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| **World Radiocommunication Conference (WRC-19)Sharm el-Sheikh, Egypt, 28 October – 22 November 2019** |  |
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| China (People's Republic of)/Russian Federation/Papua New Guinea |
| Proposals for the work of the conference |
| Technical Studies related to Agenda Item 9.1, Issue 9.1.1 |
| Agenda item 9.1(9.1.1) |

9 to consider and approve the Report of the Director of the Radiocommunication Bureau, in accordance with Article 7 of the Convention:

9.1 on the activities of the Radiocommunication Sector since WRC-15;

9.1 (9.1.1) Resolution **212 (Rev.WRC-15) -** Implementation of International Mobile Telecommunications in the frequency bands 1 885-2 025 MHz and 2 110 2-200 MHz

# 1 Introduction

The ITU-R studies under agenda item 9.1, issue 9.1.1 have been the responsibility of Working Parties 4C and 5D. While the two working parties have not been able to finalise the planned ITU-R Report containing the technical studies before WRC-19, the different studies give a clear and consistent indication of the interference situations for each of the scenarios considered. The document that has been worked on by both working parties is currently around 430 pages and is difficult to be easily referenced by those who have not been directly involved in the studies and hence this document is intended to give a summary of the main findings of the interference studies.

There are four interference scenarios considered under this agenda item and the figure below shows an example of terrestrial IMT and satellite IMT system deployment in two different countries, which are not necessarily sharing a border between them.



Table 1: Scenarios considered and the interference situations

|  |  |
| --- | --- |
| **Scenario** | **Interference/Comment** |
| **A1** | Exceedance up to 52.2 dB - not currently addressed by the RR |
| **A2** | Interference issues can be handled by existing cross-border coordination provisions in the RR |
| **B1** | Interference issues can be handled by existing cross-border coordination with amended provisions in the RR (see Annex C) |
| **B2** | Interference can be addressed by inclusion of a new pfd coordination threshold |

Table 1 above summarizes the four scenarios studied, the corresponding interference situations and how the issue of interference could be handled (with the exception of scenario A1). This document is focused on the scenario A1 (i.e. interference from terrestrial IMT base stations to IMT satellite receivers in the band 1 980-2 010 MHz), which is the most critical scenario addressed under this agenda item, as very high levels of interference would prevent use of the band by the MSS.

# 2 Interference from mobile base stations is demonstrated by technical studies

A simple interference analysis from a single IMT base station as given in Table 2 shows that interference would exceed the MSS *I*/*N* protection criterion.

Table 2: A single IMT base station interference into different satellites systems

|  |  |  |
| --- | --- | --- |
| **Interferer** | **Satellite Type** | **Exceedance Level (dB)** |
| Single IMT base station | LEO | 10.2 |
| MEO | 7.0 |
| HEO | 11.8 |
| GEO | 20.7 |

Details of the calculation of results in Table 2 are given in Annex A.

Naturally, interference from an aggregation of IMT base stations would exceed the protection criterion by a very large amount. Table 3 below summarizes the results of interference analysis carried out in the studies under this agenda item, using parameters and assumptions contained in ITU-R Recommendation M.2101 and Report M.2292.

Table 3: Aggregate IMT base station interference into different satellites systems

|  |  |  |
| --- | --- | --- |
| **Interferer** | **Satellite Type** | **Exceedance Level (dB)** |
| Multiple IMT base stations  | LEO | 39.5 |
| MEO | 37.2 |
| HEO | 48.0 |
| GEO | 52.2 |

For such high levels of exceedance of the MSS systems protection criteria, no effective mitigation measures have been identified that can eliminate interference through coordination. Excessive interference can occur when the countries using terrestrial IMT and satellite IMT share a border and also when they are geographically separated by thousands of kilometres.

Interference into the MSS from aggregate UEs (maximum UE EIRP of 20 dBm/5 MHz) was shown to be benign.

# 3 Interference from IMT base stations is real - as demonstrated by actual interference cases

Measurements of interference have been carried out by one MSS operator using an in-orbit MEO satellite operating in the 2 GHz MSS bands. A summary of the measured interference levels is shown in Table 4.

Table 4: Interference levels measured by an operational MEO satellite

|  |  |  |
| --- | --- | --- |
| **Spotbeam Location** | **Distance from IMT Deployment (km)** | **Exceedance Level (dB)** |
| Mexico | 200 km | 36.0 |
| West Africa | 6 000 km  | 20.7 |
| United Kingdom | 5 000 km | 23.6 |
| Papua New Guinea | 10 000 km | 26.7 |

As indicated in Table 4 above, the aggregate interference from an actual terrestrial IMT deployment has been shown to exceed the interference protection criterion of an operational IMT satellite by several orders of magnitude for sampled spotbeams that collectively span much of the Earth’s surface. Additional material on spectrum measurements is provided in Annex B.

In a separate case, interference to a UK notified MSS satellite operating in the band 1 980-2 010 MHz has been reported to the ITU Bureau under the RR Article 15 procedures.

# 4 Possible measures to ensure coexistence between IMT base stations and IMT satellites

One measure to ensure coexistence between IMT base stations and IMT satellites is a proposal to place an e.i.r.p. limit on mobile base stations operating in the band 1 980-2 010 MHz. An alternative operational measure (in lieu of the e.i.r.p limit above) that ensures coexistence would be to follow a frequency arrangement that uses the band 1 980-2 010 MHz for the UE transmit, and the band 2 170-2 200 MHz for base station transmit.

Recommendation ITU-R M.1036-5 includes several recommended frequency arrangements, including “B6” and “B7”. Arrangement “B6” would be a natural supplemental arrangement for those administrations that have already implemented IMT in the bands 1 920-1 980 MHz and 2 110-2 170 MHz using the “B1” frequencies arrangement[[1]](#footnote-1).

# 5 Conclusion

ITU-R studies have shown that IMT satellites receive very high levels of interference when the band 1 980-2 010 MHz is used by transmitters of terrestrial IMT base stations. The very high level of interference poses an existential problem for satellite receivers in the band 1 980-2 010 MHz when this band is used for terrestrial IMT and satellite IMT in different countries.

The theoretical studies have been validated by actual interference measurements, which show that harmful interference occurs today in large segments of the 1 980-2 010 MHz band. Amendments to the Radio Regulations are therefore necessary for the band 1 980-2 010 MHz in order to prevent this band being rendered unusable by the MSS.

The introduction of power limits for terrestrial IMT base stations as proposed or alternatively an operational measure limiting the use of the frequency band 1 980-2 010 MHz by the terrestrial component of IMT to transmissions from user equipment to base stations would provide adequate protection to IMT satellites and also ensure the coexistence of terrestrial and MSS IMT operations. The proposed solutions would also allow administrations to deploy terrestrial IMT, if they so wish, in a manner compatible with MSS operations and consistent with the co-primary status of the two services.

Annex A

Calculation of interference from a single IMT base station to an MSS satellite

Table A1 shows the detail of the calculation of interference from a single base station to an MSS satellite, under the assumption that the IMT base station and the MSS service area are different countries.

Table A1: A single IMT base station interference into different satellites systems

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **BS to GEO** | **BS to LEO** | **BS to HEO** | **BS to MEO** | **Units** |
| Centre frequency | 1 995 | 1 995 | 1 995 | 1 995 | MHz |
| Distance from satellite to BS | 41 402 | 2 430 | 51 500 | 13 912 | km |
| Elevation angle (from BS to satellite) | 2.5 | 30 | 5 |  15 | deg |
| Free space loss | 190.8 | 166.1 | 192.7 |  181.3 | dB |
| Satellite noise temperature | 27.6 | 29 | 29.0 |  26.0 | dBK |
| Protection threshold (I/N) | –12.2 | –12.2 | –12.2 |  –12.2 | dB |
| Acceptable interference power spectral density | –183.2 | –181.8 | –181.8 |  –184.8 | dBm/Hz |
| Satellite peak antenna gain | 50.6 | 23 | 44.8 |  30 | dBi |
| Satellite antenna gain in the direction of the BS | 43.6 | 21 | 42.8 |  27 | dBi |
| Uplink transmitting power spectral density (with feeder loss) | –27 | –27 | –27 |  –27 | dBm/Hz |
| (43 dBm/5MHz) | (43dBm/5MHz) | (43dBm/5MHz) | (43dBm/5MHz)  |
| BS antenna gain in the direction of the satellite  | 11.7 | 0.5 | 6.9 |  2.6 | dBi |
| BS Interference EIRP spectral density | –15.3 | –26.5 | –20.1 |  –23.4 | dBm/Hz |
| **Exceedance level** | **20.7** | **10.2** | **11.8** | **7.0** | dB |

Annex B

Measurements of interference to an operational MEO satellite

The following visualisations indicate the geographical extent of the interference measured from terrestrial downlink emissions from terrestrial IMT deployments in North America (Region 2) over the frequency range 1 990-1 995 MHz. These measurements were recorded by receive spot beams from an operation IMT satellite in Medium Earth Orbit (MEO). The visualisations in this Annex are traceable to the appropriate numerical values of interference exceedance that are shown in Table 4 of this document.

The circles indicate the position of the satellite when each measurement was recorded, while the colour of the circles indicate the level of exceedance of the satellite’s protection criteria in dB. The triangle indicates the centre location of the spot beam from which the interference measurements were recorded.

The plot in Figure B1 below shows measured interference into West Africa (Region 1) from terrestrial IMT base station downlink emissions in Region 2.

Figure B1: Measured interference into MEO IMT satellite for spotbeam over West Africa



The plot in Figure B2 below shows measured interference into Papua New Guinea (Region 3) from terrestrial IMT base station downlink emissions in Region 2.

Figure B2: Measured interference into MEO IMT satellite for spotbeam over Papua New Guinea



Both plots above indicate that terrestrial IMT downlink operation is demonstrably shown to cause significant interference to IMT satellite uplinks, even when the respective terrestrial and satellite deployments are many thousands of kilometres apart. This conclusion confirms that interference from terrestrial IMT downlink operations into the satellite IMT uplink segment is an international concern, affecting global technical compatibility between terrestrial and satellite IMT in the band 1 980-2 010 MHz.

Annex C

Derivation of parameter values for Table 7a of Appendix 7

To address interference scenario B1, additions to Appendix 7 are proposed to include relevant parameters for digital modulation required for the determination of coordination distance for a transmitting earth station. The parameters are based on the characteristics of receiving IMT base stations, consistent with Report ITU-R M.2292. This addition would aid administrations in establishing the necessary coordination distances. The remarks of the following table describe the different parameters and the calculations.

Table C1: Parameters required for the determination of coordination distance for
a transmitting earth station

| **Transmitting spaceradiocommunication service designation** | **Mobile-satellite** | **Remarks** |
| --- | --- | --- |
| Frequency bands (MHz) | 1 980-2 025 | - |
| Receiving terrestrial service designations | Fixed, mobile | - |
| Method to be used | § 1.4.6 | - |
| Modulation at terrestrial station 1 | A | N | - |
| Terrestrial station interference parameters and criteria | *p*0 (%) | 0.01 | 20 | percentage of the time during which the interference from all sources may exceed the threshold value |
| *n* | 2 | 1 | number of equivalent, equal level, equal probability entries of interference, assumed to be uncorrelated for small percentages of the time |
| *p* (%) | 0.005 | 20 | percentage of the time during which the interference from one source may exceed the permissible interference power value; since the entries of interference are not likely to occur simultaneously *p* = *p0*/*n* |
| *NL* (dB) | 0 | 0 | The factor *NL* is the noise contribution to the link. In the case of a satellite transponder, it includes the uplink noise, intermodulation, etc. In the absence of table entries, it is assumed: *NL* = 1 dB for fixed‑satellite links    = 0 dB for terrestrial links |
| *Ms* (dB) | 26 2 | 1 | for BS IMT station NF=5 dB. Therefore N=-204 dBW/Hz +5dB=-199 dBW/Hz.Therefore based on *I*/*N* = –6 dB I=-205 dBW/Hz or 169 dBW/4kHz)Since *Pr*(*p*) = –169 dBW/4kHz) than *Ms* = 1 dB |
| *W* (dB) | 0 | 0 | When the wanted signal is digital, *W* is usually equal to or less than 0 dB, regardless of the characteristics of the interfering signal. |
| Terrestrial station parameters | *Gx* (dBi) 3 | 49 2 | 16.1 | Receiving antenna gain without feeder loss of IMT base station towards the direction to MSS earth station  |
| *Te* (K) | 500 2 | 925 | for BS IMT station NF=5 dB and N = –199 dBW/Hz *Te* = 10^(*N*/10)/*k* = 925 K |
| Reference bandwidth | *B* (Hz) | 4 × 103 | 4 x 103 | - |
| Permissible interference power | *Pr*(*p*) (dBW)in *B* | −140 | –169 |  *k*: Boltzmann's constant (1.38 × 10−23 J/K) *Te*: thermal noise temperature of the receiving system (K), at the terminal of the receiving antenna *NL*: link noise contribution *B*: reference bandwidth (Hz), i.e. the bandwidth in the receiving station that is subject to the interference and over which the power of the interfering emission can be averaged *p*: percentage of the time during which the interference from one source may exceed the permissible interference power value; since the entries of interference are not likely to occur simultaneously, p = p0/n *p0*: percentage of the time during which the interference from all sources may exceed the threshold value *n*: number of equivalent, equal level, equal probability entries of interference, assumed to be uncorrelated for small percentages of the time *Ms*: link performance margin (dB) *W*: a thermal noise equivalence factor (dB) for interfering emissions in the reference bandwidth; it is positive when the interfering emissions would cause more degradation than thermal noise |

1 A: analogue modulation; N: digital modulation.

2 The parameters for the terrestrial station associated with transhorizon systems have been used. Line-of-sight radio-relay parameters associated with the frequency band 1 668.4-1 675 MHz may also be used to determine a supplementary contour.     (WRC‑03)

3 Feeder losses are not included.

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1. ITU-R frequency arrangement “B1” is also known as 3GPP “Band 1” and is widely implemented. The combination of ITU-R frequency arrangement “B1” and “B6” is known as 3GPP “Band 65”. [↑](#footnote-ref-1)