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GSOA

Agenda Item 1.2

Part A: Description

Agenda item 1.2 is to consider identification of the frequency bands 3 300-3 400 MHz, 3 600-3 800 MHz, 6 425-7 025 MHz, 7 025-7 125 MHz and 10.0-10.5 GHz for International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, by Resolution **245 (WRC-19)**;

This paper highlights the technical challenges of introducing IMT terrestrial mobile service to the uplink C-band spectrum. These bands are allocated globally to the FSS and the Fixed Service (FS) on a primary basis.

Part B: Key Elements – the notables

WRC-23 agenda item 1.2 is to study several bands, many of which are allocated to several services, including satellite services, on a co-primary basis. Some of these frequency bands already contain critical satellite operations or are planned for future satellite systems. Therefore, careful consideration for the bands under agenda item 1.2 is needed before considering additional spectrum for IMT2020 services without jeopardising existing critical FSS, planned band operation as per AP30B by African Administrations, as well as adjacent band WiFi operations in the lower 6GHz band.

The following bands are to be considered under AI 1.2 for identification to IMT in different Regions:
3 300-3 400 MHz (R1, R2), 3 600-3 800 MHz (R2), 6 425-7 025 MHz (R1), 7 025-7 125 MHz (R1, R2, R3) and 10.0-10.5 GHz (R2).

Allocation to services		
Region 1	**Region 2**	**Region 3**
5 925-6 700	FIXED 5.457 FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B MOBILE 5.457C 5.149 5.440 5.458	

6 700-7 075	FIXED FIXED-SATELLITE (Earth-to-space) (space-to-Earth) 5.441 MOBILE 5.458 5.458A 5.458B
7 075-7 145	FIXED MOBILE 5.458 5.459

Some uses of the band in Africa are:

Use	**Frequency range**
Fixed links in the Fixed Service (FS)	6425-7125 MHz
Fixed Satellite Service (FSS) uplink (VSAT/SNG)	6425-6725 MHz
Appendix 30B uplinks (FSS)	6725-7025 MHz
Radio Astronomy (RRNo.5.149)	6650-6675.2 MHz

In Region 1, the band 3.3-3.4 GHz is already allocated to mobile and identified for IMT by many countries via footnotes **5.429, 5.429A** and **5.429B**. This band forms part of the 3.5 GHz range, which is used for 5G services.

The band 6 425-7 125 GHz is considered for IMT2020 services.

Use of C-band for National Universal Connectivity

Today, many African countries continue to extensively use C-band fixed satellite services (FSS) for numerous national and regional applications, including humanitarian relief operations and critical aeronautical and navigation operations to broadcast nationwide and Government connectivity. Emergency responders relied upon the essential use of C-band satellite communications services.

The use of C-band FSS is imperative to many African countries due to the need for nationwide communications for economic livelihood in connecting communities and Government agencies. C-band FSS, which is vital and extensively used, must continue to operate in the allocated FSS bands. Many C-band FSS terminals are used in the frequency range from 3.6 to 4.2 GHz for the downlink. Also, in the uplink for critical communications between gateways and space stations, the frequency band 6.425 to 7.025 GHz is utilised. So, any measures to re-assign these frequencies for IMT would have severe implications to the provisioning of C-band services impacting communities and Government operations and any humanitarian relief operations for the livelihood of the communities at the large whose dependency on C-band connectivity is critical.

The bands identified for region one also have global implications and impact many developing economies, including African countries.

Assured access to FSS C-band satellite spectrum is essential

Unlike other countries in region 1, C-band's unique characteristics have been ideal for deployment by many African countries given its low cost of operations, resilience and reliability.

C-band represents a solution to connectivity with over eighty satellites serving the African continent with a range of critical services. These cover applications from broadcasting with thousands of TV channels for remote communities to backhaul infrastructure whereby fibre is not possible to humanitarian use for emergency communications to rural/remote communications for mining, oil/gas, etc., to serving aeronautical sector for critical safety communications, meteorology, etc.

Given the unique qualities of the C-band propagation and coverage characteristics, it is impossible to replicate its qualities in other frequency bands. Satellite C-band facilitates continent wise and global communications services for communities in Africa. Many countries all over the African continent rely heavily on C-band satellite services. They are keen to ensure that these services continue their operations while also noting the requirements from the terrestrial deployment.

Part C: Current Status of Band

Critical utilisations of C-band

Many countries throughout the continent rely heavily on C-band satellite services as part of their national infrastructure. A framework to protect this FSS infrastructure from widespread mobile deployment in neighbouring or nearby countries must be assessed carefully.

FSS use of the band 6425 to 7125 MHz

The 6 GHz frequency band under consideration for agenda item 1.2 is differentiated into the following sub-bands for a variety of applications in use by the Administrations as follows: -

i. 6 425-6 725 MHz: this frequency band is allocated to the FSS globally (Earth-to-space) and is not subject to a Plan. The band is used for the uplinks by large numbers of GSO FSS networks covering all regions, including the African continent. MSS satellite systems also utilise the band as uplink feeder links from gateway stations to satellite to support the L-band MSS services from several GSO satellites, including African continent coverage. These systems use this link spectrum to support safety-related L-band services, including the GMDSS and AMS(R)S. Interference to these satellite's feeder uplinks could harm those critical L-band services.

ii. 6 725-7 025 MHz: this frequency band is allocated to the FSS globally (Earth-to-space) and used for FSS as per the provisions of Appendix 30B (RR No. 5.441). The band is used for the uplinks by GSO FSS networks in the Plan and the List covering all Regions. The AP30 Bn objective is to guarantee, in practice, for all countries, equitable access to the geostationary-satellite orbit in the frequency bands of the FSS. Due to the size of an FSS satellite footprint, FSS satellite receivers used, for example, by Administrations in Africa, would likely see the interference from an IMT deployment in Europe. The satellite used in this frequency range must be respected and protected by all countries in region 1.

iii. 6 700-7 025 MHz: this frequency band is allocated to the FSS globally (space-to-Earth); this allocation is limited to feeder links for non-geostationary satellite systems of the mobile-satellite service. It is subject to coordination under RR No. 9.11A. The use of this band by feeder links for non-geostationary satellite systems in the mobile-satellite service is not subject to RR No. 22.2 as per footnote RR No. 5.458B. Co-existence issues between IMT and receiving FSS earth stations would be similar to those studied in Report ITU-R S.2368, i.e., separation distances and coordination contours would be necessary around receiving FSS earth stations to achieve co-existence.

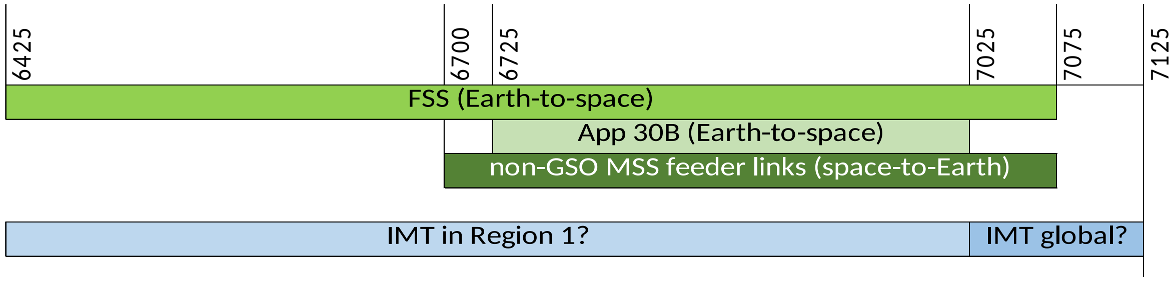
iv. 7 025-7 075 MHz: this frequency band is allocated to the FSS globally (Earth-to-space) and is not subject to a Plan.

v. 7 075-7 125 MHz: there is no FSS allocation, so no direct impact.

Figure 1 below outlines the current uses of the upper 6GHz band by various services and applications

Figure 1

Current uses of the band from 6 425 MHz to 7 125 MHz and bands considered for IMT identification



Findings from Existing studies and Future studies requirement

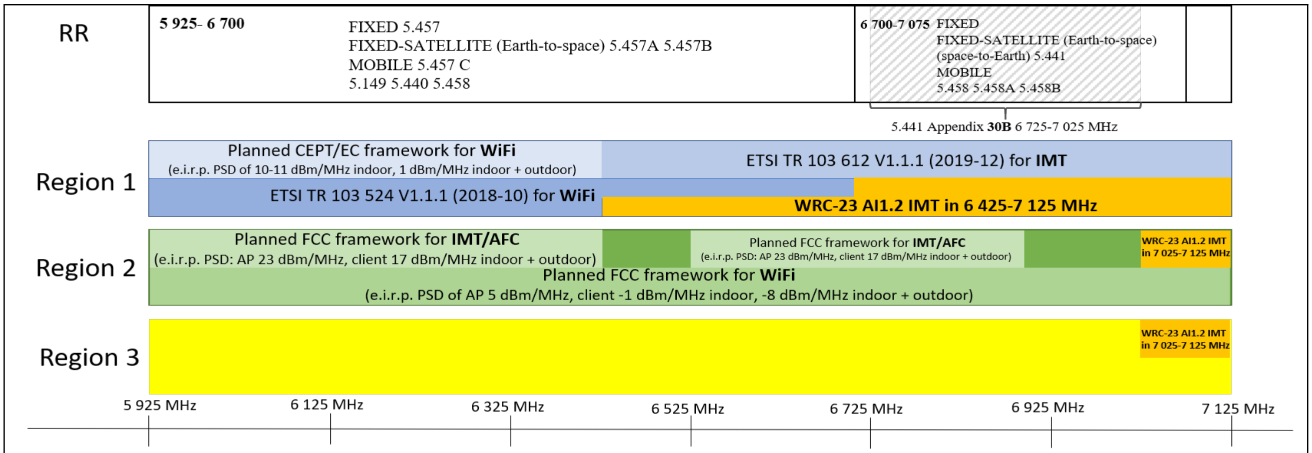
	IMT-Advanced (4G)	IMT-2020 (5G)
ITU studies	Report ITU-R S.2367	To be done under AI 1.2

ITU-R studies to date have been carried out in the adjacent band 5 925 – 6 425 MHz between IMT-Advanced (4G) and FSS as outlined in the ITU-R Report 2.2367. FSS characteristics used in ITU-R Report S.2367 are similar to those in the band adjacent band 6 425-6 575 MHz.

The existing studies conducted by the ITU-R for the frequency range 5 850-6 425 MHz are related to IMT-Advanced and show minimal potential for IMT operations whilst protecting FSS uplinks. The studies concluded that FSS space receivers would be subjected to excessive interference from the aggregate operation of IMT base stations, irrespective of whether they are deployed outdoors or indoors. It was stated that necessary conditions for deployment of IMT systems would include indoor and establishing strict limits (indoor use only, 10-15 dBm e.i.r.p. limit critical) on maximum allowable e.i.r.p. for IMT stations.

Studies conducted by CEPT between RLAN and FSS as outlined in the ECC report 302 in the adjacent frequency range 5 925-6 425 MHz indicated that outdoor usage of RLANs is not feasible without causing interference to FSS satellite receivers. Studies were done for a representative set of satellites currently operating, some of which work above 6 425 MHz. These studies in Europe show that sharing with unlicensed Wi-Fi indoors could be more feasible with FSS than IMT.
Also, regional regulatory and standardisation initiatives on using C-band uplink for both Wi-Fi and IMT type usage are shown in Figure 2 below. Figure 2

Regional regulatory and standardization



This document covers sharing and compatibility studies conducted as follows.

a) For the band 6 425 – 7025 FSS earth to space operations – to examine the results of aggregate interference from IMT base stations into receiving FSS space stations.

b) For the band 6 725 to 7 025 MHz concerning the planned band's Appendix 30B to examine studies on interference from IMT to planned national allotments;

Studies should also be conducted to evaluate the feasibility of IMT operations in the context of interference from transmitting earth stations to IMT systems and from IMT systems to receiving earth stations (used for non-GSO MSS feeder links). Additional studies on these aspects may be submitted at a later time.

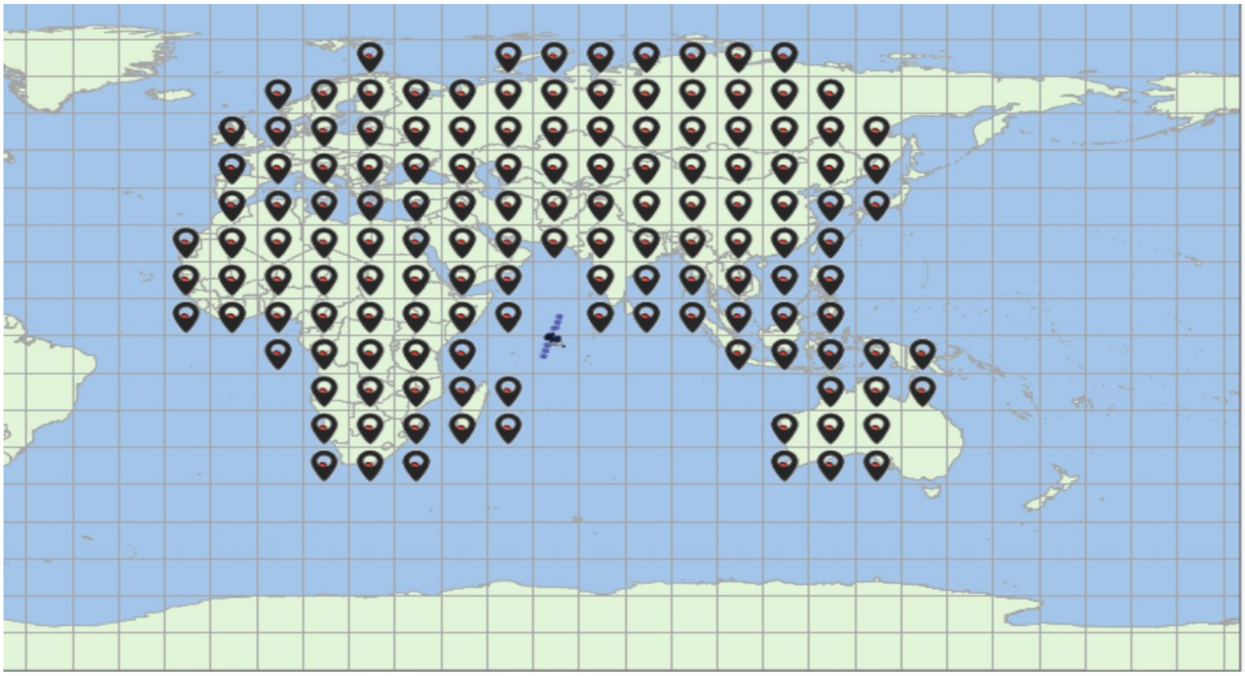
Description of the methodology

The methodology simulates a distribution of IMT stations throughout the visible earth surface, as seen from a given GSO satellite. The Earth's surface is divided into a grid of 10x10 deg in latitude and longitude (referred to here as a grid "square", even though they are not square). Two "reference stations" are placed in the centre of each square; one to represent the rural and suburban IMT stations and another to represent the urban IMT macro base stations. In the current simulation, small cell and microcell base stations, indoor and outdoor, are not modelled. Also, interference from IMT user equipment is not modelled.

The EIRP of the reference station is determined by first simulating a single IMT sector, communicating with three UEs randomly located within the sector. For a given elevation angle to the satellite, the statistics of the interference in the direction of the satellite is determined through a monte carlo simulation. The cdf of the interference from a single sector is applied to 500 reference stations at a given elevation angle, the aggregate interference from 500 reference stations.

The number of base stations in each square is proportional to the land area within that square. The land area of each square is determined, and the number of rural, suburban and urban macro base stations is selected from the agreed density figures (see below). The interfering power from each reference station is set according to the number of stations in the square, relative to 500. For example, for 1000 base stations, the interfering power is increased by 3 dB.

When all reference stations have been assigned the appropriate cdf of interference, a monte carlo simulation is performed. For each sample, the power radiated by the reference station is obtained and used to calculate the interference from the reference station at the satellite receiver. This takes into account the propagation path loss and the satellite antenna gain pattern. The aggregate interference at each sample is determined by summing the contributions from all reference stations. Repeating the analysis for multiple samples allows for a distribution (cdf) of interference at the satellite to be obtained.



IMT base station characteristics

Base station characteristics are taken from Table 7-1 of Annex 4.4 to Document 5D/716. The following notes and clarifications apply:

- In TDD, 75% of the time transmission is from BS; this is modelled by reducing transmit power by 1.25 dB corresponding to 10*log(0.75)
- 20% network load is assumed, which is (-7 dB) is taken into account in the transmit power
- 3 dB polarisation loss is considered in the transmit power configuration.
- The antenna pattern follows the Recommendation M.2101 model, and currently, the sub-array model has not been implemented.

Number of IMT Stations

An essential assumption for modelling interference to satellite receivers is the number of IMT stations. WP5D did not agree on any single set of assumptions for the deployment of IMT BS in Rural, Suburban, and Urban areas.

For Rural deployment, the range of deployment is given as 0.001 to 0.006 sectors per sq km, where Rural is included in the modelling.

The values for Suburban and Urban areas are as outlined in Table 11 from Annex 4.4 to Document 5D/716, shown below. The parameters to determine areas of Suburban/Urban coverage are:

- Rb: Fraction of the area that is “built.”

- Ra: Fraction of the “built” area that has IMT coverage

TABLE 11

Values for Ra and Rb to be used in studies involving IMT deployments for frequency bands between 6 and 8 GHz

	Options *	Macro	Micro
Ra	1	30% Urban (area < 200 000 km²) 10% Urban (area > 200 000 km²) 10% Suburban (area < 200 000 km²) 5% Suburban (area > 200 000 km²)	10% Urban (area < 200 000 km²) 5% Urban (area > 200 000 km²)
	2	45% Urban, 20% Suburban	10% Urban
Rb (depending on the area under study)	1	5% (area < 200 000 km²) 2% (200 000 - 1 000 000 km²) 1% (area > 1 000 000 km²)	5% (area < 200 000 km²) 2% (200 000 - 1 000 000 km²) 1% (area > 1 000 000 km²)
	2	5% (area < 3 500 000 km²) 3% (area > 3 500 000 km²)	5% (area < 3 500 000 km²) 3% (area > 3 500 000 km²)
	3	2.5% (area < 200 000 km²) ** 2% (200 000 - 1 000 000 km²) 1% (area > 1 000 000 km²)	2.5% (area < 200 000 km²) ** 2% (200 000 - 1 000 000 km²) 1% (area > 1 000 000 km²)

* The Ra and Rb values used in the sharing and compatibility studies should be provided together with the results of studies, for the purpose of comparison, as well as information on which specific geographical location the analysis is applicable to.

** The value is applicable for Region 1, for bands considered globally the value of 5% should be used.

For Suburban Macrocells: Density of sectors is 2.4 sectors per sq km, in Suburban coverage areas
For Urban Macrocells: the density of sectors is ten sectors per sq km in Urban coverage areas.

For these studies, values of IMT BS density in the ranges as agreed by WP5D are used to assess the impact to the satellite receiving station; hence for Urban/Suburban, Ra and Rb using the lowest values (Ra1/Rb1) and the highest values (Ra2/Rb2) for the large areas in the ranges provided by WP5D. The simulations consider IMT deployment over a large area (e.g. the entire visible Earth surface). Hence, only the large area values for Ra and Rb are considered (e.g. figures for Ra for area < 200 000 km^2 are not considered).

Considering the large area modelled for the rural base station density, the middle of the range value for Rural average density of 0.003 sectors per sq km is used.

The simulation area considers IMT coverage over Europe, the Middle East, Africa and much of Asia. The total land area is 91,632,815 sq km, and the total number of BSs arrives at 433,729, as shown in Table 1 below. Note that the percentage of the land area for IMT coverage ranges from 0.22% for the lower values for Ra/Rb to 2.02% for the higher values for Ra/Rb.

Table 1

Number of base stations in the simulation area

	The total land area covered (sq km):		91,632,815
		Ra1/Rb1	**Ra2/Rb2**

	Rural Macro	Suburban Macro	Urban Macro	Suburban Macro	Urban Macro
Number of IMT sectors	274898	109959	916328	1319513	12370430
Number of IMT BSs	91633	36653	305443	439838	4123477
Area covered (sq km)	64279	45816	91633	549797	1237043

Ra1/Rb1	**Total IMT Macro BSs**	**433,729**
	% area covered by IMT	**0.22%**
Ra2/Rb2	**Total IMT Macro BSs**	**4,654,947**
	% area covered by IMT	**2.02%**

Many African Administrations support the assumptions made based on their existing and likely future deployment of the BS for IMT. The values for the low end of the range could be considered extremely low (only 0.22% of land covered). However, the values assumed for the studies are supported by the submitting Administrations, including the assumption of some rural deployment of base stations.

Clutter Modelling

The recommended clutter loss model assumed is given by Recommendation ITU-R P.2108 for these sharing and compatibility studies, even though the current version does not cover the 6 GHz band. For the time being, the P.2018 model has not been applied, but a simplified approach is implemented for all BSs. Clutter loss does not apply to those base stations above the height of surrounding rooftops, and hence for those stations, no clutter loss is applied. The BSs below the rooftop are assumed to have infinity clutter loss and are discounted. This is an optimistic assumption (likely to underestimate interference) and is one area that may be improved in the future.

Interference Criteria and Apportionment

The interference criteria to be applied to the receiving space station has been provided by WP4A in document 5D/734 as outlined in the table below, along with some of the relevant notes.

TABLE 2

Protection Criteria (see Notes 1, 2, 3, 4, 5, 6, 7 and 8)

Frequency Ranges	Percentage of time for which the *I/N* value could be exceeded (%)	*I/N* Criteria (dB)
3 600-3 800 MHz	20% 0.005%	-10.5 -1.3
6 425-7 075 MHz (E-s)	20% 0.001% 0.03%	-10.5 -2.33 -6
6 700-7 075 MHz (s-E)	20% 0.005%	-10.5 -1.3

Note 1: The noise *N* in the *I/N* criteria as specified above is the system receiver noise (i.e. thermal noise) and is equal to the receiver antenna noise plus the receiver noise referred to the antenna. Hence studies conducted by WP 5D should only use the values presented above when evaluating the compliance with the protection criteria.

Note 3: It is worth to mention that apportionment of the *I/N* protection criteria that apply to other co-primary services should be done on a case-by-case basis by WP 5D. Such apportionment decided needs to be clearly specified in the study performed. The protection criteria values given in this document correspond to the total *I/N* contributions present at the satellite or earth station receiver.

For these studies, to allow for possible simultaneous use of the 6 GHz band by the fixed service, the apportionment applied is 3 dB apportionment to the long-term criterion and 50% apportionment applied to the short-term criterion as shown in the table below.

Table 2

Interference criteria

	Interference criteria provided by WP 4A		**With apportionment**	
	Percentage of time that criteria may be exceeded	I/N (dB)	Percentage of time that standards may be exceeded	I/N (dB)
Long term	20%	-10.5	20%	-13.5
Short term (1)	0.03%	-2.33	0.015%	-2.33
Short term (2)	0.001%	-6	0.0005%	-6

These criteria are used to assess the impact of interference on FSS satellites.

Satellite characteristics

All satellites modelled are geostationary satellites. Based on the parameters provided by WP 4A, an example of a satellite global coverage and hemispherical coverage beam are used.

TABLE 3

Non-planned satellite characteristics

	Peak receive antenna gain (dBi)	Antenna pattern	System receive noise temperature (K)
Global beam	20	ITU-R S.672-4 Annex 1Ls = -25	400
Hemi beam (Regional)	28	ITU-R S.672-3 Ln = -25	400

Examples of satellite characteristics based on Appendix 30B allotments have also been used, as shown in Table 4.

Table 4

Example planned satellite characteristics.

	Rwanda	Burundi	Kenya	Tanzania	Uganda
Allotment	RRW00000	BDI00000	KEN00000	TZA00000	UGA00000
Nominal orbital position (deg)	17.6	-3.5	78.20	67.50	31.5
Longitude of the boresight (deg)	29.7	29.9	38.40	35.40	32.2
Latitude of the boresight (deg)	-1.9	-3.4	0.80	−5.90	0.90
Major axis (deg)	1.6	1.6	2.10	2.40	1.6
Minor axis (deg)	1.6	1.6	1.60	1.60	1.6
Orientation of the ellipse (deg)	90	90	95	117	90
G_{max} (dBi)	40.4	40.4	39.2	38.6	40.4
Receiver temp (K)	500	500	500	500	500

Note that in the case of modelling of interference to satellites following the App 30B allotment characteristics, it is assumed that the country in question does not deploy IMT stations within their own territory. Hence all interference is contributed from IMT stations assumed to be deployed in other countries.

Part D: Conclusion of the results of studies, if any

Simulation Results

For the studies conducted, the Visualyse simulation tool was used to conduct the Monte-Carlo simulation based on a set of assumptions and methodology as outlined above. Results are presented in cdfs of aggregate interference from IMT stations, with the three criteria included.

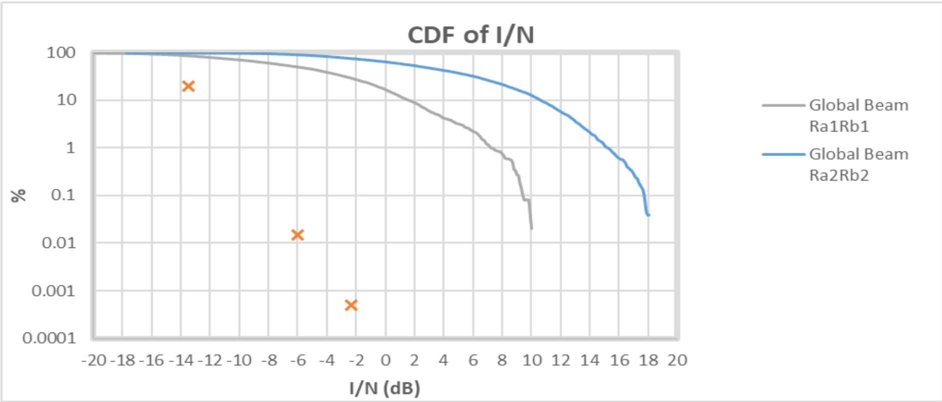
Some simplifying assumptions have been made which will tend to underestimate the interference, for example:

- Ignoring the contribution from small cells
- Ignoring the contribution from IMT user equipment
- Ignoring the contribution from IMT base stations below the rooftop
- Modelling only the M.2101 antenna model (the use of the sub-array model is expected to lead to higher interference)

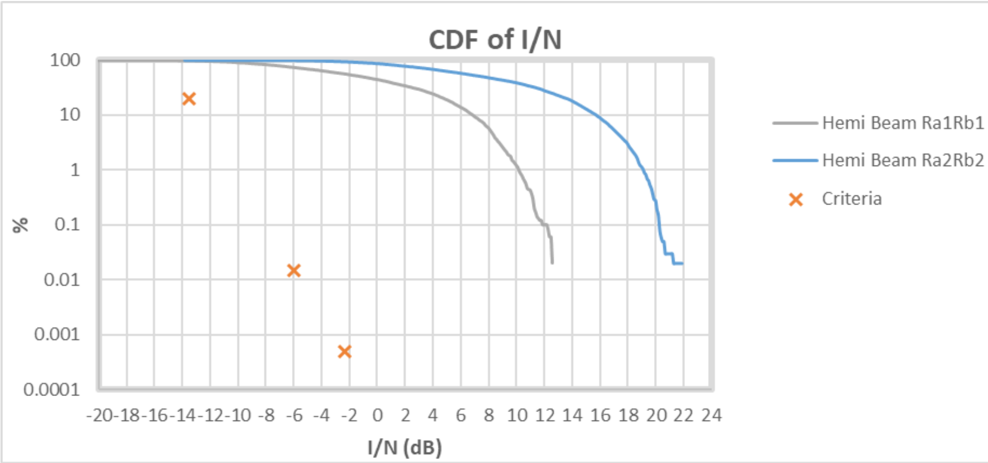
If necessary, improvements to the modelling, including these factors, may be made.

The results show that interference exceeds the criteria in all cases.

GSO global beam



GSO Hemi beam



App 30B Allotments

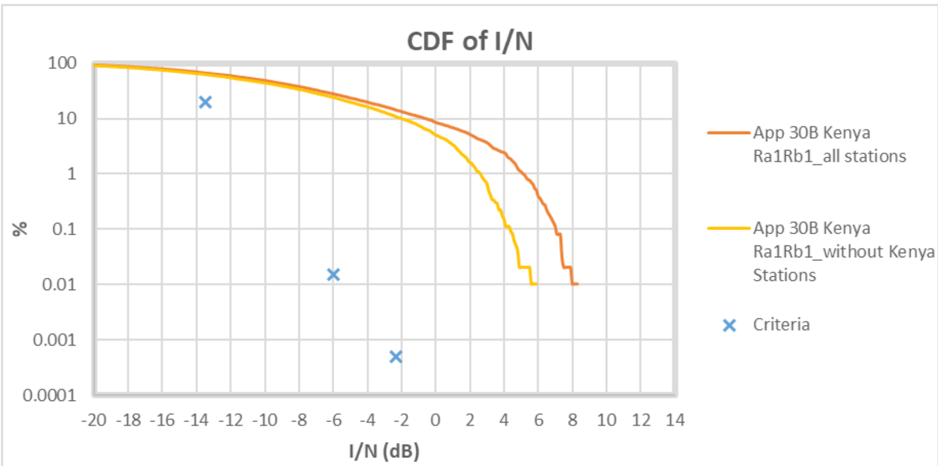
EACO countries have been provided with an allotment for the bands 4500-4800 MHz, paired with 6725-7025 MHz, as summarised in the following table.

Country	**Allotment code**	**Nominal orbital position (deg)**
Burundi	BDI00000	-3.5
Kenya	KEN00000	78.2
Rwanda	RRW00000	17.6
South Sudan	-	-
Tanzania	TZA00000	67.5
Uganda	UGA00000	31.5

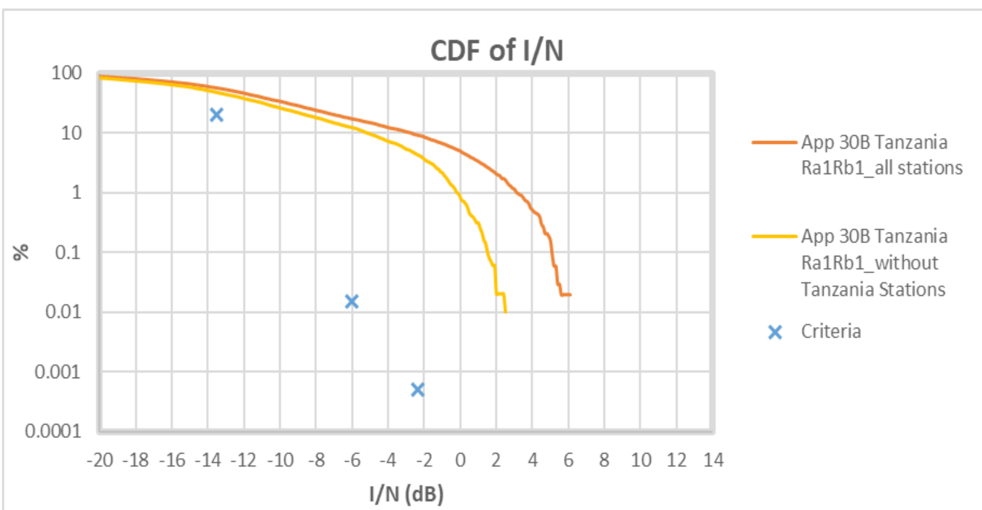
Several African Administrations intend to operate in this band over their territory without time limits. The List associated with the Plan contain assignments resulting from the successful application of the provisions of Article 6 of Appendix 30B or the implementation of Resolution 148 (WRC-07). The Plan includes all national allotments of all countries and needs particular attention due to the super-status of the Plan with regards to the List and other services.

Several African administrations intend to deploy their own domestic satellite system and utilise this planned band as per AP30B and could be impacted.

Kenya



Tanzania



Part E: Options and Associated Implications

Many African Administrations are acutely aware of the growing demand for Wi-Fi connectivity and even mobile operators' use of Wi-Fi to offload a substantial amount of their traffic in urban environments. With such growing requirements, many African Administrations have assigned or intend to assign the lower part of the 6GHz – 5925 to 6425 GHz to RLANs/WiFi for such applications as community-based networks. Some Administrations are also considering the upper 6 GHz band from 6425 to 7 125 MHz for indoor use of Wi-Fi.

GSOA also notes that based on input received from the Wi-Fi industry, penetration of IMT base stations' signals indoor would impact and interfere with the provisioning of Wi-Fi services. Therefore Administrations may wish to carefully re-consider any IMT identifications in the 6 GHz bands.

GSOA has participated in studies conducted in other regions, such as the work undertaken by the CEPT for WLAN devices in the band 5925-6425 MHz. The CEPT studies for that band are contained in ECC Report 302[1] and ECC Decision ECC/DEC/(20)01[2]. Those studies have considered the potential aggregate interference to FSS satellite receivers in this band. It is noted that co-existence between FSS and Wi-Fi is feasible without interfering with either service.

Part F: Proposed African Common View and/or Position

C-band FSS forms a vital component of the telecommunication infrastructure today and in the future for many African countries. C-bands unique characteristics and resistance to rain fade, and continent-wide reach make them ideal for the African environment.

EACO Administrations are invited to support the findings from this initial compatibility study in the bands 6425-7125 MHz and to participate and further refine the initial studies to see if co-existence is feasible or not between FSS and IMT.

EACO Administrations are invited to consider the demand for WiFi in the band 6425-7125 MHz, which may be a more favourable mobile service to share with the FSS.

Part G: Recommendations and Way Forward

Previous ITU-R studies in Report ITU-R S.2367 in the adjacent band below 6 425 MHz indicated that co-frequency sharing with IMT is neither feasible nor practical between mobile service and fixed-satellite service (FSS) in the lower 6GHz. Nonetheless, GSOA has carried out further study work based on WP5D and WP4A's agreed set of values and parameters and seeks to work together with EACO Administrations. The results of these further initial studies as presented confirm the findings from the ITU-R S.2367 that IMT operation is not feasible in the band 6425-7125 MHz.

EACO Administrations are invited to carefully consider these initial findings and consider the demand for additional spectrum for WIFI growth in the band 6425-7125 MHz. The benefits of having both satellite and Wi-Fi in the 6GHz bands could have a significant social and economic impact on the EACO national economies.

[1] available at https://docdb.cept.org/document/10170

[2] available at https://docdb.cept.org/document/16737