



Report ITU-R SA.2162
(09/2009)

**Sharing conditions between space research
service extra vehicular activities (EVA)
links and fixed and mobile service links
in the 410-420 MHz band**

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***Note:** This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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1 Introduction

At the World Administrative Radio Conference for dealing with frequency allocations in Certain Parts of the Spectrum (WARC-92) (Malaga-Torremolinos, 1992), a secondary allocation was made to the space research service in the 410-420 MHz band for space-to-space operations. These operations, limited to 5 km from an orbiting manned space vehicle, are to permit EVA communications between astronauts and between astronauts and primary or base space vehicles. As permanent space facilities are developed in the future, the needs and requirements for EVA will also increase in order to support many of the planned and envisioned space activities. This is particularly true when considering the construction, maintenance, and operation of space facilities.

This Report contains update to the work done at (CCIR, 1991). It shows the EVA communication requirements in the 410-420 MHz band and identifies typical communication characteristics for the fixed and mobile services in the band. The Report contains the interference investigation/analysis from the space research EVA systems to the fixed and mobile service systems in terms of power flux-densities incident at the surface of the Earth. A representative fixed service system and a representative mobile service system are used in evaluating interference to the space research EVA links. The power flux-density (pfd) levels in this Report under § 4 (called new proposed PFD limits) are those in No. 5.268 in the Radio Regulations (RR).

2 Space research service objectives and requirements

The primary purpose for the space research space-to-space links in the 410-420 MHz band is to provide high quality communication links for astronauts who have exited a space vehicle and are engaged in extra-vehicular activity. These links serve to provide the following three necessary communication requirements:

- a direct means of voice communication between astronauts engaged in EVA operations;
- a direct means of voice communication between an astronaut and the primary space vehicle;
- a direct means of data communication from an astronaut to the primary space vehicle.

Astronauts communicate via an EVA mobility unit (EMU) attached to the astronaut's life support suit. Although communications may be required infrequently, the need for establishing the link must be available at any time. A maximum of four astronauts will be able to communicate simultaneously with the primary space vehicle.

Typical orbital altitudes for EVA activities range from 333 km to 460 km with inclination angles of up to 60°. Maximum operational distance for communications between astronauts is 500 m. For communications between an astronaut and primary space vehicle, the maximum operational distance is 1 000 m.

3 System description and characteristics

The required communications in this system results in the following three links:

- links between two (or more) astronauts (EMU-to-EMU);
- links from an astronaut to the base vehicle (EMU-to-base);
- links from the base vehicle to one (or more) astronauts (base-to-EMU).

Table 1 lists the communication characteristics and Table 2 shows the link equations for this system. Antenna radiation pattern diagrams for the EMU antenna and the base vehicle antenna are given in Figs. 1 and 2.

TABLE 1
EVA system characteristics

Frequency (MHz)	415	
Modulation	TDMA/CPFSK	
Burst data rate (kbit/s)	695	
Bandwidth (kHz)	800	
Required bit error rate	1×10^{-5}	
Required E_b/N_0 (dB)	12.6	
	EMU	Base vehicle
<i>Transmitter parameters:</i>		
Transmitter power (dBW)	−6.0	−6.0
Transmitter line losses (dB)	−0.2	−7.0
Maximum antenna gain (dBi)	1.5	3.0
Minimum antenna gain (dBi)	−10.0	−6.0
Antenna polarization	Linear	Circular
Maximum e.i.r.p. (dBW)	−4.7	−10.0
<i>Receiver parameters:</i>		
Maximum antenna gain (dBi)	1.5	3.0
Minimum antenna gain (dBi)	−10.0	−6.0
Antenna cable loss (dB)	−0.2	−7.0
System noise temperature (K)	1 820	2 754

TABLE 2
EVA system link budgets

	EMU-to-EMU	EMU-to-base	Base-to-EMU
<i>Transmitting system:</i>			
Transmitter power (dBW)	−6.0	−6.0	−6.0
Transmitter line losses (dB)	−0.2	−0.2	−7.0
Minimum antenna gain (dBi)	−10.0	−10.0	−6.0
E.i.r.p. (dBW)	−16.2	−16.2	−19.0
Maximum distance (m)	500	1 000	1 000
Space loss (dB)	−78.8	−84.8	−84.8
<i>Receiving system:</i>			
Minimum antenna gain (dBi)	−10.0	−6.0	−10.0
Antenna cable losses (dB)	−0.2	−7.0	−0.2
Polarization loss (dB)	−3.0	−3.0	−3.0
Received power (dBW)	−108.2	−117.0	−117.0
System noise temperature (K)	1 820	2 754	1 820
Noise spectral density (dB(W/Hz))	−196.0	−194.2	−196.0
Bit rate bandwidth (dB(Hz))	58.4	58.4	58.4
Implementation loss (dB)	−3.0	−3.0	−3.0
Received E_b/N_0 (dB)	26.4	15.8	17.6
Required E_b/N_0 (dB)	12.6	12.6	12.6
Link margin (dB)	13.8	3.2	5.0