JAXA's Study of a Lunar ISRU Pilot Plant

- In-situ Production of Oxygen & Hydrogen from Lunar Regolith -

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Contents


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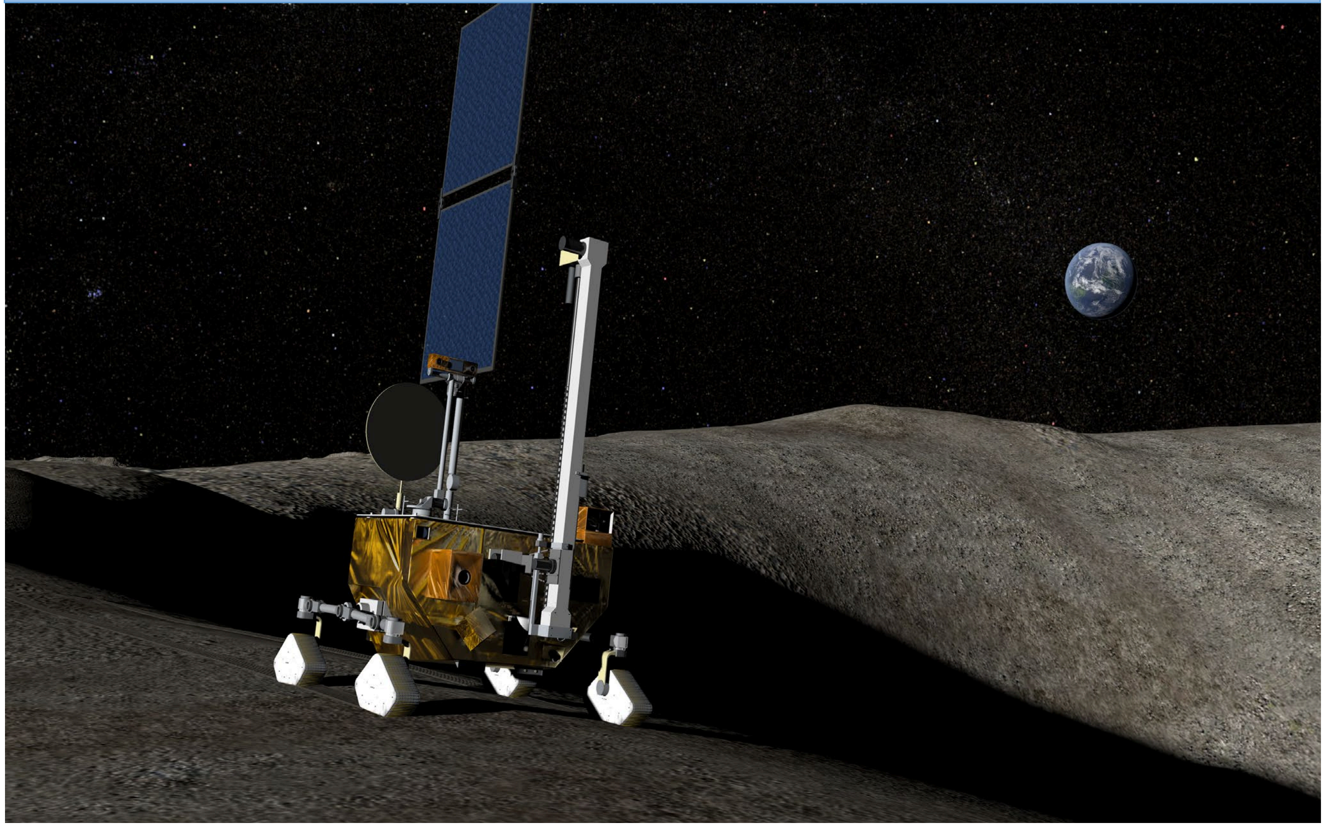
1. Introduction - Latest Updates -

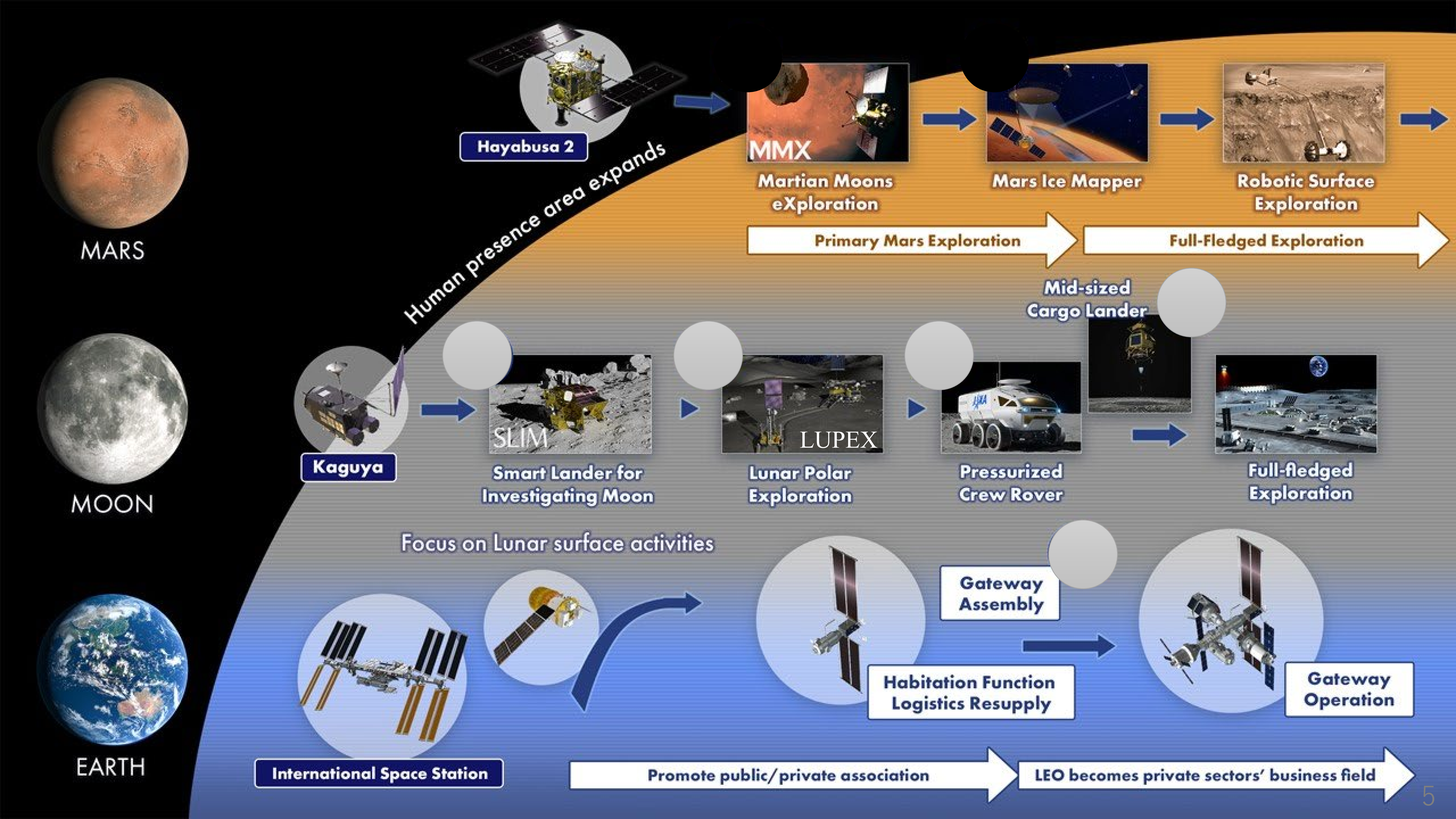
Smart Lander for Investigating Moon (SLIM)

・100m precision landing tech demo
・Mass: 200kg (Dry) Size: 2.4m x 1.7m x 2.7m
・Landed on the Moon on Jan 20, 2024.
・Landing Site: Vicinity of "Sea of Nectar"

Lunar Polar Exploration (LUPEX)

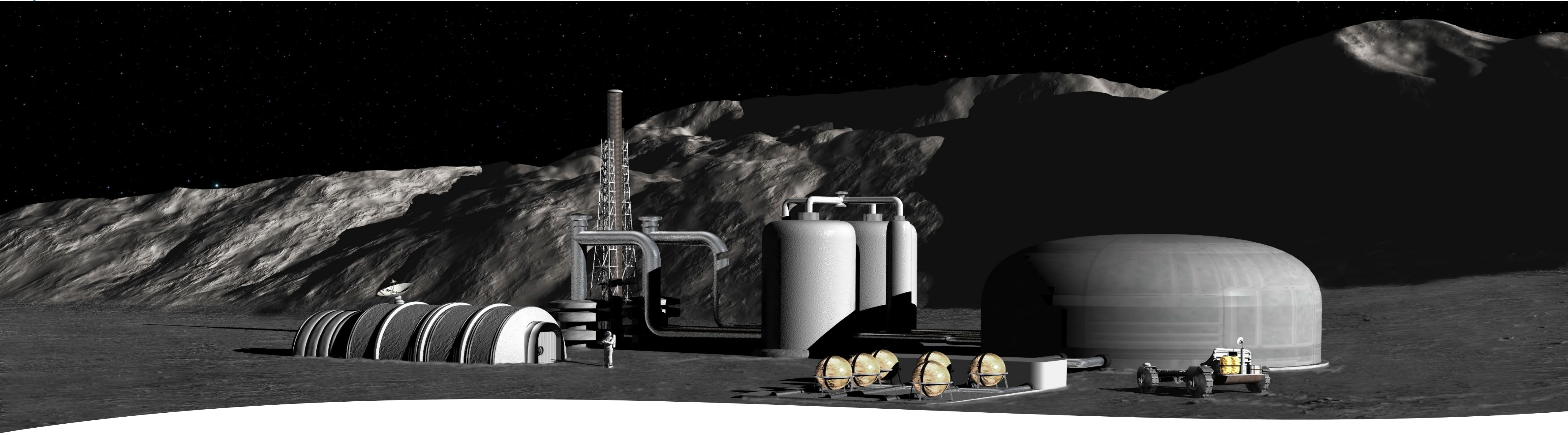
・Explore the south pole region by 350kg class rover
・Investigate availability of water-ice resources
・Planned to be launched in JFY2025
・Collaborated w/ Indian Space Research Organisation





MARS
MOON
EARTH
Hayabusa 2
Human presence area expands
MMX
Martian Moons eXploration
Mars Ice Mapper
Robotic Surface Exploration
Primary Mars Exploration
Full-Fledged Exploration
Mid-sized Cargo Lander
Kaguya
SLIM
Smart Lander for Investigating Moon
LUPEX
Lunar Polar Exploration
Pressurized Crew Rover
Full-fledged Exploration
Focus on Lunar surface activities
Gateway Assembly
Habitation Function Logistics Resupply
Gateway Operation
International Space Station
Promote public/private association
LEO becomes private sectors' business field

2. Baseline Requirements for In-Situ Production



Pilot Plant

- Perform a sub-scale tech demo on the Moon.
- Produce water (340 kg/year TBD) and/or Oxygen (150 kg/year TBD) from regolith.

Large-scale Plant

- Commence to build a large-scale lunar ISRU plant.
- Produce LOX (49.3 ton/year TBD) and LH2 (8.3 ton/year TBD) from regolith to refill spacecrafts.

NOTICE: Above-mentioned plans and requirements stem from the conceptual study of a lunar ISRU plant by JAXA and JGC Cooperation. Target production rate may change. Not budgeted by the Government of Japan at this moment.

Conceptual Study of Full-scale Lunar ISRU Plant

As presented in SRR2023, JAXA carried out conceptual study of a full-scale ISRU plant with JGC Corporation, one of the largest total engineering companies in the world.

- ☐ Mass of a whole plant system to produce 57.6 tons of LOX/LH2 propellant:

  Approx. 30 ton - 293 ton

- ☐ Total area of Photovoltaics:

  Approx. 2,000 m^2

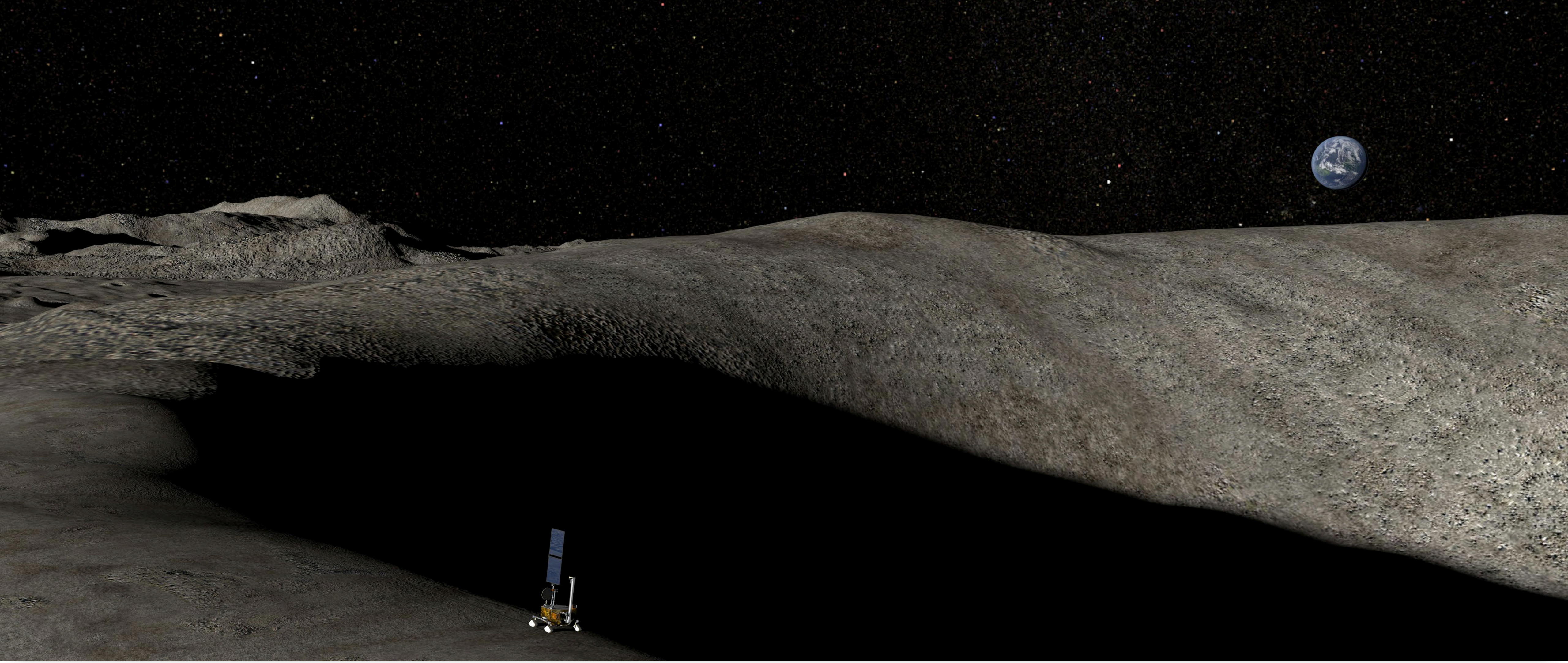
- ☐ Target volume of a ISRU plant:

  < 33.1m^3 (= 1,169 cu ft.)

  ≒ Inside cubic capacity of 20ft. ISO Container

Configuration of a lunar ISRU Plant

20ft. ISO Container

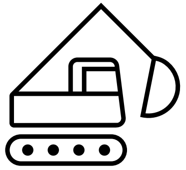


3. Results of Study on ISRU Pilot Plant with Plant Engineering Companies

3.1. Configuration Patterns & Operational Scenarios

Common Feature

-Deploy an excavator to a target area and excavate regolith.



Pattern A) Excavator equipped w/ ISRU Experimental Devices

-Process regolith to produce O_2 and H_2 on excavator in the vicinity of excavation point.

Pattern B) Excavator equipped only w/ Water Extraction Device

-Extract water on excavator in the vicinity of excavation point and dump dried regolith.

-Return to the landing site and transfer **extracted water** to lander.

-Electrolyze water to produce O_2 and H_2 on lander.

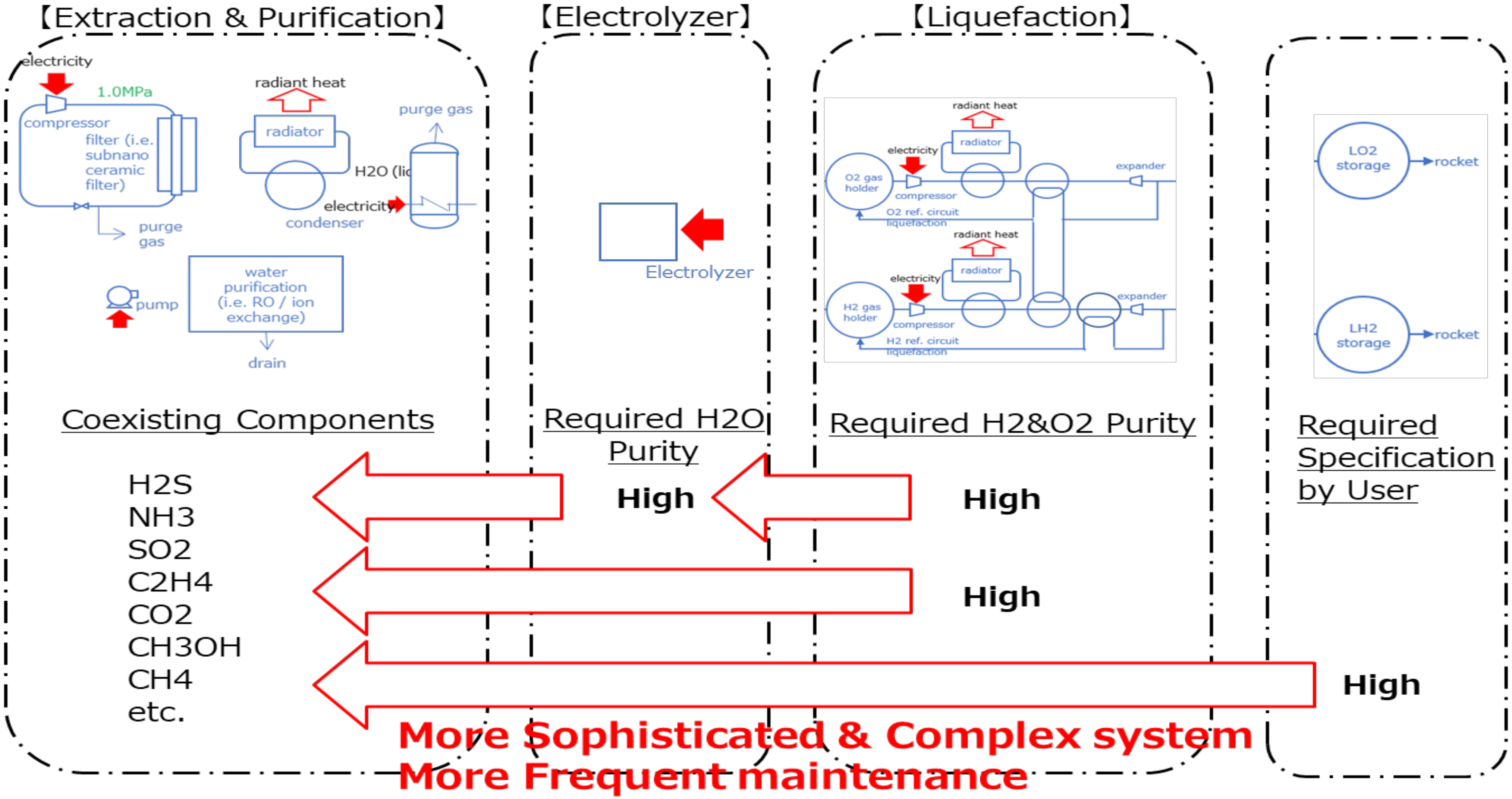
Pattern C) Excavator w/o ISRU experimental Devices

-Return to the landing site and transfer **regolith** to lander.

-Process regolith to produce O_2 and H_2 on lander.

3.2. Resource Estimation and R&D Prioritization

	JGC Corporation	Chiyoda Corporation
Baseline	☐ $H_2O(L)$: 340 kg/year ☐ Operation: 308 days (=14 days x 2 x 11)	☐ $H_2O(L)$: 9,180 kg/year (= 340 kg/year x 27) Note: This size of a pilot plant considered practical approach to develop with equipment / device proven in ground-market and utilize as a basic unit to connect and scale up to a large-scale plant.
Resource Estimation	☐ Mass: < 250 kg (except Regolith Excavator) ☐ Size: < 2 m^3 ☐ Power: < 2 kW (peak)	☐ Mass: < 6,200 kg (except Regolith Excavator) ☐ Size: < 200 m^3 ☐ Power: < 118 kW (peak)
R&D Priority	☐ Low-power water extraction from regolith simulant and treatment of residue ☐ Effect analysis of regolith contamination ☐ Energy-efficient liquefaction of O_2 & H_2	☐ Water purification after extraction from regolith simulant with various coexisting components ☐ Electrolyzer performance to electrolyze H_2O with some contamination


【Extraction & Purification】
electricity
1.0MPa
compressor
filter (i.e. subnano ceramic filter)
purge gas
radiant heat
radiator
condenser
purge gas
H2O (liq
electricity
pump
water purification (i.e. RO / ion exchange)
drain
Coexisting Components
H2S
NH3
SO2
C2H4
CO2
CH3OH
CH4
etc.
【Electrolyzer】
Electrolyzer
Required H2O Purity
High
【Liquefaction】
radiant heat
radiator
electricity
O2 gas holder
compressor
expander
O2 ref. circuit liquefaction
H2 gas holder
H2 ref. circuit liquefaction
Required H2&O2 Purity
High
High
LO2 storage
rocket
LH2 storage
Required Specification by User
High
More Sophisticated & Complex system
More Frequent maintenance

4. Future Work - R&D Strategy -

System Requirements Definition

- Define system requirements of a ISRU pilot plant taking account of stakeholders' expectations and constraints.
- Flow down system requirements from a plant system level to a subsystem level.

Building an R&D Strategy and Project Plans

- Concept and technology development from a system integration standpoint.
- Deepen fundamental research for key technical elements based on requirements.
- Research on construction & infrastructure technology on a lunar surface in cooperation with general contractors and construction machinery manufacturers.
- Demonstrate LOX/LH2 production technologies from regolith simulant with water contents on the ground through development of an integrated ISRU system in the early 2020s.
- Develop a pilot plant for a sub-scale tech demo on the moon.

75th INTERNATIONAL ASTRONAUTICAL CONGRESS

MILAN 2024

14 – 18 OCTOBER 2024 MILAN – ITALY

VALUE OF RESOURCES: RECIPE FOR IN-SITU RESOURCE UTILIZATION ON SPACE FRONTIERS

Day: Tuesday 15 October

Time: 13:45 - 14:45 CEST

Location: Auditorium, Level 3, South Wing, MiCo Convention Centre