

# UPDATE ON SFCG LUNAR WIRELESS FREQUENCIES

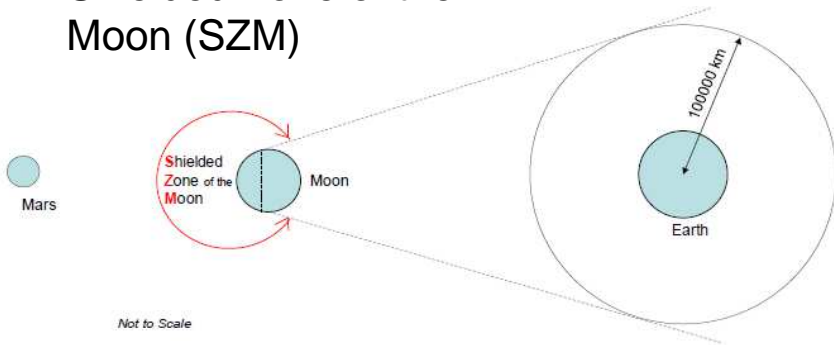
CCSDS meeting; WIR-SOIS Plenary



# ITU Radio Regulation in the Shielded Zone of the Moon and SFCG recommendations for lunar in-situ PNT



ITU Definition of the Shielded Zone of the Moon (SZM)



**RR: ITU Article 22 section V + ITU REC RA 479-5: Protection of Radio Astronomy in the SZM**

Most of communication frequencies **below 2 GHz**, in particular **any RNSS or RDSS frequency L-band**, are not allowed in the **SZM** without agreement of the Radio Astronomy community (**even if declared on a non interference basis: ITU article 4.4**), **and also C band**

**What is at stake is continuum RA observations in the SZM in L band, and also in C band**

## SFCG REC 32-2R4



- d) that missions may require Global Navigation Satellite Service (GNSS) signals for accurate Positioning, Navigation, and Timing (PNT) in the lunar region, and that these GNSS signals may originate from either Earth or Moon orbiting satellite constellations;



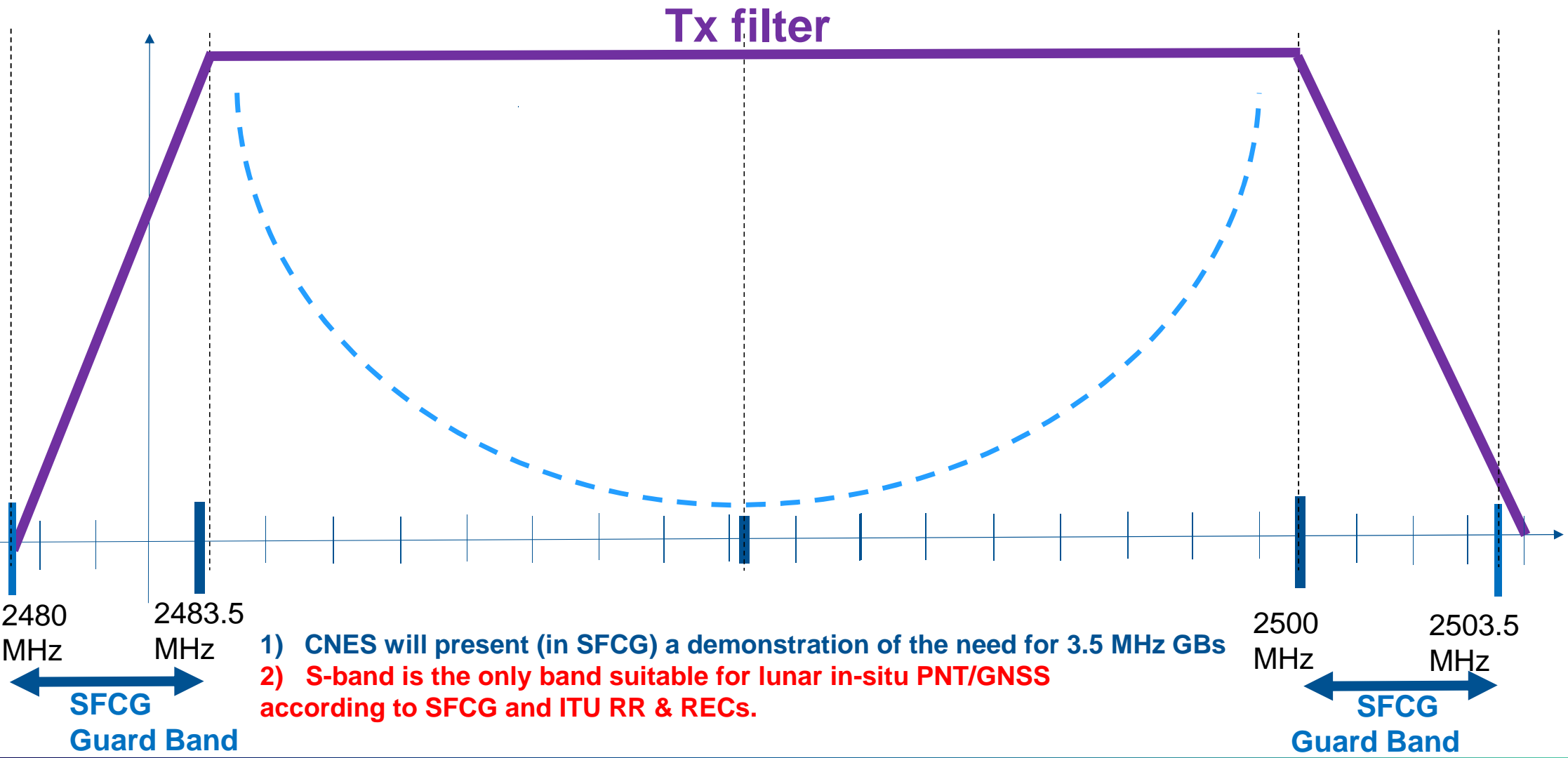
**Table 2: Recommended Frequency Bands for RNSS or RDSS Applications in the Lunar Vicinity**

Link	Frequency
Earth-based GNSS to Lunar Orbit and Lunar Surface	1164-1215 MHz
	1215-1300 MHz
	1559-1610 MHz
In-situ Lunar based RNSS/RDSS to Lunar Orbit and Lunar Surface	2483.5-2500 MHz

# Compatibility of GNSS bands for in-situ lunar PNT with Radio Regulation and Recommendations related to protection of Radio Astronomy in the SZM

	<b>L-band</b> (RNSS-GNSS : 1164-1300 MHz & 1559-1610 MHz) *	<b>S-band</b> (RDSS-GNSS : 2483.5-2500 MHz)	<b>C-band</b> (RNSS: 5010-5030 MHz) *
 <p>Compatibility with ITU RR &amp; REC RA 479-5 *</p>	<b>NO (ILLEGAL)</b>	<b>YES</b>	<b>RA band 4.99-5.00 GHz and above</b>
 <p>Compatibility with SFCG REC 32-2R4</p>	<b>NO (Radio Astronomy in SZM at stake)</b>	<b>YES</b>	<b>NO (moreover: C-band R. A. in SZM at stake)</b>

# Lunar in-situ GNSS need a 16.5 MHz filter and a 3.5 MHz guard band « below » and « above »



- 1) CNES will present (in SFCG) a demonstration of the need for 3.5 MHz GBs
- 2) S-band is the only band suitable for lunar in-situ PNT/GNSS according to SFCG and ITU RR & RECs.

# New SFCG REC on lunar frequencies (REC 32-2R4) [1]

## Recommendation SFCG 32-2R4

### COMMUNICATION AND POSITIONING, NAVIGATION, AND TIMING FREQUENCY ALLOCATIONS AND SHARING IN THE LUNAR REGION

Lunar Surface Wireless Network	390-405	MHz (Note 4)
	410-420	MHz (Note 8)
	435-450	MHz (Note 4)
	2.400-2.480	GHz (Note 7)
	2.5035 – 2.655	GHz (Note 9) ← Range increased in R4 compared to R3
	3.5-3.8	GHz
	5.15-5.835	GHz (Note 6)
	5.855-5.925	GHz
	25.25-25.5	GHz
	27.225-27.5	GHz
27.5-28.35	GHz	

(Note 4) Frequencies to only be transmitted or received outside the Shielded Zone of the Moon (SZM).

(Note 6) 5.25-5.57 GHz is allocated to SRS (active) on a primary basis; use of these frequencies for communications in the lunar region is on a non-interference and unprotected basis to SRS (active).

(Note 7) Out-of-band filtering of the harmonic falling in the 4.8-4.99 GHz band (secondary RAS) is necessary in the SZM

(Note 8) 410-420 MHz is a space research service (space-to-space) allocation, and therefore, per ITU Radio Regulations Article 22 (specifically No. 22.24), is allowed for use in the SZM. The use of the 410-420 MHz frequency range shall take into account the protection of radio astronomy systems below 410 MHz through the use of measures to minimize out-of-band emissions.

(Note 9) The use of the 2.5035 – 2.655 GHz and 14.5-15.35 GHz frequencies shall take into account the protection of radio astronomy systems in 2.655 - 2.670 GHz (secondary allocation for RAS), 15.35-15.5 GHz (primary allocation for RAS, and 14.35-14.5 GHz (secondary allocation for RAS).

# New SFCG REC on lunar frequencies (REC 32-2R4) [2]



Link Type	Frequency Band	Users	Service Type	Typical Data Rate per User	Limitations
5.0 Lunar Surface Communications	390-405 MHz	Lunar Module Rover, Lander	Telemetry, Data	128 kbps, 1 Mbps	See Note 4 to Table 1
	410-420 MHz	Lunar Module, Rover, Lander	Command/Telemetry/ Data	Up to 1 Mbps	
	435-450 MHz	Lunar Module, Rover, Lander	Command	1 kbps	See Note 4 to Table 1
	2.400 – 2.480 GHz	EVAs	Voice/data (comm & PNT)/ video	3 Mbps (max, rate will drop as distance increases)	2.480-2.4835 MHz is considered as the guard band. Sufficient OOB filtering to protect the 2483.5-2500 MHz LO-to-LS PNT band is necessary. OOB filtering of the harmonic falling in 4.8-4.99 GHz band (secondary RAS) is necessary in the SZM
		Rover - LCT	Voice/data (comm & PNT)/video	30 Mbps (max)	
		EVAs – Landers, Rover	Voice/data (comm & PNT)/video	3 Mbps (max)	
	2.5035 – 2.655 GHz	EVAs	Voice/data (comm & PNT)/video	100 Mbps (max)	2.500-2.5035 MHz is considered as the guard band. Sufficient OOB filtering to protect the 2483.5-2500 MHz LO-to-LS PNT band is necessary. See Note 9 of Table 1
		Rover - LCT			
		EVAs – Landers, Rover			
	3.50 – 3.8 GHz	EVAs	Voice/data (comm & PNT)/video	100 Mbps (max)	
5.15-5.835 GHz	Rover - LCT	Voice/data (comm & PNT)/ video	3 Mbps (max, rate will drop as distance increases)		
		EVAs – Landers, Rover	Voice/data (comm & PNT)/video	30 Mbps (max)	
		EVAs – Landers, Rover	Voice/data (comm & PNT)/video	3 Mbps (max)	

# New SFCG REC on lunar frequencies (REC 32-2R4) [3]



Link Type	Frequency Band	Users	Service Type	Typical Data Rate per User	Limitations
5.0 Lunar Surface Communications	5.855-5.925 GHz	EVAs	Voice/data (comm & PNT)/video	100 Mbps (max)	
		Rover - LCT			
		EVAs – Landers, Rover			
	25.25-25.5 GHz	Base Station to LCT	Voice/data (comm & PNT)/video	20 Mbps	Subject to SFCG Rec. 15-2R4
	27.225-27.5 GHz	User Radio to LCT	Voice/data (comm & PNT)/video	9.5 Mbps	Subject to SFCG Rec. 15-2R4
	27.5-28.35 GHz	EVAs	Voice/data (comm & PNT)/video	1 Gbps (max)	
Rover - LCT					
EVAs – Landers, Rover					

**Taken into account CNES study results showing the need to keep lower and upper guard band to protect lunar in-situ PNT/GNSS in 2483.5-2500 MHz (*only possible band for lunar in-situ PNT according to ITU and SFCG*), CNES proposal is:**

**For the near term in order lunar 5G 3GPP FDD to be compatible with PNT: two 3GPP FDD channels of 15 MHz (*that is a 30 MHz total bandwidth for each of the 2 directions*). An interest would be to have only one format for the 2 channels: 15 MHz each.**

**If 30 MHz bandwidth would be really not sufficient for the short term, CNES suggest wider aggregated bands accessible inside 2503.5-2655 MHz with other 5G or 4G 3GPP standards.**

**If not any 3GPP 4G or 5G or ... would be really not sufficient for the short term inside 2503.5-2655 MHz, CNES kindly suggest to go directly to 3.5-3.8 GHz.**