NASA GER Community Workshop

Human Assisted Lunar Sample Return

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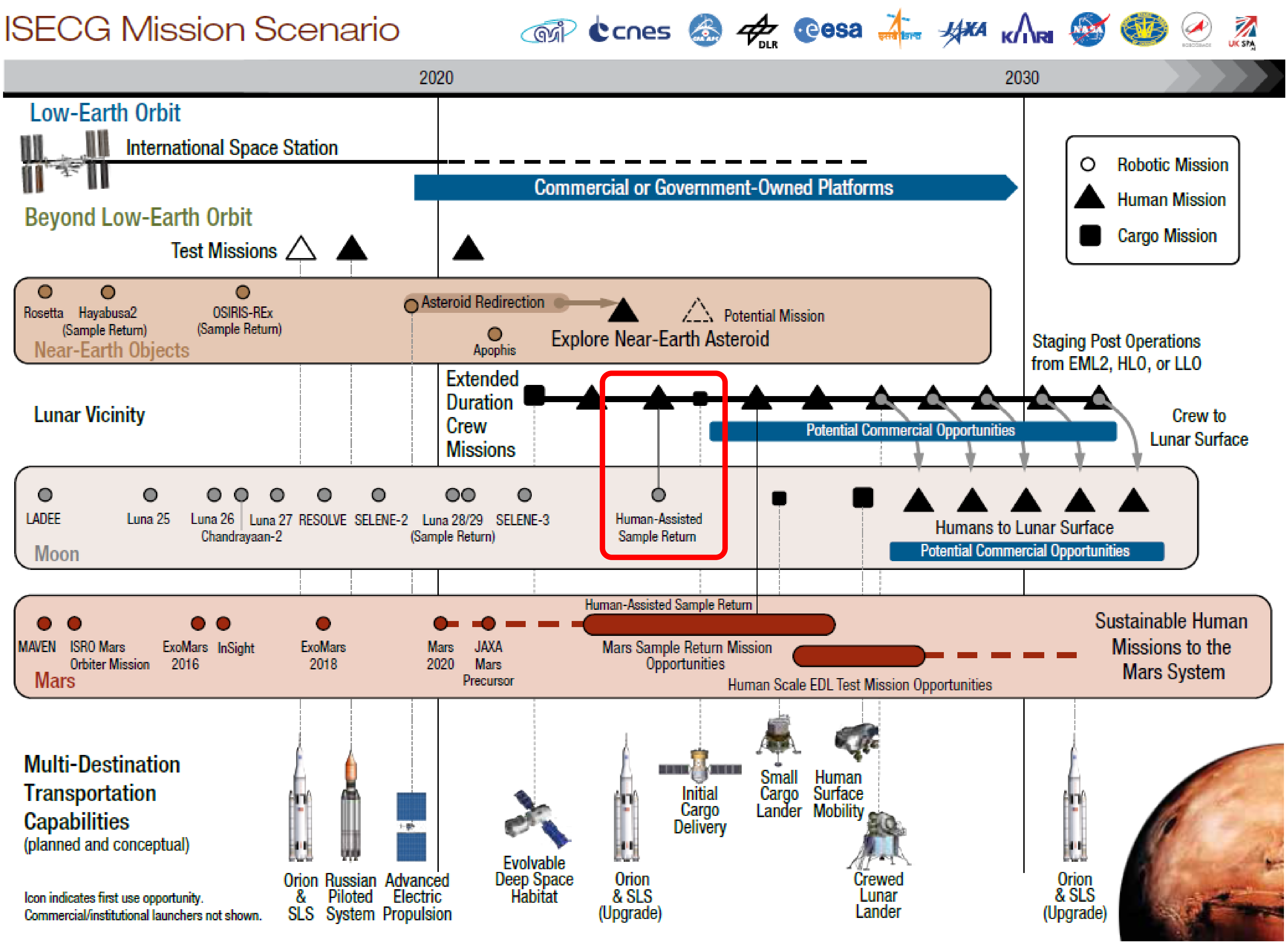

ISECG Mission Scenario
2020
2030
Low-Earth Orbit
International Space Station
Commercial or Government-Owned Platforms
Beyond Low-Earth Orbit
Test Missions
Robotic Mission
Human Mission
Cargo Mission
Rosetta
Hayabusa2
(Sample Return)
OSIRIS-REx
(Sample Return)
Asteroid Redirection
Potential Mission
Explore Near-Earth Asteroid
Apophis
Near-Earth Objects
Staging Post Operations
from EML2, HLO, or LLO
Extended
Duration
Crew
Missions
Lunar Vicinity
Potential Commercial Opportunities
Crew to
Lunar Surface
LADEE
Luna 25
Luna 26
Chandrayaan-2
Luna 27
RESOLVE
SELENE-2
Luna 28/29
(Sample Return)
SELENE-3
Human-Assisted
Sample Return
Humans to Lunar Surface
Potential Commercial Opportunities
Moon
Human-Assisted Sample Return
MAVEN
ISRO Mars
Orbiter Mission
ExoMars
2016
InSight
ExoMars
2018
Mars
2020
JAXA
Mars
Precursor
Mars Sample Return Mission
Opportunities
Human Scale EDL Test Mission Opportunities
Sustainable Human
Missions to the
Mars System
Mars
Multi-Destination
Transportation
Capabilities
(planned and conceptual)
Icon indicates first use opportunity.
Commercial/institutional launchers not shown.
Orion
&
SLS
Russian
Piloted
System
Advanced
Electric
Propulsion
Evolvable
Deep Space
Habitat
Orion
& SLS
(Upgrade)
Initial
Cargo
Delivery
Small
Cargo
Lander
Human
Surface
Mobility
Crewed
Lunar
Lander
Orion
& SLS
(Upgrade)

Human-Robotic Partnership in GER2 (1/2)

- The conceptual architecture represented in the ISECG Mission Scenario provides the opportunity to study ideas which further expand the human-robotic partnership. New mission concepts, defined below, merit further study.

<Human-Assisted Sample Return>

- The concept of human-assisted sample return is based on the assumption that human missions in the lunar vicinity will take place for advancing broader exploration goals and taking the first steps toward enabling human missions to the Moon, deep space and Mars. The presence of a crew can enhance the value of samples to the exploration community in the following ways:
  - Increased science return with a larger and more diverse set of samples
  - Reduced complexity of robotic mission, transferring sample handling responsibilities to the crew
  - Improved mission robustness and reliability due to having a human in the loop
  - Better opportunities for public engagement due to astronaut involvement, enabling demonstration of the significance of lunar science to a broader community
  - Broader opportunities for international cooperation
- Human space flight capabilities related to sample acquisition and return should strive to minimize the hardware and complexity required on the robotic vehicles.

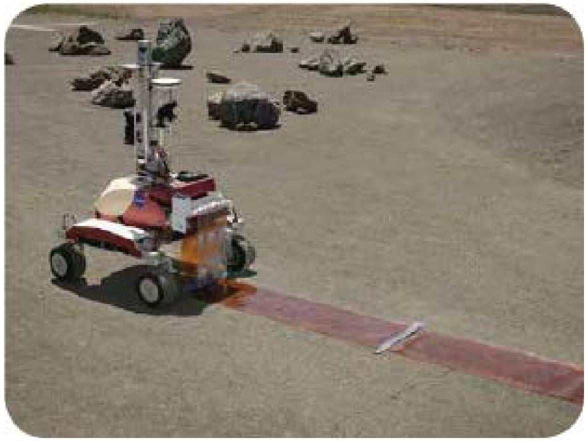
Human-Robotic Partnership in GER2 (2/2)

<Tele-Presence>

- Tele-presence can be defined as tele-operation of a robotic asset on a planetary surface by a person who is relatively close to the planetary surface, perhaps orbiting in a spacecraft or positioned at a suitable Lagrange point. Tele-presence is a capability which could significantly enhance the ability of humans and robots to explore together, where the specific exploration tasks would benefit from this capability. These tasks could be characterized by:
  - High-speed mobility
  - Short mission durations
  - Focused or dexterous tasks with short-time decision-making
  - Reduced autonomy or redundancy on the surface asset
  - Contingency modes/failure analysis through crew interaction

<Observation>

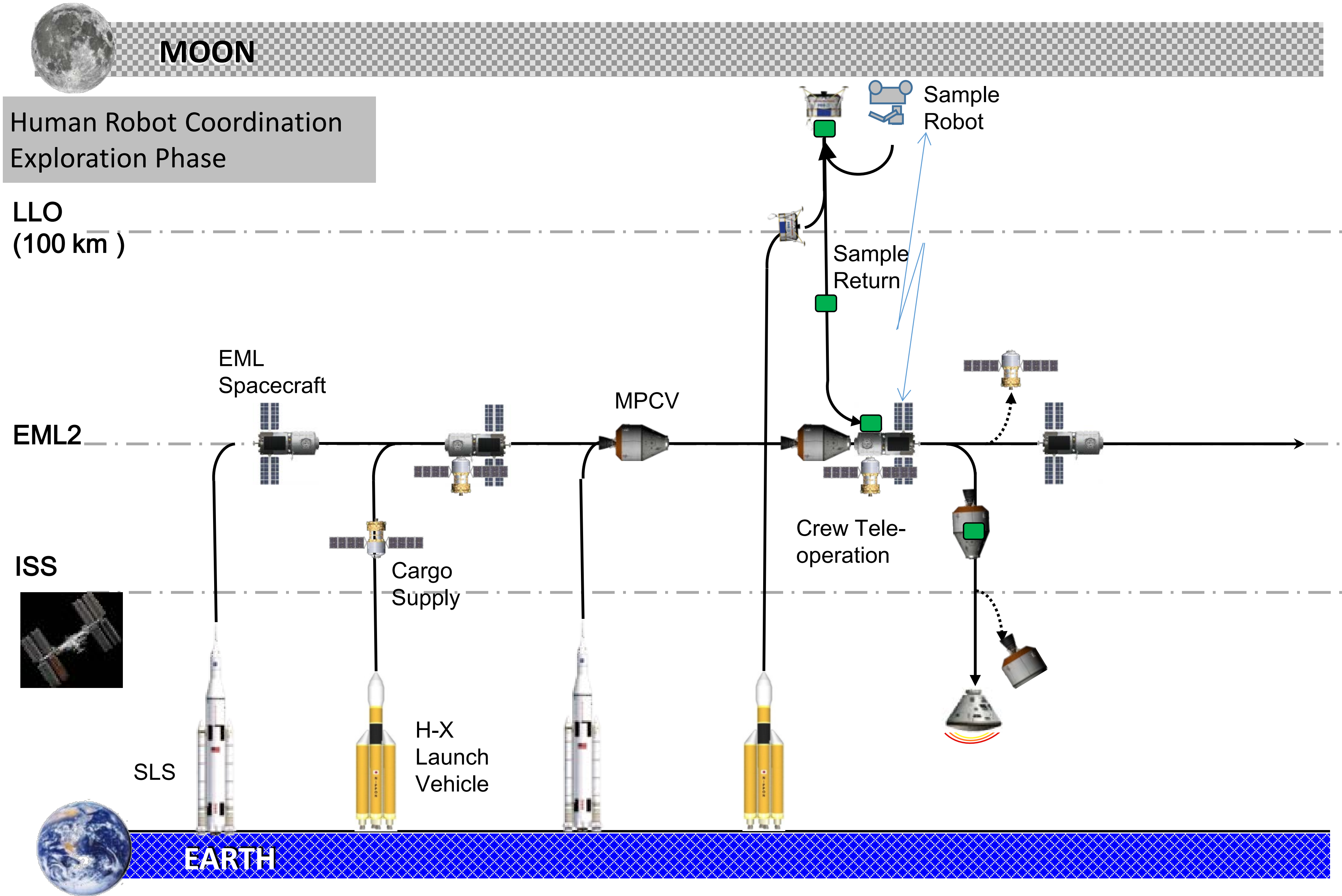
- New mission concepts, such as human-assisted sample return and tele-presence should be further explored, increasing understanding of the important role of humans in space for achieving common goals.



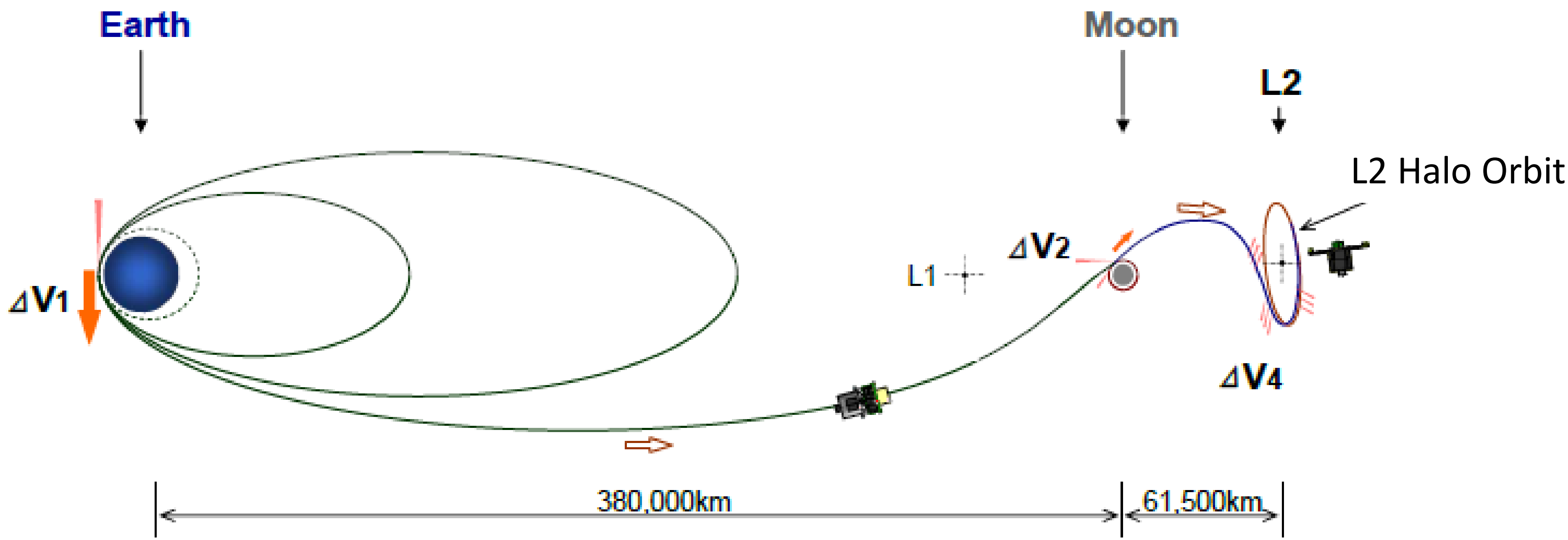
From the ISS, astronaut Chris Cassidy operated this high-fidelity planetary rover, located at Ames Research Center's analogue facility. The ISS is conducting demonstrations such as this to gather engineering data useful to advancing the concept of tele-presence.

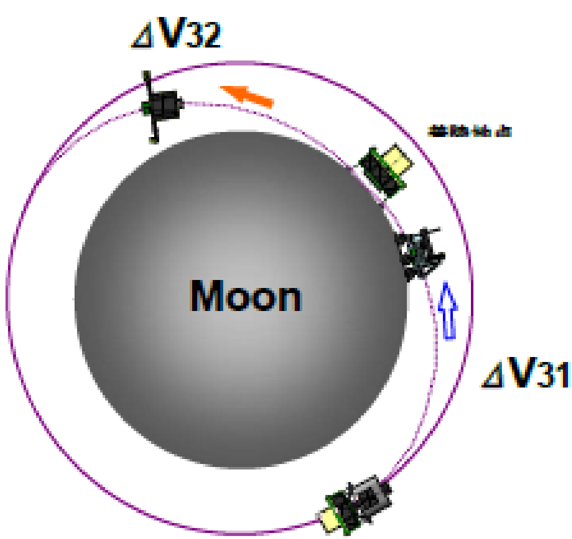
Artist's concept of opportunities to apply tele-presence capabilities to surface telerobotic operation.

Human Assisted Lunar Sample Return Architecture



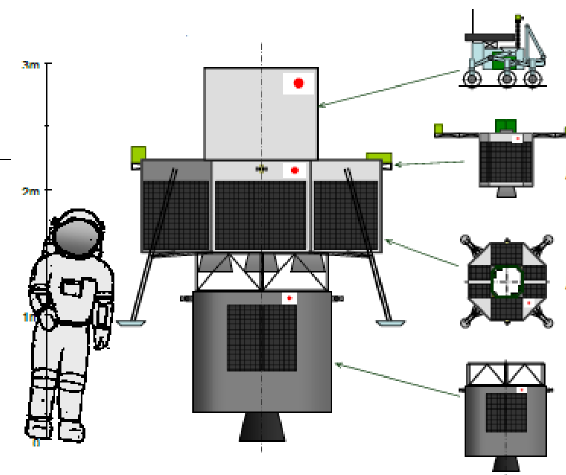
Human Assisted Lunar Smple Return Mission Profile





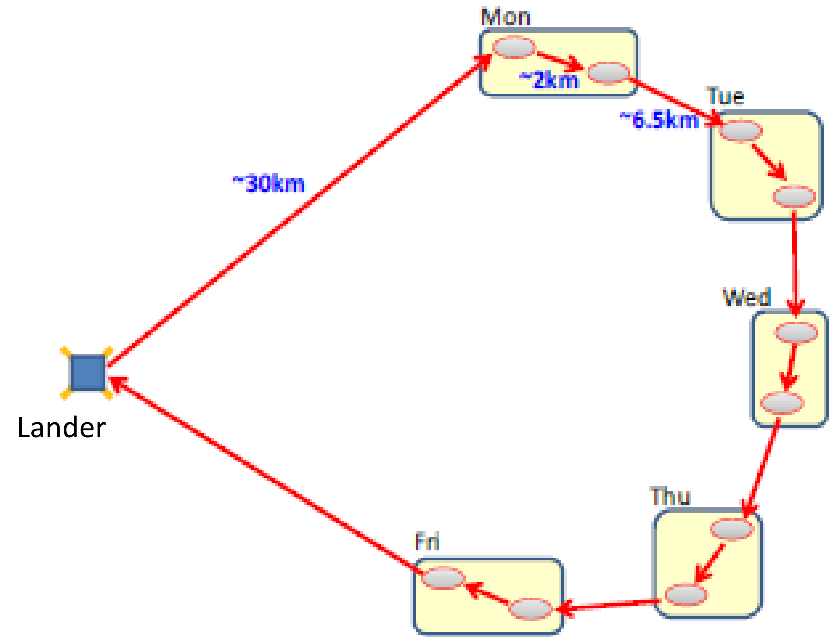
delta V Estimation

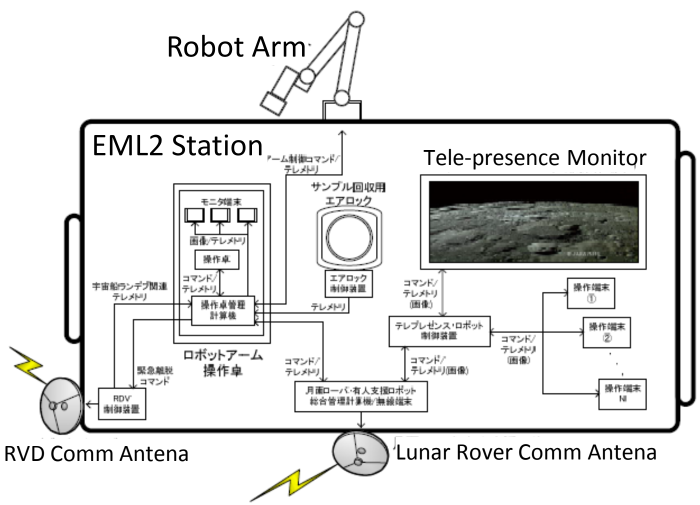
⊿V1	3200
⊿V2	900
⊿V31	2000
⊿V32	2000
⊿V4	700

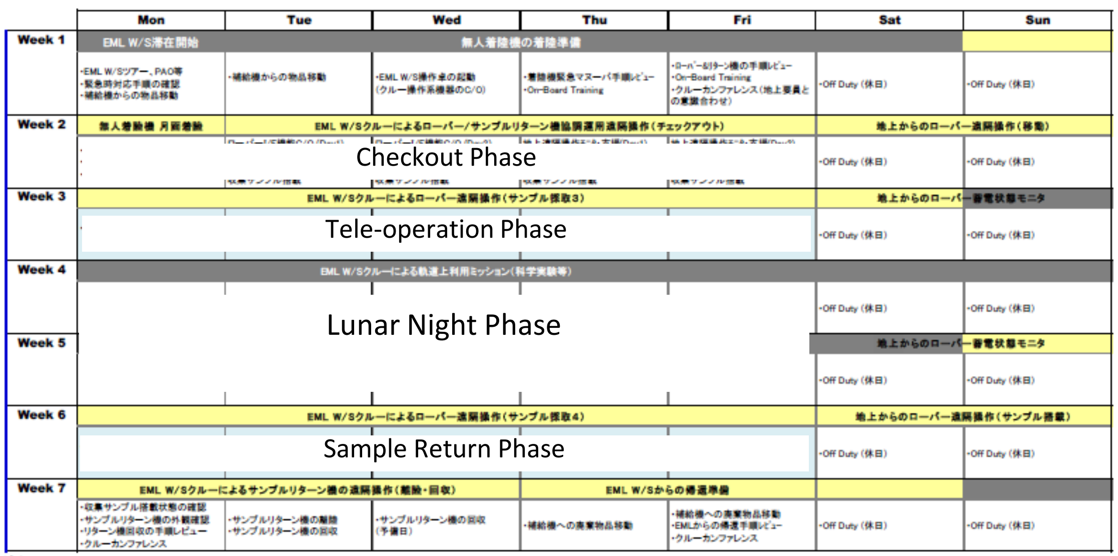


Operation Concept during Tele-operation

- 1st Lunar Day Operation Concept
  - Daytime (8hours)
    - teleoperation by crew
  - Nightime (16hours)
    - autonomous locomotion
- 1st Lunar Night Operation Concept
  - Other Mission
- 2nd Lunar Day Operation Concept
  - Monitor Mission that return the sample from Lunar Surface to EML Station and retrieve the sample







Planning Concept of Sample Return for 50 days of Crew Stay

Operationl Concept during Retrieving Sample Module

- Standarization of Robot Contorl Staion
  - Rover Teleoperation / Sample Retrieve / Operation of Airlock and so on.
- RVD System Standarization
  - Retrieving sample may require rendevous system which may be used for EML RVD system for Visiting Vehicle to EML. The RVD system could be standarized in the future.
- Communication between EML and Lunar Surrece
  - Hight Speed Communication may be requried