

INDEPENDENT COMMUNICATIONS AUTHORITY OF SOUTH AFRICA

NO. 3246

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**HEREBY ISSUES A NOTICE REGARDING THE FINAL RADIO FREQUENCY
ASSIGNMENT PLAN FOR THE IMT450 FREQUENCY BAND IN TERMS OF
REGULATION 3 OF THE RADIO FREQUENCY SPECTRUM REGULATIONS, 2015.**

1. The Independent Communications Authority of South Africa ("the Authority"), hereby publishes the **Final Radio Frequency Spectrum Assignment Plan for the frequency band 450 MHz to 470 MHz** in terms of Regulation 3 of the Radio Frequency Spectrum Regulations, 2015, read with Regulation 5 of the Radio Frequency Migration Regulations, 2013, and the International Mobile Telecommunications (IMT) Roadmap 2014 and 2019.

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Radio Frequency Spectrum Assignment Plan

Rules for Services operating in the Frequency Band
450 MHz to 470 MHz
(IMT450)

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1 Glossary

In this Radio Frequency Spectrum Assignment Plan, terms used will have the same meaning as in the Electronic Communications Act 2005 (no. 36 of 2005); unless the context indicates otherwise:

“3GPP”	means the 3 rd Generation Partnership Project (3GPP), which consists of six telecommunications standard development organisations
“Act”	means the Electronic Communications Act, 2005 (Act No. 36 of 2005) as amended
“CRASA ECC”	means the Communications Regulators’ Association of Southern Africa (CRASA) Electronic Communications Committee (ECC)
“DM RS”	means Demodulation Reference Signal
“ECC/REC (11)04”	means ECC Recommendation (11)04 - Cross-border Coordination for Mobile/Fixed Communications Networks (MFCN) in the frequency band 790-862 MHz, Edition 3 February 2017
“ECC/REC (15)01”	means ECC Recommendation (15)01 - ECC Recommendation (15)01 “Cross-border coordination for Mobile/Fixed Communications Networks (MFCN) in the frequency bands: 694-790 MHz, 1427-1518 MHz and 3400-3800 MHz”. Amended on 14 February 2020
“ECC”	means Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT)
“FDD”	means Frequency Division Duplex
“HCM”	means Harmonised Calculation Method
“HIPSSA”	means Sub-Saharan Africa Assessment Report on Harmonization of ICT Policies in Sub-Saharan Africa
“IMT”	means International Mobile Telecommunications
“IMT700”	means IMT in the 700 MHz band (703 MHz to 733 MHz and 758 MHz to 788 MHz)
“ICNIRP”	means International Commission on Non-Ionizing Radiation Protection (ICNIRP)
“ITA”	means Invitation to Apply
“ITU”	means the International Telecommunication Union
“ITU-R”	means the International Telecommunication Union Radiocommunication Sector

“LTE”	means Long Term Evolution, which 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
“NRFP”	means the National Radio Frequency Plan 2021 for South Africa
“PCI”	means Physical-Layer Cell Identities
“PRACH”	means Physical Random-Access Channel
“PSTN”	means Public Switched Telephone Network
“PUCCH”	means Physical Uplink Control Channel
“RFSAP”	means Radio Frequency Spectrum Assignment Plan
“TCA”	means Terrain Clearance Angle
“TDD”	means Time Division Duplex
“WRC-12”	means World Radiocommunication Conference 2012 held in Geneva
“WRC-15”	means World Radiocommunication Conference 2015 held in Geneva
“WRC-19”	means World Radiocommunication Conference 2019 held in Sharm el-Sheikh

2 Purpose

- 2.1** A Radio Frequency Spectrum Assignment Plan (RFSAP) for the band IMT450 provides information on the requirements attached to using a frequency band in line with the allocation and other information in the National Radio Frequency Plan (NRFP). This information includes technical characteristics of radio systems, frequency channelling, coordination, and details on required migration of existing users of the band and the expected method of assignment.
- 2.2** The feasibility study consultation concerning the 450 - 470 MHz band¹, mandated by the Frequency Band Migration Regulation and Plan contained in the IMT Roadmap 2014² and IMT Roadmap 2019³, concluded that the Authority proceeds with an RFSAP for IMT in this band.
- 2.3** This Frequency Assignment Plan states the requirements for the utilisation of the frequency band between 450 MHz and 470 MHz for IMT450 in South Africa.
- 2.4** The International Telecommunications Union (ITU) states that International Mobile

¹ Implementation of the Radio Frequency Migration Plan and the International Mobile Telecommunications (IMT) Roadmap for public consultation, Government Gazette No. 45690, 24 December 2021

² Final (Draft) IMT Roadmap 2014, Government Gazette Vol. 593, 14 November 2014 No. 38213

³ Final (Draft) IMT Roadmap 2019, Government Gazette Vol. 645, 29 March 2019 No. 42361

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 are:

- a high degree of commonality of functionality worldwide whilst 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

3 General

- 3.1** Technical characteristics of the equipment used in IMT450 systems will conform to all applicable South African standards, international standards, ITU and its radio regulations as agreed and adopted by South Africa.
- 3.2** All installations must comply with safety rules as specified in applicable standards.
- 3.3** The equipment used will be certified under South African law and regulations.
- 3.4** The allocation of this frequency band and the information in this RFSAP are subject to review.
- 3.5** Frequency bands identified for IMT include the bands from 450 - 470 MHz.
- 3.6** Likely use of this band will be for rural mobile broadband, Public Protection and Disaster Relief (PPDR) or machine-to-machine (M2M) communications nationwide.
- 3.7** The requirements for the standard families which can provide IMT450 services include, but are not limited to:
- IMT-2000;
 - IMT-Advanced; and
 - IMT-2020.
- 3.8** Typical technical and operational characteristics of IMT systems, as identified by the ITU, are described in the following documents⁴:
- Recommendation ITU-R M.2012-5 (02/2022): Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-Advanced (IMT Advanced);
 - Report ITU-R M.2110 (07/2002): Sharing studies between Radiocommunication services and IMT systems operating in the 450-470 MHz band;
 - Recommendation ITU-R M.1645 (06/2003): Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000;

⁴ These and other IMT documents are available at <https://www.itu.int/rec/R-REC-M/en>

- Recommendation ITU-R M.1036-6 (10/2019): Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR); and
- Recommendation ITU-R M.2150-1 (02/2022): Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020).

The ITU also provides guidelines for modelling and simulation, e.g.:

- Recommendation ITU-R M.2070-1 (02/2017): Generic unwanted emission characteristics of base stations using the terrestrial radio interfaces of IMT-Advanced;
- Recommendation ITU-R M.2071-1 (02/2017): Generic unwanted emission characteristics of mobile stations using the terrestrial radio interfaces of IMT-Advanced;
- Recommendation ITU-R M.2090 (10/2015): Specific unwanted emission limit of IMT mobile stations operating in the frequency band 694-790 MHz to facilitate protection of existing services in Region 1 in the frequency band 470-694 MHz; and
- Recommendation ITU-R M.2101 (02/2017): Modelling and simulation of IMT networks and systems for use in sharing and compatibility studies.

4 Channelling Plan

- 4.1 The frequency band 450 – 470 MHz provides a total bandwidth of 2×5 MHz FDD or 10 MHz TDD for IMT450.
- 4.2 The recommended frequency arrangements for implementation of IMT in the band 450 - 470 MHz are summarised in Table 1 and Figure 1.

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)	
D8					450 - 470 TDD
D12	450.0 - 455.0	5.0	460.0 - 465.0	10	None
D13	451.0 - 456.0	5.0	461.0 - 466.0	10	None
D14	452.5 - 457.5	5.0	462.5 - 467.5	10	None

Table 1: Frequency arrangements in the band 450 - 470 MHz

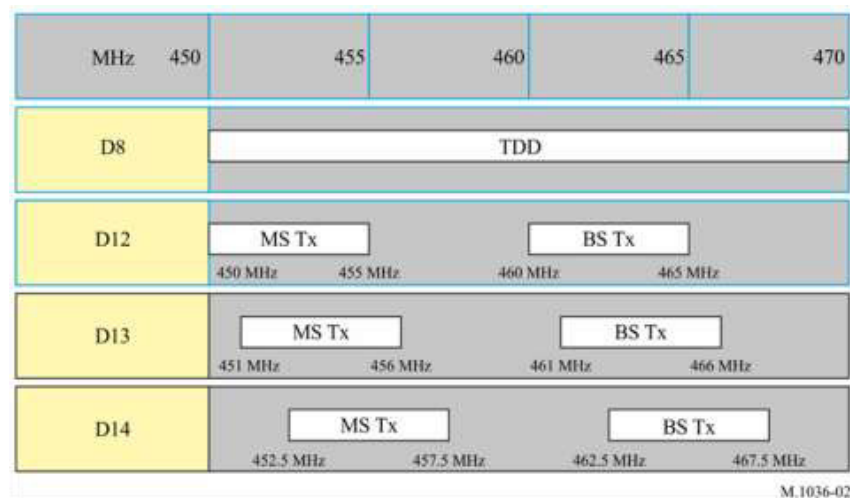


Figure 1: Frequency arrangements in the band 450 - 470 MHz (i.e., D8, D12, D13 and D14)

Both D13 and D14 configurations are most widely being considered or used around the world for IMT and PPDR systems in the 450-470 MHz band. The ecosystem for these band arrangements is currently available and rapidly emerging⁵.

5 Requirements for usage of radio frequency spectrum

- 5.1 This section covers the minimum key characteristics considered necessary in order to make the best use of the available frequencies.
- 5.2 The use of the band is limited to IMT services; narrowband services capable of coexistence with IMT may also be permitted. PPDR-supporting, M2M and mission critical communication services might be implemented via IMT.
- 5.3 Only systems using digital technologies that promote spectral efficiency will be issued with an assignment in the band. Capacity-enhancing digital techniques are being rapidly developed and such techniques that promote efficient use of spectrum, without reducing quality of service are encouraged.
- 5.4 In some cases, a radio system conforming to the requirements of this RFSAP may require modifications if harmful interference is caused to other radio stations or systems.
- 5.5 The allocation of spectrum and shared services within these bands are found in the National Radio Frequency Plan (NRFP) and an extract of the NRFP is shown in Appendix A.
- 5.6 Maximum radiated power:
 - 5.6.1 Base Station transmissions should not exceed 61 dBm / 5 MHz EIRP;
 - 5.6.2 Mobile Station transmissions should not exceed 23 dBm EIRP;
 - 5.6.3 On a case-by-case basis, higher EIRP may be permitted if acceptable technical justification is provided;

⁵ Implementation of the Radio Frequency Migration Plan and the International Mobile Telecommunications (IMT) Roadmap for public consultation, Government Gazette No. 45690, 24 December 2021

- 5.6.4** Where appropriate, subscriber terminal stations should comply with the technical specification outlined under the latest version of 3GPP TS 36.521-1 and 3GPP TS 38.521-1 for 5G NR connected to the relevant technology (e.g., LTE/LTE-Advanced/NR).
- 5.7** ICNIRP Guideline compliance is required, where applicable; and
- 5.8** Criteria and guidelines for interference mitigation are described in Appendix D.
- 6 Implementation**
- 6.1** Following clear and preferred feedback after the Feasibility Study⁶ consultation with stakeholders (including the first and even a second⁷ Consultation on Draft Assignment Plans for this band), the Authority has decided to proceed with licensing to the D14 band plan (i.e. 3GPP Band 31) for this band.
- 6.2** The Feasibility Study consultation conducted for this band concluded that the Authority proceeds with the *implementation* of the RF migration plan for the 450 MHz band in the following three steps for the consultation:
- 6.2.1** Clear the band as per the current regulations; as per the date of the Government Notice⁸.
- 6.2.2** Licence to IMT System using 3GPP Band 31 (D14) arrangements.
- 6.2.3** Licencing of additional services, including Narrowband services capable of coexistence with IMT (e.g. IoT, M2M, PPDR, etc.), would be permitted and licensed. PPDR-supporting or M2M services might be implemented via IMT too.
- 6.3** The Authority recognises there are Government services used in this band. The Authority confirms that it will develop exclusion zones as part of any new IMT licensing (via an ITA) in order to protect them, where absolutely required. Transnet (in particular) would furnish and publish a clear digital migration plan and provide information which would enable the Authority to publish the necessary technical transmission parameters and locations of legacy services with a future Invitation to Apply (ITA) published for new assignments for this band.
- 6.4** This Radio Frequency Assignment Plan comes into effect upon publication of the final RFSAP in the Government Gazette.
- 6.5** No new assignments in the band 450 - 470 MHz will be approved unless they comply with this RFSAP.

7 Coordination Requirements

- 7.1** Cross Border Frequency Coordination will abide by the Harmonised Calculation Method for Africa (HCM4A) Agreement. This follows the 3rd CRASA AGM⁹ that agreed that CRASA

⁶ Implementation of the Radio Frequency Migration Plan and the International Mobile Telecommunications (IMT) Roadmap for public consultation, December 2021, Government Gazette No. 45690, 24 December 2021

⁷ [2nd-Draft-Radio-Frequency-Spectrum-Assignment-Plan-for-the-frequency-band-825-MHz-to-830-MHz-and-870-MHz-to-875-MHz.pdf](https://www.icasa.org.za/uploads/files/2nd-Draft-Radio-Frequency-Spectrum-Assignment-Plan-for-the-frequency-band-825-MHz-to-830-MHz-and-870-MHz-to-875-MHz.pdf) (icasa.org.za) - <https://www.icasa.org.za/uploads/files/2nd-Draft-Radio-Frequency-Spectrum-Assignment-Plan-for-the-frequency-band-825-MHz-to-830-MHz-and-870-MHz-to-875-MHz.pdf>

⁸ Government Gazette Number 38640, 30 March 2015

⁹ Maseru, Lesotho, 2014

should implement the Cross Border Frequency Coordination Harmonised Calculation Method for Africa (HCM4A) Agreement.

- 7.2** The ECC had noted the need for a greater understanding of the concept and need for harmonisation in the signing of the HCM4A Agreement by the SADC Member States if the implementation of the Agreement was to be effective. The ECC, therefore, agreed to convene a workshop on HCM4A and requested CRASA Members to consider signing the agreement. These activities were part of the Frequency Planning Sub Committee (FPSC) Operations Plan 2015/16.
- 7.3** At the 5th CRASA AGM, Swakopmund, Namibia – 07-08 April 2016¹⁰, the subject of Cross Border Frequency Coordination using the Harmonised Calculation Method for Africa (HCM4A) was discussed in detail, following similar efforts in Europe. The Resolution CRASA/AGM/15.16/07 stipulates, “The AGM urged CRASA Members to prioritise the motivation to their administrations who are yet to indicate their interest to sign the Harmonised Calculation Method for Africa (HCM4A), to do so as soon as possible”.
- 7.3.1** Therefore, coordination would follow the HCM4A as detailed in Sub-Saharan Africa Assessment Report on Harmonization of ICT Policies in Sub-Saharan Africa¹¹ (HIPSSA)
- 7.4** A harmonized calculation method (HCM4A) brings these benefits:
- 7.4.1** Based on the HCM Agreement used in Europe;
 - 7.4.2** Optimize spectrum usage;
 - 7.4.3** Prevent harmful interferences;
 - 7.4.4** Confer an adequate protection for stations;
 - 7.4.5** Define technical provisions and administrative procedures;
 - 7.4.6** Quick assignment of preferential frequencies;
 - 7.4.7** Transparent decisions through agreed assessment procedures;
 - 7.4.8** Quick assessment of interference through data exchange.
- 7.5** HCM4A involves all 4 sub regions of Africa. This means the HCM4A project includes performing a survey and a comparative analysis of existing administrative and technical procedures related to bilateral and multilateral cross-border frequency coordination agreements across the 4 geographical sub-regions as defined by the African Union (AU), namely:
- 7.5.1** Central Africa [Burundi, Central African Republic, Chad, Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon, Sao Tome, and Principe];
 - 7.5.2** East Africa [Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Mauritius, Rwanda, Seychelles, Somalia, Sudan, Tanzania, Uganda];
 - 7.5.3** Southern Africa [Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe];
 - 7.5.4** West Africa [Benin, Burkina-Faso, Cape Verde, Côte d’Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Sierra Leone, Senegal, Togo].

¹⁰ https://www.google.com/url?sa=t&ret=j&q=&esrc=s&source=web&cd=&ved=2ahUKewi81bOFz6P2AhUwQUEAHe1YDIgQFnoECAIQAQ&url=https%3A%2F%2Fextranet.crasa.org%2Fzip-agm.php%3Fid%3D332&usg=AOvVaw1bVAuEnE8a2iJnP20F_b_2

¹¹ https://www.itu.int/en/ITU-D/Projects/ITU-EC-ACP/HIPSSA/Documents/FINAL%20DOCUMENTS/FINAL%20DOCS%20ENGLISH/hcm4a_agreement.pdf

- 7.6 HCM4A also comes with a software tool for Sub-Saharan Africa¹²
- 7.6.1 Optimise spectrum usage by accurate interference field strength calculations;
 - 7.6.2 Establish general parameters, improvement, and supplementation of technical provisions, individual restrictions;
 - 7.6.3 Establish models for computer-aided interference range calculations;
 - 7.6.4 Harmonise parameters: objectively predictable towards transparent decisions.
- 7.7 As per ECC/REC T/R 25-08 [¹³] and in ECC/REP 276 [¹⁴], the following field strength thresholds have to be assured. Operator-to-operator coordination may be necessary to avoid interference.
- 7.7.1 Indicative coordination threshold¹⁵ E_{th} for analogue or digital land mobile systems (in order to avoid harmful interference between stations located in neighbouring countries, indicative coordination thresholds are established which should not be exceeded without coordination between neighbouring countries) is expressed as $E_{th} = 20 + 10 \times \log_{10}(\text{channel bandwidth (MHz)} / 0.025)$, in dB μ V/m, and provided at the border-line for the co-channel, 50% locations, 10% time.
- For the typical channel bandwidth of 5 MHz, this corresponds to the value of the indicative coordination threshold of 43 dB μ V/m/5 MHz for 10 m antenna height above ground. Converted for a receiving antenna height of 3 m using ITU-R P.1546¹⁶, the indicative coordination threshold is written as 53.3 dB μ V/m/5 MHz (using HCM¹⁷, the threshold is 52 dB μ V/m/5 MHz).
- 7.7.2 **IoT vs Broadband:** Field strength levels for cross-border coordination between FDD land mobile systems using narrowband (typical in the Internet of Things (IoT)) preferential channels up to 25 kHz and systems using a channel greater than 1 MHz (more common in broadband applications) may be found in Annex 3 of ECC/REC T/R 25-08:

This section considers the coordination between preferential channels of land mobile systems up to 25 kHz on one side and land mobile systems with a channel greater than 1 MHz on the other side of the border. An illustration of such scenario, with an overlapping narrower channel and wider channel land mobile systems across the border,

¹² PowerPoint Presentation (itu.int) <https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2017/May%20BKK/Presentations/HCM%20and%20HCM4A%20BKK%2020170504%20IB.pdf>

¹³ ECC Recommendation TR 25-08 "Planning criteria and cross-border coordination of frequencies for land mobile systems in the range 29.7-470 MHz", Amended 28 September 2018.

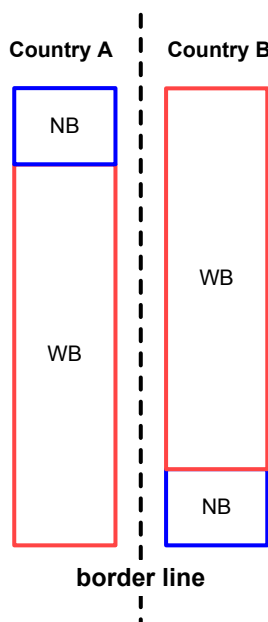
¹⁴ ECC Report 276 "Thresholds for the coordination of CDMA and LTE broadband systems in the 400 MHz band", 27 April 2018.

¹⁵ The approach used for setting up the "COMMON UNDERSTANDING ON THE NEED FOR COORDINATION OF RADIO STATIONS BETWEEN SWEDEN AND LITHUANIA IN THE FREQUENCY BAND 450-470 MHz" (https://www.pts.se/globalassets/startpage/dokument/legala-dokument/avtal/ovriga-lander/50_common-understanding-swe-ltu_450mhz_180116_dnr18-431.pdf)

¹⁶ ITU-R Recommendation P.1546-6 (08/2019): Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz (<https://www.itu.int/rec/R-REC-P.1546/en>).

¹⁷ HCM Agreement (Harmonised Calculation Method) between the administrations of Austria, Belgium, the Czech Republic, Germany, France, Hungary, the Netherlands, Croatia, Italy, Liechtenstein, Lithuania, Luxembourg, Poland, Romania, the Slovak Republic, Slovenia, and Switzerland on the Coordination of frequencies between 29.7 MHz and 43.5 GHz for the Fixed Service and the Land Mobile Service. The latest version of this agreement can be found from http://www.hcm-agreement.eu/http/englisch/verwaltung/index_europakarte.htm

is shown in the following figure (where NB refers to narrowband and WB refers to wideband):



The following should be taken into account:

- ECC Report 276 **Error! Reference source not found.** provides a technical background for cross-border coordination of systems with a channel greater than 1 MHz in the 450-470 MHz and proposes a method which can be applied in bilateral or multilateral agreements that allow for higher cross-border coordination thresholds for wideband systems in the 450 MHz band in situations where no or some overlap of narrowband and wideband allocations across the border occurs. In consequence, it means that land mobile systems up to 25 kHz keep their existing preferential rights and may extend them to all non-preferential channels in the overlapping range, if preferential rights of other administrations involved are not affected;
- The overlap is typically as small as a few hundred kiloHertz. ECC Report 276 does not cover the case of full overlap between land mobile systems up to 25 kHz on one side and land mobile systems with a channel greater than 1 MHz on the other side of the border;
- In the situation where land mobile systems up to 25 kHz use preferential rights not to the full extent, i.e. they do not generate the maximum allowed field strength at a distance of 40 km or 50 km in the territory of the neighbouring administration, solutions should be found between administrations or operators. One possible solution would be to increase the radiated power of the preferential system to the extent possible under preferential rights conditions. If not possible, a reduction of the radiated power of the system with a channel bandwidth > 1 MHz within the preferential frequency of the system with channel bandwidth up to 25 kHz may be considered;
- The two most common preferential regimes for narrowband systems were considered, both defined as the field strength threshold of 20 dBμV/m at 10 m height in 25 kHz at a distance inside the neighbouring country: Preferential Regime a) at 40 km distance and Preferential Regime b) at 50 km distance. The

proposed coordination thresholds for a partial overlap of narrowband land mobile systems up to 25 kHz on one side and wideband land mobile systems with a channel greater than 1 MHz on the other side of the border at a height of 10 m above ground are summarised in the following table (where “@” stands for “at a distance inside the neighbouring country”):

	Preferential Regime a) at 40 km distance	Preferential Regime b) at 50 km distance
System up to 25 kHz using preferential frequency	20 dBµV/m/25 kHz @40 km beyond the borderline	20 dBµV/m/25 kHz @50 km beyond the borderline
System up to 25 kHz using NON-preferential frequency	20 dBµV/m/25 kHz @0 km (on the borderline)	20 dBµV/m/25 kHz @0 km (on the borderline)
System with a channel greater than 1 MHz	41 dBµV/m/25 kHz @0 km (on the borderline)	48 dBµV/m/25 kHz @0 km (on the borderline)
Note 1: Predictions for calculations: 50% location probability, 10% time probability Note 2: If a channel bandwidth other than 25 kHz is used, then a bandwidth conversion factor of $10 \times \log_{10}(\text{channel bandwidth} / 25 \text{ kHz})$ should be added to the field strength values. Note 3: For narrowband land mobile systems using preferential frequencies and bandwidth greater than 25 kHz (e.g. 50 kHz, 100 kHz, 150 kHz or 200 kHz), indicative coordination threshold levels should be applied within every 25 kHz bandwidth within the channel spacing.		

Note: Partially different coordination thresholds are used for coordination between Sweden and Germany¹⁸:

- To protect simplex narrowband systems PMR/PAMR *uplink* used close to the border from a Mobile/Fixed Communications Networks *downlink* (with receiving antenna at 10 m height), the coordination field strength is:
 $14 + 10 \times \log_{10}(\text{BW (in MHz)} / 0.025 \text{ MHz}) \text{ (dBµV/m)}$
 This coordination threshold is 6 dB stricter than the ECC's one.
- To protect duplex narrowband systems PMR/PAMR used close to the border (with receiving antenna at 10 m height), the coordination field strength is:
 $20 + 10 \times \log_{10}(\text{BW (in MHz)} / 0.025 \text{ MHz}) \text{ (dBµV/m)}$
- In these expressions, BW stands for the bandwidth of the channel, in MHz.
- To protect Mobile/Fixed Communications Networks *uplink* from simplex narrowband systems PMR/PAMR *downlink* used close to the border (with receiving antenna at 10 m height), the coordination field strength is 20 dBµV/m.

¹⁸ Detailed in the document: “Agreement between the German Federal Network Agency and the Swedish Post and Telecom Authority concerning the use of the frequency bands 452.5 - 457.5 MHz and 462.5 - 467.5 MHz for Land Mobile Service Stations in the border areas”, Feb 2017

This threshold is more relaxed than the one from ECC/REC T/R 25-08 as even narrower channels do not receive a lower threshold value.

7.7.3 Broadband vs. broadband coordination: field strength levels for cross-border coordination between FDD land mobile systems with channels greater than 1 MHz in the frequency bands 450 - 470 MHz may be found in Annex 3 of ECC/REC T/R 25-08.

Field strength trigger values for LTE vs LTE and CDMA vs. CDMA systems:

- Base stations using the same technologies on both sides of the border line with centre frequencies not aligned, or using preferential PCIs codes given in Annex 5 of ECC/REC T/R 25-08 with centre frequencies aligned may be used without coordination between neighbouring countries if the mean field strength produced by the cell (all transmitters within the sector) does not exceed the value of 55 dBμV/m/5 MHz at a height of 3 m above ground at the border line between neighbouring countries and does not exceed a value of 37 dBμV/m/5 MHz at a height of 3 m above ground at a distance of 10 km inside the neighbouring country.
- Base stations using the same technologies on both sides of the border line with centre frequencies aligned and using non-preferential PCIs may be used without coordination between neighbouring countries if the mean field strength produced by the cell (all transmitters within the sector) does not exceed the value of 37 dBμV/m/5 MHz at a height of 3 m above ground at the border line between neighbouring countries.

Note: For the same conditions a lower planning coordination threshold of 29 dBμV/m/5 MHz exists between Norway and Sweden and also Germany and Sweden.¹⁹

Field strength trigger values between LTE and CDMA:

- In the case of different technologies used on opposite sides of the border line, with centre frequencies aligned or not aligned, base stations may be used without coordination with a neighbouring country if the mean field strength produced by the cell (all transmitters within the sector) does not exceed the value of 55 dBμV/m/5 MHz at a height of 3 m above ground at the border line between neighbouring countries and does not exceed a value of 37 dBμV/m/5 MHz at a height of 3 m above ground at a distance of 10 km inside the neighbouring country.
- Summary for LTE and CDMA combinations:
- The trigger values of field strength (dBμV/m/5 MHz) at a height of 3 m above ground for FDD LTE/CDMA systems, in the case of no overlap between narrowband and wideband assignments are summarised in the following table (where “@” stands for “at a distance inside the neighbouring country”):

¹⁹ Detailed in the documents: “Agreement between the Norwegian Communications Authority and the Swedish Post and Telecom Authority concerning the use of the frequency bands 452.5 - 457.5 MHz and 462.5 - 467.5 MHz for Land Mobile Service Stations in the border areas”, February 2017 and the “Agreement between the German Federal Network Agency and the Swedish Post and Telecom Authority concerning the use of the frequency bands 452.5 - 457.5 MHz and 462.5 - 467.5 MHz for Land Mobile Service Stations in the border areas”, Feb 2017.

	Non-Preferential frequency usage		
	Centre frequencies aligned		Centre frequencies not aligned
	Preferential PCI codes	Non-preferential codes	All codes
LTE vs. LTE or CDMA vs. CDMA	55 dB μ V/m @0km 37 dB μ V/m @10km	37 dB μ V/m @0km	55 dB μ V/m @0km 37 dB μ V/m @10km
LTE vs. CDMA	55 dB μ V/m @0km 37 dB μ V/m @10km		

Notes: Estimations are based on 50% locations and 10% time. If a channel bandwidth other than 5 MHz is used, then the following bandwidth conversion factor may be utilised: $10 \times \log_{10} (\text{channel bandwidth} / 5 \text{ MHz})$.

Table 2: Field Strength Trigger Values for FDD LTE/CDMA

- 7.8** Use of these frequency bands will require HCM4A coordination with the neighbouring countries within the coordination zones, of the above-mentioned distances (such as 0 km and 10 km from the border-line for the broadband case), inside the neighbouring country. The coordination distance is continuously being reviewed, and these may be updated from time to time.
- 7.9** If neighbouring administrations wish to agree on frequency coordination based on preferential frequencies, whilst ensuring equitable treatment of different operators within a country, the Authority will add these into the mutual agreements.
- 7.10** As per ECC/REC (11)04 for 790-862 MHz, stations of IMT systems may be operated without coordination if the mean field strength produced by the cell (all transmitters within the sector) does not exceed the value of 15 dB μ V/m/5 MHz at 10% time, 50% of locations at 3 metres above ground level at the border line. Adjusting this value by the ratio of the attenuations in the bands, i.e., $20 \times \log_{10}(790 \text{ MHz} / 450 \text{ MHz}) = 5 \text{ dB}$, the adjusted mean field strength produced by the cell (all transmitters within the sector) does not exceed the value of 10 dB μ V/m/5 MHz.
- 7.11** Technical analysis may be conducted by the Authority before an assignment is issued according to Appendix B based on an extract from ECC/REC (11)04.
- 7.12** Specific information regarding coordination may be found in Appendix C, an extract from ECC/REC (11)05.
- 7.13** In the event of any interference, the Authority will require affected parties to carry out coordination. In the event that the interference continues to be unresolved after 24 hours, the affected parties may refer the matter to the Authority for a resolution. The Authority will decide upon the necessary modifications and schedule of modifications to resolve the dispute. The Authority will be guided by the Frequency Coordination Process as shown in Appendix D.
- 7.14** Assignment holders will take full advantage of interference mitigation techniques such as antenna discrimination, tilt, polarisation, frequency discrimination, shielding/blocking (introduce diffraction loss), site selection, and/or power control to facilitate the coordination of systems.

8 Assignment

- 8.1** An Invitation to Apply will be published for any new Band 31 assignments in this band in line

with regulations developed in line with Section 31(3) of the Electronic Communications Act (Act No. 36 of 2005).

- 8.2 Transnet's existing assignment in this frequency band will be amended in accordance with Regulation 6 of the Radio Frequency Migration Regulation 2013, in order to implement the provisions of Section 10.2 below post 1st April 2025.

9 Revocation

- 9.1 All existing radio frequency spectrum licences as of the 1st of April 2023 are revoked except for cases of some Government licences. The migration started in 2016 and was to be completed in 2022 with Dual Illumination ending in 2022.

10 Radio Frequency Migration

- 10.1 This RFSAP will come into effect upon publication. The Authority expects an ITA process to commence for this band (Band 31 assignment) post 1st April 2025.

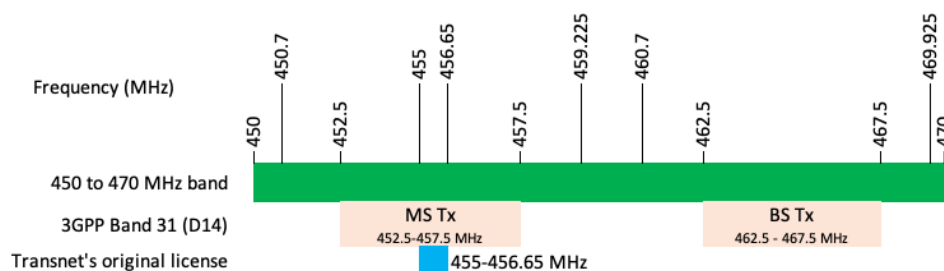


Figure 2: 450 - 470 MHz new licence holder coexistence arrangements

- 10.2 The Migration Process agreed in 2015/16 noted:

- Migration starts in 2016 and is completed in 2022; and
- Dual illumination stops in 2022²⁰.
- SAPS – free up 406 - 426 MHz and migrate to 380 - 400 MHz:
 - Additional 2×3 MHz are still free for potential PPDR licences, e.g., emergencies, airports (SAA).
- Transnet – free up 450 - 470 MHz and potentially migrate to 406 - 426 MHz:
 - From 2016 Transnet can commence migration to 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; and
 - Transnet may also migrate to the GSM R.

²⁰ The announcement of the date for the final Switch-Off of the analogue signal and the end of dual illumination was announced as the 31st of March 2022 by the Minister of Communications and Digital Technologies, Government Gazette, 28 February 2022 No. 45984. The Authority notes the unanimous judgment on 28 June, wherein the Constitutional Court determined that the Government's order declaring the analogue switch-off date as unconstitutional, invalid, and to be set aside.

- **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 cases of PPDR-use also to 387 - 390//397 - 400 MHz.
- **430 - 440 MHz** (amateurs) may be used in cases of congestion for a defined period, e.g., two years.
- Many municipality networks are in the 440-450 MHz bands. Depending on future demand, a harmonisation might take place.
- Potential extensions to the IMT450-band have been identified in order to mitigate potential interference with the direct neighbour bands. These might be reserved in cases of extending 2×5 MHz to 2×10 MHz or to minimise interference.

Specific Procedure: Existing licensees must migrate according to the specified process unless otherwise exempted by the Authority.

- 10.3** After the 2nd Consultation on the Draft Assignment Plan for this band²¹, the Authority has decided that Transnet stays on in the band. Transnet will be required to work with the new IMT licence holder to ensure Transnet's new digital switchover implementation of its analogue services can co-exist with the new band licence holder.
- 10.4** All the other licensees in the band whose licences are revoked as of the 1st of April 2023 can obviously no longer claim any interference protection if they are still operating in the band. The Authority also provides some further justifications of its decision made at the conclusion of two consultations in the accompanying Reasons Document published with this RFSAP.

11 Repeals

- 11.1** These notices will be repealed following the publication of this RFSAP:

11.1.1 (Notice 270 of 2015) of Government Gazette Number 38640 – the prior “Final Radio Frequency Spectrum Assignment Plan for the Frequency Band 450 to 470 MHz”.

11.1.2 Government Gazette Number 38640 (Notice 387 of 2015)

²¹ [2nd-Draft-Radio-Frequency-Spectrum-Assignment-Plan-for-the-frequency-band-825-MHz-to-830-MHz-and-870-MHz-to-875-MHz.pdf](https://www.icasa.org.za/uploads/files/2nd-Draft-Radio-Frequency-Spectrum-Assignment-Plan-for-the-frequency-band-825-MHz-to-830-MHz-and-870-MHz-to-875-MHz.pdf) (icasa.org.za) - <https://www.icasa.org.za/uploads/files/2nd-Draft-Radio-Frequency-Spectrum-Assignment-Plan-for-the-frequency-band-825-MHz-to-830-MHz-and-870-MHz-to-875-MHz.pdf>

Appendix A National Radio Frequency Plan

Table 3 shows an extract from the National Radio Frequency Plan for South Africa.

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
450-455 MHz FIXED MOBILE 5.286AA 5.209 5.271 5.286 5.286° 5.286B 5.286C 5.286D 5.286E	450-455 MHz FIXED MOBILE 5.286AA NF9 SPACE OPERATION (Earth-to-space) SPACE RESEARCH (Earth-to-space) 5.209 5.286 5.286A 5.286B 5.286C	 Fixed links (450 – 453 MHz) Government Services Single Frequency Mobile (453 – 454 MHz) Paging (454 – 454.425 MHz) Trunked Mobile BTX (454.425 – 460 MHz) IMT450 PMR and/or PAMR	 Paired with 460 – 463 MHz Paired with MTX (464.425 – 470 MHz) This band is currently used for a variety of fixed and mobile systems in the various SADC countries. ITU-R Recommendation M.1036-6 latest version. Resolution 224 (Rev WRC-19) Radio Frequency Spectrum Regulations as amended (Annex B) (GG. No. 38641, 30 March 2015). Radio Frequency Spectrum Assignment Plan 2015, Government Gazette 38640 (Notice 270 of 2015) International Mobile Telecommunication Roadmap (GG No. 42829 Notice 600 of 2019). New RFSAP to be developed.
455-456 MHz FIXED MOBILE 5.286AA 5.209 5.271 5.286° 5.286B	455-456 MHz FIXED MOBILE 5.286AA NF9 5.209 5.286A 5.286B 5.286C	 Government Services Trunked mobile BTX (454.425 – 460 MHz) IMT450	 Paired with 464.425 – 470 MHz ITU-R Recommendation M.1036-6 latest version Resolution 224 (Rev WRC-19) Radio Frequency Spectrum Regulations as amended (Annex B) (GG. No. 38641, 30 March 2015). Radio Frequency Spectrum Assignment Plan 2015, Government Gazette 38640 (Notice 270 of 2015) International Mobile Telecommunication Roadmap (GG No. 42829 Notice 600 of 2019). New RFSAP to be developed

IMT RFSAP 450MHz

17

5.286C 5.286E			
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) IMT450 Government Services	Paired with 464.425 – 470 MHz ITU-R Recommendation M.1036-6 latest version Resolution 224 (Rev WRC-19) Radio Frequency Spectrum Regulations as amended (Annex B) (GG. No. 38641, 30 March 2015). Radio Frequency Spectrum Assignment Plan 2015, Government Gazette 38640 (Notice 270 of 2015) International Mobile Telecommunication Roadmap (GG No. 42829 Notice 600 of 2019). New RFSAP to be developed
459-460 MHz FIXED MOBILE 5.286AA 5.209 5.271 5.286° 5.286B 5.286C 5.286E	459-460 MHz FIXED MOBILE 5.286AA NF9 5.209 5.286A 5.286B 5.286C	Trunked Mobile BTX 454.425 – 460 MHz IMT450 Government Services	Paired with 464.425 – 470 MHz ITU-R Recommendation M.1036-6 latest version Resolution 224 (Rev WRC-19) Radio Frequency Spectrum Regulations as amended (Annex B) (GG. No. 38641, 30 March 2015). Radio Frequency Spectrum Assignment Plan 2015, Government Gazette 38640 (Notice 270 of 2015) International Mobile Telecommunication Roadmap (GG No. 42829 Notice 600 of 2019). New RFSAP to be developed

460-470 MHz	460-470 MHz		
FIXED	FIXED		
MOBILE	MOBILE 5.286AA		
5.286AA	NF9	Fixed Links (460 – 463 MHz)	Paired with 450 – 453 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)	Paired with BTX (454.425 – 460 MHz)
		Trunked Mobile MTX (464.425 – 470 MHz)	ITU-R Recommendation M.1036-6 latest version Resolution 224 (Rev WRC-19)
		IMT450	Radio Frequency Spectrum Regulations as amended (Annex B) (GG. No. 38641, 30 March 2015).
		Security Systems (464.5375 MHz)	Radio Frequency Spectrum Assignment Plan 2015, GG 38640 (Notice 270 of 2015)
		Non-specific SRDs (464.5 – 464.5875 MHz)	International Mobile Telecommunication Roadmap (GG No. 42829 Notice 600 of 2019).
		Government Services	New RFSAP to be developed
Meteorological-satellite (space-to-Earth)	Meteorological-satellite (space-to-Earth)		
	Earth exploration-satellite (space-to-Earth)		
5.287 5.288			
5.289			
5.290	5.287 5.289		

Table 3: National Radio Frequency Plan for South Africa for 450 - 470 MHz band

Appendix B Propagation Model

Propagation Model

The following methods are proposed for assessment of anticipated interference inside neighbouring countries based on established trigger values. Due to the complexity of radio-wave propagation, different methods are proposed to be considered by administrations and are included here for guidance purposes only. It should be noted that the following methods provide theoretical predictions based on available terrain knowledge. It is practically impossible to recreate these methods with measurement procedures in the field. Therefore, only some approximation of measurements could be used to check compliance with those methods based on practical measurement procedures. The details of such approximations are not included in this recommendation and should be negotiated between countries based on their radio monitoring practices.

Path specific model

Where appropriately detailed terrain data is available, the propagation model for interference field strength prediction is the latest version of ITU-R Rec. P.452²². For the relevant transmitting terminal, predictions of path loss would be made at x km steps along radials of y km at z degree intervals²³. The values for those receiver locations within the neighbouring country would be used to construct a histogram of path loss – and if more than 10% of predicted values exceed the threshold, the station should be coordinated.

Site general model

If it is not desirable to utilise detailed terrain height data for the propagation modelling in the border area, the basic model to be used to trigger coordination between administrations and to decide if coordination is necessary, is ITU-R Rec. P.1546²⁴, “Method for point to area predictions for terrestrial services in the frequency range 30 to 3000 MHz”. This model is to be employed for 50% of locations, 10% time and using a receiver height of 3 m. For specific reception areas where terrain roughness adjustments for improved accuracy of field strength prediction are needed, administrations may use correction factors according to terrain irregularity and/or an averaged value of the TCA parameter in order to describe the roughness of the area on and around the coordination line.

Administrations and/or operators concerned may agree to deviate from the aforementioned model by mutual consent.

Area calculations

In the case where greater accuracy is required, administrations and operators may use the area calculation below. For calculations, all the pixels of a given geographical area to be agreed between the Administrations concerned in a neighbouring country are to be taken into consideration. For the relevant base station, predictions of path loss should be made for all the pixels of a given geographical area from a base station and at a receiver antenna height of 3 m above ground.

For evaluation:

- Only 10% of the number of geographical area pixels between the border line (including the border

²² Recommendation ITU-R P.452-17 (09/2021, with Editorial corrections on 28 October 2021) “Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz” (<https://www.itu.int/rec/R-REC-P.452/en>).

²³ Values for x , y , z , and path specific field strength levels are to be agreed between the administrations concerned

²⁴ P.1546 : Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 4 000 MHz (itu.int) <https://www.itu.int/rec/R-REC-P.1546-6-201908-1/en>

line) and the 6 km line itself inside the neighbouring country may be interfered with by higher field strength than the trigger field strength value given for the border line in the main text above at a height of 3 m above ground.

- Only 10% of the number of geographical area pixels between the 6 km (including also the 6 km line) and 12 km line inside the neighbouring country may be interfered with by a higher field strength than the trigger field strength value given for the 6 km line in the main text above at a height of 3 m above ground.

It is recommended that during area calculations, not only detailed terrain data but also clutter data be taken into account. Use of correction factors for clutter is crucial in particular where the border area is 'open' or 'quasi-open' from the point of view of clutter or where the interfering base station is just a few kilometres from a border line.

If the distance between a base station and a terrain point of a border line is closer than or equal to 1 km, the free space propagation model needs to be applied. Furthermore, if there is no terrain obstacle within the 1st Fresnel zone, the free space propagation model should be applied.

If clutter data is not available, it is proposed to extend the usage of the free space propagation model to a few kilometres, depending on the clutter situation in border areas.

For area type interference calculations, propagation models with path-specific terrain correction factors are recommended (e.g., the latest Recommendation ITU-R P.1546²⁵ with the Terrain Clearance Angle correction factor TCA, HCM²⁶ method with the Terrain Clearance Angle correction factor or Recommendation ITU-R P.1812^{[27], [28]}).

As to correction factors for clutter in 'open area' and 'quasi-open area', 20 dB and 15 dB should be used, respectively. Recommendations ITU-R P.1406²⁹ and/or ITU-R P.2108³⁰ should be used if a finer selection of clutter is required.

It must be noted that terrain irregularity factor Δh is not recommended to be used in area calculations. Administrations and/or operators concerned may agree to deviate from the aforementioned models by mutual consent.

²⁵ P.1546 : Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 4 000 MHz (itu.int) <https://www.itu.int/rec/R-REC-P.1546-6-201908-1/en>

²⁶ HCM Agreement (Harmonised Calculation Method) between the administrations of Austria, Belgium, the Czech Republic, Germany, France, Hungary, the Netherlands, Croatia, Italy, Liechtenstein, Lithuania, Luxembourg, Poland, Romania, the Slovak Republic, Slovenia, and Switzerland on the Coordination of frequencies between 29.7 MHz and 43.5 GHz for the Fixed Service and the Land Mobile Service. The latest version of this agreement can be found from http://www.hcm-agreement.eu/http/englisch/verwaltung/index_europakarte.htm

²⁷ Recommendation P.1812-6 (09/2021) "A path-specific propagation prediction method for point-to-area terrestrial services in the frequency range 30 MHz to 6 000 MHz" (<https://www.itu.int/rec/R-REC-P.1812/en>).

²⁸ Annex 5: Determination of the interference field strength in the Land Mobile Service (<https://www.itu.int/en/ITU-D/Projects/ITU-EC-ACP/HIPSSA/Documents/REGIONAL%20documents/HCM4A-E-Annex05.pdf>)

²⁹ Recommendation P.1406-2 (07/2015) "Propagation effects relating to terrestrial land mobile and broadcasting services in the VHF and UHF bands" (<https://www.itu.int/rec/R-REC-P.1406/en>).

³⁰ Recommendation P.2108-1 (09/2021) "Prediction of clutter loss" (<https://www.itu.int/rec/R-REC-P.2108/en>)

Appendix C Coordination for IMT-Systems

PREFERENTIAL PHYSICAL-LAYER CELL IDENTITIES (PCI) FOR IMT-2000/LTE³¹

The following is extracted from ECC/REC (11)05 as an operational example and can be adapted for the SADC countries for LTE. A respective extract from ECC/REC (15)01 may be considered for expanding the same onto NR.

PCI coordination is only needed when channel centre frequencies are aligned independently of the channel bandwidth.

3GPP TS 36.211³² defines 168 “unique physical-layer cell-identity groups” in §6.11, numbered 0.167, hereafter called “PCI groups” for LTE. Within each PCI group, there are three separate PCIs giving 504 PCIs in total.

Administrations should agree on a repartition of these 504 PCIs on an equitable basis when channel centre frequencies are aligned, as shown in the table below. It has to be noted that dividing the PCI groups or PCIs is equivalent. Each country should only use their own preferential PCIs close to the border and can use all PCIs away from the border. This transition distance between “close to the border” and “away from the border” should be agreed between neighbouring countries.

Administrations may wish to define different field strength levels (than those provided in the main text referring to this Appendix) for non-preferential PCIs.

As shown in the table below, the PCIs should be divided into 6 sub-sets containing each one sixth of the available PCIs. Each country is allocated three sets (half of the PCIs) in a bilateral case and two sets (one third of the PCIs) in a trilateral case.

Four types of countries are defined in a way such that no country will use the same code set as any one of its neighbours. The following lists describe a sample distribution for African countries:

Country type 1: Botswana, Cameroon, Comoros, Democratic Republic of the Congo, Ghana, Guinea-Bissau, Kenya, Liberia, Malawi, Mauritius, Niger, Republic of the Sudan, Swaziland.

Country type 2: Algeria, Angola, Benin, Cape Verde, Chad, Cote d'Ivoire, Egypt, Ethiopia, Madagascar, Senegal, United Republic of Tanzania, Zimbabwe.

Country type 3: Burkina Faso, Congo, Djibouti, Equatorial Guinea, Guinea, Mauritania, Nigeria, Rwanda, Sao Tome and Principe, Seychelles, South Africa, South Sudan, Tunisia, Zambia.

Country type 4: Burundi, Central African Republic, Eritrea, Gabon, Gambia, Lesotho, Libyan Arab Jamahiriya, Mali, Morocco, Mozambique, Namibia, Sierra Leone, Somalia, Togo, Uganda.

(Note: A sample country type map can be found in the figure below).

For each type of country, the following tables and figure describe the sharing of the PCIs with its neighbouring countries, with the following conventions of writing:

Preferential PCI

³¹ ECC/REC(11)05

³² 3GPP TS 36.211 “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation”. (<https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=2425>, also provided in ETSI TS 136 211). In comparison, 3GPP 38.211 (and ETSI TS 138 211) define NR Physical channels and modulation, in NR 2-step identification using PSS/SSS detection of the Physical Cell ID (same as LTE), the number of different cell IDs has been increased from 504 in LTE to 1008 for NR. Thus, for the deployment of LTE systems only the PCIs between 0 to 503 should be used and for NR systems PCIs between 0 to 1007 may be used.

Non-preferential PCI

The 504 physical-layer cell-identities should be divided into the following 6 sub-sets when the carrier frequencies are aligned in border areas:

							PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 1	0..83	84..167	168..251	252..335	336..419	420..503	Country 2	0..83	84..167	168..251	252..335	336..419	420..503
Border 1-2							Border 2-1						
Zone 1-2-3							Zone 2-3-1						
Border 1-3							Border 2-3						
Zone 1-2-4							Zone 2-1-4						
Border 1-4							Border 2-4						
Zone 1-3-4							Zone 2-3-4						

PCI	Set A	Set B	Set C	Set D	Set E	Set F	PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 3	0..83	84..167	168..251	252..335	336..419	420..503	Country 4	0..83	84..167	168..251	252..335	336..419	420..503
Border 3-2							Border 4-1						
Zone 3-1-2							Zone 4-1-2						
Border 3-1							Border 4-2						
Zone 3-1-4							Zone 4-2-3						
Border 3-4							Border 4-3						
Zone 3-2-4							Zone 4-3-1						

Table 4: Sharing of PCIs between Countries

Notes

- 1) All PCIs are available in areas away from the border.
- 2) In certain specific cases (e.g., if Angola and Botswana happened to have the same Country type/PCI code) where the distance between two countries of the same type number is very small (below a few tens of kilometres), it may be necessary to address the situation in bilateral /multilateral coordination agreements as necessary and may include further subdivision of the allocated codes in certain areas.

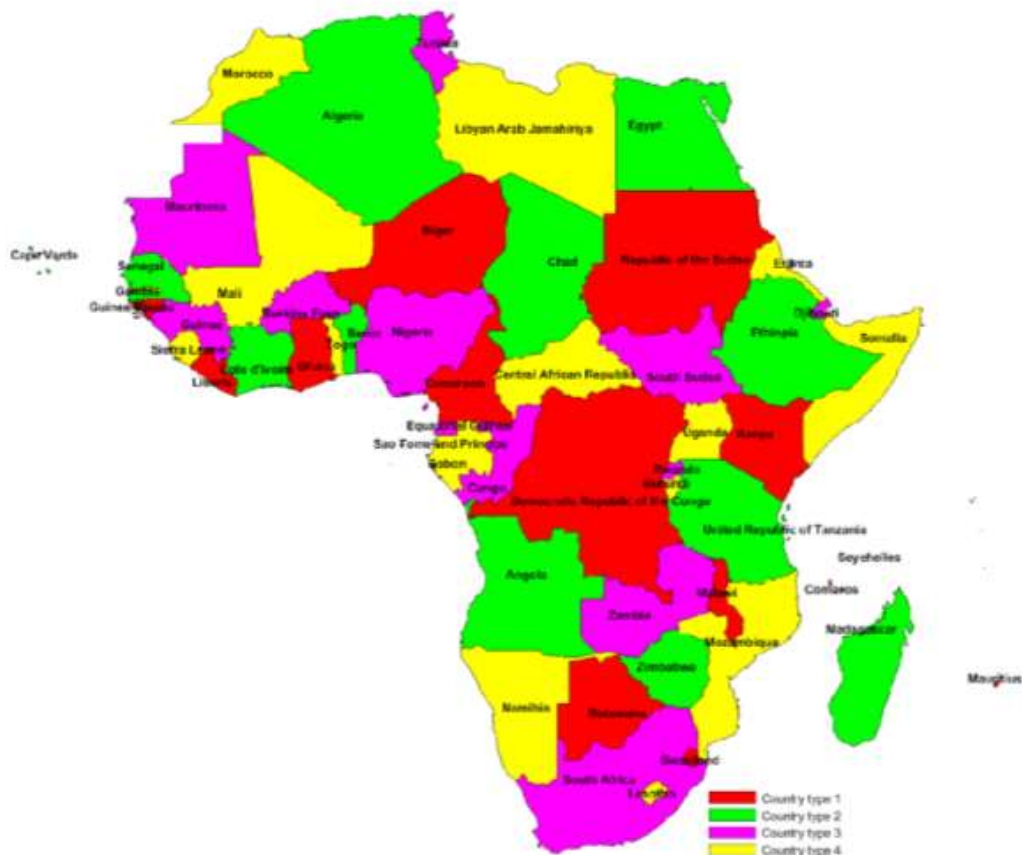


Figure 3: Country type map/PCI distribution map

GUIDANCE ON THE CONSIDERATION OF LTE RADIO PARAMETERS FOR USE IN BILATERAL AND MULTI LATERAL AGREEMENTS

This section is provided for guidance purposes for use in bi-lateral and multilateral discussions. For LTE, it may be beneficial to coordinate other radio parameters besides PCI in order to minimise deteriorating effects of uplink interference.

The parameters described in this section are usually optimised during LTE radio network planning of an operator's network. The idea of optimisation is to plan the parameters taking into account specific correlation properties of the uplink control signals, which enable more stable and predictable operation of the network. In the cross-border scenario the optimisation of parameters among neighbouring operators could provide better control of uplink interference. However, because of the difference between intra-network and inter-network interference and due to limited experience in the LTE cross-border deployment, it is difficult to assess the benefits of such optimisation. The following guidance provides the basis for operators to consider in border areas in case of high levels of uplink interference.

1. Demodulation Reference Signal (DM RS) coordination

Demodulation reference signals (DM RS) are transmitted in the uplink and used for channel estimation. There is a risk of intercell interference between neighbouring cells even in case of no frame

synchronisation. That is why special measures for DM RS allocation between networks in neighbouring countries occupying the same channel may need to be applied.

The case of partial channel overlap has not been studied but due to DM RS occupying resource blocks of separate users, there is a risk of DM RS collisions between neighbouring networks when the subcarriers' positions coincide (the frequency offset between central carriers of neighbouring networks is multiple of 300 kHz). Some minor benefits from DM RS coordination in these particular cases could be expected.

There are a number of possible approaches to the coordination of DM RS:

- In the basic planning procedure, only 30 DM RS sequence groups with favourable correlation characteristics are available: (0...29). In this case, each cell could be assigned one of the 30 DM RS sequence groups providing a cluster size of 30.
- It is possible to extend each DM RS sequence group to generate up to 12 time shifted sequence groups by applying the cyclic shift parameter stated in 3GPP TS 36.211 for LTE. For example, each tri-sector site could be assigned one DM RS sequence group with each co-sited cell having its own cyclic shift of $2\pi/3$, which provides cluster size 30 only with 10 DM RS sequence groups. The latter case corresponds well to the case of DM RS sequence groups repartition between neighbouring countries when only limited number of groups is available for network planning. The drawback of DM RS sequence group cyclic shift is a loss of orthogonality of DM RS due to fading channels which has been found during first trials of LTE and caused throughput loss as well as time alignment problems.
- Another approach for DM RS coordination is to implement dynamic DM RS sequence group allocation, also called pseudo-random group hopping. In this method, nearby cells are grouped into clusters up to 30 cells, and within each cell cluster, the same hopping-pattern is used. At the border of two clusters, inter-cell interference is averaged since two different hopping patterns are utilised. There are 17 defined hopping patterns, numbered (0...16), which leads to some minor unfairness in case of apportioning these patterns between neighbouring countries. Even in a trilateral case each operator will have at least 5 hopping patterns available near the border, which should be enough for planning purposes. It should be noted the pseudo-random group hopping option could be absent in the first generations of LTE equipment.

The decision of which of these methods to use in cross-border coordination should be agreed upon by the interested parties. Specific DM RS sequence groups or hopping patterns repartition is not provided in this text but could be deduced in a similar manner to the PCI repartition.

2. Physical Random-Access Channel (PRACH) coordination

Another radio network parameter that is considered during radio network planning is PRACH configuration which is needed to distinguish random access requests addressed to different cells. PRACH resources are allocated by specifying the PRACH Resource Blocks time positions within the uplink frame, their frequency position within the LTE channel bandwidth and by apportioning cell-specific root sequences. During radio network planning, these parameters are usually used in the following way:

- Time positions for PRACH resource allocations are usually used to create time collision of PRACH resources of co-sited/frame synchronised cells because PRACH-to-PRACH interference is usually less severe than PUSCH-to-PRACH interference;
- Frequency positions within the LTE channel bandwidth are usually the same for all cells, again because PRACH-to-PRACH interference case is a more favourable one.
- Cell-specific root sequences are used to distinguish between PRACH requests addressed to different cells.

For cross-border coordination, it is proposed to use frequency position offsets to exclude the possibility of so-called “ghost” PRACH requests caused by neighbouring networks. The PRACH is configured in LTE to use only 6 Resource Blocks or 1.08 MHz of the LTE channel bandwidth except in regions used by PUCCH. In case of overlapping or partially overlapping channel bandwidths of neighbouring networks, it is enough to establish non-overlapping PRACH frequency blocks to perform coordination. Because it is difficult to establish an implementation dependent procedure for such allocation, it will be the responsibility of operators to manage such frequency separation during coordination discussions.

In an early implementation, it is possible that a very limited number of frequency positions could be supported by LTE equipment which will not be enough to coordinate in the trilateral case. In such cases, root-sequence repartition could be used. There are 838 root sequences in total to be distributed between cells, numbered (0..837). There are two numbering schemes for PRACH root sequences (physical and logical) and that only logical root sequences numbering needs to be used for coordination. Unfortunately, the process of root sequences planning doesn't involve direct mapping of root sequences between cells because the number of root sequences needed for one cell is dependent on the cell range.

The table showing such interdependency is presented below:

PRACH Configuration	Number of root seq. per cell	Cell Range (km)
1	1	0.7
2	2	1
3	2	1.4
4	2	2
5	2	2.5
6	3	3.4
7	3	4.3
8	4	5.4
9	5	7.3
10	6	9.7
11	8	12.1
12	10	15.8
13	13	22.7
14	22	38.7
15	32	58.7
0	64	118.8