ISRU MISSION OBJECTIVES AND TECHNOLOGY DEVELOPMENT AT JAXA. J. Shimada[1] (shimada.jun@jaxa.jp), H. Meguro[1], S. Okamoto[1], T. Iwaki[1], K. Fukaura[2], Y. Tanaka[2], S. Mori[2], T. Yokoyama[2], M. Masugi[2], K. Ishiwata[3], S. Miyamoto[3], S. Izawa[3], Y. Imamura[3] and D. Tomisaki[3], [1]Japan Aerospace Exploration Agency (JAXA), Tsukuba Space Center, Ibaraki, Japan, [2]JGC Corporation, Kanagawa, Japan, [3]Kurita Water Industries Ltd., Tokyo, Japan.

Introduction: This paper summarizes mission objectives and technology development related to lunar In-situ Resource Utilization (ISRU) led by Japan Aerospace Exploration Agency (JAXA) in accordance with the National Space Technology Strategy formulated by the Government of Japan. A series of research programs were launched by JAXA in 2024 to investigate the technical practicability of producing water and oxygen from lunar regolith, designed to cover a wide range of research from technology demonstration on core elements to integrated system design for ground demonstration. This work is performed by JAXA in cooperation with JGC Corporation, one of the world's largest total engineering companies, and Kurita Water Industries Ltd., one of the leading industrial water solutions providers in the world.

Background: In-situ productions of consumables such as water, oxygen and propellant are of the essence to establish long-term human presence on space frontiers by drastically reducing launch mass and attendant risks for periodic resupply of these consumables. Figure 1 illustrates a full-scale lunar ISRU plant designed for on-site production of liquid hydrogen (LH2) and liquid oxygen (LOX) from lunar regolith. Either lunar regolith excavated in the Permanently Shadowed Regions (PSRs) or extracted water is transferred to a lunar ISRU plant located on illuminated crater rim by transporter(s) as shown in Figure 2. Hydrogen and oxygen produced by electrolysis are transferred to the liquefaction element at a plant. LH2 and LOX are stored in cryogenic storage tanks to be filled into spacecrafts on demand.

Baseline Requirements: Considering the target of in-situ propellant production defined in the Global Exploration Roadmap 2024 published by the International Space Exploration Coordination Group (ISECG), JAXA defined the target of annual production rates of LOX and LH2 as 49.3 ton/year and 8.3 ton/year respectively at an early stage of lunar exploration. Based on JAXA's original calculation, sub-scale production requirements are set as >340 kg/year of water and >150 kg/year of oxygen as intermediates to produce propellant for ISRU ground demonstration.

Preconditions and Assumptions: This study was performed on the preconditions as defined in Table 1. The assumptions regarding concentrations of impurities trapped in regolith simulant prior to water extraction are defined in Table 2.

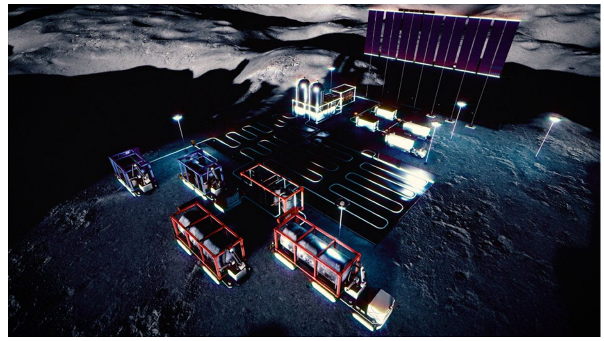

Figure 1. Image of Lunar ISRU Plant. ©JAXA

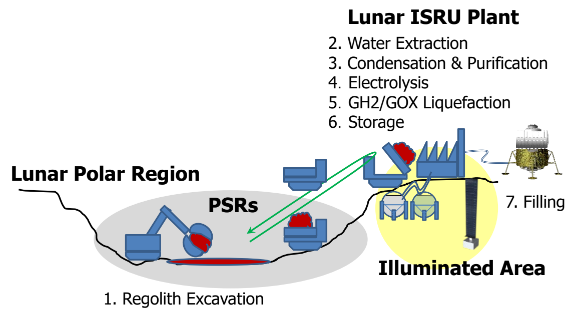

Figure 2. Full-scale production of LH2/LOX.

Table 1. Preconditions for ISRU ground demo

Item	Preconditions
Production rate	H_2O(l) : >340kg/year O_2(g) : >150kg/year
Regolith simulant	FJS-1 (Shimizu Corporation)
Water content	5wt% prior to extraction

Table 2. Assumptions on concentrations of impurities trapped in regolith simulant for ground demo

Substance	Concentration of impurities [mol/mol H2O%]	
	Limited Case*2	Worst Case*3
H_2S	0.13	16.75
NH_3	0.05	6.03
SO_2	N/A	3.19
C_2H_4	N/A	3.12
CO_2	0.02	2.17
CH_3OH	N/A	1.55
CH_4	0.01	0.65

*1 Originally defined by JAXA's ISRU Research Team in consideration with the limitation of water treatment technology on Earth.

*2 Defined based on remote sensing data acquired by NASA's Lunar Crater Observation and Sensing Satellite (LCROSS) mission.

End-to-end System Design: The main objective of the end-to-end ground demonstration is to investigate technical feasibility and identify technical challenges from a system integration standpoint, studied by JAXA and JGC Corporation based on the given requirements and preconditions.

Scope. The system design for end-to-end ISRU ground demonstration covers upstream subsystems for in-situ propellant production ranging from water extraction to electrolysis.

Fundamental Research on Core Technologies: The fundamental research on core technologies for lunar ISRU with the aim of raising technical readiness level includes water extraction from lunar regolith simulant, water purification and electrolysis.

Water Extraction. Extraction from lunar regolith simulant which contains a certain amount of water and predefined impurities in the vacuum environment.

Purification of extracted water. Purification of extracted water to satisfy the water quality requirement to be properly processed by downstream subsystems without causing efficiency degradation and malfunctions due to residual impurities trapped in extracted water.

Water Electrolysis. Production of gaseous hydrogen and oxygen by electrolysis.

References: [1] JAXA (2022) *Japanese International Space Exploration Scenario 2021*. [2] ISECG (2024) *Global Exploration Roadmap (GER) 2024*. [3] NASA (2020) *Cross-Program Design Specification for Natural Environments (DSNE)*.