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Radiocommunication Sector of ITU

Recommendation ITU-R F.1570-2
(04/2010)

Impact of uplink transmission in the fixed service using high altitude platform stations on the Earth exploration-satellite service (passive) in the 31.3-31.8 GHz band

F Series
Fixed service

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R F.1570-2*

Impact of uplink transmission in the fixed service using high altitude platform stations on the Earth exploration-satellite service (passive) in the 31.3-31.8 GHz band

(2002-2003-2010)

Scope

This Recommendation provides guidance on the interference evaluation method of high altitude platform stations (HAPS) uplink on the EESS (passive) in the 31.3-31.8 GHz band. Annex 1 provides considerations on a limit for the level of unwanted emissions of a transmitter at the input of a HAPS ground station antenna using the typical parameters for the HAPS system in the band 31-31.3 GHz given in Recommendation ITU-R F.1569.

The ITU Radiocommunication Assembly,

considering

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

b) that the 31.3-31.8 GHz band is allocated to the radio astronomy, Earth exploration-satellite service (EESS) (passive) and space research service (passive), and it is necessary to appropriately protect these services from unwanted emissions from HAPS ground stations operated in the 31-31.3 GHz band, taking into account the interference criteria given in the relevant ITU-R Recommendations,

recognizing

a) that the 27.9-28.2 GHz and 31-31.3 GHz bands may also be used for HAPS in the fixed service in certain countries on a non-interference, non-protection basis,

recommends

1 that § 1 in Annex 1 should be used for the parameters regarding EESS (passive) for the interference evaluation of HAPS uplink (ground-to-airship direction) on the EESS (passive) in the 31.3-31.8 GHz band;

2 that Recommendation ITU-R F.1569 should be used for the typical parameters regarding HAPS system for the impact evaluation of HAPS system on the EESS (passive) in the 31 GHz band;

3 that § 2 in Annex 1 should be used for the interference evaluation method of HAPS uplink on the EESS (passive) in the 31.3-31.8 GHz band.

* This Recommendation should be brought to the attention of Radiocommunication Study Group 7.

Annex 1

Impact of uplink transmission in the FS using HAPS on the EESS (passive) in the 31.3-31.8 GHz band

1 Parameters of the EESS (passive) and HAPS system

Table 1 shows the parameters used for the interference evaluation in this study. The parameters regarding the EESS (passive) correspond to a pessimistic case, which might be operated as the worst case in the future. The parameters regarding HAPS system are based on Recommendation ITU-R F.1569 in which the typical HAPS operation is assumed taking into account the sharing with other services.

TABLE 1

Parameters of EESS (passive) and HAPS system used in this study

EESS (passive)	
Earth exploration satellite EES altitude	300 km
Sensor antenna gain	50 dBi
Sensor antenna pattern	Recommendation ITU-R S.672
Sensor protection requirement (from Recommendation ITU-R RS.1029)	−183 dB(W/MHz)
Sensor antenna tilt angle	0°
HAPS system	
HAPS airship altitude	20 km(1)
HAPS ground station antenna gain	35 dBi
HAPS system availability	99.4%(2)
Minimum HAPS ground station elevation angle	20°(3)
Number of simultaneously transmitting HAPS earth stations	1 468(4)
Estimated number of HAPS	1(5)
HAPS ground station antenna pattern	Recommendation ITU-R F.1245
Rain rate for system availability	Moderate(6)
Required E_b/N_0 for BER = 1×10^{-6}	5.5 dB(7)
HAPS system margin(8)	3 dB

Notes relating to Table 1:

(1) Although the RR defines the upper bound of HAPS altitude as 50 km, the deployment of HAPS system at an altitude below 25 km would be more realistic from the viewpoint of present technology (see § 3 in Recommendation ITU-R F.1569). Although the HAPS altitude of 20 km is used for the design of link budget for HAPS uplink in this study, this link budget holds for the HAPS altitude of 25 km without increasing the output power of HAPS ground station (see § 3 in Recommendation ITU-R F.1569).

(2) ATPC technique can make it possible to enhance the availability without increasing the interference to the EESS (passive). As shown in § 8 in Recommendation ITU-R F.1569, the use of ATPC with the range of 12.2 dB can realize the availability of 99.8%.

(3) In this study, 20° of the minimum operation elevation angle is used as the typical value. To determine the minimum operational elevation angle of HAPS system is required for further study taking into account the sharing with other co-primary services, introduction of some interference mitigation techniques (e.g. ATPC) and so on (see § 4 and 7 in Recommendation ITU-R F.1569).

(4) The number of HAPS ground stations in the area covered by one HAPS is limited up to 1 468 (see § 10 in Recommendation ITU-R F.1569) assuming that available frequency band is 300 MHz, frequency reuse factor is 4, signal bandwidth is 20 MHz, and the number of spot beams is 367.

(5) Principal interference comes from the HAPS ground stations in the limited area near the main beam direction of the passive sensor. Therefore the interference evaluation from HAPS ground stations covered by one HAPS would give almost the same result as that of the interference evaluation for the model consisted of many HAPS airships.

(6) In this study, the rain rate in Tokyo (rain climatic zone: M in Recommendation ITU-R P.837) is used for the design of link budget as an example of the moderate rain area. In case of the heavy rain rate condition (e.g. rain climatic zone: P in Recommendation ITU-R P.837), the introduction of ATPC will be required (see § 8 in Recommendation ITU-R F.1569).

(7) Coding technique is indispensable in the present communication system. Therefore use of required E_b/N_0 around 5 dB for BER = 1×10^{-6} is reasonable.

(8) Further work is needed to determine the apportion of the interference into EESS between HAPS in the FS and other FS systems.

The footprint illuminated by a spot beam is regarded as a cell in the HAPS network. Frequency reuse factor of four is adopted in this study, that is, frequency band of 300 MHz (31-31.3 GHz) available for HAPS uplink is equally divided into four and the divided sub-band of 75 MHz is repeatedly used for uplink transmission in every four cells. In this study, it is assumed that automatic transmitting power control (ATPC) with variable step of 6 dB is introduced to HAPS ground station. The level of unwanted emissions from the HAPS station used in this study is −105 dB(W/MHz).

2 Interference evaluation procedure

Geometry of impact evaluation model used in this study is shown in Figs. 1 (whole view) and 2 (top view). The number of HAPS ground stations that are allowed to transmit signals simultaneously is limited due to the limitation of available frequency bandwidth. As described in § 1, available frequency bandwidth is 75 MHz in one spot beam (= cell). Since it is assumed that the signal bandwidth is 20 MHz per carrier, number of HAPS ground stations that are allowed to transmit signals simultaneously is 3.75 in one cell. Considering this limitation of available frequency band, the impact from four HAPS ground stations located at the centre of each spot beam is calculated. In this case, aggregate interference from $4 \times 367 = 1\,468$ HAPS ground stations is summed up. Four

HAPS ground stations are located at the centre of each cell (5.5 km intervals). It is assumed that all the antennas of HAPS ground station are pointing toward the HAPS airship at an altitude of 20 km and the antenna pattern of HAPS ground station is calculated by Recommendation ITU-R F.1245. It is assumed that the passive sensor is pointing toward the nadir direction and the antenna pattern of passive sensor is calculated by Recommendation ITU-R S.672. In order to consider the worst case of the interference, HAPS airship and the passive sensor are just above the HAPS ground station located at the centre in the nadir cell of HAPS as shown in Fig. 2. The level of unwanted emissions of –105 dB(W/MHz) under clear-sky conditions is used for the impact evaluation. Although the level of unwanted emissions under rain conditions increases up to 6 dB compared with clear-sky conditions, the increased unwanted emission power is partly attenuated in the rain path. The propagation loss between HAPS ground station and the passive sensor is calculated as free space propagation.

FIGURE 1

Geometry of impact evaluation model (whole view)

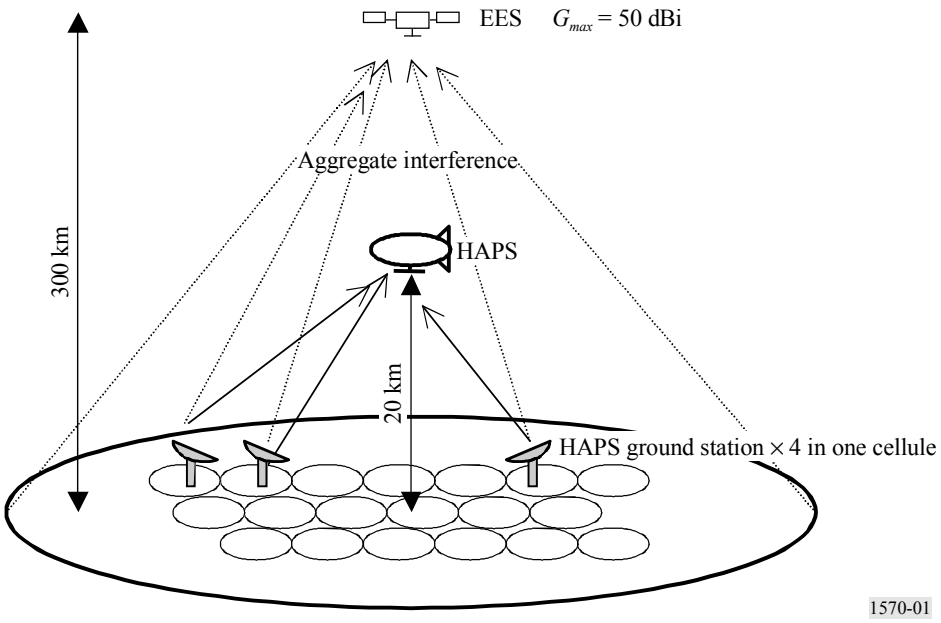
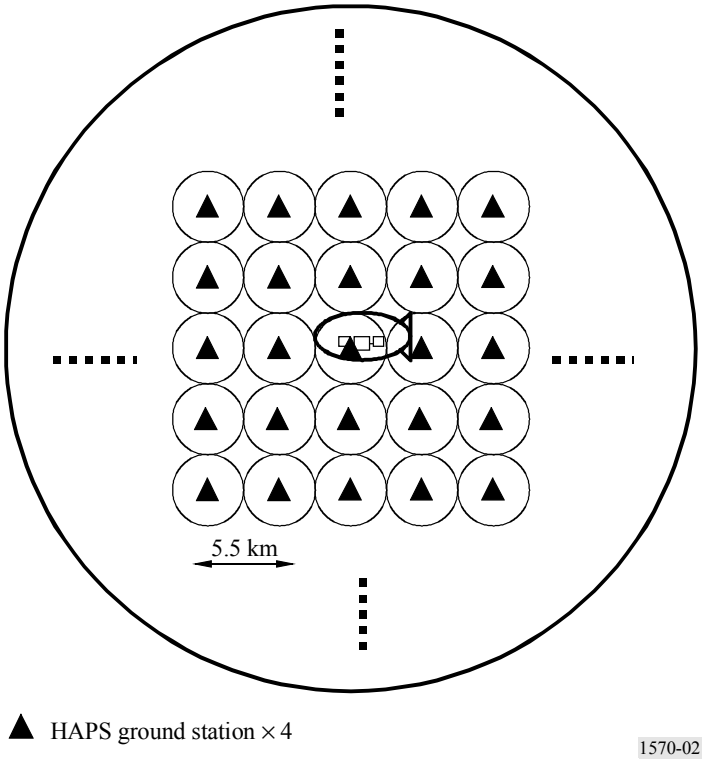


FIGURE 2

Geometry of impact evaluation model (top view)



The aggregate interference I is calculated by (1).

$$I = 10 \log \left(4 \sum_{i=1}^{367} \left(P \cdot Gt_i \cdot (4\pi d_i / \lambda)^2 \cdot Gr_i \right) \right) \quad \text{dB(W/MHz)} \quad (1)$$

where:

P: unwanted emission level: $1 \times 10^{-10.5}$ W/MHz (= –105 dB(W/MHz))

Gt_i: transmission antenna gain of the i-th HAPS ground station for EESS satellite calculated by Recommendation ITU-R F.1245 (dBi) (maximum gain = $10^{3.5}$ (= 35 dBi))

d_i: distance between the i-th HAPS ground station and passive sensor (m)

λ: wavelength of the carrier signal (m): in this study, frequency of 31.28 GHz

Gr_i: receiving antenna gain of passive sensor for the i-th HAPS ground station calculated by Recommendation ITU-R S.672 (dBi) (maximum gain = 10^5 (= 50 dBi)).

Protection criterion of EESS (passive) is defined by Recommendation ITU-R RS.1029 which provides the threshold level of –183 dB(W/MHz) not to be exceeded for more than 0.01% of time.

3 Study result

Under the above conditions, aggregate interference of 4 × 367 HAPS ground stations to the passive sensor is –185.9 dB(W/MHz) which is 2.9 dB lower than the protection criterion of the EESS (passive) in the band 31-31.3 GHz. The aggregate interference from the HAPS ground stations in the area covered by another HAPS is negligible (30 dB less than –185.9 dB(W/MHz)). Therefore the aggregate interference from the HAPS ground stations covered by 200 HAPS airship does not exceed the protection criterion of the EESS (passive).

Required guardband is 10 MHz for 20.2 MHz IF filter bandwidth (–3 dB). This guardband depends on the signal bandwidth and the attenuation characteristics of the IF band-pass filter.