APPENDIX 5: Geostationary Satellite Orbit Avoidance

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1. Introduction
As detailed in the Spectrum Plan1, most of the frequency bands used by the fixed service (FS) are shared with other radiocommunication services, including geostationary orbit (GSO) space radiocommunication services. Annex A to this appendix provides a summary of fixed service bands which currently share with GSO space services. In order to facilitate spectrum sharing between the terrestrial fixed service and (existing and future) GSO based space radiocommunication services, it is necessary to limit the EIRP of fixed service systems in the direction of the GSO to avoid long term interference to sensitive space station receivers. Conversely, in some situations where the azimuth of a receiving station in the fixed service constitutes a look angle to a co-frequency transmitting station in the GSO, the fixed service may be subject to significant long-term interference, depending upon the sensitivity of the FS receiver and the satellite system power flux density at the receiver location.

2. GSO avoidance necessary to protect space station receivers.
In accordance with International Radio Regulation S21.3, the maximum EIRP of a station in the fixed service shall not exceed 55 dBW. This limit is reduced, in accordance with the criteria outlined in the following tables, for cases where the fixed service antenna main beam illuminates the GSO. Accordingly, for those fixed services employing maximum EIRP in excess of the relevant values, radiocommunication sites should be selected such that the direction of maximum radiation of the antenna is separated from the GSO by at least the specified minimum angular separation.

1 “Australian Radiofrequency Spectrum Plan, January 1997”.

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2.1 Orbit Avoidance Criteria for specific frequency bands

<table>
<thead>
<tr>
<th>Band (GHz)</th>
<th>EIRP limit (dBW)</th>
<th>Minimum Separation Angle (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.025-2.110</td>
<td>+8 (Note 1)</td>
<td>2°</td>
</tr>
<tr>
<td>2.200-2.290</td>
<td>+8 (Note 1)</td>
<td>2°</td>
</tr>
<tr>
<td>25.25-27.50</td>
<td>+24 (Note 1)</td>
<td>1.5°</td>
</tr>
</tbody>
</table>

Table 1. Orbit avoidance for specific frequency bands.

Note 1: The orbit avoidance criteria specified in Table 1 for the bands 2025-2110 MHz, 2200-2290 MHz and 25.25-27.5 GHz, are based on ITU-R Recommendations F.1247 and F.1249 and are intended to protect Data Relay Satellites (DRS) operating in specific GSO locations from the emissions of terrestrial fixed services which may illuminate these orbital positions. As far as practicable, the fixed service station EIRP in the direction of the given orbital positions should not exceed the values in Table 1. Orbital positions visible from Australian mainland longitudes and identified (in Recommendation ITU-R SA.1276) as requiring protection are located in the GSO at:


Separation angles between these specified GSO locations and terrestrial fixed services may be calculated using the algorithm given in Annex 2 of ITU-R Recommendation F.1249.

The limits shown in Table 1 for the bands 2025-2110 MHz and 2200-2290 MHz apply to point-to-point systems. For point-to-multipoint systems or point-to-point systems employing Automatic Transmit Power Control (ATPC) other limits may apply (refer to Recommendation F.1247).

2 ITU-R Recommendation F.1247 “Technical and operational characteristics of systems in the Fixed Service to facilitate sharing with the Space Research, Space Operation and Earth-Exploration Satellite Services operating in the bands 2025-2110MHz and 2200-2290 MHz”.

3 ITU-R Recommendation F.1249 “Maximum Equivalent Isotropically Radiated Power of transmitting stations in the Fixed Service operating in the frequency band 25.25-27.5 GHz shared with the Inter-Satellite Service”.

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2.2 Default Orbit Avoidance Criteria

For the cases not covered in Table 1 (see section 2.1), the default orbit avoidance criteria specified in Table 2 shall apply.

<table>
<thead>
<tr>
<th>Band (GHz)</th>
<th>EIRP limit (dBW)</th>
<th>Minimum Separation Angle (Note 2) (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>+35</td>
<td>2°</td>
</tr>
<tr>
<td>10-15</td>
<td>+45</td>
<td>1.5°</td>
</tr>
<tr>
<td>&gt;15</td>
<td>+55</td>
<td>Not defined</td>
</tr>
</tbody>
</table>

Table 2. General (default) orbit avoidance criteria.

Note 2: Separation angles need to be calculated for all services whose EIRP exceeds the relevant (Table 2) limits. Separation angles with the GSO may be calculated using the algorithm provided in Annex 25 of ITU-R Recommendation SF.765 “Intersection of Radio-Relay Antenna beams with orbits used by Space Stations in the Fixed-Satellite Service”.

3. GSO avoidance necessary to protect the fixed service

Many fixed service band allocations are shared with GSO space radiocommunication services operating in the space-to-Earth direction. Normally the relevant power flux density limits (applicable to the space based service and specified at the surface of the Earth) serve to fully protect the operation of fixed and other terrestrial services. However, in situations where main beam or significant sidelobe coupling occurs between a receiving station of the fixed service and a co-frequency transmitting station within the GSO, severe long term interference may be experienced. The severity of such interference is dependent upon the degree of antenna coupling, pfd levels at the FS receiver location and FS receiver sensitivity.

In the absence of detailed orbit avoidance criteria for the protection of fixed service receivers from the emissions of GSO based space-to-Earth emissions, the following methodology may be used to evaluate potential interference levels on a case-by-case basis:

1. Determine co-frequency pfd levels at the terrestrial fixed service location, as typically provided in ITU-R satellite notices (pfd footprint) or use regulatory limits;
2. Calculate interference noise power ($I_r$) at the FS receiver input:

$$I_r = pfd + G + 10 \log \left( \frac{\lambda^2}{4\pi} \right) + 10 \log B - L_r \quad \text{(dBW)}$$

where:

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4 Based upon the requirements specified under Article S21 (WRC-95) of the ITU Radio Regulations.
5 Includes computer program source code facilitating the calculation of separation angles.
pfd - power flux density (dB(W/m²/MHz)) at the FS receiver location;
G - FS receiver antenna gain (dBi) in direction of GSO satellite (Note 2);
\( \lambda \) - wavelength at operating frequency (m);
B - FS receiver bandwidth (MHz); and
Lr - FS receive feeder loss (dB).

The above calculation is based on a 1 MHz reference bandwidth. Where a different reference bandwidth is adopted an appropriate correction will need to be incorporated in the calculation (eg. 4 kHz is traditionally specified for analogue systems); and

3. Compare the calculated interference noise power against the FS system wanted receive signal power and the relevant interference management criteria (ie. ITU-R recommendations, in particular, F.758 and F.1094).

As a general comment, fixed service operators should seek to avoid main beam coupling with the GSO for their own protection at the route/network planning stage. Even where a band may not currently be co-allocated with space radiocommunication services, the world-wide trend is for increased frequency sharing and avoidance of the GSO (where possible) should be taken into account at the planning stage as part of prudent risk management.