

RECOMMENDATION ITU-R M.1641-1*

A methodology for co-channel interference evaluation to determine separation distance from a system using high-altitude platform stations to a cellular system to provide IMT-2000 service

(2003-2006)

Scope

This Recommendation contains a methodology for evaluating co-channel interference and a separation distance between a high-altitude platform stations (HAPS) system as a base station for IMT-2000 and a terrestrial tower-based cellular system providing IMT-2000 service.

Annex 1 describes a methodology for co-channel interference evaluation from a HAPS base station and cellular base stations to a cellular mobile station to provide IMT-2000. The C/I ratio is used as a criterion to set separation distance between a HAPS system and a cellular system. For evaluating the interference within a cellular system, a simplified extended version of Hata's model is applied. An example of calculation for the separation distance between a HAPS system and a cellular system is contained in Annex 2.

Appendices 1 and 2 present the equations for interference calculations used in Annex 1 and the antenna radiation pattern, respectively.

The ITU Radiocommunication Assembly,

considering

- a) that new technology utilizing high-altitude platform stations (HAPS) in the stratosphere is being developed;
- b) that WRC-2000 made provision for use of HAPS providing IMT-2000 in the bands 1 885-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170 MHz in Regions 1 and 3 and 1 885-1 980 MHz and 2 110-2 160 MHz in Region 2;
- c) that Resolution 221 (WRC-03) requested studies on sharing between HAPS and other stations within IMT-2000, and considered the compatibility of HAPS within IMT-2000 with some services having allocations in the adjacent bands;
- d) that, in accordance with No. 5.388A of the Radio Regulations (RR), HAPS may be used as base stations within the terrestrial component of IMT-2000 in the bands 1 885-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170 MHz in Regions 1 and 3 and 1 885-1 980 MHz and 2 110-2 160 MHz in Region 2; the use by IMT-2000 applications using HAPS as base stations does not preclude the use of these bands by any station in the services to which they are allocated and does not establish priority in the RR,

recommends

- 1 that the methodology in Annex 1 should be used as guidance for determining separation distance between HAPS systems and cellular systems to provide IMT-2000 service in the frequency bands in *considering* b) above.

* This Recommendation should be brought to the attention of Radiocommunication Study Group 9.

NOTE 1 – Recommendation ITU-R M.1456 should be referred to for the typical parameters regarding a HAPS system for sharing studies between a HAPS IMT-2000 and a cellular service in the frequency bands in *considering* b) above.

Annex 1

A methodology for co-channel interference evaluation to determine separation distance from a system using HAPS to a cellular system to provide IMT-2000 service

1 Introduction

Recommendation ITU-R M.1456 provided a co-channel spectral power flux-density (spfd) limit on HAPS emissions and out-of-band spfd limits on HAPS emissions on the Earth's surface, as well as HAPS performance requirements to protect terrestrial mobile stations and fixed stations operating in bands adjacent to transmissions from HAPS.

However, for designing a cellular system, the multi-users interference in the system should be considered as well as other services' interferences; the spectrum efficiency depends on the interference from the same and adjacent cells.

In this Recommendation, guidance is provided to estimate the co-channel interference effects into the terrestrial cellular IMT-2000 system, which is tower-based, from a HAPS IMT-2000 system considering two interferers: the same and adjacent cells interference in the cellular system itself, and the HAPS IMT-2000 interference. Since HAPS IMT-2000 interference is based on the HAPS antenna pattern described in Recommendation ITU-R M.1456, this pattern is used to evaluate the appropriate interference power of cellular systems so that all interference power can be derived. The interference to a cellular mobile station from cellular base stations and a HAPS base station is estimated in terms of the C/I with the parameters of the HAPS system such as the number of users per cell, cell radius, and transmission power. For each estimated case, the optimum values are determined for the above parameters in the HAPS IMT-2000 system in order to be compatible with the cellular system. This Recommendation will give guidance for evaluating the separation distance between a HAPS IMT-2000 system and a cellular IMT-2000 system to IMT-2000 service providers using those different systems.

2 System model

2.1 HAPS IMT-2000

HAPS is being developed in accordance with Recommendation ITU-R M.1457 to possibly provide IMT-2000 service in the 1 885-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170 MHz in Regions 1 and 3, and 1 885-1 980 MHz and 2 110-2 160 MHz in Region 2. In addition, HAPS as a base station to provide IMT-2000 will have its antenna pattern complied with the following:

$$G(\psi) = \begin{cases} G_m - 3(\psi / \psi_b)^2 & \text{dBi} & \text{for } 0 \leq \psi \leq \psi_1 \\ G_m + L_N & \text{dBi} & \text{for } \psi_1 < \psi \leq \psi_2 \\ X - 60 \log(\psi) & \text{dBi} & \text{for } \psi_2 < \psi \leq \psi_3 \\ L_F & \text{dBi} & \text{for } \psi_3 < \psi \leq 90^\circ \end{cases} \quad (1)$$

where:

- $G(\psi)$: gain at the angle ψ from the main beam direction (dBi)
- G_m : maximum gain in the main lobe (dBi)
- ψ_b : one-half the 3 dB beamwidth in the plane of interest (3 dB below G_m) (degrees)
- L_N : near-inside-lobe level (dB) relative to the peak gain required by the system design, and has a maximum value of -25 dB
- $L_F = G_m - 73$ dB far side-lobe level (dBi)
- $\psi_1 = \psi_b \sqrt{-L_N / 3}$ degrees
- $\psi_2 = 3.745 \psi_b$ degrees
- $X = G_m + L_N + 60 \log(\psi_2)$ dB
- $\psi_3 = 10^{\frac{X - L_F}{60}}$ degrees.

The 3 dB beamwidth ($2\psi_b$) is again estimated by:

$$\psi_b = \sqrt{\frac{7.442}{10^{0.1 G_m}}} \quad \text{degrees}$$

where G_m is the peak aperture gain (dBi).

2.2 Propagation model

For the cellular system, a simplified extended version of Hata's model is considered and for the HAPS system, the free space loss model is used.

This free space loss model is adequate for a high elevation angle and it should be used with precaution for low elevation angles, until a better model is developed for HAPS systems; at that time this methodology should be reviewed.

2.2.1 Simplified model of an extended version of Hata's model

An extended version of the Hata's model in equation (2) is widely used for the radio channel modelling of cellular systems in urban areas with a base station antenna height of 30 m and a mobile antenna height of 1.5 m.

$$L = 25.87 + 33.9 \log_{10}(F) + 35.2 \log_{10}(R) \quad (2)$$

where:

- L : path loss (dB)
- F : frequency (MHz)
- R : range (km).

The general use of the fourth power path loss law in terrestrial cellular networks as a simplified extended version of Hata's model is applied as shown in equation (3) to simplify the derivation of the formula.

$$L = 25.87 + 33.9 \log_{10}(F) + 40 \log_{10}(R) \quad (3)$$

2.2.2 Free space loss model

$$L = 32.4 + 20 \log_{10}(F) + 20 \log_{10}(R) \quad (4)$$

where:

- L : path loss (dB)
- F : frequency (MHz)
- R : range (km).

3 C/I analysis at a cellular mobile station and the required C/I to determine the separation distance between HAPS system and cellular system

3.1 C/I analysis at a cellular mobile station

Figure 1 shows the interference model to a cellular mobile station from cellular base stations and the HAPS base station. An interfered cellular mobile station is assumed to be located at the nearest point of the HAPS service area as shown in Fig. 1. The interference power received by a cellular mobile station can be obtained by equation (5), taking into account the interference from the cellular base stations and the HAPS base station (see Appendix 1). Since the cellular mobile station is located at the border of the coverage of the cellular system, it is assumed that the intra-cell interference is negligible.

$$I = I_{Cellular} + I_{HAPS} = \sum_{n=1}^N \left\{ K_c S_i 10^{\frac{G_i}{10}} \left[\sum_{m=1}^{c_{in}} d_{inm}^{-4} \right] + K_h S_{hn} d_h^{-2} \left[\sum_{m=1}^{c_{hn}} 10^{\frac{G_{hn}(\varphi_{hnm})}{10}} \right] \right\} \quad (5)$$

where:

- α_i : voice activity factor in cellular system
- S_i : cellular forward link power from cellular base station to the user at the edge of each cell (mW)
- M_i : number of cellular users per cell
- l_i : cellular system path loss per kilometre
- c_{in} : number of interfering cells of n -th tier in cellular system ($= 2n + 1$, n : integer)
- N : number of tier