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Lunar GNSS Receiver (LuGRE) Missions and future moon navigation opportunities

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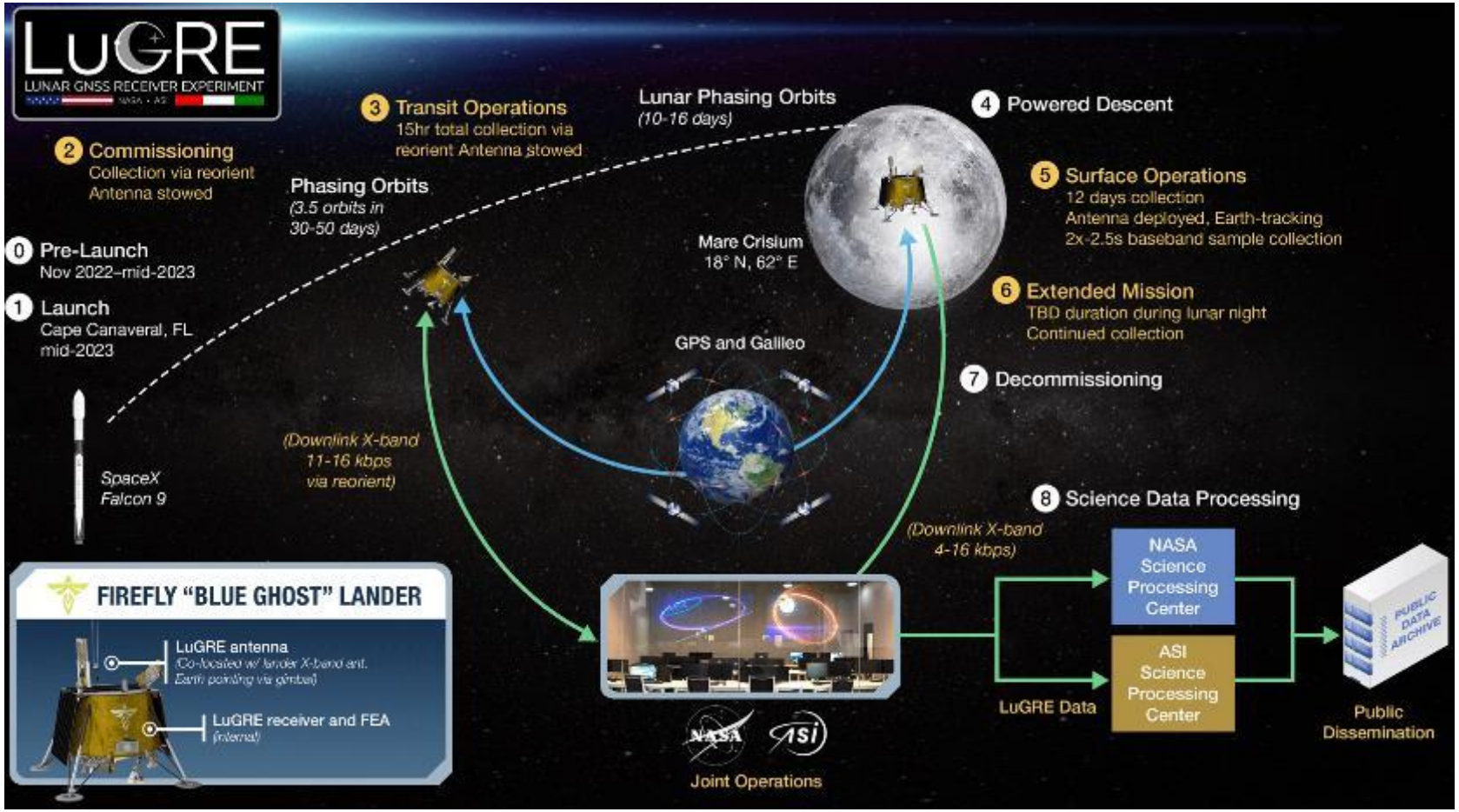
LuGRE Mission Overview

Mission Details

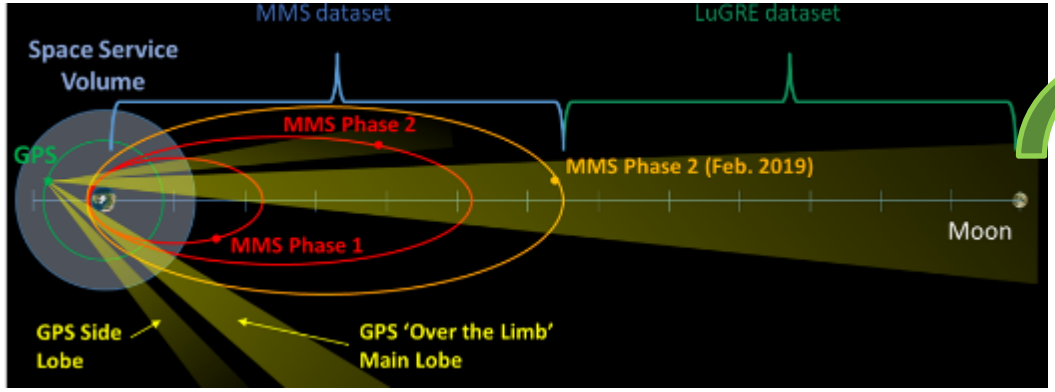
- LuGRE as Lunar GNSS Receiver Experiment
- NASA payload for CLPS 19D flight
- Joint NASA – Italian Space Agency mission
- “Do No Harm” class
- Firefly BGM1 commercial lander, landing in Mare Crisium 18°N, 62°E
- Observation campaign both in transit (40-50 Earth days) and surface (one lunar day, ~12 Earth days)

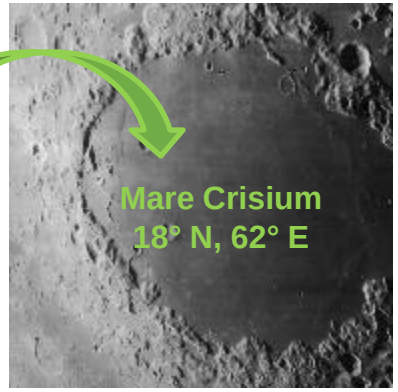


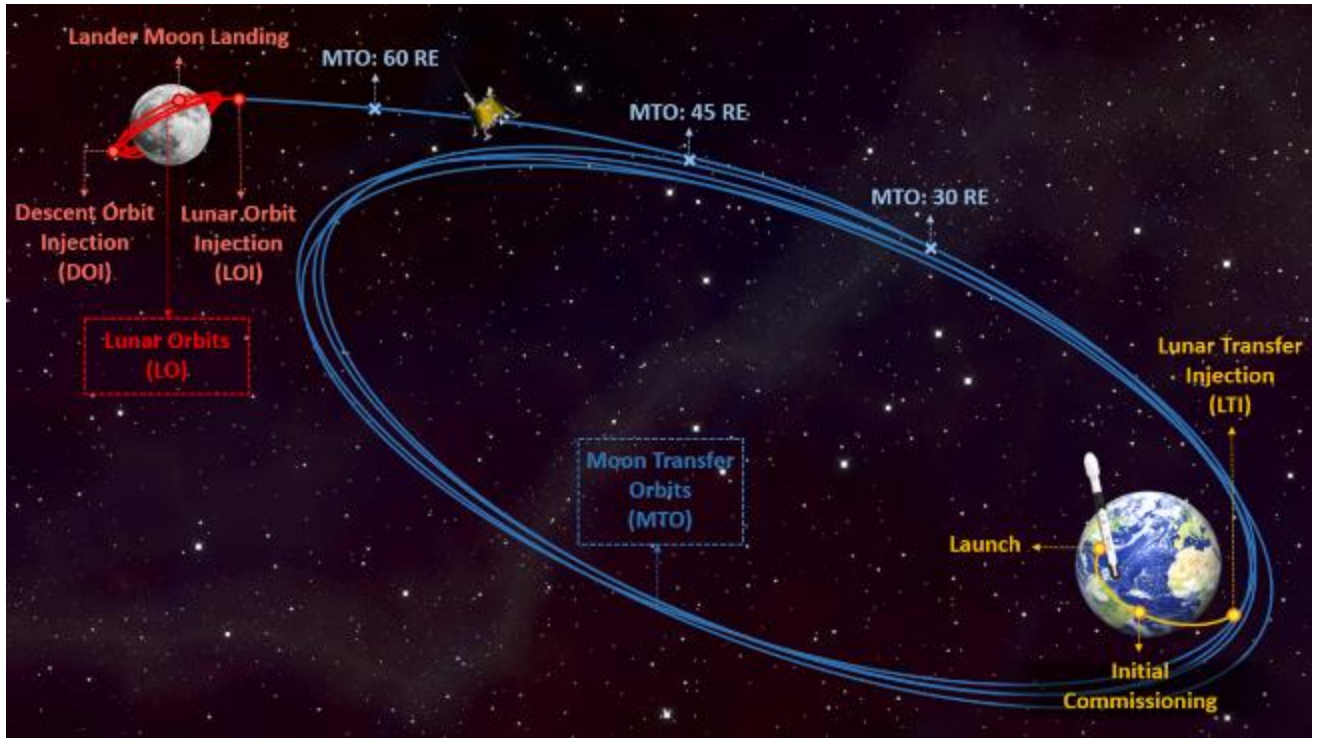
LuGRE Payload - Objectives

Payload Objectives

- Receive GNSS signals from above LEO to the lunar surface
- Demonstrate deep space navigation and time estimation in lunar and cislunar environment
- Collect data for future research
- Foster the use of GNSS for future lunar technologies
- Establish a crucial precedent for the development of future GNSS space receivers



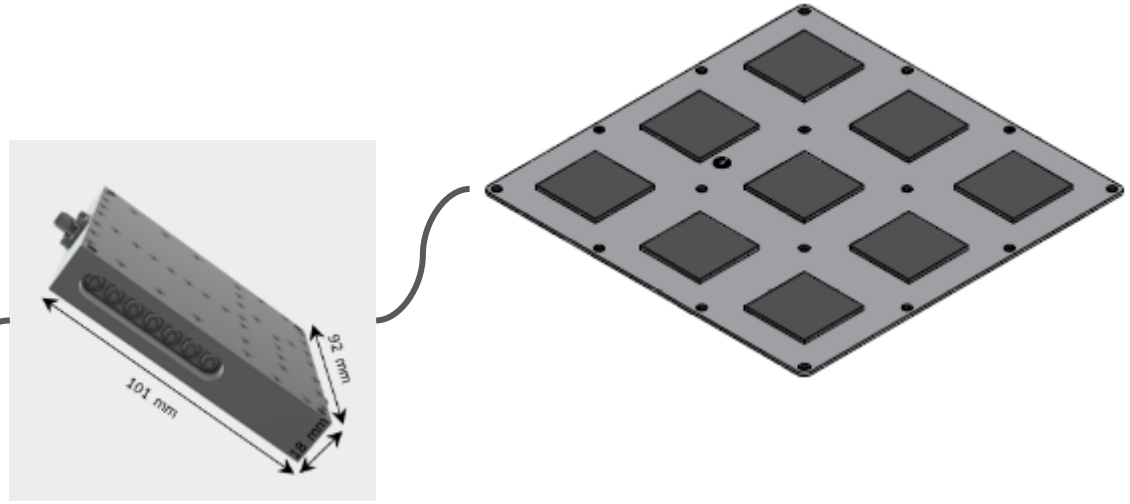


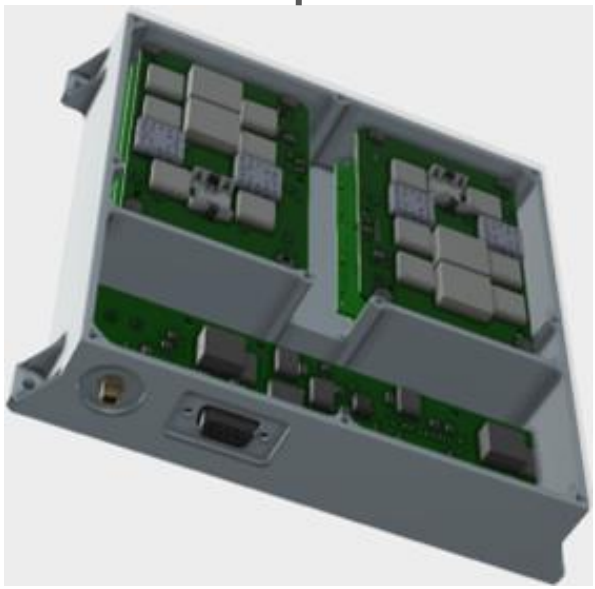


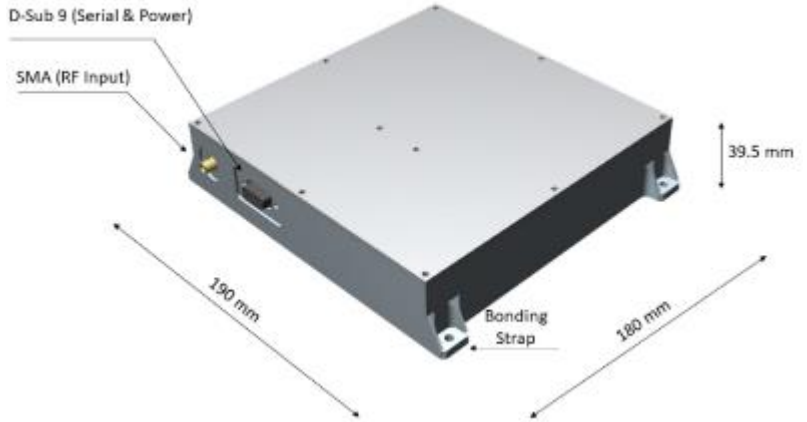
LuGRE Payload - Architecture

Payload Architecture

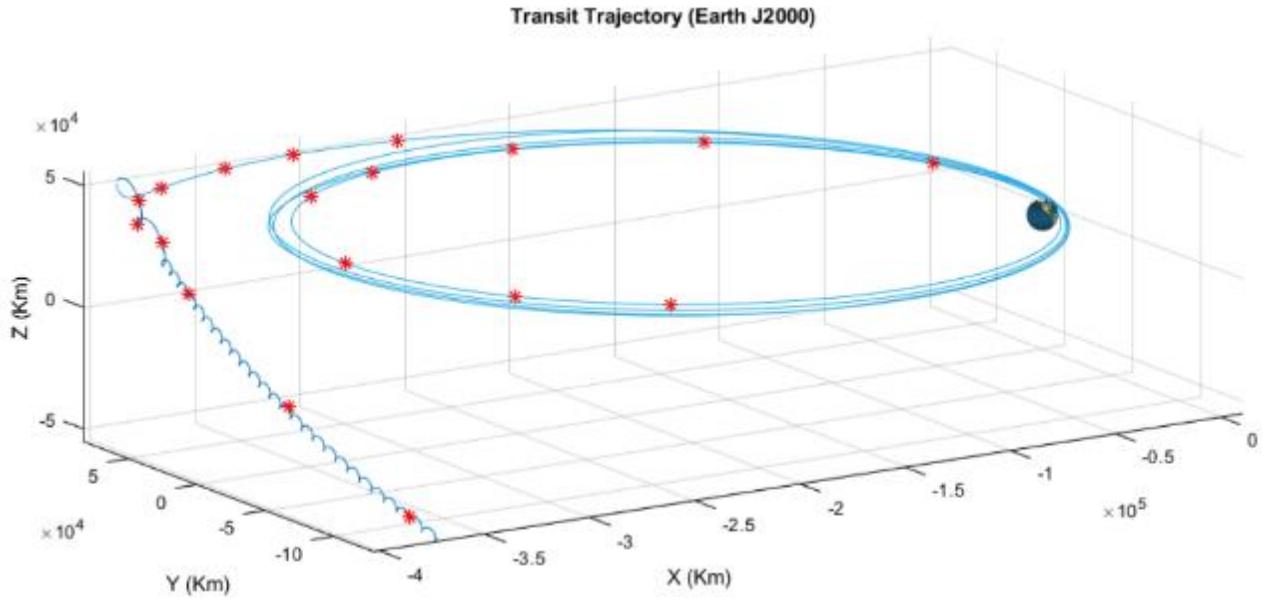
- LuGRE payload consists of:
  - A RHCP passive L-band HGA, operating in L1/E1 and L5/E5a GNSS bands
  - A Low-Noise Amplifier
  - A Moon-customized QASCOM-SPACE GNSS receiver, in cold redundant configuration
  - A supervisory board managing the dual receiver configuration



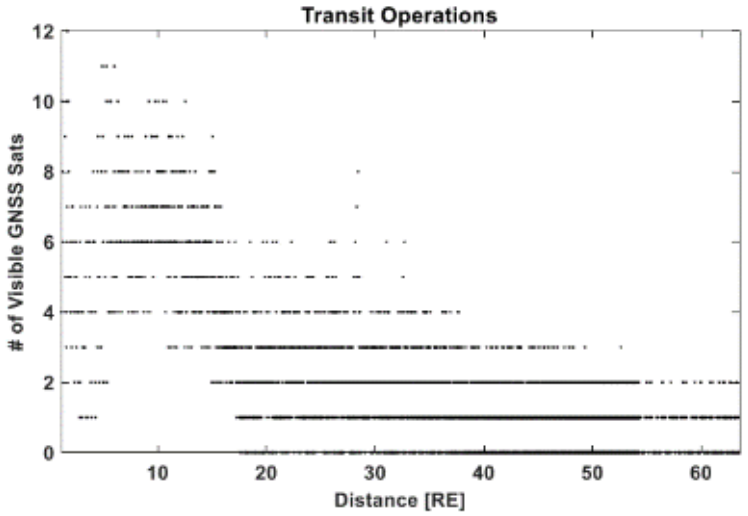


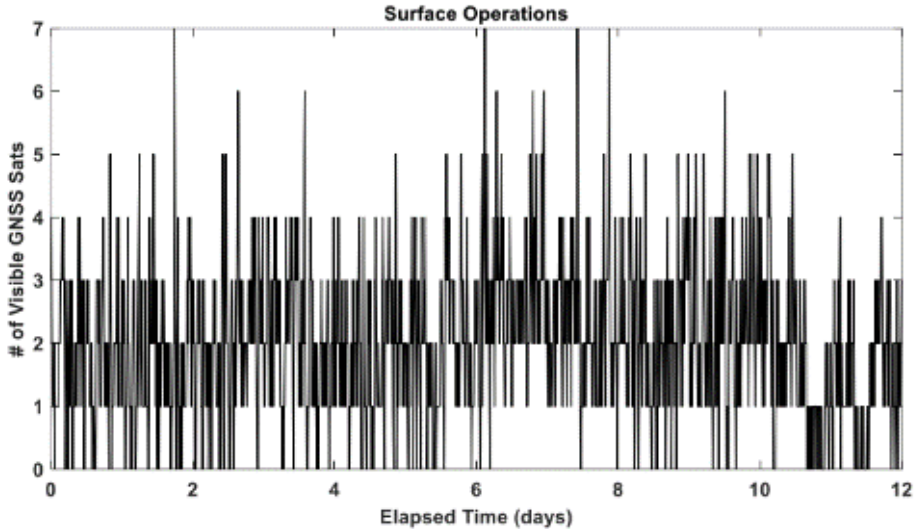


Mission Scenarios



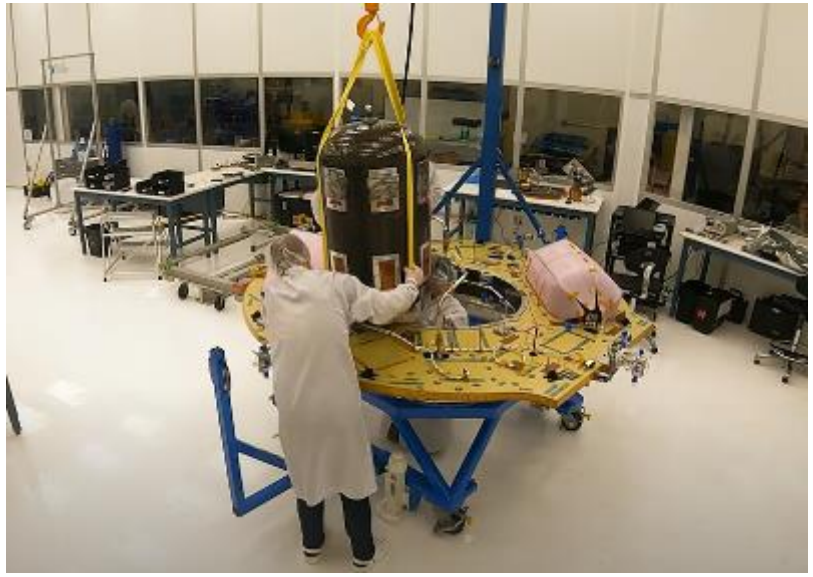
Earth-centered transit trajectory in the J2000 frame. Measurement periods are indicated by red stars





Summary of expected total GNSS visibility throughout transit (left) and during surface operations (right).

Receiver Integration phase in the Lander

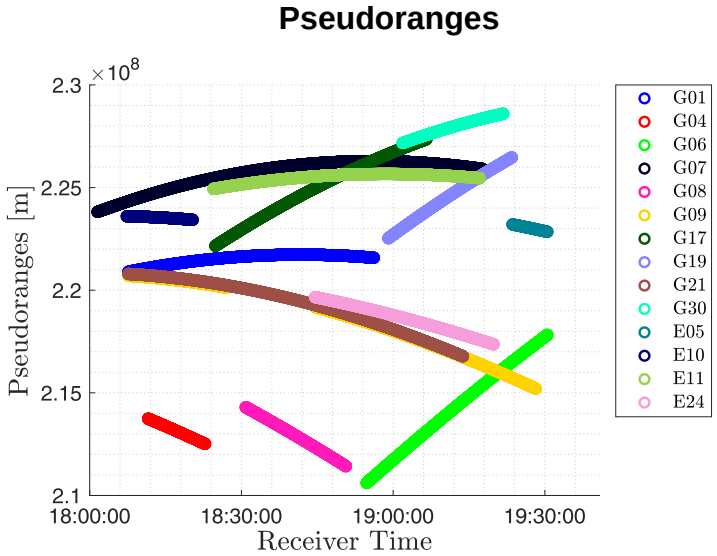


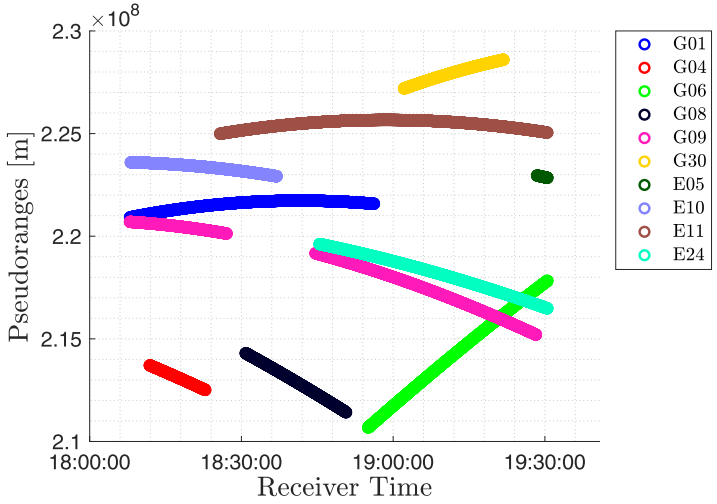
Currently the LuGRE receiver is undergoing mechanical integration and electrical integration of the payload in the lander is foreseen in the next months.

Test Results: Measurements

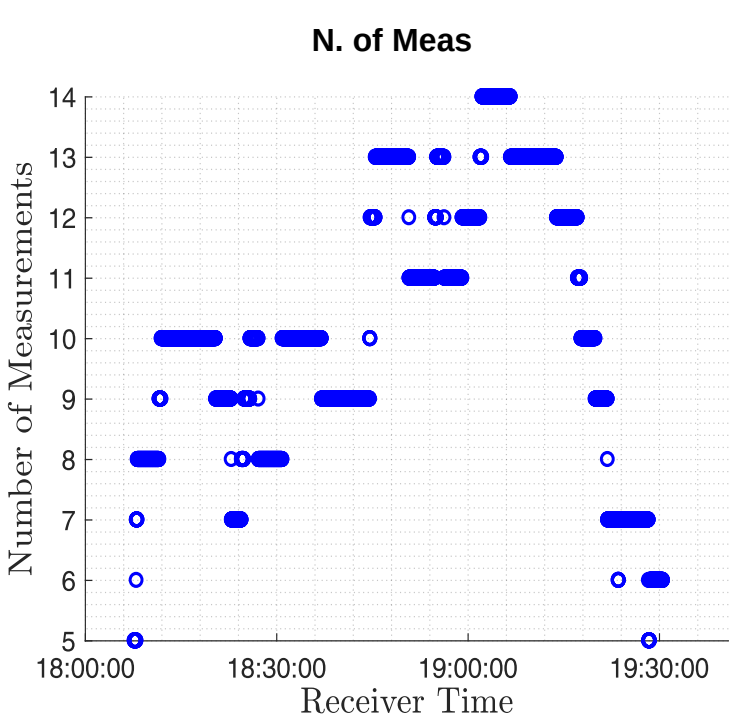
- Results related to a MTO scenario, simulating the receiver position at a distance from Earth equal to 30 Radius Earth (RE).
- The real-time data generated by the receiver are then processed to obtain the following Key Performance Indicators (KPIs):

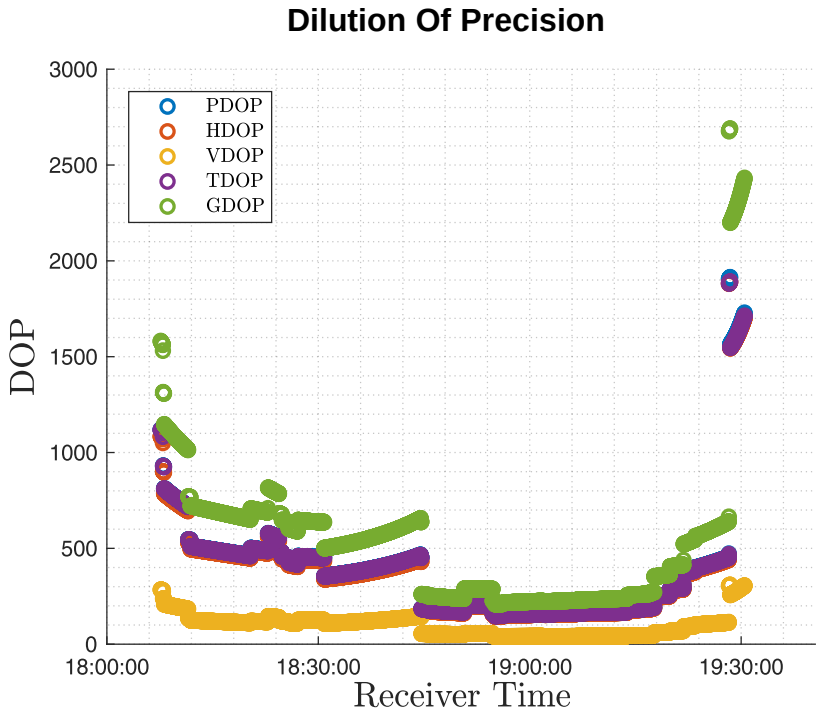
1. Range measurements
2. Number of signals (LOS)
3. The position and velocity error profiles.
4. The Dilution of Precision (DOP).
5. The PVT availability

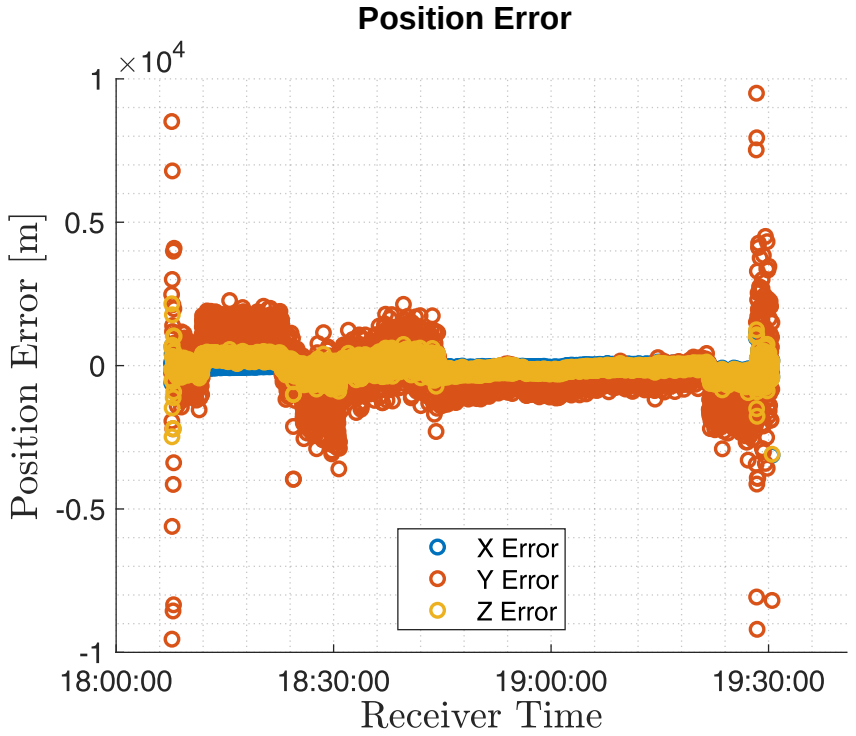




Test Results: Navigation

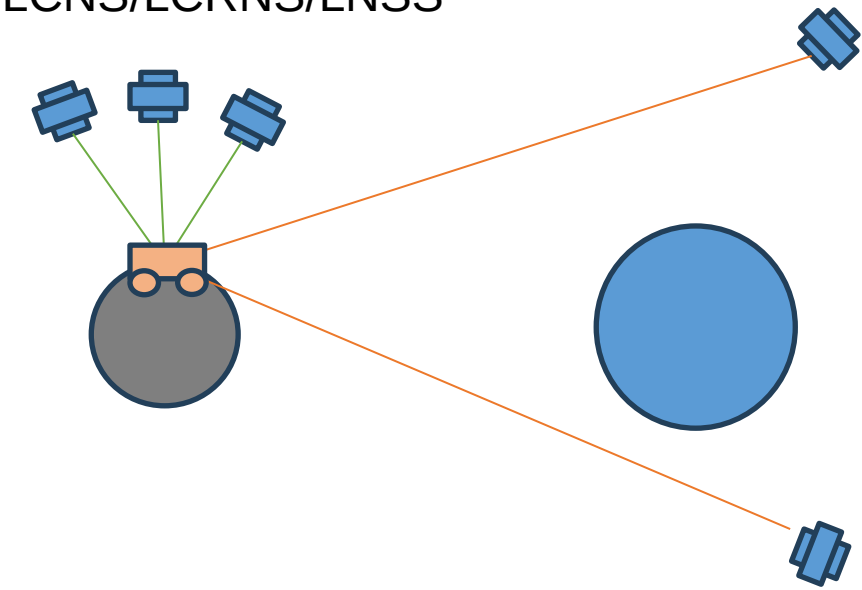




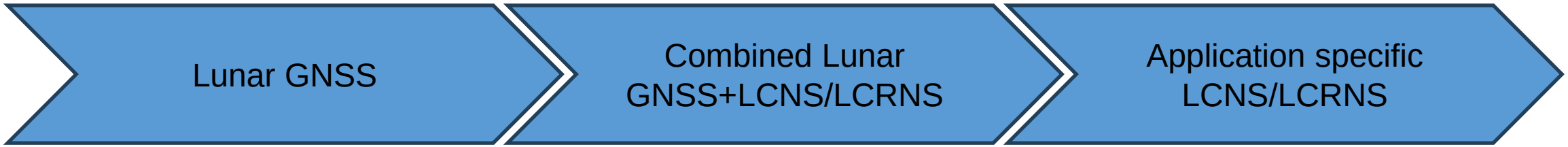


Future challenges and opportunities

LCNS/LCRNS/LNSS



- Qascom is currently developing an LCNS receiver for the moonlight program
- Our roadmap foresee the development of combined GNSS/LCNS/LCRNS/LNSS receivers.
- The main challenges are:
  - Integration of the two baseband processing of GNSS+LCNS/LCRNS
  - Antenna deployments, high gain GNSS + LCNS/LCRNS patch antenna
  - Low mass, power and size



2022 - 2024

2024 - 2026

>2026

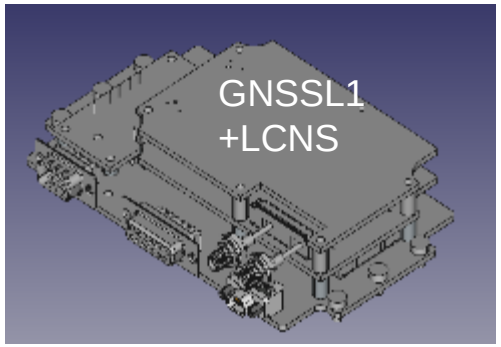
Current Qascom baseline for integrated GNSS/LCRNS/LCNS/LNSS

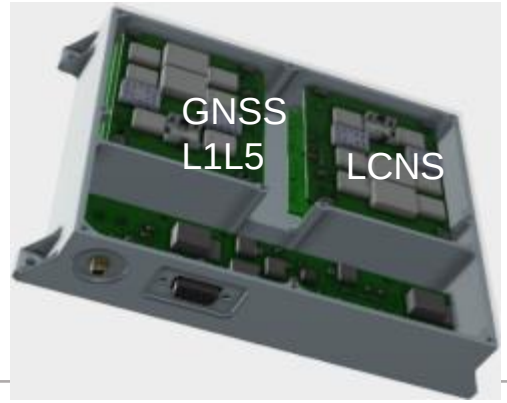
The baseline radio front end is for GNSS L1 and L5 (GPS + Galileo)

Currently Qascom is developing a prototype front end for the European LCNS (moonlight), in the S band.

The option to accommodate GNSS+LCRNS can be achieved with two approaches:

- Dual receiver configuration, single radhard supervisor that controls a GNSS L1+L5 receiver and a LCNRS S band receiver
- A single receiver with a radio front end capable to acquire GNSS L1 only + LCNRS S band.



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“Only those who attempt the absurd
can achieve the impossible”,
Albert Einstein
Thank you!