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Annex 29 to Joint Task Group 4-5-6-7 Chairman's Report

WORKING DOCUMENT FOR ATTACHMENT TO
JTG 4-5-6-7 CHAIRMAN'S REPORT

Sharing studies of IMT-Advanced systems in the mobile service with respect to systems in the mobile-satellite service in the frequency bands 1 518-1 559 MHz, 1 626.5-1 660.5 MHz and 1 668-1 675 MHz

[***Editorial Note:***

This document was not agreed by JTG 4-5-6-7. This document would need substantial work before it would be ready as a draft new Report.]

Scope

This Report describes [potential band sharing][a [co-channel] sharing study]between IMT-Advanced systems and geostationary satellite (GSO) networks in the mobile-satellite service (MSS) in the bands 1 518-1 559 MHz, 1 626.5-1 660.5 MHz and 1 668-1 675 MHz. This Report was developed as a consequence of studies required for WRC-15 agenda item 1.1. [This Report does not address sharing and compatibility issues between IMT-Advanced systems and integrated MSS and terrestrial systems.]

1 Introduction

This Report examines the interference between MSS systems and potential new IMT-Advanced systems in the bands 1 518-1 559 MHz, 1 626.5-1 660.5 MHz and 1 668-1 675 MHz. [The Report does not address adjacent band compatibility with IMT systems.]

2 Background

The frequency bands 1 525-1 559 MHz (space-to-Earth) and 1 626.5-1 660.5 MHz (Earth-to-space) are used by a number of GSO MSS operators. The frequencies are shared on the basis of a Memorandum of Understanding, agreed between a number of administrations.

The frequency bands 1 518-1 525 MHz and 1 668-1 675 MHz were allocated to the MSS at WRC-03 and are being used by some MSS operators. It is noted that in some countries there are substantial constraints that prevent operations of MSS in the two frequency bands due to use by other services.

These bands are also identified for the satellite component of IMT and some of the services offered by some MSS operators form part of the satellite component for IMT-2000, as defined by Recommendation ITU-R M.1850-1.

3 Technical characteristics and analysis

3.1 MSS downlinks (space-to-Earth)

In this scenario, potential interference from terrestrial IMT transmitters to receiving mobile earth stations (MESs) is assessed. Mobile earth stations receivers are required to be highly sensitive to allow them to receive the wanted signal transmitted by the geostationary satellite. MESs would therefore be vulnerable to interference from terrestrial IMT transmitters operating in the same band.

MESs in these frequency bands may be operated on land, on aircraft and on ships. The characteristics of the MESs do not differ significantly depending on whether terminals are used on land, in the air or at sea. Recommendation ITU-R M.1184 contains a range of characteristics of MSS systems operating in these bands. Only a single set of MSS characteristics is used here. The characteristics are within the range of characteristics contained in the Recommendation, but are *not worst case* from an interference perspective.

Using characteristics of an IMT-Advanced user equipment and an IMT-Advanced macro base station, the required separation distance to protect a typical MES receiver is shown in the table below. The e.i.r.p. in the direction of maximum radiation is 58 dBm. For base station-1, the benefit from base station antenna down tilt is not considered. For base station-2, three degree antenna downtilt is assumed, which reduces the e.i.r.p. in the horizontal direction by 2 dB.

TABLE 1

Baseline analysis of interference from IMT-Advanced station to MES

IMT station type	User equipment	Base station-1 (peak gain)	Base station-2 (-2 dBi from boresight)
IMT station e.i.r.p. (dBm)	20	58	56
Emission bandwidth (kHz)	5 000	5 000	5 000
Reference bandwidth (kHz)	200	200	200
IMT station e.i.r.p. in reference BW (dBW)	–24.0	14.0	–11
Polarisation loss (dB)	3	3	3
MES receiver temp (K)	316	316	316
MES antenna gain (dBi)	2	2	2
MES noise in reference BW (dBW)	–150.6	–150.6	–150.6
I/N criterion (dB)	–10	–10	–10
Maximum interference in ref BW (dBW)	–160.6	–160.6	–160.6
Minimum coupling loss (dB)	135.6	173.6	171.6

The required separation distance depends on the applicable propagation model, which depends on the type of MES and the terrain type. Separation distances for example propagation models are shown in the Appendix. From these results, the separation distances for normal propagation conditions are the following: for land based MESs, the separation distances range from 1 to 72 km. For maritime mobile earth stations, the separation distances range from 24 to 132 km. For aeronautical mobile earth stations, the separation distances range is 92 to 546 km.

For anomalous propagation conditions, the –10 dB *I/N* value would be exceeded for separation distances up to the following: for land based MESs (0.1% time), the separation distances range from 105 to 384 km. For maritime mobile earth stations (0.1% time), the separation distances range from 174 to 834 km. For aeronautical mobile earth stations (1% time), the separation distances range from 208 to 594 km.

Interference could also be caused in the downlink (space-to-Earth) bands by the MSS satellite emissions being received by the IMT user equipment and base station. MSS satellites use very large antennas—a satellite antenna diameter of around 10 metres is typical, and some L-band MSS operators have deployed antennas of around 20 metres in diameter. The large antenna reflector allows high gain spot beams to be used, which lead to a high power flux density (pfd) on the Earth's surface. This is necessary to provide sufficient signal power to small MSS user terminals, which include hand portable devices with small antennas, mainly using (quasi-) omni-directional antennas.

In the case that MSS downlinks are required to protect MS receivers, this could lead to constraints on the downlink pfd. The table below shows the interference from an example MSS downlink carrier to example terrestrial IMT stations. For base station-1, interference is received on the direction of peak antenna gain of the base station. For base station-2, interference is received 8 degrees off-axis, as would be the case for a base station antenna with 3 degrees downtilt, with the satellite located at 5 degrees elevation.

TABLE 2

Baseline analysis of interference from MSS downlinks to IMT-Advanced stations

IMT station type	User equipment	Base station	Base station (–11 dBi from boresight)
MSS e.i.r.p. (dBW)	43	43	43
Reference bandwidth (kHz)	200	200	200
pfd on earth surface (dBW/m^2) (slant range 36,000 km)	–119.1	–119.1	–119.1
IMT station thermal noise (for 5 MHz receiver BW) (dBm)	–98	–102	–102
IMT station thermal noise in reference BW (dBm)	–112.0	–116.0	–116
Antenna gain in direction of satellite (dBi)	–3	18	7
Feeder loss (dB)	0	3	3
I/N criterion (dB)	–10[1]	–10[2]	–10
Maximum interference in reference BW (dBW)	–152.0	–156.0	–156
Polarisation loss (dB)	3	3	3
Ae iso (dBm^2)	–25.1	–25.1	–25.1
Interference received (dBW)	–150.2	–132.2	–143.2
Interference excess (dB)	1.8	23.8	12.8

Interference exceeds the criterion by 1.8 dB for the mobile station, by 23.8 dB for the base station-1 and by 12.8 dB for base station-2. Hence, if the MSS downlink emissions needed to protect terrestrial IMT systems, it would constrain MSS operations such that some current services could

[1] Recommendation ITU-R M.1646 recommends an *I/N* criterion of –10 dB for analysis of interference from BSS downlinks into IMT-2000 systems in the frequency band 2 630-2 655 MHz. In some cases an *I/N* criterion of –6 dB might be applied, but this would not significantly alter the conclusions.

no longer be provided and development of future services would be constrained. It is important to stress here that limiting the pfd in a particular beam affects the entire beam coverage area, and hence could constrain MSS not only in any particular country which might deploy terrestrial IMT systems, but also in the neighbouring seas and countries.

3.2 MSS uplinks (Earth-to-space)

Regarding potential use of the MSS uplink frequencies (1 626.5-1 660.5 MHz and 1 668-1 675 MHz), interference could be caused by terrestrial IMT user devices or base stations to MSS satellite receivers.

This interference issue has been studied by the ITU in Recommendation ITU-R M.1799 for the frequency band 1 668.4-1 675 MHz. The Recommendation considers several different types of mobile system, including “cellular or similar high-density mobile systems” for which the characteristics are based on terrestrial IMT systems. The Recommendation includes the following conclusion: “The study confirms Report ITU-R M.2041 (for frequency bands around 2.5 GHz) that co-frequency sharing between MSS uplinks and mobile is not possible in the same geographic area. Furthermore, interference from such mobile service systems may cause harmful interference to any visible satellite operating in the same frequency band. Hence if systems with characteristics similar to those assumed in § 3.3 [cellular or similar high-density mobile systems] were to be used, the impact on MSS could be significant—potentially preventing use of the frequency band for MSS.” Although this study is related to the frequency band 1 668.4-1 675 MHz, the characteristics of MSS systems are the same for all of the frequency range 1 626.5-1 660.5 MHz and 1 668-1 675 MHz, and hence these conclusions are equally applicable to all these MSS uplink frequencies.

4 Summary

The frequency bands 1 518-1 559 MHz, 1 626.5-1 660.5 MHz and 1 668-1 675 MHz are used by the MSS.

In the MSS downlink bands, geographic separation between IMT stations and MES would be required to avoid harmful interference to MESs. The minimum separation distances depend on a number of factors, including the operational scenario for the mobile earth stations (whether land, maritime or aeronautical), and the propagation conditions between the two stations. Example minimum separation distances calculated here range from 1 kilometre to 830 kilometres. [It should be noted that some of the assumptions used here are not necessarily worst case (including the IMT station height above ground, the MES characteristics and the IMT station characteristics), and consequently minimum separation distances could be larger in some cases. The IMT systems would also receive excessive interference from MSS downlinks.]

[In the MSS uplink frequency bands, existing ITU-R studies in Recommendation ITU-R M.1799 have shown that the co-frequency operation of IMT base stations and user equipment is not feasible.]

[Given that MSS MESs are operating in these bands over very large regions (e.g., the visible Earth’s surface as seen from a geostationary satellite), it is not feasible to deploy terrestrial IMT systems in these bands.]

5 Conclusions

[The frequency bands 1 518-1 559 MHz, 1 626.5-1 660.5 MHz and 1 668-1 675 MHz should be considered as not feasible for the operation of terrestrial IMT-Advanced systems in areas with

MSS operations in those frequency bands and in the case that the terrestrial system is not coordinated with the MSS.]

Appendix: 1

APPENDIX 1 (TO ATTACHMENT 2)

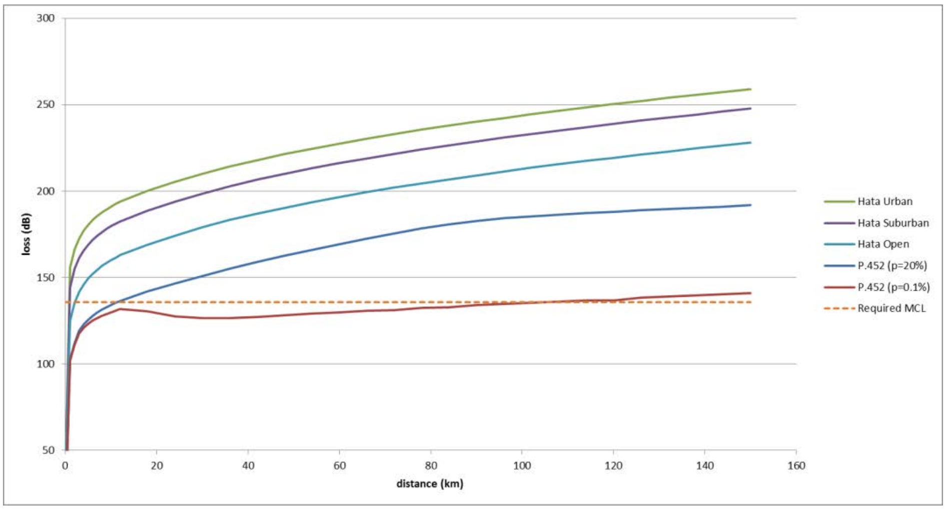
Example separation distances for interference from IMT station to mobile earth stations

A1 Land based mobile earth stations

Figure 1 shows the predicted loss versus the minimum separation distances for interference from an *IMT user equipment to an MSS MES for a land path*. The Hata propagation model and the Recommendation ITU-R P.452 propagation model were used. The Hata model is not strictly relevant in this context as it does not consider temporal variations in propagation conditions. It is intended primarily for coverage prediction rather than for interference analysis and hence has a tendency to overestimate the basic transmission loss. Its inclusion may provide a “lower bound” to the required separation distances. Both the MES and the MS were assumed to be 2 metre height above ground level. For the Recommendation ITU-R P.452 calculations, a smooth earth surface (no terrain) was assumed and the percentages of time of 20% and 0.1% are used to represent nominal and anomalous propagation conditions. Short term interference criteria for mobile earth stations are not defined in ITU-R Recommendations. Hence, as a conservative assumption, the same interference criterion (–10 dB *I/N*) has been assumed for both nominal and anomalous propagation conditions.

FIGURE 1

Minimum separation distance for interference from IMT user equipment (land path)

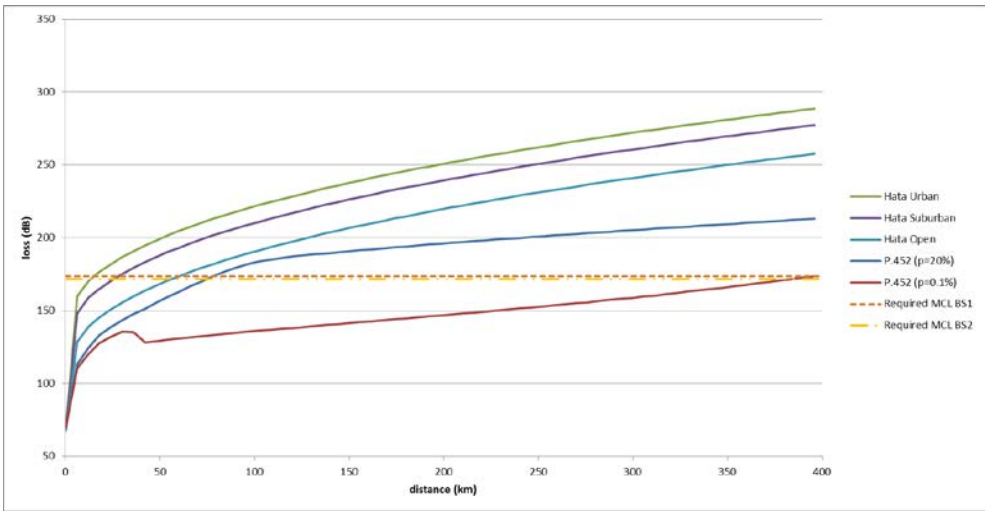


The minimum separation distance to meet the minimum coupling loss of 135.6 dB is 1 kilometre for the Hata urban and suburban models, 3 kilometres for the Hata Open model, 12 kilometres for Recommendation ITU-R P.452 (p = 20%) and 105 kilometres for Recommendation ITU-R P.452 (p = 0.1%).

Figure 2 shows the predicted loss versus the minimum separation distances for interference from an *IMT base station to an MES for a land path*. The Hata propagation model and the Recommendation ITU-R P.452 propagation model were used. The MES was assumed to be 2 metres height above ground level and the IMT base station was assumed to be 30 metres above ground level. For the Recommendation ITU-R P.452 calculations, a smooth earth surface (no terrain) was assumed and the percentages of time of 20% and 0.1% are used to representative nominal and anomalous propagation conditions.

FIGURE 2

Minimum separation distance for interference from IMT base station (land path)



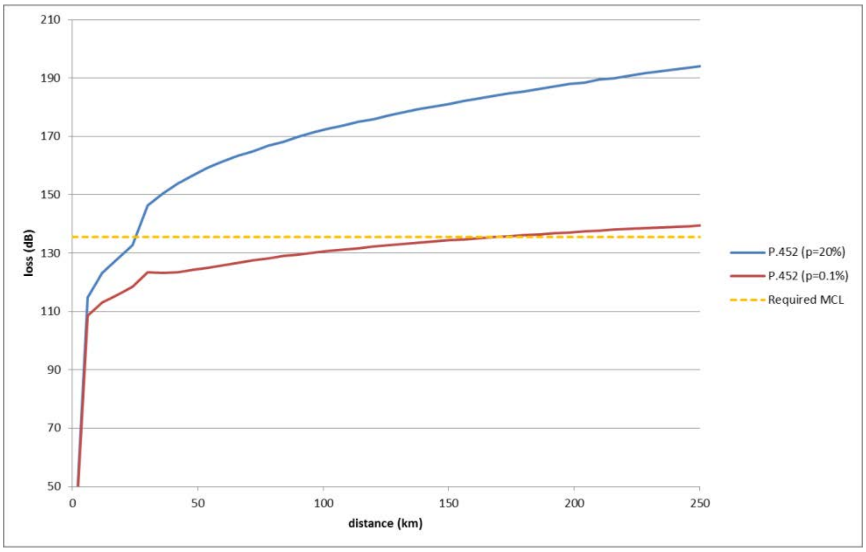
The minimum separation distance to meet the minimum coupling loss of 173.6 dB (base station-1) and 171.6 dB (base station-2) is 18 and 12 kilometres respectively for the Hata Urban model, 30 and 24 kilometres respectively for the Hata Suburban model, 60 and 54 kilometres respectively for the Hata Open model, 72 kilometres for Recommendation ITU-R P.452 (p = 20%) and 384 kilometres for Recommendation ITU-R P.452 (p = 0.1%).

A2 Sea based mobile earth stations

Figure 3 shows the predicted loss versus the minimum separation distances for interference from an *IMT user equipment to a ship earth station*, assuming a 100% sea path. The Recommendation ITU-R P.452 propagation model was used. The MES was assumed to be located 10 metres above sea level and the MS was assumed to be 2 metres height above sea level. A smooth earth surface (no terrain) was assumed and the percentages of time of 20% and 0.1% are used to represent nominal and anomalous propagation conditions.

FIGURE 3

Minimum separation distance for interference from IMT user equipment (sea path)

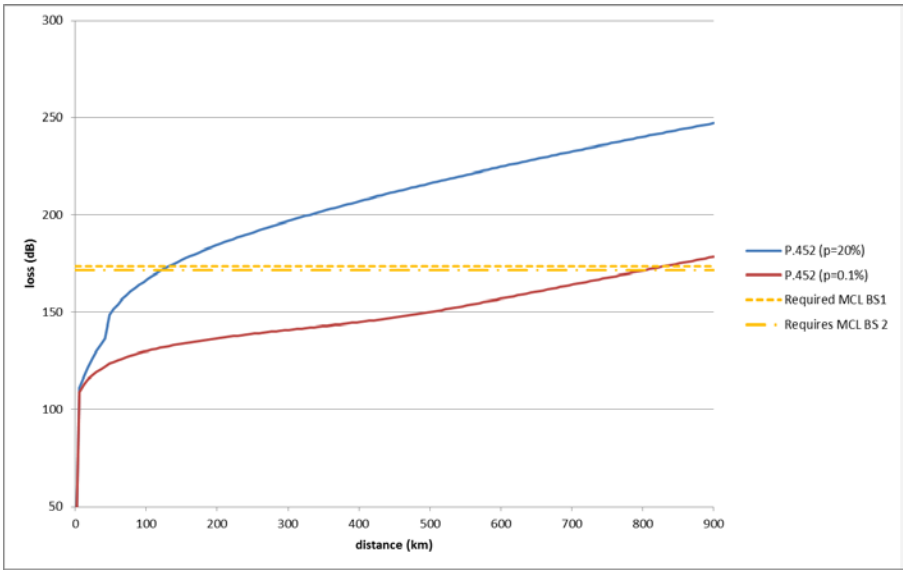


The minimum separation distance to meet the minimum coupling loss of 135.6 dB is 24 kilometres in nominal propagation conditions and 174 km in anomalous propagation conditions.

Figure 4 shows the predicted loss versus the minimum separation distances for interference from an *IMT base station to a ship earth station*, assuming a 100% sea path. The Recommendation ITU-R P.452 propagation model was used. The MES was assumed to be located 10 metres above sea level and the IMT base station was assumed to be 30 metres height above sea level. A smooth earth surface (no terrain) was assumed and the percentages of time of 20% and 0.1% are used to represent nominal and anomalous propagation conditions.

FIGURE 4

Minimum separation distance for interference from IMT base station (sea path)



The minimum separation distance to meet the minimum coupling loss of 173.6 dB (base station-1) and 171.6 dB (base station-2), is 132 and 126 kilometres respectively in nominal propagation conditions and 834 km and 804 km respectively for anomalous propagation conditions.

A3 Aircraft based mobile earth stations

Figures 5 and 6 show the predicted loss versus the minimum separation distances for interference from an *IMT user equipment and base station to an aircraft earth station*. The curves contained in Recommendation ITU-R P.528 were used, interpolated to be applicable for the frequency 1 518 MHz. Curves applicable to 50% time were used to represent nominal propagation conditions (Figure 5) and curves applicable to 1% time were used to represent anomalous propagation conditions (Figure 6). The three curves in each figure show the distance required for an IMT station at 1.5 metres, 30 metres and 1 000 metres height (the first two are representative of an IMT user equipment and base station at sea level; the latter may be representative of an IMT station on a mountain or other high terrain). The aircraft height is taken as 10 000 metres (33 000 feet). In this analysis the fuselage shielding has not been taken into account, but it’s worth noting that consideration of an additional attenuation might reduce the interference.

FIGURE 5

Minimum separation distance for interference from IMT user equipment and base station (nominal propagation conditions)

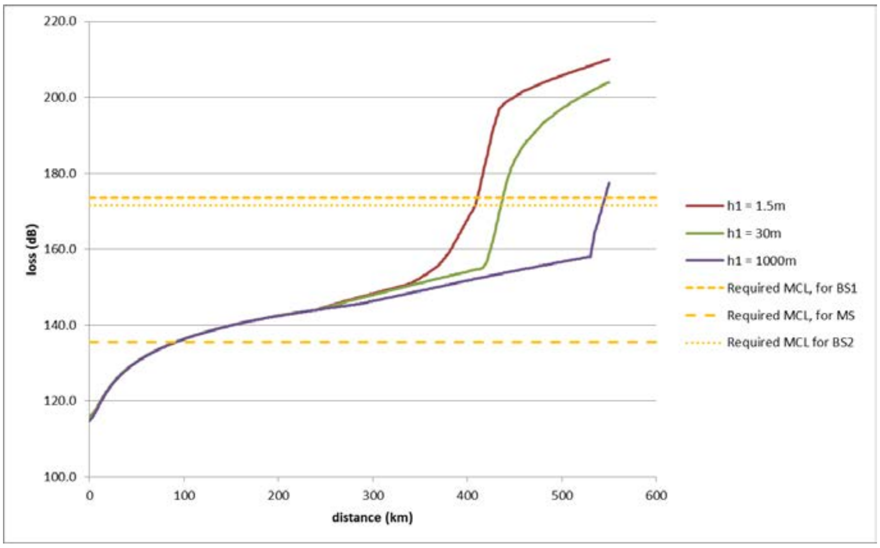
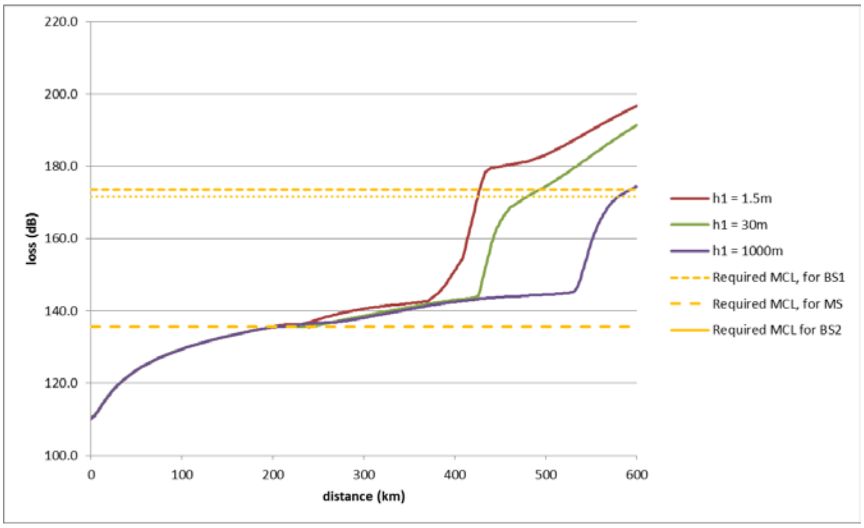


FIGURE 6

Minimum separation distance for interference from IMT user equipment and base station (anomalous propagation conditions)



For an IMT user equipment, the minimum separation distance ranges from 92 kilometres to 208 kilometres. For an IMT base station-1, the minimum separation distance ranges from 438 kilometres to 594 kilometres. For an IMT base station-2, the minimum separation distance ranges from 436 kilometres to 580 kilometres.