RECOMMENDATION ITU-R SA.1160-2

INTERFERENCE CRITERIA FOR DATA DISSEMINATION AND DIRECT DATA READOUT SYSTEMS IN THE EARTH EXPLORATION-SATELLITE AND METEOROLOGICAL-SATELLITE SERVICES USING SATELLITES IN THE GEOSTATIONARY ORBIT

(Question ITU-R 141/7)

(1995-1997-1999)

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 interference criteria may be determined using the methodology described in Recommendation ITU-R SA.1022 and the performance objectives listed in Recommendation ITU-R SA.1159;

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 Earth exploration-satellite service (EESS) and meteorological-satellite (MetSat) service must specify interference thresholds at levels greater than or equal to the permissible levels;

e) that Annex 1 presents the parameters of representative systems that provide the basis for permissible levels of interference for pertinent transmissions in the EESS and MetSat service,

recommends

1 that the interference levels specified in Table 1 be used as the permissible total levels of interfering signal power at the antenna output of stations operating in the EESS and MetSat service.

TABLE 1

Interference criteria for stations in the EESS and MetSat service using spacecraft in the geostationary orbit

Frequency band (MHz)	Function and type of earth station	Interfering signal power (dBW) in the reference bandwidth to be exceeded for no more than 20% of the time	Interfering signal power (dBW) in the reference bandwidth to be exceeded for no more than *p*% of the time
1 670-1 710 space-to-Earth	Direct data readout High gain antenna	–153.8 dBW per 2.6 MHz	–148.6 dBW per 2.6 MHz $p = 0.025$
	Data dissemination Low gain antenna	–167.5 dBW per 4 kHz	–160.4 dBW per 4 kHz $p = 0.025$
	Data dissemination High gain antenna	–153.4 dBW per 2.11 MHz	–148.1 dBW per 2.11 MHz $p = 0.025$
2 025-2 110 Earth-to-space	Command data acquisition (CDA) station High resolution data	–136.7 dBW per 2.11 MHz	–133.4 dBW per 2.11 MHz $p = 0.025$
	CDA station WEFAX data	–147.8 dBW per 4 kHz	–140.7 dBW per 4 kHz $p = 0.025$
25 500-27 000 space-to-Earth	Direct data readout	–131.7 dBW per 10 MHz	–116.3 dBW per 10 MHz $p = 0.25$

NOTE 1 – The interfering signal powers (dBW) in the reference bandwidths are specified for reception at elevation angles ≥ 3°.

NOTE 2 – The total interfering signal power level that may be exceeded for no more than *x*% of the time, where *x* is less than 20% but greater than the specified short-term time percentage (*p*% of the time), may be determined by interpolation between the specified values using a logarithmic scale (base 10) for percentage of time and a linear scale for interfering signal power density (dB).

NOTE 3 – The sharing criteria can be expressed as permissible power flux-densities into the main beam of the receive antenna by subtracting 10 log($G\ \lambda^2/4\pi$) from the value given in Table 1, where G is the receive antenna gain and λ is the wavelength.

NOTE 4 – Although the interference criteria are based on the systems described in Annex 1, the interference criteria apply to all systems that operate in the subject frequency bands and which provide the specified service functions.

ANNEX 1

Basis for interference criteria

This Annex presents the parameters used as inputs to the methodology of Recommendation ITU-R SA.1022 to determine the interference criteria for data dissemination and direct readout systems.

1 Direct readout systems

Table 2 develops these criteria for direct readout systems, in which all of the interference enters the receiving station directly, and none is received at the station via the satellite that originates the data.

The interference criteria can be expressed as permissible power flux-densities into the main beam of the receive antenna by subtracting 10 log($G\ \lambda^2/4\pi$) from the values given in Table 2, where G is the receive antenna gain and λ is the wavelength.

TABLE 2

Direct data readout system performance used as a basis for interference criteria of stations operating with satellites in geostationary orbit

a) Frequency band 1 670-1 710 MHz

Link parameter		Value	Notes
Down-link e.i.r.p.		16.1 dBW	
Down-link loss		190.1 dB	Free-space, polarization, and antenna pointing
Down-link G/T		24.4 dB(K^{-1})	
Down-link C/N_0		79.0 dB/Hz	
Data rate		2.6 Mbit/s	
Required C/N_0		78.1 dB/Hz	BER = 1×10^{-6} 2.2 dB implementation loss 1 dB modulation loss
Margin		0.9 dB	Long-term and short-term
Receive antenna gain		45.1 dBi	
Receiver noise density		–207.9 dB(W/Hz)	
Interference criteria	Long-term	–153.8 dB(W/2.6 MHz)	q = 1/3 and M_{min} = 1.2 dB
	Short-term	–148.6 dB(W/2.6 MHz)	q = 1 and M_{min} = 1.2 dB

TABLE 2 (*continued*)

b) Frequency band 25.5-27.0 GHz

Link parameter		Value	Notes
Down-link e.i.r.p.		50.8 dBW	
Down-link loss	Long-term	213.2 dB	Free-space, polarization, and antenna pointing
	Short-term	220.3 dB	7.1 dB excess path loss
Down-link G/T		31.6 dB(K^{-1})	
Down-link C/N_0	Long-term	97.8 dB/Hz	
	Short-term	90.7 dB/Hz	
Data rate		15 Mbit/s	
Required C/N_0		83.8 dB/Hz	BER = 1×10^{-7} 0.5 dB implementation loss 1 dB modulation loss
Margin	Long-term	14.0 dB	
	Short-term	6.9 dB	
Receive antenna gain		60.1 dBi	
Receiver noise density		–200.1 dB(W/Hz)	
Interference criteria	Long-term	–131.7 dB(W/10 MHz)	q = 1/3 and M_{min} = 1.2 dB
	Short-term	–116.3 dB(W/10 MHz)	q = 1 and M_{min} = 1.2 dB

2 Data dissemination systems

Dissemination of high-resolution processed data and lower-resolution WEFAX data is affected by interference received at the station via the satellite as well as by interference transmitted directly into the station in the 1 670-1 710 MHz band. The high-resolution processed data and the WEFAX data are up-linked to the satellite in the 2 025-2 110 MHz band, and relayed, along with interfering signals entering the satellite in the same band, to the Earth station receivers via fixed-gain satellite transponders.

The up-link and down-link carrier-to-noise plus interference density ratios are respectively:

$$\left(\frac{C}{N_0 + I_0} \right)_{up} = \frac{(C/N_0)_{up}}{1 + \dfrac{I_{01}}{k\,T_1}}$$

and

$$\left(\frac{C}{N_0 + I_0} \right)_{down} = \frac{(C/N_0)_{down}}{1 + \dfrac{I_{02}}{k\,T_2}}$$

where:

I_{01} and I_{02}: interference densities transmitted into the satellite and station receivers

T_1 and T_2: system noise temperatures of the satellite and station receivers

k: Boltzmann's constant.

The composite carrier-to-noise plus interference density ratio is:

$$\frac{C}{N_0 + I_0} = \left[\left(\frac{C}{N_0 + I_0} \right)_{up}^{-1} + \left(\frac{C}{N_0 + I_0} \right)_{down}^{-1} \right]^{-1}$$

From Recommendation ITU-R SA.1022 this can also be written:

$$\frac{C}{N_0 + I_0} = M^{-q} \frac{C}{N_0}$$

where:

M: interference-free margin

q: action of the interference-free margin that the interference is allowed to consume

C/N_0: composite carrier-to-noise density ratio given by:

$$C/N_0 = \left[(C/N_0)_{up}^{-1} + (C/N_0)_{down}^{-1} \right]^{-1}$$

From the foregoing equations:

$$M^q = 1 + \frac{\frac{I_{01}}{k\,T_1}(C/N_0)_{up} + \frac{I_{02}}{k\,T_2}(C/N_0)_{down}}{(C/N_0)_{up} + (C/N_0)_{down}}$$

Assume that the up-link and down-link interference are allocated so that a fraction p of the interference received at the earth station is received via the satellite, and that a fraction $1 - p$ is transmitted directly into the station. It is desirable for p to be near 1/2 in order to provide a reasonable balance in the interference allocated to the up-link and to the down-link. For a fixed-gain transponder it can be shown that:

$$\frac{I_{02}}{k\,T_2} = \frac{1 - p}{p} \frac{I_{01}}{k\,T_1} \frac{(C/N_0)_{down}}{(C/N_0)_{up}}$$

so that:

$$M^q = 1 + \frac{1}{p} \frac{I_{01}}{k\,T_1} \left[1 + \frac{(C/N_0)_{up}}{(C/N_0)_{down}} \right]^{-1}$$

Accordingly, the permissible up-link interference density becomes:

$$I_{01} = 1 + p\,k\,T_1 \left[1 + \frac{(C/N_0)_{up}}{(C/N_0)_{down}} \right] \left(M^q - 1 \right) \qquad \text{for } M > M_{mín}$$

where, according to Recommendation ITU-R SA.1022, M_{min} is the smallest interference-free margin for which only a fraction q of the margin is consumed by the interference. Correspondingly, the permissible down-link interference density is:

$$I_{02} = (1 - p)\,k\,T_2 \left[1 + \frac{(C/N_0)_{down}}{(C/N_0)_{up}} \right] \left(M^q - 1 \right) \qquad \text{for } M > M_{min}$$

Tables 3 and 4 summarize the calculation of I_{01} and I_{02} for high-resolution and WEFAX data respectively, assuming that $p = 1/2$, $q = 1/3$, and $M_{min} = 1.2$ dB for long-term interference, and that $p = 1/2$, $q = 1$, and $M_{min} = 1.2$ dB for short-term interference.

The interference criteria can be expressed as permissible power flux-densities into the main beam of the receive antenna by subtracting $10 \log(G\,\lambda^2/4\pi)$ from the values given in Tables 3 and 4, where G is the receive antenna gain and λ is the wavelength.

TABLE 3

Performance analysis used as a basis for interference criteria of high-resolution data dissemination systems using geostationary satellites

Link parameter		Value	Notes
Up-link e.i.r.p.		72.1 dBW	
Up-link loss		191.7 dB	Free-space, polarization, and antenna pointing
Up-link G/T		–17.5 dB(K^{-1})	Post-launch measurement
Up-link C/N_0		91.5 dB/Hz	
Down-link e.i.r.p.		23.8 dBW	
Down-link loss		190.1 dB	Free-space, polarization, and antenna pointing
Down-link G/T		15.2 dB(K^{-1})	
Down-link C/N_0		77.5 dB/Hz	
Composite C/N_0		77.3 dB/Hz	
Data rate		2.11 Mbit/s	
Required C/N_0		75.9 dB/Hz	BER = 1×10^{-6} 1.9 dB implementation loss
Margin		1.4 dB	
Up-link receive antenna gain		9.5 dBi	
Up-link noise density		–201.6 dB(W/Hz)	T = 500 K
Up-link interference criterion	Long-term	–136.7 dB(W/2.11 MHz)	q = 1/3
	Short-term	–133.4 dB(W/2.11 MHz)	q = 1
Down-link receive antenna gain		39.5 dBi	
Down-link noise density		–204.3 dB(W/Hz)	T = 269 K
Down-link interference criterion	Long-term	–153.4 dB(W/2.11 MHz)	q = 1/3
	Short-term	–148.1 dB(W/2.11 MHz)	q = 1

TABLE 4

Performance analysis used as a basis for interference criteria of WEFAX data dissemination systems using geostationary satellites

Link parameter	Value	Notes
Up-link e.i.r.p.	66.7 dBW	
Up-link loss	191.7 dB	Free-space, polarization, and antenna pointing
Up-link G/T	–17.5 dB(K^{-1})	Post-launch measurement
Up-link C/N_0	86.1 dB/Hz	
Down-link e.i.r.p.	24.3 dBW	
Down-link loss	189.6 dB	Free-space and polarization
Down-link G/T	–0.3 dB(K^{-1})	
Down-link C/N_0	63.0 dB/Hz	

TABLE 4 (*end*)

Link parameter		Value	Notes
Composite C/N_0		63.0 dB/Hz	
IF bandwidth		50 kHz	
Required C/N_0		57.0 dB/Hz	10 dB FM threshold
Margin		6.0 dB	
Up-link receive antenna gain		9.5 dBi	
Up-link noise density		–201.6 dB(W/Hz)	T = 500 K
Up-link interference criterion	Long-term	–147.8 dB(W/4 kHz)	q = 1/3
	Short-term	–140.7 dB(W/4 kHz)	q = 1
Down-link receive antenna gain		30.1 dBi	
Down-link noise density		–198.2 dB(W/Hz)	T = 1 100 K
Down-link interference criterion	Long-term	–167.5 dB(W/4 kHz)	q = 1/3
	Short-term	–160.4 dB(W/4 kHz)	q = 1