Sharing Study of IMT-2020(5G) and SRS in 25.5-27GHz

Jiajia Chen¹,*, Zhaojun Qian¹, Tan Wang¹ and Xi Li²
¹State Radio Monitoring Center, Beijing, China
²Beijing Credit Top Company Limited, Beijing, China
chenjiajia@srrc.org.cn

Abstract. Based on the WRC-19 1.13 issue research framework and the compatibility analysis requirements for the fifth generation of mobile communication candidate bands above 6GHz in China, this paper studied the coexistence between IMT-2020(5G) and Space Research(space to ground) system(SRS) in the same running bands 25.5-27GHz. The interference of IMT-2020(5G) system to the downlink of the SRS is analysed by the aggregated interference assessment method. The research shows that, IMT-2020(5G) would not interfere SRS harmfully by the certain isolation distance. The results can provide a technical basis for the actual deployment of IMT-2020(5G) and protection of SRS system in the frequency bands 25.5-27GHz in the future.

1. Introduction
At present, with the rapid development of the international mobile system, the spectrum demand of IMT-2020(5G) will become more. In order to effectively improve the data transmission rate and system capacity, meet the need of 5G communication, the IMT system needs to excavate the frequency spectrum resources of high frequency bands above 6GHz. 25.5-27GHz band is relatively low and continuous large bandwidth, regarded as IMT system’s candidate frequency by some countries and regions in the world. This frequency band is also one of the most important candidate frequency bands of IMT system in China. However, the band has been widely used in earth exploration satellite system (space to ground), Inter-satellite system, Space research system (space to ground). It is an important band for developing and planning large capacity broadband satellite. China also has more than one satellite systems running and planning to be established in this band. So the planning and deployment of IMT system in this band would have an impact on satellite communication. The compatibility analysis between them is urgently needed.

Accounting the domestic research need of the fifth generation mobile communication candidate bands allocation, the framework of WRC-19 1.13 issues and ITU-R M.2101, investigating the typical parameters of satellites operating and planning in 25.5-27GHz in China, the research between IMT system and Non-GSO SRS system was carried out. Based on the typical deployment model and typical parameters of IMT, this paper analysed the impact from IMT system to SRS Non-GSO system and preliminarily concluded that the two systems can coexist and share the same bands by certain isolation distance.

2. The allocation situation in 25.5-27GHz
The 25.5-27GHz band allocation given by the 2016 edition of ITU <Radio Regulation>[1]is shown in Table 1. In the 2014 edition of radio frequency allocation in China, the frequency allocation is the
same as that of ITU RR in 25.5-27GHz. The SRS is allocated in the frequency band 25.25-27.5 GHz as primary service.

**Table 1.** Frequency allocation in the 25.25-27.5 GHz frequency range

| International Table |
|---------------------|
| Region 1 | Region 2 | Region 3 |
| 25.5-27 |
| EARTH EXPLORATION-SATELLITE (space-to-Earth) |
| FIXED |
| INTER-SATELLITE |
| MOBILE |
| SPACE RESEARCH (space-to-Earth) |
| Standard frequency and time signal-satellite (Earth-to-space) |

Part of the band 25.5-27 GHz is allocated to SRS (space-to-Earth). IMT system would interfere SRS Non-GSO earth station if the IMT system is deployed around the SRS earth station when the two systems use the same 25.5-27GHz frequency band. The interference model is shown in figure 1. The protection distance is needed and this paper analysed how long the protection distance is needed and whether the two systems can share the frequency band of 25.5-27GHz.

![Figure 1](image)

**Figure 1.** Scenario for SRS earth station interference from IMT-2020

3. **Technical characteristics**

3.1. **Technical and operational characteristics of IMT systems operating in the 25.5-27.0 GHz frequency range**

The technical and operational characteristics of IMT-2020 are given in the following subsections.

3.1.1. **IMT-2020 base station.** All the parameters and values are calculated from Recommendation ITU-R M.2101-0[2] with input parameters from the liaison statement from WP 5D to TG 5/1. The composite antenna gain pattern for the base station generated from both the documents is shown in figure 2.
Table 2. IMT-2020 base station/UE parameters

| Parameters                                           | Base Station | User Equipment |
|------------------------------------------------------|--------------|----------------|
| Antenna height (m)                                   | 6            | 1.5            |
| Antenna array configuration (Row x Column)           | 8x8          | 4x4            |
| Sectorization                                        | Single sector|                |
| Downtilt and pointing                                | -10º to UE   | To BS          |
| Antenna pattern                                      | ITU-R M.2101 |                |
| Element gain (dBi)                                   | 5            |                |
| Horizontal/vertical 3 dB bandwidth of single element | 65º for both H/V |                |
| Horizontal/vertical front-to-back ratio (dB)         | 30º for both H/V |                |
| Antenna polarization                                 | Linear ±45º  |                |
| Horizontal/Vertical radiating element spacing        | 0.5 of wavelength for both H/V |        |
| Array Ohmic loss (dB)                                | 3            |                |
| Conducted power per antenna element (dBm/200 MHz)    | 10           |                |
| BS maximum coverage angle in the horizontal plane    | 120º         |                |
| Deployment area                                      | 50 km²       |                |
| Network loading factor                               | 50%          |                |
| TDD activity factor                                  | 80%          | 20%            |
| Density                                              | 30 BS/km² (urban), 10 BS/km² (suburb) |        |
| Transportation Model                                 | ITU-R P.452, ITU-R P.2108-0 |        |
| Hotspot coverage ratio (Ra), Built-up area ratio (Rb)| Ra=7%(urban), 3%(suburb), Rb=100% |        |

3.1.2. IMT-2020 user equipment. All the parameters and values are calculated from Recommendation ITU-R M.2101-0. The composite antenna gain pattern for the user equipment is shown in Figure 3.

Figure 3. The 3D polar plot on the composite antenna gain pattern for user equipment according to Recommendation ITU-R M.2101-0
3.2. Technical and operational characteristics of SRS

The characteristics for the SRS systems for non-GSO satellites in the band 25.5-27 GHz can be found in Table 3.

| Simulation Parameters                  | Value          |
|----------------------------------------|----------------|
| Carrier frequency (MHz)                | 26 250         |
| Necessary bandwidth (MHz)              | 300            |
| Earth station antenna radius (m)       | 35             |
| Earth station antenna gain toward satellite (dBi) | 78             |
| Earth station antenna radiation diagram | ITU-R S.465-6[3] |
| Earth station receiver noise temperature (K) | 70             |
| Minimum elevation angle (degree)       | 5/10           |
| Earth station antenna polarisation     | RHCP/LHCP      |

The composite antenna gain pattern for the SRS earth station is shown in Figure 4.

Figure 4. The 3D polar plot on the antenna gain pattern for SRS earth station according to Recommendation ITU-R M.465-6

Recommendation ITU-R SA. 609[4] contains the protection criteria for radio communication links for manned and unmanned near-Earth research satellites. In the frequency range 20-30 GHz, harmful interference can occur if the total time during which the power density of noise-like interference or the total power of CW-type interference in any single band or in all sets of bands 1 MHz wide, is greater than -156 dB(W/MHz) at the input terminals of the receivers for a period exceeding 0.001% of the time for manned missions, and 0.1% of the time for all other near-Earth space research missions.

3.3. Propagation models for sharing and compatibility studies in the 25.5-27.0 GHz frequency range

For the study of single-entry interference, the propagation model used is Recommendation ITU-R P.452-16[5] with a 50 metre resolution terrain. No clutter is considered.

For the study of aggregate interference, the propagation model in Recommendation ITU-R P.452-16 with a 50 metre resolution terrain is used for the interference path. The interference path also includes clutter loss calculated in accordance with the statistical model for terrestrial paths method described in Recommendation ITU-R P.2108[6].

4. Technical analysis

This study analyses the interference from IMT stations (base stations and user equipment) to Non-GSO SRS systems.

4.1. Interference topology from IMT base station / UE to SRS

According to the parameters provided by WP 5D, the IMT BSs can be deployed in four scenarios: outdoor suburban open space hotspot, outdoor suburban hotspot, outdoor urban hotspot and indoor.

Compared with the other three scenarios, when IMT BSs are deployed indoor, the building entry loss will introduce significant attenuation to the IMT signal. So the aggregate interference power will be smaller than that in the other three scenarios.
As for the outdoor suburban open space hotspot scenario, the density of BSs is 0 or 1 BS/km². However, the densities of BSs in outdoor suburban hotspot and outdoor urban hotspot scenario are respectively 10 and 30 BS/km². When the BSs are deployed in different scenarios they follow the same distribution, fewer BSs are most likely to lead to smaller aggregate interference power.

Comparing the outdoor suburban hotspot and the outdoor urban hotspot scenarios, the latter has a larger BS density and Ra, so the aggregate interference will be larger.

As was stated above, the interference from BSs deployed in the outdoor urban hotspot scenario to the EESS systems is most likely to be the worst.

Recommendation ITU-R M.2101 provides the methodology how to model the IMT network and use Monte-Carlo simulation to evaluate the aggregated interference to other systems.

In the case of the aggregated interference, there are some options to deployment of IMT base stations and UEs.

The topology of equally-spaced IMT macro base stations located around the SRS earth station is assumed. And the IMT micro base stations which may interfere with the SRS earth station are located in the macro base station area. Taking the outdoor urban IMT scenario as an example, the number of IMT macro base stations is assessed according to the separation distance and the base station inter-site distance as following:

The radius of the ith ring is:

\[
D(i) = D_{\text{protection}} + (i - 1) \times D_{\text{intersite}}
\]  

(1)

The number \( N(i) \) of IMT macro base stations located on the ith ring is assessed according to the corresponding distance \( D(i) \) and the base station intersite distance range as following:

\[
N(i) = \frac{\pi}{\sin^{-1}(D_{\text{intersite}}/(2 \times D(i)))}
\]  

(2)

It should be noted that IMT-2020 networks will only be deployed in a hotspot area and not as seamless coverage. Some areas will not deploy IMT systems and the real deployed IMT base station numbers will be less than \( N(i) \), see Figure 5.

**Figure 5. Aggregated IMT base stations scenario**

### 4.2. Calculation of aggregate interference

A Monte-Carlo simulation was developed in order to assess the aggregate interference from multiple base stations and UEs deployed at a given distance from the EESS earth station. In a single snapshot of the Monte-Carlo simulation, the aggregate interference from IMT base stations or user equipment can be calculated as follow.

\[
I_{BS/UE} = 10 \log \left( \sum_{n=1}^{N_{BS/UE}} 10^{\left( PD_{tx} - OL_{tx} + G_{tx} - L_{n} + G_{n} - \theta_{n} \right)} \right)
\]  

(3)

where:
- \( I_{BS/UE} \): Aggregate interference from all IMT base stations or UEs;
- \( N_{BS/UE} \): Total number of base stations or UEs;
- \( n \): index of the base station or UE;
- \( PD_{tx} \): Transmit station signal power density;
- \( OL_{tx} \): Transmit station array ohmic loss;
Gtx(θtx): Transmit station antenna gain in direction of receive station;  
Ln: propagation loss between the base station and UE of index n and the SRS station (based on Recommendation ITU-R P.452 and ITU-R P.2101);  
Grx(θrx): Receive station antenna gain in direction of transmit station taking into account the off-axis angle.

The aggregate interference from IMT base stations and UEs can be calculated as follows:

\[ I_{\text{aggr}} = 10 \log_{10}(TDDFactor_{\text{BS}} \times 10^{\frac{\text{Dprotection}}{10}} + TDDFactor_{\text{UE}} \times 10^{\frac{\text{Grx}}{10}}) \]  

where:

\( I_{\text{aggr}} \): Aggregate interference power from IMT base stations and UEs;
\( TDDFactor_{\text{BS}} \): TDD activity factor of base station;
\( TDDFactor_{\text{UE}} \): TDD activity factor of user equipment;

The time percentage value used in Recommendation ITU-R P.452 is set as a fixed value, which is equal to the time percentage in interference criteria. In the simulation, an aggregate interference value is calculated in each snapshot and the linear average value is generated from all snapshot. The additional margin could be calculated by subtraction linear average of aggregate interference value from interference criteria.

5. Simulation results of interference from IMT system to SRS

As was analysed in section 3 and 4, take a typical big city in China as reference, set the simulation area to about 50 km² and it was assumed that the IMT base stations are deployed in the suburban outdoor hotspot scenario. The SRS earth station is located in the centre of the simulation area and ensures that the distance between the SRS earth station and the nearest IMT micro BS is 2000 m. The IMT network loading factor is 20%. According the simulation assumptions above, the simulation results are as follow.

5.1. Interference caused by IMT BSs

The simulation results of the interference from IMT BSs to SRS earth station are shown in Table 4.

| earth station elevation (degrees) | Dprotection (m) | Aggregate interference (dB(W/MHz)) | Interfering signal power at the input terminals of the receivers to be exceeded for a period not exceeding p% of the time (dB(W/MHz)) | Interference margin (dB) |
|----------------------------------|----------------|-----------------------------------|-------------------------------------------------------------------------------------------------|--------------------------|
| 5                                | 2000           | -166.7                            | -156 \( p=0.1 \)                                                                               | 11.7                     |
| 10                               | 2000           | -170.1                            | ------------------------------------------------------------------------------------------------| 14.1                     |
| 5                                | 2000           | -161.0                            | -156 \( p=0.001 \)                                                                               | 15.0                     |
| 10                               | 2000           | -164.2                            | ------------------------------------------------------------------------------------------------| 18.2                     |

If the separation distance is set to 2000 m, the simulation results meet the protection criterion of an SRS earth station in the 25.5-27 GHz frequency range.

5.2. Interference caused by IMT UEs

The simulation results of the interference from IMT UEs to SRS earth station are shown in Table 5.

| earth station elevation (degrees) | Dprotection (m) | Aggregate interference (dB(W/MHz)) | Interfering signal power at the input terminals of the receivers to be exceeded for a period not exceeding p% of the time (dB(W/MHz)) | Interference margin (dB) |
|----------------------------------|----------------|-----------------------------------|-------------------------------------------------------------------------------------------------|--------------------------|

Table 4. Interference caused by IMT BSs to SRS earth station

Table 5. Interference caused by IMT UEs to SRS earth station
If the separation distance is set to 2,000 m, the simulation results meet the protection criterion of an SRS earth station in the 25.5-27 GHz frequency range.

5.3. Interference caused by IMT stations (BSs and UEs)
The simulation results of the interference from IMT stations to SRS earth station are shown in Table 6.

| Earth station elevation (degrees) | D_\text{protection} (m) | Aggregate interference (dB(W/MHz)) | Interfering signal power at the input terminals of the receivers to be exceeded for a period not exceeding p\% of the time (dB(W/MHz)) | Interference margin (dB) |
|----------------------------------|-------------------------|-----------------------------------|-----------------------------------------------------------------|-------------------------|
| 5                                | 2,000                   | -167.1                            | -156 p=0.1                                                      | 11.1                    |
| 10                               | 2,000                   | -169.7                            |                                                                  | 13.7                    |
| 5                                | 2,000                   | -165.1                            | -156 p=0.001                                                   | 9.1                     |
| 10                               | 2,000                   | -167.5                            |                                                                  | 11.5                    |

If the separation distance is set to 2,000 m, the simulation results meet the protection criterion of an SRS earth station in the 25.5-27 GHz frequency range.

6. Conclusion
According to the interference protection criteria and the characteristic parameters of reference, the IMT system and SRS earth station can coexist when the protection distance is 2,000 m when using the same frequency band 25.5-27 GHz, and the interference margin was above 10 dB.

The next work should be to clarify the interference protection distance between the IMT system and the SRS system earth station under the actual geographical and terrain conditions, and to delimit the isolation area.

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Reference
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