OBJECTIVE AND CONFIGURATION OF A PLANNED LUNAR POLAR EXPLORATION MISSION. M. Ohtake[1], Y. Karouji[1], H. Inoue[1], H. Shiraishi[1], T. Hoshino[1], and D. Asoh[1], [1] Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa, 252-5210, Japan (ohtake.makiko@jaxa.jp).

Introduction: Multiple remote sensing dataset (e.g. visible and near-infrared [1], Layman-α [2], and neutron [3] observation of the lunar surface) derived by recent lunar exploration missions suggested that water ice might be widely present in the lunar polar region. For example, neutron spectrometer data indicates that hydrogen abundance is much higher at the latitude higher than 85 degree in both north and south poles than in the lower latitude [4]. And the estimated water equivalent hydrogen in the top ~1 m layer of lunar regolith is up to ~0.5 wt.% [4]. Also, near-infrared spectral measurements of the ejecta induced by artificial-impact in the permanently shadowed region reported that the water abundance at the impact site is several wt.% and the water came out from the relatively shallow depth (up to several meters) [5]. The observed water ice is assumed to be foreign origin, which is delivered to the lunar surface as a comet or asteroidal impactor or formed by interaction between the solar wind and minerals in regolith.

However, currently, its actual origin, abundance, condensation mechanism, and lateral and vertical distribution is not clear. This information will enable us to understand transportation (or probably formation) mechanism with supply flux of the water to the Earth-Moon region in the solar system. In addition to the scientific interest, there is strong interest in using water ice (if present) as an in-situ resources. Specifically, using water ice as a propellant will significantly affect future exploration scenarios and activities because the propellant generated from the water can be used for ascent from the lunar surface and can reduce the mass of the launched spacecraft of lunar landing missions. To access the abundance and distribution of the water in the lunar polar region, Japan Aerospace Exploration Agency (JAXA) is planning a polar exploration mission in collaboration with Indian Space Research Organisation (ISRO). In this presentation, we discuss an objective, current configuration, and landing site candidates of the polar exploration mission.

Mission objective: Many studies searching water in the lunar polar region reports positive results as nicely reviewed in [6]. However, each of the currently available datasets have limitation. For example, in the neutron observation, it detects hydrogen but cannot directly measure water. For spectral measurements, it can detect water ice at the very surface of the lunar regolith [1, 2] though water can be present at the deeper area, where the temperature is lower. Also, the estimated abundance of the water varies from less than 0.1 wt.% up to ~30 wt.%. And there are negative reports regarding water presence [7, 8]. Therefore, currently, abundance, condensation mechanism, and lateral and vertical distribution of the water at the lunar polar region is unclear.

To solve these problems, JAXA is planning a lunar polar exploration mission [9] within the framework of international collaboration with ISRO. Objective of the polar exploration mission is to obtain information regarding water abundance, distribution, and condensation mechanism at the lunar polar region to evaluate possibility for utilizing water as a resource in the future missions. To attain this objective, we need to land on the lunar surface at the polar region and directly measure water by conducting in-situ measurements. And if there is water, we also need to know it's quantity (how much), quality (does it contain other phases such as CO_2 and CH_4 or not), and usability (how deep do we need to drill or how much energy is required for drilling the regolith to derive the water) for assessing if we can use it as resources.

The mission passed the mission definition review and project readiness review in JAXA last year, and it is planned to be a phase A mission early this year (2020). The launch will be by JAXA's H3 rocket in around 2023.

Spacecraft configuration: In this mission, we are planning that ISRO and JAXA develop a lander and a rover respectively (Fig. 1). Mass of the rover is around 350 kg (including payloads) and will carry multiple instruments both developed by JAXA and ISRO to attain

Launch date	2023~
Launcher	JAXA's H3 rocket
Mass of the rover	~350 kg
Mission duration	More than 2 months
Landing site	Lunar polar region (> 85 degrees in latitude)

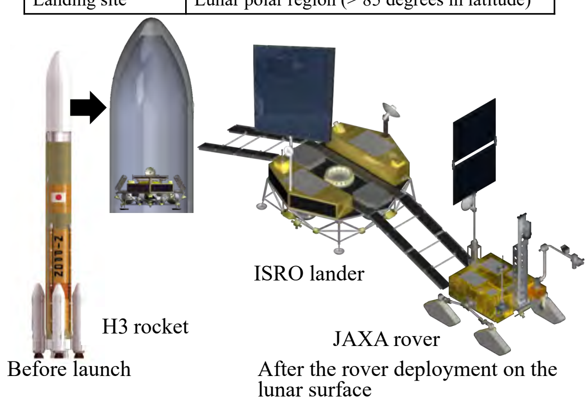

Fig.1 Configuration of the lunar exploration mission

objective of the mission. The rover also has capability of drilling the surface regolith up to 1.5 m depths, bringing up the regolith sample from the drilled depth, and transferring it to the instruments. The rover is designed to move and carried out measurements at the shadowed area for a short period of time. Overall mission duration is estimated to be more than 2 months after the landing onto the lunar surface.

Landing site selection: To attain the objective of this mission, considering unique condition of the lunar polar region, we listed the following parameters as constraints to select the landing site (see a presentation by Inoue et al. in this meeting for the detail discussion of the data analyses).

1) Presence of water: Hydrogen distribution map derived by neutron observation [4] suggests that water possibly distributed widely in the polar region (> 85 degree). Though, the available neutron observation dataset is not capable to identify the hydrogen-rich location in less than 10 km scale, we can use the lunar surface temperature data [10, 11] to identify favorable sites.
2) Surface topography: Detailed surface topography data obtained by the Orbiter Laser Altimeter onboard Lunar Reconnaissance Orbiter and the Terrain Camera onboard SELENE (Kaguya) is used to identify suitable location for the landing.
3) Communication capability: Direct communication from the Earth is a fundamental requirement for our mission. Visibility from the Earth is calculated for each location.
4) Duration of sunshine: To enables the long mission periods, longer illumination condition for the lander is required. Illumination condition is simulated using digital elevation models to obtain the sunlight days per year and the number of continuous sunshine periods at each site.

These analytical results were superimposed to select the landing site candidates (Fig.2). Currently, around 30 sites in total are identified as the candidates for the north and the south pole.

Model instruments and operation: JAXA set model instruments for this mission to obtain information regarding water to evaluate possibility for utilizing water as a resource in the future missions. The model instruments were set to help designing the rover though instrument selection procedures have not yet started. The model instruments are; neutron spectrometer, infrared spectral imager, ground penetrating radar, direct water measurement package (consist of a thermogravimetric analyzer, mass spectrometer, and cavity ring-down spectrometer). By conducting measurements from the surface and of the heated regolith samples, we are going to obtain direct evidence of the presence of water. And also, will get information of its abundance, distribution, and condensation mechanism and origin (see Karouji et al. in this meeting for the detail discussion of the instrument specification and their operation plan).

References: [1] Li S. et al. (2018) *Proc. Natl. Acad. Sci.*, 201802345. [2] Gladstone G. R. et al. (2012) *J. Geophys. Res. 117*, E00H04, doi:10.1029/2011JE003913. [3] Mitrofanov I. G. et al. (2010) *Science 330*, 483-486. [4] Sanin, A. B. et al. (2017) *Icarus 283*, 20-30. [5] Colaprete, A. et al. (2010) *Science 80*, 463-468. [6] Lawrence D. J. (2017) *J. Geophys. Res., 122*, 21-51. [7] Fa W. and Cai Y. (2013) *J. Geophys. Res., 118*, 1582-1608. [8] Eke V. R. et al. (2014) *Icarus, 241*, 66-78. [9] Hoshino T. et al. (2017) *68th IAC*, IAC-17-A3.2B.4. [10] Paige D. A. et al. (2010) *Science, 330*, 479-482. [11] Schorghofer N. and Aharonson O. (2014) *The Astrophys. J. 788*, 169.

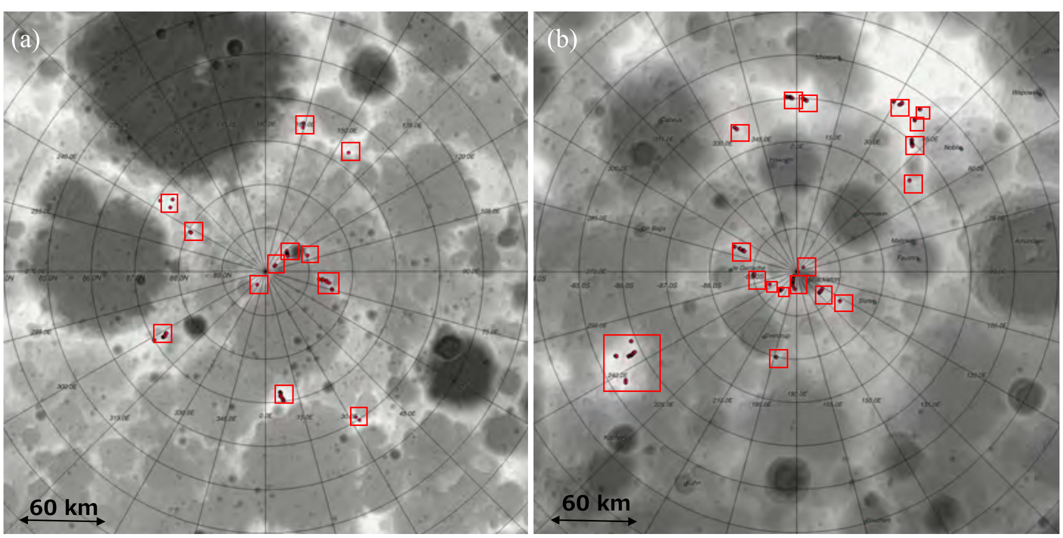

Fig. 2 Landing site candidates selected based on our data analyses on the north pole (a) and the south pole (b). Red dots indicate the candidate sites shown on the gray scale elevation map derived by the Lunar Orbiter Laser Altimeter onboard Lunar Reconnaissance Orbiter. Latitude grids are drawn for every degree.