT backhauling. There might be some Mobile Virtual Network Operators (MVNOs) offering hotspot broadband internet in their restaurants or Wi-Fi kiosks to low income groups in areas that are not currently covered.

Both coverage bands (IMT450 and IMT700) are expected to be embedded in connected car solutions as backhaul technology to other Wi-Fi-capable devices. Potentially larger antenna sizes due to lower frequency are possible within car or home environments than within small smart phones.

Expected services are uplink-oriented/focussed, like M2M, messaging, VoIP over IMS and uplink use of broadcasting services. M2M and "Internet of things IoT" or smart metering/grid services might need different network parameters optimised for uplink or for small data rate requirements. Any congestion due to millions of small-sized messages needs to be prevented. Therefore, an optimised network for M2M applications seems more cost-efficient.

Potential Wi-Fi-offload-oriented areas should be implemented with a balanced or downlink favoured TDD-scheme which would affect the coverage improvements.

In addition to above mentioned usage, alternatively 2×5 MHz FDD could be used for public safety agencies, if needed, in addition to the currently implemented systems (TETRA & WiMAX) within 380-400 MHz for SAPS.

[29] Maximum bandwidth to be considered in dependence to interferences with broadcast channel 21 from 470-478 MHz; 1×15 MHz seems realistic.

A.2 Economic benefit of using 450-470 MHz band for IMT

A.2.1 Coverage Aspects

The 450-470 MHz band is characterised by its small bandwidth (15 MHz or 2×5 MHz) with low propagation loss and penetration loss. Therefore 450-470 MHz is best suited for coverage purposes; the propagation conditions are ~4 dB improved compared to 700 MHz band; penetration losses are also less.

In the case of TDD usage, the coverage is reduced depending on the TDD configuration scheme with downlink preference, e.g. 30% uplink vs. 70% downlink, a 5 dB reduction. So, the overall coverage for mobile terminal or Wi-Fi offloading with IMT backhauling usage might be comparable to 450 MHz TDD and 700 MHz FDD. For uplink preference schemes, the performance reduction, relative to FDD, is less (e.g. 70% uplink vs. 30% downlink has 1.5 dB reduction) and IMT450 has significant coverage advantages over IMT700 with regards to the coverage of economically, less-attractive rural areas with lower capacity demand. For final cost benefit evaluations, the real antenna realisations must be taken into account. In cheap M2M realisations, the antenna performance might degrade by 3dB or more, which reduces coverage benefits of IMT450 relative to IMT700. However, for proper antenna installations or car environments with improved MIMO decoupling opportunities, the full antenna performance secures the coverage gain of IMT450.

It is not clear when the devices for M2M in LTE technology would be available. Currently most M2M services are within 2G networks, especially in GSM900 due to better propagation conditions. It is expected that an increase in M2M traffic would reduce 2G signalling capacity; so some traffic shift to 4G technology would be needed to free up 2G voice capacities again. In addition, current 2G M2M devices might be at the end of their lifetime soon. Even if the 4G M2M demand might be delayed, relative to the network deployment, a clear stimulus is needed to move the industry forward. The rollout delay from the decision made for IMT use to first customer usage of approximately 5-7 years gives the industry sufficient time to engage. New clients for M2M or connected cars would be arising via specialised mobile virtual network operators and less probably via classical mobile network operators. Devices for IMT450 will be in place when needed, depending on the applications, starting with fixed Wi-Fi offload CPEs and mobile dongles, followed by smart phones and finally M2M devices.

It is reasonable to focus on different parameter settings for M2M in a different LTE network from the classical communication networks with LTE downlink focus.

TDD LTE is capable of adjusting to uplink-focused configurations. An operator with TDD spectrum in 450 MHz requires large coverage requirements in uplink. If the same operator owns TDD spectrum in higher bands, e.g. 700, 2300 or 2600 MHz, the different demands could be handled more efficiently. For example, small volume messaging with less priority might be supported by IMT450; high data rate uplink CCTV services in IMT3500 with uplink scheme; then broadcasting services would be better transmitted via IMT700 or IMT3500 in downlink scheme depending on the needed coverage.

(Note: it does not mean that 450 MHz and 2300 MHz would build a quasi FDD-like system because both networks' coverage would differ too much in general, but some uplink-critical applications would be better handled in the 450 MHz band.)

The same idea of uplink TDD spectrum holds also for IMT750 TDD band if IMT450 would be used in FDD 2x5 MHz for PPDR network, e.g. ,operated by SAPS; then the TDD bands of IMT750 and IMT2100 might be paired within one operator.

A.2.2 Value of IMT450 versus IMT700/IMT800

One general issue with the estimation of value and the demand of 450-470 MHz spectrum is the regulator`s obligations or announcements to cover the population with service by ~90%. In the past, the operators (all over the world) have claimed having already reached this target for many years. This might be correct concerning the usual assumptions for coverage of the last years of the deployments of these networks, but it is a well-known fact that terminals worsened over time from the radio perspective. The smaller the terminal size and the more bands to be covered by the small invisible antennas, the higher the degradation in their performance; the larger the displays, the higher the power consumption - smaller battery sizes are also leading to reduced RF output powers. Therefore, the deployment of the networks over time was partly driven by capacity demands, but also by coverage demands to prevent customer complaints. In most cases, the users are shifted from low quality 3G conditions to better 2G coverage conditions with less performance in general. This simple trend is less obvious with more deployments of 3G in 900 MHz as well, after expensive refarming and user traffic migration to 1800 or 2100 MHz bands.

Now it is valuable to have a large coverage network to cover higher data rates at larger distances or within higher penetrations, but the operators, who know their networks best, will not provide real population coverage figures per band or service. They might have internal studies about the 'real' or 'more accurate' population coverage figures, e.g. 77% for GSM900 instead of >95% as promised, or ~45% of UMTS instead of ~75% as announced to get new customers[30],but no operator will reveal the real figures which would be less than regulator obligations. Therefore, no precise studies are available to illustrate the real benefit of new, additional coverage and quality in some areas which are covered now.

IMT450 is most attractive for complementary rollout starting in rural areas and would need new larger terminals (fixed or in-car). In this case new radio access network and backhauling infrastructure has to be deployed and potential sharing is attractive for all players. IMT450, with realistic coverage and capacity obligations over time, might be attractive for a new entrant especially in the instance of non/partially overlapping customers.

[30] These values are just an exemplary guess

But there is also value of spectrum due to competition. If an entrant uses new spectrum, there must be sufficient new spectrum available to give the entrant power of cost-effective competition. This is not the case for 450-470 MHz.

If there were an entrant within 450-470 MHz, there would be a need for additional spectrum in other bands as well, especially in the high capacity, density-frequency ranges. The revenues from the attractive capacity regions would subsidise the cost–intensive, rural rollout with regulator obligations. Even if the observation made above for the deployment of a new network holds also for IMT2300 or IMT3500 as well as IMT450, new tower investments are used at least for two or more networks instead of one.

A.3 Country Examples

A.3.1 Australia

In 2010, Australia conducted a review of the 400-520 MHz band. In Australia, the DTT is already finished. There are no DTT broadcast services in 470-520 MHz . DTT is foreseen

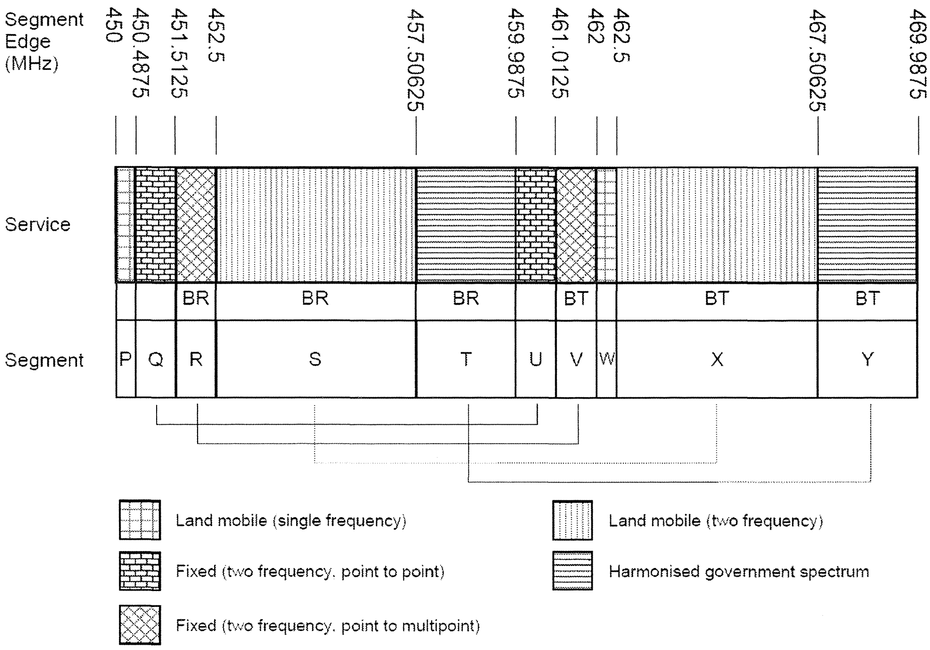


Figure 52: 450-470 MHz band in Australia *(Source ACMA)*

in 520-698 MHz. In response to a review of the 400-520 MHz band, a wide range of changes were introduced including the adoption of 12.5 kHz channels throughout the narrowband channel raster, realignment of segment boundaries and the restructuring of 450–470 MHz to accommodate a 10 MHz duplex frequency split (IMT450-option D4). Segments were set aside to be used exclusively for federal, state and territory government purposes.

Australia opted for a co-existence scenario of IMT and non-IMT technologies, but it is not known if the Australian Communications and Media Authority (ACMA) considered any interference analyses.

A.3.2 Brazil

The 225-470 MHz band was suggested as an alternative to accommodate broadband services and applications in the National Broadband Plan (Plano Nacional de Banda Larga) in 2010. The focus was on providing broadband to rural areas - lower frequency bands are suitable for this. Prior to 2010, the spectrum below 1 GHz was allocated to point-to-point and point-to-multipoint voice services, audio and video broadcasting and other specialised services, such as paging in Brazil. The Brazilian regulatory rules defined that, by December 31, 2015, all rural areas up to 30 km from the headquarters of all Brazilian municipalities must have LTE coverage in the 450 MHz band with voice and data services.

Deadline	Counties serviced	Download rate (kbps)	Upload rate (kbps)
30/06/2014	30	256	128
31/12/2014	60	256	128
31/12/2015	100	256	128
31/12/2017	100	1024	256

Table 42: 4G licence requirements in Brazil *(Source: ANATEL)*

ANATEL allocated IMT450-option D10: two sub-bands of 7 MHz each in the frequency ranges 451-458 MHz and 461-468 MHz to fixed and mobile radio services operating in frequency-division, duplex mode. Brazil auctioned this band along with the 2.5 GHz band in June 2012, assigning the 2×7 MHz of spectrum to mobile operators TIM Brasil, Vivo, Claro, and Oi (each getting all 2×7 MHz of spectrum for a different part of the country).

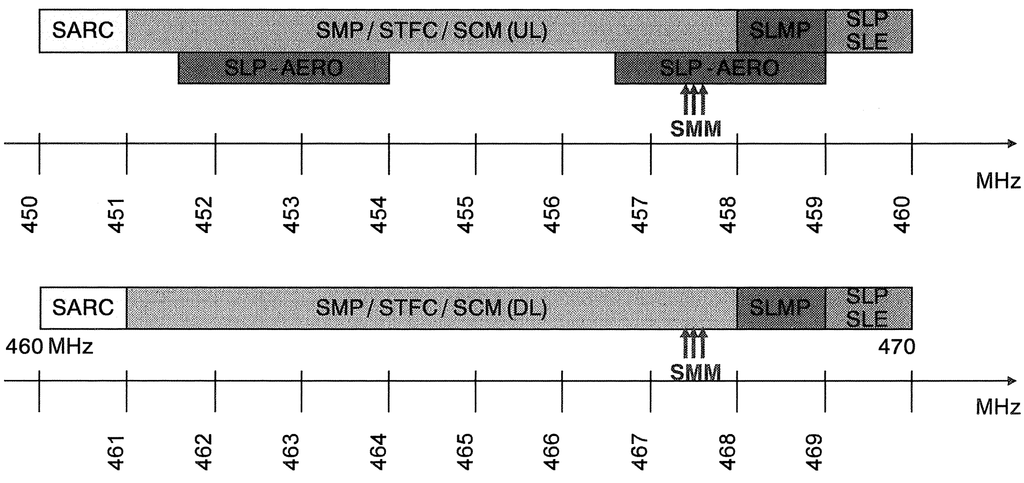


Figure 53: ANATEL Brazil band plan for 450 MHz including co-existence usage

The other services have the following characteristics:

- Random in time (PTT) and in spectrum position (fixed-to-mobile links);
- Use narrow-band channels: 12.5 kHz or 25 kHz (NFM / Voice);
- SLP stations can be applied to low speed data (FSK / PSK), for telemetry;
- There are co-ordination rules among SLP-Aero, SMM and the broadband services. All of them have sub-bands designated in primary basis, without exclusivity;
- SARC – Broadcast Ancillary Service (studio-to-transmitter and studio-to-mobile);

- SMP – Personal Mobile Service (Cellular PCS);
- STFC – POTS (Fixed Switched Voice Service);
- SCM – Multimedia Service (Internet Local Provider);
- SLMP – Private Mobile Limited Service;
- SLP – Private Limited Service (Fixed to Mobile and point-to-point);
- SLE – Specialised Limited Service (Same as SLP, but provided to another enterprise);
- SLP-Aero – Airport ground communications (airport operations); and
- SMM – Maritime Mobile Service (off-shore and ground to off-shore);

It is worth noting, however, that the deployment in the sub-bands allocated by ANATEL yields to a frequency spacing between uplink (at 452-457 MHz) and downlink (at 462-467 MHz) of only 5 MHz.

A.3.2 450 MHz Solutions Being Developed in Brazil

In Brazil, the Centre for Research and Development (CPqD), an independent private foundation, is developing LTE technology adapted to the 450 MHz band. It is designed to meet the challenges of service delivery in rural and suburban areas, the solution consists of several products: antennas; RF devices; eNodeB; split system and network management. The solution, called “LTE 450 MHz” increases coverage, has higher data rates (up to 25 Mbps in download and 12.5 Mbps in upload), consists of an all-IP architecture and has lower latency and better performance when compared with current 3G technologies. CPqD is planning to make the technology available by transferring it to WxBR, a Brazilian company that will be responsible for its production and commercialisation in the global market. Some of the technology was tested in February 2012.

To accelerate the adoption of the frequency allocated by the regulator ANATEL in the 4G auction that took place in June 12, 2012, CPqD is developing a user terminal that transfers the signal to Wi-Fi, so it can be used with the equipment available on the market today. The solution has already caught the attention of operators who deal with CPqD, and they plan to begin testing it in 2013. At its current stage, the solution is not finalised because it requires some additional costs for deployment of LTE 450 MHz transmitters. However, adoption is a very attractive option for mobile services providers that acquired 4G frequency bands last year and must deliver broadband services in rural localities by 2014.

A.3.3 UK

Within Europe, the Radio Spectrum Policy Programmes (RSPP), which was adopted by the European Parliament and Council in April 2012, set out last year its policy objective of seeking to identify a total of at least 1200 MHz of spectrum for mobile broadband by 2015. The RSPG has delivered an opinion on wireless broadband that includes its assessment of which bands may be suitable for wireless broadband in the future, along with an indication of the associated timeframes. The 450-470 MHz band is not being considered at this stage for mobile broadband because:

- current capacity available in the 450-470 MHz band is extensively used by business radio users;
- responses to both Ofcom consultations were relatively limited as was the interest expressed by stakeholders in the prospect of using this band for LTE for public mobile networks in the long term;
- Ofcom also previously noted that the use of larger antenna sizes at this frequency may pose challenges for integration into mobile handsets;
- The low frequency of the band means that it might become beneficial in providing a near ubiquitous coverage layer for applications that do not depend on mass market mobile handsets, e.g. possibly for some future M2M applications. In the Ofcom Spectrum Management Strategy statement they identified enabling growth and innovation in M2M applications as an area for further priority work. Ofcom will therefore keep potential mobile use of this band under review as work on M2M and incumbent use of the band progresses.

A.4 Availability of Devices

The availability of 450 MHz IMT-capable devices is summarised as follows:

- 3GPP standardisation has already taken place;
- The ecosystem for 450 MHz is currently less developed because there are not many IMT assignments currently. This is expected to change when operators announce that they will soon be using the 450 MHz spectrum for IMT ;
- There will be a demand for cheap M2M RF-units in this band as well as for other IMT bands. Due to the limited capacity in 450 MHz the terminals may by design remain simple;
- It is not clear if multimode smart phone terminals would be needed from the beginning. Depending on the operator's service strategy, the demand for fixed CPEs with 450-470 MHz modem and Wi-Fi capability would be sufficient for the initial phase with reduced availability of terminals. In addition, in-car, embedded solutions are more likely to be developed as IMT450 backhaul for general Wi-Fi connectivity;
- In a second phase with higher traffic demands there will be a need for multimode devices (fixed CPEs or smart phones) to enable efficient, traffic-steering mechanisms between different bands, especially in the case of TDD usage between IMT450 and IMT2300, IMT2600 or IMT3500, and the other FDD IMT bands;
- Huawei is commercially testing LTE450 solutions in China, Brazil and Belarus. In the second quarter of 2014, Huawei Technologies will release CPE terminals covering all the local frequency ranges in Brazil. It is expected that these CPEs might be customisable to any local frequency range;
- Brazil has tested terminals – still under development. (Voiceover LTE terminals have been tested);
- One of the companies developing technology for assessment is Aricent;
- Other ecosystem players providing LTE450 MHz support include Altair SemiConductor, which announced chipsets to support the band in November 2012; and
- Qualcomm also has multimode chips that can support LTE operating at 450 MHz.

A.5 Scenarios for 450-470 MHz Band

In general for each band there exist at least 3 possible scenarios for migration:

1. All licensees remain in the band as at present;
2. All licensees have to move to new destination bands within defined time frames; and
3. Parts of the band will be used for IMT; other parts might be used in co-existence with IMT, either nationwide or regionally. It has to be clarified in trials if any co-existence scenario is possible in general due to interference issues.

These three scenarios will be discussed in the following. Any geographical split of IMT450 and non-IMT technologies is possible in general, but NOT recommended due to large separation distances between these technologies.

A.5.1 Remain As-is

A.5.1.1 Description

The 450-470 MHz band is important to the community. It carries radio communications for a diverse range of industry and government organisations that deliver essential public and private services. The band is one of the most heavily used parts of the spectrum and is congested in major cities. But the current use by many different users and applications might lead to inefficient spectrum usage due to different technologies in more or less uncoordinated interference situations. In addition, despite some assignments being effective in use, most telecommunication equipment might be outdated or even unused, and continue obstructing spectrum usage and in most cases they not be updated or upgraded to ensure spectrum-efficient usage.

Some licensees use their spectrum for backhauling purposes despite other professional alternatives in higher bands with higher capacities.

A.5.1.2 Costs

It might be possible to estimate the absolute costs of additional IMT sites for 700 MHz or 800 MHz relative to 450 MHz to cover rural or more areas if the real area demands, targeted terminals and the final technology selection is known. The relative costs of a rural only network within 700 MHz would increase by 55% - 85% relative to 450 MHz. In the case of deep-indoor demands in urban areas for M2M, smart metering, etc., the cost would double in the case of 700 MHz.

These additional costs for rural coverage have to be compared to the migration costs of all different licensees in the case of full migration due to exchanges/tuning of potential splitters of antennas and potential exchange of user terminals.

In addition, current congestion due to inefficient spectrum use in this band might lead to other investments in higher bands due to higher capacity needs. These congestion-related costs might not occur if the migration could be combined with modernisation activities which would result in more efficient spectrum use, on the one hand, or synergy effects due to service migration instead of spectrum migration on the other. It is quite difficult to quantify the opportunity to modernise and harmonise licensees' networks with higher spectrum efficiency, lower power consumption, more features and better operation possibilities.

A.5.2 Partial Allocation to IMT

A.5.2.1 Description

The different IMT450 options might give the opportunity to operate 2×5 MHz IMT in co-existence with other analogue or digital technologies.

Australia opted for a co-existence scenario (option D4), however it is not clear if any interferences or inter-modulation degradations to existing or neighbouring application might occur, especially since Australia does not have to deal with broadcast guard bands. Therefore no interference experiences from Australia are available.

So far, for other IMT bands, no co-existence exists. Between LTE FDD and LTE TDD 5 MHz of guard band are assumed until further optimisation and improved filters would reduce this guard band. IMT450 option D9 retains 2.5 MHz isolation between FDD and TDD on both sides.

Until no other guard band separation to channel 21 (470-478) is known, 2.5 MHz are taken as an initial assumption, shown in Figure 54. The suggestions of Transnet for co-existence usage were also allocated [31] assuming that Transnet`s current spectrum assignment of 2×1.8 MHz will be needed in the future.

[31] Transnet proposed two allocations in some IMT options

IMT Roadmap 2014

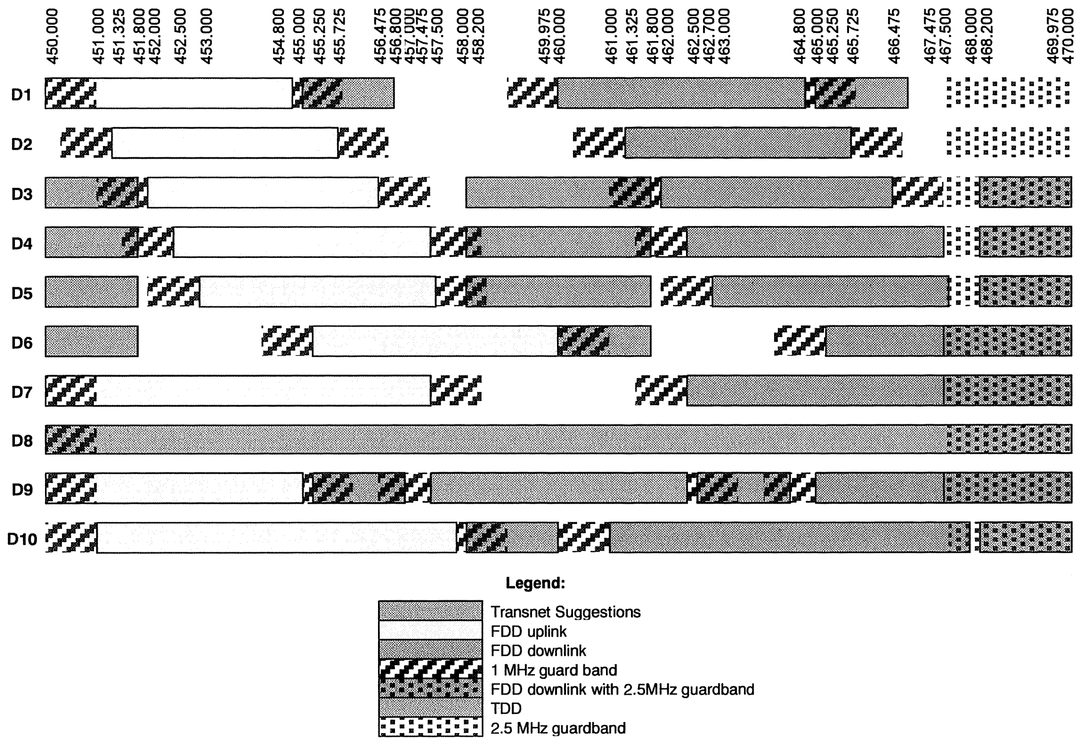


Figure 54: IMT-options for 450-470MHz including 1 MHz guard bands (black hatched) to TETRA (or comparable narrowband systems)

- IMT450-D1, D7 and D9 need 1 MHz separation to 450 MHz, so at least 449-450 MHz might be cleared as well.
- IMT450 option D8 is a no co-existence option. D8 might reduce TDD spectrum until 449-450 MHz is free. It is expected that D8 would start with 15 MHz from 451-466 MHz with 4 MHz isolation to channel 21.
- IMT450-options D6, D7 and D9 would not be possible unless at least 2.5 MHz guard band to channel 21 are needed. D10 would not use the full 7.0 MHz bandwidth for IMT.
- Under these guard band assumptions, the IMT450-options D2-D5 would remain attractive co-existence solutions with different bandwidths, which could range from 2×0.8 to 2×2 MHz with a 10 MHz duplex gap which is good for decoupling. It might be an opportunity for one or two operators to align closely with both networks, e.g. enhanced PPDR services or Transnet/PRASA for broadband services within trains.

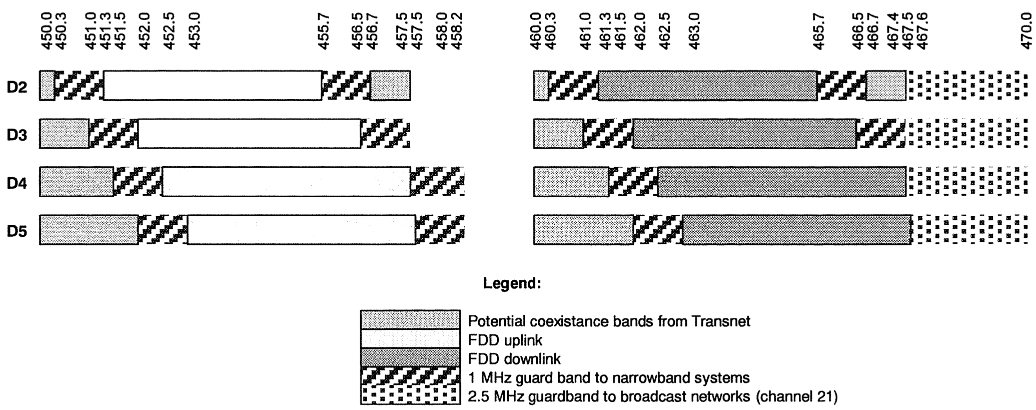


Figure 55: Potential co-existence scenarios for IMT450 with different bandwidths

Transnet's options (green blocks) might range from 2×0.8 MHz to 2×2 MHz, each with 10 MHz duplex gap

A.5.2.2 Costs

For partial allocation of IMT and other technologies, co-existence trials/investigations have to be done in advance to assure the 1 MHz or 2.5 MHz guard bands to prevent unexpected delays of use of IMT due to protection of existing services, especially with higher reliability for operations like Transnet in SA.

These interference trials have not been performed so far and might need to take place over a protracted period until all technologies of interest are investigated. To perform such trials at least some parts of the spectrum have to be cleared, especially in urban areas, which seems unrealistic. It might not be sufficient to test co-existence scenarios and guard band requirements in rural areas only.

In any case, IMT and potential co-existence technologies have to be aligned with option 2×5 MHz FDD. It is not expected that many players would use this band, hence the general directive to migrate all existing licensees out of IMT450. (Otherwise the process could be a time-consuming, and lengthy and make any IMT usage and potential planning and deployments more and more expensive). Some IMT users might search for alternatives to cover their IMT demands – such alternatives might be more expensive in the long term.

Therefore, the costs of investing in new equipment remains high for most licensees, except for those few licensees who might be able to tune potential splitters to the lower sub-band parts. However, these licensees would still have to invest in modernisation of equipment even if they do not migrate.

A.5.3 Full Allocation to IMT

A.5.3.1 Description

In the responses to the draft Radio Frequency Migration Plan with regard to full allocation to IMT, the stakeholder responses can be summarised as follows:

- **Cell C, Neotel, Altech, MTN, QUALCOMM** and **Telkom** support the migration proposal;
- **SAPS:** recommends a dedicated public safety broadband, guiding public safety users to build a shared infrastructure or at least standardise on one technology;
- **Altech:** proposes to dedicate band for Public Safety LTE; encourage Public Safety users to adopt a common standard and common platform;
- **Banzinet** made suggestions to use higher spectrum ranges:
  - No push to talk technology is currently available in the 3 GHz band, also the required number of base stations would be 3-4 times the current number to provide the same coverage;
  - **Proposal**: **470-485 MHz** band to be made available for rural broadband; also trunking technology from **485-530 MHz;**
  - **Proposal**: use GSM-R spectrum (876-880 and 921-925 MHz) for rail operators;
- **Transnet** modernised large parts of their (analogue) equipment in 2012 and suggested a minimum usage time from of 7-10 years (~2019-2022). Transnet expected 3 years of dual illumination with new technology and/or spectrum;
- **Transnet** suggested (option 2) a co-existence scenarios with IMT-services with 450-470 MHz (to reuse equipment)
- **Banzinet** and **Transnet** (option 3): Migration to 410-430 MHz band for public trunking services, but clearance of new destination required
- **Telkom**: stated further consultation needed: time frame, IMT-options D1-10, technical, social and economic consequences
- **Telkom**: migration of 690 networks (with low capacity long hop length Point to Point (PtP) links): expensive and unclear feasibility for new spectrum.

The full allocation of the 450-470 MHz band to IMT would increase spectrum efficiency and would give a general opportunity to modernise the different networks to cost-efficient realisations of different service demands. If the full band were to be cleared, all existing licensees would be able to move without the need of prioritisation and potential delays in the migration process.

Consideration should be given to clearing the whole band to also enable TDD usage, which would be quite favourable for M2M and IoT uplink-oriented applications.

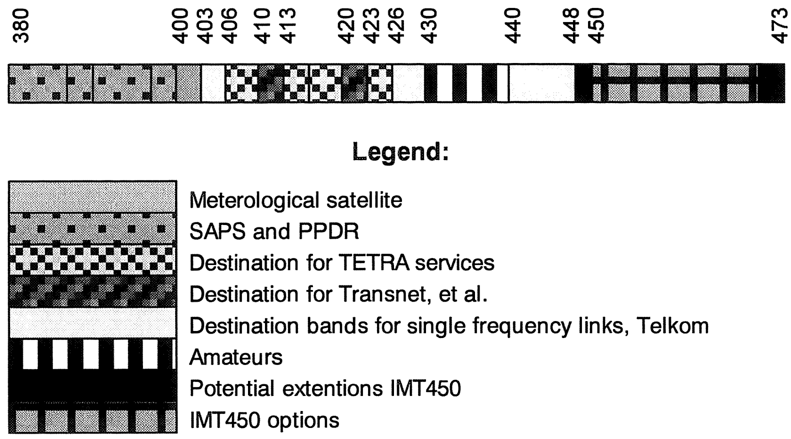


Figure 56: 450-470 MHz potential destination spectrum

Suggested timeline:

- Migration starts 2016 and is finished in 2022;
- Dual illumination stops 2024;
- **SAPS:** free up 406-426 MHz and migrate to 380-400 MHz:
  - **SAPS** have already started in 2010 migration from 406-410//416-420 and 413-416//423-426 MHz (for R1 billion (est.)) with 5-year migration plan until 2015, suggested/potential delay of 1 year - in 2016, the end of dual illumination phase.
  - Additional 2×3 MHz are still free for potential PPDR licences, e.g. emergency, airports (SAA).
- **Transnet**: free up 450-470 MHz and migrate to 406-426 MHz:
  - Transnet decision regarding migration from analogue to digital technology; current equipment should be used until 2019.
  - Transnet´s data demands increased, so building and operating LTE450 network might be one possible scenario for Transnet.
  - From 2016 Transnet could start migration towards 410-413 // 420-423 MHz (2×3 MHz). Alternatively, there are 2×4 MHz and 2×3 MHz for TETRA available in 406-426 MHz.
  - End of migration of 5 years = 2022; dual illumination phase could be started regionally from 2017 onwards, so maximum of 3 years' dual illumination.
- **Other licensees**: migrate from 450-470 MHz to:
  - 403-406 MHz (unpaired);
  - 426-430 MHz (unpaired);
  - 440-450 MHz (paired or unpaired), potentially for municipality networks; and
  - In case of PPDR-use also to 387-390//397-400 MHz

- **430-440 MHz** (amateurs) might be used when there is need due to congestion;
- Many municipality networks are in 440-450 MHz. Depending on future demand, harmonisation may occur;
- In Figure 18 potential extensions to IMT450-band are marked as well, in order to pay attention to the direct neighbour bands. These might be reserved in case of extending 2×5 MHz to 2×10MHz or to minimize interference. Therefore these potential bands might be used only in congestion cases - 448-450 MHz and 470-473 MHz (currently used by broadcaster) until the final IMT option and potential interferences are known. Potential **smart grid application** demands for energy companies: depending on selected technology and demand, smart energy services could be handled in IMT450 or in 403-406 MHz, 426-430 MHz.

Migration Objectives	
380-400MHz	**380-400MHz** band is assigned as PPDR usage band with TETRA as one technology. SAPS have already decided for TETRA in 380-387//390-397MHz. Remaining 2*3MHz might be used by emergency, security, or airport services.
400-403MHz	The band from **400-403MHz** is assigned to "METEROLOGICAL AIDS SPACE OPERATION (Space to earth)", but not used in South Africa so far.
403-406MHz	**403-406MHz** could be used for "METEROLOGICAL AIDS, **Fixed, Mobile** except for aeronautical mobile", which offers potential for short range devices (SRD).
406-426MHz	**406-426MHz** could be used for TETRA (2*4MHz) and other PMR (2*3MHz); additional 2*3MHz used for other duplex technologies
426-430MHz	The range from **426-430MHz** is current without any assignment in South Africa.
430-440MHz	The range from **430-440MHz** is reserved for amateur radio. There will be no general change in this band, even if the utilisation is currently low about 1MHz bandwidth. Potential (temporary) use for single links might be discussed.
440-450MHz	The band **440-450MHz** is mainly used by municipalities and security services

Figure 57: Summary of migration of 450-470 MHz and destination bands

A.5.3.2 Benefits

The full allocation of the 450-470 MHz band to IMT (scenario 3) will result in increasing the spectrum efficiency in the 450-470 MHz band. Additionally, as a result of the execution of scenario 3, licensees will have the opportunity to modernise their networks for higher cost-efficiency and the support of new services.

A.5.3.3 Costs

The costs of allocating the 450-470 MHz exclusively to IMT services are related to the incremental expenditure to be incurred by all licensees migrating out of the band. In this case, the estimation of the costs of migration is complicated by the fact that many licensees in the band are preparing, coincidentally, to modernise their networks. Network modernisation may require a migration on its own if the destination service is deployed in a different band. Furthermore, additional costs related to interference assessment depend on the chosen IMT configuration for the 450-470 MHz band.

A.6 Summary: Proposals Arising out of Feasibility Study

IMT450 is a very valuable spectrum for cost-efficient coverage for rural area connectivity initiatives, but depending on the final decision for TDD or FDD in IMT450 and the target terminal performance, the real coverage might be comparable to IMT700, which has more capacity and would be more attractive for operators. The new terminals and applications might be complementary to existing services and therefore IMT450 might be more attractive to new entrants such as wholesale operators providing service MVNOs. In this case, the same commercial operator would need additional spectrum for capacity and operational reasons. There would be additional TDD-spectrum available in IMT2300, IMT2600 and IMT3500.

If South Africa decides on Option 2 or Option 3 it may consider LTE-TDD, using 15 MHz for uplink scheme in IMT450 and LTE-TDD with 15-25 MHz for downlink scheme in IMT750. The Option 1 for IMT700 would not offer TDD-spectrum in 750 MHz, consequently IMT450 would be the only uplink favouring IMT network for M2M applications.

IMT spectrum in 450-470 MHz has to be considered for full clearance within an economically and operationally feasible time frame. It is expected that 3-8 years should be sufficient for existing licensees to move to new destinations and parallel deployments of new sites for the IMT450 network.

For mission critical operations and Transnet operation service, the risk is high and potential interference could not be excluded right now. IMT co-existence scenarios should be investigated soon, when final decisions are made concerning the IMT-options (e.g. FDD or TDD, guard bands, final neighbour allocations, etc.). This means spectrum clearance must occur first followed, by a second phase of potentially efficient, co-existent usage of remaining spectrum within 450-470 MHz.

In general, the following migration objectives and principles should be considered:

- **Clearance in an economically and operationally-feasible time:**
  - IMT usage as a main target to support future data demands for SA Connect and
  - High potential is seen in general, but is hard to quantify right now.
- **All licensees should contribute to the overall target:**
  - Migration is an opportunity to modernize telecommunications infrastructure.
- **Increase of spectrum-efficient usage of all bands:**
  - Migration of licensees might result in congestion in new destination bands; and
  - Spectrum usage harmonisation aligned with increase of spectrum efficient usage due to the latest technology for all bands of focus: 380-470 MHz.
- **Clearance first, followed by co-existence usage**

- IMT co-existence scenarios to be investigated, when final decisions are made concerning the IMT-options (e.g. FDD or TDD, guard bands, neighbour allocations).

- **Service migration**
  - Service demands have changed. It is expected that some current licensees would not continue with their own networks and would migrate service due to other cost-efficient alternatives (e.g. LTE networks).

- **Spectrum migration**
  - Nationwide deployments with reliability services.

    Migrate sensitive licensees with high reliability services and nationwide network deployments (like Transnet) first, which already started with SAPS in 2010.
  - Companies and private users step-by-step.

Appendix B Feasibility study for the 880-960 MHz band

B.1 Introduction

B.1.1 Purpose

The purpose of this document is to conduct a feasibility study concerning the 880-960 MHz band based on the Frequency Band Migration Regulation and Plan contained in the Government Gazette No. 36334, Notice No. 352 of 3rd April 2013.

Of importance are two issues in the band: harmonising the GSM900 spectrum for contiguous assignments to all players and resolving the existing overlap of CDMA assignments and GSM-R assignments.

B.1.2 Definitions

B.1.2.1 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.*

B.1.2.2..Spectrum Refarming

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 whereby a GSM operator changes the use of all or part of the spectrum used for GSM to 3G or LTE; especially where the spectrum licence has specified the technology (as GSM) and the operator licence has to be changed[34] .
- The situation whereby 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 when the licence period has expired; this is happening in Europe where the original GSM licences are expiring.[35]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

---

[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.

[35] A good example is in Ireland ref: "Multi-band Spectrum Release: Release of the 800 MHz, 900 MHz and 1800 MHz Radio Spectrum Bands' – various consultations by ComReg 2012.

include change in the specified technology and does not necessarily mean that the licenced user has to vacate the frequency.

B.2 Background

B.2.1 The Electronic Communications Act

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

B.2.1.1 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, 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;

(m) ensure the provision of a variety of quality electronic communications services at reasonable prices;

(y) refrain from undue interference in the commercial activities of licensees while taking into account the electronic communication needs of the public; and

(z) promote stability in the ICT sector.

B.2.1.2 Chapter 2: Policy and regulations

Ministerial Policy and Policy directions

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

(a) the radio frequency spectrum;

(b) 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.

B.2.1.3 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 and 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.

B.2.2 The National Radio Frequency Plan

On review of the National Radio Frequency Plan contained in Government Gazette No. 36336, Vol. 576, 2013 (which incorporates the decisions made at World Radiocommunications Conferences, including up to WRC 2012 which was concluded in Geneva in February 2012), the following allocations for the 880 – 960 MHz band were noted.

ITU Region 1 allocations and footnote	South African allocations and footnotes	Typical applications	Comments
862-890 MHz FIXED MOBILE except aeronautical mobile 5.317A	**862-890 MHz** FIXED MOBILE except aeronautical mobile 5.317A, NF9, NF10	Fixed links (856-864.1 MHz), Mobile Wireless Access (872.775-877.695 MHz) GSM-R (MTX) 877.695-880 MHz) NF10, IMT900 MTX (880-915 MHz), Wireless Audio systems and Wireless microphones (863-865 MHz) CT2 cordless phones (864.1-968.1 MHz) CT2 FWA (864.1-868.1 MHz) RFID (865-868 MHz) Non-specific SRD and RFID (869.4-869.65 MHz) Non-specific SRDs (868 – 868.6 MHz, 868.7-869.2 MHz,869.4 - 869.65 MHz, 869.7-870 MHz) Alarms (868.6-868.7 MHz, 869.25-869.3 MHz, 869.65-869.7 MHz)	Paired with 868.1-876 MHz Paired with 872.775-832.695 MHz Paired with 921-925 MHz Paired with 925-960 MHz Radio Frequency Spectrum Regulations (annex B) (GG. No. 34172, 31 March 2011) Spectrum Re-allocation for (RFID) (GG. No. 31127, 5 June 2008) Radio Frequency Spectrum Regulations (Annex B) (GG. No. 34172, 31 March 2011)
BROADCASTING 5.322 5.319 5.323			
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, NF9, NF10, NF11	GSM (BTX) (921-925 MHz), IMT900 MTX (880-915 MHz), IMT900 BTX (925-960 MHz), RFID (including, passive tags and vehicle location (915.1-921 MHz	Paired with 877.695-880 MHZ. Paired with 925-960 MHz Paired with 880-915 MHz Spectrum re-allocation for RFID (GG. No. 31127, 5 June 2008)
942-960 MHz FIXED MOBILE except	**942-960 MHz** MOBILE except aeronautical mobile	IMT900 BTX (925-960 MHz)	Paired with 880-915

aeronautical mobile 5.317A BROADCASTING 5.322 5.323	5.317A, NF9		MHz

Table 43: National Radio Frequency Spectrum Plan extract

B.2.3 The Frequency Migration Regulations and Plan

B.2.3.1 Principles governing spectrum refarming

B.2.3.1.1 Identification of bands which are subject to frequency migration

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

- First Level – where the ITU radio regulations / decisions of a World Radio Conference (WRC) require a change in national allocation that will require existing users to be migrated;
- Second Level - where a Regional Radio Conference requires a change in national allocation that necessitates existing users to be migrated;
- Third Level – where the SADC Frequency Allocation Plan (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.

B.2.3.1.2 Process

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

The key processes are described in the Radio Frequency Spectrum regulations, and are as follows:

- Preparation of a Radio Frequency Spectrum Assignment Plan (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.

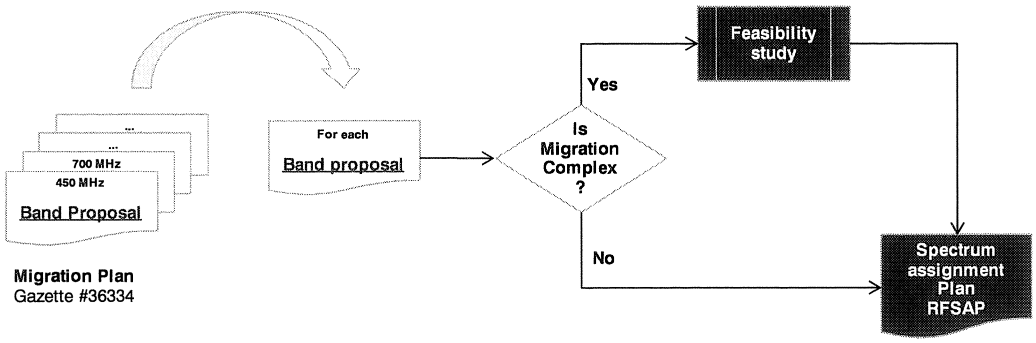


Figure 58: Process for frequency migration

The requirement for a Feasibility Study is usually, but not necessarily, indicated in the Frequency Migration Plan. 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 their specific requirements of the user. The spectrum pricing regime is intended to facilitate this process and guide users to the 'optimal' choice.

B.2.3.1.3 Time Frame for Migration

In principle, the Authority can migrate a user to another location as part of sound radio frequency spectrum management as required. However, an appropriate time frame should be applied as a matter of standard practice. In determining the time frame, the following factors are taken into account:

- the duration of the spectrum licence;
- the time frame to migrate existing customers (end-users);
- the economic life of the equipment installed; and
- adequate forward planning.

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

B.2.3.2 Reframing Plan for 880-960 MHz

As a result of the introduction of new services and technologies, it may be required for some frequency bands to be re-farmed. Due to the complexities of re-farming, the potential huge costs associated with such an exercise, as well as the different stages in application within the various SADC countries, this matter has not been addressed in detail in the SADC FAP. Although the issue of migration was considered, it was resolved that it would be addressed in relevant separate documents.

Frequency Band (MHz)	Allocation in NRFP 2013 (Applications)	Proposed Utilisation/ Applications	Notes on migration/ usage
862-890 MHz	FIXED MOBILE except aeronautical mobile (Fixed Links 856-864.1 MHz) (Mobile Wireless Access 872.775-877.695 MHz paired with 827.775-832.695 MHz) (Mobile (MTX) 876-880 MHz paired with 921-925 MHz GSM-R – note that 876-877.695 is assigned) (IMT900 MTX 880-915 MHz paired with 925-960 MHz) (Wireless Audio systems and Wireless microphones 863-865 MHz) (CT2 cordless phones 864.1-868.1 MHz) (CT2 FWA 864.1-868.1 MHz) (RFID 865-868 MHz) (Non Specific SRDs 868-868.6 MHz, 868.7-869.2 MHz, 869.4-869.65 MHz, 869.7-870.0 MHz) (Alarms 868.6-868.7 MHz, 869.25-869.3 MHz, 869.65-869.7 MHz)	Mobile (IMT) (as per SADC FAP proposed common sub-allocation/ utilisation)	Develop RFSAP with consideration to: ■ Use of the band for IMT ■ Harmonisation and alignment with ITU-R WP5D agreement on the appropriate channel plan for the 700 MHz/800 MHz frequency bands for Region 1. ■ GSM R in 876-880 MHz paired with 925-935 MHz
890 - 942	MOBILE except aeronautical mobile (Mobile (MTX) 921-925 MHz paired with 876-880 MHz GSM-R - note that 876-877.695 is assigned) (Mobile 880-915 MHz paired with 925-960 MHz) (Several SRD 915.1-921 MHz) (GSM900 band)	Allocations maintained as-is	Develop RFSP for purposes of harmonisation including in-band migration in the GSM 900 band.
942 – 960	MOBILE except aeronautical mobile (GSM 900)		Develop RFSP for purposes of harmonisation including in-band migration in the GSM 900 band.

Table 44: Frequency migration plan 862-960 MHz

The 876-890 MHz Band

A Radio Frequency Spectrum Assignment Plan will be developed with consideration paid to:

- Re-plan the entire band to accommodate IMT (terrestrial) as per SADC FAP proposed common sub-allocation/ utilisation; and
- The reservation of the GSM-R bands (876-880 MHz paired with 921-925 MHz) for use by the Passenger Railway Authority of South Africa for the MetroRail network.

The 890-942 MHz Band

- A Radio Frequency Spectrum Assignment Plan (RFSAP) will be developed regarding the Mobile (890-915 MHz paired with 935-960 MHz) bands with respect to harmonisation including in-band migration;
- Otherwise, allocations remain as they are; and
- The GSM-R 921-925 MHz (paired with 876-880 MHz) band will continue to be reserved for use by the Passenger Railway Authority of South Africa for the Metro Rail network.

The 942-960 MHz Band

- A Radio Frequency Spectrum Assignment Plan (RFSAP) will be developed regarding the Mobile bands with respect to harmonisation, including in-band migration.

B.2.4 ITU Position

B.2.4.1 ITU Position on 862-960 MHz as Overlaps with 876-960 MHz

According to the ITU Recommendation ITU-R M.1036-4 (03/2012), the recommended frequency arrangements for implementation of IMT in the band 862-960 MHz are summarised in the table and figure below.

Frequency arrangements	Paired arrangements				Unpaired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
A1	824-849	20	869-894	45	None
A2	880-915	10	925-960	45	None

Table 45: Frequency arrangements in the 862-960MHz band

Notes to Table 45:

NOTE 1 – Due to the different usage in the bands 698-960 MHz between regions, there is no common solution possible at this time.

NOTE 2 – The frequency arrangements for the band 698-960 MHz have been developed taking into consideration and recognising the above. The frequency arrangements for

PPDR systems using IMT technologies in the bands identified in Resolution 646 (WRC-03), according to *considering* h) and *resolves* 6 of that Resolution, are outside the scope of this Proposal. There are inherent benefits of deploying IMT technologies for PPDR applications in this band, including advantages of large coverage area and possible interoperability across the 700 and 800 MHz bands, noting the differences in operational requirements and implementations.

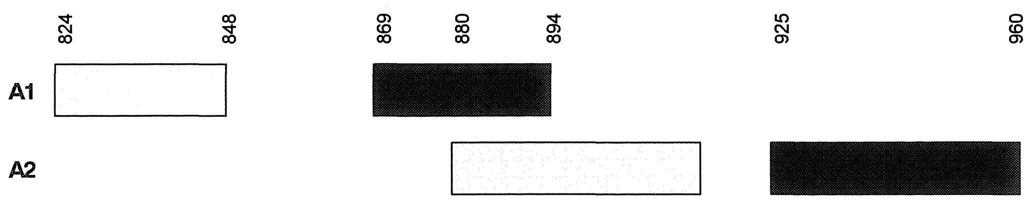


Figure 59: Frequency arrangements for 862-960 MHz

B.2.5 SADC

The Southern African Development Community (SADC) Frequency Allocation Plan (FAP) of 2013 creates a framework for the harmonisation across SADC on the use of the radio frequency spectrum.

As a result, the SADC Frequency Allocation Plan proposes that the 862-960 band MHz be allocated to Mobile IMT, PMR and /or PAMR. There is no preference given for IMT over other services. The use of this band for IMT in the future is to be investigated as part of the development of harmonised IMT channelling arrangements.

The 862-960 MHz band is currently used for a variety of mobile and aeronautical mobile systems in various SADC countries.

The SADC FAP recognises that frequency channelisation of several key frequency bands must be developed and preferably harmonised throughout SADC. 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
862-890 MHz FIXED MOBILE except aeronautical mobile 5.317A BROADCASTING 5.322 5.319 5.323 5.316A 5.319	**862-890 MHz** MOBILE except aeronautical mobile 5.317A SADC14	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.
		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 IMT	Paired with 925-960 MHz
890-942 MHz FIXED MOBILE except aeronautical mobile 5.317A	**890-942 MHz** MOBILE except aeronautical mobile 5.317A	915-921 MHz PMR and/or PMR	
		921-925 MHz	Paired with 876-880 MHz.

BROADCASTING 5.322 Radiolocation 5.323		IMT PMR and/or PAMR	
		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		

Table 46: SADC allocations for 862-960 MHz

B.3 Methodology of the Feasibility Study

This section describes the structure and methodology adopted in the feasibility analysis for the 880-960 MHz band. The primary objective of the feasibility analysis is to propose an in-band migration plan to harmonise spectrum assignments into contiguous bands. Such a harmonisation will lead to more efficient spectrum usage and greater flexibility in network planning and configuration for licensees.

The structure of the study analysis reflects the various categories of services (or sub-band allocations) existing in the 880-960 MHz band. The 880-960 MHz band is currently assigned to GSM, GSM-R (downlink) and a number of non-IMT applications (e.g. RFID). Furthermore, relevant considerations of the IMT roadmap document are reflected in the feasibility analysis, especially, when such considerations lead to new migration scenarios.

The methodology of the study considers the relevant regulatory texts, the outcome of related consultations as well as international best practices to generate a set of feasible scenarios. These scenarios, in turn are critically analysed considering the objectives and constraints of the Authority. Finally, a prioritised list of proposals is proposed for each sub-band as identified in the chapter above.

B.3.1 Methodology of the Study

The applied methodology in this feasibility study involves the analysis of regulatory, technical and economic factors. In each case, relevant regional and international practices are reflected.

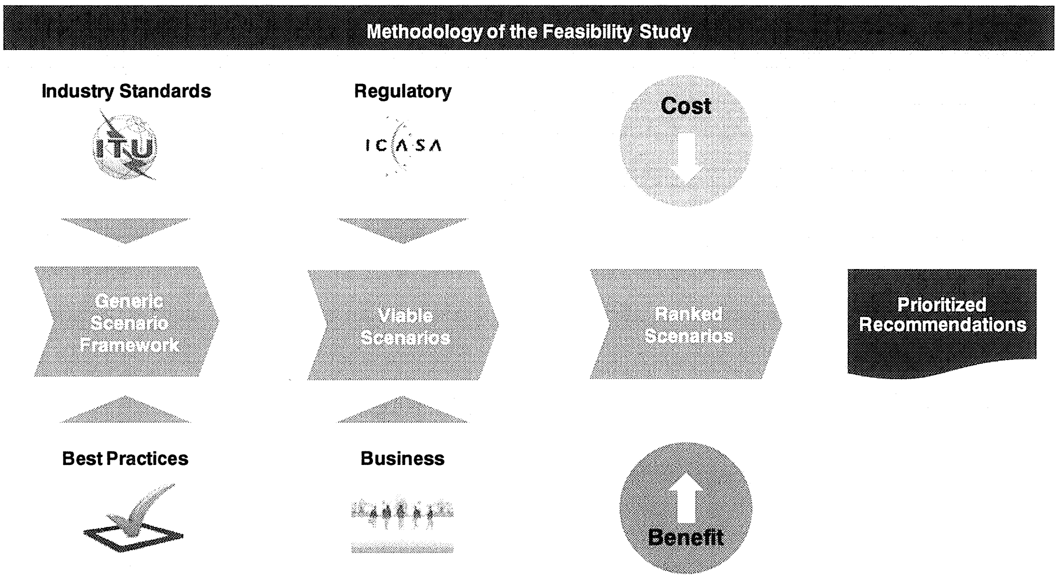


Figure 60: Methodology of Feasibility Study

For each sub-band (and the corresponding service categories), the feasibility analysis starts with a review of the applicable regulatory texts. The relevant sections of the Electronic Communications Act of 2005 contained in the Government Gazette No. 28743, No. 36 of 2005 as well the Electronic Communications Amendment Act of 2014 contained in Government Gazette No. 37536, Act No. 1 of 2014 provide a legal and regulatory canvas for the subsequent analyses.

With the regulatory contour defined, the next step involves the review of band-specific documents with an objective to further refine the regulatory context and identify the technical and service specifications. These steps include the review of the National Radio Frequency Plan (2013) and the Frequency Migration Strategy and Plan (2013) which contain critical information on the permitted services as well as the migration strategy of the Authority. Relevant international texts are also brought in at this stage. These include, but are not limited to, SADC and ITU Region 1 documents, relevant ITU reports and trends.

Next, consultation documents are reviewed with the goal of understanding industry interests and motivations in technical, regulatory and economic terms. The review of consultation documents completes the stakeholder interest map. The various interests of stakeholders provide a basis for the scenario assessment and final proposal.

As a result of the inputs from regulatory texts, consultation documents and international best practices and technical possibilities, a broad set of migration and harmonisation options is derived with advantages and disadvantages with regard to various stakeholder objectives, are determined.

The next step is the prioritisation of relevant factors (advantages and disadvantages). The prioritisation criteria reflect the stated objectives of the Authority and its obligations and mandates. For instance, advantages that fulfil the Authority's prioritised objectives score high while disadvantages that hurt the Authority's prioritised objectives score low.

Lastly, all the benefits are consolidated to get a picture of the most beneficial scenarios from an aggregated perspective. Many of the advantages and disadvantages are qualitative or cannot reasonably or reliably be predicted. In such cases, qualitative analyses are made based on the best available knowledge and practices.

B.3.2 Structure of the Analysis

The feasibility analysis is structured around sub-bands and service categories. The 880-960 MHz band allocation is broad and multiple types of services are currently deployed in the band including GSM, GSM-R and RFID for instance. For clarity, we consider two sub-bands for the feasibility study:

- The GSM band (880-915 MHz paired with 925-960 MHz)
- The GSM-R band (921-925 MHz in the downlink)

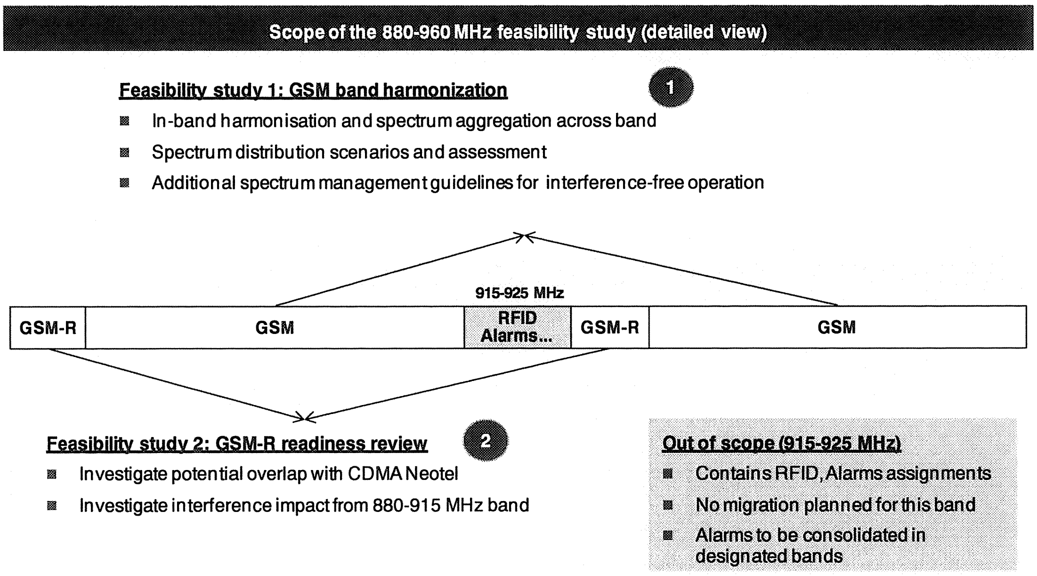


Figure 61: Scope of feasibility study

For the GSM band, the feasibility study aims to determine the optimal in-band harmonisation to do away with the current fragmentation.

For the GSM-R band, the feasibility study is primarily a benchmark of international practices with an objective of ensuring safe adjacency with the GSM band and providing examples of assignment guidelines when multiple licensees are involved.

B.4 The 880-915 MHz band (paired with 915-960 MHz)

B.4.1 Current status in the 880-915 MHz band in South Africa

This section documents the relevant local information and decisions pertaining to the 880-915 MHz band. First, the permissible services in the band as well as additional restrictions are illustrated in the national allocation plan. Next, a view of the landscape of current licensees as well as industry input in consultations lay the foundation for the stakeholder map to be considered in the scenario analysis phase. The Authority's migration strategy represents the major decision around which the feasibility study shall be carried out.

B.4.1.1 Allocations in the 880-915 MHz band

The following are excerpts of the South African National Allocation Table for the 890-942 MHz band. The relevant portions for this section are the 890-915 MHz band in the first table excerpt and the 890-915 MHz in the second table.

ITU Region 1	SA allocation	Typical applications	Comments
862-890 MHz	862-890 MHz		
FIXED	FIXED	Fixed links (856-864.1 MHz),	Paired with 868.1-876 MHz
MOBILE except aeronautical mobile 5.317A	MOBILE except aeronautical mobile 5.317A, NF9, NF10	Mobile Wireless Access (872.775-877.695 MHz)	Paired with 872.775-832.695 MHz
		GSM-R (MTX) 877.695-880 MHz) NF10,	Paired with 921-925 MHz
		IMT900 MTX (880-915 MHz),	Paired with 925-960 MHz
		Wireless Audio systems and Wireless microphones (863-865 MHz) CT2 cordless phones (864.1-968.1 MHz) CT2 FWA (864.1-868.1 MHz)	Radio Frequency Spectrum Regulations (annex B) (GG. No. 34172, 31 March 2011)
		RFID (865-868 MHz) Non-specific SRD and RFID (869.4-869.65 MHz)	Spectrum Re-allocation for (RFID) (GG. No. 31127, 5 June 2008)
		Non-specific SRDs (868 – 868.6 MHz, 868.7-869.2 MHz,869.4 - 869.65 MHz, 869.7-870 MHz) Alarms (868.6-868.7 MHz,, 869.25-869.3 MHz, 869.65-869.7 MHz)	Radio Frequency Spectrum Regulations (Annex B) (GG. No. 34172, 31 March 2011)
BROADCASTING 5.322 5.319 5.323			

Table 47: Allocations in the 880-890 MHz band

ITU Region 1	SA Allocation	Typical Applications	Comments
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, NF9, NF10, NF11	GSM (BTX) (921-925 MHz), **IMT900 MTX (880-915 MHz),** **IMT900 BTX (925-960 MHz),** RFID (including, passive tags and vehicle location (915.1-921MHz	Paired with 877.695-880 MHz. Paired with 925-960 MHz Paired with 880-915 MHz Spectrum re-allocation for RFID (GG. No. 31127, 5 June 2008)

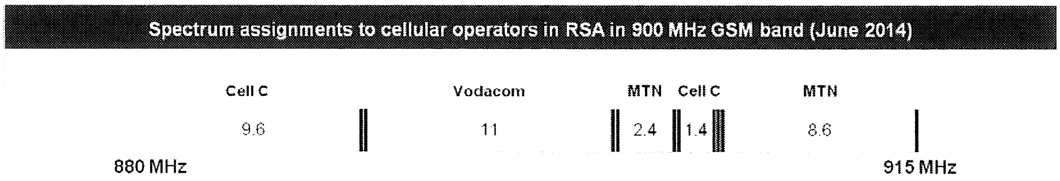
Table 48: Allocations in the 890-942 MHz band

B.4.1.2 Current Assignments in the Band

The 25 MHz spectrum starting at 890 MHz has been allocated in ITU Region 1 for mobile applications and is paired with 935-960 MHz band. This paired band is standardised by ITU and widely adopted as the primary GSM (P-GSM) band in ITU Region 1 and globally.

Likewise, the 10 MHz spectrum starting at 880 MHz has been allocated in ITU Region 1 for mobile applications and is paired with 910-920 MHz band. This paired band is standardised by the ITU and is widely adopted as the primary GSM (E-GSM) band in ITU Region 1 and globally.

The graph below describes the current landscape of assignments in the 880-915 MHz in South Africa:



Cell C	11 MHz
MTN	11 MHz
Vodacom	11 MHz
Guard bands	10*0.2 = 2 MHz

- The 880-915 MHz is **fragmented** resulting in non-contiguous assignments for 2 licensees
- Both MTN and Cell C do not have 10MHz contiguously
- Guard bands represent 5.7% of the width of the band
- Cell C's assignments are almost all in the **E-GSM** band (880-890 MHz)
- Vodacom and MTN assignments are all in **P-GSM** band (890-915 MHz)

Figure 62: 900 MHz spectrum assignments in South Africa

The 880-915 MHz band has also been allocated as the first leg of the paired GSM band. Assignments in the 880-915 MHz band consist of 5 segments licensed to MTN, Vodacom, and Cell C:

- Cell C and MTN each operate on two non-contiguous sub-bands of 11 MHz each; and
- Vodacom operates a contiguous band of 11 MHz.

B.4.1.3 Challenges in the 880-915 MHz band

As part of its regulatory mandate, the Authority must see to it that spectrum is managed and used efficiently and provides the highest utility to the country. In this context, the current assignment in the 880-890 MHz band could be improved given the current fragmentation and the resulting inefficiencies such as wasted guard band spectrum.

First, the current assignments result in unnecessary fragmentation.

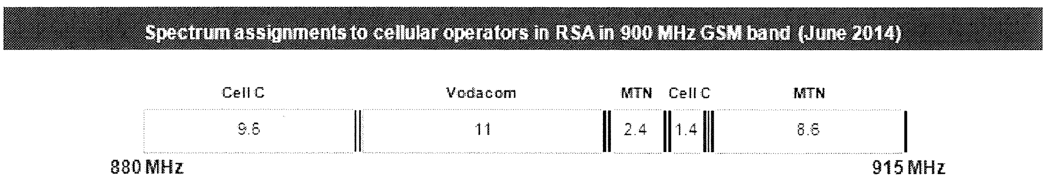


Figure 63: Spectrum assignments to cellular operators in the 900 MHz band

Both MTN and Cell C are assigned non-consecutive chunks of GSM channels. Cell C's two chunks of spectrum (9.6 MHz and 2.4 MHz) are 11 MHz apart from each other and MTN's two chunks (2.4 MHz and 8.6 MHz) are 1.4 MHz apart.

Next, and as a consequence of this fragmentation, more channels are wasted for guard bands than would have been necessary for contiguous assignments. Indeed, there are currently 5 guard bands in each of the 2 sides of the duplex band.

Further, the fragments' sizes reduce flexibility in network planning and in providing broadband services. Both Cell C and MTN have two non-contiguous segments, with one segment being much larger than the other. For radio planning purposes, contiguity between segments is typical and therefore well understood by radio network planners. However fragmented assignments, where some blocks are very small block sizes (1.2 MHz for MTN or 2.4 MHz for Cell C), may make network planning more complex.

Another consequence of fragmentation is the potential financial and technical burden on network owners in terms of equipment tuning. Operators routinely use equipment with radio amplifiers. The introduction of SDR (software-defined radio) equipment will likely be costlier for operators whose spectrum is spread over a large band. SDR-technology uses wideband amplifiers, the cost of which increases significantly with the width of the band. It is therefore conceivable that scattered assignments may lead to higher costs since amplifiers must cover a larger range of scattered spectrum than if the spectrum were contiguous.

B.4.1.4 The Authority's Migration Strategy

The underlying principles and framework for the in-band migration in the 880-960 MHz band is the 'Process for Radio Frequency Migration' draft regulations S 4 (e) which states that "*The authority shall initiate a process of radio frequency migration in the following circumstances: where the authority has determined that a change in a radio frequency spectrum licence holder's assignment within a radio frequency band is required to enable more efficient use of the radio frequency spectrum (in-band migration).*"

The Authority's migration reference document for the 880-915 MHz band states:

- *A Radio Frequency Spectrum Assignment Plan (RFSAP) will be developed regarding the Mobile (890-915 MHz paired with 925-935 MHz) bands with respect to harmonisation including in-band migration; and*
- *Otherwise, allocations remain as they are.*

In other words, it is the Authority's objective to carry out an in-band migration (harmonisation) of the current GSM assignments. The primary objectives of the migration are to achieve contiguous assignments for each of the three cellular carriers while increasing spectrum efficiency (fewer guard bands)

B.4.1.5 Consultations and industry input

The following describes various inputs from the industry relative to the harmonisation of the GSM900 band. The Authority engaged current licensees to get an accurate idea of the potential costs that licensees are to incur. Such analysis helps the Authority balance its objectives. However, as stipulated in the regulations, it is not the Authority's practice to compensate any licensees for migration.

Positions on 880-960 MHz In-band migration

Cell C

- Proposal of the harmonisation of E & P GSM for contiguity and spectrum aggregation
- Currently has 2 non-contiguous block assignments (resp. in E and P GSM)
- Highlights gain of 2 channels for all

MTN

- Self-assessed costs of **ZAR 40 million**
  - Retuning of over 4,000 sites
  - 2 years to implement
- Poor network quality country-wide during migration
- Currently has 2 non-contiguous block assignments in P-GSM

Vodacom

- Self-assessed costs of **ZAR 86,2+ million**
  - Replacement of cell extenders
  - DAS replacement and frequency retune
- Poor network quality country-wide during migration
- Contiguous block of spectrum assigned

Figure 64: Positions on 890-915 MHz in-band migration

All licensees operating in the E/P GSM band (890-915 MHz) engaged with the Authority's consultative proposal to harmonise the E/P GSM band. MTN and Vodacom voiced concerns about the complexity and cost of such a migration while Cell C expressed its support. Formally, no-one from the concerned parties opposed the in-band migration.

Cell C supports the proposal (which it originated) for contiguity of all the assignments of each operator. To support its proposal, Cell C provided an illustration of the target spectrum arrangement in the band.

MTN highlighted the scale of such a migration on a nationwide scale as well as the costs. Specifically, MTN stated it would have to retune over 4000 sites over a period of 2 years at a cost to the tune of ZAR 40 million.

Vodacom presented both a financial and operational impact of the in-band migration on its network. The overall quantifiable financial impact exceeded ZAR 86 million. In addition, Vodacom expects unquantifiable disadvantage resulting from poor network performance that it expects to result from the in-band migration.

B.4.2 Trends in the 880-915 MHz Band

This section describes the useful developments in the 880-915 MHz band on three levels (global, ITU Region 1, SADC) as applicable alongside the South Africa case. Furthermore, exemplary spectrum assignment plans are presented for the 880-915 MHz band for relevant countries (in terms of region, comparable telecom context to South Africa). Lastly, we discuss relevant IMT guidelines for the 880-915 MHz band.

In summary, spectrum assignments tend to be contiguous (that is, not fragmented) across most countries in the region.

B.4.2.1 Summary of Best Practices in the 880 - 915 MHz band

The main objective of this section is to identify practices in ITU Region 1 as well as international best practices in terms of the distribution of 880-915 MHz across multiple licensees.

Similar exercises such as the current in-band migration in South Africa have been carried out in other countries.

A few key lessons can be learnt that are relevant for the South African context:

- Contiguous assignments are desirable in most countries and considered a key objective in spectrum refarming;
- An increasing number of regulators do away with the internal guard bands (separating assignments between different licensees within the same band); and
- Many countries are moving to a band plan of 5 MHz blocks across all IMT bands.

B.4.2.2 The case of Norway

In Norway, the simultaneous redistribution of spectrum in the 900 MHz and 1800 MHz band occurred in the context of the upcoming expiry of existing licences and the introduction of a new licence.

In the 900 MHz band, the redistribution resulted in the elimination of 2×1.4 MHz of internal guard bands and the redistribution of spectrum to accommodate the introduction of a 4th player.

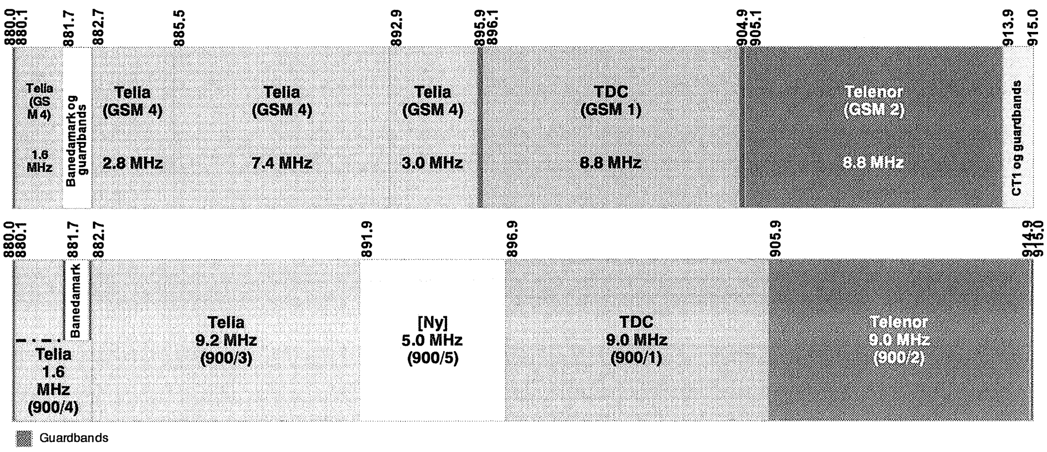


Figure 65: 900 MHz spectrum allocation in Norway

The relevant lessons learnt for South Africa in this case are the following:

- **Removal of internal guard bands for two reasons:** Firstly, this decision increases spectral flexibility by removing the imposition of 0.2 MHz of guard band (or more) on licensees. Secondly, even in GSM where the guard bands could have been argued for, most deployments include frequency-hopping which tolerates up to a certain level of close frequency reuse without undue impact on the network (note that no guard bands are typically used between cross-operator carriers in UMTS).Thirdly, the decision to remove guard bands transfers some responsibility of interference co-ordination from the Authority to licensees. In summary, the removal of guard bands provides the upside of flexibility and does not constitute an unresolvable solution to interference prevention or resolution.

- **Restructuring of band into channels of 5+ MHz.** This decision recognises the growing trend toward the expanded use of the 900 MHz band for broadband services, with 5 MHz minimal viable bandwidth, and demand from new or potential entrants. In the 1800 MHz band, the redistribution of spectrum resulted in the achievement of contiguity for one licensee and the accommodation of an extra licensee.

Relevant lessons learnt for South Africa from the 1800 MHz band in Norway include:

- **Contiguous bands for each licensee**. TDC licences assigned prior to the redistribution covered three blocks of which only two are contiguous. The regulatory authority of Norway considered the achievement of contiguity as an essential part of the re-farming process.
- **Restructuring of blocks (contiguous or not) into 5 MHz+ blocks**. The lesson learnt here varies slightly from that of the 5 MHz+ blocks in the 900 MHz because: the difference is that here, even when blocks are contiguous, the regulator sought to make each block 5 MHz or more. The rationale for such a choice is spectrum trading. Even though the contiguous blocks of 2.2 and 14.4 MHz of TDC taken together result in more than 5 MHz+ spectrum, any subsequent trading of any of those two blocks will result in a 2.2 (sub-5 MHz block). However, with the rearrangement into two blocks of 11.8 and 10 MHz, the blocks are individually tradable. Similarly, all other assignments in the 1800 MHz band are of 5 MHz+ blocks after the re-farming process.

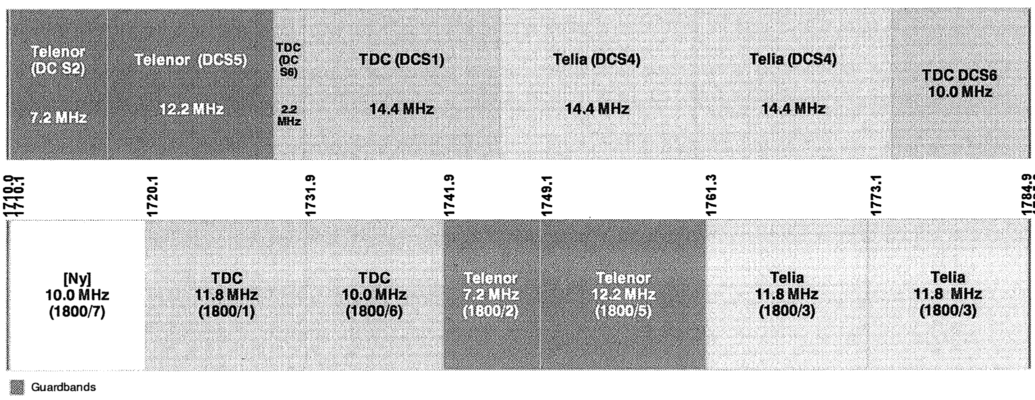


Figure 66: 1800 MHz in Norway

B.4.2.3 The case of Sweden

The spectrum redistribution in the GSM 900 MHz band in Sweden happened in the context of an expanded availability of spectrum (30 to 35 MHz), entry of a new player, and renewal of existing licences.

This case presents at least two relevant lessons for the Authority:

- Contiguous assignments for each operator represent an important regulatory objective. The Swedish regulator recognised the need to give players the opportunity to deploy wider carriers of new mobile technologies (e.g. UMTS, LTE). In this case, although every licensee moved spectrally, the sequence of blocks as well as general spectral location remained unchanged;
- Block size of 5 MHz to recognise the right of licensees to deploy 3G and 4G technologies (minimum spectrum of 5 MHz required) in the bands; and
- Explicit request for non-interference on GSM-R. The co-existence of GSM-R and GSM (or UMTS/LTE) has the potential to interfere across the entire GSM-R band. Many studies and parties have called for an EU-wide, regulatory position on the subject. Sweden has included clauses in the licences of cellular operators making it possible to request them to alter their network in case of interference against GSM-R.

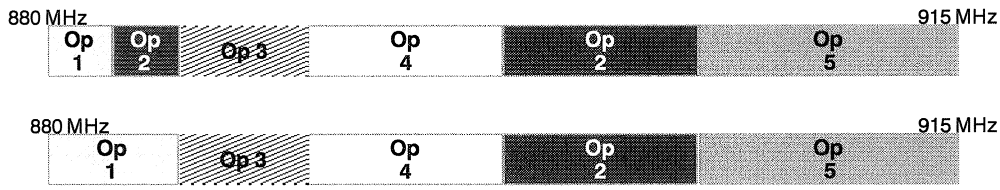


Figure 67: 900 MHz spectrum allocation in Sweden

B.4.2.4 The Case of France

The re-farming of 900 and 1800 MHz in France was closely connected to plans to introduce a fourth 3G operator. The existing assignments differed from the benchmarks in that some operators were licensed in certain sub-bands only in specific, dense areas. ARCEP, the regulator identified two scenarios for spectrum reshuffling (to accommodate a 4th player or not).

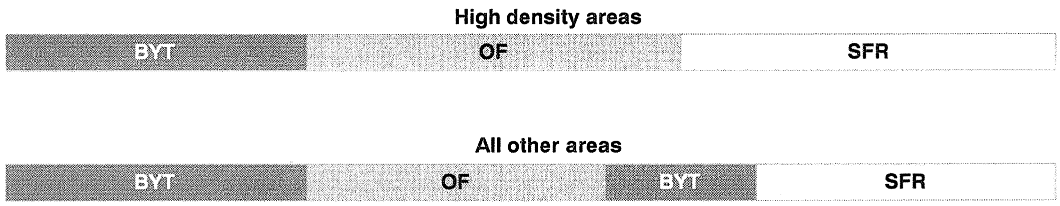


Figure 68: Status quo of 900 MHz in France

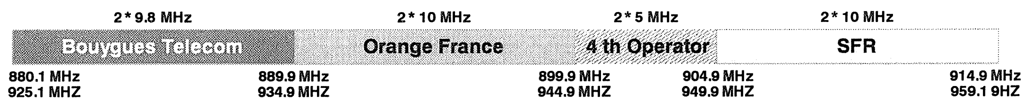


Figure 69: 4 licensee scenario in the band - France

Both scenarios (3 or 4 licensees) are relevant for South Africa for the following reasons:

- Elimination of guard bands and self-management of interference. Even in the scenario with three licensees, ARCEP still decided to eliminate the guard bands and increase interference self-management amongst cellular licensees ;
- Acknowledgement of the trend toward 5 MHz+ blocks of licence. Similar to Norway and Sweden, ARCEP also assigns 5 MHz+ blocks of spectrum for each licensee. In the specific scenario of the entry of a fourth operator, the block sizes are exact multiples of 5 MHz with all three existing licensees having 10 MHz each and the fourth having 5 MHz;
- Pre-commitment clause to future frequency redistribution: As ARCEP planned for the introduction of a 4th player, it sought to make this a smooth process by pre-committing the existing licensees to releasing some of their spectrum. Such a measure simplified consultative processes and minimised legal challenges that might arise from existing licensees; and
- Interference levels in 3G were no greater than those in 2G. In order to protect services in bands adjacent to GSM 900 MHz, ARCEP requires licensees to ensure interference levels with other technologies are no greater than those with the incumbent technology (GSM).

B.4.2.5 The case of Nigeria

In Nigeria, the distribution of spectrum assignments in 880-960 MHz band is contiguous. The lower 880 – 890 MHz band is currently allocated to ISPs. Assignments in these lower data bands differ across regions in the country.

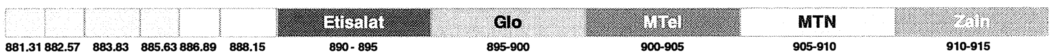


Figure 70: 900 MHz band in Nigeria

This case presents at least two relevant lessons for the Authority:

- Absence of guard bands and self-management of interference. In this scenario, operators were advised to resolve interference problems among themselves before contacting The Nigerian Communications Commission (NCC) with an interference report. On receipt of the interference report, the NCC would mobilise all necessary resources to investigate and take necessary steps to eliminate the interference. In the case of a frivolous complaint, which is discovered to be as a result of internal equipment malfunctioning, the complainant would be required to pay the cost of NCC mobilisation and time wasted. Also, the interfering operator would be charged for the expenses incurred by the regulatory authority in detecting and clearing the interference. This is in addition to fines that may be imposed as stipulated in the spectrum licence.
- Acknowledgement of the trend toward 5 MHz+ blocks of licence for GSM operators -. In similar fashion to Norway, Sweden and France, the NCC assigns 5 MHz+ blocks of spectrum for each licensee allowing for more competition as Nigeria has five mobile operators as opposed to typically three operators as in South Africa.

- In Nigeria, the 10 MHz in the E-GSM band (880-890 MHz) is assigned to pure data players (ISPs).

B.4.2.6 Underlying Framework for the Scenarios

This section describes the constraints and guidelines imposed by the Authority's mandate and objectives on the relevance of migration scenarios. Such constraints and guidelines constitute a framework within which each scenario shall be evaluated and prioritised.

Viable re-farming scenarios must be aligned with the Authority's mandate and objectives and impartially benefit the various licensees and stakeholders. The Authority's mandates of technology-neutrality, spectrum-efficiency, and promotion of investment are of particular importance herein. Additionally, the Authority's specific objective of achieving band contiguity for each of the licensees must be realised.

In terms of technology neutrality, the Authority continues to observe its non-partisan stance when it comes to the technologies deployed. In the GSM900 band, the Authority will therefore acknowledge and facilitate the right of licensees to deploy non-GSM technologies such as Universal Mobile Telecommunications System (UMTS) and LTE - the case studies of Sweden, Norway and France adopt similar neutrality views.

The Authority has the opportunity to reduce the current number of guard bands in the 900 MHz band. Two broad options exist depending on the channelisation plans selected and the policy option preferred by the Authority with respect to responsibility for interference management. Applicable channelisation plans include 200 KHz and 5 MHz (applicable 3G, 4G technologies in ITU Region 1 and in South Africa). Responsibility for interference management currently with the Authority can also be shared to some extent with operators, thereby eliminating the very conservative imposition of explicit guard bands.

It is also the Authority's mandate to promote a vibrant wireless industry. To reach this goal, the Authority must promote competition and avoid imposing undue costs on the licensees. In addition to measures such as investment protection, it is in the spirit of' the Authority's mandate to select the least costly options in the in-band migration of the 880-960 MHz band. Specifically, migrations must ensure that licensees are not moved extensively or unnecessarily again the cases of Sweden and Norway support such orientation.

Given these factors, 3 migration scenarios can be considered:

- Scenario 1: Equal assignments of contiguous 5 MHz+ blocks with guard bands;
- Scenario 2: Equal assignments of contiguous 5 MHz+ blocks without guard bands; and
- Scenario 3: Differentiated assignments of contiguous 5 MHz+ blocks without guard bands (case of 3 players).

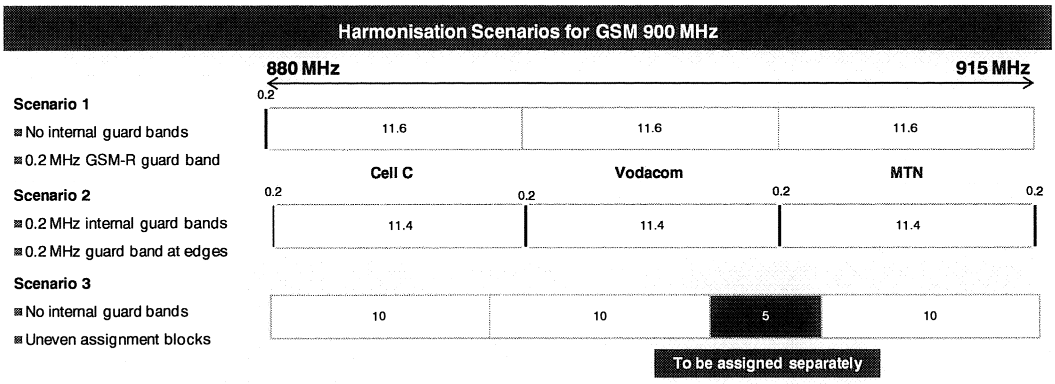


Figure 71: In-band migration scenarios 880-915 MHz

B.4.2.7 Scenario 1: Equal 5 MHz+ Blocks with Guard Bands

This scenario involves the assignment of equal shares of spectrum to licensees and the elimination of internal guard bands. Additionally, the left-edge guard band is expanded to a full GSM channel (0.2 MHz) and the right-edge guard band is removed.

The primary drivers for this scenario are contiguity and spectral efficiency with the assumption of three players (the *status quo* in South Africa).

As compared with the current distribution of spectrum in the band, the benefits of the current assignment arrangement are as follows:

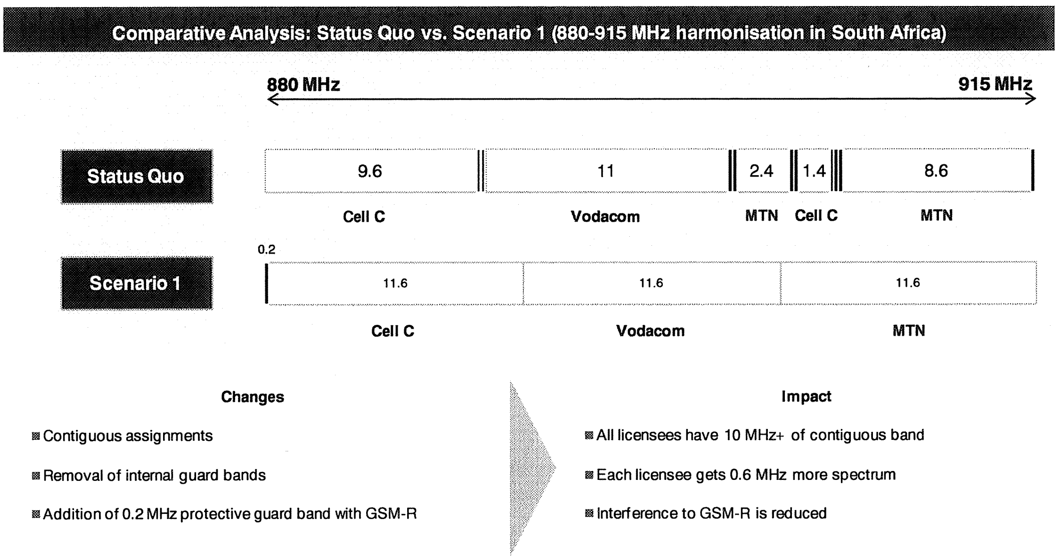


Figure 72: Status quo vs. scenario 1 (880-915 MHz harmonisation)

This scenario, like all others achieves the essential objective of contiguity. As a result, each licensee can now deploy either GSM or any of the other common technologies (3G or LTE). However, the scenario is still based on GSM channelisation (0.2 MHz) as evidenced by the GSM-R guard band of 0.2 MHz on the left-edge of the 880-915 MHz.

The key feature of this scenario is the complete removal of internal guard bands. This removal saves 1.8 MHz simultaneously: 1.4 MHz contiguity gain and 0.4 MHz internal guard band gain. As indicated earlier removing guard bands is a paradigm shift that benefits licensees with more spectrum and empowers them to co-ordinate interference issues among themselves. Given the use of interference-resistant technologies such as frequency hopping in GSM, rigid measures, such as guard bands, are less and less relevant to protect licensees in the same band from mutual interference.

Additionally, the 0.2 MHz remaining from the three-way division of the band has been assigned to the left-edge of the band (before the GSM-R allocation). The goal of this guard band is to provide spectral protection for the GSM-R band. It is important to note that guard bands are still very useful between different service classes and especially with GSM-R. Many GSM-R services are mission-critical and faults carry enormous safety and financial risks; therefore, explicit measures such as guard bands are justified whenever feasible to add another layer of protection to deployments.

B.4.2.8 Scenario 2: Equal 5 MHz+ blocks Without Guard Bands

In this scenario, licensees receive equal shares of spectrum and guard bands are maintained both between licensees within the band and at the two edges of the band. This scenario is the most conservative, contiguous arrangement assuming only 0.2 MHz of guard band.

The primary drivers for this scenario are also contiguity and spectral efficiency with the assumption of three players (the *status quo* in South Africa for this band).

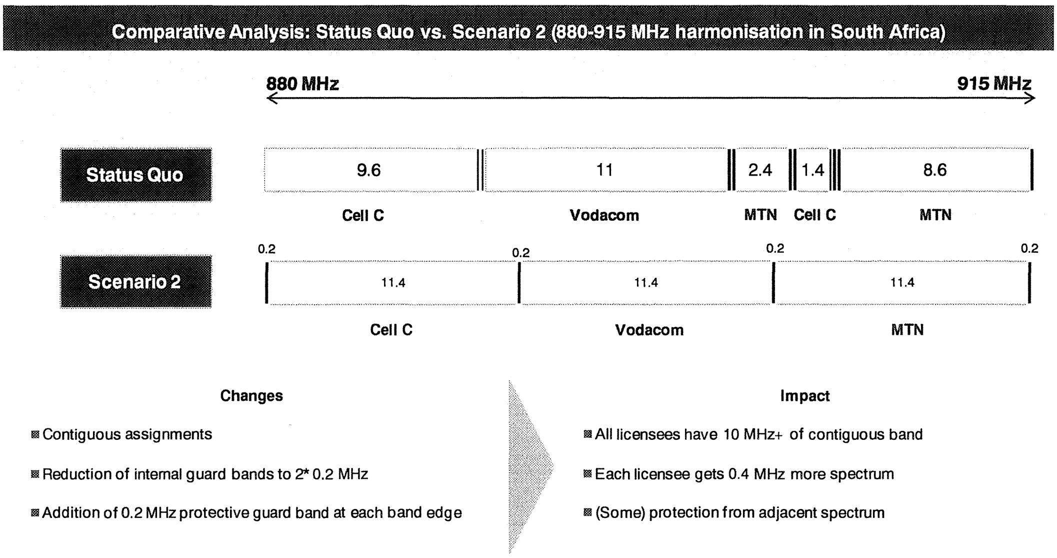


Figure 73: Status quo vs. scenario 2 (880-915 MHz harmonisation)

In summary, the objective of contiguous achievement is achieved and all players gain 0.4 MHz more spectrum while explicit guard bands increase protection from mutual interference. Channelisation of 0.2 MHz is still based on GSM.

The key difference between scenario 1 and others, is that guard bands are maintained between players. While removing guard bands favours increased spectrum and soft interference management, maintaining guard bands focuses on interference prevention.

In addition to an increased guard band with GSM-R, this approach also adds a guard band on the right-edge of the 880-915 MHz band. A variation on scenario 2 is to increase the guard band with GSM-R by shifting the right-edge guard band to the left-edge. Such a measure is a preventive move for the protection of mission-critical GSM-R services. The final decision about the merit of this variation of scenario 2 would be best made after interference analysis on GSM-R and also taking into account the density of deployments immediately to the right of 915 MHz.

B.4.2.9 Scenario 3: Differentiated ×5 MHz blocks without guard bands

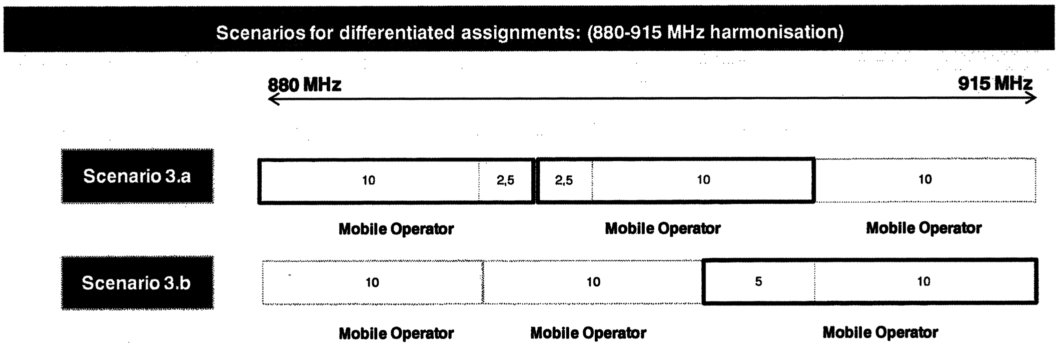
This scenario consists of 4 contiguous blocks (3×10 MHz + 1×5 MHz) and no internal or external guard bands. Further variations on the scenario include the allocation of the 5 MHz to a new entrant or to existing players on a differentiated need basis.

The key features are the new channelisation of 5 MHz and the provision of a fourth licensee (alternatively, the option of uneven allocations among the existing three licensees).

The primary drivers of this scenario include a focus on broadband as well as differentiated assignments (uneven spectrum assignments to licensees based on such factors as market share and geographic differentiation).

The assignment is intended primarily to accommodate broadband services. UMTS and LTE (the two major 3G and 4G technologies) are realistically deployed in bands of 5, 10, 15 or 20 MHz.

The snapshot below illustrates scenarios 3.a and 3.b



Notes on scenarios 3.a and 3.b

- The spectral positions of "mobile operators" indicated above are purely hypothetical and may not be interpreted based on current assignments
- Scenarios 3.a and 3.b involves 1 or 2 of the licensees giving up spectrum for the benefit of 1 or 2 others
- Decision about what licensee gets the 5 MHz to be made using 'need-based' criteria such as market share, traffic volume

Figure 74: Scenarios for differentiated assignments (880-915 MHz)

The 5 MHz block assignment can also be used for differentiated assignments in a way that is compatible with both GSM and IMT. That is, each existing player has enough spectrum to deploy either or both GSM and 3G/4G in the same band (with 10 MHz assignments) while the Authority has the flexibility to assign the extra 5 MHz on an 'incremental-need' basis. In other words, the Authority can assign extra spectrum to a licensee with a demonstrable need (in a given geographical region for a given period upon which the need is re-evaluated). The rationale behind 'need-based' primary assignments is that beyond a certain minimum amount of spectrum required for basic operation of a network, incremental assignments must recognise the actual need for spectrum. It is common practice among regulators to allocate uneven amounts of spectrum to licensees. Such decisions may result from the history of assignments or be based on such factors as market share, penetration or revenues

B.4.2.10 Additional Terms for Licensees

Two key conditions must accompany the redistribution of spectrum in the 880 - 960 MHz band to ensure stable and predictable operations within the band and adjacent bands:

- Coordination for GSM-R protection; and
- Management of interference devolved primarily to licensees.

Any scenario chosen for the harmonisation of the 880-960 MHz band is best complemented with regulatory measures to ensure that the behaviour of licensees is aligned with the Authority's targets. The Authority aims to ensure good co-ordination between licensees and the commitment of licensees.

Co-ordination measures are important to prevent and resolve interference issues, which are bound to occur. These measures become especially important between licensees of different bands deploying different technologies.

B.4.2.11 GSM-R adjacency co-ordination

GSM-R is used in mission-critical deployments and has been identified as a promising technology for transportation management. Therefore, adequate interference protection from adjacent bands is crucial. Adjacent bands include GSM 900 MHz and CDMA. Historically, guard bands were a key measure to prevent interference because very little additional measures (antenna power, positioning, for instance) were required. However, guard bands alone are not enough anymore because they have become smaller and more valuable and networks have become denser. Additional measures such as coordination of power levels and site-by-site interference analysis are required.

However, licensees can be expected to be primarily interested in their own network and therefore it is incumbent on the Authority to put in place a framework that incentivises or forces licensees to co-ordinate and solve interference issues. In putting in place such a framework, practical considerations must be observed. Specifically, the bulk of the actions to prevent or manage interference should fall on the GSM and CDMA licensees, not on the GSM-R licensees sandwiched. For one, the geographical scope of the GSM-R network is small (along tracks mostly), giving GSM-R licensees less room to manoeuvre in changing physical configurations of their network. Secondly, interference studies carried out between GSM-R and systems in the GSM900 MHz band have shown that the latter has potential to interfere across the entire GSM-R band. Thirdly, given that GSM900 system deployments are denser, the interference these deployments cause on GSM-R is expected to be cumulatively greater. Fourthly, GSM-R being a niche technology, its ecosystem of interference management tools is not as great as that of GSM-R. Therefore, more responsibility should rest with licensees in adjacent bands to actively avoid interfering than on GSM-R licensees to experience and fight interference.

Licensees in the adjacent bands to GSM-R (more importantly the licensees with spectrum immediately before and after the GSM-R block) must therefore commit to the following:

- Committing to special radio network planning guidelines in geographical areas of overlap (e.g. along tracks and at stations) agreed with GSM-R players and the Authority that reasonably protect GSM-R operations. Specifically, sharp filters must be used in the radios to avoid spurious out-of-band emissions and intermodulation products must be carefully avoided. Additionally, in areas of geographical overlap of adjacent networks, the licensees with adjacent spectrum to GSM-R must prefer, where it is reasonable to do so, to use other channels over those immediately adjacent to the GSM-R band;
- Committing to actively and promptly investigate interference detected by GSM-R players as well as making swift changes to their radio network configurations to solve such interference issues; and
- Committing to take swift corrective measures in the form of network reconfiguration (physical and spectral) once interference has been identified and investigated. Specifically, for severe interference issues (where the GSM-R network is exposed to extremely dangerous risks of dysfunction), the interfering licensees may be asked to switch off the interfering sites or reduce power significantly with immediate effect.

B.4.2.12 Co-ordination and interference self-management by licensees

In IMT bands, emerging options to manage interference are focused on co-ordination rather than guard bands (prevention) as has been the case until recently.

Given the increasing value of spectrum, guard bands that are not absolutely necessary are perceived as wasteful. In the specific case of cellular technologies, the underlying standards have consistently evolved to tolerate more interference than before. As a consequence, strict preventive interference measures, such as the use of internal guard bands, are abandoned.

With high-availability and business-sensitive services such as GSM, interference resolution usually needs to be performed very quickly. The old approach of having the regulator mediate interference resolution lengthens the process unnecessarily for at least two reasons. Firstly, licensees usually co-operate well on most interference cases. Additionally, the regulator is usually not in a position to provide logistical or technical help.

An option is for the Authority to disengage partially from co-ordination and interference management. Under the proposed scenario, the Authority would come into the picture only when licensees are not able to come to an agreement.

Such a measure is a good complementary measure to the removal of guard bands suggested in scenarios 1 and 3.

B.4.3 Cost-benefit analysis

The cost-benefit analysis complements the technical feasibility study by assessing the burden that in-band migration scenarios impose on the ecosystem. Such analysis is crucial for definitive conclusions on spectrum migration. It is important to avoid unintended consequences on end-users, especially for vital services such as cellular communications and transportation management (GSM-R).

This analysis considers three stakeholders and assesses the potential costs and benefits to each. These stakeholders are:

- End-users who represent the most important category. All the regulatory objectives of the Authority could be traced back to the benefits to end-users.
- Licensees who invest in networks and make services available: The objective of assessing costs and benefits in this category is to ensure that licensees are adequately incentivised and not put under conditions where reasonable, profitable business is impossible.
- The Authority who must be able to continue to manage spectrum without incurring unduly high costs or be put in a situation where it must compromise the interests of the end-users.

B.4.3.1 Perspective of licensees

The methodology of this section involves the presentation of impact analyses prepared by operators and comments as appropriate to these analyses. Any additional impacts that could be foreseen are also highlighted.

The Authority engaged all three licensees (Cell C, MTN, Vodacom) in the 880-915 MHz for feedback about the spectrum aggregation proposal put forward by Cell C. MTN and Vodacom provided financial assessments of the impact of spectrum aggregation on their respective businesses. The spectrum scenario used as a basis for this financial assessment is equivalent to scenarios 1 and 2 proposed above in terms of financial costs involved for licensees. Furthermore, potential impacts are evaluated for scenarios 3.a, and 3.b, to the extent that such impact could be reasonably assessed.

B.4.3.1.1 Vodacom

The Vodacom impact analysis refers to quantifiable cost impact as well as unquantifiable impacts of implementing the Cell C proposal (equivalent to scenarios 1 and 2).

- Quantifiable impact: Vodacom states that the migration would involve:
  - the replacement of cell extenders (15,000 low-power and 100 high-power cell extenders across the country for a total cost of ZAR 75.5 million);
  - The replacement of DAS systems (ZAR 2.66 million with the DAS systems in 19 locations); and

  - A frequency retune of the network (ZAR 8 million based on a reference quote provided in another scenario by a retune service company).

- Unquantifiable impact: Vodacom further warns of the substantial degradation of quality of service during the migration process. Cost assessments were not provided.

Cell extenders	DAS Replacement	Frequency Retune
▪ Around 15,000 low-power & 100 high-power Vodacom cell extenders to be impacted in RSA ▪ Actual required change is frequency tuning to new band ▪ Practically, replacement by new cell extenders is realistic ▪ Proposed unit cost of cell extender: ZAR 75.5 million	▪ Vodacom DAS systems installed in 19 locations in RSA ▪ Action required is the replacement of the pre-tuned filter modules ▪ A lump sum valuation of this replacement stands at ZAR 2.66 million	▪ Vodacom base stations need to be assigned new frequencies ▪ A network-wide frequency re-planning (retune) is required ▪ Cost of frequency retune based on historic comparable ▪ Amount required: ZAR 8,000,000

Figure 75: Impact of migration on Vodacom

Vodacom values the quantifiable part of cost of in-band migration as per the Cell C proposal at over ZAR 86 million. The unquantifiable impact presented included considerable disruption and poor quality of service during the spectrum migration.

B4.3.1.2 MTN

MTN provided an impact analysis focused on:

- frequency retune of over 4,000 sites at a cost of around 40 million and
- the timeframe for implementation of two years. MTN is the only licensee to provide a timeframe for implementation.

B.4.3.1.3 Cell C

It is worth noting that Cell C initiated the retune proposal that was put to the other two licensees in the 900 MHz band. Cell C did not provide an impact analysis but stated that "*all three mobile operators are to make adjustments to their network to incorporate the free guard bands resulting in equal allocations*."

B.4.3.1.4 Assessment of the perspective of licensees

This assessment is performed separately for scenarios 1 and 2 on the one hand and scenario 3 on the other. The focus of each assessment is on two aspects:

- A critical review of the type of changes as well as timelines provided by the licensees in their impact analyses where applicable:
- An analysis of the benefits of the migration for licensees.

A review of financial impact suggested by MTN and Vodacom is not covered due to the lack of comparable benchmarks in South Africa.

For scenarios 1 and 2, the following are assessments of positive and negative impacts on licensees:

- Costs in terms of changes required on the physical network: Because the 880-960 MHz migration is in-band, radio network equipment is typically built to operate in any channel within the band. Furthermore, it is standard practice for operators to purchase equipment that is tuned over the entire range allocated to the communication technology in any given band. Therefore, it would be unexpected that radio equipment (including repeaters) require a change of physical hardware in order to operate in a different sub-band;

  Furthermore, the impact of scenarios 1 and 2 (equivalent to the Cell C proposal) on Vodacom should be minimal because the proposed assignment for Vodacom is a slightly larger minimal offset (2 MHz) of Vodacom's existing assignment. In other words, a mere software reconfiguration of all Vodacom base stations would yield a sensibly similar network;
- Costs in terms of frequency retune: a frequency retune is typically carried out at least once a year even without frequency migration. The shift in frequencies represents sufficient grounds to conduct a frequency retune. Cell C and MTN would have to perform the most extensive frequency retune as a result of the aggregation of fragmented spectrum. Vodacom does not necessarily need an extensive frequency retune;
- Benefits in terms of radio planning flexibility and service quality: Scenarios 1 and 2 result respectively in 0.6 MHz (three GSM channels) and 0.4 MHz (two GSM channels) more for each licensee in the 'coverage layer' (900 MHz) of GSM networks. Typically, the 900 MHz (or coverage layer) provides better reception and limited capacity for all users. With the 0.4 or 0.6 MHz spectrum expansion, licensees have increased flexibility in planning their network with less interference (better quality of service);
- Benefits in terms of network traffic capacity: Scenarios 1 and 2 result respectively in 0.6 MHz (three GSM channels) and 0.4 MHz (two GSM channels) more for each licensee in the 'coverage layer' (900 MHz) of GSM networks. If this additional spectrum is used to provide more capacity in GSM, up to three new channels can be added overall depending on network configuration and reuse scenarios. In other words, each licensee can benefit by up to 3×7×2 =42 additional, simultaneous, voice communications.
- Benefits in terms of broadband readiness: Spectrum aggregation resulting in contiguous assignments means that MTN and Cell C can now plan to offer more

broadband services on the 'coverage layer'. In fact, in the existing spectrum configuration, MTN and Cell C could only deploy one block of 5 MHz even though they each had 11 MHz of spectrum in total.

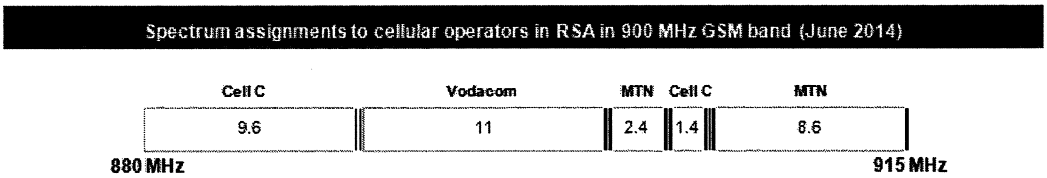


Figure 76: 900 MHz spectrum assignment

With one block of 5 MHz, MTN and Cell C could deploy at most one UMTS carrier and no LTE carrier at 10 MHz (the minimum commonly accepted LTE spectrum bandwidth in a real network). In scenarios 1 and 2, both MTN and Cell C can offer up to 2 UMTS carrier or introduce a reasonable LTE network over 10 MHz of spectrum. Vodacom could already deploy two 3G carriers or 1 LTE carrier in the existing configuration.

Scenario 3 provides all the benefits of scenarios 1 and 2 but also attracts all the costs. The key differences between the two scenarios are as follow:

- Only two of the three licensees would enjoy benefits in scenario 3. Those benefits, although of the same type as in scenarios 1 and 2 are more extensive because one (respectively two) licensee(s) get(s) 5 MHz (respectively 2.5 MHz) more spectrum than currently while they only get 1.6 MHz more spectrum than currently in scenarios 1 and 2; and
- One of the licensees gets 1 MHz less spectrum and therefore faces all the costs described above (Vodacom would face less costs). In addition, the licensee with 1 MHz less spectrum would not enjoy any of the benefits described above except that of broadband readiness (Vodacom would already enjoy that benefit).

It is worth noting that all licensees do not have equal needs for spectrum in practice. Therefore, the costs or disadvantages listed here may not apply in case of scenario 3. In practice, even licensees without a need for spectrum still request it for the other benefits such as convenience and future growth plans. An objective evaluation of costs for such a licensee in the absence of objective and thorough data on network utilisation, as well as market dynamics may be speculative in the end.

B.4.3.2 Perspective of end-users

Three categories of impact may be reasonably expected to be felt by end-users:

- Type of service;
- Quality of service; and
- Price of service.

In terms of quality of service, scenarios 1, 2, and 3 can be translated into better quality of service for users if the existing service configurations are maintained by all licensees.

In terms of service price, other factors are likely more decisive in determining the orientations of licensees.

In terms of new types of service, theoretically, licensees could introduce more broadband services to the entire population even in rural areas. In practice, service decisions result from company strategies and the business opportunities available in various geographic areas.

B.4.3.3 Perspective of the Authority

The potential costs and benefits to the Authority (and by extension, the government) are related primarily to the spectrum and licence fee income as well as the expenses associated with the migration process.

As far as benefits are concerned, any of the new scenarios (1, 2, or 3) would result in marginal additional spectrum fee income for the Authority. As a result of the in-band harmonisation, 1.8 MHz more spectrum would be made available in scenario 1 and 3, while 1.2 MHz of spectrum would be made available under scenario 2. The incremental revenue from spectrum fees is valued at ZAR1.62 and 1.08 million respectively for scenarios 1/3 and scenario 2.

Incremental spectrum fee income for ICASA from 880-960 MHz in-band harmonisation

	Scenario 1 (11.6 MHz *3)	Scenario 2 (11.4 MHz *3)	Scenario 3 (Differentiated Assignments)
Incremental Spectrum Made Available (MHz)	1.8	1.2	1.8
Incremental Spectrum Fees Income for ICASA (SAR)	1.62 million	1,08 million	1.62 million

Observations

- The amounts result from the Excel calculation spreadsheet made available by the Authority
- Assumptions include frequency factor (0.5), congestion factor (1.5), geographic factor (1), sharing factor (1), uni/bi directional factor (1) and area sterilised factor (600)

Figure 77: The Authority's revenue from incremental spectrum fees for all 3 harmonisation scenarios

An increase or a decrease of benefits may accrue as a result of more or less turnover from licensees. Migration scenarios that result in the affordability and high quality of existing and broadband services are likely to generate more demand from more users and potentially more revenue for licensees.

The costs on the Authority are primarily related to the involvement of the Authority during the consultations and implementation phase of the selected scenario. It is foreseeable that scenario 3 may result in protracted consultations and even legal challenges from the licensee that would end up with less spectrum. Furthermore, depending on the level of involvement of the Authority in supporting the migration process, additional costs may occur with further studies, arbitration of disputes and interference management during the transition phase of the migration. Lastly, the Authority runs the risk of negative brand exposure if the migration results in substantial disruption of the quality of service to the public.

B.4.3.4 Prioritisation of impact items

The Authority aims to comparatively evaluate all the costs as well as benefits associated with the various migration options. The Authority proposes to consider the best option option overall based on a balanced consideration of short, medium and long term interests and policy objectives.

The impact items (costs, benefits, implementation guidelines) are ranked by decreasing order of importance below:

- Quality of existing services to end-users during and after the migration: this category includes the end-user perception of quality of service, the ability of the network to provide a good quality of service and the incentives for licensees to provide a good quality of service;
- Affordability of existing services to end-users: this category is related to the technical constraints imposed on licensees, the costs of migration to licensees as well as the opportunities afforded to licensees in terms incremental bandwidth; and
- Availability of broadband services: this category includes the readiness of licensees to provide broadband services and the diversity of technologies available to them

B.4.4 Proposal

The proposals depend on the target market structure for the cellular industry.

For a 3-player market structure, by decreasing order of priority, the Authority proposes the following options:

- Scenario 1;
- Scenario 3a and 3b; and
- Scenario 2.

The following table summarises the expected benefits from each scenario.

Cost-benefit Analysis of the Migration Scenarios for the Cellular Spectrum

Stakeholders	Impact items	Scenarios			
		0*	1	2	3
Licensees	Amount of spectrum held (MHz)	11	11.6	11.4	10 or 12.5
Licensees	Cost of migration	NC	Low	Low	Low
End users / Licensees	Quality of existing service	Baseline	Best	Better	High
End users / Licensees	Affordability of existing services	Baseline	Baseline	Baseline	Better/Best
End users / Licensees	Availability of broadband services	Baseline	High	High	High
ICASA	Revenue from spectrum management	Baseline	More	More	More

<u>Costs and benefits of various migration scenarios</u>

- Scenario 1 provide the best overall benefits to the end users in a 3-player cellular scenario
- Scenario 1 is easier and faster to implement given that operator buy-in exists.

*0: Current spectrum distribution

Figure 78: Cost benefit analysis of migration scenarios for the cellular spectrum

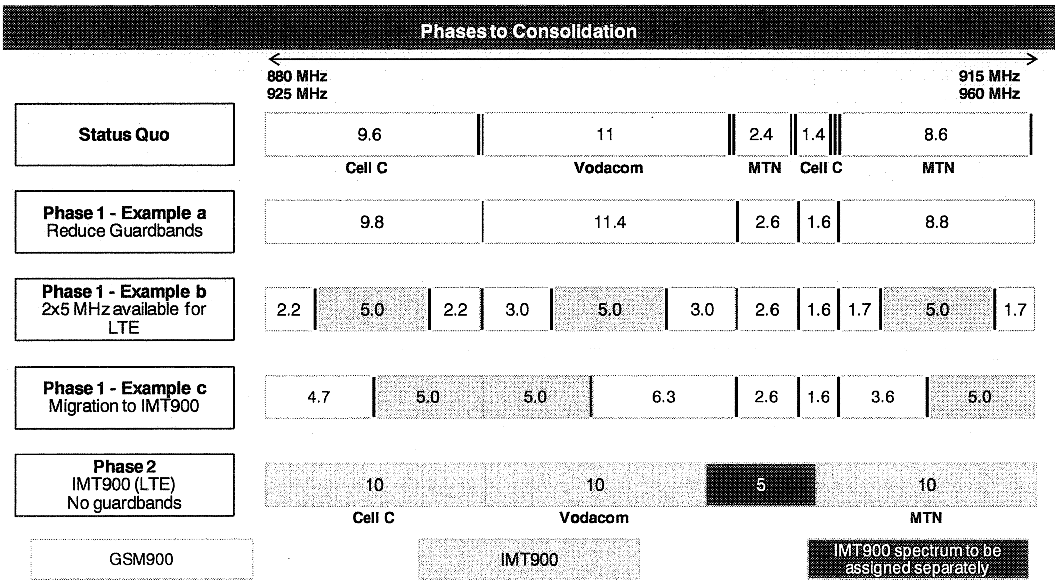


Figure 79: Steps to the harmonisation of the 900 MHz band

B.4.5 Implementation Guidelines

The implementation phase of the 880-915 MHz migration requires planning and collaboration from all parties to avoid considerable or prolonged service disruption. The Authority will ensure that the views and constraints of the licensees as well as other stakeholders are considered. Additionally, the Authority should lead the process of defining a clear governance framework while removing itself from operational aspects.

Oversee the definition of a plan

- ICASA to identify all stakeholders in the 880-960 migration plan and understand interests
- ICASA to set timelines leading to a migration in less than 2 years from validation of the plan (geographically s

Set clear governance rules and roles

- Define reporting metrics to the public and to ICASA
- Define a conflict resolution process with last resort to ICASA

Ensure communication and awareness

- Include a timely and transparent communication plan in the project plan
- Ensure proper communication between entities and ICASA

Figure 80: Implementation guidelines

B.4.5.1 Readiness for migration

Licensees are used to planning for frequency retunes (a key part of this migration). An important added challenge in this case is the co-ordination across licensees and the involvement of other stakeholders such as the Authority, representatives of consumers or other stakeholders as appropriate. Before migration commences, the Authority will ensure that all stakeholders are identified and present their constraints, perceived risks and recommendations for a smooth and successful outcome. Specifically, licensees must acquaint one another with their constraints and corporate policies for external co-ordination and communications. The Authority, as a neutral party and the regulatory body of the industry is best placed to oversee the successful completion of the readiness phase.

Aspects such as geographical sequence of migration are best left for co-ordination between licensees. However, the Authority should step in for arbitration in the case of irreconcilable differences between the parties.

Communication to the public during the migration must be transparent and all parties including the Authority must maintain open lines with the public.

B.4.5.2 Processes and governance

The Authority will be involved in defining the governance rules that form the basis for decision-making and arbitration for all parties during the migration. Additionally, the Authority will make sure that well-defined migration processes are in place that cover switchover procedures, disaster management and fallback processes.

The process of developing governance rules will be inspired by the typical problems that arise in multi-party transition processes in the telecom industry as well as common rules of migration processes. The various interests of parties must be clearly understood and weighed. In addition, governance rules must cover the post-migration periods where multiple adjustments to the network would be necessary to reach a fully-operational phase again. All switchovers during migration phases must occur at times of minimal traffic (usually at night).

In terms of process, the usual migration processes for frequency retune must be refined to include the cross-operator component. The most critical aspect of processes is to ensure working and speedy interfaces between licensees so that cross-operator notifications during the switchover are seamless.

B.4.5.3 Project management of the migration

The Authority shall ensure that there exists a sound and executable migration plan with input from all stakeholders.

Important aspects of the migration plan include the drafting of a co-ordinated project timeline, a communication plan as well as disaster-recovery and business continuity plans.

The project plan must clearly identify the phases of the migration (including the sequence of geographical areas affected), the dependencies between various phases and all key milestones related to the beginning and the end of migration within each geographical area.

B.5 The 921-925 MHz band

In the rest of this section, mentions of the 921-925 MHz band refer to the paired band 876-880 MHz // 921-925 MHz.

B.5.1 Current status in the 925-925 MHz band in South Africa

This section documents the relevant local information and decisions pertaining to the 921-925 MHz band. First, the permissible services in the band are illustrated in the national allocation plan. Next, the current assignments in the band are presented.

In summary, the 921-925 MHz band is allocated for PMR services and assigned for GSM-R use currently in South Africa.

B.5.1.1 Allocations in the 921-925 MHz band

According to the South African National Frequency Allocation Plan, the 921-925 MHz band is paired with 876-880 MHz for the provision of trunked mobile services.

Although the band is *de facto* associated with GSM-R, the actual allocation in South Africa prescribes a broader interpretation of the services allowed. Specifically, the band is allocated for 'Trunked Mobile Radio' services in South Africa. Additionally, the national footnotes for 921-925 MHz band (NF31) state the following:

"This band is currently proposed in Europe for digital private mobile radio for the railways using a PMR system based on GSM (GSM-R). In South Africa also, this band offers the possibility for large organisations (such as the railways) to use GSM-based PMR systems. The band might also be one in which TETRA-based equipment is available in the future.

There may also be a possibility of FWA sharing these frequencies, particularly in rural areas.

Although the national railway operator does not foresee the future usage of GSM-R, there have been enquiries from other entities who see the possibility of GSM-R use in projects like GAUTRAIN. The Authority has decided to allocate this band to digital trunking systems on a national basis. This does not preclude the use of GSM-R in certain projects where it might be feasible."

ITU region 1	SA allocation	Typical applications	Comments
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, NF9, NF10, NF11	**GSM-R(BTX) (921-925 MHz),** IMT900 MTX (880-915 MHz), IMT900 BTX (925-960 MHz), RFID (including, passive tags and vehicle location (915.1-921 MHz	Paired with 877.695-880 MHz. Paired with 925-960 MHz Paired with 880- 915 MHz Spectrum re-allocation for RFID (GG. No. 31127, 5 June 2008)

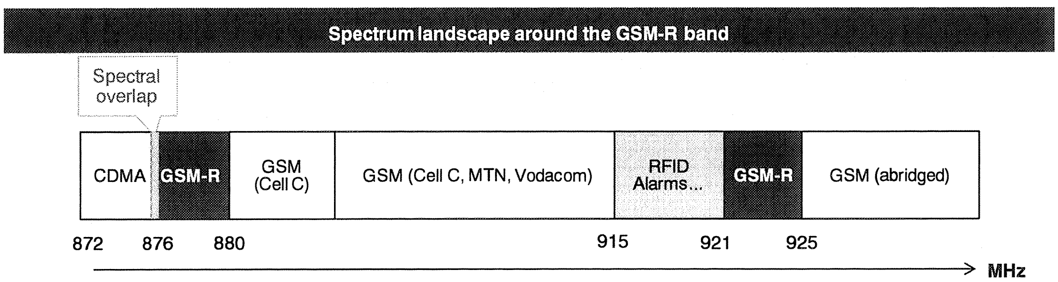
Table 49: Allocations in the 921-925 MHz band

B.5.1.2 Current assignments in the 921-925 MHz band

The 921-925 MHz band (paired with 876-880 MHz) is currently entirely assigned to PRASA as a GSM-R Radio Frequency licence. The area of operation is restricted to railway lines in metro areas across South Africa. The applicable technical parameters follow the GSM-R standards prescription.

Furthermore, the Authority has assigned this licence on a shared basis and reserves the right to assign the same frequencies to another operator subject to co-ordination and synchronisation. Other potential users of the band include Transrail and Gautrain for instance.

The entire GSM-R band has been allocated to PRASA. Furthermore, both the lower and upper bands of the GSM-R assignments have close adjacencies:



GSM-R and adjacencies

- The 2*4 MHz at 876-880 MHz & 921-925 MHz have been allocated in Region 1 exclusively for GSM-R
- The uplink of the band (876-880 MHz) is adjacent to CDMA(assigned to Neotel) on the left & GSM(Cell C) on the right
- The CDMA adjacency to the left of the 876-880 MHz overlaps by 1.08 MHz with the GSM-R uplink band

Figure 81: Spectrum landscape around GSM-R

The lower (uplink) GSM-R band is adjacent to the CDMA band (assigned to Neotel) on the left and to the GSM band (specifically, the Cell C band) to the right. The upper (downlink) GSM-R band is adjacent to a relatively empty band (occupied sparsely by Radio Frequency Identification (RFID) and alarm systems) to the left and to a GSM band (specifically, the Cell C assignment) to the right.

B.5.1.3 Challenges in the band allocated for GSM-R

The main challenge with the current GSM-R allocation is its potential overlap with another assignment on the 876-880 MHz leg. The following presents the actual overlap and the obligations of the Authority.

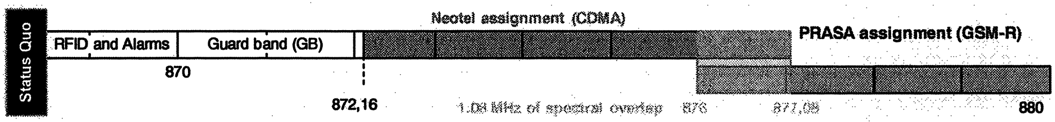


Figure 82: Spectrum overlap of CDMA and GSM-R assignments around the 876 MHz frequency

The Authority has a fundamental duty to ensure an environment where assigned spectrum is interference-free. Interference prevention options vary depending on the exclusive or shared nature of the spectrum.

- Where spectrum is assigned on an exclusive basis, interference is prevented usually through the use of guard bands and strict technical restrictions on emission profiles (spectral masks, EIRP limits).
- If spectrum is assigned on a shared basis however, interference prevention is commonly achieved through geographical exclusivity. In this case, licensees agree to deploy their systems in different areas at emission levels that ensure interference-free boundaries. In the case of trunking systems, it may also be agreed that all involved parties operate in the same network using different sub-network identifications.

In the 876-880 MHz band, there is a challenge of overlapping assignments. Indeed, Neotel has been assigned the frequency band 832.08 – 877.08 MHz (licence 5060831). As per the Gazette No. 34872 in section 7.1., Neotel "*has been assigned 2×4.92 MHz which spread throughout the frequency range 827.775 - 832.695 paired with 872.77.*" This assignment overlaps with the 876-880 MHz lower band of the GSM-R allocation. At least two types of challenges arise from this overlap:

- Legally, there is potentially a case against the Authority for attributing the 876-877,08 MHz band to two different licensees. The GSMR license (876-880 MHz) is assigned on a shared basis subject to co-ordination with other users. Therefore, there is a risk of a legal challenge from either Neotel or PRASA (the GSM-R license holder); and
- Technically, and assuming that both the Neotel and PRASA licences have been assigned on a shared basis, there is the potential for overlap at least at train stations and in residential areas along the railway lines used by PRASA.

B.5.1.4 The migration strategy

In the Radio Frequency Migration Plan, the Authority proposed allocating the 921-925 MHz band to GSM-R as follows:

- Assignment to GSM-R must be done in consultation with Transnet; and
- Assignment to GSM-R must be aligned with Government Gazette No. 34872.

The government Gazette No.34872 of 2011 is about the joint allocation of 800 MHz and 2600 MHz spectrum as part of a broadband IMT initiative. The in-band migration proposed in the Gazette is now obsolete and has not been followed through. Therefore, no further alignment with the dispositions in the Gazette has to be made.

In summary, the Authority's decision for the GSM-R band is to rephrase the allocation language from 'Trunking Services' to GSM-R. This removes any ambiguity in the allocation language.

B.5.2 Trends in the 921-925 MHz band

This section describes the directives, guidelines and trends in the 921-925 MHz band on three levels (global, Region 1, SADC) side-by-side with the South Africa dispositions. Furthermore, relevant benchmarks pertaining to GSM-R or the 921-925 MHz band are discussed.

ITU Allocation for Region 1	**SADC Allocation**			**South African Allocation**		
890 – 942 MHz	**890 – 942 MHz**			**890 – 942 MHz**		
FIXED MOBILE except aeronautical mobile	FIXED MOBILE except aeronautical mobile			FIXED MOBILE except aeronautical mobile		
		880 – 915 MHz IMT	Paired with 925 – 960 MHz		IMT 900 MTX (880 – 915 MHz)	Paired with 925 – 960 MHz
		915 – 921 MHz PMR &/or PAMR				
		921 – 925 MHz IMT PMR and /or PAMR	Paired with 876 – 880 MHz		**GSM–R (BTX) (921-925 MHz)**	**Paired with 877.695 – 880 MHz**

BROADCASTING Radiolocation		925 – 960 MHz IMT			IMT900 BTX (925 – 960 MHz) RFID (including passive tags and vehicle location) (915-921 MHz)	Paired with 880 – 915 MHz Spectrum Re-allocation for RFID (GG. No 31127, 5 June 2008)

Table 50: Comparison for allocation at ITU, SADC and South Africa level for 890-942 MHz

GSM-R (GSM Railway) is a customisation of the GSM standard for railway traffic management applications. The GSM-R specifications were finalised in 2000 and the standard is now part of the European Rail Traffic Management System. Over 38 countries have adopted the technology to date. A typical deployment involves a string of base stations along railway lines at intervals of 7 and 15 km for high redundancy and robustness of the network. In addition to GSM, a number of trunking features are built into GSM-R and service quality is designed for mission-critical applications as well as speeds of up to 500 km/h.

In summary, the 876-880 MHz paired with 921-925 MHz has not been exclusively allocated for GSM-R used at any level (region 1, SADC, South Africa). However, in much of Western Europe (and now increasingly Eastern Europe), GSM-R is routinely the only service deployed in the band.

B.5.2.1 Worldwide Trends for GSM-R or 921-925 MHz

GSM-R is standardised for use in either 900 or 1800 MHz bands.

In Europe, GSM-R is deployed by all member states as well as Turkey and Ukraine in the 876-880 MHz (paired with 921-925 MHz band). In Germany, this allocation has been extended by 3 MHz (873-876 MHz) to cater for the extensive and dense network of the railway company (Deutsche Bahn). It is important to note that the 873-876 MHz band was previously used for Trunking services.

In Australia, GSM-R is deployed in the DCS band (1800 MHz). The GSM band was auctioned to allow participation from the railway companies.

Other large countries that have adopted GSM-R include China in 2008 (aligned with European bands) and India (in the P-GSM band).

However, it is important to note that most frequency allocation tables do not make explicit allocations to GSM-R. Instead (as in the case of Ofcom for instance), the allocation is to mobile services while a footnote refers to GSM-R operation in the band.

B.5.2.2 Trends in Africa

To date, according to publically-available information, Algeria is the only other country in Africa other than South Africa to have deployed a GSM-R network. This deployment started between 2006 and 2008 and is in line with the broader European norms.

B.5.2.3 Outlook

GSM-R deployment remained highly concentrated in Europe with 35 of the 38 reported deployments in the early 2000s. Large European railway companies including Deutsche Bahn run GSM-R and have not indicated short-term plans of migrating to different technologies. This ensures a stable interest in GSM-R and the strengthening of the GSM-R standard in the band as well as the availability of equipment.

Outside of Europe, a relatively small number of countries have adopted the standard worldwide, suggesting a slow uptake. However, these countries include India and China, the largest emerging economies which have the potential to sway industries.

Most African countries have yet to adopt the standard. A deeper analysis reveals however that the slow adoption in African is due to the under-developed and under-funded railway networks. As markets continue to grow and infrastructure spending increases in Africa, it is therefore likely to see more GSM-R networks rolled out in the *de facto* Region 1 band of 876 – 880 MHz paired with 921-925 MHz.

In conclusion, GSM-R will likely be a major and growing standard for railways around the world. Since GSM-R is primarily deployed in the 921.925 MHz band, this allocation will remain for the foreseeable future.

It might also be possible to omit GSM-R and to leap frog directly to LTE-R in the IMT850 band. Potential migration from GSM-R to LTE-R could be performed smoothly with Single RAN equipment deployed. Potential coexistence scenarios might be developed with ~2×1MHz in GSM-R for voice focused services and 2×5 MHz for data demands.

Appendix C Glossary

3G	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 Multiplex 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 isotropically 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 Multiplex 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;
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 2013 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 consist 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 Multiplex 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;
WBS	means Wireless Business Solutions 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 planned to be held in 2015

C.1 Definitions

C.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.*

C.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[36] describes spectrum re-farming:

---

[36]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.

as a process constituting any basic change in conditions of frequency usage in a given part of radio spectrum (see The ICT Regulation Toolkit)[37].

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 changed38 .
- 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.

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

[38] 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.

Printed by and obtainable from the Government Printer, Bosman Street, Private Bag X85, Pretoria, 0001
Publications: Tel: (012) 748 6052, 748 6053, 748 6058
Advertisements: Tel: (012) 748 6205, 748 6208, 748 6209, 748 6210, 748 6211
Subscriptions: Tel: (012) 748 6054, 748 6055, 748 6057