

RECOMMENDATION ITU-R F.1607

Interference mitigation techniques for use by high altitude platform stations in the 27.5-28.35 GHz and 31.0-31.3 GHz bands

(Question ITU-R 212/9)

(2003)

The ITU Radiocommunication Assembly,

considering

- a) that new technology utilizing high altitude platform stations (HAPS) in the stratosphere is being developed;
- b) that WRC-97 made provisions for operation of HAPS within the fixed service 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 WRC-2000 made a provision for the use of HAPS in the fixed service in the bands 27.5-28.35 GHz and 31.0-31.3 GHz in certain countries on a non-harmful interference, non-protection basis in order to address issues of rain attenuation associated with the 47 GHz bands (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 referred to in *considering* d) above,

recommends

1 that the following general interference mitigation techniques be considered in the development of a system using HAPS in the 27.5-28.35 GHz and 31.0-31.3 GHz bands (Notes 1 and 2):

- 1) increasing minimum operational elevation angle;
- 2) improvement of radiation patterns of antennas on board HAPS and their ground stations;
- 3) shielding effect by HAPS airship envelope;
- 4) dynamic channel assignment;
- 5) automatic transmitting power control (ATPC).

NOTE 1 – Annex 1 describes general principles of the above interference mitigation techniques and Annex 2 gives a more detailed description of dynamic channel assignment.

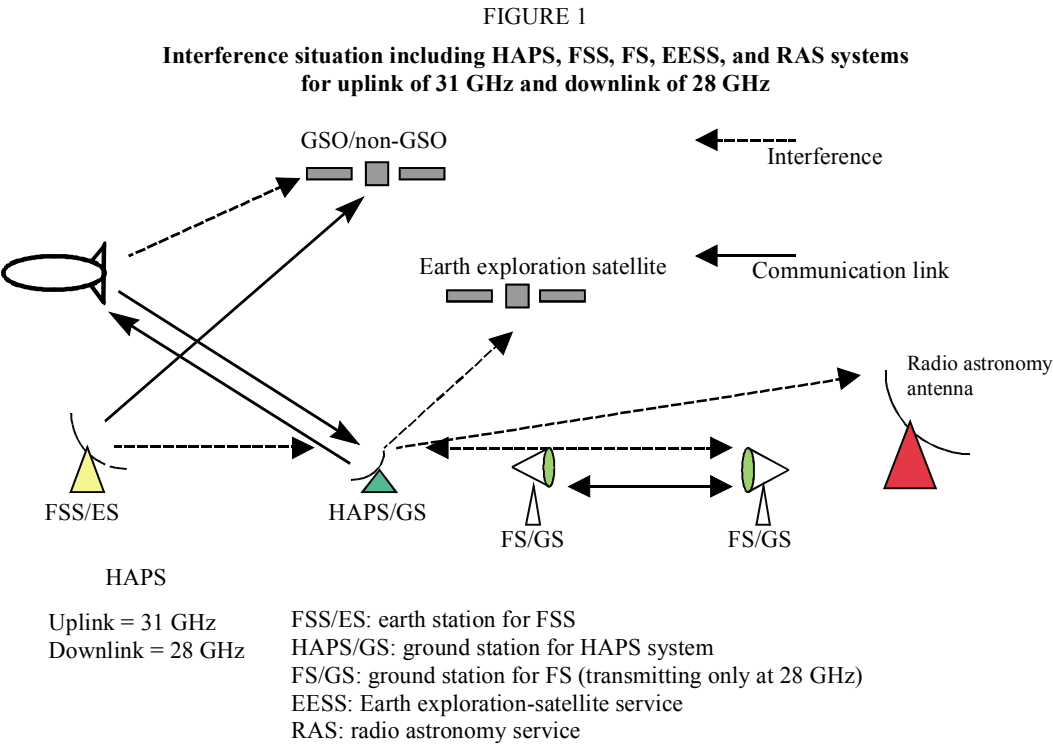
NOTE 2 – Recommendation ITU-R F.1569 should be referred to for the HAPS system using the frequency bands 27.5-28.35 GHz and 31.0-31.3 GHz.

Annex 1

Interference mitigation techniques proposed for use by HAPS
in the 27.5-28.35 GHz and 31.0-31.3 GHz bands

1 Interference situation

Figure 1 shows an example of interference situation between HAPS system and other services. This Annex lists the interference mitigation techniques for frequency sharing between the HAPS system with other services and describes their principle and advantages.



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2 Interference mitigation techniques

Table 1 summarizes the relation between the mitigation technique and its effective interference situation. The technical principle and advantages of each mitigation technique follow Table 1.

TABLE 1

Relation between interference mitigation techniques and interference scenarios

Systems for sharing and interference scenario Interference mitigation techniques		FSS (in-band interference)		To/from FS (in-band)	Science service (interference to adjacent band)	
		To FSS satellite	From FSS/ES		To EESS satellite	To RAS station
1)	Increasing minimum operational elevation angle		√	√		√
2)	Improvement of radiation patterns of antennas on board HAPS and ground station	√	√	√		√
3)	Shielding effect by HAPS airship envelope	√				
4)	Dynamic channel assignment		√	√		
5)	Automatic transmitting power control			√	√	√
	HAPS uplink			√	√	√
	HAPS downlink	√		√		

√: Effective.

1) *Increasing minimum operational elevation angle*

Interferences from the FSS earth station to the HAPS ground station, that between FS ground station and HAPS ground station and that from the HAPS ground station to the RAS station could be reduced by increasing minimum operational elevation angle of HAPS ground station so as to increase antenna separation angle toward ground stations for other services. As a result, required separation distance could be shortened.

For example, in the case that the minimum operation angle of the HAPS ground station is increased from 20° to 40°, the separation distance is reduced to about half (0.42 in precise) as shown below. In the theoretical analysis, radiation pattern of HAPS ground station antenna in that range of off-axis angle is given by the following equation, Recommendation ITU-R F.1245:

$$G(\varphi) = 39 - 5 \log_{10}(D/\lambda) - 25 \log_{10}(\varphi)$$

where:

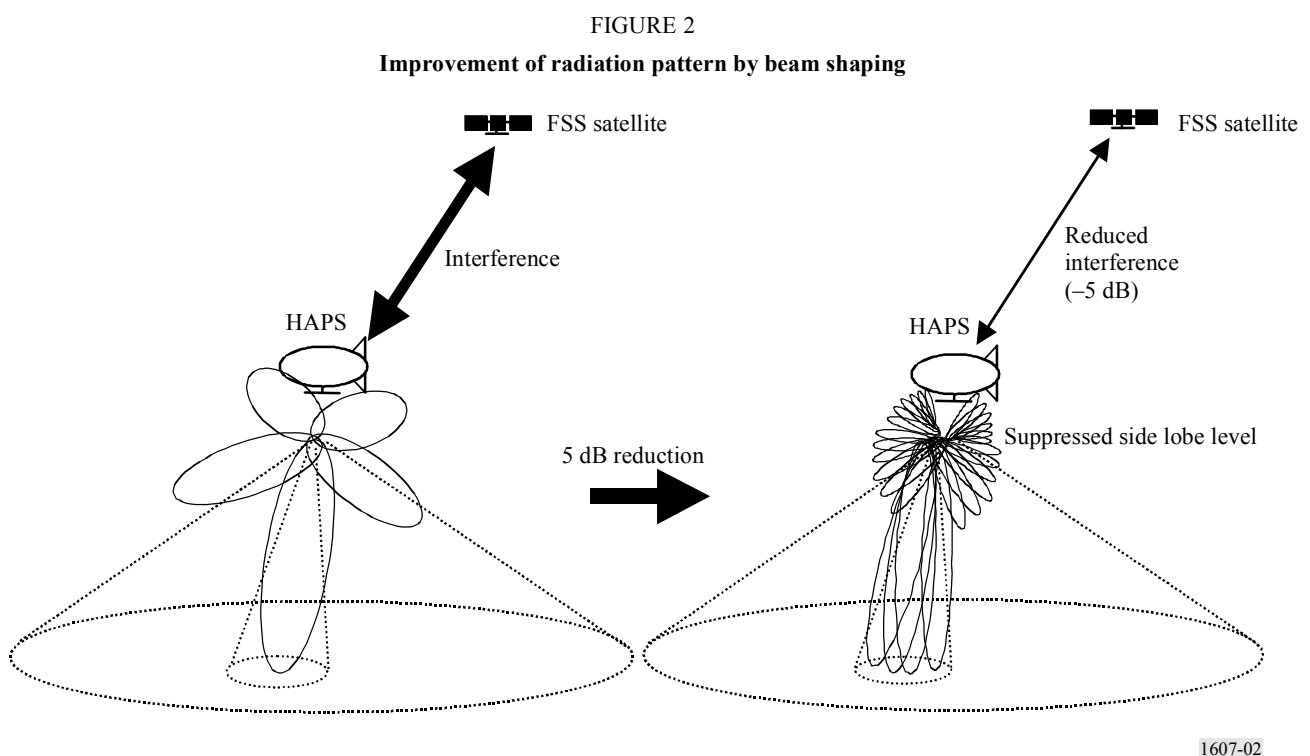
 φ : off-axis angle (degrees) D : antenna diameter λ : wavelength
 $\left. \begin{array}{l} \\ \\ \end{array} \right\}$ expressed in the same units

The difference between antenna gain for 20° off-axis and that for 40° is calculated to be about 7.5 dB. Therefore, the reduction is calculated by $1/\sqrt{10^{7.5/10}} = 0.42$, since path loss is proportional to the square of transmission distance. It is noted in the case of minimum elevation angle of 40° that the required number of HAPS airship needs to be increased so as to keep the total service coverage unchanged.

2) *Improvement of radiation patterns of antennas on board HAPS and ground station*

Interference from the HAPS airship to the satellite space segment could be reduced by pattern shaping of each beam of multibeam antenna on board HAPS airship, because the pattern shaping improves main-lobe and side-lobe characteristics.

As a preliminary study result, radiation power of side lobe and back lobe is expected to be reduced by about 5 dB, by shaping the antenna beam pattern having the worst characteristics with four cluster beams as depicted in Fig. 2. The improvement is due to the transmission power reduction by gain increase of the antenna for boresight and also due to side-lobe gain reduction.



Improvement of radiation pattern (gain suppression in the elevation angle smaller than the minimum operational elevation angle in HAPS system) of the antenna in the HAPS ground station is also effective to reduce interference between the HAPS ground station and stations on the ground in other services (station in FS, FSS earth station and RAS station).

3) *Shielding effect by HAPS airship envelope*

This effect is given from the metal coating of HAPS airship envelope. Interference calculation between HAPS airship and satellite space segment is reduced by taking into account shielding effect to the side-lobe and back-lobe beam characteristics of the antenna on board the HAPS airship.

The expected shielding effect is examined by electromagnetic scattering analysis using the model of 2-D cylindrical conductor with plane wave normal incidence. According to the analysis and its approximation in equation expression, the following shield effect mask could be used for the maximum diameter of HAPS airship body more than 15 m and frequency of signals higher than 20 GHz.

0 dB	for $0^\circ \leq \theta \leq 90^\circ$
$0.5(\theta - 90)$ dB	for $90^\circ < \theta \leq 120^\circ$
15 dB	for $120^\circ < \theta \leq 180^\circ$

where θ is the separation angle to the direction of interest (such as a satellite) from the nadir direction of HAPS.

The more precise value of shielding effect is required to be investigated by experiments.

4) *Dynamic channel assignment (DCA)*

DCA is the interference mitigation scheme, which searches a non-use frequency or time slot and utilizes it, not so as to give the interference to other services and not so as to be received from other services. When communication systems operate on a demand-assignment basis, DCA using self-controlled scheme is effective for sharing with other services.

As one example, dynamic channel activity assignment system (DCAAS) could be referred, which is facilitated in the LEOTELECOM-1 mobile-satellite service satellite system (non-GSO). In replacing the non-GSO satellite system using DCAAS with HAPS-based system, one example of DCA for HAPS is as follows:

- HAPS airship includes on-board frequency monitoring function;
- it monitors the status of frequency use of other systems with which frequency sharing is done;
- HAPS system assigns monitored non-use frequency slot for communication link.

In the situation that the frequency sharing is required in the same frequency band and the same service area, only the DCA scheme could be effective. Preliminary study results of DCA applied to the frequency sharing between HAPS system and fixed wireless access (FWA) system is attached to Annex 2.

5) *Automatic transmitting power control (ATPC)*

In the radiocommunication system using higher frequency band, the system design takes into account the rain attenuation. To compensate the attenuation, the transmission power is increased by the value of rain attenuation. The ATPC scheme has the function to control the output power in monitoring the weather condition or receiving power. The transmission power is increased under the rain condition and it is decreased under the clear-sky condition.

Since the ATPC is essentially the scheme to avoid the unnecessary higher transmission power of signal, the ATPC is useful from the viewpoint of the interference reduction. In the case of in-band interference between the HAPS ground station and the ground station for FS, its effect directly appears. In the case of interference resulting from unwanted emissions, which may affect the science services such as EESS and RAS using the adjacent band, the ATPC could bring about the reduction of the unwanted emission level.

The ATPC at the HAPS on-board transmitter of individual spot beams reduces the downlink interference into satellites using the same band under the clear-sky condition, whereas the interference power increases under rain condition. The hard rain areas that need high power transmission by ATPC and the time percentage for such needs, however, would actually be very limited and impact of the aggregate interference from all the spot beams and all the HAPSs into the satellites could not be so much.

Regarding the out-of-band noise level of the RF module such as high power amplifier, it is necessary to study the effect of the ATPC to the noise level performance through the hardware manufacturing.

Annex 2

Dynamic channel assignment to facilitate sharing the 27.5-28.35 GHz and 31.0-31.3 GHz bands between the FS using HAPS and conventional FS stations

1 Introduction

For the FS using HAPS, WRC-2000 decided to allow the use of the band 27.5-28.35 GHz for downlink (HAPS-to-ground direction) and 31.0-31.3 GHz for uplink (ground-to-HAPS direction) in interested countries on non-harmful interference and non-protection basis (RR No. 5.537A and No. 5.543A). Because these bands have primary allocation to FS, HAPS-based FS is subject to share those bands with other FS systems.

Among some possible mitigation techniques, DCA is a strong candidate to facilitate sharing between those services. This Annex provides the current status of feasibility study on the DCA in the HAPS-based FS to be introduced to share with other conventional FS systems. The study focuses on the feasibility of sensing FS carriers at the HAPS system when the conventional FS, point-to-multipoint (P-MP) FWA is considered.

2 Interference paths and carrier sensing for DCA

There are the following interference paths between HAPS-based FS and P-MP FS sharing the 28 GHz band or the 31 GHz band (see Fig. 3):

- (i) interference from HAPS GS to FS SUB (31 GHz);
- (ii) interference from HAPS GS to FS HUB (31 GHz);