International Telecommunication Union

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Recommendation ITU-R F.1501

(05/2000)

Coordination distance for systems in the fixed service (FS) involving high-altitude platform stations (HAPs) sharing the frequency bands 47.2-47.5 GHz and 47.9-48.2 GHz with other systems in the fixed service

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.1501*

COORDINATION DISTANCE FOR SYSTEMS IN THE FIXED SERVICE (FS) INVOLVING HIGH-ALTITUDE PLATFORM STATIONS (HAPSs) SHARING THE FREQUENCY BANDS 47.2-47.5 GHz AND 47.9-48.2 GHz WITH OTHER SYSTEMS IN THE FIXED SERVICE

(2000)

Scope

This Recommendation provides calculation methods to determine coordination distances between the fixed service using high altitude platform stations (HAPS) and other systems in the fixed service in the bands 47.2-47.5 GHz and 47.9-48.2 GHz.

The ITU Radiocommunication Assembly,

considering

a) that WRC-97 designated the bands 47.2-47.5 GHz and 47.9-48.2 GHz for use by HAPSs in the FS;

b) that these bands are also allocated for use by the fixed, fixed-satellite and mobile services;

c) that frequency sharing for fixed-service systems using HAPSs and other systems in the FS is being considered in ITU-R;

d) that there may be a requirement to establish criteria for determining coordination distances within which detailed sharing arrangements would need to be considered, or that there may be a requirement to specify predetermined coordination distances,

recommends

1 that Annex 1 should be used for the determination of coordination distance or as a basis for establishing a predetermined coordination distance between stations operating in a high-altitude platform network (HAPN) and other stations in the FS.

ANNEX 1

Coordination distance for systems involving the use of HAPSs

1 Geometrical coordination distance

For an initial assessment, it may be appropriate to use a coordination distance based on the above-the-horizon visibility (including atmospheric refraction) between a HAPS and other stations in the conventional FS or in HAPN.

The following predetermined coordination distance (measured from the sub-HAPS point) should be adopted between a HAPS and ground terminals of other systems in the conventional FS or in different HAPNs:

$$150 + (141.6 - 0.274\,h)\sqrt{h} \qquad \text{km} \tag{1}$$

where h is the HAPS altitude (km) above sea level in the 20-50 km range.

The following predetermined coordination distance (measured from the sub-HAPS point) should be adopted between HAPSs in different systems:

$$(141.6 - 0.274\,h_1)\sqrt{h_1} + (141.6 - 0.274\,h_2)\sqrt{h_2} \qquad \text{km} \tag{2}$$

where h_1 and h_2 are the HAPS altitude (km) above sea level of two systems, both in the 20-50 km range.

* Study Group 5 made editorial amendments to this Recommendation (on 7-8 December 2009) in accordance with Resolution ITU-R 1.

2 Coordination distance using typical system parameters and representative propagation conditions for the bands of 47.2-47.5 GHz and 47.9-48.2 GHz

2.1 Minimum propagation attenuation due to atmospheric gases

2.1.1 Attenuation between a HAPS and ground terminals

In the path between a HAPS and ground terminals of other systems in the conventional FS or in different HAPN, atmospheric gases including water vapour cause attenuation, which depends on the distribution along the path of meteorological parameters such as temperature, pressure and humidity, and thus varies with the geographic location of the site, the month of the year, the height of a ground terminal above sea level, the elevation angle of the slant path and the operating frequency.

According to Recommendation ITU-R SF.1395, the following numerical formulae can be used for estimating minimum slant path attenuation in the 47 GHz band where:

$A_L(h, \theta)$, $A_M(h, \theta)$ and $A_H(h, \theta)$: total atmospheric absorption loss (dB) for the low-latitude (within 22.5° of the Equator), mid-latitude (greater than 22.5°, but less than 45° from the Equator) and high-latitude (45° or more from the Equator) areas, respectively;

h and θ: ground terminal antenna altitude above sea level (km) and elevation angle (degrees), respectively.

The approximation was carried out for $0 \leq h \leq 3$ km and $0 \leq \theta \leq 90°$. The actual elevation angle may be determined from the elevation angle developed under free space propagation conditions using the method in Recommendation ITU-R F.1333. For actual elevation angles below 0°, the attenuation for 0° should be used.

Frequency band 47.2-47.5 GHz

In this frequency band, the attenuation is larger at higher frequencies and, therefore, the following formulae give the attenuation at 47.2 GHz.

$$A_L(h, \theta) = 52.43/[1 + 0.7364\,\theta + 0.03601\,\theta^2 - 0.001099\,\theta^3 + 0.8024 \times 10^{-5}\,\theta^4 + h(0.2624 + 0.2479\,\theta) + h^2(0.08130 + 0.02637\,\theta)] \quad (3a)$$

$$A_M(h, \theta) = 47.00/[1 + 0.7004\,\theta + 0.03568\,\theta^2 - 0.001081\,\theta^3 + 0.7878 \times 10^{-5}\,\theta^4 + h(0.2527 + 0.1970\,\theta) + h^2(0.05539 + 0.03239\,\theta)] \quad (3b)$$

$$A_H(h, \theta) = 46.70/[1 + 0.6872\,\theta + 0.03637\,\theta^2 - 0.001105\,\theta^3 + 0.8087 \times 10^{-5}\,\theta^4 + h(0.2472 + 0.1819\,\theta) + h^2(0.04858 + 0.03221\,\theta)] \quad (3c)$$

Frequency band 47.9-48.2 GHz

In this frequency band, the attenuation is larger at higher frequencies and, therefore, the following formulae give the attenuation at 47.9 GHz.

$$A_L(h, \theta) = 57.90/[1 + 0.7262\,\theta + 0.03534\,\theta^2 - 0.001074\,\theta^3 + 0.7826 \times 10^{-5}\,\theta^4 + h(0.2576 + 0.2382\,\theta) + h^2(0.07645 + 0.02443\,\theta)] \quad (4a)$$

$$A_M(h, \theta) = 53.06/[1 + 0.6962\,\theta + 0.03555\,\theta^2 - 0.001076\,\theta^3 + 0.7840 \times 10^{-5}\,\theta^4 + h(0.2495 + 0.1940\,\theta) + h^2(0.05420 + 0.03176\,\theta)] \quad (4b)$$

$$A_H(h, \theta) = 53.21/[1 + 0.6864\,\theta + 0.03632\,\theta^2 - 0.001103\,\theta^3 + 0.8073 \times 10^{-5}\,\theta^4 + h(0.2476 + 0.1812\,\theta) + h^2(0.04791 + 0.03191\,\theta)] \quad (4c)$$

2.1.2 Attenuation between two HAPSs

If two HAPSs use two frequency bands for opposite directions of transmission, there is a possibility of unacceptable interference between them. If the distance between sub-HAPS points is sufficiently large, the path may be subject to attenuation due to atmospheric gases mainly in the lower atmosphere. The method of estimating the minimum value of this attenuation is described below.

First, calculate the average altitude, h_0 (km), of the altitudes h_1 and h_2 of two HAPS platforms as follows:

$$h_0 = (h_1 + h_2)/2 \tag{5}$$

It is assumed that h_1 and h_2 may be different, but the difference is not significant (see Note 2).

Then from Table 1 for $20 \leq h_0 \leq 30$ km, calculate the minimum altitude of the path, h (km), between two HAPSs. For those values of h_0 and the distance which are not given in Table 1, the minimum altitude of the path can be estimated by means of an appropriate interpolation.

Table 1 was produced for the atmospheric refractivity model of maximum refraction as defined in Recommendation ITU-R SF.765.

TABLE 1

Minimum altitude of the path between two HAPSs

Sub-HAPS distance (km)	Minimum altitude of the path, h (km)					
	For average altitude of two HAPSs, h_0					
	20 km	22 km	24 km	26 km	28 km	30 km
350	17.63	–	–	–	–	–
400	16.91	–	–	–	–	–
450	16.10	–	–	–	–	–
500	15.20	17.16	–	–	–	–
550	14.22	16.16	–	–	–	–
600	13.16	15.08	17.03	–	–	–
650	12.03	13.92	15.85	17.79	–	–
700	10.84	12.69	14.59	16.51	–	–
750	9.61	11.41	13.26	15.16	17.08	–
800	8.36	10.09	11.89	13.74	15.63	17.55
850	7.11	8.75	10.47	12.27	14.12	16.01
900	5.89	7.42	9.05	10.77	12.56	14.40
950	4.73	6.13	7.64	9.26	10.97	12.75
1 000	3.64	4.91	6.29	7.79	9.39	11.08
1 050	2.66	3.77	5.01	6.37	7.85	9.43
1 100	1.78	2.75	3.84	5.05	6.38	7.83
1 150	1.00	1.84	2.79	3.85	5.03	6.33
1 200	0.32	1.04	1.89	2.78	3.80	4.95
1 250	–	0.35	1.05	1.84	2.72	3.71
1 300	–	–	0.35	1.02	1.77	2.62
1 350	–	–	–	0.32	0.96	1.68
1 400	–	–	–	–	0.26	0.87
1 450	–	–	–	–	–	0.18

When $h \geq 17$ km, the attenuation is negligibly small. If $0 \leq h < 17$ km, the minimum propagation attenuation can be estimated by the following numerical formulae, where:

$A_L(h)$, $A_M(h)$, $A_H(h)$: total atmospheric absorption loss (dB) for the low-latitude, mid-latitude and high-latitude areas, respectively.

Frequency band 47.2-47.5 GHz

$$A_L(h) = 104.36/(1 + 0.25960\,h + 0.092795\,h^2 - 0.0047598\,h^3 + 0.00018436\,h^4 + 0.000031666\,h^5) \quad (6a)$$

$$A_M(h) = 93.94/(1 + 0.28813\,h + 0.010729\,h^2 - 0.018033\,h^3 - 0.0024068\,h^4 + 0.00014071\,h^5) \quad (6b)$$

$$A_H(h) = 93.39/(1 + 0.27156\,h + 0.023900\,h^2 + 0.0096081\,h^3 - 0.0013613\,h^4 + 0.00012031\,h^5) \quad (6c)$$

Frequency band 47.9-48.2 GHz

$$A_L(h) = 115.28/(1 + 0.25520\,h + 0.085840\,h^2 - 0.0041978\,h^3 + 0.00016894\,h^4 + 0.000030414\,h^5) \quad (7a)$$

$$A_M(h) = 106.07/(1 + 0.28529\,h + 0.0097223\,h^2 + 0.017834\,h^3 - 0.0023697\,h^4 + 0.00013852\,h^5) \quad (7b)$$

$$A_H(h) = 106.44/(1 + 0.27253\,h + 0.023020\,h^2 + 0.0095858\,h^3 - 0.0013468\,h^4 + 0.00011928\,h^5) \quad (7c)$$

NOTE 1 – When $0 \leq h \leq 3$ km, the values of equations (6a)-(7c) are almost twice the values of equations (3a)-(4c) for the same altitude and $\theta = 0°$.

NOTE 2 – For the same average altitude h_0, when h_1 and h_2 are unequal, the minimum altitude of the path becomes slightly lower, resulting in slightly larger atmospheric absorption loss. Table 2 shows the minimum altitude (km) of the path for the case of $h_0 = 25$ km. The effects of unequal HAPS altitudes are small.

TABLE 2

Minimum altitude of the path for the case of $h_0 = 25$ km

Sub-HAPS distance (km)	Minimum altitude of the path (km)					
	For h_1 and h_2					
	25/25 km	24/26 km	23/27 km	22/28 km	21/29 km	20/30 km
700	15.55	15.52	15.45	15.32	15.14	14.90
900	9.90	9.88	9.84	9.77	9.66	9.53
1 100	4.43	4.42	4.40	4.36	4.31	4.24
1 300	0.68	0.67	0.66	0.64	0.62	0.58

2.2 Coordination distance using typical system parameters

This matter requires further study.