

EUROPEAN SPACE AGENCY

22GHz Modulations for High Rate Lunar Links

A. Modenini, M. Martinez, M. Lanucara, G. Sessler

Abstract

This paper deals with the modulation formats for Earth-to-Moon communications and Lunar Cross links in the K-Band 22.55-23.15 GHz and 23.15-23.55 GHz (here simply denoted as, *22 GHz links*), with special reference to high rate links.

This paper is presented to the SLS-RFM working group for assessing the need of possible standardization activities of modulation schemes in such band, as planned in the SLS-RFM charter.

1. Introduction

Recent studies are pointing out that a large variety of Lunar missions will benefit from having a high-rate links in the 22 GHz frequency allocation. A list of examples (but not exhaustive) is:

- *Lunar Orbital Platform – Gateway (LOP-G)*;
- *Human Lunar Outposts*;
- *Lunar relays*.

Although the SLS-RFM charter included standardization activity of the 22 GHz uplink modulations since long time, so far no inputs were submitted by CCSDS members. Hence, the objective of this paper is to provide a quick overview of some future mission scenarios, and to invite CCSDS members to assess the possible standardization of such modulation systems for uplink, possibly including Lunar cross links.

The remainder of this paper is organized as follows: Section 2 gives a brief overview of mission scenarios that will benefit of using the 22 GHz frequency band (with particular reference to the IOAG report in [RD1]). Then, Section 3 describes the current gap in CCSDS recommendation [RD2] for covering these links. Finally, Section 4 draws conclusions.

2. Cis-lunar missions

The lunar communication architecture working group (LCAWG) has been tasked by IOAG to conduct a study for defining a future Lunar Communications Architecture that will facilitate cross supporting within the IOAG members. The main output of the LCAWG is the report “The Future Lunar Communication Architecture” [RD1] that highlights important aspects:

- the planning in 2018-2028 are showing an unprecedented number of future missions in the lunar environment;

- 22 GHz Earth-to-Moon links (22.55-23.15 GHz) and Cross links (23.15-23.55 GHz) are foreseen for high rate applications, with bit rates even larger than 10 Msps;
- it is imperative to select suitable standards (in terms of modulation, coding, space data link protocol and security, and ranging) for avoiding a multitude of different formats that will prevent interoperability.

A quick overview of the mission scenarios foreseen by IOAG is reported in Figure 2-1, for which it can be seen the links in 22 GHz as *Earth to LOP-G*, *Earth to Lunar Relay*, *LOP-G to Lunar Relay*, *LOP-G to Human Outpost*, etc. For these links, the IOAG has preliminary down-selected **Filtered-OQPSK** and **GMSK**, for having telemetry-like links using protocols as AOS and USLP. Additionally, IOAG is considering the potential use of **VCM schemes** (as SCCC/DVB-S2/LDPC-VCM as provided in [RD3], [RD4], and [RD5] respectively) that imply the use of **filtered high order modulations** (theoretically, from QPSK till 64APSK, or a subset of them).

For further details, the reader can refer to the full report [RD1].

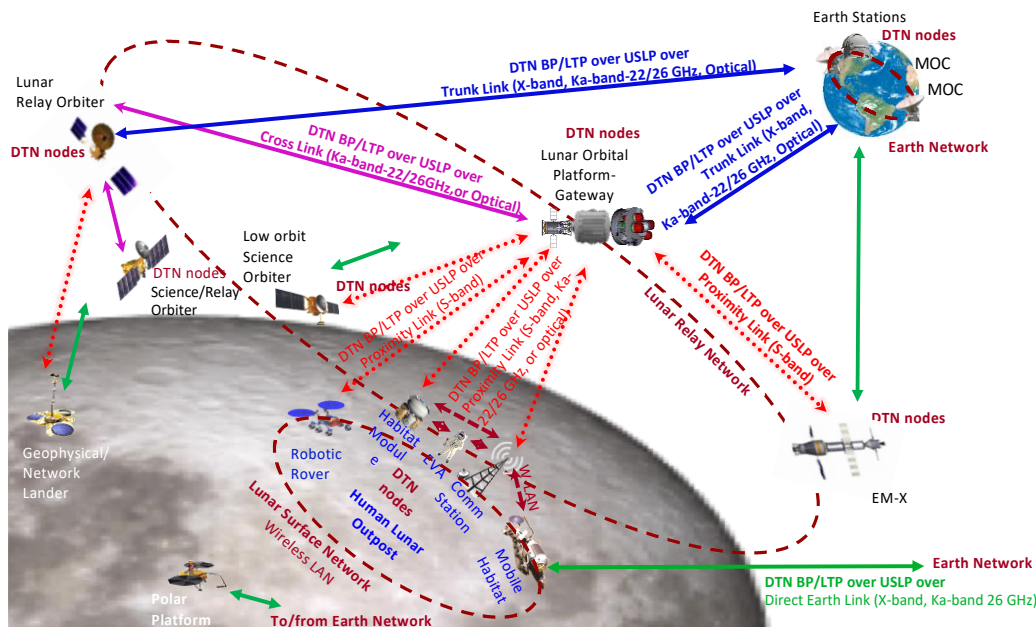


Figure 2-1: Future Lunar Communication Architecture – A conceptual view (from [RD1])

3. CCSDS activities

From the previous section, it can be noticed that CCSDS recommendations in 401.0-B-29 have currently some gaps. For instance, CCSDS allows Earth-to-Moon links (that fall under the Earth-to-Space category) only with standard TC up to 2 Msps, while IOAG foresees up to 50 Msps (that may be extended to 200 Msps, [RD1]) with AOS or USLP protocol. Instead Lunar cross links (including Lunar relays) are currently not covered.

Consequently, CCSDS could consider how to cover such modulation schemes in the existing Blue Book.

Finally, for information to the CCSDS, it is reminded that 22 GHz modulations for high rate links are also currently adopted by data relays with physical layer as provided in the ESA/JAXA/NASA

SNIP agreements. Thus, as option, the standardization of 22 GHz modulations for high rate lunar links could be done in harmonization with the existing agreements for data relay links (TBC).

4. Conclusions

This paper has been presented to the SLS-RFM working group for showing the 22 GHz modulation schemes planned for high rate Lunar links (Earth-to-Moon and Lunar cross links).

ESA invites all interested CCSDS members to take action and provide their views for next CCSDS Spring Meeting 2020.

5. References

- [RD1] IOAG, LCAWG members, “The Future Lunar Communications Architecture”.
- [RD2] CCSDS 401.0-B-29, “Radio Frequency And Modulation Systems—Part 1 Earth Stations And Spacecraft”.
- [RD3] CCSDS 131.2-B, “Flexible advanced coding and modulation scheme for high rate telemetry applications”
- [RD4] CCSDS 131.3-B, “CCSDS Space Link Protocols over ETSI DVB-S2 Standard”
- [RD5] CCSDS 431.1-R, “Variable coded modulation protocol”