The Interference Analysis of the Terrestrial Components of International Mobile Telecommunications to the Satellite Mobile Communication System in S-band

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Abstract. In accordance with the Radio Regulations, the S-band (Earth-to-Space 1980-2010 MHz, Space-to-Earth 2170-2200 MHz) is currently a shared frequency band both for the mobile service and the mobile-satellite (MSS) service. Both the terrestrial and satellite components of IMT have already been deployed or are being considered for deployment in some countries with the frequency bands 1 980-2 010 MHz and 2 170-2 200 MHz. Both the terrestrial and satellite components of IMT have already been deployed or are being considered for deployment. When Therefore, the potential interference issues between the two systems need to be studied. According to the characteristics of the terrestrial components of IMT and satellite mobile communication system, this paper analyzes the impact of the terrestrial components of IMT on satellite mobile communication system, and gives measures to eliminate interference.

1. Introduction
In accordance with the Radio Regulations¹, the S-band (Earth-to-Space 1980-2010 MHz, Space-to-Earth 2170-2200 MHz) have been identified for International Mobile Telecommunications (IMT), which is currently a shared frequency band both for the mobile service and the mobile-satellite (MSS) service. At present, some countries, including China, have deployed the mobile-satellite systems within this frequency band. At the same time, the terrestrial components of IMT has developed to the fourth generation (4G), and gradually advanced to the fifth generation (5G). With the rapid development of the terrestrial components of IMT, the demand for frequency is also increasing. Some countries are planning to deploy the S-band terrestrial components of IMT. If the countries covered by satellite beams deploy the terrestrial components of IMT, it will have an impact on the MSS. Therefore, the potential interference issues need to be studied.

This paper first introduces the interference scenario, and then gives the typical parameters of the MSS and the terrestrial components of IMT. Based on the typical parameters, the interference from the terrestrial components of IMT to the MSS uplink and downlink are analyzed. Finally, measures and suggestions to reduce interference are concluded.

2. Interference Scenarios
The terrestrial components of IMT interferes with MSS satellite systems mainly in A1 and A2 scenarios (shown in Figure 1). This paper focuses on the A1 and A2 scenarios.

Scenario A1: the uplink interference issue from UEs and BSs to the satellite in 1 980-2 010 MHz
Scenario A2: the downlink interference issue from BSs to satellite MES in 2170-2200 MHz

Figure 1. Interference scenarios between the MSS and terrestrial components of IMT

| IMT: International Mobile Telecommunications |
| UE: User Equipment of the terrestrial components of IMT |
| BS: Base Station of the terrestrial components of IMT |
| MES: Mobile Earth Station of the MSS |
| GSO: Geo-Stationary Orbit |

3. MSS and Terrestrial Components of IMT Typical Parameters

Table 1 and Table 2 below list the receive parameters respectively of the GSO MSS[2] satellite and MES.

**Table 1.** GSO MSS satellite receive parameters

| Type                           | Value   |
|--------------------------------|---------|
| Rx antenna gain (dBi)          | 41.6    |
| Satellite G/T (dB/K)           | 20      |
| Polarization                   | Circular|
| Receiver noise temp (K)        | 575     |
| Minimum elevation angle from the MES | 5°      |
| Bandwidth (kHz)                | 21.6 to 1 296 |
| Receiver thermal noise (dB(W/Hz)) | −201    |
| Interference criteria for purposes of this study | ΔT/T = 6% in-band |

**Table 2.** MSS System MES characteristics

| MES type       | Maximum antenna gain | Maximum density | e.i.r.p. | Receiving noise temp. | system |
|----------------|----------------------|-----------------|---------|-----------------------|--------|
| 3G Handset     | 0 dBi                | −7 dBW/21.6 kHz | 290K    |                       |        |
| Portable       | 2 dBi                | 5 dBW/21.6 kHz  | 200 K   |                       |        |
| Vehicular      | 10 dBi               | 20 dBW/216 kHz  | 250 K   |                       |        |

**Table 3.** The terrestrial components of IMT parameters

| UE             | BS                     |
|----------------|------------------------|
| Interference e.i.r.p. psd (dBmW/Hz) | -36.6 | -15.3 (main-lobe) |
|                 | -35.3 (side-lobe)      |
4. Analysis

4.1. The uplink interference analysis from UEs and BSs to the satellite (Scenario A1)

Currently, a recommended value for the protection criterion related to interference from IMT terrestrial to MSS does not exist.

According to Appendix 8 of the Radio Regulations, the geostationary orbit satellite long-term interference protection criterion for the satellite service is in (1).

\[
I/N = -12.2 \text{ dB}
\]

The maximum EIRP density of the IMT terrestrial emission is calculated in (2).

\[
\text{EIRP density}_{\text{max}} = -12.2 + \text{Ls} - \text{Gr} + \text{KT}
\]

The interference analysis is showed in Table 4. As can be seen from the table, when the aggregate transmit power spectral density of the UEs and BSs does not exceed -64.5 dBW/Hz, it will not interfere with the reception of the satellite repeater.

It can be showed from the terrestrial component of IMT parameters (Table 3) that when the elevation angle of the BS is high, that is, when the main lobe of the BS directly faces the satellite, it will interfere with the reception of the satellite repeater. When the side lobe is facing the satellite, it may not interfere with the reception of the satellite repeater. However, if the satellite receives multiple BS and UE signals in the same receiving beam, even if the main lobe of BS is not directly faced with the satellite, it will also interfere with the satellite repeater. The spatial distribution of the BSs and UEs belonging to the terrestrial IMT deployment(s) in view of the satellite will impact the e.i.r.p. of the Earth to space interference emissions predominately as a function of elevation angle to the satellite.

### Table 4. Interference analysis of the Scenario A1

| Type                        | Value   |
|-----------------------------|---------|
| Frequency(GHz)              | 1.995   |
| I/N (dB)                    | -12.2   |
| Distance(km)                | 36000   |
| Free Space Loss(dB)         | 189.6   |
| Sat Rx Gain(dBi)            | 41.6    |
| Sat Noise Temp(K)           | 575     |
| IMT Terminal aggregate EIRP density(dBW/Hz) max | -65.2   |

Furthermore, the position of the BSs and UEs with respect to the satellite beam coverage area will impact the received interference power at the satellite as a function of satellite beam directivity. However, it has been observed in the aggregate interference analysis results that terrestrial IMT interference from the BS terminals to satellite transponders is very serious. Therefore, it is recommended that the BS transmitting frequency band uses 2170-2200MHz to reduce interference to the satellite uplink.

The aggregate interference from UEs into GSO satellite does not show exceedance of the I/N protection criterion of -12.2dB. The margin is in the range of 1.4 dB to 26.1 dB depending on the location, the elevation angle of the satellite relative to the locations of the UEs, as well as the geographical area in which the aggregate interference was calculated.

Based on the above mentioned it is could be concluded that the aggregate interference from UE IMT stations towards GSO satellite system is not expected. At the same time the aggregate interference from BS IMT stations towards GSO satellite system is expected.

As can be seen from the above summary results, the risk of interference from IMT base station deployment is very high, while there is less risk of interference from IMT UEs.

4.2. The downlink interference analysis from BSs to satellite MES in 2170-2200 MHz (Scenario A2)

The signal transmitted by the BSs in the 2170-2200MHz frequency band will interfere with the reception of the MES. So the minimum separation distances should be calculated.
The interference analysis methodology is based on the propagation model from Recommendation ITU-R P.452\textsuperscript{[3]} and taking into account actual antenna gains in the direction of interference. Several parameters are shown in the following Table V. Path loss versus distance plots are obtained to calculate separation distances between IMT systems and MES at frequency 2185 MHz, assuming a 100% land path. For a given value of required link loss, the corresponding separation distance may be determined from the graphs. These graphs are used to determine the separation distances for scenario A2.

From this propagation loss the resulting separation distances were obtained for several IMT BSs with various e.i.r.p. levels to predict the interference into MESs over and paths. A static analysis was done for propagation losses not exceeded for time percentages of 10% and 50% over 100 % land path without clutter effect.

Given a lack of protection criterion for compatibility studies between the terrestrial and satellite components of IMT, considers the most appropriate criteria to be used for studies is 6% (\(-12.2 \text{ dB I/N}\)). The results of the studies undertaken are summarized below:

The minimum separation distance between a single BS and MES of the systems studied over a 100% land path using I/N protection criterion of \(-12.2 \text{ dB}\) varied in different studies:

- For \(p=10\%\), studies had results that varied from 48 to 123 km;
- For \(p=50\%\), studies had results that varied from 35 to 51 km.

The potential interference may be mitigated by one or more of: assessment of terrain and clutter effects and system characteristics, deployment environments, and separation distance.

### Table 5. Parameters values for land path model

| Land path model parameters | Input values | Remark       |
|----------------------------|--------------|--------------|
| \(f\) (GHz)                | 2.185        |              |
| \(p\) (%)                  | 10/50        |              |
| \(htg\) (m)                | 1.5          | MES         |
| \(hrg\) (m)                | 1.5/30       | UE/BS       |
| \(G_t\) (dBi)              | 2            | MES portable|
| \(G_r\) (dBi)              | 18           | BS rural    |
| \(\Delta N\) (N-units/km)  | 41.13        |              |
| \(N_0\) (N-units)          | 320.5        |              |
| \(dct\) (km)               | 500          |              |
| \(dcr\) (km)               | 500          |              |
| Path profile height        | 0            |              |
| Path profile zone          | A2           | Inland      |

![Figure2. Propagation loss of a land path from a IMT System to a MES](image-url)

\[\text{Figure2. Propagation loss of a land path from a IMT System to a MES}\]
5. Interference Avoidance Measures

In the frequency band 1 980-2 010 MHz, it was observed that the level of potential interference from IMT BS into MSS is high, while the level of potential interference from IMT UE into MSS is low. The spatial distribution of the BSs and UEs belonging to the terrestrial IMT deployment(s) in view of the satellite will impact the e.i.r.p. of the Earth to space interference emissions predominately as a function of elevation angle to the satellite. It is recommended that the BSs use the 1980-2010 MHz frequency band to work in the receiving mode.

In the frequency band 2170-2200 MHz, co-frequency deployment of independent MSS and terrestrial components of IMT in the same geographical area is not feasible. It is recommended that takes some techniques, such as the use of an appropriate guardband or the unified design of the two systems to ensure coexistence and compatibility between the terrestrial and satellite components of IMT. The implementation of mitigation measures may be considered on a case by case basis by administrations.

6. Conclusions

For areas where the terrestrial components of IMT cannot be deployed or the deployment cost is too high, the satellite mobile communication system can meet the needs of user mobile communication and global coverage with no blind zone. In addition, MSS are an irreplaceable under emergency communications such as during the natural disasters or wartimes. China and some other countries has high, the satellite mobile communication system can meet the needs of user mobile communication.

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7. References

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