The Moon: the next step towards sustainable expansion into space?

Lecture organised by RAeS Hamburg Branch
Hamburg Aerospace Lecture Series
(DGLR, RAeS, VDI, ZAL, HAW Hamburg)
07.11.2019
HAW Hamburg (Hamburg University of Applied Sciences)
https://doi.org/10.5281/zenodo.5556631

Silvio Sandrone, Airbus
7 November 2019

Presentation to the Hamburg chapter of the Royal Aeronautical Society

Deutsche Gesellschaft für Luft- und Raumfahrt Lilienthal-Oberth e.V. Bezirksgruppe Hamburg

ROYAL AERONAUTICAL SOCIETY HAMBURG BRANCH e.V.

ZAL

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Hamburg Aerospace Lecture Series
Hamburger Luft- und Raumfahrtvorträge

HAW HAMBURG

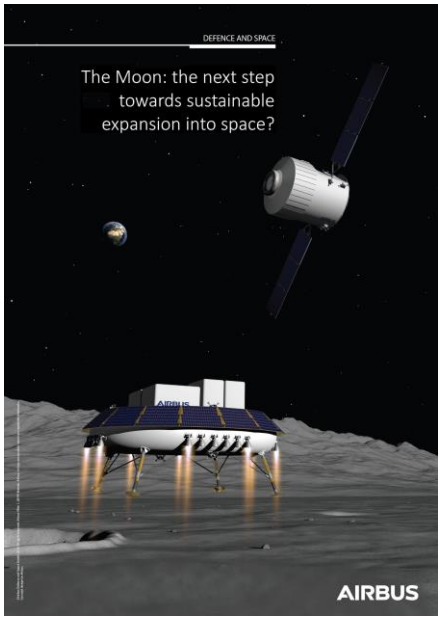
RAeS Hamburg in cooperation with the DGLR, VDI, ZAL & HAW invites you to a lecture

The Moon: The Next Step towards Sustainable Expansion into Space?

Silvio Sandrone, Vice President Advanced Projects and Products, In- Orbit Services and Exploration, Space Systems, Airbus Defence & Space

Date: Thursday 07 November 2019, 18:00
Location: HAW Hamburg Berliner Tor 5, (Neubau), Hörsaal 01.11

Lecture followed by discussion
No registration required !
Entry free !



Although humans have not travelled beyond the Moon (or even back to the Moon, yet), global space business (excluding the downstream services) exceeds nowadays €80bn a year. This figure depends on a business model in which every kilogram of required hardware or resource is brought from Earth, which raises questions about its sustainability and growth potential.
It is in this context that all major space powers are heading back to the Moon. The possibility of extracting raw materials, resources and – above all – rocket propellant, is what drives the US, Russia, China and others to prospect and settle around the lunar south pole.
The presentation will outline the lunar programme of NASA and ESA, and introduce a few thoughts about Europe's options for projecting influence and protecting its stake in a quest shaped by both co-operation and competition.

Silvio leads the Advanced Projects and Products business, creating programmes and technologies to make human expansion into space possible and sustainable. Until 2017 he was in charge of strategic industrial partnerships at Ariane Group (Paris area). Between 2009 and 2014 he led the development of new launch vehicles programmes and business for Airbus Defence and Space – among which Ariane 6, ADELINE and Liberty. He joined the Airbus Group in 2005 to manage Astrium Space Transportation relations with the European Space Agency. He also spent three years in Arianespace Launch Operations Team in French Guiana, participating in 28 consecutive Ariane 4 successful launches during that period.

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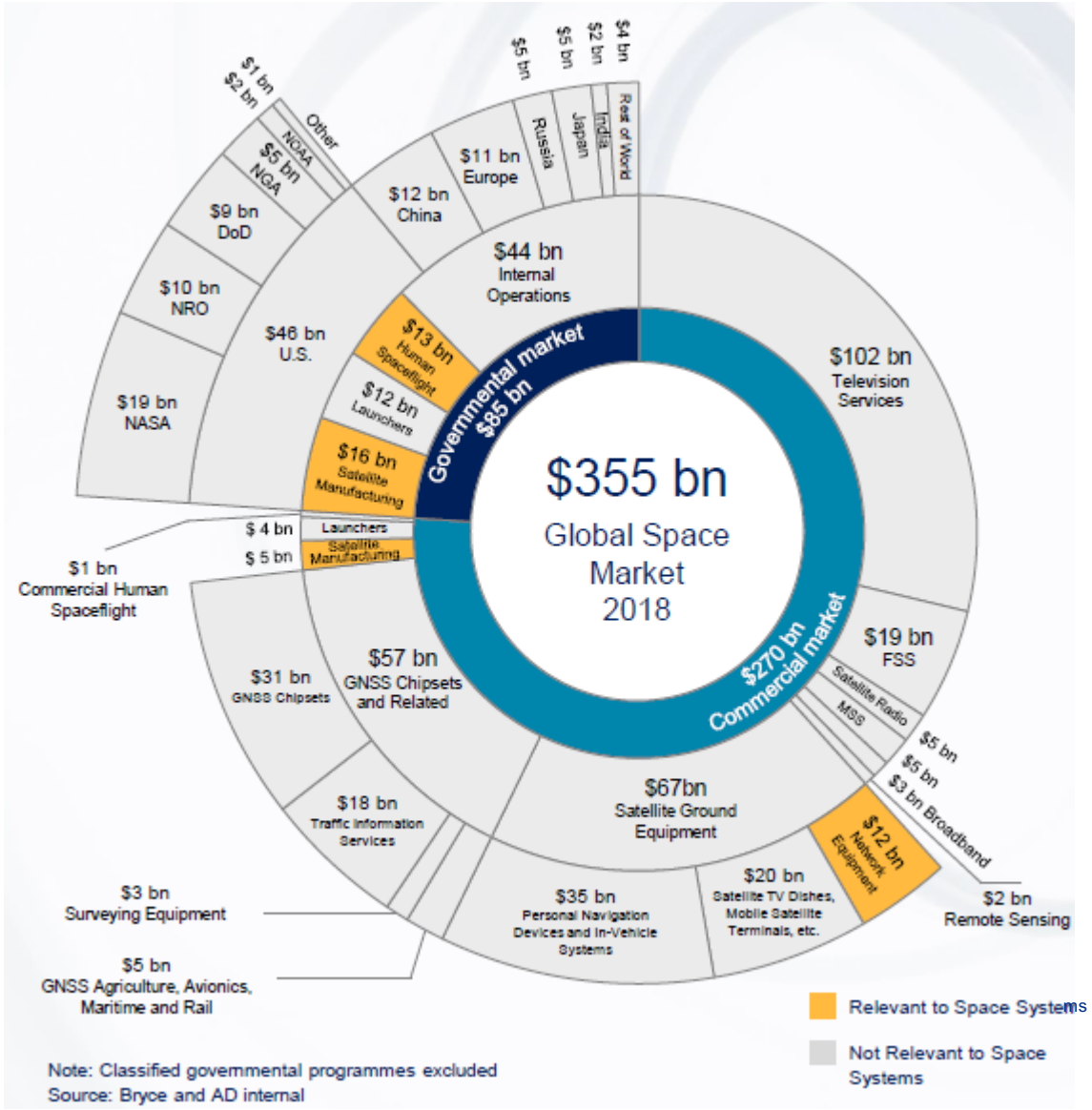
http://hav-connect.aero/Group/Lectures

The worldwide space economy



8378 objects launched in space

4994 still in space

1957 active

382 launched in 2018

114 launches

Source: UN OOSA and Concerned Scientists

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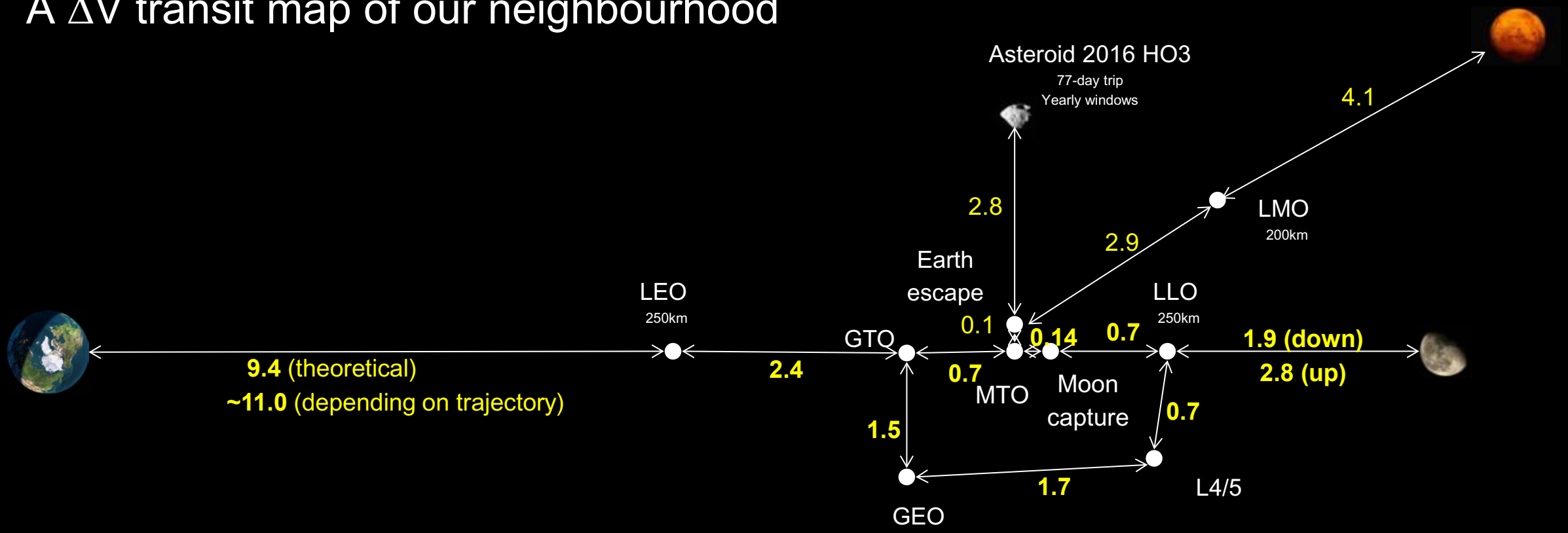
A ΔV transit map of our neighbourhood



A few notable approximate ΔV

Earth to GEO: 14.9 km/s	Moon to GEO: 5.2 km/s
Earth to LEO: 9.4-11 km/s	Moon to LEO: 6.8 km/s
Earth to GTO: 13.4 km/s	Moon to GTO: 4.4 km/s
Earth to LLO: 15 km/s	Moon to LLO: 2.8 km/s

Each figure is ΔV between two points in km/s
Diagram roughly to scale
Sources

- Wikipedia (en)
- TU Delft website
- Stackexchange.com
- Aerospace America, September 2016

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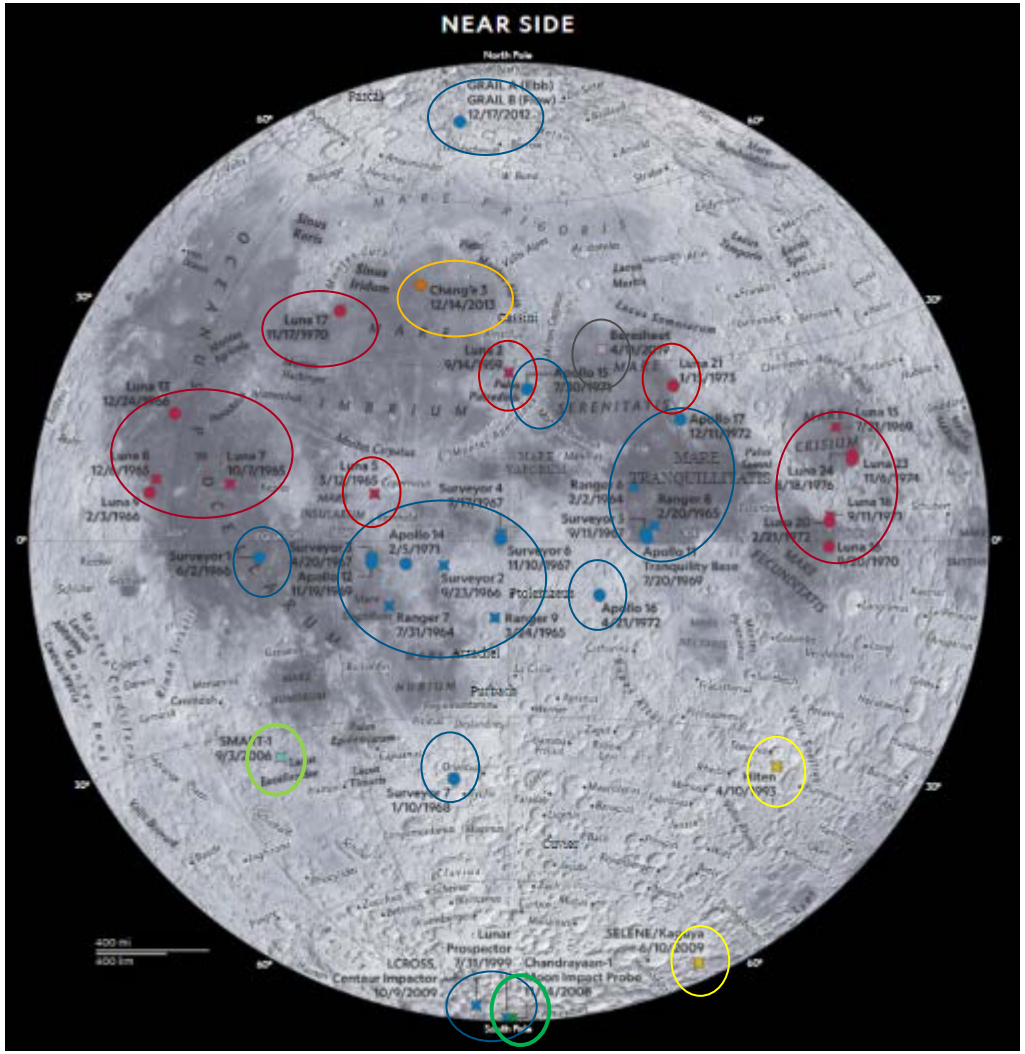
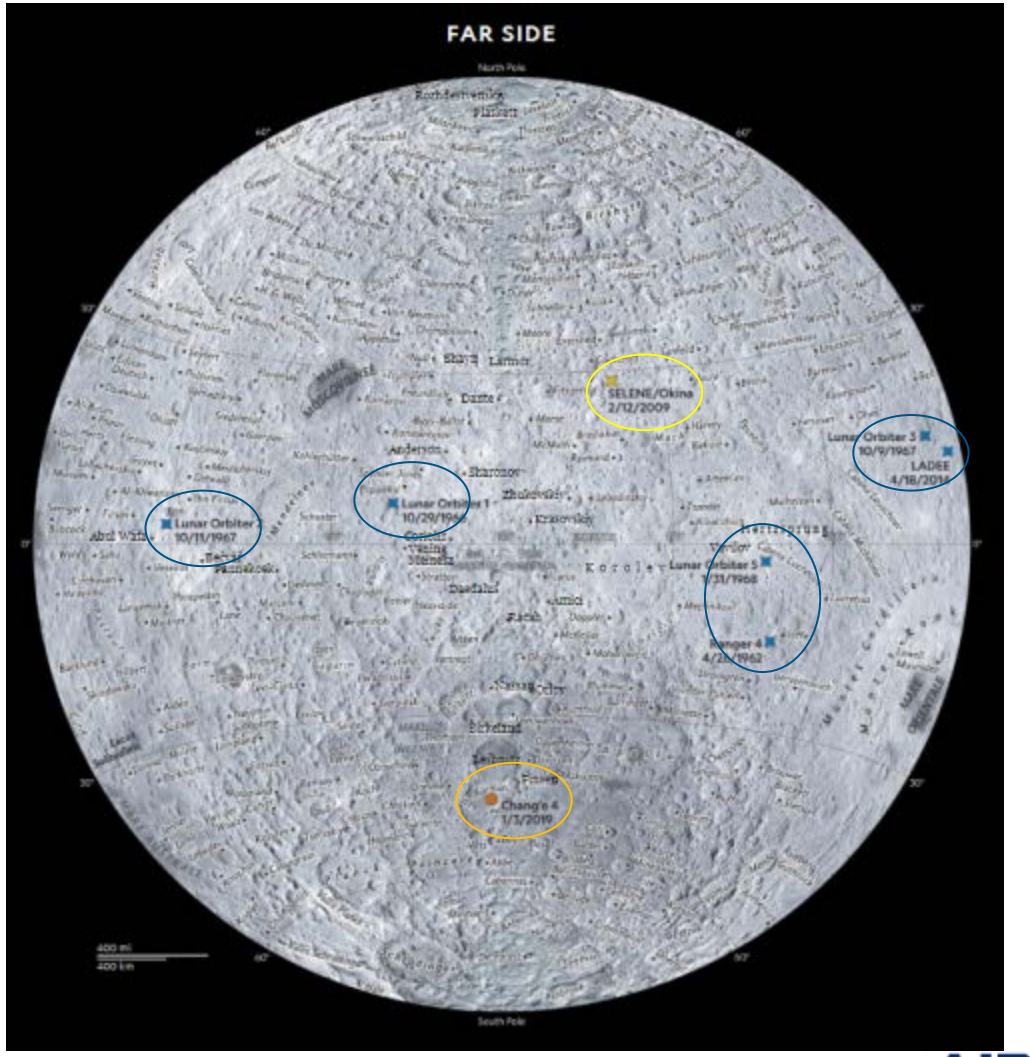
Implemented lunar missions

US Russia China Israel
Japan Europe India





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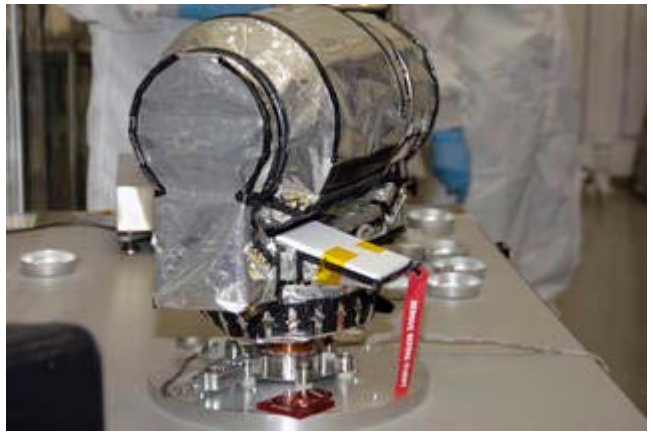
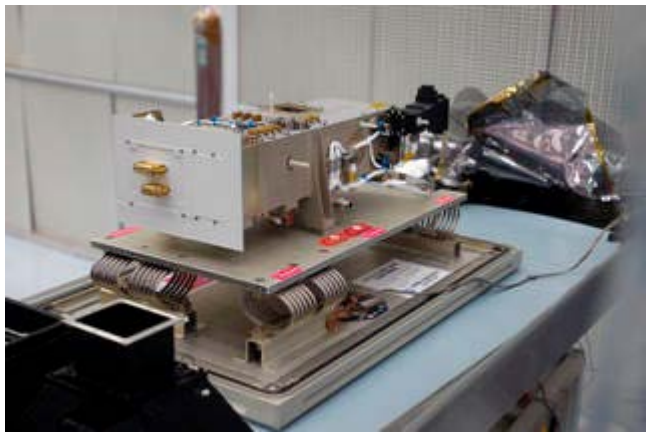
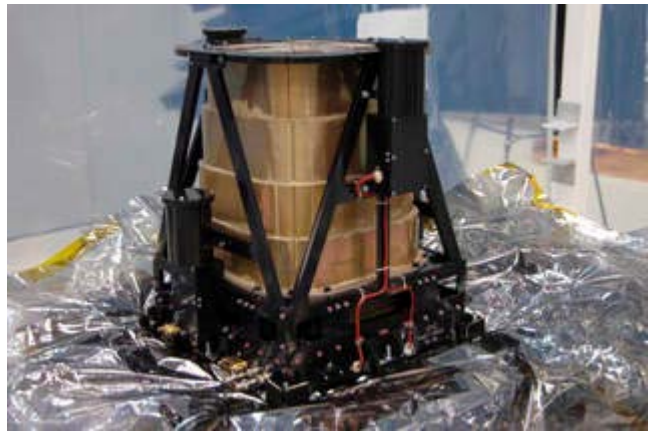
Lunar Reconnaissance Orbiter – LRO (2009)



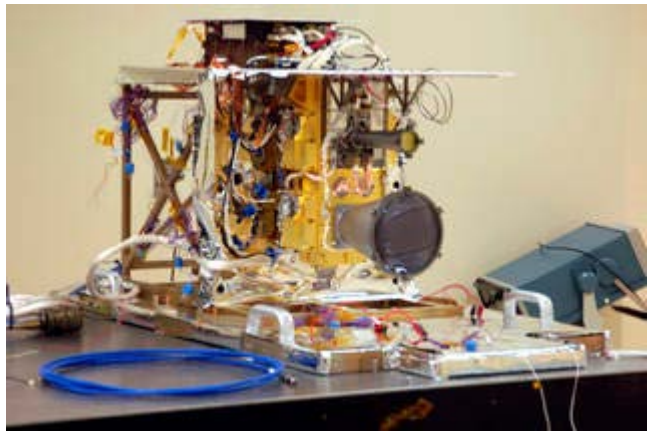
Diviner Lunar Radiometer Exp.
Identify cold traps



LAMP
Surface ice and frost



Lunar Exploration Neutron Detector
Hydrogen distribution

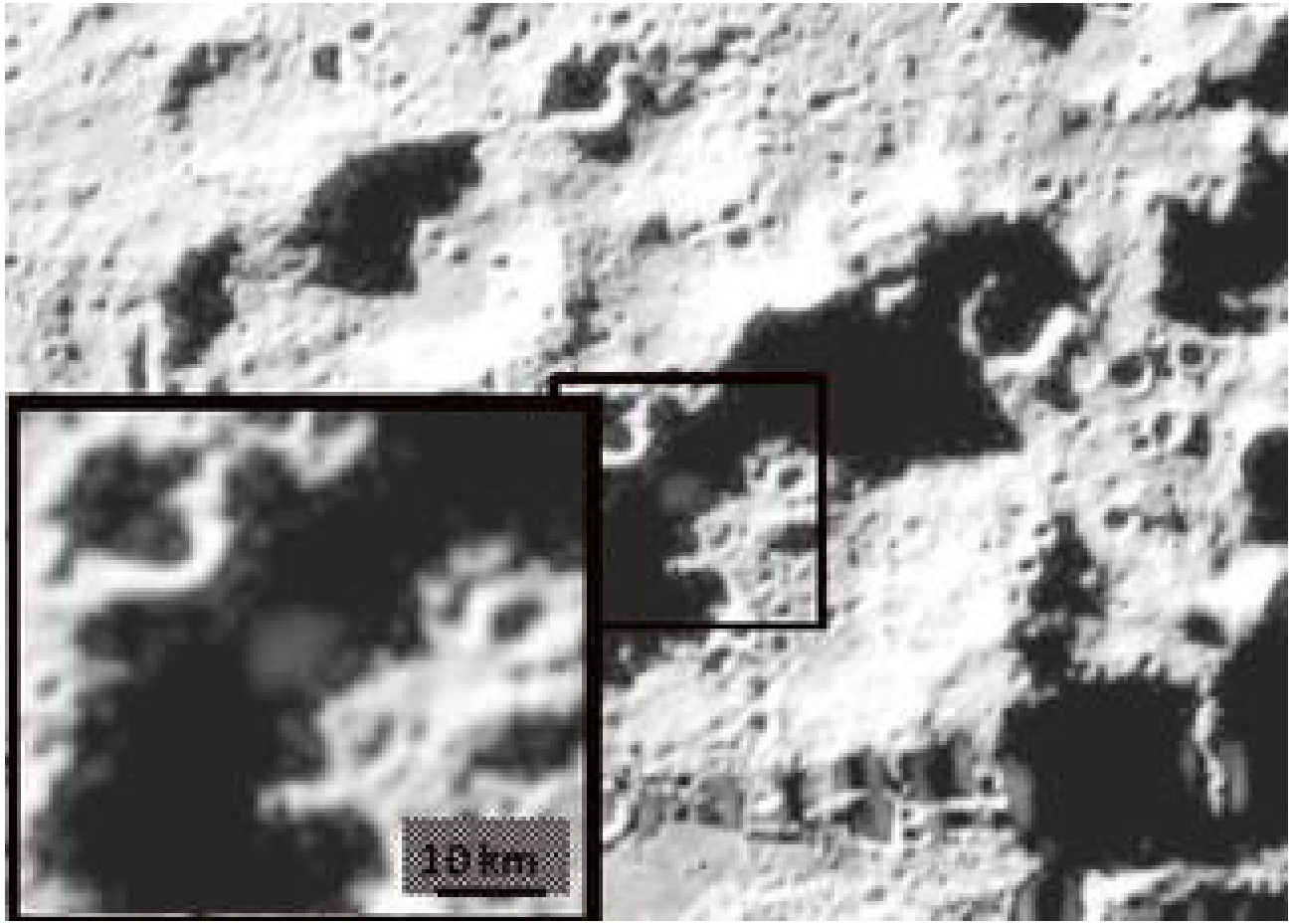


Lunar Orbiter Laser Altimeter
Determine illuminated/shaded areas

Source: NASA

LCROSS – digging for water (2009)

Source: NASA



Source: NASA

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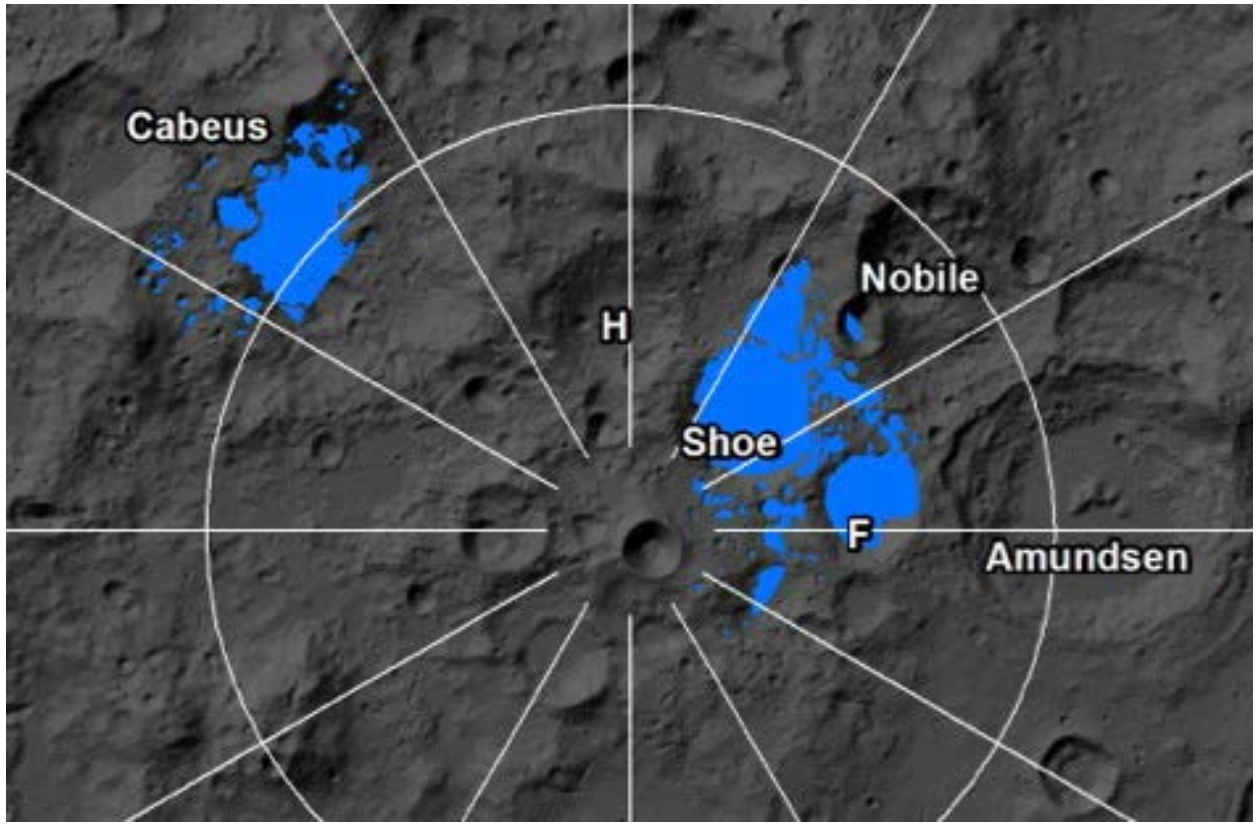
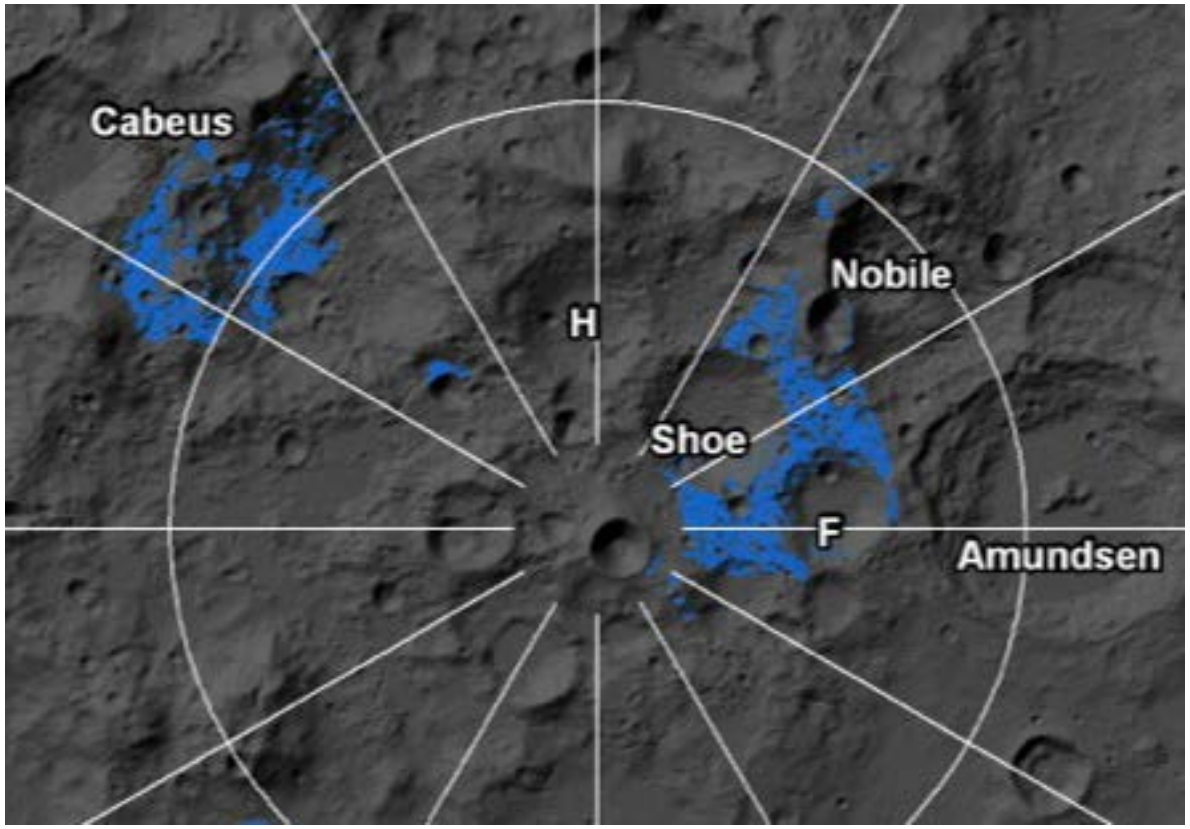
The South Pole example



Close to LCROSS site in T and H concentration



H concentration > 150ppm

Average T < 110K

Slope < 10°

Outside but adjacent to PSR

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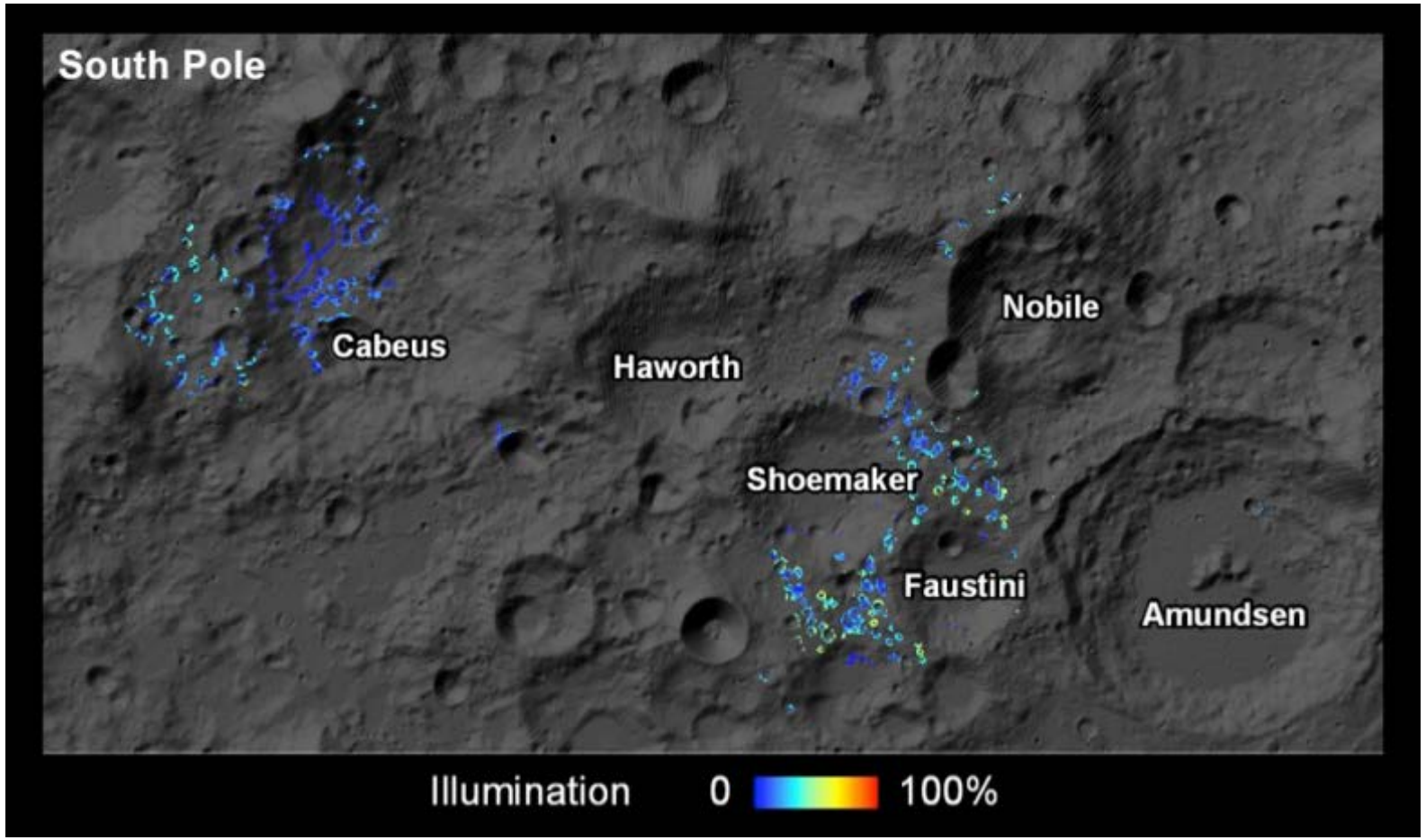
The South Pole example



H concentration > 150ppm

Average T < 110K

Slope < 10°

Within 1km of a PSR

Illumination available

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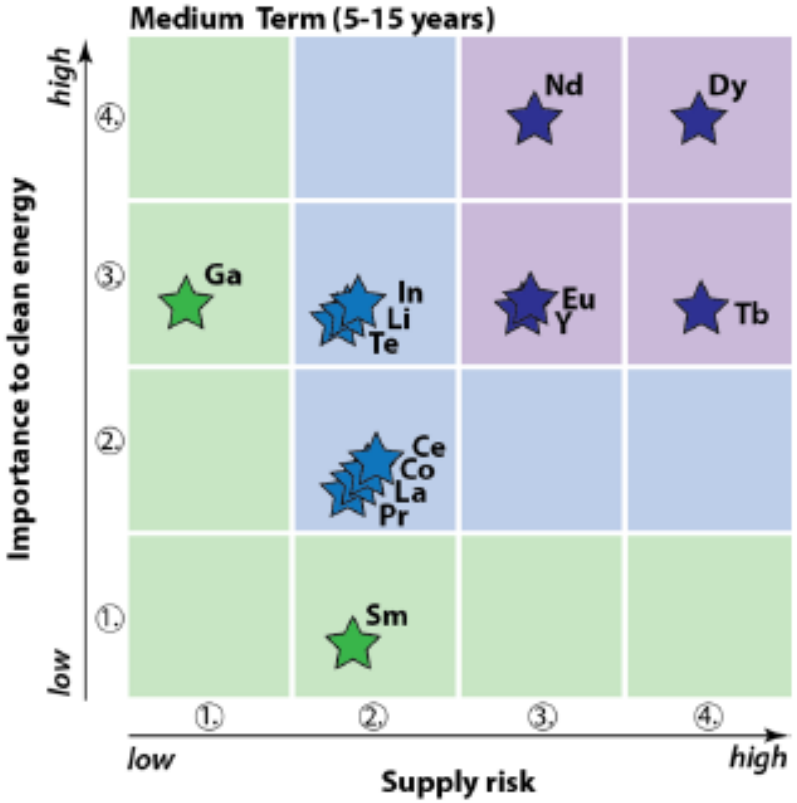
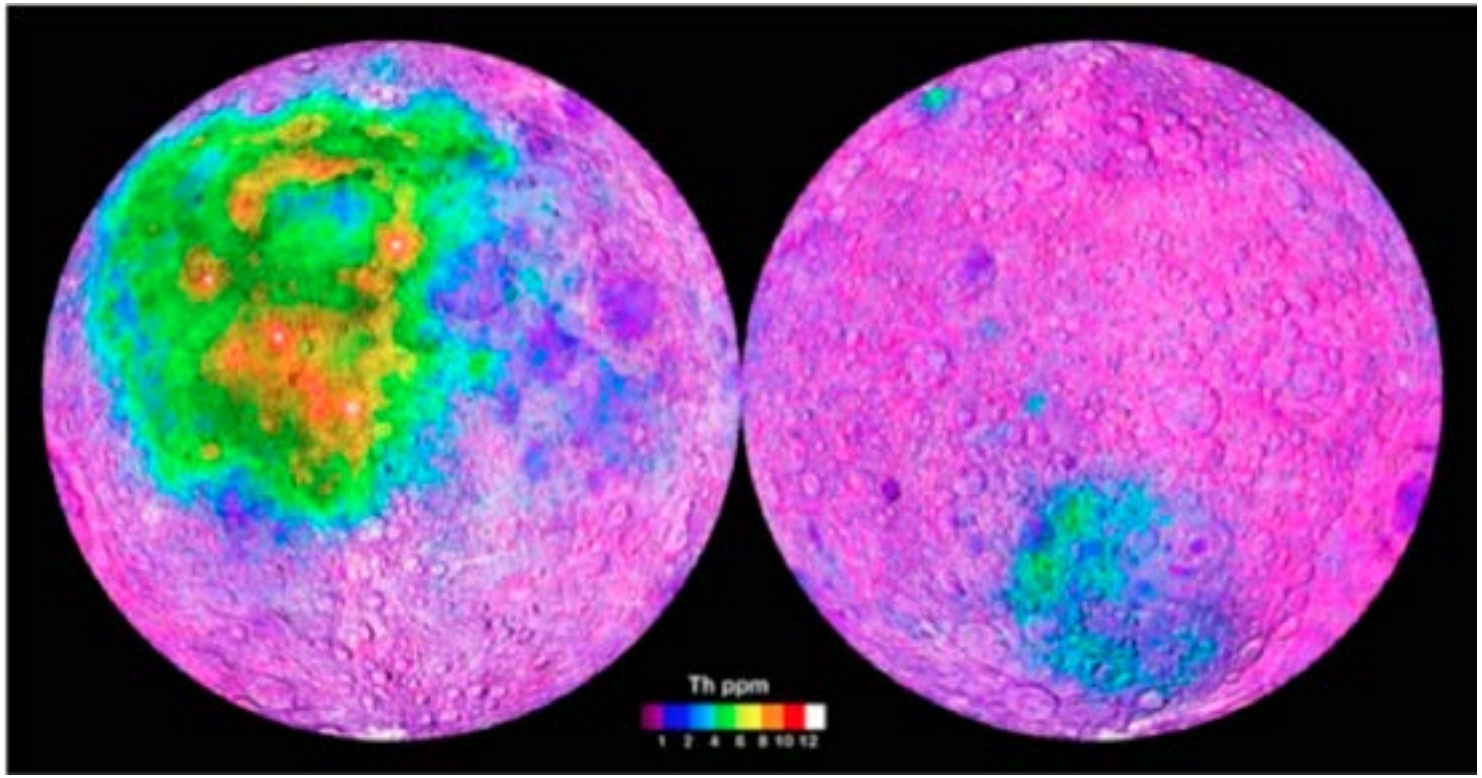
Beyond water: rare earths?



Supply risk of REE relevant to clean energy

Source: McLeod et al, Florida University, Creative Commons Attribution License



Thorium Distribution Map

Source: NASA

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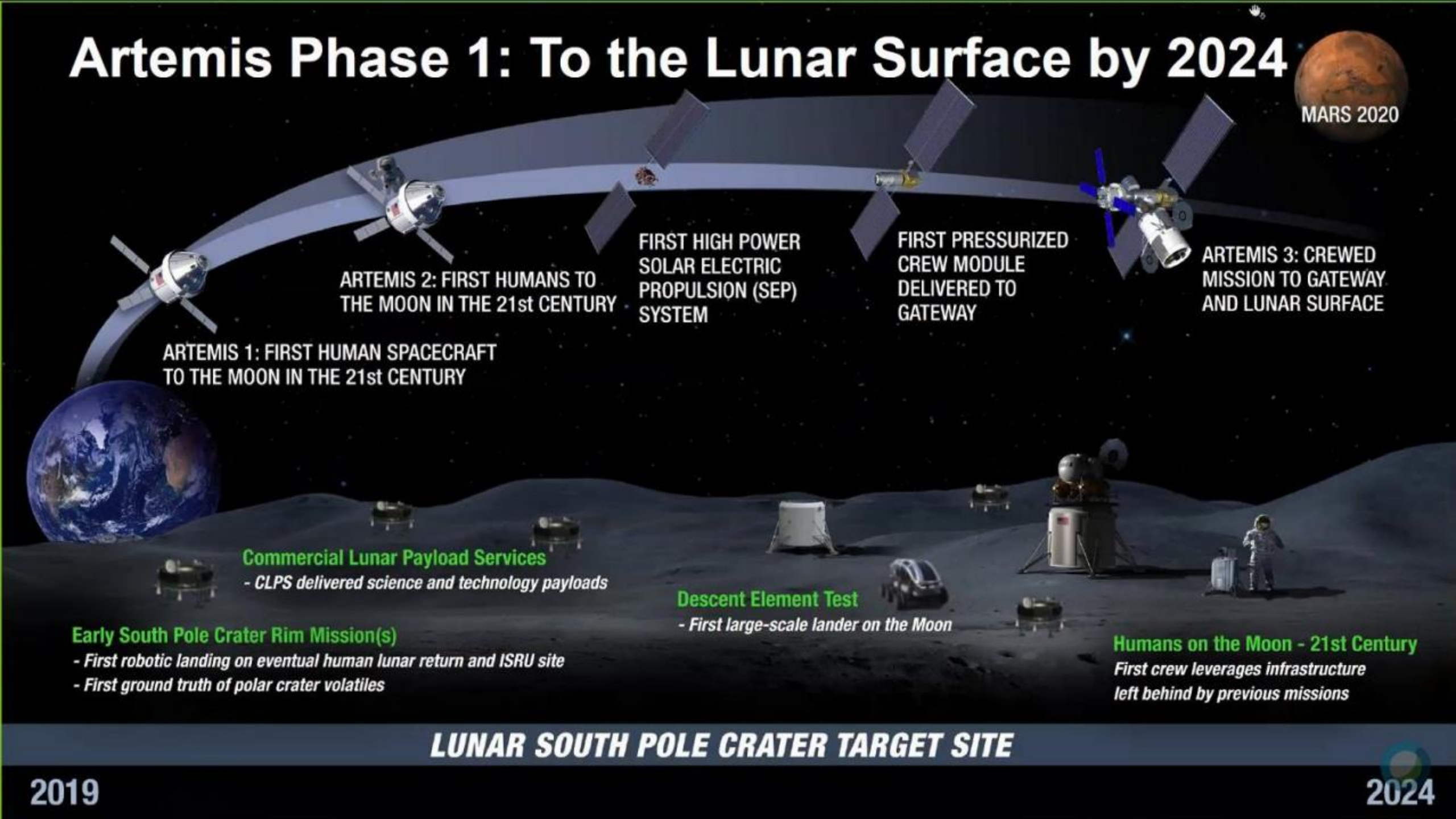
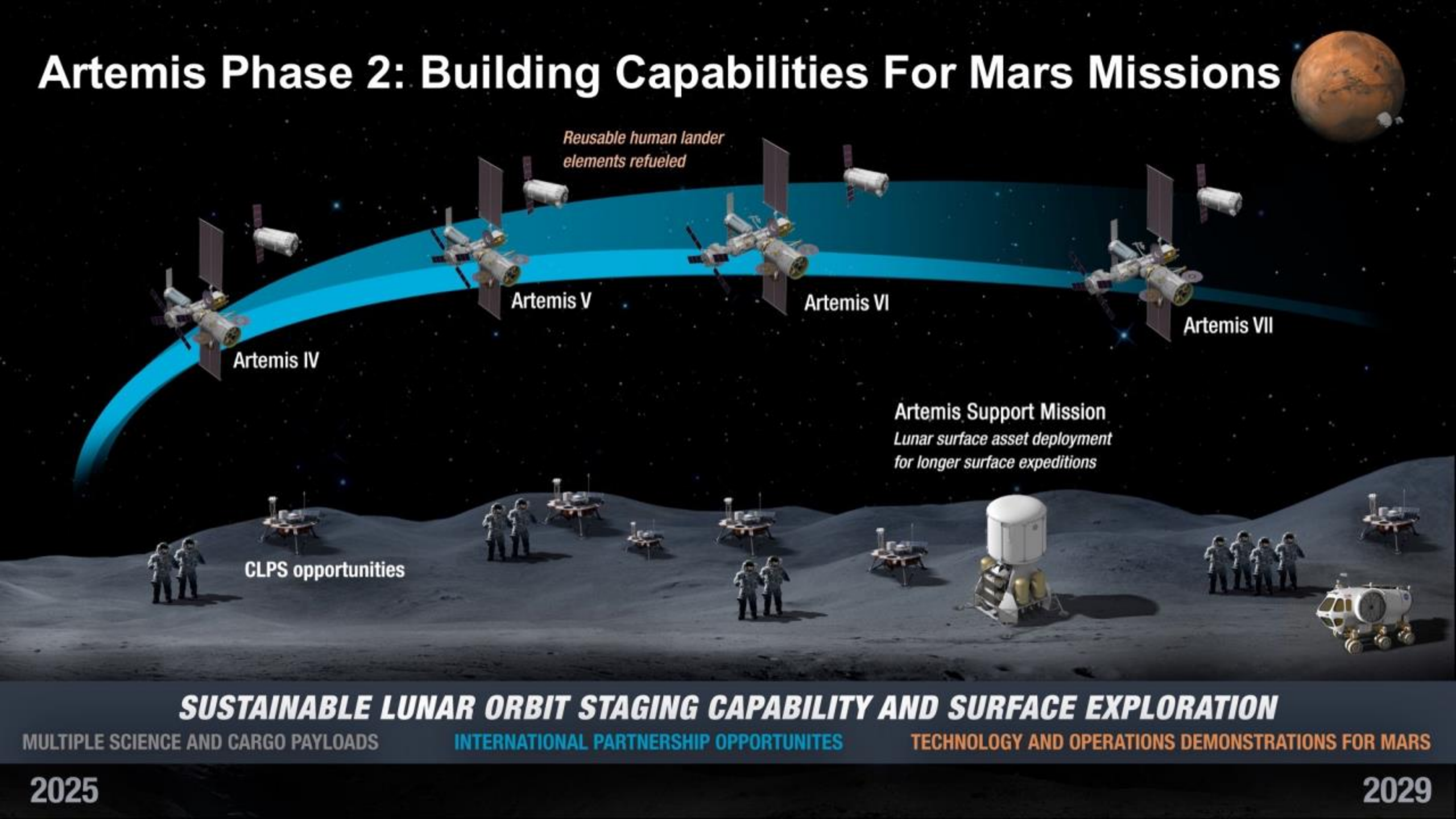
Artemis Phase 1: To the Lunar Surface by 2024



Artemis Phase 2: Building Capabilities For Mars Missions

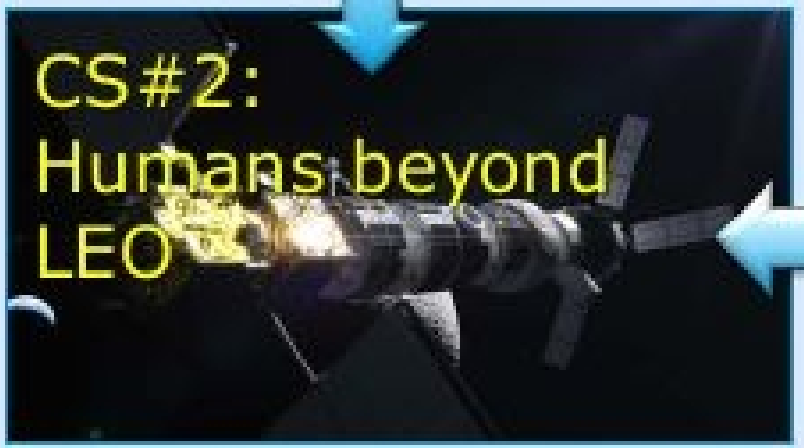


SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

MULTIPLE SCIENCE AND CARGO PAYLOADS | INTERNATIONAL PARTNERSHIP OPPORTUNITES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS

2025 — 2029

6 Activities; 4 Cornerstone campaigns; 1 Programme

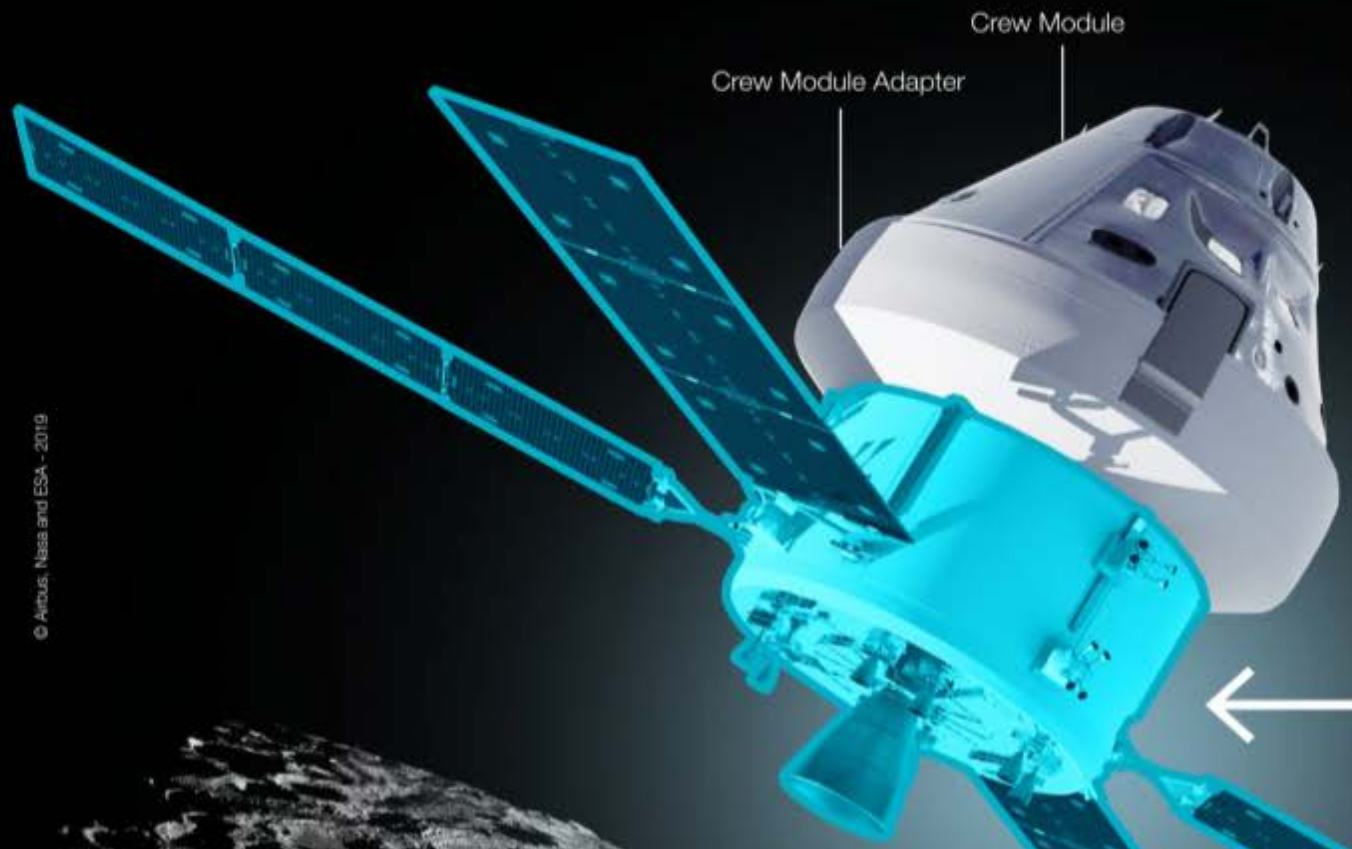


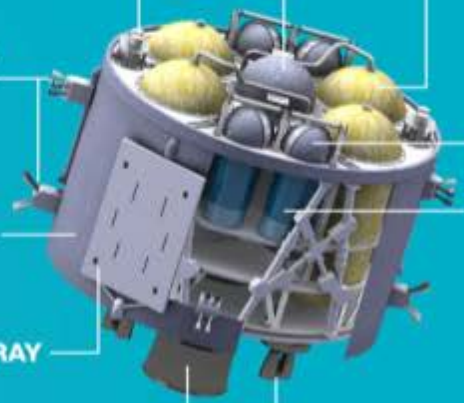
TO THE MOON AND BEYOND WITH THE ORION

EUROPEAN SERVICE MODULE ESM - BUILT BY AIRBUS

1ST SUPPLY OF CRITICAL FUNCTIONS FOR A NASA SPACE MISSION

- Spacecraft **PROPULSION**
- **CONSUMABLES** (air and water)
- **ELECTRICAL POWER** supply
- **THERMAL** control





PRESSURE CONTROL assembly (2x)

HELIUM pressurant tanks (2x)

PROPELLANT tanks (4x)

REACTION CONTROL thrusters (24x)

GAS tanks (4x)

WATER tanks (4x)

RADIATOR PANELS (6 in total)

SOLAR ARRAY panels (4x)

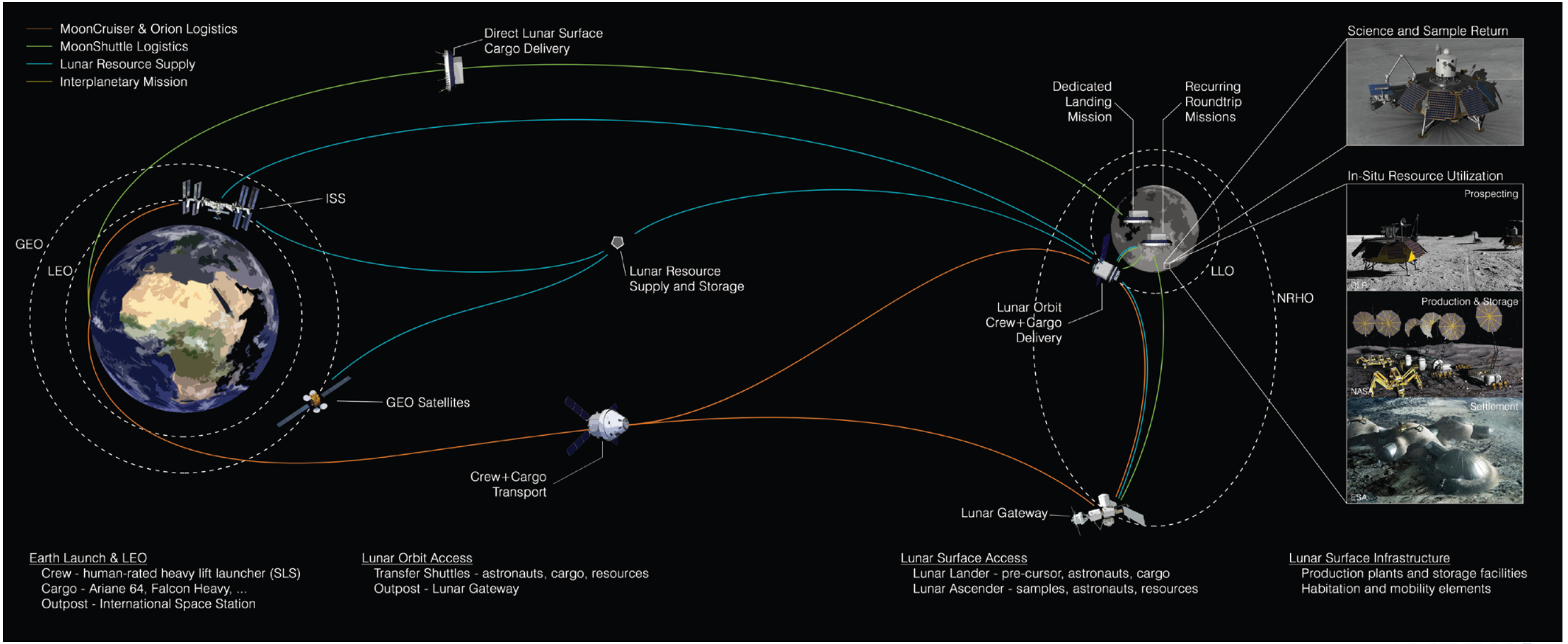
Main **ENGINE**

Auxiliary **THRUSTERS** (8x)

Airbus is prime contractor to ESA

Lunar Logistics – Moon Shuttle and Moon Cruiser

Utilization of Lunar Resources by a Cis-Lunar Economy



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CLTV

Europe's own Earth-Moon transport and contribution to Gateway logistics

Missions linked to the Gateway

Cargo delivery

Module delivery

GTO/LTO to LLO tugging of EL3 lander

NRHO to LLO tugging

Orbital propellant depot

Missions compatible with Ariane 6

FEATURES

- Enabler for EL3 extended missions
- Participates in Gateway logistics
- Valuable contribution for international co-operation
- Designed for Ariane 6, but in principle compatible with others

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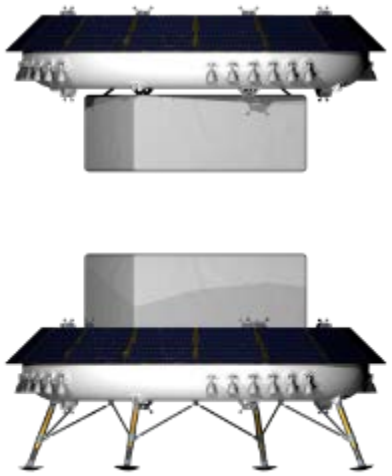
EL3

And Airbus‘ concept for the world‘s first reusable lander/ascender

Single Shot Mission

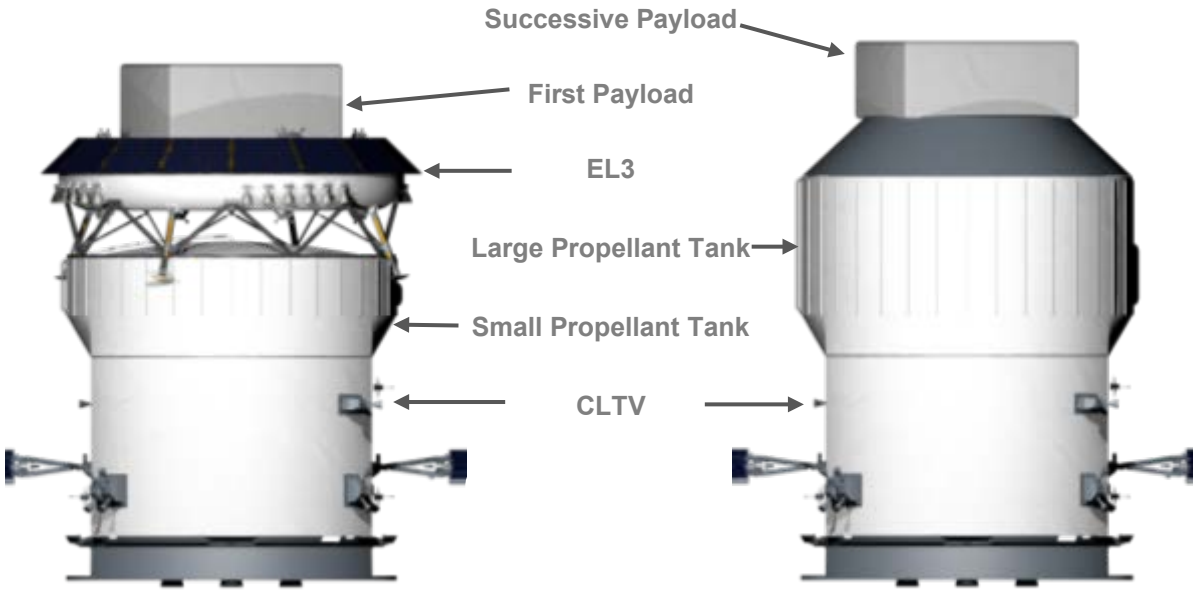
Moon Shuttle on Ariane 64



Round Trip Mission

Moon Shuttle and Moon Cruiser

First Round Trip **Recurring Round Trip**



AUTONOMOUS MISSIONS

- Goal EL3: >1.5t cargo to the lunar surface on Ariane 64
- Independent of Gateway and US capabilities
- Significantly extends first US crewed surface missions

SYNERGIES WITH CLTV

- Same vehicle returns to orbit (no debris left on Moon)
- Return payload from surface
- Refueling in LLO and resupply by CLTV

- Recurring cargo capacity depending on launcher GTO/TLI performance

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Artist‘s impression of a human landing mission in 2024

THANK YOU

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