INDEPENDENT COMMUNICATIONS AUTHORITY OF SOUTH AFRICA

NO. 2891 **20 December 2022**

HEREBY ISSUES A NOTICE REGARDING FINAL RADIO FREQUENCY ASSIGNMENT PLANS FOR THE IMT3300 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 3300 MHz to 3400 MHz** in terms regulation 3 of the Radio Frequency Spectrum Regulations 2015 and the International Mobile Telecommunication Roadmap 2019.
2. This Radio Frequency Spectrum Assignment Plan ("RFSAP") supersedes any previous spectrum assignment arrangements for the same spectrum location. However, if it happens that on the date a provision of the RFSAP comes into effect, there is a conflict between the RFSAP and the latest versions of the National Radio Frequency Plan ("NRFP") and Terrestrial Broadcasting Frequency Plan, the NRFP and the Terrestrial Broadcasting Frequency Plan will prevail.

DR CHARLES LEWIS
ACTING CHAIRPERSON

Radio Frequency Spectrum Assignment Plan

Rules for Services operating in the Frequency Band from 3300 MHz to 3400 MHz (IMT3300)

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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 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) 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 the 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 the ECC Recommendation (15)01 - (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 the Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT)
“FDD”	means the Frequency Division Duplex
“HCM”	means the Harmonised Calculation Method
“HCM4A	means the Harmonised Calculation Method for Africa
“**HIPSSA**”	means the Sub-Saharan Africa Assessment Report on Harmonisation of ICT Policies in Sub-Saharan Africa
“ICNIRP”	means the International Commission on Non-Ionizing Radiation Protection (ICNIRP)
“IMT”	means the International Mobile Telecommunications
“IMT3300”	means the IMT in the 3300 MHz band (3300 MHz to 3400 MHz)
“ITA”	means the Invitation to Apply
“ITU”	means the International Telecommunication Union
“ITU-R”	means the International Telecommunication Union Radiocommunication Sector
“LTE”	means the 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 the Physical-Layer Cell Identities
"PRACH"	means the Physical Random-Access Channel
"PSTN"	means the Public Switched Telephone Network
"PUCCH"	means the Physical Uplink Control Channel
"RFSAP"	means the Radio Frequency Spectrum Assignment Plan
"TCA"	means the Terrain Clearance Angle
"TRP"	means the total radiated power. The TRP is defined as the integral of the power transmitted in different directions over the entire radiation sphere.
"TDD"	means the Time Division Duplex
"WRC-12"	means the World Radiocommunication Conference 2012 held in Geneva
"WRC-15"	means the World Radiocommunication Conference 2015 held in Geneva
"WRC-19"	means the World Radiocommunication Conference 2019 held in Sharm el-Sheikh

2 Purpose

2.1 A Radio Frequency Spectrum Assignment Plan (RFSAP) provides information on the requirements attached to the use of 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 concerning the 3300 MHz to 3400 MHz band is mandated by the Frequency Band Migration Regulation and Plan contained in the IMT Roadmap 2014, and IMT Roadmap 2019, which concluded that the Authority proceeds with an RFSAP for IMT in this band.

2.3 This RFSAP states the requirements for the utilisation of the frequency band between 3300 MHz - 3400 MHz for IMT3300.

2.4 The ITU states that 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 the IMT systems 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 equipment used in IMT3300 systems will conform to all applicable South African standards, international standards, including those of the 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 Radio Frequency Spectrum Assignment Plan (RFSAP) are subject to review.

3.5 The IMT3300 band ranges between 3300 MHz to 3400 MHz.

3.6 The IMT 3300 band will be used for IMT TDD.

3.7 The requirements for technologies that can provide IMT3300 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 documents [1]:

- 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.2074-0 (2006): Report on Radio Aspects for the terrestrial component of IMT-2000 and systems beyond IMT-2000;
- Recommendation ITU-R M.1645 (06/2003): Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000;
- 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).

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; 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 3300-3400 MHz provides a total bandwidth of 100 MHz TDD for IMT3300 service.

4.2 Channel arrangements for the IMT3300 band are according to the Region 1 recommendation by the ITU, as provided in Figure 1.

[1] These and other IMT documents are available at https://www.itu.int/rec/R-REC-M/en

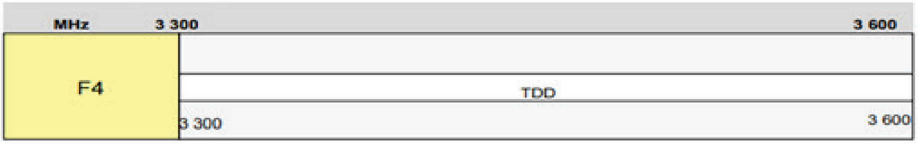

Figure 1: Frequency arrangements, 3300 MHz – 3600 MHz[2]

5 Requirements for the usage of the radio frequency spectrum

5.1 This chapter covers the minimum key characteristics considered necessary in order to make the best use of the available frequencies.

5.2 The use of the IMT3300 band is limited to IMT services.

5.3 Only systems using digital technologies that promote spectral efficiency will be issued with an assignment. Capacity-enhancing digital techniques are being rapidly developed and such techniques that promote efficient spectrum use without reducing service quality. These techniques 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 The conservative in-block base station power limit is 68 dBm/ (5 MHz) EIRP.;

5.6.2 The Authority acknowledges the feedback from the consultation that it should include a Total Radiated Power (TRP) limit for AAS base stations into the assignment plans. Stakeholders noted that this inclusion would bring South Africa in line with global industry development, and that if it is not done, the restrictive nature of the regulations will inevitably have a detrimental effect on the quality of service that can be expected from radio networks. TRP specifications are only allowed for and provided for mobile stations;

5.6.3 Mobile Station transmissions should not exceed 23 dBm EIRP;

5.6.4 Mobile Station transmissions should not exceed 25 dBm TRP;

5.6.5 On a case-to-case basis, higher EIRP may be permitted if acceptable technical justification is provided;

[2] Electronic Communications Act: Implementation of the Radio Frequency Migration Plan and of the International Mobile Telecommunications (IMT) Roadmap: Comments invited (www.gov.za) GG 45690, Annex 5

5.6.6 Where appropriate, subscriber terminal stations should comply with the technical specification outlined under the latest version of 3GPP specifications, e.g., TS 36.521-1 for LTE, 38.521-1 for 5G New Radio (NR);

5.6.7 ICNIRP Guideline compliance is required, where applicable; and

5.6.8 Criteria and guidelines for interference mitigation are described in Appendix D.

6 Implementation

6.1 The Feasibility Study[3] conducted for this band stated that the Authority's plan to proceed with the implementation of the RF migration plan for the 3300 MHz to 3400 MHz band proposed to proceed with an RFSAP for IMT in this band:

6.2 This Radio Frequency Assignment Plan comes into effect on the 1st of April 2023.

6.3 The process of assignment may commence prior to the date referred to in section 6.2.

6.4 No new assignments in the band 3300 MHz to 3400 MHz will be approved unless it complies 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 AGM that agreed that CRASA should implement the Cross Border Frequency Coordination Harmonised Calculation Method for Africa (HCM4A) Agreement.

7.2 The ECC had noted the need for greater understanding of the concept and need for harmonisation in the signing of the HCM4A Agreement by SADC Member States if the implementation of the Agreement is 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 2016[4] , 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".

[3] Implementation of the Radio Frequency Migration Plan and the International Mobile Telecommunications (IMT) Roadmap for public consultation, GOVERNMENT GAZETTE No. 45690, 24 December 2021

[4] https://www.google.com/url?sa=t&rct=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

7.3.1 Therefore, coordination would follow the HCM4A as detailed in Sub-Saharan Africa Assessment Report on Harmonisation of ICT Policies in Sub-Saharan Africa[5] (HIPSSA)

7.4 A harmonised calculation method (HCM4A) brings these benefits

7.4.1 Based on HCM Agreement used in Europe

7.4.2 Optimise 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; Transparent decisions through agreed assessment procedures; Quick assessment of interference through data exchange

7.5 HCM4A involves all 4 sub regions of Africa. This means the HCM4A projects include 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 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]; and

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].

7.6 HCM4A also comes with a software tool for Sub-Saharan Africa[6]

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.

7.7 Harmonise parameters: objectively predictable towards transparent decisions

7.8 Use of these frequency bands will require coordination with the neighbouring countries within the coordination zones of 6 kilometres in cases of LTE-to-LTE or 9 kilometres in cases of LTE-to-other technologies from the neighbouring country and at the border itself. The coordination distance is continuously being reviewed and these may be updated from time to time.

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

[6] 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

7.9 The following field strength thresholds have to be assured based on ECC/REC (15)01 for the 3400 MHz to 3800 MHz band, here also applied for 3300 MHz to 3400 MHz band, based on the close proximity and similarity of these bands.

Operator-to-operator coordination may be necessary to avoid interference.

7.10 The below follows ECC/REC (15)01:

A) TDD, Synchronised case
Base stations of synchronised TDD systems on both sides of the border line with centre frequencies not aligned for all PCIs or with centre frequencies aligned and for preferential PCIs may be used without coordination with a neighbouring country if the mean field strength of each cell produced by the base station does not exceed the values of 67 dBμV/m/5 MHz at a height of 3 m above ground at the border line between countries and 49 dBμV/m/5 MHz at a height of 3 m above ground at a distance of 6 km inside the neighbouring country.

Base stations of synchronised TDD systems on both sides of the border line with centre frequencies aligned and for non-preferential PCIs may be used without coordination with a neighbouring country if the mean field strength of each cell produced by the base station does not exceed the value of 49 dBμV/m/5 MHz at a height of 3 m above ground at the border line between countries.

The following table gives an overview of the trigger values of the field strength at a height of 3 m above ground between synchronised TDD systems:

SYNCHRONISED CASE		
Centre frequencies aligned		**Centre frequencies not aligned**
Preferential PCIs	**Non-preferential PCI**	**All PCIs**
67 dBμV/m/5 MHz @ 0 km, and 49 dBμV/m/5 MHz @ 6 km	49 dBμV/m/5 MHz @ 0 km	67 dBμV/m/5 MHz @ 0 km, and 49 dBμV/m/5 MHz @ 6 km
@ stands for "at a distance inside the neighbouring country".		
Note (1): It should be noted that for NR base station, in case of same PCIs use when centre frequencies are not aligned, the field strength levels for synchronised operation should be further studied. In fact, in NR, if the centre frequencies are not aligned it doesn't imply automatically that SSB blocks are not aligned. In case of LTE centre frequencies alignment is equivalent to synchronisation signals alignment.		
Note (2): However, in case of advanced antenna system (AAS) systems, these thresholds are not sufficient to deploy networks in border areas without further measures to be studied.		

Table 1: Field Strength Trigger Values between Synchronised TDD Systems

B) TDD, Unsynchronised case
1. Base stations of unsynchronised TDD systems on both sides of the border line for all PCIs may be used without coordination with a neighbouring country if the mean field strength of each cell produced by the base station does not exceed a value of 0 dBμV/m/5 MHz at a height of 3 m above ground level at the border line between countries.
If preferential and non-preferential frequency blocks are defined and are distributed between neighbouring countries, the following provisions apply:

2. Base stations of unsynchronised TDD systems on both sides of the border line with preferential frequency blocks and for preferential PCIs may be used without coordination with a neighbouring country if the mean field strength of each cell produced by the base station does not exceed the trigger values of:

- 45 dBμV/m/5 MHz at a height of 3 m above ground at the border line between countries, and
- 27 dBμV/m/5 MHz at a height of 3 m above ground at a distance of 6 km inside the neighbouring country.

3. Base stations of unsynchronised TDD systems on both sides of the border line with preferential frequency blocks and for non-preferential PCIs may be used without coordination with a neighbouring country if the mean field strength of each cell produced by the base station does not exceed the trigger values of 27 dBμV/m/5 MHz at a height of 3 m above ground at the border line between countries.

4. Base stations of unsynchronised TDD systems on both sides of the border line with non-preferential frequency blocks and for all PCIs may be used without coordination with a neighbouring country if the mean field strength of each cell produced by the base station does not exceed the trigger values of 0 dBμV/m/5 MHz at a height of 3 m above ground level at the border line between countries.
The following table gives an overview of the trigger values of the field strength at a height of 3 m above ground for preferential frequency blocks of unsynchronised TDD systems:

UNSYNCHRONISED CASE		
PREFERENTIAL FREQUENCY BLOCKS		NON-PREFERENTIAL FREQUENCY BLOCKS
Preferential PCIs	Non-preferential PCI	All PCIs
45 dBμV/m/5 MHz @ 0 km and 27 dBμV/m/5 MHz @ 6 km	27 dBμV/m/5 MHz @ 0 km	0 dBμV/m/5 MHz @ 0 km
@ stands for "at a distance inside the neighbouring country"		

Table 2: Field Strength Trigger Values between Unsynchronised TDD Systems

For field strength predictions, the calculations should be made according to Appendix B. In the case of channel bandwidth other than 5 MHz, a factor of 10 x $\log_{10}$(channel bandwidth (MHz) [7] /5 MHz), should be added to the field strength levels.

For this band, due to the low field strength level in the unsynchronised case, in order to enable the field strength measurement, a conversion factor of 23 dB from 3 m to 10 m could be applied for a suburban environment.

[7] Not occupied bandwidth

GUIDANCE FOR OPERATORS FOR DEPLOYMENT IN BORDER AREAS

This section lists different techniques as a guidance for operators that can be used to reduce the interference across the border in case of both TDD and FDD systems. In the context of TDD systems, while these techniques decrease the interference, they may not be sufficient to enable unsynchronised operation of TDD networks across the border.

Antenna tilting and restricted beamforming: The downtilt of the base station antennas is adjusted such that there is suppression of all signals towards the horizon, thereby reducing the horizon component of interference to the base stations. In the case of advanced antenna system (AAS) antennas at the base stations, configured elevation-domain codeword subset restriction may also be used to decrease the interference to the base stations across the border.

Downlink power reduction: Another possible solution could be to reduce the downlink power on the base station sectors which are facing the border or located at sites near the border. One of the main advantages of this technique is that there is less interference radiated across the border. Moreover, since the difference between the uplink and downlink transmit powers is smaller, there is reduced UL/DL imbalance in a cell. The direct consequence of this technique is that the downlink to uplink interference becomes less problematic as there is a smaller area with vulnerable user equipment (UE). Also, smaller cells can be deployed closer to the border, providing a stronger uplink. Additionally, the performance degradation due to downlink power reduction can be compensated by link adaptation.

Minimum inter-cell interference scheduling: The selection of start Physical Resource Blocks (PRB) or Resource Block Group (RBG) in the scheduler can be enhanced to reduce the inter-cell interference. This can be accomplished through restricted or randomised distributed PRB scheduling in uplink or RBG scheduling in downlink.

TDD Downlink only scenario should be considered as FDD downlink scenario.

For field strength predictions, the calculations should be made according to Appendix B. In cases of other frequency block sizes $10*\log_{10}$ (frequency block size/5 MHz) should be added to the field strength values.
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.

7.11 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)05 and ECC/REC (15)01.

7.12 Specific information regarding coordination may be found in Appendix B based on an extract from ECC/REC (11)05 and ECC/REC (15)01.

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 the 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 This spectrum band will be assigned through an Invitation to Apply in line with regulations developed in terms of section 31(3) of the Act.

9 Amendments

9.1 Following the feasibility study consultation[8], which determined that this band should be assigned exclusively for IMT, existing licensees will have their licences amended (or revoked) and be moved to a different destination band.

10 Radio Frequency Migration

10.1 All existing transmissions from 3300 MHz - 3400 MHz band should be cleared.

[8] Government Gazette Number 45690 (Notice 739 **of 2021)**

Appendix A National Radio Frequency Plan

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

ITU Region 1 allocations and footnotes	South African allocations and footnotes	Typical Applications	Notes and Comments
3 300-3 400 MHz	**3 300-3 400 MHz**		
RADIOLOCATION	RADIOLOCATION	Radio astronomy (CH Molecules)	See section 5 for coordination with radio astronomy Recommendation ITU-R M.1036-6 (International Mobile Telecommunications (IMT))
	MOBILE except aeronautical mobile	IMT Res. 223 (Rev.WRC-15)	Develop a RFSAP for the band
	5.149 5.429A 5.429B		
5.149 5.429 5.429A 5.429B 5.430			

Table 3: National Radio Frequency Plan for South Africa for 3300 MHz to 3400 MHz band[113]

Appendix B 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 approximation 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.452 [9]. For the relevant transmitting terminal, predictions of path loss would be made at *x* km steps along radials of *y* km at *z* degree intervals[10]. 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.1546, "Method for point to area predictions for terrestrial services in the frequency range 30 to 3000 MHz"[11] . 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.

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[9] 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).

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

[11] 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).

For evaluation:

- Only 10% of the number of geographical area pixels between the border line (including the border 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 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.1546[12] with the Terrain Clearance Angle correction factor TCA, HCM [13] method with the Terrain Clearance Angle correction factor or Recommendation ITU–R P.1812 [14], [15]).

As to correction factors for clutters 'open area' and 'quasi-open area', 20 dB and 15 dB should be used, respectively. Recommendations ITU–R P.1406 [16] and/or ITU-R P.2108 [17] should be used if a finer selection of clutter is required.

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[12] 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)

[13] 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

[14] 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).

[15] 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)

[16] 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).

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

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.

Appendix C Coordination for IMT-Systems

PREFERENTIAL PHYSICAL-LAYER CELL IDENTITIES (PCI) FOR IMT-2000/LTE[18]

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 36.211[19] 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 each containing 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).

[18] ECC/REC (11)05

[19] 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.

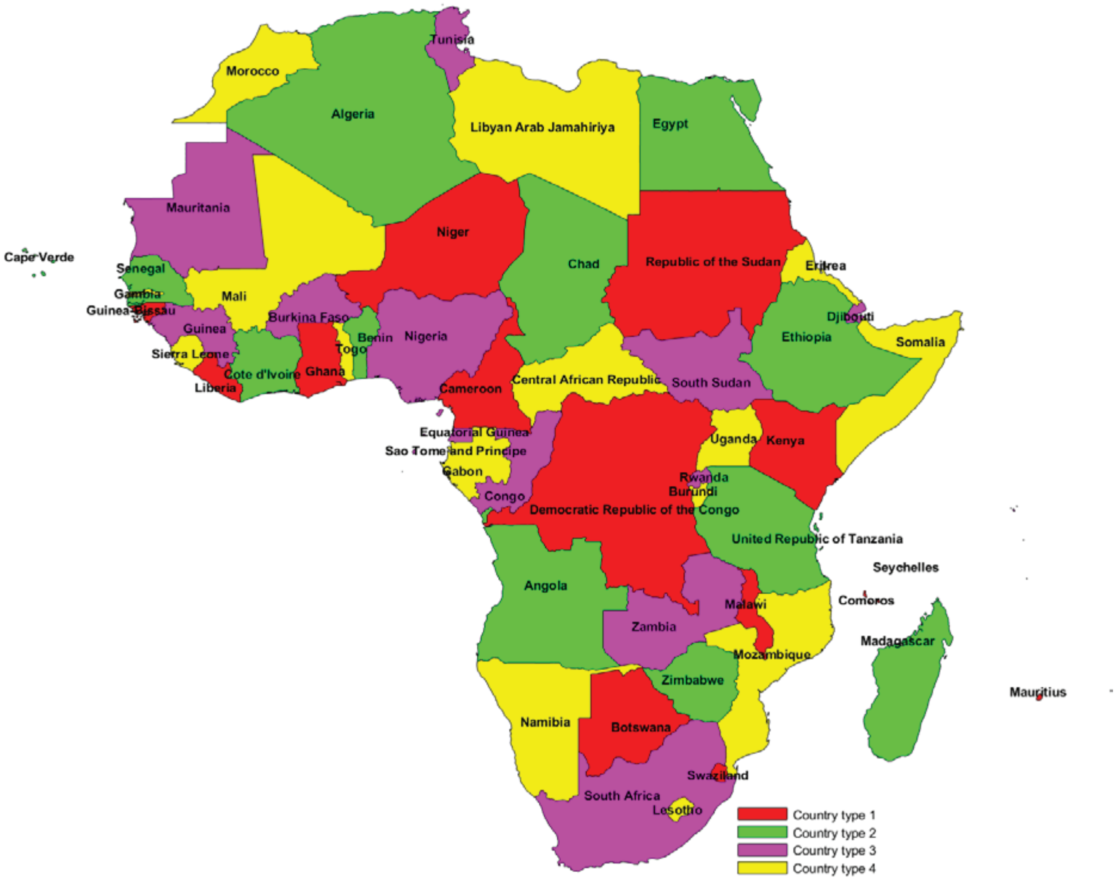

Figure 2: **Country type map/PCI distribution map**

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
	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:

Country 1	0..83	84..167	168..251	252..335	336..419	420..503
Border 1-2	■	■				■
Zone 1-2-3	■	■				

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

Border 1-3	■	■	■			
Zone 1-2-4	■					■
Border 1-4	■		■			■
Zone 1-3-4	■		■			

Border 2-3		■	■	■		
Zone 2-1-4			■	■		
Border 2-4			■	■		■
Zone 2-3-4			■	■		

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
Border 3-2	■				■	■
Zone 3-1-2					■	■
Border 3-1				■	■	■
Zone 3-1-4					■	■
Border 3-4			■		■	■
Zone 3-2-4					■	■

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

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 bilateral 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 cases 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 inter cell interference between neighbouring cells even in cases 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 a 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 cyclical shift parameter stated in 3GPP TS 36.211. For example, each tri-sector site could be assigned one DM RS sequence group with each co-sited cell having its own cyclical shift of $2\pi/3$, which provides cluster size 30 with only 10 DM RS sequence groups. The latter case corresponds well to the case of DM RS sequence group repartition between neighbouring countries when only a limited number of groups are available for network planning. The drawback of DM RS sequence group cyclical shift is a loss of orthogonality of DM RS due to fading channels which has been found during first trials of LTE and has 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 of 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 used. There are 17 defined hopping patterns, numbered {0…16}, which lead to some minor inequality in the 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 Block 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 the PRACH-to-PRACH interference case is the more favourable one; and
- 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 cases 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 only logical root sequence 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

Table 5: PRACH – Range Interdependency

Thus, in the case of root sequence repartition, it will be the responsibility of radio network planners to assign the correct number of root sequences in order not to overlap with the root sequence ranges of other operators. It also should be noted that different root sequences have different cubic metrics and correlation properties, which affect PRACH coverage performance and planning of so-called high-speed cells. For simplicity of cross-border coordination, it is proposed to ignore these properties.

In summary, it should be stipulated that frequency separation of PRACH resources should be used as the main coordination method. PRACH root sequences repartition should be avoided and used only in exceptional cases. Specific PRACH root sequence repartition is not provided in this text but could be deduced in a similar manner to the PCI repartition.

Additional guidance for cross-border coordination of synchronised and unsynchronised LTE and 5G/NR TDD systems may be found in ECC/REC/ (15)01 [20] and ECC Report 296 [21].

[20] 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.

[21] ECC Report 296: "National synchronisation regulatory framework options in 3400-3800 MHz: a toolbox for coexistence of MFCNs in synchronised, unsynchronised, and semi-synchronised operation in 3400-3800 MHz", March 2019.

Appendix D Frequency Coordination Process

Technical procedures related to bilateral and multilateral cross-border frequency coordination agreements for 4 geographical sub-regions are defined by the African Union which includes the Southern African sub-region of 10 countries. Cross-Border Frequency Coordination and interference resolution should follow the Harmonised Calculation Method for Africa (HCM4A)[22].

When requesting coordination, the relevant characteristics of the base station and the code or PCI group number should be forwarded to the Administration affected. All of the following characteristics should be included:

a) carrier frequency [MHz].
b) name of transmitter station;
c) country of location of transmitter station;
d) geographical coordinates [latitude, longitude];
e) effective antenna height [m];
f) antenna polarisation;
g) antenna azimuth [degrees];
h) antenna gain [dBs];
i) effective radiated power [dBW];
j) expected coverage zone or radius [km];
k) date of entry into service [month, year];
l) code group number used; and
m) antenna tilt [degrees].

The Administration affected will evaluate the request for coordination and will, within 30 days, notify the result of the evaluation to the Administration requesting coordination. If, in the course of the coordination procedure, the Administration affected requires additional information, it may request such information.

If no reply is received by the Administration requesting coordination within 30 days, it may send a reminder to the Administration affected. An Administration not having responded within 30 days following communication of the reminder will be deemed to have given its consent and the code coordination may be put into use with the characteristics given in the request for coordination.

The periods mentioned above may be extended by mutual consent.

[22] Cross-Border Frequency Coordination: Harmonised Calculation Method for Africa (HCM4A) https://www.itu.int/en/ITU-D/Projects/ITU-EC-ACP/HIPSSA/Documents/FINAL%20DOCUMENTS/FINAL%20DOCS%20ENGLISH/hcm4a_agreement.pdf.pdf