

Moonlight

Pioneering Communication and Navigation for Lunar Exploration



Moonlight is the European Space Agency's (ESA) program to enable connectivity and navigation services to lunar users by delivering a constellation of satellites around the Moon. ESA initiated the program to both support its own Moon missions and to create a European commercial operator to commercialise services for other lunar operations, including landed and orbital missions.

With over **400 lunar missions** planned by space agencies and private companies in the next twenty years, Moonlight represents a crucial step toward **sustainable lunar exploration** and the development of a robust lunar economy.

The program aims to support both institutional and commercial missions, enabling precise autonomous landings, surface mobility, and high-speed, low-latency, mission-critical data transfer between Earth and the Moon.

This infrastructure will aim to support not only humanity's return to the Moon but also **establish a stable and long-term presence in support of space exploration missions**.

Lunar Communication and Navigation Services

As part of ESA's MOONLIGHT initiative, The Lunar Communication and Navigation Service program (LCNS) seeks to lay the foundation for a **stable and sustainable future in lunar exploration**, fostering international cooperation and creating new commercial opportunities within the lunar economy through a deployment of a space asset.

With an innovative infrastructure, this programme enables future missions to rely on a dependable network for communication and navigation, supporting both human and robotic exploration and advancing new goals in space exploration.

The Role of the European Consortium

Since October 2024, Telespazio has been working with ESA for the development of a satellite constellation aiming to provide **communication and navigation services for future lunar missions**.

The project, called Lunar Communication Navigation Service (LCNS), involves a consortium of specialized companies, with Telespazio as the prime contractor and overall system integrator.

The consortium includes as industrial partners **HispaSat, Viasat, Thales Alenia Space Italia, Qascom, KSat, Telespazio UK, Telespazio Iberica**, and as university providers **SDA Bocconi, Polimi, CRAS (La Sapienza)**, and **SIA (La Sapienza)** for the design, realization, and operational qualification of the system.

The LCNS Service Infrastructure

The Lunar Communication and Navigation Services infrastructure is designed to bring together communication and navigation into one high-performance service. By harmonising different capabilities, LCNS plans to unlock the full potential of lunar exploration and surface operations: precise lunar positioning can enable safe, reliable exploration and autonomous operations, while continuous communications can ensure full control, coordination, and data exchange for all mission activities.

The LCNS infrastructure consists of three key elements:

- › **Lunar Space Segment:** a planned constellation of up to five satellites for both navigation and communication. These satellites aim to provide high-speed, low-latency communication services, along with precise navigation signals that aim to enable autonomous landings and surface mobility

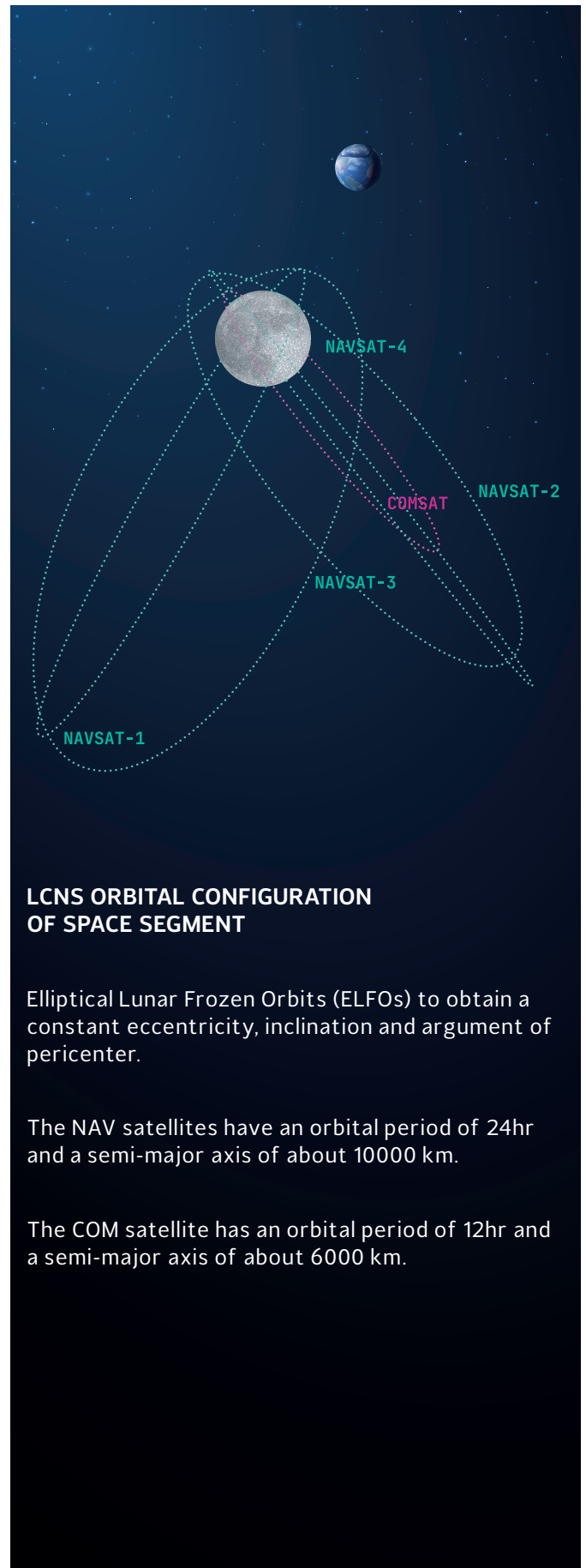
The satellites would be positioned to ensure extensive coverage of the lunar South Pole, an area of particular interest for future missions due to resources like lunar ice in the “eternal darkness” craters and “peaks of eternal light,” which are ideal for solar energy harvesting.

The constellation of LCNS satellites is designed to provide optimized service coverage of the lunar south pole, both for communication and navigation. We choose an Elliptical Lunar Frozen Orbits (ELFOs) to obtain a constant eccentricity, inclination and argument of pericenter.

- › **Earth Ground Segment:** ground stations on Earth together with a state-of-the-art Ground Station Network with an associated ground segment element deployed over a public cloud, playing a key role in monitoring and managing the entire infrastructure.

The EGS infrastructure would be crucial in ensuring the continuity of services and the connection between the Moon and Earth, coordinating all operations of the constellation and supporting the communications and navigation network.

- › **Lunar User Segment:** granting LCNS services access for end-users through Qualified Type Approval Lunar User Terminals (LUT) aiming first to validate the communication and navigation services once during the in-orbit qualification and then to provide end-to-end services to the final user.



Communication Service Capabilities

The LCNS Services are planned to provide high availability and daily temporal coverage. The following communication service characteristics are planned to be supported:

- › **High-throughput K-band and wide-area S-Band services**
- › **Real-Time and Store and Forward Data Relay Service**
- › **QoS for prioritization Nominal and Critical operations**
- › **Real time data transferred in seconds**
- › **Support to several concurrent user sessions**

A Direct to Earth (DTE)/Direct with Earth (DWE) service complement the LCNS data relay services for improving temporal and geometrical coverage.

Navigation Service Capabilities

The following navigation services capabilities are provided:

- › **Real time services:**
 - › One-Way Ranging (OWR)
 - › Position, Velocity and Time (PVT)
 - › Time Dissemination Service (TS)
 - › Two-Way Measurement (TWM – To be confirmed)
 - › Navigation Service Availability and Performance Prediction
- › **Non-real-time services granting highly accurate PVT post processing**

MISSIONS LCNS CAN SUPPORT

Robotic

On lunar orbit



- Cubesat
- Orbiter

On lunar surface



- Rover
- Sensors
- Lander
- Lunar Infrastructure

Crewed



- Pressurized vehicle
- Crewed Lander
- Habitat
- Crew Extra Vehicular Activities



Interoperability and International Cooperation

LCNS will be part of the LunaNet and as that will adhere to LunaNet Interoperability Specification (LNIS) for the service provision.

- › The services provided by LCNS will conform to the LunaNet framework of mutually agreed-upon standards, protocols, and interface specification that enable interoperability with other LunaNet Service Providers.
- › The flexible approach of LunaNet, of providing incremental services, starting from an IOC phase until a sustained capability phase, is followed in the LCNS setup, which will undergo a progressive deployment of the communication and navigation services from the IOC to the FOC phase.

LCNS is compliant with Interagency Operations Advisory Group (IOAG), Space Frequency Coordination Group (SFCG), and Consultative Committee on Space Data Systems (CCSDS) standards and recommendations.

Service Availability

LCNS Service is released in a staggered approach and the services are expected to be scaled from initial to final capabilities over the next five years.

Key Benefits of the LCNS Program

- › **Enhanced Communication:** LCNS aims to enable high speed data transmission, allowing lunar missions to communicate effectively. This improves operational efficiency, reduces mission weight and power requirements and minimizes the need for direct to Earth communications.
- › **Precise Navigation:** the LCNS constellation plans to provide highly accurate positioning signals, reducing the complexity and cost of navigation for landers, rovers, and orbiters. It decreases the risk of lunar exploration by ensuring PVT services.
- › **Commercial Opportunities:** By creating reliable lunar communication and navigation services, Moonlight opens new possibilities within the growing lunar economy, facilitation technological advancements and sustainable exploration.

In summary, LCNS aims to sustain advanced, longer scientific missions, technology development, establishing a human presence on the moon.

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