



Recommendation SFCG 32-2R2

**COMMUNICATION FREQUENCY ALLOCATIONS AND
SHARING IN THE LUNAR REGION**

THE SFCG

CONSIDERING

- a. that a regional communication network at the Moon can be expected in the foreseeable future as missions to the lunar region increase in number and variety;
- b. that frequencies for direct communication between a spacecraft in the lunar region and an earth station are provided in the existing allocations to Space Research Service (SRS);
- c. that separate frequencies are needed in the lunar region for compatible local communications between a surface vehicle and an orbiter, between surface vehicles, and between orbiters;
- d. that major criteria for allocating frequencies in the lunar region include RF compatibility, technology availability and performance, mission scenarios, cost, and ability to conduct testing and emergency support from the Earth;
- e. that the major benefit of an agreed frequency plan for the lunar region enables interoperability and sharing of communications infrastructure and service assets to support individual or joint exploration missions to accomplish complex objectives;
- f. that envisioned lunar missions will involve complex communications architectures using earth stations that can communicate with near-Earth relay satellites, lunar orbiting satellites, and lunar surface elements in view of Earth based space stations;
- g. that it is envisioned that missions in the lunar region will employ Lunar Relay Satellites (LRS) to allow relay communication coverage and to forward data gathered from lunar surface elements to earth stations;
- h. that it is envisioned that missions in the lunar region by multiple administrations either independently or jointly can occur during the same time period and each mission may employ

many simultaneous communications links with another orbiter, the lunar surface elements, LRS, lunar communications terminals (LCT) and earth stations;

- i. that sufficient frequency separation is required to enable compatible and simultaneous communications for a multiplicity of spacecraft in the lunar region with each other, earth stations, LRS, local lunar based vehicles, a lunar outpost and lunar vehicles transmitting to an earth station;
- j. that lower frequency provides better SNR performance for a communication link between two vehicles using low gain broad beam antennas, such as between a vehicle in the lunar region and a LRS;
- k. that higher frequency provides wider bandwidth and higher data throughput performance between two vehicles employing high gain antennas, such as between a large lander and an LRS with accurately pointed antennas;
- l. that techniques such as self-test on board are available to minimize the need for testing with Earth-based signals;

NOTING

- a) that the SFCG has resolved to provide assistance to member agencies in coordinating frequency assignment for lunar and Martian missions (see RES SFCG A26-1R5);
- b) that, according to the provisions of the Radio Regulations, testing lunar local link radios with signals transmitted from an earth station is allowed only if it does not interfere with Earth-based radio systems operating in accordance with the Radio Regulations;
- c) that lunar missions need interoperable relay links to maintain communication with the Earth;
- d) that passive observations in space need to be protected to the extent provided in the Radio Regulations.

RECOGNISING

- a) that lunar local links must not interfere with the direct communication links between space and the Earth using frequencies provided in the Radio Regulations;
- b) that multiple frequency bands are needed for missions to meet various communications requirements and satisfy cost, mass and performance objectives.

RECOMMENDS

1. that for communications in the lunar region agencies select frequencies from Table 1 for which examples of communication service requirements are given in Table 2;
2. that testing lunar local links in flight with signals transmitted from an earth station be minimized and non-interfering to the Earth-based radio systems operating under the provisions of the Radio Regulations;
3. that assignment of lunar local link frequencies be coordinated within the SFCG in accordance with RES A 26-1.

Table 1: Recommended Frequency Bands for Communications in the Lunar Region

Link	Frequency	
Earth to Lunar Orbit	2025-2110	MHz
	7190-7235	MHz
	22.55-23.15	GHz
	40.0-40.5	GHz
Lunar Orbit to Earth	2200-2290	MHz
	8450-8500	MHz
	25.5-27.0	GHz
	**37-38	GHz
Earth to Lunar Surface	2025-2110	MHz
	7190-7235	MHz
	22.55-23.15	GHz
Lunar Surface to Earth	2200-2290	MHz
	8450-8500	MHz
	25.5-27.0	GHz
Lunar Orbit to Lunar Surface	390-405	MHz
	2025-2110	MHz
	2483.5-2500	MHz
	23.15-23.55	GHz
Lunar Surface to Lunar Orbit	435-450	MHz
	1614 -1626.5	MHz
	2200-2290	MHz
	27.0-27.5	GHz
Lunar Surface Wireless Network	390-405	MHz
	410-420	MHz
	435-450	MHz
	2.4-2.48	GHz
	*25.25-25.60	GHz
	*27.225-27.5	GHz
Lunar Relay to Lunar Relay Cross Link	13.75-14	GHz
	14.5-15.35	GHz
	23.15-23.55	GHz
	27.0-27.5	GHz
	**37-38	GHz
	40-40.5	GHz

25.25-25.60 and 27.225-27.5 GHz bands subject to SFCG Rec. 15-2R4

**37-38 GHz band subject to SFCG Rec.14-2R5

Table 2: Example of Lunar Communications Service Requirements

Link Type	Frequency Band	Users	Service Type	Typical Data Rate per User	Limitations
1.0 Earth to Lunar Orbit (E-LO) and Lunar Orbit to Earth (LO-E)	2025-2110 MHz (E-LO)	Lunar Orbiters	Voice/Commands	72 kbps	
	2200-2290 MHz (LO-E)	Lunar Orbiters	Voice/Data	256 kbps	
	7190-7235 MHz (E-LO)	Lunar Orbiters	Commands/Ranging	Up to 1 Mbps	
	8450-8500 MHz (LO-E)	Lunar Orbiters	Telemetry/Ranging	Up to 10 Mbps	Subject to SFCG Rec. 5-1 R5, up to a maximum bandwidth of 10 MHz
	22.55-23.15 GHz (E-LO)	Lunar Orbiters	Voice/data (comm & nav)/ video	10 Mbps	RR No. 5.149 applies, taking into account 22.81-22.86 GHz and 23.07 - 23.12 GHz for RAS
	25.5-27.0 GHz (LO-E)	Lunar Orbiters	Voice/data/video	25 Mbps	
	37-38 GHz (LO-E)	Relay Satellites	Trunk line (downlink)	1200 Mbps	Subject to SFCG Rec. 14-2R5, up to a maximum of 500 MHz bandwidth
	40-40.5 GHz (E-LO)	Lunar Relay Satellites	Trunk line (uplink)	400 Mbps	Subject to SFCG Rec. 14-2R5

Link Type	Frequency Band	Users	Service Type	Typical Data Rate per User	Limitations
2.0 Lunar Surface to Earth (LS-E) and Earth to Lunar Surface (E-LS)	2025-2110 MHz (E-LS) /2200-2290 (LS-E) GHz	Surface Hubs (Hab, Landers, Rovers, etc), LCT	Voice/TT&C/ Nav	150 kbps/3Mbps	
	2025-2110 MHz (E-LS) /2200-2290 (LS-E) MHz	End nodes (EVA, Science sites, robotic assistants)	Voice or health status/TT&C	8 kbps	
	7190-7235 MHz (E-LS)	Surface Landers (Landers, Rovers, etc)	Commands/ Ranging	Up to 1 Mbps	
	8450-8500 MHz (LS-E)	Surface (Landers, Rovers, etc)	Telemetry, Ranging	Up to 10 Mbps	Subject to SFCG Rec. 5-1 R5
	22.55-23.15 (E-LS)/25.5-27(LS-E) GHz	LCT	Voice/TT&C/ data/ video	25 Mbps/100 Mbps	
	22.55-23.15 (E-LS) /25.5-27 (LS-E) GHz	Surface hubs (Hab, Landers, Rovers, etc)	Voice/TT&C/ data/ video	10 Mbps/ 25Mbps	

Link Type	Frequency Band	Users	Service Type	Typical Data Rate per User	Limitations
3.0 Lunar Orbit to Lunar Surface (LO-LS) and Lunar Surface to Lunar Orbit (LS-LO)	390-405 MHz (LO-LS)	Orbiter, Lunar Module, Rover, Lander	Command	1 kbps	
	435-450 MHz (LS-LO)	Orbiter, Lunar Module, Rover, Lander	Data/ Telemetry	8 kbps, 32 kbps, 1Mbps	
	1614-1626.5 MHz (LS-LO)	Rover	Voice/ TT&C / Data (comm & nav)	10 kpbs (bi-directional)	
		EVAs	Voice/ TT&C / Data (comm & nav)	10 kpbs (bi-directional)	
		Surface hubs (Hab, Landers, etc)	Voice/ TT&C / Data (comm & nav)	10 kpbs (bi-directional)	
	2025-2110 (LO-LS)/2200-2290 (LS-LO) MHz	Surface Hubs (Hab, Landers, etc), Lunar Module	Voice/ TT&C	150 kbps (bi-directional)	
		LCT	Voice/TT&C	3 Mbps (bi-directional)	
		EVAs, Robotics Assistants	Voice/health & status	8 kbps (bi-directional)	

Link Type	Frequency Band	Users	Service Type	Typical Data Rate per User	Limitations
3.0 Continued Lunar Orbit to Lunar Surface (LO-LS) and Lunar Surface to Lunar Orbit (LS-LO)	2483.5 - 2500 MHz (LO-LS)	Rover-Orbiter	Voice/ TT&C / Data (comm & nav)	10 kbps (bi-directional)	
		EVA's-Orbiter	Voice/ TT&C / Data (comm & nav)	10 kbps (bi-directional)	
		Surface hubs (Hab, Landers, etc) - Orbiter	Voice/ TT&C / Data (comm & nav)	10 kbps (bi-directional)	
	23.15-23.55 (LO-LS) /27-27.5 (LS-LO) GHz	LCT	Voice/TT&C/ data/video	200 Mbps/400 Mbps	
	23.15-23.55 (LO-LS) /27-27.5 (LS-LO) GHz	Surface hubs (Hab, Landers, etc)	Voice / TT&C	25/10 Mbps	

Link Type	Frequency Band	Users	Service Type	Typical Data Rate per User	Limitations
4.0 Lunar Surface Communications	390-405 MHz	Lunar Module Rover, Lander	Telemetry, Data	128 kbps, 1 Mbps	
	410-420 MHz	Lunar Module, Rover, Lander	Command/Telemetry/Data	Up to 1 Mbps	
	435-450 MHz	Lunar Module, Rover, Lander	Command	1 kbps	
	2.4 – 2.48 GHz	EVAs	Voice/data (comm & nav)/low rate video	3 Mbps (max, rate will drop as distance increases)	
	2.4 - 2.48 GHz	Rover - LCT	Voice/data (comm & nav)/video	30 Mbps (max)	
	2.4 – 2.48 GHz	EVAs – Landers Rover	Voice/data (comm & nav)/video	3 Mbps (max)	
	25.25-25.6 GHz	Base Station to LCT	Voice/data (comm & nav)/video	20 Mbps	Subject to SFCG Rec. 15-2R4
	27.225-27.5 GHz	User Radio to LCT	Voice/data (comm & nav)/video	9.5 Mbps	Subject to SFCG Rec. 15-2R4

Link Type	Frequency Band	Users	Service Type	Typical Data Rate per User	Limitations
5.0	13.75 -14 GHz	LRS	User data	Up to 300 Mbps	

Lunar Relay to Lunar Relay Cross Link	14.5 - 15.35 GHz	LRS	User data	Up to 300 Mbps	
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Acronym List for typical lunar communication elements

E	Earth
EVA	Extra Vehicular Activity
Hab	Habitat
LCT	Lunar Communications Terminal
LO	Lunar Orbit
LRS	Lunar Relay Satellites
LS	Lunar Surface
SRS	Space Research Service