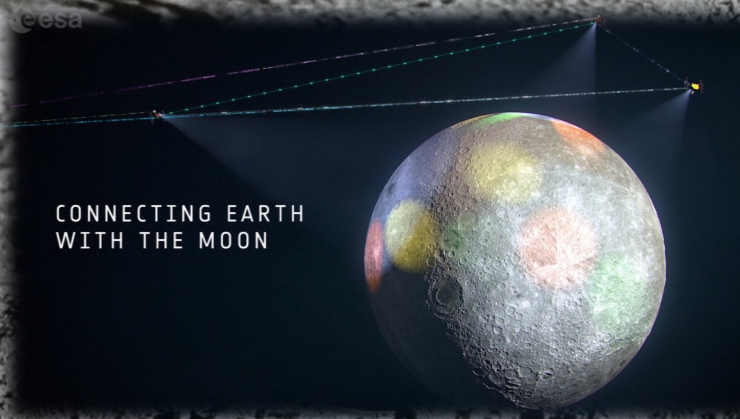


The future of Lunar Communications and Navigation Services

Nicolà De Quattro: *Head of Innovation and Technology Governance, Telespazio Belgium
PNT Infrastructures and Solutions Domain Manager, Telespazio Group*

*Giuseppe Tomasicchio: CTIO – Head of System Engineering,
Moon Exploration and Space Logistics Domain Manager, Telespazio SpA*



Reference framework: the next Space Race

The Moon is the celestial body closer to Earth, a «gateway» for the whole solar system, and represents the most suitable candidate to test future space exploration activities and human settlement initiatives in the Space environment



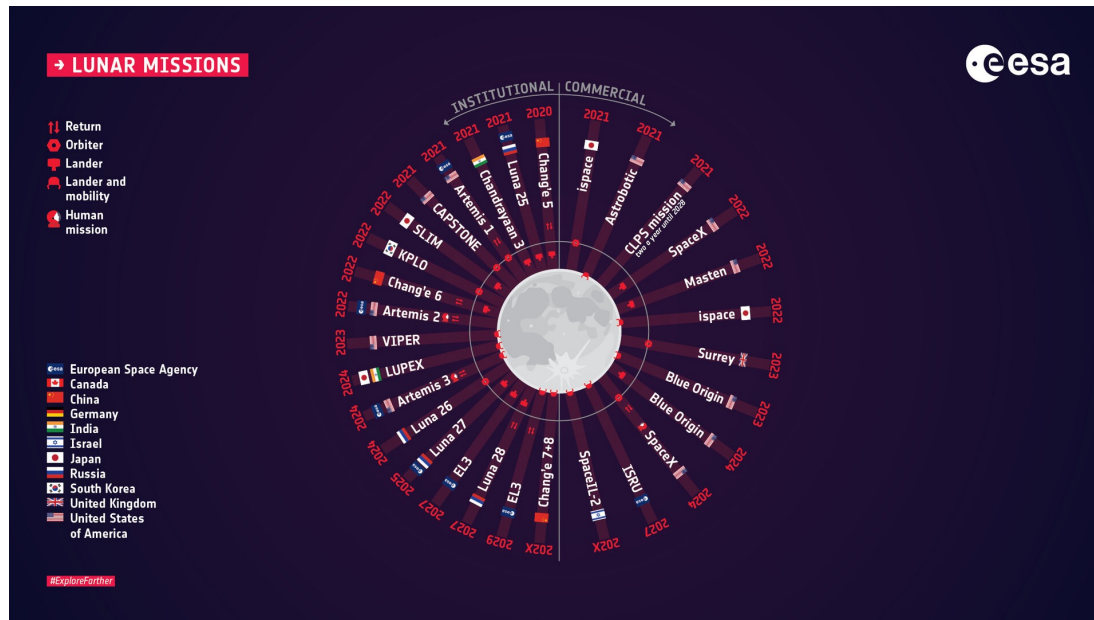
Credits: TIME



The lunar exploration at the beginning of the 21th century:

Exploration for Scientific purposes (1/2)

- ✿ 30 Lunar missions planned (10 in 2021)
- ✿ At least 12 commercial and 18 institutional missions within the next 10 years



- Artemis lunar spacecraft (NASA's Orion crew module and the European Service Module (ESM))
- Lunar Space Gateway
- Artemis Commercial Lunar Payload Services (CLPS)
- European Large Logistic Lander (EL3),
- ESA PILOT for demonstrated autonomous hazard detection and avoidance and
- ESA PROSPECT, Russian Luna landers as part of the Roscosmos exploration program.

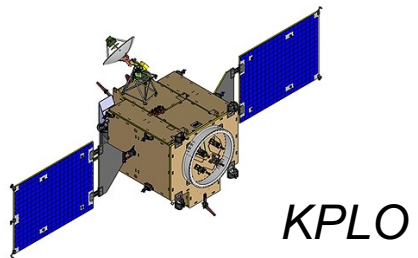
- Chandrayaan program, (Indian Lunar Exploration Programme)
- Chinese Lunar Exploration Program (CLEP) – Chang'e Project
- Russian Lunar Program (Luna-Glob) - ESA contributes to LUNA-27, planned in 2025 on the South Pole, with a scientific payload.



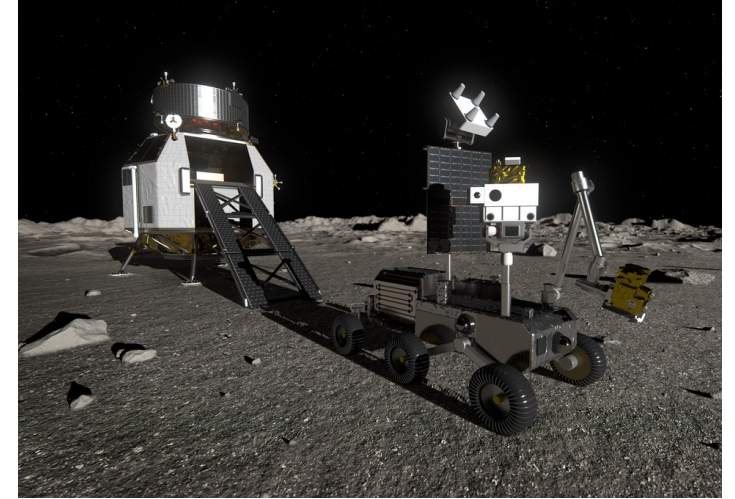
The lunar exploration at the beginning of the 21th century:

Exploration for Scientific purposes (2/2)

- * Permanent scientific missions (lander, surface operations)
- * Scientific missions with return (lander, surface operations, return)
- * Human exploration missions (lander, surface operations, return)
- * Scientific missions for lunar observation (orbiting)



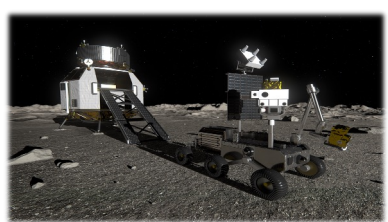
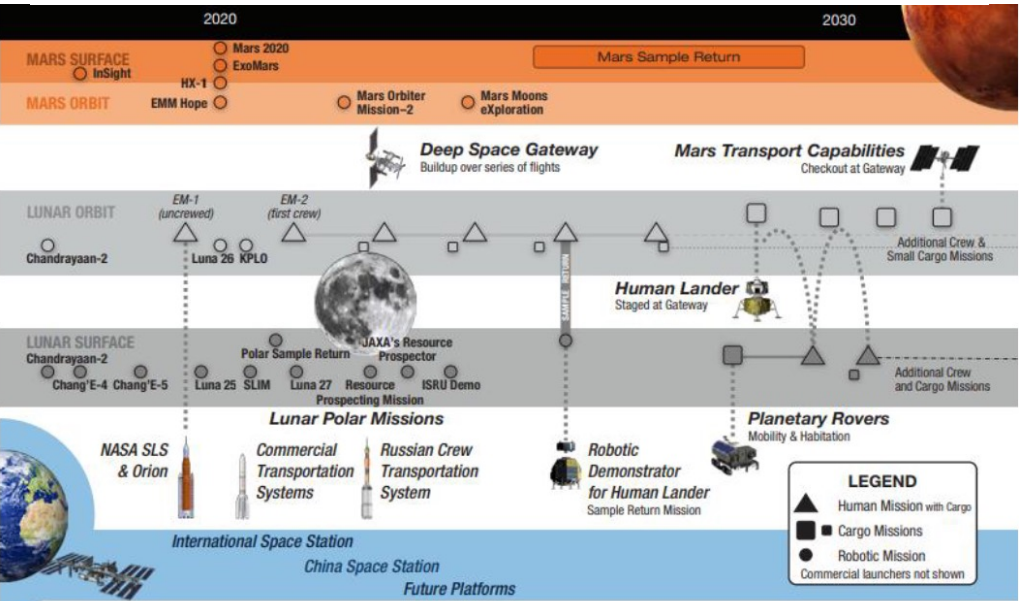
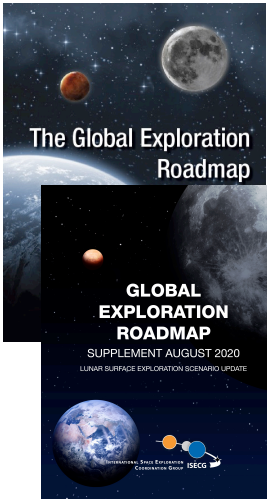
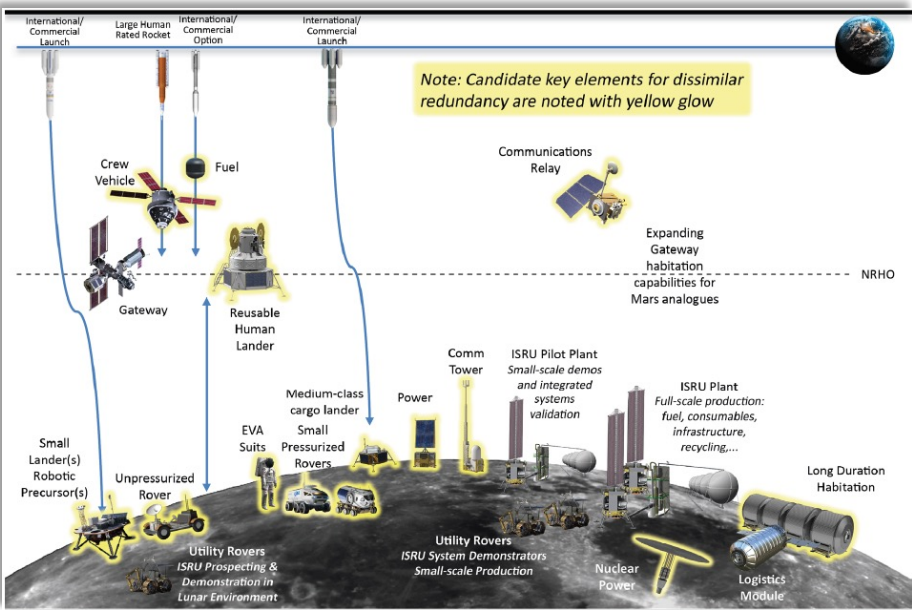
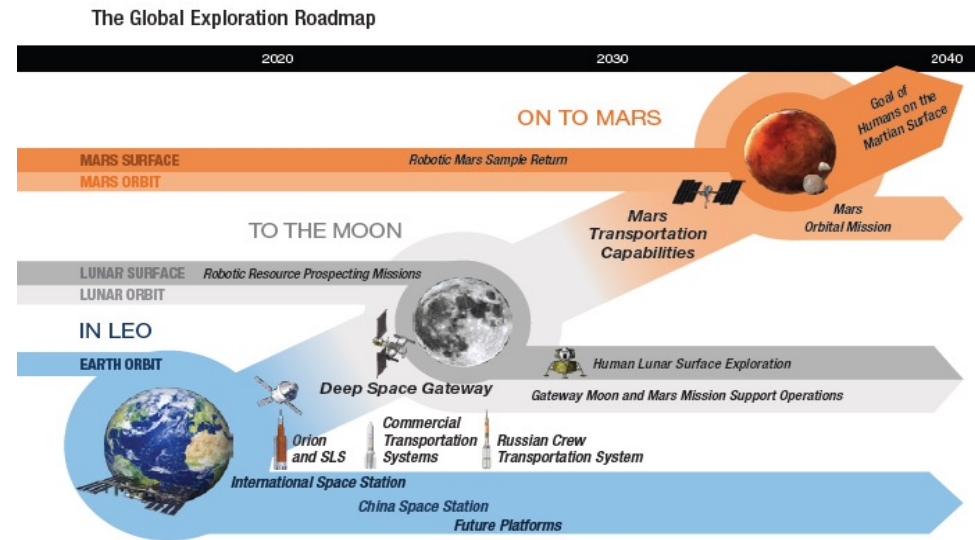
Heracles (Institutional)



SpaceX (commercial)



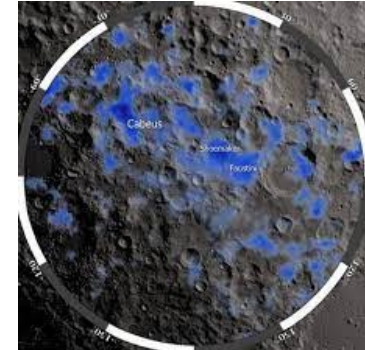
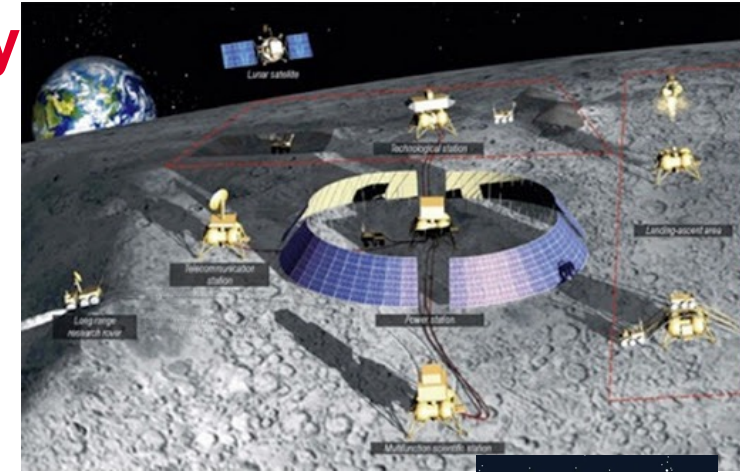
The lunar exploration at the beginning of the 21th century: From Scientific Exploration to Space Commercialization



The lunar exploration at the beginning of the 21th century

Exploration for commercial purposes

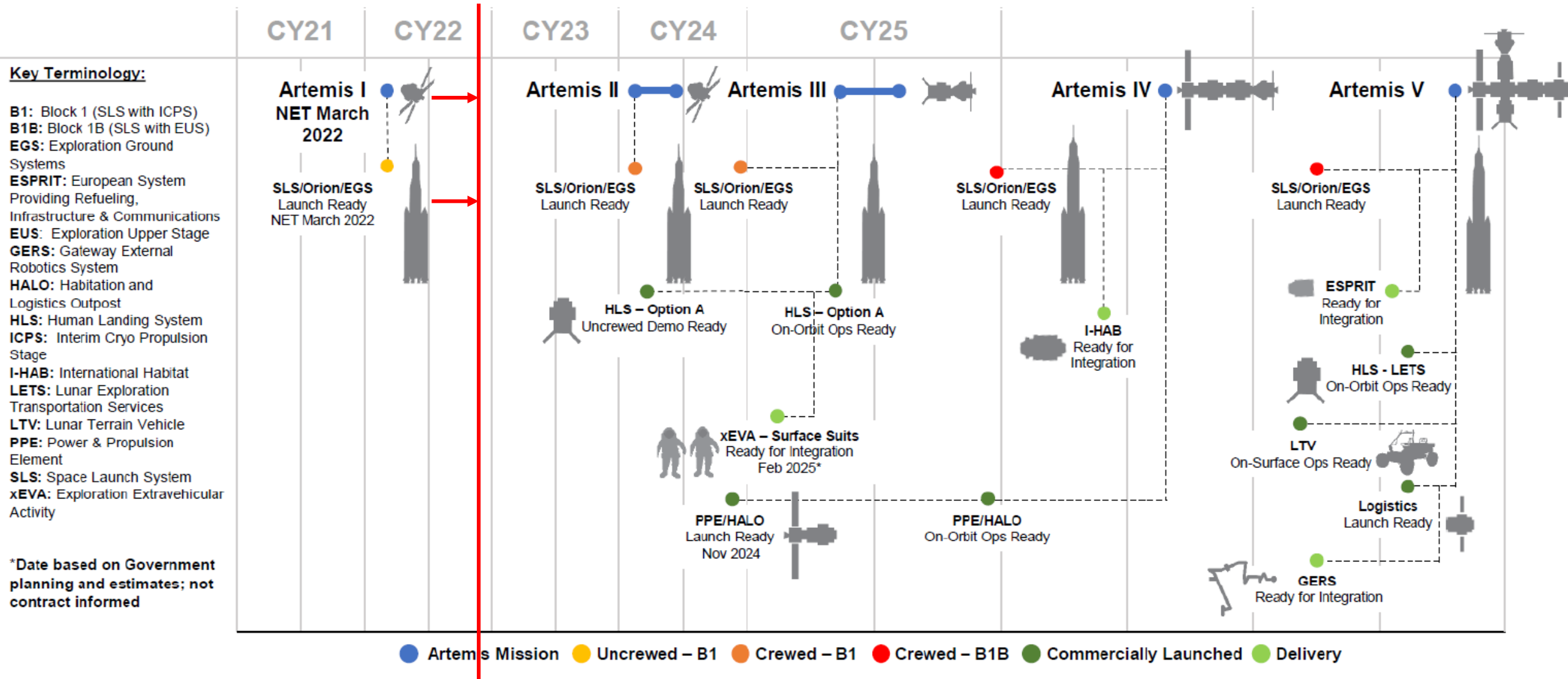
- ✧ Space has become a domain for commercial efforts and business
- ✧ New **business models and value propositions**
- ✧ Vision: to create a **real LUNAR SPACE ECONOMY**.
- ✧ More solid business scenarios:
 - ✧ **Lunar mining infrastructures**, for natural resources extractions (He-3, ice, and rare soils).
 - ✧ **Exploitation of the Helium-3** on the Moon for nuclear fusion.
 - ✧ Development of infrastructures for the transportation of **rare soils** on the Earth.
 - ✧ Development of infrastructures for **cryogenic fuel supply** for space vehicles, decreasing transportation and missions costs.
 - ✧ Building of **Lunar bases (Moon village)** by exploiting lava tubes to shield the radiations.



NASA Programs



NASA Artemis Roadmap



NASA Programs

LUNANET – NASA RFI Initiative NASA “Lunar Comm. Relay and Nav. Services”

- ✧ Telespazio participated to the RFI of the NASA project LUNANET: “Lunar Comm. Relay and Nav. Services”

Networked Communication Services

- Critical data transmitted in real time.
- Data aggregated and transmitted in store-and-forward mode from orbiting and surface relays
- Data exchanged among lunar users with no need for transfer to and from Earth
- Data sent on demand by user or scheduled to better manage Earth stations loading & spectrum use

PNT Services

- LunaNet nodes provide precise position, velocity & time for autonomous navigation & collision avoidance
- GNSS-compatible transceivers at LunaNet nodes provide precise orbit determination
- Extend GNSS Space Service Volume to Moon by using/providing GNSS compatible signals



Detection & Information Services

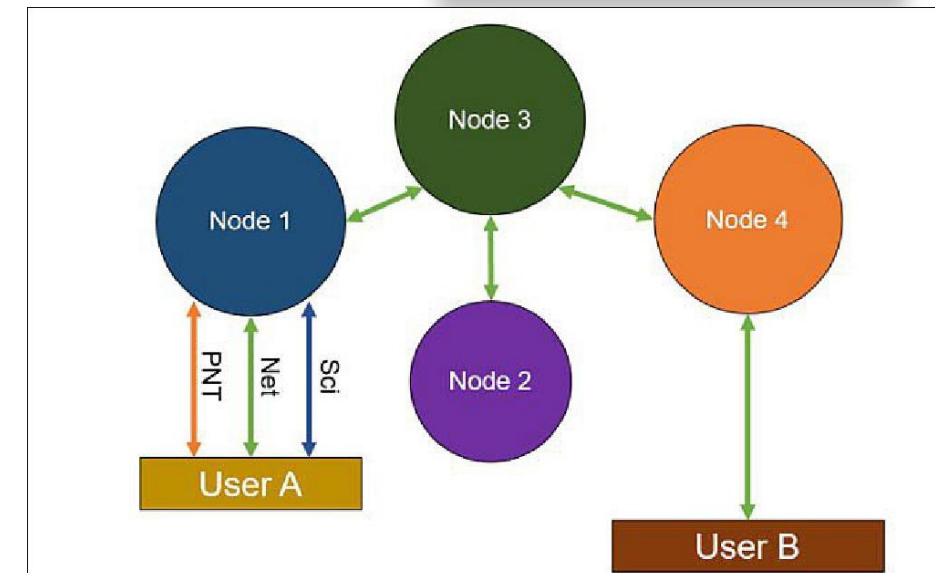
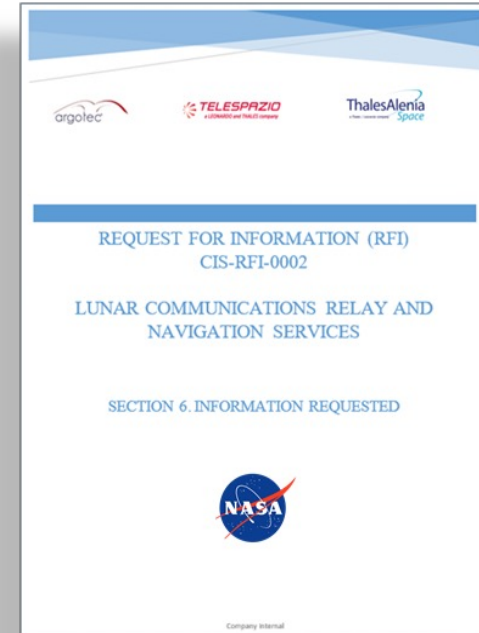
- Alerts for events such as space weather, collision avoidance, & surface impact predictions sent to all LunaNet subscribers
- Mission sensors for space weather and other measurements distribute information services to other users via LunaNet information services

Science Services

- Use RF & optical assets (part of) as scientific instruments
- Supports Radio & Radar Sciences, Radio Astronomy / Very Long Baseline Interferometry (VLBI) & other space sciences

Nodes architecture

- ✧ Every node provides a 3 services combination:
 - ✧ **Net**working (multi node)
 - ✧ Positioning, Navigation, and Timing (**PNT**)
 - ✧ **Sci**ence, “detection of situational alerts, science measurements”



ESA Programs



ESA MOONLIGHT Program



Project phases Lunar Communication and Navigation Service (LCNS)

* Main goal:

- * a European infrastructure, financially self-sufficient
- * Provide robust communication and navigation services and transparently timing distribution services
- * Targeting different assets (orbiter, landing/takeoff vehicles, rover, etc.)
- * Serving institutional and private/commercial entities

- * The Moonlight initiative allows minimizing costs for all future lunar missions
- * A shared infrastructure customized based on users' needs and the mission's required performances.
- * Based on pre-existing terrestrial and spatial infrastructures.

- * **History:** Commercial Lunar Mission Support Service, SSTL, and Goonhilly from 2015 (*Lunar Pathfinder*).

* An opportunity to exploit and grow strong competences in:

- * Space and exploration mission analysis, including users' needs, characteristics, constraints, and operations;
- * Commercialization, operations, and satellite telecommunications service provided on the Moon;
- * Satellite telecommunication and navigation systems design, development, and implementation, including Earth, space, and Moon surface-associated infrastructure and user segment.



ESA MOONLIGHT Program

Lunar Communications and Navigation Service (LCNS)

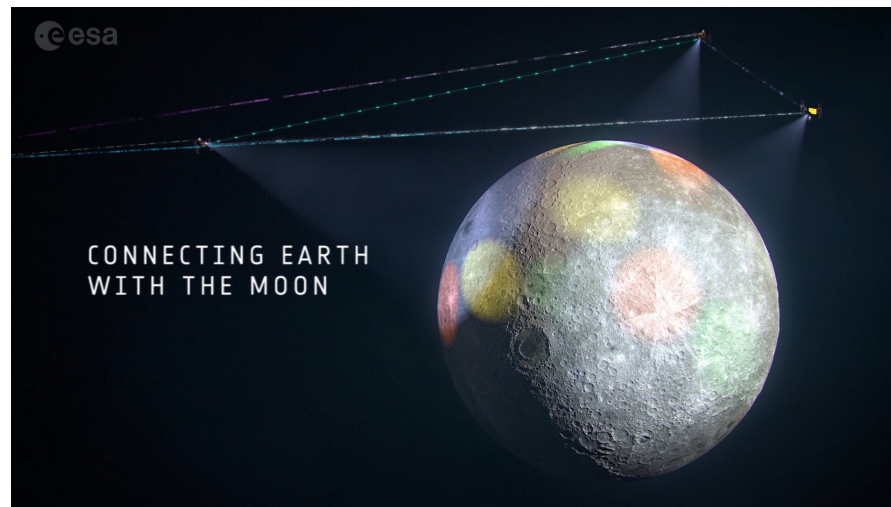


Telespazio won the study project Ph. A/B1 as Prime Contractor of an international financially self-sustainable consortium for the provision of the service infrastructure (LCNS - Lunar Comm. & Nav. Service).

- LCNS designed in stages from 2025 to 2037 and beyond
- Initial phase: Use of the terrestrial GNSS
- Intermediate phase: Infrastructure around the Moon to a first improvement of the performances
- Final and advanced phases: Deployment of a mixed satellite constellation, surface assets and in-orbit insertion of other satellites to improve the coverage



A Communication and Navigation System on the Moon

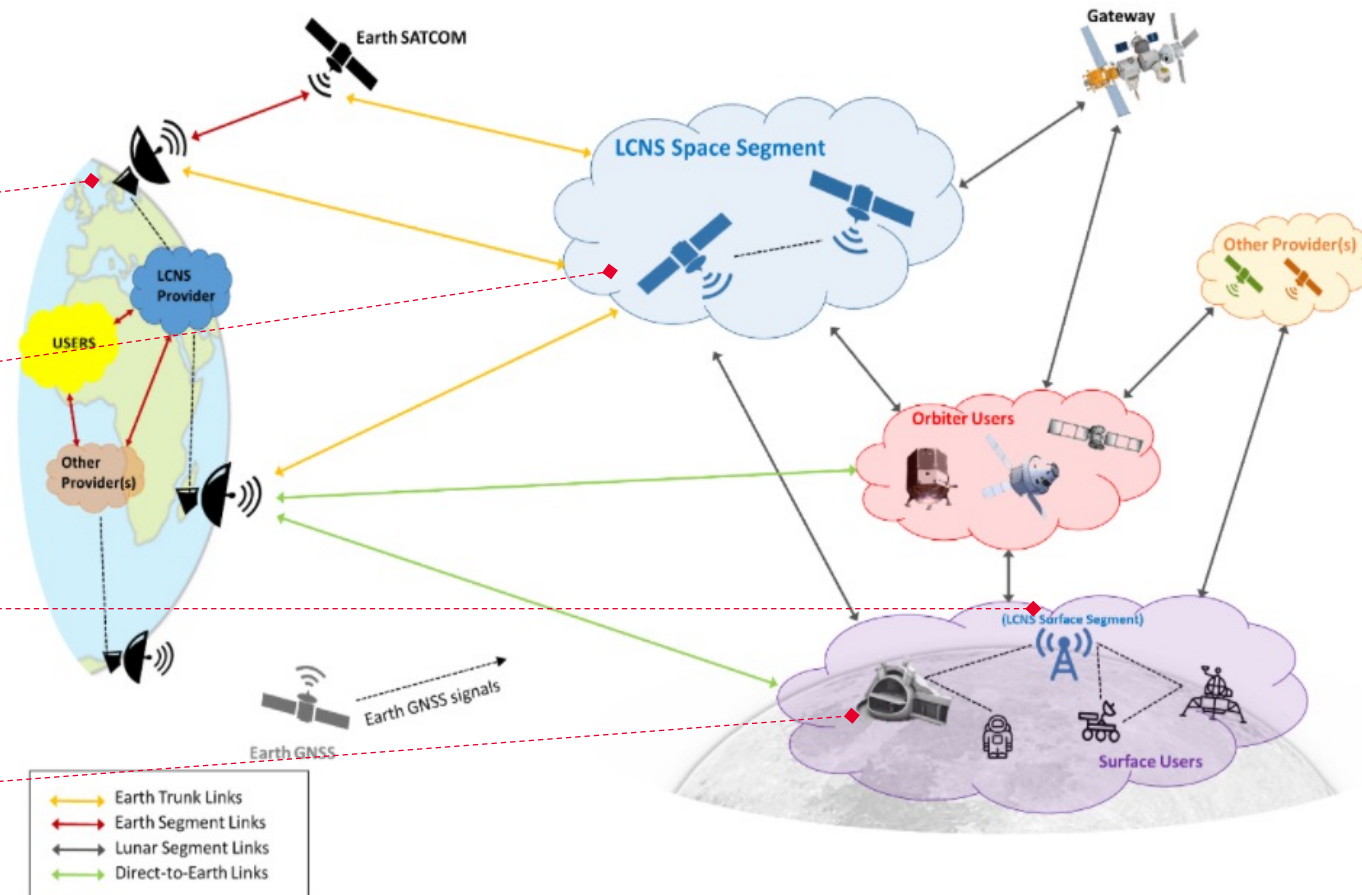


A Communication and Navigation System on the Moon

High-Level LCNS Architecture for COMM/NAV and Time Distribution services:

- ❖ Lunar Earth Ground Segment (EGS)
- ❖ Lunar Space Segment (LSS)
- ❖ Moon Surface Segment (MSS)
- ❖ Lunar User Segment (LUS)

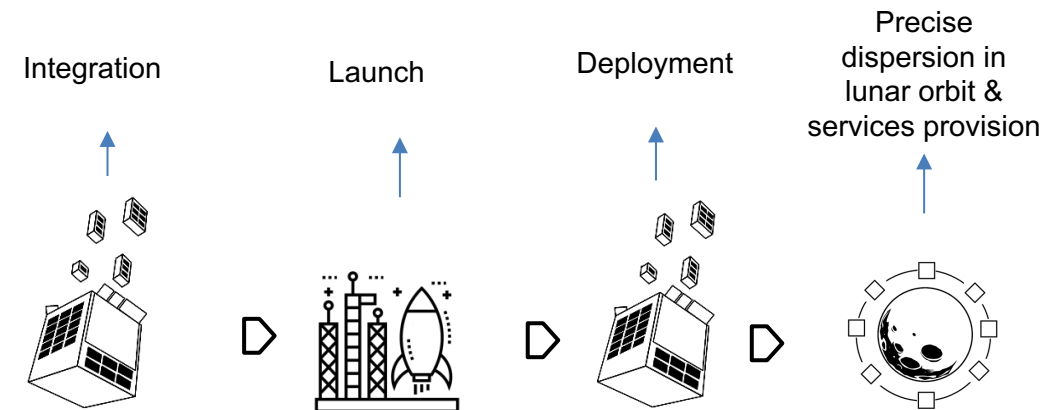
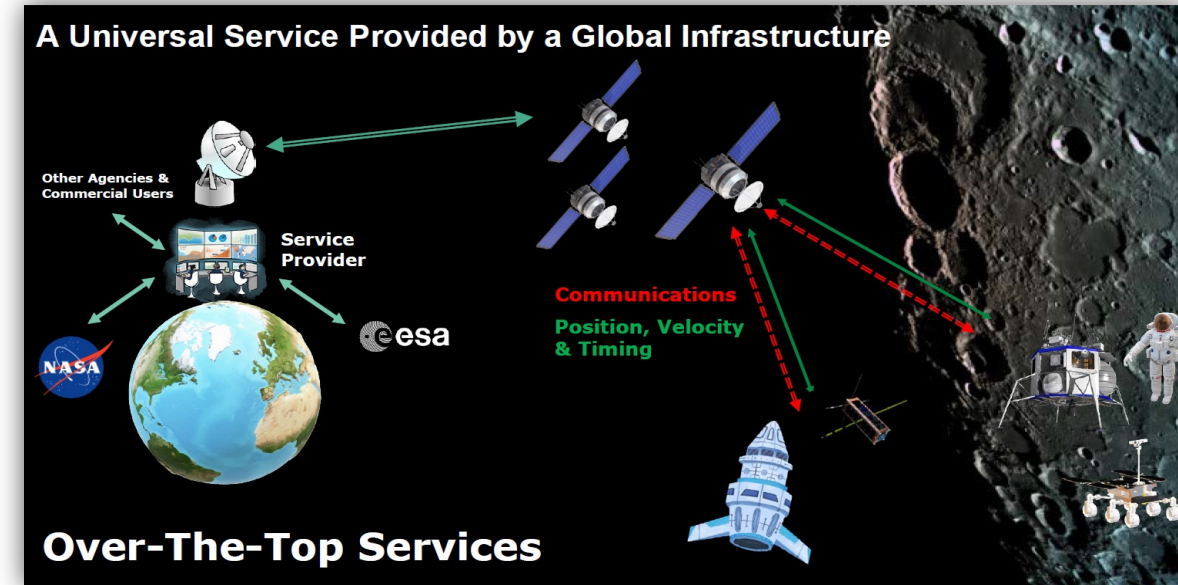
High Level LCNS Architecture



Lunar User Segment scenarios and services:

Over The Top Services / Other services and added value

- ✧ Nanosatellites transport services / small satellites to be deployed precisely around the Moon or for small landers through a mothership.
- ✧ Data transmission and relay services, with the mothership can act as a communication hub.
- ✧ Search & rescue services
- ✧ Payload experimentation demonstrations in lunar/cis-lunar orbit.
- ✧ On-orbit and logistic services in lunar orbit;
- ✧ Refueling services, deployment, and maintenance for third-party CubeSats.





THANK YOU
FOR YOUR ATTENTION

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