RECOMMENDATION ITU-R M.1828

Technical and operational requirements for aircraft stations of aeronautical mobile service limited to transmissions of telemetry for flight testing in the bands around 5 GHz

(2007)

Scope

This Recommendation provides the technical and operational requirements for aircraft stations of aeronautical mobile service limited to transmissions of telemetry for flight testing that should be used by administrations as a technical guideline for establishing conformance requirements for aircraft stations for worldwide use.

The ITU Radiocommunication Assembly,

considering

a) that various technically and operationally different aeronautical mobile service (AMS) limited to transmissions of telemetry systems for flight testing networks have been designed to commence operation in the near future;

b) that the operation of aircraft station is usually a subject of a number of national and international rules and regulations including satisfactory conformance to a mutually agreed technical standard and operational requirements;

c) that there is a need for identifying the technical and operational requirements for the conformance testing of aircraft stations;

d) that the identification of technical and operational requirements for aircraft stations would provide a common technical basis for facilitating conformance testing of aircraft station by various national and international authorities and the development of mutual recognition arrangements for conformance of aircraft stations;

e) that the technical and operational requirements need to achieve an acceptable balance between radio equipment complexity and the need for effective use of the radio-frequency spectrum,

considering also

a) that in the frequency band 5 150-5 250 MHz there are allocations to aeronautical radionavigation, fixed-satellite (Earth-to-space) and mobile services on a primary basis;

b) that there is a requirement to fully protect all primary services in the band 5 030-5 250 MHz;

c) that WRC-03 adopted Resolution 229 which governs use of band 5 150-5 250 MHz by the mobile service for the implementation of wireless access systems (WAS) including radio local area networks (RLANs);

d) that the identification by ITU-R of technical and operational requirements for aircraft stations operating in the band 5 030-5 250 MHz should prevent unacceptable interference to other services;

e) that technical and operational characteristics should be continuously and accurately measurable and controllable;

f) that the band 5 030-5 150 MHz is allocated to the aeronautical radionavigation service on a primary basis;

g) that the MLS can be protected through the implementation of an adequate separation distance between a radiating aeronautical mobile service (AMS) transmitter to support telemetry and MLS receivers;

h) that the ITU-R is in the process of developing guidance material on the application of the methodology described in Recommendation ITU-R M.1829,

recognizing

a) that the band 5 030-5 150 MHz is to be used for the operation of the international standard microwave landing system (MLS) for precision approach and landing; the requirements for this system shall take precedence over other uses of this band in accordance with No. 5.444 of the Radio Regulations (RR),

recommends

1 that the technical and operational requirements for aircraft stations of AMS limited to transmissions of telemetry for flight testing operating in the 5 GHz band given in Annexes 1 and 2 should be used by administrations as guidelines to facilitate compatibility with other services;

2 that all aircraft stations of AMS limited to transmissions of telemetry for flight testing and transmitting simultaneously within one AMS network should use non-overlapping spectrum.

Annex 1

Technical and operational requirements for aircraft stations of AMS limited to transmissions of telemetry system for flight testing networks in the bands around 5 GHz

Part A

Essential requirements related to the protection of FSS networks in the band 5 091-5 250 MHz

An aircraft station of AMS in the band 5 091-5 250 MHz should be designed in such a manner that one aircraft station transmitter power flux-density be limited to –138 dB(W/(m^2 · 1.23 MHz)) at the FSS satellite orbit for spacecraft using full Earth coverage receive antennas.

The maximum aggregate interference level of 1% $\Delta T_s/T_s$ tolerable at the receiver input is $I_{Agg\text{-}Rec}$:

$$I_{Agg-Rec} = KTB - 20 \text{ dB} = -160.3 \text{ dB(W / 1.23 MHz)}$$

where:

K: Boltzmann's constant (1.38 e-23)

T: represents the receiver noise temperature: 550 K

B: receiver bandwidth: 1.23 MHz.

Therefore at the satellite receiver antenna input the maximum pfd level produced by one AMT transmitter is:

$$pfd_{Max} = I_{Agg-Rec} - Gr + L_{Feed} + L_P - 10\log_{10}(21) + 10\log\left(\frac{4\pi}{\lambda^2}\right)$$
$$= -160.3 - 4 + 2.9 + 1 - 13.2 + 35.6$$
$$= -138 \text{ dBW}/(\text{m}^2 \times 1.23 \text{ MHz})$$

where:

G_r: FSS receiver antenna gain

21: maximum number of AMT station emitting simultaneously in the FSS receiver bandwidth.

NOTE 1 – The aforementioned limit relate to the pfd would be obtained under free-space propagation conditions.

NOTE 2 – An e.i.r.p. mask can be derived from the aforementioned pfd value by applying the method given in Part A of Annex 2. Simplification of the resulting e.i.r.p. mask could also be considered.

NOTE 3 – The afore-mentioned limit corresponds to –198.9 dB(W/(m^2 · Hz)).

NOTE 4 – The pfd limit defined in this section is based on ensuring that the increase in noise temperature of the FSS satellite (i.e. $\Delta T_{sat}/T_{sat}$) due to operation of the AMT does not exceed 1%. The methodology assumes 21 co-channel AMT transmitters operating concurrently within the field of view of the FSS satellite.

Part B

Essential requirements related to the protection of the mobile service in the band 5 150- 5 250 MHz

The essential requirements which follow only represent a technical guideline.

In the 5 150-5 250 MHz frequency band, the maximum pfd produced at the surface of the Earth by emissions from an aircraft station, of an AMS system limited to transmissions of telemetry for flight testing network should not exceed: –79.4 dB(W/(m^2 · 20 MHz)) – $G_r(\theta)$.

Administrations may choose to implement different AMS technical and operational requirements which are more stringent than those referenced in this section to protect the mobile service. Further study may be necessary if different parameters are used than those assumed in developing this guideline.

$G_r(\theta)$ represents the mobile service receiver antenna pattern versus elevation angle θ and is defined as follows:

Wireless access system elevation antenna pattern

Elevation angle, θ (degrees)	**Gain (dBi)**
$45 < \theta \leq 90$	–4
$35 < \theta \leq 45$	–3
$0 < \theta \leq 35$	0
$-15 < \theta \leq 0$	–1
$-30 < \theta \leq -15$	–4
$-60 < \theta \leq -30$	–6
$-90 < \theta \leq -60$	–5

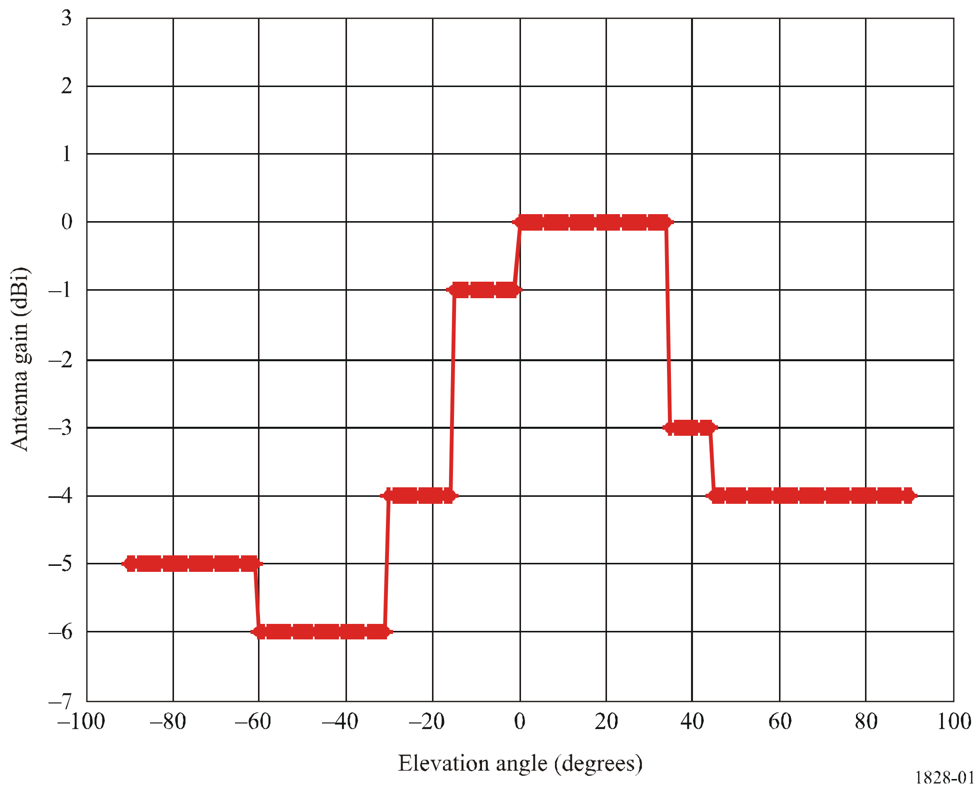
where:

$G_r(\theta)$: gain relative to an isotropic antenna (dBi)

θ: absolute value of the elevation angle relative to the angle of maximum gain (degrees)

FIGURE 1

Mobile service receiver antenna pattern



NOTE 5 – The aforementioned limits relate to the pfd and angles of arrival that would be obtained under free-space propagation conditions.

NOTE 6 – An e.i.r.p. mask can be derived from the aforementioned pfd mask by applying the method given in Part B of Annex 2. Simplification of the resulting e.i.r.p. mask could also be considered.

Part C

Essential requirements related to the protection of the aeronautical mobile (route) service (AM(R)S) in the band 5 091-5 150 MHz

The AM(R)S receiver characteristics based on IEEE 802.16e standard and ITU-R Recommendations taken into account in this sharing study are as follow:

– Protection criteria: *I*/*N* of –6 dB as expressed in Recommendation ITU-R M.1739 and which corresponds to a range reduction of 5%.
– Receiver noise factor: 10 dB.
– Implementation loss: 5 dB.
– Building loss: 0 dB (outdoor usage).
– Receiver bandwidth: 20 MHz.
– Antenna pattern: The AM(R)S receiver antenna gain versus elevation angle pattern considered in the analysis is adopted from the Recommendation ITU-R F.1336-1 and shown in Fig. 2. Peak gain is assumed to be 6 dBi.

In the 5 091-5 150 MHz frequency band, the maximum pfd produced at the surface of the Earth by emissions from an aircraft stations, of an AMS system limited to transmissions of telemetry for flight testing network should not exceed: –89.4 dB(W/(m^2 · 20 MHz))– $G_r(\theta)$.

$Gr(\theta)$ represents the mobile service receiver antenna pattern versus elevation angle θ and is defined as follows:

$$G_r(\theta) = \max\left[G_1(\theta), G_2(\theta)\right]$$

$$G_1(\theta) = 6 - 12\left(\frac{\theta}{27}\right)^2$$

$$G_2(\theta) = -6 + 10\log\left[\left(\max\left\{\frac{|\theta|}{27}, 1\right\}\right)^{-1.5} + 0.7\right]$$

where:

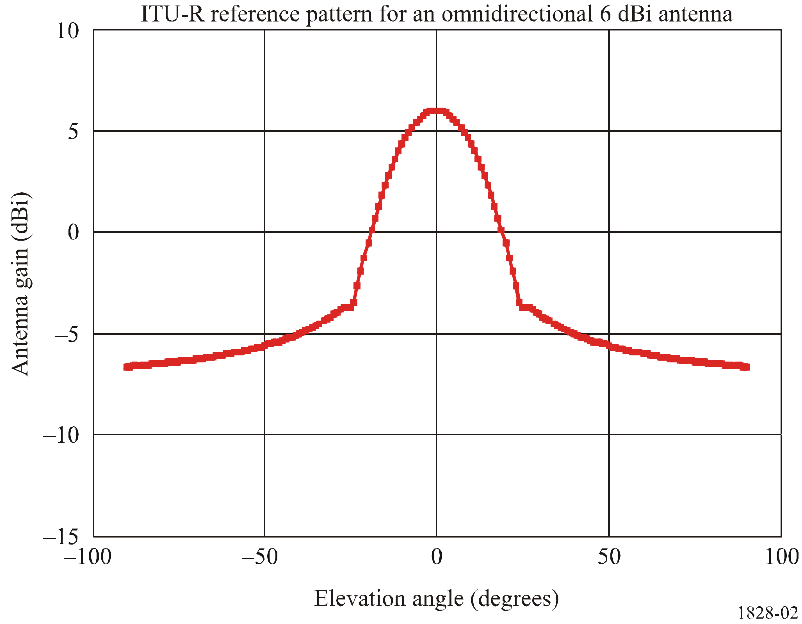
$G(\theta)$: gain relative to an isotropic antenna (dBi)

θ: absolute value of the elevation angle (degrees)

The pfd and the resultant EIRP mask are provisional, and need to be confirmed when the AM(R)S is more fully developed.

FIGURE 2

AM(R)S receiver antenna pattern



NOTE 7 – The aforementioned limits relate to the pfd and angles of arrival that would be obtained under free-space propagation conditions.

NOTE 8 – An e.i.r.p. mask can be derived from the aforementioned pfd mask by applying the method given in Part B of Annex 2. Simplification of the resulting e.i.r.p. mask could also be considered.

Part D

Essential requirements related to the protection of the aeronautical radionavigation service operating in the band 5 030-5 150 MHz

When bilateral coordination is necessary between administrations operating microwave landing systems and administrations operating AMT systems, ITU-R Recommendation presented in *considering also* h) could help for bilateral discussions.

Part E

Essential requirements related to the protection of the aeronautical security application in the band 5 091-5 150 MHz

Studies have shown that where AMS(AS) and AMS(AMT) are not operating overlapping frequencies then frequency compatibility is achieved and no essential requirements are needed to protect the AMS(AS) application.

However, for the overlapping frequency operation, further studies need to be developed.

Annex 2

Derivation of an e.i.r.p. mask from a pfd limit

Part A

Derivation of a higher hemisphere e.i.r.p. mask from a pfd limit

In testing AMS equipment limited to transmissions of telemetry for flight testing to determine if it meets a given pfd limit, such as the one in Part A of Annex 1, it may be useful to determine an equivalent e.i.r.p. mask that can be used for testing purposes.

The pfd limit can be used to mathematically determine a higher hemisphere e.i.r.p. mask, e.i.r.p. (θ, *H*) where θ is the angle above the local horizontal plane and *H* is the altitude of the aircraft. This conversion proceeds in two steps. First, θ is converted to an equivalent angle below the horizontal at the satellite, γ. Then the length of the propagation path for angle above the horizontal θ is determined and used to calculate the spreading loss for the path and the resulting e.i.r.p.

Step 1: Calculation of an angle below the horizontal at the satellite (degrees), γ, from θ and *H*:

$$\gamma = \arccos\left((R_e + H) \times \frac{\cos(\theta)}{(R_e + H_{Sat})} \right)$$

where:

θ:	angle above the horizontal at the aircraft stations
R_e:	earth radius (6 378 km)
H:	altitude of the aircraft (km)
H_{Sat}:	altitude of the FSS satellite (km)
γ:	angle below horizontal at the satellite.

Step 2: Calculation of the e.i.r.p. value from the defined pfd limit:

$$d = \left((R_e + H)^2 + (R_e + H_{sat})^2 - 2(R_e + H)(R_e + H_{sat})\cos(\gamma - \theta) \right)^{1/2}$$

$$\text{e.i.r.p.}(\theta, H) = \text{pfd} + 10\log_{10}(4\,\pi\,d^2) + 60$$

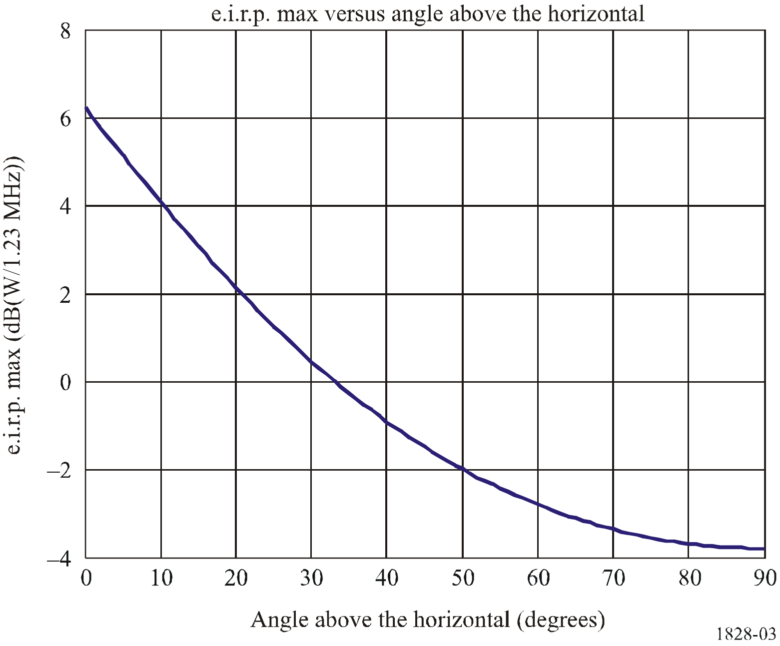
where:

d:	distance between the aircraft stations and the considered point on the Earth's surface (km)
pfd:	pfd limit (dB(W/(m^2 · MHz)))
e.i.r.p.:	(dB(W/MHz)).

Figure 3 shows this function for an aircraft altitudes of 12 km based on the pfd limit provided in Part A of Annex 1. In this example, H_{sat} is taken as 1 414 km.

FIGURE 3

e.i.r.p. max versus angle above the horizontal



Part B

Derivation of a lower hemisphere e.i.r.p. mask from a pfd limit

In testing AMS equipment limited to transmissions of telemetry for flight testing to determine if it meets a given pfd limit, such as the one in Part B of Annex 1, it may be useful to determine an equivalent e.i.r.p. mask that can be used for testing purposes.

The pfd limit can be used to mathematically determine an e.i.r.p. mask, e.i.r.p. (γ, H) where γ is the angle below the local horizontal plane and H is the altitude of the aircraft. This conversion proceeds in two steps. First, γ is converted to an equivalent angle of arrival, θ. Then the length of the propagation path for angle of arrival θ is determined and used to calculate the spreading loss for the path and the resulting e.i.r.p.

Step 1: Calculation of an angle of arrival in degrees, θ, from γ and H:

$$\theta = \arccos((R_e + H)\cos(\gamma)/R_e)$$

where:

θ: angle of arrival

R_e: earth radius (6 378 km)

H: altitude of the aircraft (km)

γ: angle below horizontal.

NOTE 1 – If the argument of the arccos function is greater than 1, the propagation path in the direction of the angle γ does not intersect the Earth. In this case, which occurs for values of γ of about 3.5° or less, a value for θ does not exist and so there is no defined value for the pfd mask.

Step 2: Calculation of the e.i.r.p. value from the defined pfd limit:

$$d = (R_e^2 + (R_e + H)^2 - 2\,R_e(R_e + H)\cos(\gamma - \theta))^{1/2}$$

$$\text{e.i.r.p.}(\gamma, H) = \text{pfd} + 10\log_{10}(4\pi d^2) + 60$$

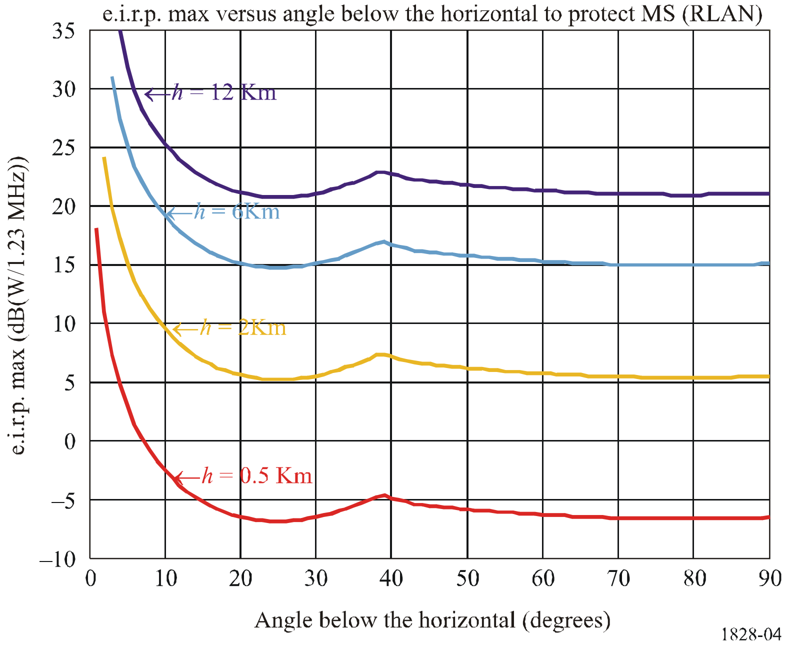
where:

- d: distance between the aircraft stations and the considered point on the Earth's surface (km)
- pfd: pfd limit (dB(W/(m^2 · MHz)))
- e.i.r.p.: (dB(W/MHz)).

Figure 4 shows this function for various aircraft altitudes based on the pfd limit provided in Part B of Annex 1.

FIGURE 4

e.i.r.p. max versus angle below the horizontal to protect MS (RLAN)



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