RECOMMENDATION ITU-R SF.1601

A methodology for interference evaluation from the downlink of the fixed service using high altitude platform stations to the uplink of the fixed-satellite service using the geostationary satellites within the band 27.5-28.35 GHz

(Questions ITU-R 218/9 and ITU-R 251/4)

(2002)

The ITU Radiocommunication Assembly,

considering

a) that new technology utilizing high altitude platform station (HAPS) in the stratosphere is being developed;

b) that WRC-97 made provisions for operation of HAPS within the fixed service (FS) in the bands 47.2-47.5 GHz and 47.9-48.2 GHz;

c) that since the 47 GHz bands are more susceptible to rain attenuation in those countries listed in Nos. 5.537A and 5.543A of the Radio Regulations (RR), the frequency range 18-32 GHz has been studied for possible identification of additional spectrum in ITU-R;

d) that since the 47 GHz bands are more susceptible to rain attenuation in certain countries, WRC-2000 made a provision for the use of HAPS in the FS in the bands 27.5-28.35 GHz and 31.0-31.3 GHz in certain countries under the condition that it does not cause harmful interference to, nor claim protection from, other types of FS systems or other co-primary services (RR Nos. 5.537A and 5.543A);

e) that Resolution 122 (Rev.WRC-2000) urgently requested studies on technical, sharing and regulatory issues in order to determine criteria for the operation of HAPS in the bands 27.5-28.35 GHz and 31.0-31.3 GHz;

f) that the band 27.5-28.35 GHz is allocated to the fixed-satellite service (FSS) (Earth-to-space direction) on a primary basis,

recommends

1 that the methodology contained in Annex 1 may be used to assess the level of interference from the HAPS-to-ground (downlink) transmission in the FS to the Earth-to-space (uplink) of the FSS using geostationary (GSO) satellites within the frequency band 27.5-28.35 GHz.

Annex 1

A methodology for interference evaluation from the downlink of the FS using HAPS to the uplink of the FSS using GSO satellites within the band 27.5-28.35 GHz

1 Introduction

This Annex provides a methodology for interference evaluation from the FS using HAPS to a GSO satellite system in the FSS within the band 27.5-28.35 GHz. This band is used for the Earth-to-space (uplink) direction by the GSO/FSS system.

2 A methodology for interference evaluation

2.1 Interference from a HAPS system

Figure 1 shows the analysis model assumed for the evaluation of interference from a HAPS system to a GSO satellite. The interference power level in 1 MHz, $I(g,h,b,r)$ due to a spot beam of a HAPS, received by a GSO satellite (g) is calculated using equation (1):

$$I(g,h,b,r) = P^H(b) - F_{loss} + G^H{}_{tx}(\varphi(g,h,b)) - FSL(g,h) + G^S{}_{rx}(\varphi(h,g,r)) \qquad \text{dB(W/MHz)} \quad (1)$$

where:

- $P^H(b)$: transmitter power in 1 MHz (dB(W/MHz)) at the input of HAPS antenna for the beam (b)
- F_{Loss}: feeder loss (dB)
- $\varphi(g,h,b)$: discrimination angle (degrees) at the HAPS (h) between the pointing direction of a HAPS spot beam (b) and the GSO satellite (g)
- $G^H{}_{tx}(\varphi(g,h,b))$: transmitter antenna gain (dBi) of the HAPS (h) for off-axis angle $\varphi(g,h,b)$
- $FSL(g,h)$: free space loss (dB) between the GSO satellite (g) and the HAPS (h)
- $\theta(h,g,r)$: discrimination angle (degrees) at the GSO satellite (g) between the pointing direction of a GSO FSS reference point (r) and a HAPS (h), see Fig. 2
- $G^S{}_{rx}(\theta(h,g,r))$: receiver antenna gain (dBi) of the GSO satellite (g) for off-axis angle $\theta(h,g,r)$.

FIGURE 1

Interference evaluation model from a HAPS to a GSO satellite

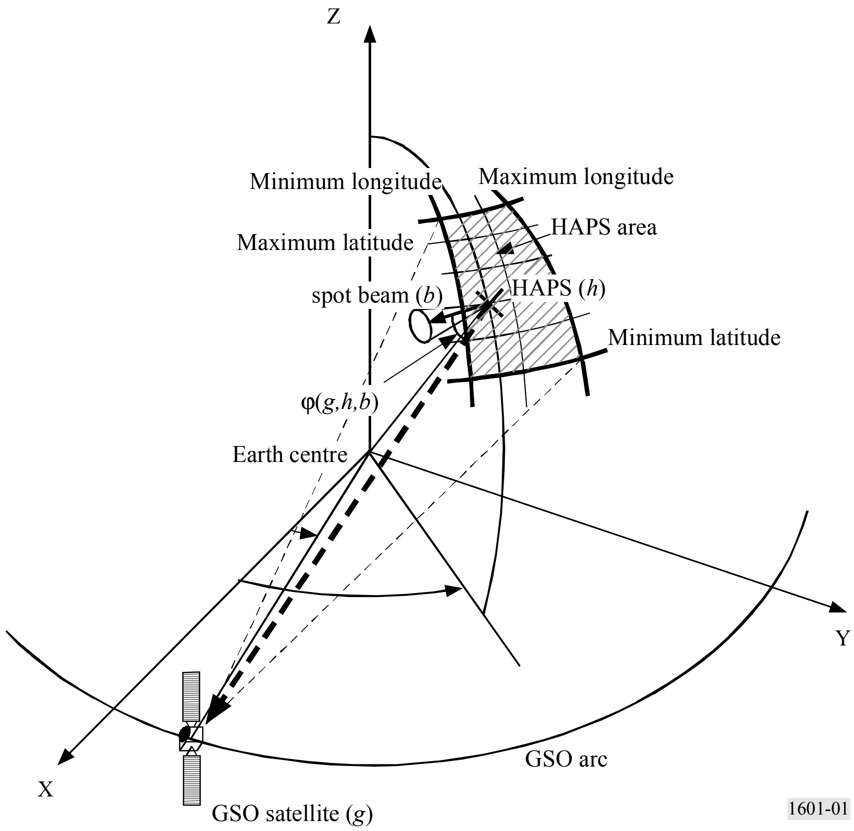
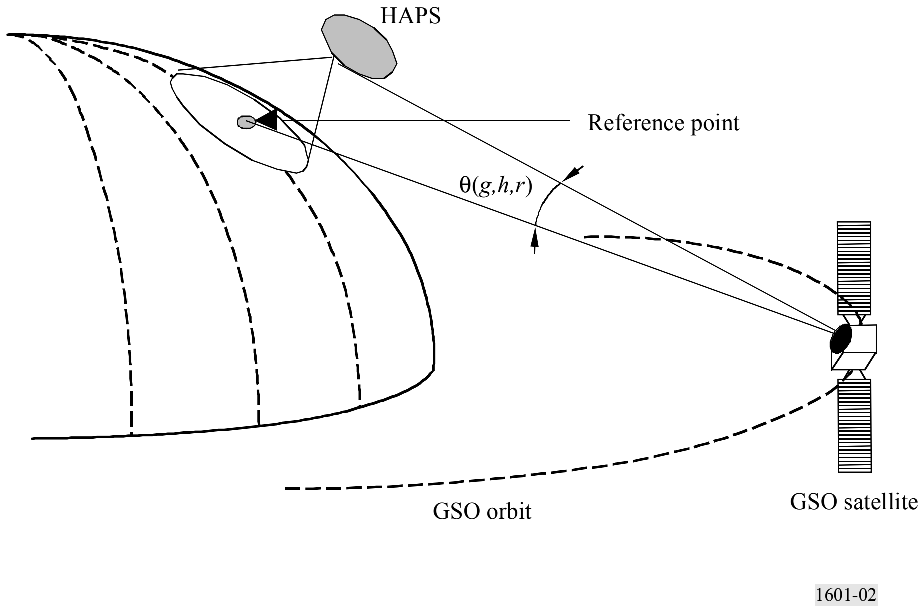


FIGURE 2

Geometric model of the reference point for a GSO satellite



To calculate the discrimination angle at a GSO satellite, a reference point must be established for the calculations. The reference point is selected as a specific location on the surface of the Earth. It is then assumed that the boresight of the spot beam antenna of the GSO satellite is always directed to the reference point, regardless of the orbital location of the spacecraft. In cases where the reference point is not visible to the GSO satellite, then it is assumed that the reference point is moved to another point under the condition that the elevation angle toward the GSO satellite is the minimum value. Figure 2 shows the geometric model of the example including the reference point.

Based on an operational scenario of the HAPS system in which a HAPS can transmit multiple carriers in each spot beam, it is assumed that HAPS downlink multiple carriers could exist in the entire receiver bandwidth at the GSO satellite. The aggregate interference from a HAPS system is expressed as I_{single} and calculated as a sum of the spectral density $I(g,h,b,r)$ of all the possible spot beams of the HAPS which could use the same frequency as shown in equation (2).

$$I_{single} = 10 \log \left(\sum_{h=1}^{h_n} \sum_{b=1}^{b_n} 10^{I(g,h,b,r)/10} \right) \qquad \text{dB(W/MHz)} \qquad (2)$$

where b_n indicates the number of spot beams which could use the same frequency and h_n indicates the number of HAPS which one HAPS system consists of.

Once the interference level received by the FSS has been assessed, the I/N ratio can be assessed as follows:

$$I/N_{single} = I_{single} - N = I_{single} - 10 \log(k \, T_{sat}) - 60 \qquad (3)$$

where:

- I/N_{single}: interference-to-thermal noise ratio (dB)
- N: thermal noise power of satellite receiver in 1 MHz (dB(W/MHz))
- k: Boltzmann's constant (W/(K · Hz))
- T_{sat}: system noise temperature of a GSO/FSS satellite (K).

The calculated aggregate interference level would then be compared with an appropriate interference threshold in order to determine if the HAPS system is causing harmful interference to the FSS.

2.2 Interference from multiple HAPS systems

Situations could arise in which several operational HAPS systems could cause interference to a certain GSO satellite. The aggregate interference from multiple HAPS systems is expressed as $I_{multiple}$ and derived from the sum total of each interference level from each HAPS system to the GSO satellite as shown in equation (4).

$$I_{multiple} = 10 \log \left(\sum_{s=1}^{s_n} \sum_{h=1}^{h_n} \sum_{b=1}^{b_n} 10^{I(g,h,b,r)/10} \right) \qquad \text{dB(W/MHz)} \qquad (4)$$

where s_n indicates the number of HAPS systems. The other terms are as described above for the case of interference from a single HAPS system.

For an exact evaluation of a multiple HAPS situation, the characteristics of each HAPS system should be used in the calculations. In the absence of such information for one or more of the systems, an approximate indication of the resulting interference can be obtained by using the characteristics of a reference HAPS system in the calculations.

Once $I_{multiple}$ has been found, it can be used instead of I_{single} in equation (3) in order to assess the impact of the interference upon the FSS.

2.3 Downlink power control

The interference from HAPS downlink to GSO/FSS uplink is maximum under the condition of maximum transmission power of HAPS downlink or under the rain condition. When using downlink power control in HAPS system, aggregate transmission power of HAPS downlink can be reduced under clear sky condition. As a result, the interference received at the FSS spacecraft is reduced in clear sky condition.

2.4 Input parameters

Interference studies applying the methodology of this Annex should use actual characteristics of FSS and HAPS systems under consideration if available. In their absence, the following values may be used:

2.4.1 HAPS characteristics

See Recommendation ITU-R F.1569.

2.4.2 FSS input characteristics

– T_{sat}: 500 K
– Antenna beamwidth (small stations): 0.3°
– Antenna beamwidth (hub stations): 2°
– Antenna gain: Recommendation ITU-R S.672, Annex 1, (L_s = –20 dB).[1]

[1] Recommendation ITU-R S.672 provides design objectives for spacecraft antenna designers. Providing objectives for shaped beam is not possible for typical cases as there is no knowledge of the FSS service area. A specific rolloff performance of L_s = −10 dB may be used so as to characterize the shaped beam case. Further study is required on the rolloff performance.