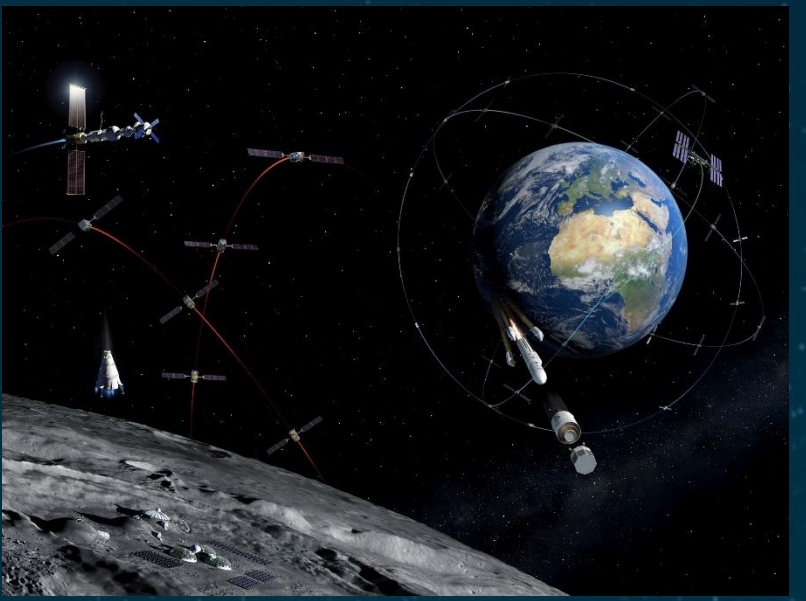
ESA Lunar PNT on-going activities: The ESA Moonlight Programme



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D/NAV

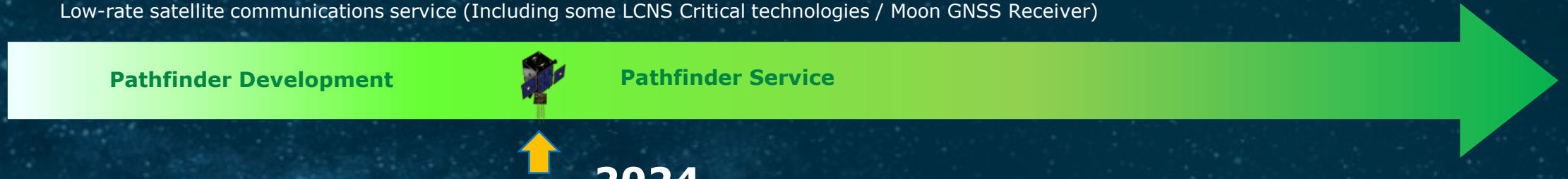
05/05/2021

Moonlight / LCNS

Moonlight Roadmap

Step 1: Moonlight / LUNAR PATHFINDER – GNSS In Lunar Orbit demonstration

Low-rate satellite communications service (Including some LCNS Critical technologies / Moon GNSS Receiver)

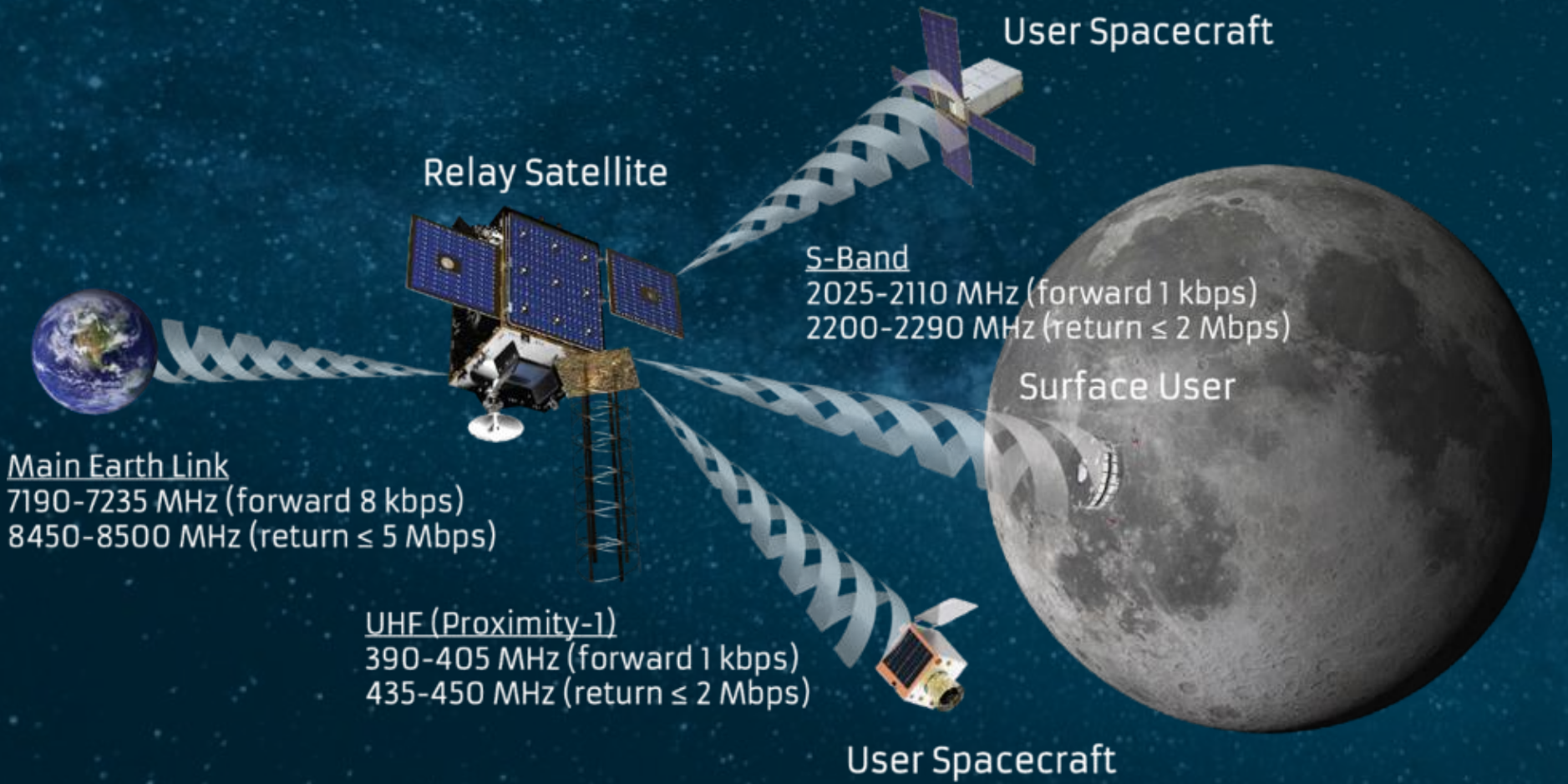


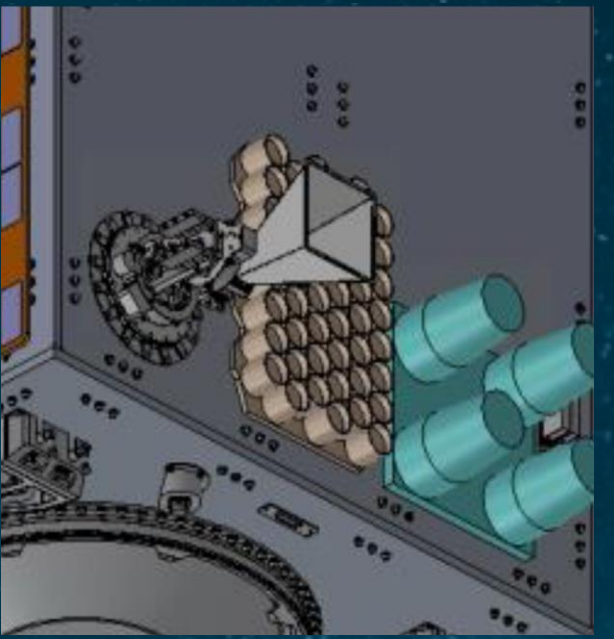
Step 2: Moonlight / LCNS (dedicated lunar Constellation)

High-data rate satellite communications and navigation service

Future Lunar Pathfinder IoD GNSS Payload and Laser Retroreflector experiment with NASA (launch 2024)

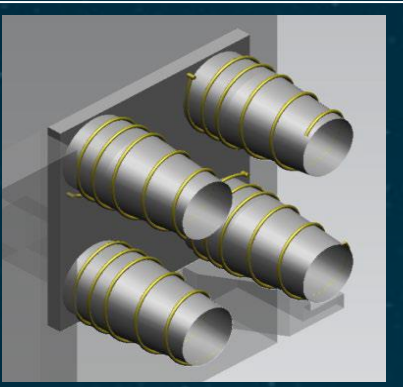
First ever demonstration of GNSS reception on Lunar orbit.





GNSS Receiver and GNSS antenna high-level specifications

High-sensitive GNSS Receiver



High-gain GNSS Antenna

Parameter	Value
Acquisition sensitivity	15dBHz
Tracking sensitivity	15dBHz
3D Position accuracy	< 100m RMS
3D Velocity accuracy	< 0.1 m/s RMS
Mass	1.3 Kg
Size	24x12x7cm
Power	< 12W

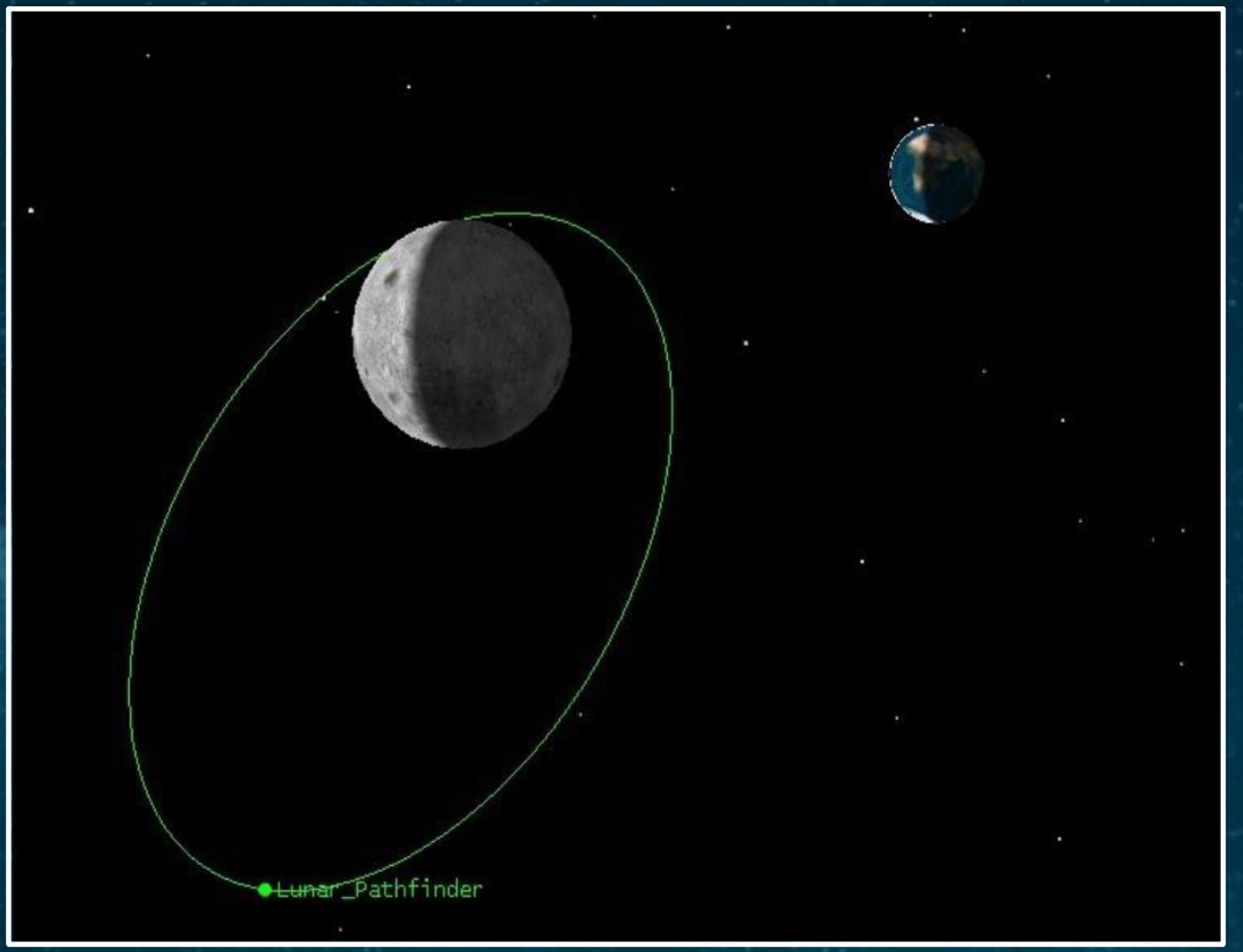
Parameter	Value
L1 boresight gain	15 dBi
L5 boresight gain	12 dBi
Polarization	RHCP
Mass	~2Kg
Size	26*26*28cm

The **on-board navigation filter** in the receiver implements Earth and Sun point mass and the Moon gravity field up to **10x10 order and degree harmonics**.

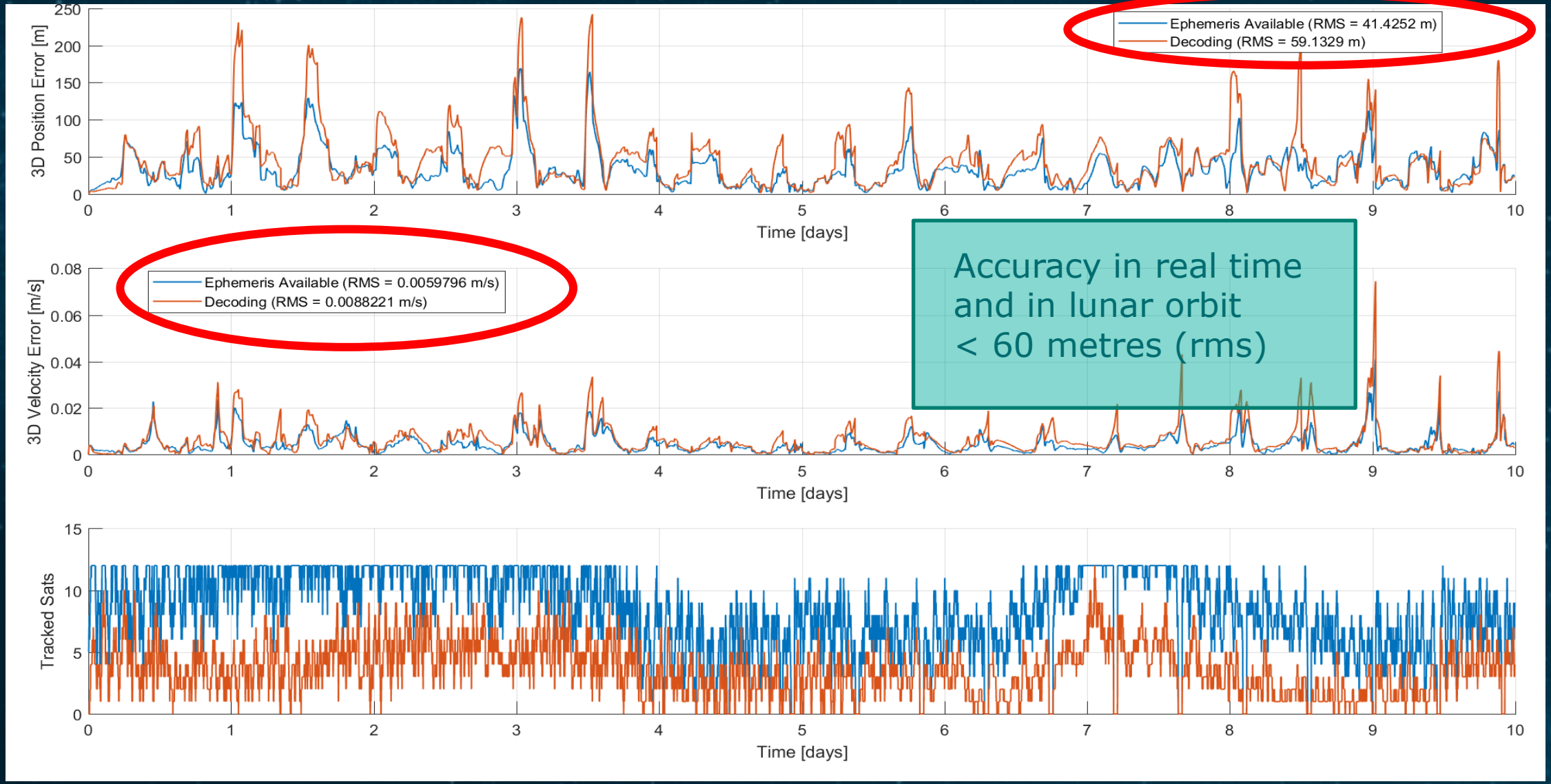
Lunar Pathfinder Operational orbit

Satellite will be an elliptical lunar frozen orbit with the apoapsis over the lunar South Pole

Aposelene height : 7500 Km
Periselene Height: 500 Km
Eccentricity: 0.61
Inclination (deg): 57.8



Estimated performances: very accurate simulation LP

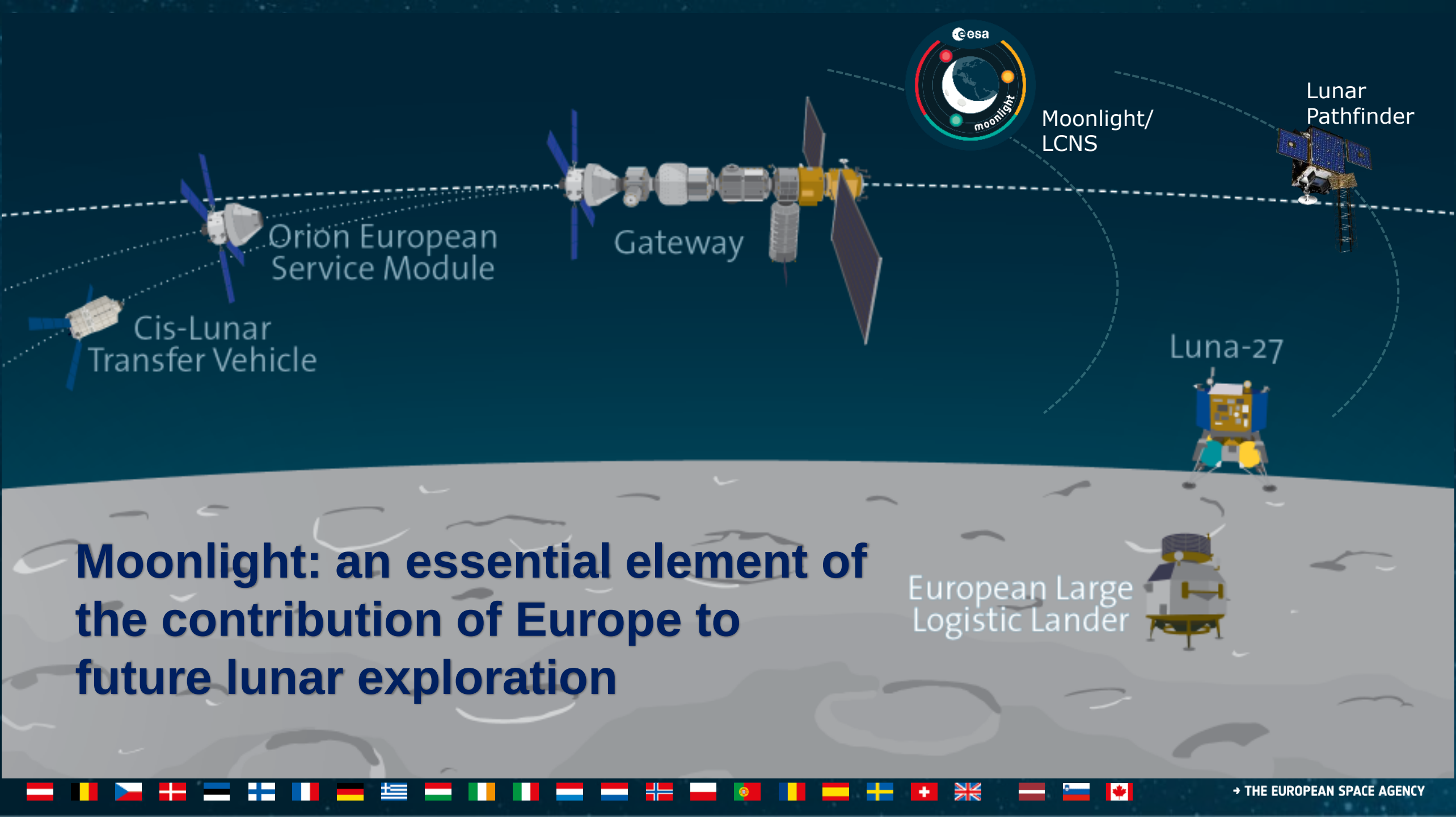


Accuracy in real time
and in lunar orbit
< 60 metres (rms)

Step 2: Moonlight / LCNS

ESA Moonlight: Mission statement

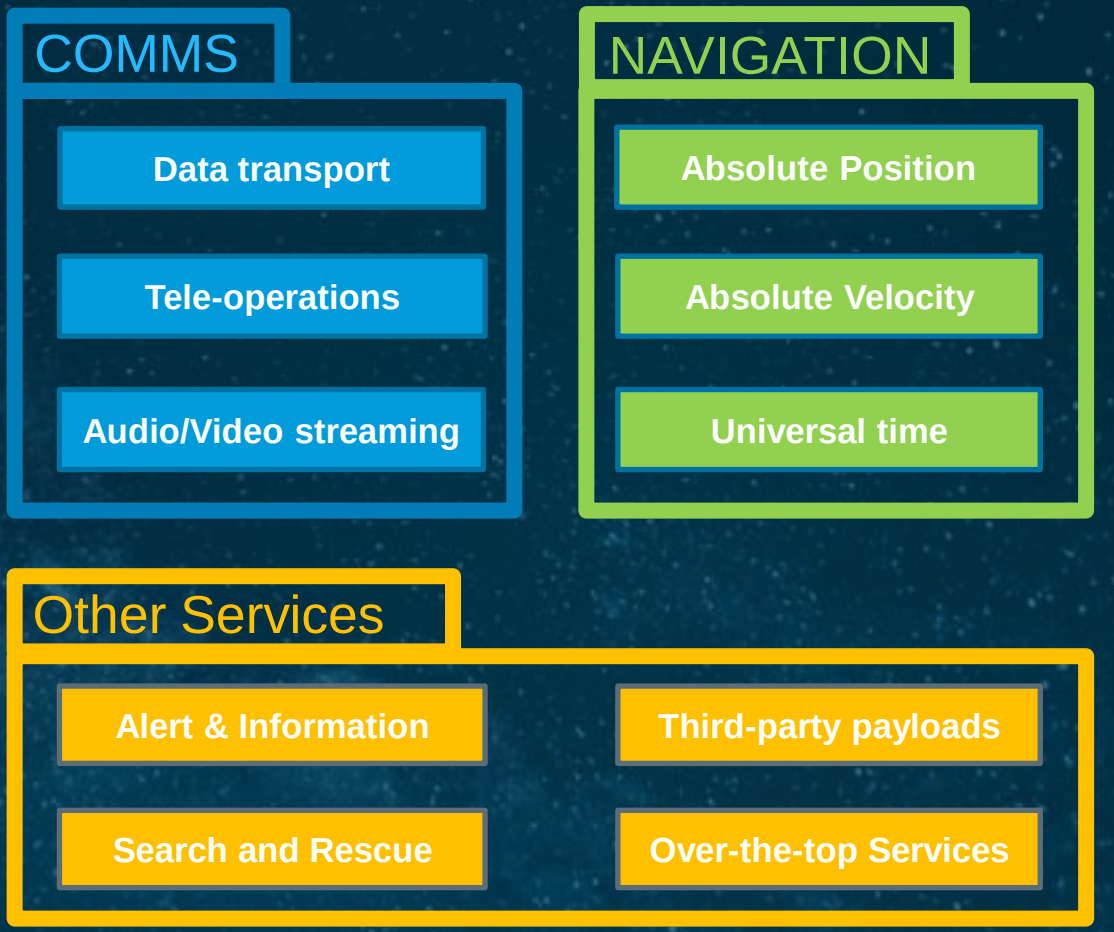
To enable the delivery of Communications and Navigation Services that will support the current and next generations of institutional and commercial Lunar explorers



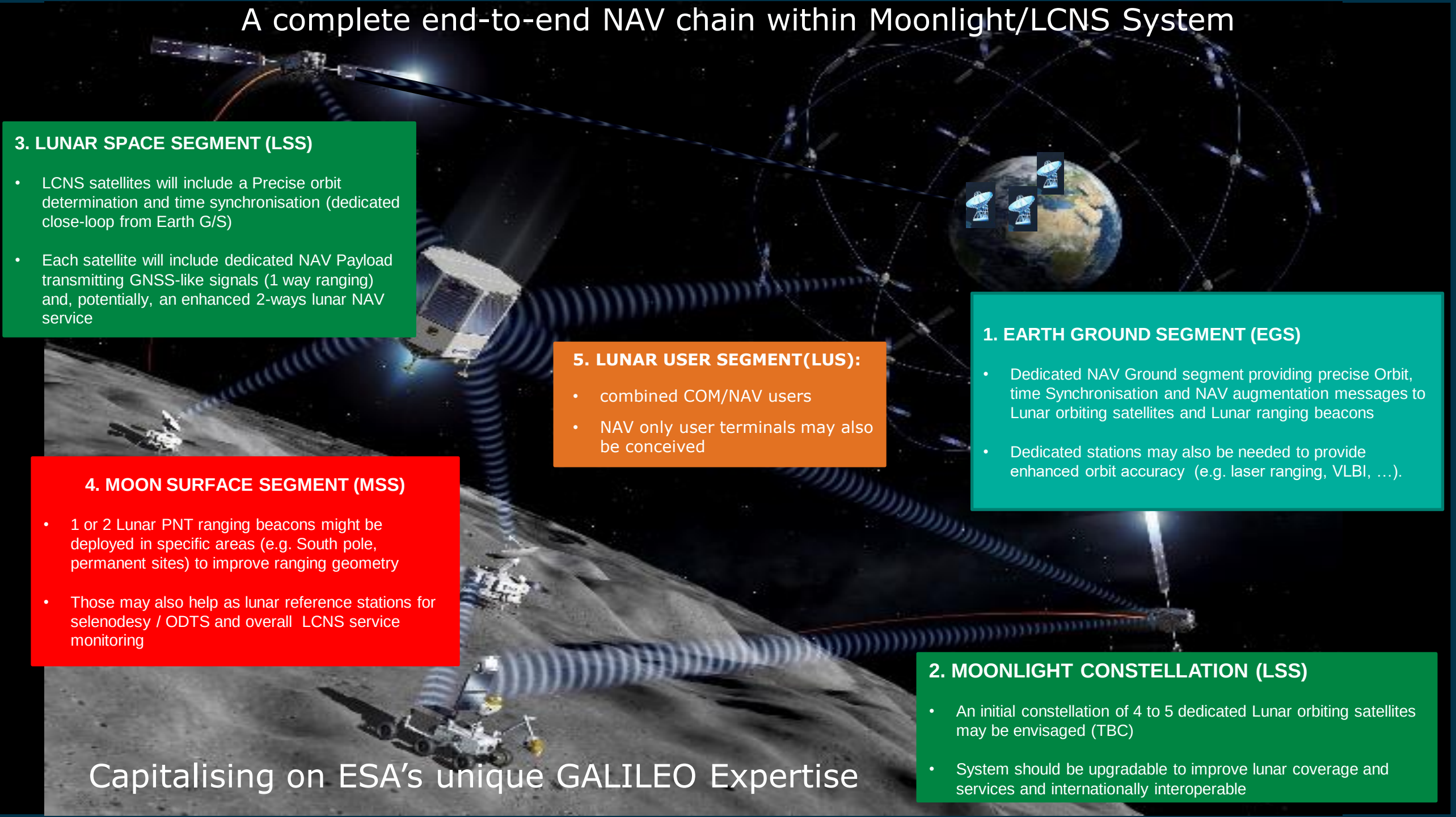
Moonlight: an essential element of the contribution of Europe to future lunar exploration

Moonlight / LCNS Service offer

- ✓ Initial set of capabilities identified by ESA for our industrial teams to focus on and elaborate further;
- ✓ The Phase A/B1 work aims at defining a feasible concept traceable to these capabilities;
- ✓ Further capabilities may be considered (e.g. outcome of the users workshops)



A complete end-to-end NAV chain within Moonlight/LCNS System



3. LUNAR SPACE SEGMENT (LSS)

- LCNS satellites will include a Precise orbit determination and time synchronisation (dedicated close-loop from Earth G/S)
- Each satellite will include dedicated NAV Payload transmitting GNSS-like signals (1 way ranging) and, potentially, an enhanced 2-ways lunar NAV service

5. LUNAR USER SEGMENT(LUS):

- combined COM/NAV users
- NAV only user terminals may also be conceived

1. EARTH GROUND SEGMENT (EGS)

- Dedicated NAV Ground segment providing precise Orbit, time Synchronisation and NAV augmentation messages to Lunar orbiting satellites and Lunar ranging beacons
- Dedicated stations may also be needed to provide enhanced orbit accuracy (e.g. laser ranging, VLBI, …).

4. MOON SURFACE SEGMENT (MSS)

- 1 or 2 Lunar PNT ranging beacons might be deployed in specific areas (e.g. South pole, permanent sites) to improve ranging geometry
- Those may also help as lunar reference stations for selenodesy / ODTS and overall LCNS service monitoring

2. MOONLIGHT CONSTELLATION (LSS)

- An initial constellation of 4 to 5 dedicated Lunar orbiting satellites may be envisaged (TBC)
- System should be upgradable to improve lunar coverage and services and internationally interoperable

Capitalising on ESA's unique GALILEO Expertise

LCNS Initial Mission Assumptions (1/2)

Commercial & Institutional Missions

Open Interface

Interoperability

Beyond 2026

Scalability

Standardisation

Support all Mission Phases

1000Km Service Volume [to 70000Km]

South Pole Coverage [to Far side & Global]

LCNS Initial Mission Assumptions (2/2)

Compatible with Earth GNSS

Precise timing (sub µs)

Position accuracy
Landing: 100m [to 30m]
Surface: 50m [to 10m]

Velocity accuracy
Landing: 0.5m/s
Surface: 0.1m/s

20Mbps/user
[to 50Mbps/user]

10GB/hour
[to 100GB/hour]

Security functions

Slotted Real time services

Moonlight / LCNS Implementation Steps

Q1'2018 Prior Work → Q2'2020 Phase A/B1 CFI → Q3'2020 Phase A/B1 ITT Release → Q2'2021 Phase A/B1 2x Studies (YOU ARE HERE) → Q4'2022 (TBC) Phase B2/C/D/E1

TELESPAZIO (a LEONARDO and THALES company): ThalesAlenia Space, ALTEC, argotec, Nanoracks, OHB, hispasat, inmarsat, MDA, POLITECNICO MILANO 1863, SDA Bocconi

SSTL LUNAR: AIRBUS, gmv, gmv NSL, KSAT, GOONHILLY, SES, SURREY

Service Definition / Business Development / Partnership Models

Mission Requirements Definition	Service and System Concept Development	System Architecture Development	System Detailed Definition
Apr'21 Kick-Off	Q3'21 MRR	Q4'21 SCR	Q1'22 PRR	Q3'22 iSRR

- Kick off of Moonlight Phase A/B1 held on April 2021
- Industrial teams include satellite operators (potential service providers) and large space&ground system integrators
- **Initial Moonligth services planned for 2026-2028**

Recent ESA publications at Inside GNSS Journal