

DEVELOPMENT OF ISRU UNITS ON MOON WITH LUNAR CAVES AS SOURCE OF MINERALS.

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Introduction to LUNAR ISRU: Lunar In Situ Research Utilization Units are future of lunar surface exploration. For the first time to establish ISRU units on the moon its payload co-ordinates on the moon's surface and mining range from metals. ISRU units are the future technologies for the permanent habitation for human beings on the moon which would cover wide areas from catering the energy need to the water processing and mineral refining over the lunar surface.

Ideal Location on moon for ISRU Project: The Oceanus Procellarum is a mare on the surface of the moon. It has been found that there exists lava tube with potential for human habitation coming years. This cave structure could save humans from the radiation storms and extreme weather conditions which include drastic temperature change. Thus for human exploration missions the caves would serve as natural shelters and help cave dwelling humans to turn into cave dwelling martians. The water processing ISRU has a capacity of 500 tons of water in the form of a below-ground pool walled with sintered lunar regolith. After the complete water extraction structure is abandoned and new structure is built on new ice deposit. Much more units can be built once a trial unit is tested.

Use of robotics for Surface Exploration: . As mentioned importance of Oceanus Procellarum the metal refining ISRU units would be situated here. Most metals are found in high concentration here Namely, Thorium (Th), Titanium (Ti), and Iron (Fe) are commonly found in the area which is around Copernicus crater. For ISRU processing the lunar regolith around ISRU is mined and ISRU grinds up the lunar regolith with the power generated from a reactor (The power supply is clearly mentioned in ISRU project).

Use of robots as transportation systems: It is possible that the mobile transportation robots used for transportation of lunar regolith are initially powered by Li-ion batteries, If Li-ion batteries lose charge they may be retrofitted with new hydrogen cells when the improvised system is available. With today's battery charging algorithms if we consider improvements on smaller scale for charging and discharging cycle with increased battery capacity as Tesla cars are expected in near future these vehicles would require nearly half charging time. One must consider for a 24 hours schedule the device works for 12 hours a day with 6 hours for unloading and maintenance. As the battery degrades there would be extra time required for charging the device. Afterwards, When extracted regolith has been transported to the ISRU with help of mobile

vehicles, it is separated into its composite oxides via selective reduction. This result into several different oxides, such as CaO, TiO₂, FeO, Fe₂O₃, Al₂O₃, and others, which can be easily, separated using magnetic or chemical means.

Use of robots on the moon of Saturn 'Titan': With Similar Physics as the Earth, Titan has an exception of water ice as rocks due to cold. ISRU plant would be placed near a point on the surface where the crust is thin, allowing water to seep up from Titan's interior. The site ultimately chosen was on the slopes of a cryo volcano near Titan's equator compared to geothermal power plants near volcanoes and geysers to take advantage of the heat seeping up from the Earth's interior. On Titan, a small fleet of protected rovers designed to cut out blocks of water ice from the cryovolcano flows. ISRU lander perform melting, purification, and processing of these blocks. Nitrogen and methane could be harvested from Titan's atmosphere. The only technological needs are those robot rovers and shuttles which would carry export of materials from ISRU Units.

Future Scope: In near future the importance of lunar surface structures would be emphasized like never before due to moons position and resource availability. The team studying this project would identify the use of resources obtained from lunar caves on the lunar structures, their feasibility, practical implementation This work is under my project ISRU Units whose paper was published in Annual Meeting of Lunar Exploration Analysis Group (LEAG) 2019 (Link for E-poster : <https://www.hou.usra.edu/meetings/leag2019/eposter/5030.pdf>)