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Interference criteria for meteorological aids operated in the 400.15-406 MHz and 1 668.4-1 700 MHz bands

RS Series

Remote sensing systems

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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 RS.1263-1

Interference criteria for meteorological aids operated in the 400.15-406 MHz and 1 668.4-1 700 MHz bands

(Question ITU-R 144/7)

(1997-2010)

Scope

This Recommendation provides interference criteria data which should be used for compatibility and sharing studies for MetAids operating in the 400.15-406 MHz and 1 668.4-1 700 MHz bands.

The ITU Radiocommunication Assembly,

considering

a) that interference criteria are needed to ensure that systems can be designed to achieve adequate performance in the presence of interference;

b) that the performance objectives for radiosonde, dropsonde, and rocketsonde systems are specified in Recommendation ITU-R RS.1165;

c) that interference criteria assist in the development of criteria for sharing bands among systems, including those operating in other services;

d) that systems in the meteorological aids (MetAids) service must specify interference thresholds at least equal to the permissible levels,

recommends

1 that the interference levels specified in Tables 1 and 2 should be used as the permissible total levels of interfering signal power at the antenna output of receiving stations operating in the MetAids service based on the MetAids parameters of representative systems as provided in Annex 1.

TABLE 1

Interference criteria for radiosonde systems in the MetAids service

Parameter	Radio direction finding (RDF) radiosonde system 1 668.4-1 700 MHz	GPS radiosonde system 1 675-1 683 MHz	NAVAID with directional antenna 400.15-406 MHz	NAVAID with omnidirectional antenna 400.15-406 MHz
System reference bandwidth	1 300 kHz	150 kHz	300 kHz	
Interference signal power (dBW) in the reference bandwidth to be exceeded no more than $P_{LOCK\text{-}LOSS}$% of the time	–135.3	–137.2	–141.9	Not applicable[1]
Percentage of time, $P_{LOCK\text{-}LOSS}$ (%)[2]	0.02	0.025	0.02	Not applicable[1]
Interference signal power (dBW) in the reference bandwidth to be exceeded no more than $P_{DATA\text{-}LOSS}$% of the time	–139.4	–145.7	–149.6	–154.4
Percentage of time, $P_{DATA\text{-}LOSS}$ (%)[2]	0.8	0.125	0.2	0.2
Interference signal power (dBW) in the reference bandwidth to be exceeded no more than 20% of the time[2]	–155.2	–152.6	–156.1	

(1) Systems with omnidirectional antennas are not vulnerable to losing antenna lock on the signal due to interference or signal fading.

(2) This percentage of time shall not be exceeded on a per-flight basis.

TABLE 2

Interference criteria for rocketsonde and dropsonde systems in the MetAids service

Parameter	Airborne dropsonde systems 400.15-406 MHz	Rocketsonde systems 400.15-406 MHz
System reference bandwidth	20 kHz	3 MHz
Interference signal power (dBW) in the reference bandwidth to be exceeded no more than $P_{LOCK\text{-}LOSS}$% of the time	Not applicable(1)	–116.9
$P_{LOCK\text{-}LOSS}$ (%)(2)	Not applicable(1)	0.02
Interference signal power (dBW) in the reference bandwidth to be exceeded no more than $P_{DATA\text{-}LOSS}$% of the time	–161.6	–122.1
$P_{DATA\text{-}LOSS}$ (%)(2)	0.060	0.060
Interference signal power (dBW) in the reference bandwidth to be exceeded no more than 20% of the time	–168.9	–135.6

(1) Systems with omnidirectional antennas are not vulnerable to losing antenna lock on the signal due to interference or signal fading.

(2) This percentage of time shall not be exceeded on a per-flight basis.

Annex 1

Basis for performance and interference criteria for MetAids in the 400.15-406 MHz and 1668.4-1700 MHz bands

1 Introduction

The bands 400.15-406 MHz (referred to as the 403 MHz bands throughout) and 1668.4-1 700 MHz (referred to as the 1680 MHz band throughout) are allocated to MetAids on a primary basis. The bands 400.15-403 MHz and 1670-1700 MHz are also allocated to the meteorological satellite (METSAT) users on a co-primary basis; and the band 400.15-401 MHz is allocated to the mobile-satellite service (MSS) worldwide. The band 1 668.4-1 675 MHz is allocated to the mobile-satellite service (MSS) on a worldwide basis.

The term MetAids is used to describe a variety of types of meteorological equipment; radiosondes, dropsondes and rocketsondes. MetAids are flown worldwide for the collection of upper atmosphere meteorological data for weather forecasts and severe storm prediction, collection of ozone level data, and measurement of atmospheric parameters for various other applications. The data collected from these flights, or soundings, is of extreme importance for the protection of life and property through the prediction of severe storms and providing vital data for commercial airlines operations.

2 Methodology for calculation of MetAids interference criteria

Since MetAids are typically most vulnerable to interference at the maximum slant range of operation, the interference criteria will be established based on the link margin at the maximum slant range. Although this assumption does not allow other potential users of the bands the flexibility of taking advantage of the higher link margins at shorter slant ranges, this factor may be applied, if appropriate, in detailed sharing studies. This range will be a typical maximum slant range for most of the world, but does not represent the extreme conditions encountered in wintertime at high latitudes.

The interference criteria of MetAids will be established at three points for systems with directional antennas: an interference level and percentage time for loss of receiver tracking lock, an interference level and percentage time for loss of data, and a long -term interference level to be exceeded for no greater than 20% of the time. The loss of receiver lock values are not applicable to MetAids systems with omnidirectional antennas since the antennas cannot be misdirected away from the signal during a period of signal loss or interference. For MetAids systems with omnidirectional antennas, an interference level and percentage of time will be calculated for data loss and for a long-term interference level to be exceeded for no greater than 20% of the time. Since the different types of MetAids are utilized in different applications and exhibit different characteristics, criteria will be established for each.

The first level of short-term interference criteria to be established, applicable only to systems with directional tracking antennas, will be the level associated with loss of receiver tracking lock, which is allowable for only a brief period of time and is only applicable to systems with directional tracking antennas. This is the maximum time in which the receiver can withstand loss of signal and still recover and lock the tracking antenna back on the signal when it returns. The total time percentage, $P\%_{TOTAL}$, loss of tracking lock that may occur will be calculated according to the system and application. That percentage will then be subdivided into a percentage for intrasystem sources, and a percentage for intersystem sources. In this case, loss of lock will be subdivided so that 25% of $P\%_{TOTAL}$ is attributed to intersystem interference.

The interference criteria for loss of tracking lock will be calculated in the following manner:

$$I_{LOCK\text{-}LOSS} = N_{RX} + 10 \log (10^{M/10} - 1) \quad (1)$$

where:

N_{RX}: receiver noise spectral density from link budget (see Tables 4 and 5)

M: margin calculated for loss of lock calculated from link budget (see Tables 4 and 5).

The level, $I_{LOCK\text{-}LOSS}$, shall not be exceeded more than $P\%_{LOCK\text{-}LOSS}$, where:

$$P\%_{LOCK\text{-}LOSS} = 0.25 \ (P\%_{TOTAL})$$

The second level of short-term interference criteria, applicable to all systems, is the level at which loss of data will occur. The percentage of time for this occurrence may be obtained from the user's data availability objectives. The published data availability requirements of MetAids typically are for all sources of data loss and data error. MetAids flights experience sensor data errors, in addition to data loss, which are filtered out during data processing. 25% of the total data loss/error percentage $P\%_{TOTAL}$ will be attributed to interference and 25% of this may be attributed to intersystem interference, hence:

$$P\%_{DATA\text{-}LOSS} = (25\%)\,(25\%)\,(P\%_{TOTAL}) = (6.25\%)\,(P\%_{TOTAL})$$

The interference criteria for data loss will be calculated in the following manner:

$$I_{DATA\text{-}LOSS} = N_{RX} + 10 \log (10^{M/10} - 1) \quad (2)$$

where:

N_{RX}: receiver noise spectral density from link budget (see Tables 4 and 5)

M: margin calculated for data loss from link budget (see Tables 4 and 5).

The level $I_{DATA\text{-}LOSS}$ shall not be exceeded more than $P\%_{DATA\text{-}LOSS}$.

The third interference level will be the long-term level, to be exceeded no more than 20% of the time. The long-term interference level can be calculated based on both the short-term margins for loss of lock (when applicable) and data loss. The level calculated from the short-term loss of lock margin is insignificant since it is dominated by the level calculated from the data loss margin. For the long term (20%), 2/3 of the margin associated with data loss will be retained for MetAids. The interference criteria for data loss will be calculated in the following manner:

$$I_{20\%} = N_{RX} + 10 \log (10^{M/30} - 1)$$

or

$$N_{RX} - 10 \text{ dB, whichever is greater} \quad (3)$$

where:

N_{RX}: receiver noise spectral density from link budget (see Table 4)

M: margin calculated for data loss from link budget (see Table 4).

The level $I_{20\%}$ shall not be exceeded more than 20% of time.

TABLE 3

Percentages of time associated with representative MetAids systems

Percentage	RDF system 1 668.4-1 700 MHz	GPS system 1 675-1 683 MHz	NAVAID system with directional antenna	NAVAID system with omnidirectional antenna	Dropsonde system	Rocketsonde system
Tracking loss percentage of time ($P\%_{TOTAL\text{-}LOCK}$)	0.08%	0.1%	0.08%	N/A[1]	N/A[1]	0.08%
Percentage of tracking loss attributed to intersystem interference ($P\%_{LL\text{-}INTERSYSTEM}$)	25%	25%	25%	N/A[1]	N/A[1]	25%
Maximum link unavailability percentage of time ($P\%_{TOTAL}$)[2]	13.5%	2.0%	1%	1%	1.0%	1.0%
Percentage of data loss attributed to interference ($P\%_{DL\text{-}INTERFERENCE}$)	25%	25%	25%	25%	25%	25%
Percentage of data loss attributed to intersystem interference ($P\%_{DL\text{-}INTERSYSTEM}$)	25%	25%	25%	25%	25%	25%
Resulting percentage of time for tracking loss interference criteria ($P\%_{LOCK\text{-}LOSS}$)	0.02%	0.025%	0.02%	N/A[1]	N/A[1]	0.02%
Resulting percentage of time for data loss interference criteria ($P\%_{DATA\text{-}LOSS}$)	0.8%	0.125%	0.2%	0.2%	0.06%	0.06%

N/A: Not applicable.

(1) Systems with omnidirectional antennas are not vulnerable to losing antenna lock on the signal due to interference or signal fading.

(2) Elements of this table were derived from total flight data availability data taken from Recommendation ITU- RS.1165-2.

3 Link budget analysis for MetAids

The various types of MetAids are utilized for different purposes and have different system characteristics, and as a result have different link budget calculations. Tables 4 and 5 list the link budget calculations for representative systems used worldwide.

TABLE 4

Link budget calculations for MetAids operated in the band 400.15-406 MHz

Performance factor	NAVAID directional antenna		NAVAID omnidirectional antenna	Dropsondes	Rocketsonde	
Modulation type	FM				AM	
Frequency range (MHz)	400.15-406					
Per cent time performance is not exceeded (%)	0.02 track loss	0.2 data loss	0.2 data loss	0.06 data loss	0.02 track loss	0.06 data loss
1 Transmitter output power (dBW)	–6.0		–6.2	–8.5	–5.2	
2 Antenna gain average (dBi)	2.0		–4	2.0	0.0	
3 Transmitter e.i.r.p. (dBW)	–4.0		–10.2	–6.5	–5.2	
4 Maximum link length (km)	250		150	350	70	
5 Free-space path loss (dB)	132.5		128.0	135.4	121.4	
6 Excess path loss (rain, fading, etc.) (dB)	1.5		1.0	4.0	0.25	
7 Ground station antenna gain (dBi)	8.0		2.0	0.0	20	
8 Ground station antenna pointing error (dB)	0.0				0.5	
9 Receiver system loss (antenna feed, cables, etc.) (dB)	2.0			0.0	2.0	
10 Polarization mismatch loss (dB)	0.5			0.0	0.5	
11 Received signal power (dBW)	–132.5		–133.5	–145.9	–109.85	
12 Receiver reference bandwidth (kHz)	300			20	3 000	
13 Reference bandwidth (dBHz)	54.8			42.5	64.8	
14 Received energy per Hz, C_0 dB(W/Hz))	–187.3		–188.3	–188.4	174.65	
15 Receiver system noise temperature (K)	600			410	738	
16 Receiver system noise power (dBW)	–146			–160	–165	
17 Receiver noise spectral density, N_0 dB(W/Hz))	–200.9			–202.5	–200.5	
18 Minimum C_0/N_0 (dB)	7	12	12	12	7	12
19 Actual C_0/N_0 for flight (dB)	13.6		12.6	14.1	25.8	
20 Margin (dB)	5.6	1.6	0.6	2.1	18.9	13.8

TABLE 5

Link budget calculations for MetAids operated in the band 1 668.4-1 700 MHz

		RDF system		GPS system	
Modulation type		AM		FM	
Frequency range (MHz)		1 668.4-1 700		1 675-1 683	
Per cent time performance is not exceeded (%)		0.02 track loss	0.8 data loss	0.025 track loss	0.125 data loss
1	Transmitter output power (dBW)	–6.0		–5.0	
2	Antenna gain average (dBi)	2.0		–2	
3	Radiosonde e.i.r.p. (dBW)	–4.0		–3.0	
4	Maximum link length (km)	250			
5	Free-space path loss (dB)	144.9			
6	Excess path loss (rain, fading, etc.) (dB)	2.0		5.0	
7	Ground station antenna gain (dBi)	28		26	
8	Ground station antenna pointing error (dB)	0.5		0.0	
9	Receiver system loss (antenna feed, cables, etc.) (dB)	3.0		0.5	
10	Polarization mismatch loss (dB)	0.5		3	
11	Received signal power (dBW)	–126.9		–130.4	
12	Receiver reference bandwidth (kHz)	1 300		150	
13	Reference bandwidth (dBHz)	61.1		52	
14	Received energy per Hz, C_0 (dB(W/Hz))	–188.0		–182.4	
15	Receiver system noise temperature (K)	738		1 000	
16	Receiver system noise power (dBW)	–168.7		–146.8	
17	Receiver noise spectral density, N_0 (dB(W/Hz))	–200.5		–197.4	
18	Minimum C_0/N_0 (dB)	7	12	6	12
19	Actual C_0/N_0 for flight (dB)	12.5		15	
20	Margin (dB)	5.5	0.5	9.0	3.0

4 Calculation of MetAids interference criteria

4.1 Radiosondes

The interference criteria can be calculated utilizing equations (1), (2) and (3), and the results of the link budget analysis in Table 4. The interference criteria established for each of the three radiosonde systems are presented in Tables 6 and 7.

TABLE 6

Interference criteria for radiosonde systems operating in the band 400.15-406 MHz

Parameter	NAVAID (with directional antenna) 400.15-406 MHz	NAVAID (with omnidirectional antenna) 400.15-406 MHz
Receiver noise spectral density (dB(W/Hz))	–200.9	
Receiver reference bandwidth (dB/Hz)	54.8	
Link margin (dB) $P_{LOCK\text{-}LOSS}$ = 0.02%	5.6	Not applicable(1)
Link margin (dB) $P_{DATA\text{-}LOSS}$ = 0.2%	1.6	0.6
Interference level not to be exceeded more than $P_{LOCK\text{-}LOSS}$ = 0.02% of the time (equation (1))	–141.9 dBW(300 kHz)	Not applicable(1)
Interference level not to be exceeded more than $P_{DATA\text{-}LOSS}$ = 0.2% of the time (equation (2))	–149.6 dBW(300 kHz)	–154.4 dBW(300 kHz)
Interference level not to be exceeded more than 20% of the time (equation (3))	–156.1 dBW(300 kHz)	

(1) Systems with omnidirectional antennas are not vulnerable to losing antenna lock on the signal due to interference or signal fading.

TABLE 7

Interference criteria for radiosonde systems operating in the band 1 668.4-1 700 MHz

Parameter	RDF system 1 668.4-1 700 MHz	GPS system 1 675-1 683 MHz
Receiver noise spectral density (dB(W/Hz))	–200.5	–197.4
Receiver reference bandwidth (kHz)	1 300	150
First short-term link margin (dB), $P_{LOCK\text{-}LOSS}$	5.5	9.0
First short-term percentage of time, $P_{LOCK\text{-}LOSS}$ (%)	0.02	0.025
Second short-term link margin (dB), $P_{DATA\text{-}LOSS}$	0.5	3.0
Second short-term percentage of time, $P_{DATA\text{-}LOSS}$ (%)	0.8	0.125
Interference level not to be exceeded more than $P_{LOCK\text{-}LOSS}$% of the time (equation (1) (dBW within ref. bandwidth)	–135.3	–137.2
Interference level not to be exceeded more than $P_{DATA\text{-}LOSS}$% of the time (equation (2) (dBW within ref. bandwidth)	–139.4	–145.7
Interference level not to be exceeded more than 20% of the time (equation (3) (dBW within ref. bandwidth)	–155.2	–152.6

4.2 Dropsondes

Equations (1), (2) and (3) can be used to calculate the interference criteria for dropsondes. The interference criteria for dropsondes are presented in Table 8.

TABLE 8

Interference criteria for dropsonde systems

Parameter	Dropsonde systems 400.15-406 MHz
Receiver noise spectral density (dB(W/Hz))	–202.5
Receiver reference bandwidth (dB/Hz)	42.5
Link margin (dB) $P_{DATA\text{-}LOSS}$ = 0.06%	2.1
Interference level not to be exceeded more than $P_{DATA\text{-}LOSS}$% = 0.06% of the time (equation (2))	–161.6 dBW(20 kHz)
Interference level not to be exceeded more than 20% of the time (equation (3))	–168.9 dBW(20 kHz)

4.3 Rocketsondes

Equations (1), (2) and (3) can be used to calculate the interference criteria for rocketsondes. The interference criteria for rocketsondes is presented in Table 9.

TABLE 9

Interference criteria for rocketsonde systems

Parameter	Rocketsonde systems 400.15-406 MHz
Receiver noise spectral density (dB(W/Hz))	–200.5
Receiver reference bandwidth (dB/Hz)	64.8
Link margin (dB) $P_{LOCK\text{-}LOSS}$ = 0.02%	18.9
Link margin (dB) $P_{DATA\text{-}LOSS}$ = 0.06%	13.85
Interference level not to be exceeded more than $P_{LOCK\text{-}LOSS}$ = 0.02% of the time (equation (1))	–116.9 dBW(3 MHz)
Interference level not to be exceeded more than $P_{DATA\text{-}LOSS}$ = 0.06% of the time (equation (2))	–122.1 dBW(3 MHz)
Interference level not to be exceeded more than 20% of the time (equation (3))	–135.6 dBW(3 MHz)