ASIA-PACIFIC TELECOMMUNITY

The 28th Meeting of the APT Wireless Group (AWG-28)

6 – 14 September 2021, Virtual Meeting

Document No: AWG-28/INP-IAFI-10

28 August 2021

ITU-APT Foundation of India (IAFI)[1]

COEXISTENCE BETWEEN IMT IN THE FREQUENCY BAND 1 492-1 518 MHZ AND MOBILE SATELLITE SERVICE IN THE BAND 1 518 MHZ AND ABOVE

1. Introduction

At the 27th meeting of AWG, further updates were made to the working document towards a new report on sharing and compatibility studies between IMT in the band 1492 – 1518 MHz and MSS systems in the band above 1518 MHz in the Asia pacific region (document AWG-27/TMP-52) . AWG-27 also invited further contributions to further progress this work at AWG-28.

Simultaneously, both ITU-R Working Parties WP5D and WP4C have also progressed the work related to IMT/MSS compatibility at 1 518 MHz and above. WP 4C has updated its progress and plans on the Report and Recommendation from its meeting in July 2021 to a subsequent meeting of WP5D. These include a clear definition/estimation of the PFD limits for land MSS operations and blocking resilience of next generation MESs, including timing aspects. ITU-R Working Parties aim to finalize both the Report and the Recommendations together at a subsequent future meeting of WP4C and WP5D.

2. Discussion

Following the identification of IMT in the band 1 427-1 518 MHz, administrations are looking for guidance regarding the possible frequency arrangements and/or the size of the guard band between IMT and MSS while assigning this band for IMT.

L Band MSS operations in the band 1 525-1 559 MHz are being used in India by the shipping industry, where several ships use L-band Satcom to comply with GMDSS requirements and fishing vessels use L-band Satcom to support off-shore operations. Further, L-band Satcom is also extensively used for aeronautical operations by airlines and government agencies, as well as by land-based MSS terminals.

3. Proposal

Given the ongoing progress being made within ITU-R WP4C, further modifications are proposed to the working document contained in AWG-27 -TEMP-52 in the attachment. Changes proposed in attachment are in track change mode and highlighted in green. While these revisions aim to progress the work on the draft APT Report, it is understood that the completion

[1] ITU-APT Foundation of India (IAFI) is a new Affiliate member of APT. Details of IAFI can be seen at itu-apt.org

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of the draft APT Reports on the sharing studies and the frequency arrangements are dependent on the completion of the related ITU-R Studies.

It is also proposed that in line with the concept of avoiding duplicity of work, the AWG should pause all the work on the *Working Document towards a Draft New Report on sharing and compatibility studies between IMT in the band 1492 – 1518 MHz and MSS systems in the band above 1518 MHz in the Asia Pacific Region* until ITU-R finalizes its report and recommendation on this subject and therefore the current working document (document AWG-27/TMP-52) may be carried forward until that time too.

WORKING DOCUMENT TOWARDS A DRAFT NEW REPORT ON SHARING AND COMPATIBILITY STUDIES BETWEEN IMT IN THE BAND 1492 – 1518 MHZ AND MSS SYSTEMS IN THE BAND ABOVE 1518 MHZ IN THE ASIA PACIFIC REGION

[Editor's note: Inputs contributions are invited to the next meeting to progress the work towards completing this study]

1. Introduction

At ITU World Radiocommunication Conference 2015 (WRC-15), it was agreed to identify the frequency bands 1 427–1 452MHz and 1 492–1 518 MHz for IMT in all three Regions and to identify the frequency band 1 452–1 492 MHz for IMT in Region 2, Region 3 and 54 countries in Region1 in accordance with Resolution **223 (Rev.WRC-15)**.

The frequency band 1 518-1 525 MHz (space-to-Earth) was allocated to the MSS at WRC-03, adjacent to the MSS allocation in 1 525-1 559 MHz and is subject to the provisions in RR No. **5.348**, **5.348A**, **5.348B** and **5.351A**.

2. Scope

The scope of this Report is:

- to review the results of ITU-R and other relevant studies applicable to the Asia-Pacific region;
- to conduct additional compatibility studies between IMT operating in the frequency band 1 492-1 518 MHz and MSS operating in the frequency band above 1 518 MHz applicable to the region; and
- to provide technical measures for coexistence between IMT and MSS in the adjacent frequency band for consideration by APT Members in their countries.

This Report should not duplicate studies being undertaken by ITU-R.

This Report is intended to assist administrations in implementing IMT systems including their frequency arrangements in the 1 427 – 1 518 MHz frequency band in their countries.

[This document is associated with an APT/AWG Report XX on Harmonized frequency arrangement for IMT in the frequency band 1 427-1 518 MHz currently under development on harmonized frequency arrangements for this band.]

3. Situation in the Asia-Pacific Region

To facilitate studies on possible frequency arrangement(s) for terrestrial IMT in the frequency 1 427-1 518 MHz for the Asia-Pacific region, AWG-21 developed the questionnaire on potential implementation of IMT in the frequency band 1 427-1 518 MHz in the Asia-Pacific Region. The questionnaire also seeks information on the usage of frequency band above 1 518MHz, which would impact on the development of the frequency arrangement(s).Further details of the responses provided by some APT Members can be found in Annex 4 to the working document towards a draft new Report on Harmonized frequency arrangement for IMT in the frequency band 1 427-1 518 MHz.

3.1 IMT systems

[Editor's note: Brief summary of the received responses to* the questionnaire on potential implementation of IMT in the frequency band 1 427-1 518 MHz in the Asia-Pacific Region developed at AWG-21 *may be added here.]

3.2 MSS systems

According to the responses to the above questionnaire, some APT countries have awarded the licenses for application of the MSS in the frequency band above 1 525 MHz, and MSS terminals operate on many ships and aircraft in the region, and land mobile terminals (handheld and transportable) are also in operation. Maritime applications include those related to safety of life at sea, including ship earth stations used in the GMDSS in the frequency band 1 530-1 544 MHz (RR footnote No. **5.353A**). Aeronautical applications include those by aircraft earth stations under MSS allocation in the band 1 525-1 559 MHz, noting that priority is given to the AMS(R)S in coordination in the band 1 545-1 555 MHz (see RR No. **5.357A**). Some of theterminals mentioned above are already capable of operating in the band 1 518-1 525 MHz.

[The band is being used or planned to be used for MSS by some APT countries.
In the responses to the AWG questionnaire issued in May 2017 (mentioned in section 3 above), it was noted that only one APT country has implemented MSS in 1518-1525 MHz, while one of the remaining responses indicated that they have a plan to implement MSS in 1518-1525 MHz. Since this time some Administrations may have further developed their plans.
In addition, an APT country has been implementing NGSO constellation MSS system in the frequency band 1 518-1 525 MHz and experimental satellite has already been launched and the terminal is in the process of optimising design.
The use of the 1 518-1 525 MHz band by MSS includes both GSO systems and NGSO constellation systems. Some details are in the sub-sections below.]

3.2.1 Inmarsat

Inmarsat operates a network of GSO satellites, which provide global coverage in L-band (except the polar regions). The system provides voice and data communications, mainly to mobile and portable terminals. The Inmarsat system is used by large numbers of ships and aircraft in the APT Region, including ships and aircraft which visit APT countries from other regions. The Inmarsat system provides maritime safety services as part of the GMDSS, and aviation safety services as part of the AMS(R)S. Portable and handheld devices are used on land, providing services including low data rate IoT, voice and broadband Internet connectivity.

The L-band frequency bands currently used for the Inmarsat system in the APT region are 1525-1559 MHz and 1626.5-1660.5 MHz. The "extended L-band frequencies":1518-1525 MHz and 1668-1675 MHz, are currently used by Inmarsat in Europe, the Middle East and Africa (EMEA). These bands will be available for use by Inmarsat Mobile Earth Stations (MESs) throughout the entire APT Region with the launch of the "Inmarsat-6" satellites, which are currently under construction and are planned for launch in 2021/22. Since 2013, Inmarsat MESs started to be deployed in the APT Region which are able to receive in any part of the band 1518-1559 MHz.Other existing terminals including those deployed before 2013 only receive in the band 1525 -1559 MHz.These include terminals used today with, maritime and aviation safety services which need to show correct functioning as part of safety and operational procedures, prior to departure from sea ports or airports.

[Editors Note: completion of the sub-sections below is dependent on the receipt of suitable information in an input contribution to the AWG]

3.2.2 [SYGNUS non-GSO system]

3.2.3 [Garuda]

3.2.4 [Thuraya]

[Editor's note: The text of Section 4 below may need to be updated at future meetings of AWG in accordance with the progress of ITU-R work.]

4. Status of ITU-R studies

Resolution **223 (Rev.WRC-15)***invites ITU-R*"to conduct compatibility studies in order to provide technical measures to ensure coexistence between MSS in the frequency band 1 518-1 525 MHz and IMT in the frequency band 1 492-1 518 MHz."

In response to the above *invites ITU-R*, ITU-R Working Parities 4C and 5D are developing preliminary draft new Report ITU-R M.[REP.MSS & IMT L-BAND COMPATIBILITY] to evaluate potential interference and provide technical measures for coexistence between MSS in the frequency band 1 518-1 525 MHz and IMT in the frequency band 1 492-1 518 MHz. Some studies in this ITU-R Report also address the potential interference due to blocking of MESs operating in the frequency band 1 525-1 559 MHz, including ship earth stations used in the GMDSS in the frequency band 1 530-1 544 MHz (see RR **No. 5.353A**) and aircraft earth stations under MSS allocation in the band 1 525-1 559 MHz, noting that priority is given to the AMS(R)S in coordination in the band 1 545-1 555 MHz (see RR **No. 5.357A**).

ITU-R Working Parties are expected to finalize both the Report and the Recommendations together at a subsequent future meeting of WP4C and WP5D.

Summaries of all studies in Report ITU-R M.[REP.MSS & IMT L-BAND COMPATIBILITY] can be found in its Section 5, in which the probabilities of interference from IMT base stations/mobile stations into MES are assessed considering different I/N protection criteria, receiver blocking levels, and frequency separations between IMT and MSS.

Taking into account the results of studies in this ITU-R Report, ITU-R Working Parties 4C and 5D are developing the working document towards a Preliminary Draft New Recommendation ITU-R M.[REC.MSS & IMT L-BAND COMPATIBILITY]. This Recommendation provides a framework for adjacent band compatibility between satellite systems in the mobile-satellite service operating in the band 1 518-1 525 MHz and IMT-systems operating in the band 1 492-1 518 MHz in line with the Resolution **223 (Rev.WRC-15)**.

Following elements are being considered by the ITU-R WP5D and WP4C in theReport and Recommendation being developed on this subject

- That the proposed Recommendation should apply to those administrations with maritime and aeronautical MSS operations in the frequency band 1 525-1 559 MHz

- The baseline improvement to the requirements of IMT emissions and MES receiver blocking, be explicitly identified. This should include IMT Base Station pfd limits such that the risk of interference to maritime and aeronautical MESs be reduced.

- Additional frequency separation below 1518 MHz (e.g. a total separation of 0 to 6 MHz) when IMT and MSS operations are geographically co-located.

- The Recommendation should contain protection measures for out-of-band emissions from IMT systems using the frequency band 1 427-1 518 MHz. These out-of-band protection measures should be defined/quantified for the frequency band 1 518-1 559 MHz.

- The Recommendation should contain protection measures for land MSS terminals, maritime MSS terminals at ports and aeronautical MSS terminals at airports in the bands above 1 518 MHz. This should also include necessary protection measures for terminals used for the GMDSS (i.e., especially those based on protection of current Inmarsat-C terminals).

- The Recommendation should include information regarding the process underway in IMO to ensure that next-generation GMDSS terminals have increased resilience to interference. If required, it will assist administrations in determining the timing of applying further corrective adjustments on protection limits on IMT systems.

- The limit for unwanted emissions from IMT user equipment operating in the band 1492-1518 MHz into the band 1525 – 1559 MHz, be defined.

- The Recommendation should include options to enable MSS land terminals to operate in the band above 1 518 MHz without any interference from IMT systems.

- The Recommendation should include information regarding possible guard bands to ensure coexistence between MSS and IMT.

It is expected that inclusion of the above elements in ITU-R Report andRecommendation on this subject will help inprotection of MSS in the L-band from 1518 MHz and also address protection of land MSS since these are used for disaster and logistical operations during the period of emergencies, especially during earthquakes, floods or cyclones etc.

5. Status of other relevant studies

In Europe, the CEPT has harmonised use of the band 1 427-1 518 MHz for "supplementary downlink" (SDL) IMT applications. CEPT has studied compatibility with MSS operations with the development of two ECC Reports:

ECC Report 263	Adjacent band compatibility studies between IMT operating in the frequency band 1492-1518 MHz and the MSS operating in the frequency band 1518-1525 MHz
ECC Report 299	Measures to address potential blocking of MES operating in bands adjacent to 1518 MHz (including 1525-1559 MHz) at sea ports and airports

[CEPT has produced two Decisions related to frequency arrangements and technical conditions for IMT SDL systems in the following:

ECC Decision (13)03	The harmonised use of the frequency band 1452-1492 MHz for Mobile/Fixed Communications Networks Supplemental Downlink (MFCN SDL)
ECC Decision (17)06	The harmonised use of the frequency bands 1427-1452 MHz and 1492-1518 MHz for Mobile/Fixed Communications Networks Supplemental Downlink (MFCN SDL)

Administrations in CEPT may follow ECC Decision (13)03 arrangement or may combine this with the ECC Decision (17)06 arrangement.]

6. Studies for coexistence between IMT and MSS in the L-band in the Asia-Pacific region

[As noted above, the use of the 1 518-1 525 MHz band by MSS includes both GSO systems and NGSO constellation systems, and the band 1525-1559 MHz is widely used in the APT Region by GSO MSS systems, for reception by MES terminals used on ships, aircraft andland mobile terminals. Some of these applications could be susceptible to interference from IMT systems operating in the band1492 - 1518 MHz or portions thereof. Accordingly, this section presents results of sharing and compatibility studies between IMT operating in the frequency band 1 492-1 518 MHz and MSS operating in the frequency band above 1 518 MHz and provides technical measures to ensure coexistence between IMT systems and MSS systems above 1518 MHz for consideration by APT Members.]

6.1 Study 1 –Analysis of the ITU-R studies

[The results of ITU-R studies may be used by APT Members to define technical measures for IMT systems to provide compatibility with MSS operations in their countries.

[As shown in Preliminary Draft new Report ITU-R M.[REP.MSS & IMT L-band COMPATIBILITY], various studies have been performed regarding potential interference from IMT base stations and UEs to MES receivers.

Among the factors which influence the results of the studies are the MSS interference criteria, receiver blocking levels and the acceptable probability of interference in Monte Carlo analyses.]

[Also, while next generation MESs are expected to be more resilient to blocking interference , it would be necessary to apply mitigation measures, such as lower in-band emission limits of IMT stations, to protect existing MESs in some cases. / One study suggested that next generation MESs are expected to be more resilient to blocking interference and hence it is proposed to consider different IMT emission limits would be applied at different time frame, initially to protect existing MESs and later to protect next generation MESs.]

[The ITU-R is developing a working document towards a preliminary draft new Recommendation ITU-R M.[REC.MSS & IMT L-band COMPATIBILITY] . This ITU-R Recommendation contains technical measures for achieving compatibility applicable to IMT systems in the band 1492-1518 MHz and MSS systems above 1518 MHz.

The ITU-R and CEPT studies that have been done so far considered an IMT deployment only below 1517 MHz for the protection of maritime and aviation terminals. However, some APT members are considering IMT deployment throughout the entirety of the 1427-1518 MHz

band,and therefore, a new study is required to consider the impact of IMT BS deployment when the upper edge of the channel is at 1518 MHz, and this study is presented below in section 6.2.]

[

6.2 Study related to Inmarsat GSO MSS system

When considering the compatibility of IMT systems operating below 1518 MHz with MSS systems operating above 1518 MHz, one scenario is interference from IMT Base Stations (BS) into MES receivers. IMT BS interference into MES receivers is caused by two mechanisms;

- The IMT BS in-band emission causing overload/blocking effect on the MES receivers. Results could range from performance degradation to making the MES inoperable
- The IMT BS out-of-band emissions causing increase to the noise floor of the receiver thereby degrading the service

The overload/blocking effect of IMT BS in-band emissions depends on a number of factors, the main factors being the IMT BS in-band emission level, the frequency offset (guard band) below 1518 MHz.

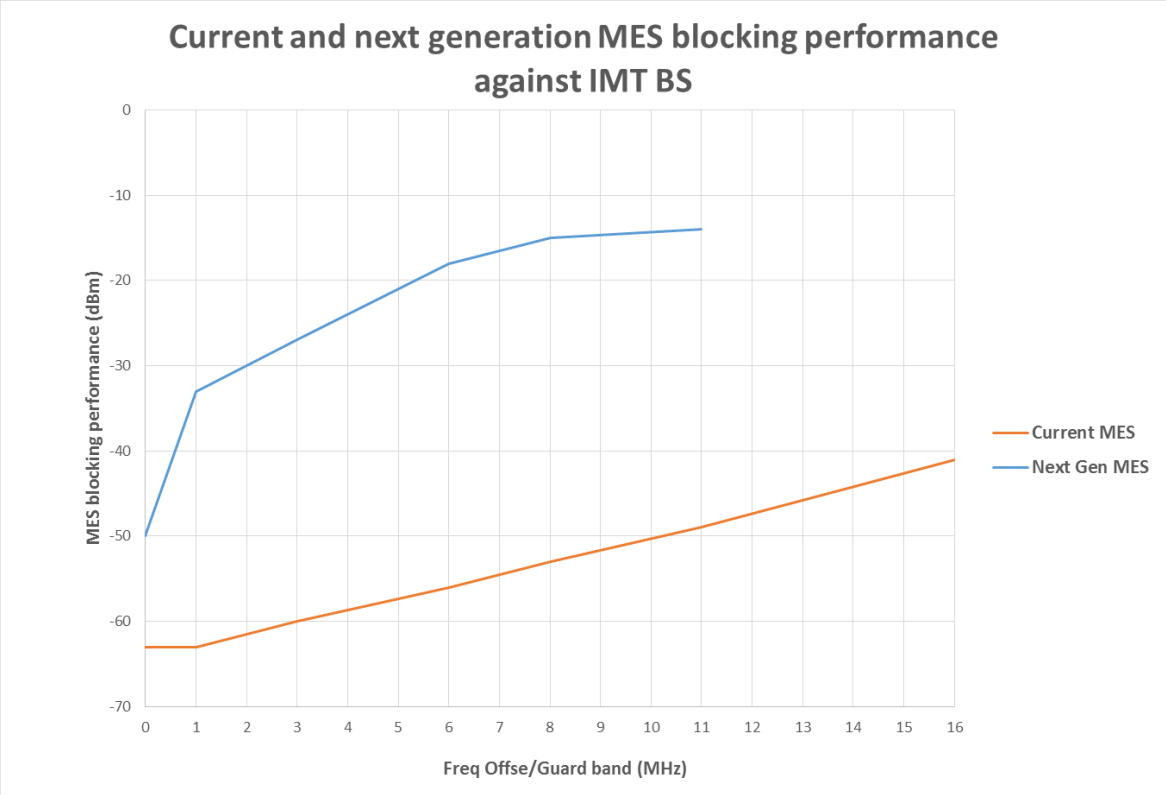
Current and next generation MES blocking performances have been measured with the LTE channel transmission at different frequency offsets from 1518 MHz to determine the blocking signal expected at the MES. The maximum blocking signal is determined using the criteria of the blocking level that causes 1 dB degradation in the MES receiver performance.

The blocking performance of current and next generation MES receivers from anIMT BS with different frequency offsets are shown in the table 1 below, the results are also plotted in Figure 1.

Table 1: Current and next generation MESs blocking performance against IMT BS at different frequency offsets of a 10 MHz wide LTE signal

Frequency offset below 1518 MHz	**0 MHz Offset**	**1 MHz Offset**	**3 MHz Offset**	**6 MHz Offset**	**8 MHz Offset**	**11 MHz Offset**	**16 MHz Offset**
Blocking (dBm) for Current MES[2]	–63	–63	–60	–56	–53	–49	–41
Blocking (dBm) for Next generation MES	–50	–33	–27	–18	–15	–14	N/A

Figure 1: Plot of Current and next generation MESs blocking performance against IMT BS at different frequency offsets



As can be seen from the Table 1 above, for current MES, the blocking impact of IMT BS transmission when the upper edge of the channel is deployed at 1517 MHzis the same as when the upper edge of the channel is deployed at 1518 MHz, and thus interference study results for this scenario would be consistent with the results of the blocking studies done in ITU-R. However, looking at the impact of frequency offset (guard band) on the blocking of next generation MESs, there is a significant difference (17 dB) between the impact of IMT BS transmission when the upper edge of the channel is deployed at 1517 MHz (1 MHz guard band) compared to when the upper edge of the channel is deployed at 1518 MHz (0 MHz guard band).

The ITU-R studies have not considered the impact of IMT BS deployment with the upper channel at 1518 MHz with respect to maritime and aeronautical MESs, and therefore this additionalstudy is needed for IMT BS deployment at 1518 MHz with no guard band.

Looking at the Table 1 above, in order to ensure protection of next generation maritime and aviation terminals from an IMT deployment at 1518 MHz, the PFD limit required on IMT BS transmission to protect next generation maritime and aviation terminals should be based on the blocking signal of -50 dBm.

For current maritime and aviation terminals, therequired PFD limits maybe based on the blocking signal levels in the ITU-R studies.

6.2.1 PFD limits for IMT base stations

In order to ensure protection of maritime and aeronautical terminals at seaports and airports respectively, it is necessary to apply a protection measure based on PFD limits on IMT BS and this methodology is described in this section.

Given the time required to deploy new terminals in the maritime and aeronautical markets, it is expected that protection measures imposed by administrations required to protect aeronautical

terminals at airports and maritime terminals at seaports will be on a phased approach; with the initial measures - Phase 1, to protect currently operating terminals which are more sensitive to blocking, followed by Phase 2 for next generation terminals which would involve more relaxed constraints on IMT BSs.

The maximum PFD limit required to protect an MES could be derived using the following formula:

$$pfd_{max} = I_{max} - Ae_{iso} - G_{MES}$$

Where:

- $pfd_{max} = MaximumPowerFluxDensity$;
- $I_{max} = MaximumInterfererlevel(i.e. blockingrequirement)$;
- $Ae_{iso} = EffectiveAppertureareaofanIsotropicAntenna\left(=\frac{\lambda^2}{4\pi}\right)$;
- $G_{MES} = GainofMESinthedirectionoftheBS.$

MESs with directional antennas point towards the GSO satellite with which they are communicating. Hence G_{MES} depends on the pointing direction of the MES at the particular location considered. For a typical scenario, three GSO satellites would be used to provide global coverage, which means that in the large geographic area of the APT some countries will see the GSO satellite with a low elevation angle, as low as the minimum specified angle of 5 deg elevation, leading to high value of G_{MES}.

As the formula above shows, the PFD limits required to protect MESs, depends, for a given frequency band, on the blocking requirement and MES antenna gain in the direction of the BS.

For phase 1, the PFD limits required to protect current maritime terminals is derived based on Inmarsat-C terminal blocking performance with an antenna gain of 3 dBi, while for aviation terminals, the blocking requirement is based on Inmarsat Classic Aero terminal which has an antenna gain of 17 dBi.

For phase 2, the PFD limits would be based on -50 dBm blocking levels resulting from an IMT deployment at 1518 MHz on Fleet broadband terminal for maritime which has an antenna gain of 19dBi, and Inmarsat Classic Aero terminals for aviation which has an antenna gain of 17 dBi.

The PFD limits required for Phase 1 and 2 were derived using the calculation method shown above, the PFD limits are given below in Table 2.

Table 2: PFD limits for Phase 1 and 2 from an IMT BS single channel transmission

Phase	Phase 1			Phase 2		
	PFD limit for BS emissions in the band 1492-1502 MHz (dBW/m^2)	PFD limit for BS emissions in the band 1502-1512 MHz (dBW/m^2)	PFD limit for BS emissions in the band 1512-1518 MHz (dBW/m^2)	PFD limit for BS emissions in the band 1492-1503 MHz (dBW/m^2)	PFD limit for BS emissions in the band 1503-1513 MHz (dBW/m^2)	PFD limit for BS emissions in the band 1513-1518 MHz (dBW/m^2)
Ports and waterways	-60.9	-75.9	-83.9	No limit required (provided BS EIRP does not exceed 68	-44.9	-73.9

				dBm)		
Airports	-42.9	-56.9	-72.2	No limit required (provided BS EIRP does not exceed 68 dBm)	-42.9	-71.9

The above PFD limits apply when an IMT BS is transmitting a single channel/LTE block, in reality, therecould be multiple channels/LTE blocks transmitted from a single IMT BS, and therefore, the PFD limit that applies for multiple transmissions, need to specify. From blocking measurements of different MESs, it is observed that the PFD limits that result from multiple channel transmission is 3 dB lower compared to the PFD limits from single channel, as shown below in Table 3.

Table 3: PFD limits for Phase 1 and 2 from an IMT BS multiple channel transmissions

Phase	Phase 1		Phase 2		
	PFD limit for BS emissions in the band 1492-1513 MHz (dBW/m^2)	PFD limit for BS emissions in the band 1513-1518 MHz (dBW/m^2)	PFD limit for BS emissions in the band 1492-1503 MHz (dBW/m^2)	PFD limit for BS emissions in the band 1503-1513 MHz (dBW/m^2)	PFD limit for BS emissions in the band 1513-1518 MHz (dBW/m^2)
Ports and waterways	-78.9	-86.9	No limit required (provided BS EIRP does not exceed 68 dBm)	-47.9	-76.9
Airports	-59.9	-75.2	No limit required (provided BS EIRP does not exceed 68 dBm)	-45.9	-74.9

For compatibility with land MESs, potential EIRP limits on IMT base stations and IMT UEs have been developed.

For compatibility with ship earth stations, including those operating in the GMDSS, pfd limits have been developed to protect currently operating and next generation earth stations. The pfd limits would be applied by administrations at the boundary of areas where protection of ship earth stations is required, e.g. at ports, some coastal areas, and some inland waterways.

For compatibility with aircraft earth stations, including those operating providing safety related services in the AMS(R)S, pfd limits have been developed to protect currently operating and next generation earth stations. The pfd limits would be applied by administrations at the boundary of areas where protection of aircraft earth stations is required, e.g. at airports.]

[Editor's note: Additional text would be added here to provide summary of ITU-R recommendation on technical measures which are applicable to the Asia-Pacific region at future meetings of AWG in accordance with the progress of ITU-R work.]
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6.3 Study 2 – Study related to new NGSO satellite constellation systems

Some countries are developing new NGSO satellite constellation systems which are designed to operate in 1 518-1 525 MHz.

Case 1:Characteristics of NGSO-MSS system 1: SYGNUS system

Table 1 NGSO-MSS terminal characteristics

	NGSO-MSS Terminal 1	**NGSO-MSS Terminal 2**
MES receiver system noise temp (K)	340	340
Polarisation	Circular	Circular
MES reference bandwidth (kHz)	25~200	6000
MES noise in reference BW (dBW)	-159.3~-150.3	-134.9
ACS (dB)	30	30
Protection criteria (I/N)(dB)	[*-20/-15.2, -6/-10*]	[*-20/-15.2, -6/-10*]
Blocking (dBm)	-60	[TBD]

[Editor's note: Further information on the blocking levels in accordance with the different frequency offset may be needed for the compatibility studies.]

One of proposed antenna pattern for the terminal of NGSO MSS system is shown in the figure below.

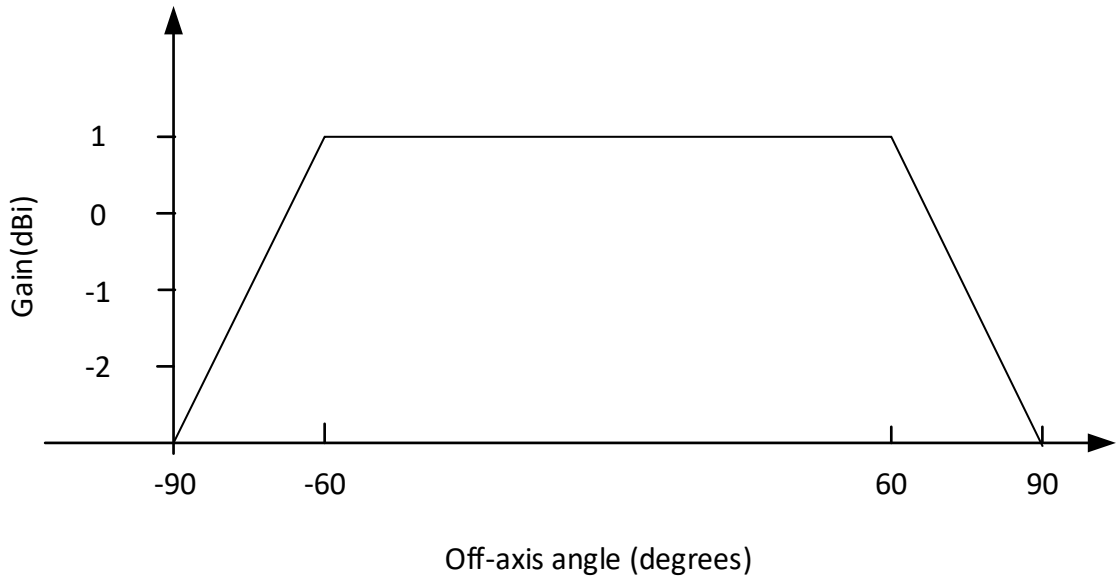

Figure 1 Proposed terminal antenna pattern

Case 2: Characteristics of NGSO-MSS system 2: XINGYUN system

The NGSO satellite system like XINGYUN will operate at an altitude between 500 km and 1 500 km.Compared to those GSO satellite systems, which operate at 35 768 km, the NGSO satellite systems have much less link loss and time delay. The terminals of the LEO satellite systems are usually omni, using low gain antenna,wide-band filter with low insertion loss before LNA, cheap, low power and low 1 dB compression point LNA.It is hard for terminals of the LEO satellite networks to add a steep filter before the LNA,which will lead to the weakness of MESs in two aspects:a) sensitivity of MES will be 3-5 dB worse because of increase in noise factor, unbalance of group-delay and flatness in RF circuits;b) Volume, power consumption and cost of MSS terminals will zoom.It is noted that LEO MSS terminals are sensitive to these factors.

[Editor's note: Additional text for Study 2 (e.g., scenarios, methodology and parameters for sharing and compatibility studies, and results of the studies would be added here.]

7. Summary of the Report

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