

RECOMMENDATION ITU-R SA.363-5*

SPACE OPERATION SYSTEMS

Frequencies, bandwidths and protection criteria

(Question ITU-R 128/7)

(1963-1974-1982-1986-1990-1994)

The ITU Radiocommunication Assembly,

considering

- a) that the frequencies technically suitable for maintenance telemetering, tracking and telecommand of developmental and operational radionavigation, meteorological, communication, earth exploration and broadcasting satellites lie in the range from 100 MHz to 30 GHz (see Annex 1);
- b) that the preferred bands of frequencies for maintenance telemetering, precision tracking and telecommand are between 1 and 8 GHz;
- c) that, as an exception, bands of frequencies above about 10 GHz are technically suitable for use for maintenance telemetering, tracking and telecommand during the re-entry of satellites into the atmosphere of the Earth (see Annex 2);
- d) that the integration of maintenance telemetering, tracking and telecommand links with data transmission and communication systems may have advantages which include, among others, efficient use of the spectrum particularly for the on-station operational phase of geostationary satellites;
- e) that the validity of this approach has been demonstrated in some operational systems;
- f) that satellite safety nonetheless requires wide-coverage antenna radiation to maintain links during specific phases of launch and orbit transfer or in cases of momentary loss of attitude, and that wide-coverage radiation is difficult to obtain at frequencies above 8 GHz;
- g) that, in the case of broadcasting satellites, Appendix 30 of the Radio Regulations (RR) provides for the use of the bands 11.7 to 12.5 GHz in Region 1 and 11.7 to 12.2 GHz in Region 3 by assigning channels to the administrations in those Regions for satellite broadcasting, but no specific assignments were made for maintenance telemetering, tracking and telecommand (although RR Annex 5 to Appendix 30 specifies guard bands at the edges of both bands) and that consequently it may be difficult to use these bands also for maintenance telemetering, tracking or telecommand. (Some potential difficulties involved in this particular implementation of the space operation function are discussed in Report ITU-R BO.1076 ex-CCIR Report 1076, Düsseldorf, 1990.) In the case of Region 2, RR Appendix 30 provides that space operation systems could be used in the specified guard bands of 12 MHz at each end of the 12.2 to 12.7 GHz band and similarly, in RR Appendix 30A in the 17.3 to 17.8 GHz band;
- h) that, in most cases, the necessary bandwidths for space operations are determined by the transmission of ranging signals, and usually lie between 200 kHz and 1 MHz with classical modulation methods;
- j) that the e.i.r.p. of space station transmitters is limited, so that earth receiving stations must operate at maximum sensitivity;
- k) that the e.i.r.p. of earth-station transmitters can be increased within the limits defined in the RR to give an acceptable protection ratio at space station receiver inputs,

* This Recommendation should be brought to the attention of Radiocommunication Study Groups 4, 3, 8, 9, 10 and 11.

recommends

1. that bands of frequencies below 1 GHz are technically suitable for use for some types of maintenance telemetering, tracking and telecommand of developmental and operational low-orbit (for example, below 2000 km) satellites;
2. that frequencies for maintenance telemetering, precision tracking and telecommand should be between 1 and 8 GHz;
3. that as an exception, bands of frequencies above about 10 GHz be used for maintenance telemetering, tracking and telecommand during the re-entry of satellites into the atmosphere of the Earth (see Annex 2);
4. that, for satellite systems such as those used for meteorological, radionavigation, communication, earth exploration and broadcasting purposes, and taking account of requirements for reliability and economical use of the frequency spectrum and for the safety of spacecraft in all phases of operation, frequencies within the mission bands used for data transmission or communications are preferred for use for maintenance telemetering, tracking and telecommand, where practicable. Where this is not practicable, frequencies in the bands specifically allocated to the space operation service should be used;
5. that the special needs for maintenance telemetering, tracking and telecommand be considered in the planning of frequencies for the broadcasting-satellite service and for the associated feeder links, especially for those assignments sharing one orbital location;
6. that the protection criteria for earth station receivers be as follows: for frequencies above 1 GHz, total interference power in each band 1 kHz wide must not exceed -184 dBW at the receiver input for more than 1% of the time each day; for frequencies below 1 GHz, this value is increased by 20 dB per decreasing frequency decade;
7. that the protection criteria for spacecraft receivers be as follows: the ratio of signal power to total interference power in each band 1 kHz wide must not fall below 20 dB for more than 1% of the time, each day;
8. that, as these criteria are insufficient to guarantee the safety of spacecraft in certain brief critical phases, such as launching, the administrations concerned should coordinate to guarantee the safety of spacecraft during such brief critical phases.

ANNEX 1

Space operation systems

Frequencies, bandwidths and protection criteria

1. Introduction

The World Administrative Radio Conference (Geneva, 1979), defined the space operation service as follows:

“A radiocommunication service concerned exclusively with the operation of spacecraft, in particular space tracking, space telemetry and space telecommand.

These functions will normally be provided within the service in which the space station is operating.”

To understand the meaning of the second sentence in the definition, it should be borne in mind that the original idea was to carry out space operation functions solely in the bands allocated to missions. Experience showed, however, that space operation could be facilitated in some cases by the specific allocation of bands to this service. In particular, this makes it possible to use a small number of stations for the space operation of satellites with missions pertaining to different services, such as the space research, meteorological-satellite, earth exploration-satellite, fixed- and mobile-satellite and broadcasting-satellite services.

Furthermore, the frequency bands technically suitable for space operation do not always coincide with the bands which are suitable to missions, and there may be different protection criteria for space operation and mission telecommunication receivers.

This Annex covers successively the functions to be carried out, the preferred frequency bands, the bandwidths, the protection criteria and various operational aspects of space operation systems.

All aspects are dealt with in such a way that the conclusions are applicable both for cases where space operation functions are performed in a frequency band related to a satellite's mission, and for cases where they are carried out in a frequency band allocated to the space operation service.

Links in space operation systems may be established either directly between spacecraft and earth stations or through data relay satellites. Only direct links are considered here. For links via data relay satellites, see Report ITU-R SA.848 (ex-CCIR Report 848, Düsseldorf, 1990).

2. Space operation functions

The main functions of space operations are:

- maintenance telemetry,
- telecommand,
- tracking,
- RF sensing for attitude control.

2.1 Maintenance telemetry

To ensure the maintenance of a spacecraft, a large number of measured data, most of them with a low data rate, have to be transmitted to the Earth. They include:

- temperature measurements, either for monitoring and regulation or for correction of on-board instrument readings in the light of their temperature;
- magnetic field measurements, to provide particulars of the instantaneous attitude of the spacecraft or its rotation speed;
- measurements of moving units: separation indicators, safety stops for deployed components;
- inertial measurements (rate gyros, accelerometers), useful for satellite attitude and station keeping;
- optical measurements, to ascertain the attitude of the spacecraft in relation to the Earth, the Sun and stars;
- measurements of pressure in tanks and electrochemical batteries;
- current and voltage measurements;
- reports on the condition of a component or the reception or execution of a command.

All these measurements may be used to monitor the condition of spacecraft and their payloads which depends on the external environment and on configuration orders addressed to the spacecraft by telecommand or provided by an on-board sequencer according to a predetermined programme.

These data are useful for ensuring proper operational conditions, optimizing the spacecraft and payload mission facilities and analysing unforeseen situations. They also serve to broaden knowledge of the behaviour of materials in orbit and to improve the development of new systems.

Telemetry data from the on-board memory may be transmitted in real time or stored and subsequently transmitted.

2.2 Telecommand

Most spacecraft should be able to receive orders by telecommand. RR No. 2612 makes this mandatory in the case of the active satellites defined in RR No. 172.

2.2.1 In the case of short-mission spacecraft, such as launchers, most of the orders can be recorded before the flight and distributed as necessary by an on-board sequencer.

Nevertheless, space telecommand is generally used for safety purposes (e.g. stopping the propulsion of a launcher deviating from its assigned trajectory or destroying it if required).

Certain telecommand functions can also be carried out by a radar transponder operating in the radiolocation service.

2.2.2 In most other cases, telecommand is needed to modify the operation of the spacecraft and its payload:

- according to successive utilization phases during the mission,
- according to different flight phases (orbit insertion, eclipse periods, etc.), or
- as a result of abnormal events, such as operational anomalies.

The orders transmitted to the spacecraft when it is in line of sight of an earth station may be either carried out immediately or stored in a memory from which they are extracted later for execution at a time also stored in the memory.

Delayed-action telecommand is particularly important for complex spacecraft missions requiring an on-board computer. In such cases, a megabit of information may have to be transmitted in a few minutes. Satisfactory reception of telecommand signals is generally acknowledged by telemetry.

2.3 Tracking

Space tracking, i.e., the determination of the orbit, velocity or instantaneous position of an object in space by means of the propagation properties of radio waves (see RR Nos. 130 and 10) has to be carried out during every space mission to meet one or more of the following requirements.

2.3.1 Spacecraft orbit control system

Broadly speaking, this is one of the methods for controlling the orbit of a spacecraft by means of telecommand facilities and on-board propulsion systems. In practice, orbit control may be used for:

- placing in parking or transfer orbit,
- modification of orbits: e.g., for changing from a transfer orbit to the geostationary-satellite orbit,
- fine orbit correction: e.g., for geostationary satellite station-keeping and for rendezvous manoeuvres,
- returning a recoverable spacecraft to Earth.

2.3.2 Surveillance, safety, recovery

The surveillance and safety functions cover anti-collision measures for spacecraft in neighbouring orbits and prediction of the impact or landing site of re-entering launcher stages or spacecraft.

2.3.3 Orbital accuracy

Evaluation of the accuracy of launches or other orbital manoeuvres.

2.3.4 Attribution of location data to mission measurements and observations

Measurements must be related to the position where the spacecraft is situated at the moment when the measurements are taken. This is particularly important when the spacecraft is carrying out scientific measurements of its environment, such as measurements of the magnetic field, particle density, etc. It is also essential in Earth observation missions, independently of the facilities offered during these missions by identification of control points on the transmitted pictures.