

MOONLIGHT



Lunar Pathfinder

(Launch End of 2025)

First ever GPS/GALILEO

reception on lunar orbit

Relay for the first US lander

on the far side of the Moon



Lunar Communication & Navigation Services

(Launch 2027 NET)

High performance, broad range of services, constellation

Data Transport

Absolute Position

Audio/Video Streaming

Absolute Velocity

Tele-Operations

Universal Time

Alert & Information

Third-party Payloads

Search and Rescue

Over-the-top Services

Lunar Pathfinder relies on an adaptation of Prox1 from UHF and Mars environment to Sband and Moon environment to establish the link and perform the communication

As Prox1 is the only existing CCSDS standard defining in details the com establishment and channel negotiation process, trend is to apply it as well, provided that it is compatible with mission needs (requires an update)

Proximity-1 evolution is a potential protocol for LCNS via the alignment with LNIS. LCNS is currently in the procurement stage and therefore application of Proximity-1 and detailed aspects are TBD/TBC.





Prox1 currently only covers UHF and Mars-type doppler effects

Lunar Pathfinder is using Sband channels in compliance with SFCG REC42-1 (updated version) for the channelisation

Doppler coverage in SBand including drift is 100kHz

The proposed channelisation in Sband includes consideration of:

- Doppler & guard band
- Achievable symbol rates
- Possibility to aggregate consecutive channels in the hailing process
- An optional additional hailing channel to manage higher number of Users
- Coherent channels with 240/221 ratio among TM and TC channels

Table 1. Lunar Relay Single Access Frequencies

Single Access Forward Service (user to relay)	Single Access Return Service (relay to user)
2066.35 – 2078.320833 MHz	2244 – 2257 MHz
2084.306250 – 2088.910417MHz (*)	2263.5 – 2268.5 MHz (*)
2095.356250 – 2099.960417 MHz (*)	2275.5 – 2280.5 MHz (*)

(*): this frequency band shall be accessed using CCSDS Proximity-1 single access services as per Prox-1 channel frequencies defined in the recommendation 3 here-below.

Table 3. Proximity-1 S-band Frequency Channels 1-9

Channel Number	Prox-1 S-band Forward Channel (MHz)	Prox-1 S-band Return Channel (MHz)
0 (hailing channel)	2084.306250 – 2085.227083	2263.5 – 2264.5
1	2085.227083 – 2086.147917	2264.5 – 2265.5
2	2086.147917 – 2087.068750	2265.5 – 2266.5
3	2087.068750 – 2087.989583	2266.5 – 2267.5
4	2087.989583 – 2088.910417	2267.5 – 2268.5
5	2095.356250-2096.277083	2275.5-2276.5
6	2096.277083-2097.197917	2276.5-2277.5
7	2097.197917-2098.118750	2277.5-2278.5
8	2098.118750-2099.039583	2278.5-2279.5
9 (optional hailing channel)	2099.039583-2099.960417	2279.5-2280.5



Prox1 currently only covers UHF-type symbol rates and the selected scrambling polynomial is not scalable to the rates achievable in Sband and KaBand.

Need to update the polynomials to 4Msps communications in Sband



Prox1 currently only covers UHF-type modulations and is not up to date with respects to the state-of-the-art of other CCSDS/ECSS standards

Need to expand the modulations, symbol rate and coding scheme set.

- SP-L/PM & GMSK
- LDPC 1/2 (1024) and LDPC 2/3 (4096)
- Rates 1 to 4096 ksps (by powers of 2)



Prox1 currently only covers UHF-type modulations and coding operating at high SNR and is based on uncoded 8bkps process. This requires a high-SNR communication establishment procedure that is not fit for long distance / low-SNR lunar communications

Need to introduce a low-SNR hailing sequence/datagram that enables a coded hailing process, for instance as follows:

Content	Tx OFF	Carrier only	Acquisition Idle	Hail Directive	Tail Idle	Tx OFF
Duration (s)		E4 <u>WT</u> = 0.25 – 2s	E5 WT = 8s	E6 WT = 2s	E7 WT = 0.26s	
Rationale	...	Duration of Rx sweep & lock	256 to 4160 bits at 1ksps	<u>1 codeblock</u> at 1ksps	256 bits	...

This coded hailing process assumes SP-L/PM at 1ksps coded rate (LDPD 1/2, k=1024), being the lowest SNR identified for the Lunar use-cases for Lunar Pathfinder



- **LCNS aligns with the LunaNet Interoperability Specification (LNIS) – current version V4 formal [V5 in draft public review]**
- **The evolution in Proximity-1 standard, currently identified as under consideration in LNIS, provides a potential opportunity for LCNS**
- **Specific items identified to be addressed for LCNS regarding the evolution of Proximity-1**
 - **Ka-band proximity links**
 - **Frequency allocation and channelisation**
 - **Doppler coverage**
 - **Scrambling polynomial**
 - **Hailing sequence/datagram**
 - **Management of the transition to coherent mode**
- **CDMA modulation schemes and provision of multiple access connectivity for a high number of lunar users is assumed to be outside the envelope of Proximity-1 evolution at present**