



Recommendation ITU-R SA.1014-3
(07/2017)

**Radiocommunication requirements for
manned and unmanned deep space research**

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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 SA.1014-3

**Radiocommunication requirements for manned
and unmanned deep space research**

(1994-2006-2011-2017)

Scope

This Recommendation briefly describes some essential characteristics of space research service (deep space) radiocommunications. These characteristics influence or determine the requirements for selection of candidate bands, coordination, band sharing and protection from interference.

Keywords

Deep space, radiocommunication, telemetry, telecommand, data rate, earth stations, space stations, ranging, radio science

Related Recommendations and Reports

Recommendation ITU-R SA.1015, Report ITU-R SA.2167, Report ITU-R SA.2177.

The ITU Radiocommunication Assembly,

considering

- a) that radiocommunications between the Earth and stations in deep space have unique requirements;
- b) that these requirements affect the selection of candidate band, band sharing, coordination, protection from interference and other regulatory and frequency management matters,

recommends

that the requirements and characteristics described in the Annex for deep space radiocommunications should be taken into account concerning space research service (deep space) and its interaction with other services.

Annex**Radiocommunication requirements for manned
and unmanned deep space research****1 Introduction**

This Annex presents some characteristics of deep space research missions, the functional and performance requirements for radiocommunications needed to conduct deep space research by means of spacecraft, and the technical methods and parameters of systems used in connection with such missions.

Considerations regarding bandwidth characteristics and requirements are found in Report ITU-R SA.2177.

2 Radiocommunication requirements

Deep space missions require highly reliable radiocommunications over long periods of time and great distances. For example, a spacecraft mission to gather scientific information at the planet Neptune takes eight years and requires radiocommunication over a distance of 4.65×10^9 km. The need for high e.i.r.p. and very sensitive receivers at earth stations is a result of the large radiocommunication distances involved in deep space research.

Continuous usage of space research service (deep space) radiocommunication bands is a consequence of the several missions now in existence and others being planned. Because many deep space missions continue for periods of several years, and because there are usually several missions in progress at the same time, there is a corresponding need for radiocommunication with several spacecraft at any given time.

In addition, each mission may include more than one spacecraft, so that simultaneous radiocommunication with several space stations will be necessary. Simultaneous coordinated radiocommunication between a space station and more than one earth station may also be required.

2.1 Telemetry requirements

Telemetry is used to transmit both maintenance and scientific information from deep space.

Maintenance telemetry information about the condition of the spacecraft must be received whenever needed to ensure the safety of the spacecraft and success of the mission. This requires a weather independent radiocommunications link of sufficient capacity. This requirement is a partial determinant of the frequency bands that are preferred for deep space research (see Report ITU-R SA.2177).

Science telemetry involves the sending of data that is collected by the on-board scientific instruments. The required data rate and acceptable error rate may be quite different as a function of the particular instrument and measurement. Table 1 includes maximum required data transmission rates for scientific and maintenance telemetry.

TABLE 1
Maximum required bit rates for deep space research

Direction and function	Link characteristic		
	Weather independent	Normal	High data rate
Earth-to-space			
Telecommand (bit/s)	1 000	1 000	2 000
Computer programming (kbit/s)	50	100	200
Audio (kbit/s)	45	45	45
Video (Mbit/s)	4	12	30
Space-to-Earth			
Maintenance telemetry (bit/s)	500	500	2×10^5
Scientific data (kbit/s)	115	500	3×10^5
Audio (kbit/s)	45	45	45
Video (Mbit/s)	0.8	8	30

Telemetry link capacity has steadily increased with the development of new equipment and techniques. This increase can be used in two ways:

- to gather larger amounts of scientific data at a given planet or distance; and
- to permit useful missions to more distant planets.

For a particular telemetry system, the maximum possible data rate is proportional to the inverse square of the radiocommunication distance. The same link capacity that provides for a data rate of 134 kbit/s from the vicinity of the planet Jupiter (9.3×10^8 km) would also provide for a data rate of 1.74 Mbit/s from the vicinity of the planet Venus (2.58×10^8 km). Because higher data rates require wider transmission bandwidths, the ability to effectively utilize the maximum telemetry capability depends on the width of allocated bands, and the number of simultaneous mission spacecraft that are within the earth station beamwidth and are operating in the same band.

An important contribution to telemetry has been the development of coding methods that permit operation with a lower signal-to-noise ratio. The coded signal requires a wider transmission bandwidth. The use of coded telemetry at very high data rates may be limited by allocation width.

2.2 Telecommand requirements

Reliability is the principal requirement of a telecommand link. Commands must be received accurately and when needed. The telecommand link is typically required to have a bit error rate not greater than 1×10^{-6} . Commands must be received successfully, without regard to spacecraft orientation, even when the primary high gain antenna may not be pointed towards the Earth. For such circumstances, reception using a nearly omnidirectional spacecraft antenna is required. Very high e.i.r.p. is needed at earth stations because of low spacecraft antenna gain, and to provide high reliability.

With computers on the spacecraft, automatic sequencing and operation of spacecraft systems is largely predetermined and stored on-board for later execution. For some complicated sequences, automatic operation is a requirement. Telecommand capability is required for in-flight alteration of stored instructions, which may be needed to correct for observed variations or malfunctions of spacecraft behaviour. This is particularly true for missions of long duration, and for those circumstances where sequencing is dependent on the results of earlier spacecraft events. For example, the commands for spacecraft trajectory correction are based on tracking measurements and cannot be predetermined.

The range of required command data rates is given in Table 1.

Reliable telecommand includes the need for reliable maintenance telemetry that is used to verify that commands are correctly received and loaded into command memory.

2.3 Tracking requirements

Tracking provides information used for spacecraft navigation and for radio science studies.

2.3.1 Navigation

The tracking measurements for navigation include radio-frequency Doppler shift, the round-trip propagation time of a ranging signal, and the reception of signals suitable for long baseline interferometry. The measurements must be made with a degree of precision that satisfies navigation requirements. Measurement accuracy is affected by variations in velocity of propagation, knowledge of station location, timing precision, and electronic circuit delay in earth and space station equipment. Table 2 lists a current example of the requirements for navigation accuracy and the associated measurements.