RECOMMENDATION ITU-R SA.1396*

PROTECTION CRITERIA FOR THE SPACE RESEARCH SERVICE IN THE 37-38 GHz AND 40-40.5 GHz BANDS

(Question ITU-R 211/7)

(1999)

The ITU Radiocommunication Assembly,

considering

a) that limiting interference criteria for telecommunication links for space research are determined by the technical considerations examined in Annex 1;

b) that two-way communication is required for many space research missions, and is vital for manned missions;

c) that space research systems will be implemented in the 37-38 GHz and 40-40.5 GHz bands;

d) that these systems will serve *inter alia* lunar and planetary manned and unmanned missions and space very long baseline interferometry (S-VLBI) missions having bandwidth requirements that cannot be accommodated in lower frequency bands allocated to the space research service;

e) that the lunar and planetary space stations planned for these bands will spend all or a part of their mission lifetimes within the ITU-defined deep space limit of 2×10^6 km from the Earth and thus cannot be accommodated within other space research bands restricted to deep space;

f) that overall system operating noise temperatures of earth stations may be as low as 60 K (equivalent to −211 dB(W/Hz)) in the 37-38 GHz band;

g) that overall system operating noise temperatures of space stations may be as low as 200 K (equivalent to −193 dB(W/20 Hz)) in the 40-40.5 GHz band;

h) that link margins for space-to-Earth links are small, typically between 2 and 4 dB;

j) that link margins for Earth-to-space links are typically between 6 and 9 dB;

k) that an increase of 1 dB in overall system noise due to interference is considered harmful to a space-to-Earth link;

l) that an increase of 3 dB in overall system noise due to interference is considered harmful to an Earth-to-space link;

m) that a noise to interference ratio of about 6 dB results in 1 dB increase in overall system operating noise;

n) that a noise to interference ratio of about 0 dB results in 3 dB increase in overall system operating noise;

o) that technical and/or regulatory limitations restrict increases in spacecraft power as a means of minimizing interference;

p) that space research protection criteria and required bandwidths can be found in Recommendations ITU-R SA.609, ITU-R SA.1157 and ITU-R SA.1015,

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* This Recommendation should be brought to the attention of Radiocommunication Study Groups 4 and 9.

noting

a) the potential difficulties to be expected in frequency sharing between stations in the space research service and certain types of stations in other services,

recommends

1 that protection criteria (see Note 1) for earth stations in the space research service be established as follows:

1.1 –217 dB(W/Hz) at the input terminals of the receiver, in the 37-38 GHz band;

1.2 that calculation of interference to a space research earth station that may result from atmospheric and precipitation effects should be based on weather statistics for 0.001% of the time for manned missions and for 0.1% of the time for unmanned missions;

2 that protection criteria (see Note 1) for space research space stations be established as follows: –193 dB(W/20 Hz) at the input terminals of the receiver, for 0.1% of the time for both manned and unmanned spacecraft, for the 40-40.5 GHz band.

NOTE 1 – These protection criteria are intended to protect unique operations during critical mission events in the space research service from unexpected interference. Levels in excess of the protection criteria may be acceptable on a case by case basis.

ANNEX 1

Protection criteria relating to space research systems in the 37-38 GHz and 40-40.5 GHz bands

1 Introduction

Lunar and planetary and other stations will be implemented in the 37-38 GHz and 40-40.5 GHz bands allocated to the space research service on primary basis worldwide. These systems will be used *inter alia* for high-rate digital data transfer of telemetry, voice, and video between the Earth and other planetary bodies such as the Moon and Mars to support manned exploration. Further, the 37-38 GHz band will be used for high-rate data transfer from an Earth-orbiting S-VLBI station. The digital data transfer will enable operations such as information management for the safe conduct of human exploration missions, coordination and status of planned activities, updating of data files, and relay of scientific data. Data rates on the order of 100 Mbit/s from planetary ranges, 500 Mbit/s from lunar range and 1 000 Mbit/s from S-VLBI station to Earth will be implemented.

2 Protection criteria

In a communication link, the permissible ratio of interference to system noise may be determined by the portion of design margin allocated to external interference. In space-to-Earth links, the incentive is to minimize link margins in order to save weight and power, to comply with emission limits, and in the interest of economy. Typical link design margins to allow for the effects of non-ideal conditions from all causes are generally in the range of 2 dB to 4 dB.

Considering these low link margins, interference can be harmful to a typical earth station in the space research service if the link performance is decreased by more than 1 dB. This corresponds to a required ratio of system noise spectral density to interference spectral density (N/I) of about 6 dB.

Considering that margins are higher for the Earth-to-space links, interference can be harmful to a typical space station in the space research service if the link performance is degraded by more than 3 dB. This corresponds to a required N/I of about 0 dB.

2.1 Reference bandwidth

The reference bandwidth in which a protection level must be specified depends upon the smallest bandwidth likely to be employed. For earth-station receivers, phase-locked loops may employ bandwidths as low as 1 Hz. The detection bandwidth of space stations is usually greater (20 Hz or more) due to the need for rapid, automatic acquisition of signals from the Earth.

Thus, recommended values for the reference bandwidths for space research receivers are:

– earth-station receivers: 1 Hz;

– space-station receivers: 20 Hz.

2.2 Reference percentage of time

When considering interference to space research earth stations, it is necessary to note that sporadic interference from man-made sources can be expected due to trans-horizon propagation, fluctuating weather conditions, and the changing gain in the link between the interfering station and the receiving station due to the relative motions of the antennas, etc. Therefore, any criterion of interference which is established must be stringent enough to minimize the possibility of this type of interference.

Further, as propagation data are usually presented in the form of a percentage of time that certain conditions are exceeded, it is necessary to relate outage time with propagation data. For manned space missions, a loss of more than 5 min of communication during critical periods would seriously affect the mission. However, it is usual that propagation conditions are such that the lowest transmission loss between two stations will persist for much longer periods than 5 min. Therefore, to provide protection which will prevent interference for longer than 5 min per day, it is necessary not only to consider the worst hour in the year, but also the worst 5 min within that hour. This is approximately 0.001% of the time. For unmanned missions, where safety of life is not a factor, the reference percentage of time is 0.1%.

2.3 Required protection levels

2.3.1 Earth-station receivers

In the 37-38 GHz region, the total noise temperature of receiving earth stations may be as low as 60 K. This total is a function of antenna elevation angle, existing meteorological conditions and other factors. Therefore, based on the established *N/I* ratio of 6 dB, and a receive noise temperature of 60 K, the following criterion is the most directly appropriate for the protection of earth stations:

In the frequency range 37-38 GHz, harmful interference can occur if the total time during which the power density of noise-like interference or the total power of CW-type interference in any single band or in all sets of bands 1 Hz wide, is greater than –217 dB(W/Hz) at the input terminals of the earth station receiver for a period exceeding 0.001% of the time for manned missions, and 0.1% of the time for all other space research missions.

2.3.2 Space-station receivers

The total noise temperature of a 40 GHz space-station receiver is generally 200 K when viewing cold space background. Based on the established *N/I* of 0 dB, the following criterion is most directly appropriate for the protection of space stations:

In the frequency range 40-40.5 GHz, harmful interference can occur if the power density of noise-like interference or the total power of CW-type interference in any single band or in all sets of bands 20 Hz wide, is greater than –193 dB(W/20 Hz) at the input terminals of the space station receiver.

Due to the motion of low-orbit spacecraft, which can be susceptible to this level of interference, the amount of time of exposure to the interference is limited to 0.1% of the time for both manned and unmanned missions.