Fraunhofer IFAM

Request for Ideas

Mini-ROXY Lunar Demonstration Mission Science Objectives

1 Background

1.1 ISRU (In situ resource utilization)

The exploration of the solar system, and as a first step of the Moon, will heavily depend on the use of local resources at exploration destinations. The build-up of lunar infrastructures and colonies will require the availability of metal-based products for construction and other applications, as well as oxygen.

There is a real and near-term potential for a commercial market for liquid oxygen (LOX) and water sourced from the Moon. It has been estimated that the cumulative ISRU market size will grow to ~1 billion $ by 2030 and further to 63 billion $ by 2040. Oxygen is expected to be the main driver of growth. Estimates for future commercial demand range from tens to hundreds of metric tons a year. Demand for metals and silicon will quickly follow.

1.2 ROXY and Mini-ROXY

Electrochemical reduction processes are preferred processes to extract oxygen and metals from regolith. Electrolyzing the regolith powder into oxygen and metals provides two very important materials from an essentially unlimited source. The obtained alloys can be used as structural materials for colonies, as feedstock for 3D metal printing, and more.

The ROXY (Regolith to Oxygen and Metals Conversion) molten salt electrolysis process developed by Airbus meets the requirements for an economically viable process to extract oxygen and metals from regolith without the drawbacks that characterize other solutions. In a larger context, the ROXY process is a core element of the end-to-end product value chain that will eventually produce metal products and oxygen from raw lunar regolith. The advanced Mini-ROXY concept further miniaturizes the electrolysis cell and is thus the next step towards higher resource efficiency.

2 Mini-ROXY Lunar Demonstration Mission

A lunar demonstration is one early step towards the development of larger scale capabilities on the Moon, as shown in Figure 1. A lunar demonstration should therefore be:

- relevant for later upscaling
- flexible in terms of accommodation, i.e., small and compact
- limited to the demonstration needs (focus on feasibility and knowledge gain for later upscaling)
- quickly implementable
- affordable

A Mini-ROXY Lunar Demonstration Mission that meets these objectives is under development as described in the remainder of this document.

In Cooperation with

TU Bergakademie Freiberg – TUBAF – Die Ressourcenuniversität. Seit 1765.

INEMET – Institut für Nichteisenmetallurgie und Reinststoffe

AIRBUS

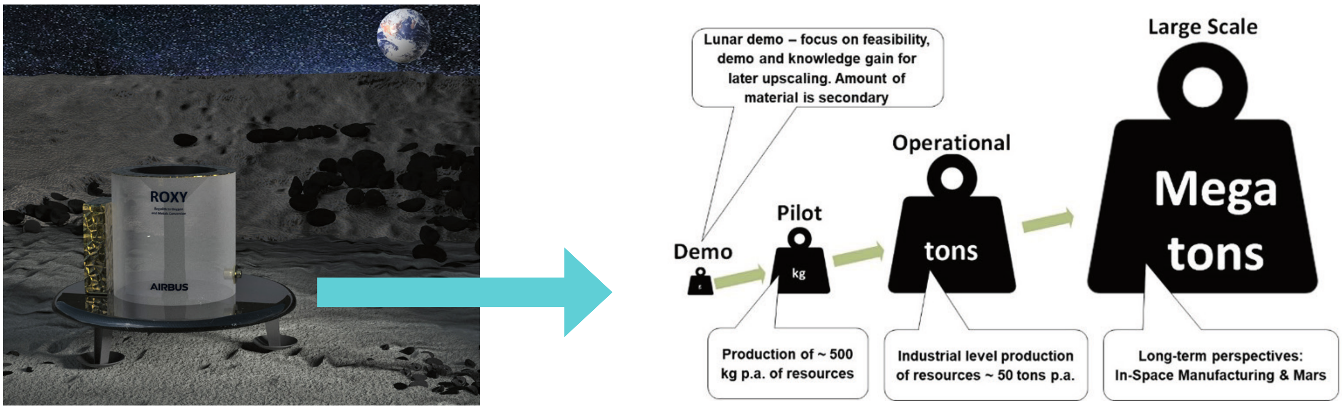


Figure 1: Lunar demonstration in a larger context. Left: Artist´s concept of a lunar Mini-ROXY demonstrator, right: Lunar production scales.

2.1 Mini-ROXY Lunar Demonstration Mission Objectives

The objectives of the Mini-ROXY lunar demonstration mission have been defined as shown below. Specific scientific objectives for the mission have been derived from these mission objectives and are elaborated in section 4.2.

Primary Mission Objectives

- Demonstrate the extraction of oxygen from regolith with the ROXY process as a first step towards larger scale lunar ISRU facilities.
- Develop a payload design that meets the process viability criteria, in particular low resource requirements, compactness, simplicity.
- Develop a payload design that will optimize the benefit-cost ratio of the demonstration mission, i.e., allow for a cost-effective mission with a payload that can be developed rapidly, while meeting the scientific requirements of the demonstration mission.
- Develop a payload design and operational concept that will provide information needed for future scale-up of the process by including state-of-the-art process diagnostics.
- Develop a modular payload complement architecture that will support collaboration with third parties that could provide elements of the mission or payload complement.
- Actively pursue international collaboration, both in terms of hardware provision and scientific collabo-ration.
- Develop a payload design that allows measurement of the amount of produced oxygen based on the oxygen ion current through the ceramic membrane of the reactor assembly.

Secondary Mission Objectives

- Perform beneficiation of the raw regolith, e.g., in terms of grain size distribution, chemical or miner-alogical composition to support systematic studies of the reduction process as a function of feed-stock properties
- Perform independent in-situ measurements of oxygen flow rate and purity
- Develop a payload design that will support sample return of processed regolith and extracted oxy-gen to Earth (Note that this applies in particular to man-tended missions)
- Develop a payload design and operations concept that contributes to the objectives of the MEFAM concept, i.e., the Metals Factory on the Moon (briefly introduced in chapter 7), by addressing some of the steps in the end-to-end metal product value chain, to the extent possible with regards to other mission constraints.
- Perform a ground-based characterization of processes to extract metals and alloys from regolith.

2.2 Ongoing and Future Work

The Mini-ROXY concept is subject to further development by a team involving Fraunhofer IFAM Dresden, TU Bergakademie Freiberg, and Airbus in the frame of a project funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK). In this project, a Mini-ROXY ground model will be built which will be used to perform an end-to-end ground test campaign of the process. In parallel, a Mini-ROXY lunar demonstration mission is being prepared by detailing the design of the Mini-ROXY lunar demonstrator, preparing a design, development and verification plan for the lunar demonstrator and assessing lunar mission opportunities. The high-level scientific objectives of the lunar demonstration mission have been defined. The main work items of this project are shown in Figure 2.
Current hardware activities include a test campaign to address relevant issues in setups that are close to the final design, plus tests to prepare the ground test campaign, such as measurements of the salt evaporation rate, pre-test to optimize the separation of the processed material from the salt, etc.
System engineering activities for lunar mission preparation are organized in a “design campaign” that will be completed in March 2024. The intended result of this campaign is a design baseline of the Mini-ROXY lunar demonstrator that responds to the mission and payload requirements, and a development plan and schedule to prepare the flight model of the Mini-ROXY lunar demonstrator.

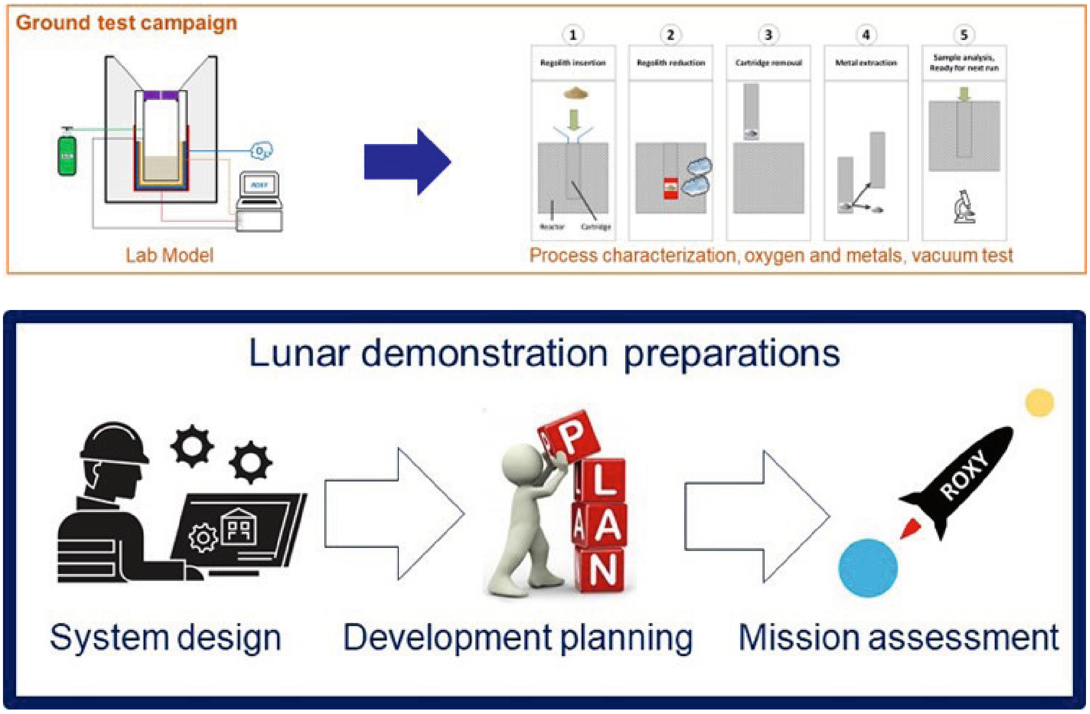


Figure 2: Main work items of current Mini-ROXY project. Top: Lab model and ground test campaign, bottom: lunar model design, development planning and mission assessment.

3 Technical Description

A high-level technical description of the intended functions and architecture of the Mini-.ROXY lunar demonstrator is provided in the following sections. More information is provided in Ref. 6 (https://ntrs.nasa.gov/citations/20230018323).

It is assumed that the Mini-ROXY demonstrator will be accommodated on a lander for lunar surface operations and will be provided with resources by the lander. The Mini-ROXY system will operate largely autonomously with support from ground control. There will be no astronauts available. The Mini-ROXY system will process samples in three cartridges (electrolysis cells) in parallel. After processing, samples and cartridges will remain in the Mini-ROXY system. Sample return is not part of the mission.

3.1 Small is Beautiful: Mini-ROXY Minimum Viable Demonstrator

The need for a lunar demonstration arises because not all factors that have an impact on the process steps can be adequately simulated on Earth. This applies in particular to any process steps that are dependent on gravity, on the properties of true lunar regolith, or both.

A key objective and justification of a lunar demonstration mission is therefore to demonstrate the extraction of oxygen from regolith with the ROXY process under lunar conditions as a first step towards larger scale lunar ISRU facilities. The main goal of such a demonstration is to characterize the oxygen production process using state-of-the-art process diagnostics. To achieve this goal, it is not necessary to produce a large amount of oxygen. Minimizing the amount of oxygen to be produced to the demonstration objectives therefore opens up the possibility of designing a cost-optimized lunar demonstration mission with a simple, compact and low-mass demonstration facility – such as the Mini-ROXY system. This leads to the definition of a minimum viable product. A key mission objective is therefore to optimize the cost/benefit ratio of the mission.

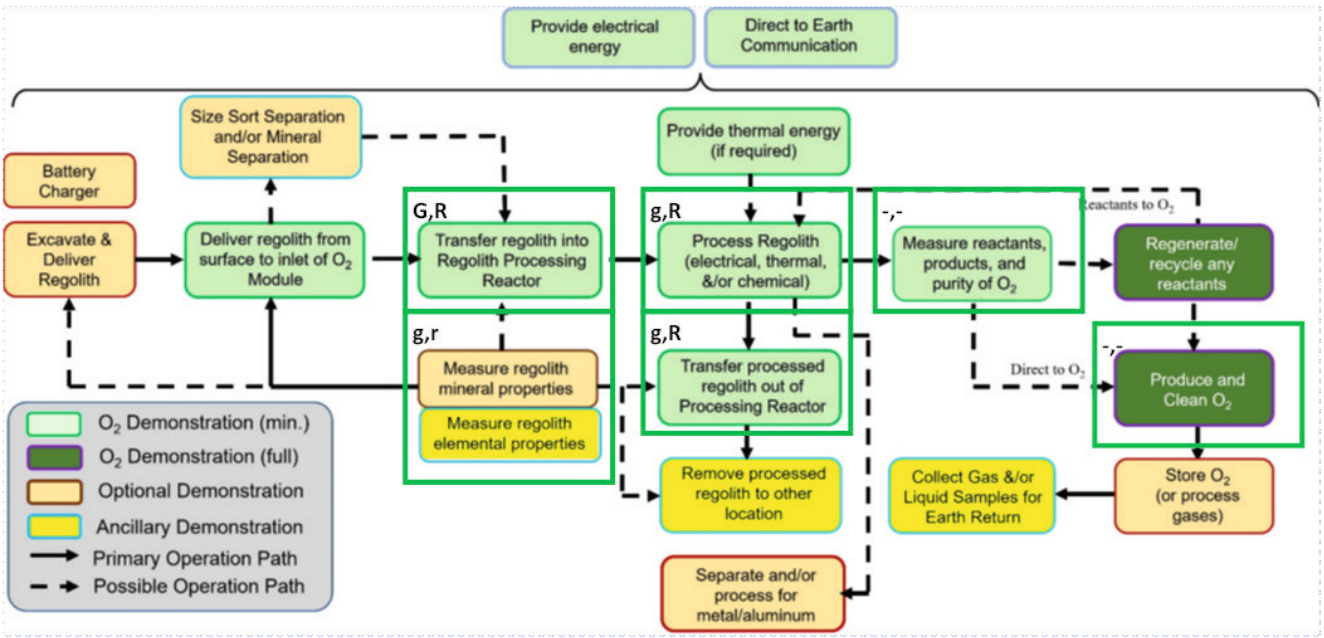
On the other hand, even a minimum viable product needs to demonstrate that the ROXY process will work under lunar conditions, in particular at 1/6 g and with true lunar regolith as feedstock. And finally, the demonstration should provide the knowledge to develop larger-scale ROXY facilities. The basic version of the Mini-ROXY lunar demonstrator has been conceived as a minimum viable product with these considerations in mind. It is the result of a radical simplification exercise, with features that have been reduced to the bare minimum. The resulting concept provides a low-complexity starting point for defining the scope of the lunar demonstration. Features may be added to this basic version depending on mission, science, programmatic, and technical objectives and constraints.

3.2 Keep it Simple: Lunar Demonstration vs. Terrestrial Qualification

Following the same reasoning as in the preceding section, process steps that are not dependent on gravity and regolith do not need to be demonstrated on the moon and can therefore be covered by terrestrial qualifications. For a ROXY system, this includes in particular the measurement of the oxygen production rate and the oxygen purity. Ground-based qualification testing will therefore aim to show the high purity of the produced oxygen and the reliability of the measurement of the produced amount of oxygen based on the ion current through the yttria stabilized zirconia (YSZ) membrane.
The extraction of processed regolith from the cartridge after processing is another case: It is expected to be weakly dependent on gravity, but including this function would significantly increase the complexity of the lunar demonstrator. It could therefore be considered to cover this function either by ground-based qualification testing or by post-flight analysis of processed cartridges. The latter would require a man-tended mission with sample return capability. Alternatively, the function could be added to the lunar demonstration.

3.3 Mini-ROXY Lunar Demonstrator Building Blocks

This section provides an assessment of how the functions provided by the Mini-ROXY lunar demonstrator relate to the building blocks that are considered necessary for a lunar oxygen extraction demonstration. The reference that is used for this assessment is the NASA ISRU Oxygen Extraction Reference Demonstration Concept, published as part of the LIFT-1 RFI, shown in Figure 3.
A mapping of the high-level functions of the Mini-ROXY lunar demonstrator to these building blocks is shown in Figure 4, and discussed in detail below.



G: strong dependency on gravity expected
g: weak dependency on gravity expected
R: strong dependency on properties of true regolith expected
r: weak dependency on properties of true regolith expected
-: no dependency on gravity or regolith expected

Figure 3: Notional NASA ISRU Oxygen Extraction Reference Demonstration Concept. From: REQUEST FOR INFORMATION: 80HQTR24L002_LIFT1 - Lunar Infrastructure Foundational Technologies-1 Demonstration.

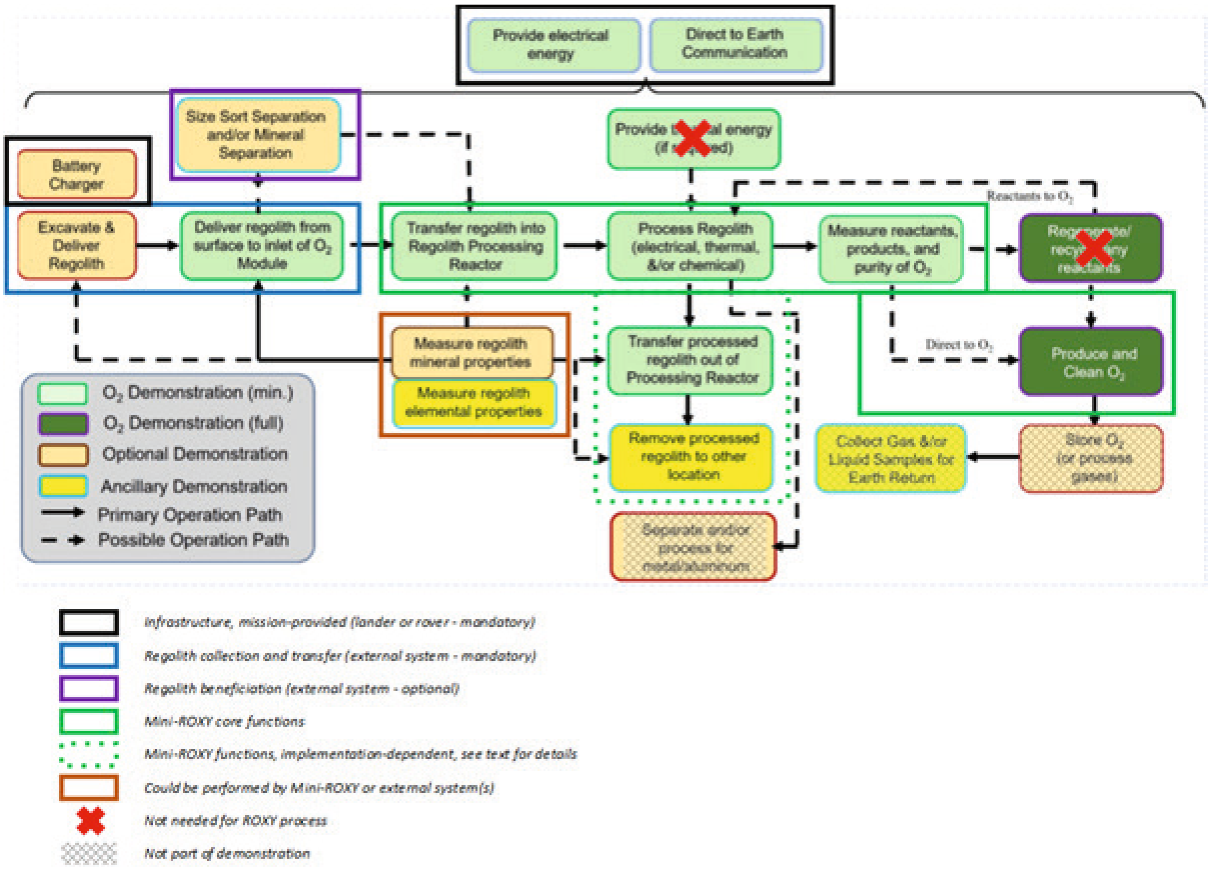


Figure 4: Mapping of Mini-ROXY demonstrator high-level functions to NASA LIFT-1 building blocks

1. Infrastructure functions (black boxes)
These functions are mandatory for the mission. These functions are assumed to be provided by the mission, i.e., the lander or rover, and are not part of the Mini-ROXY demonstrator.

2. Regolith collection and transfer to Mini-ROXY demonstrator (blue boxes)
These functions are mandatory for the mission. These functions are assumed to be provided by other equipment or mission elements, and are not part of the Mini-ROXY demonstrator.

3. Regolith beneficiation functions (purple box)
These functions are optional for the mission. Beneficiation of the regolith would add value to the mission, for example the regolith reduction process could be investigated as a function of regolith composition and/or grain size distribution. These functions are assumed to be provided by other equipment or mission elements. Alternatively, these functions could be performed by Mini-ROXY.

4. Measure regolith mineralogical/chemical composition (orange box)
These functions are mandatory for the mission. The knowledge of which material is processed by Mini-ROXY is considered essential to evaluate the performance of the process. These functions could be performed by the regolith collection and transfer equipment, or a potential regolith beneficiation equipment. It is assumed that the measurements could be an integral part of such equipment. Alternatively, the measurements could be performed by Mini-ROXY.

5. Transfer and process regolith, produce and characterize oxygen (solid green boxes)
These are the core functions of the Mini-ROXY lunar demonstrator. The regolith is transferred from the receiving interface of the system to the cartridges. Regolith in the cartridges is reduced to metal (alloys), and the resulting oxygen is separated, purified, and characterized in terms of production rate by the YSZ membrane. In the basic version of the Mini-ROXY lunar demonstrator, the produced oxygen is released to the lunar environment. The basic version could be extended to provide the oxygen to downstream external systems for oxygen storage etc.

6. Transfer processed regolith out of reactor, remove to other location (dotted green boxes)
The transfer of processed regolith out of the reactor is not part of the basic version of the demonstrator, but could be added in an advanced version. The extraction of processed cartridges by an astronaut and return of processed cartridges to Earth could be an interesting option for a man-tended mission.

7. Functions that are not needed for a Mini-ROXY demonstration (strikethrough boxes)
Thermal energy: the cartridges will be heated by resistance heaters with power from the lander, so an independent source of thermal energy such as solar concentrators is not needed. Regeneration of reactants: this is not applicable since the separation of the oxygen is an intrinsic function of the YSZ membrane, and the salt electrolyte will not be consumed.

8. Functions that are not part of the Mini-ROXY demonstration (cross-hatched boxes)
Oxygen storage is not needed for the demonstration, but could be added as needed. Post-processing/refinement of the processed regolith is not needed for the demonstration, but could be performed on Earth in case of a man-tended mission with sample return capability.

4 Goals of the Request for Interest

It is the goal of this RFI to identify parties that would be interested to contribute to the scientific aspects of the Mini-ROXY lunar demonstration mission.

The electrochemical reduction of oxides with molten salt electrolysis and solid oxide membrane (SOM)-type anodes is a wide field. The application of this process to lunar regolith is an exciting new research area which will benefit from scientific collaboration with interested parties with diverse backgrounds. In addition, the end-to-end process flow includes process steps that are not related to the electrochemical reduction of regolith but are essential for achieving the demonstration goals.

Science objectives for the mission have been derived from the mission objectives and are discussed below. In order to maximize the benefits of a Mini-ROXY lunar demonstration mission, a scientific program must be established to address the scientific objectives of the mission. It is expected that a diverse science team covering the disciplines that are addressed by the science objectives will be established to support the development of the demonstrator and mission, mission operations and post-flight analysis.

4.1 Mini-ROXY Lunar Demo Mission Science Objectives

Even though a lot of information has been gained on lunar resources such as regolith through previous and ongoing ground-based experiments and missions, there are still knowledge gaps of how best to extract and process lunar regolith into usable metal products and resources such as oxygen. In particular, there are significant uncertainties on the properties of lunar regolith. Some of these properties can be determined by established diagnostics methods e.g., to determine the chemical and mineralogical composition of the material. However, the key questions for developing methods for oxygen and metals extraction from regolith are: How will the regolith interact with the extraction method under lunar conditions, and how can the extraction method be optimized for future large-scale lunar facilities? A detailed understanding of the regolith reduction process when applied to true lunar regolith under lunar environmental conditions such as reduced gravity is therefore indispensable for future developments in this field.

This leads to the following key scientific objectives for a lunar demonstration of the ROXY process:

A. Understanding the properties of the feedstock by analyzing the feedstock and determining its rheo-logical, physical, mineralogical, and chemical properties.
B. Understanding the regolith reduction process, its performance and limitations, under lunar environ-mental conditions, in particular related to reduced gravity, vacuum, build-up of electrostatic charge and true regolith. This will allow comparison with terrestrial tests and model predictions, and analysis of likely impacts on alternative sites, feedstocks and production scales.
C. Understanding the characteristics of the product, particularly the amount and purity of oxygen pro-duced.

These key science objectives have been mapped to the building blocks introduced in section 3.3 of a Mini-ROXY lunar demonstrator to formulate six specific objectives. Objectives are therefore to characterize and understand the physical and chemical processes that are associated with the following functions:

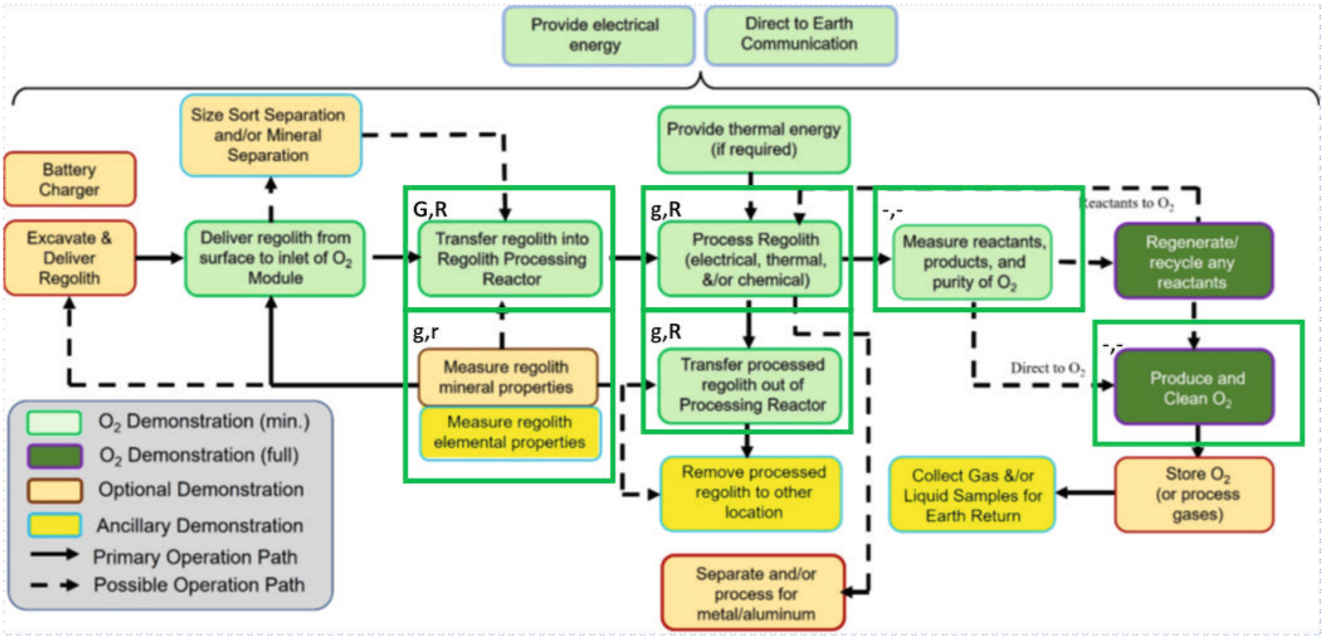
1. Size Sort Separation and/or Mineral Separation
2. Measure Regolith Mineral Properties &/or Elemental Properties
3. Transfer Regolith into Regolith Processing Reactor
4. Design of an Optimized Salt Electrolyte for Regolith Reduction
5. Diagnostics for an In-Depth Characterization of the Reduction Process
6. Transfer Processed Regolith out of Processing Reactor

Each specific science objective is detailed in the following section.

4.2 Specific Science Objectives and Requested Information

A key issue for the justification of any ISRU demonstration on the Moon is the question which of the processes are dependent on the lunar environment, in particular on the reduced gravity and the presence of true lunar regolith. This is assessed for the Mini-ROXY functions that are related to the specific scientific objectives introduced above. In general, the dependencies on gravity and regolith properties are categorized as strong or weak. The result of the assessment is summarized in Figure 5.

A further discussion of the specific scientific objectives is provided in the following sub-sections along with an identification of which ideas are requested as responses to this RFI.



G: strong dependency on gravity expected
g: weak dependency on gravity expected
R: strong dependency on properties of true regolith expected
r: weak dependency on properties of true regolith expected
-: no dependency on gravity or regolith expected

Figure 5: Mini-ROXY core process steps and categorization in terms of strong (G) or weak (g) dependency on gravity, and strong (R) or weak (r) dependency on regolith properties

4.2.1 Size Sort Separation and/or Mineral Separation

Gravity dependency: strong
Regolith dependency: strong

The objective of beneficiation is to obtain a regolith feedstock that is optimized for the downstream processes. Beneficiation may therefore include a number of process steps to alter the regolith composition and produce the desired feedstock.

Requested ideas:

- Beneficiation methods and concepts that could enhance the value of the Mini-ROXY lunar demo mis-sion
- Capabilities to beneficiate raw regolith according to different physical properties (particle size distri-bution, mineralogical and chemical composition)
- Lab experiments and modelling to support the development of the demonstrator and the mission
- Integration of beneficiation methods into Mini-ROXY lunar demonstrator architecture, taking into ac-count constraints related to accessibility, miniaturization, high temperatures, low resource require-ments such as mass, volume and power

4.2.2 Measure Regolith Mineral Properties &/or Elemental Properties

Gravity dependency: weak
Regolith dependency: weak

The measurements could be done by non-contact methods, such as Raman spectroscopy. Non-contact methods in combination with fiber optic probes could enable non-invasive chemical analysis in situ. Measurements could be realized with a compact setup compatible with the constraints of a lunar demonstration mission, in particular with small budgets for mass, energy and volume as well as high temperatures. Thus, a system based on it could be integrated into a Mini-ROXY demonstrator.

Such a system could also track the evolution of species present in the electrolyte as the process proceeds. This additional information, when combined with the electrochemical impedance spectroscopy, will reveal important details about the differences in processing real lunar regolith in lunar conditions from processing simulants on Earth.

Requested ideas:

- Sensor concepts and capabilities for mineralogical and chemical characterization of regolith and/or reduced regolith, salt electrolyte
- Lab experiments and modelling to support the development of the demonstrator and the mission
- Integration of sensor concepts into a Mini-ROXY lunar demonstrator, taking into account constraints related to accessibility, miniaturization, high temperatures, low resource requirements such as mass, volume and power

4.2.3 Transfer Regolith into Regolith Processing Reactor

Gravity dependency: strong
Regolith dependency: strong

The transfer involves moving the regolith from a funnel-type interface at the top of the Mini-ROXY demonstrator into the cartridges, whereby it must be ensured that a defined small amount of regolith will arrive at the reaction volume of each cartridge. It is known that regolith handling is dependent on gravity and the properties of the regolith such as electrostatic charging, agglutination etc.

When developing a transfer mechanism for regolith such effects will have to be considered: the granular material itself exhibits distinct physical properties, characterized by sharp and abrasive particles with a significant fine fraction; the reduced gravity alters particle interactions, making cohesive forces predominant; and the singular lunar environment, encompassing low gravity, high vacuum, and electrostatic charges from solar winds, has a complex influence on regolith behavior.

Requested ideas:

- Identification of critical parts and process steps of the regolith transport mechanism and test of these items in an appropriate lunar-like environment, especially under lunar gravity.
- Simulations of expected regolith behavior on the Moon and of the interaction of lunar regolith with the hardware of the demonstrator, including if possible a virtual materials testing approach to predict the behavior of lunar regolith under lunar environmental conditions based on simulations that use experimental data as a starting point

4.2.4 Design of an Optimized Salt Electrolyte for Regolith Reduction

Gravity dependency: weak
Regolith dependency: strong

The ROXY process will electrochemically reduce the regolith and oxygen will be transferred through the YSZ membrane. As a result, the major gravity dependency of molten salt electrolysis processes that is due to the bubbling of molecular oxygen in the salt electrolyte is eliminated. Therefore, only a weak gravity dependency of the process is expected. On the other hand, the process is known to depend strongly on the material that is subject to reduction, for example in terms of sintering, evaporation of metals with high vapor pressure, interaction with the salt, etc., so there is a strong dependency on the properties of true lunar regolith. This is one of the major reasons why a lunar demonstration of the ROXY process is highly relevant for the development of future larger-scale systems.

Molten salts are composed of ionic species having structures that are not very well understood. These melts, although mostly un-optimized, are employed in many important industrial applications. These melt systems are multi-component and complex and are often used at high temperatures. Acquiring accurate property data is time-consuming, expensive, and sometimes experimentally very difficult. Often empirical strategies are employed to identify salts for a particular application. For instance, the salts for SOM-based electrolysis are selected such that their properties like ionic and (low) electronic conductivity, melting range, viscosity, and vapor pressure are comparable to other molten salts used in metal electrolysis. Such techniques can be employed to obtain optimum salt for SOM-based regolith reduction by the Mini-ROXY process.

Requested ideas:

- Approach to develop the optimum salt for ROXY:
- Measurement of relevant thermophysical properties (viscosity, surface tension, density, diffusivities, vapor pressures and electrical conductivity) of candidate salt systems as a function of temperature
- Combination of these experiments with various types of structural simulation techniques such as ab initio and machine-learning based molecular dynamic simulations to obtain detailed structural infor-mation and relate them to their thermophysical and thermochemical properties.

4.2.5 Diagnostics for an In-Depth Characterization of the Reduction Process

Gravity dependency: weak
Regolith dependency: strong

A thorough understanding of the reduction process when applied to real lunar regolith is essential for future advances in the field and is therefore of great importance. These effects can be determined by electrochemical modeling of the cell performance assisted by various potential-current measurements including frequency dependent (electrochemical impedance spectroscopy or EIS) measurements. Electrochemical cell diagnostics will thus provide a general guideline for the design of optimal regolith reduction electrolytic cells for future larger scale applications such as pilot plants and operating plants.

Requested ideas:
- Electrochemical methods to characterize the ROXY process in-situ, such as EIS
- Measurement set-up and strategy
- Lab experiments and modelling to support the development of the demonstrator and the mission
- Combination with other possible measurements

4.2.6 Transfer Processed Regolith out of Processing Reactor

Gravity dependency: weak
Regolith dependency: strong

The transfer of processed regolith out of the reactor involves three steps: 1 - removal of the regolith container (cathode cup) from the cartridge, 2 - removal of the processed regolith from the cathode cup, and 3 - separation of the processed regolith from the remaining salt in the cathode cup. In particular the second and third steps strongly depend on the properties of the (processed) regolith, and should therefore be investigated in detail to gain knowledge for future larger-scale systems. It is therefore considered that it could be advantageous to perform these steps on Earth, however, this implies a sample-return capability of the mission. The gravity dependency of steps 1 and 2 is expected to be weak, while the gravity dependency of step 3 will depend on the details of the process. Currently, the preferred process for salt-metal separation is hot centrifuging, for which it could be argued that gravity dependency is weak.

Requested ideas:
- Approaches and techniques to contain the fine fraction of the regolith by the cathode, e.g. by us-ing metallic structures with designed porosity
- Approaches to reduce losses of regolith (both processed and unprocessed) per cycle to a level many orders of magnitude below the critical contamination threshold, to be able to run many cy-cles of the reduction process without the need to replace the salt electrolyte.
- Consideration of various technologies for separation
- Approaches to remove the processed regolith from the container after separation from the salt.

5 Who Can Apply

Universities and Non-University Research Institutions from the US and Germany.

The response deadline for the RFI is **15 June 2024.**

If you intend to apply, we kindly request that you send a **short message declaring your intention to respond** as soon as possible. This message should include your institution and the prospective topic of your reply.

Please send all inquiries and responses to the following e-mail address:

georg.poehle@ifam-dd.fraunhofer.de

6 Incentives

- Access to experts at DLR, Fraunhofer IFAM Dresden, TU Bergakademie Freiberg and Airbus
- Possibility to pitch to DLR, Fraunhofer IFAM Dresden, TU Bergakademie Freiberg and Airbus
- Preparation of joint publications
- Preparation of proposals (with the aim of a joint application for public funding)

7 Evaluation Criteria

RFI responses will be assessed using the following criteria:

- Scientific content and significance to the Mini-ROXY lunar demonstration objectives
- Research approach
- Background and experience

8 References

Publications listed below are provided in the annex and provide information that may be useful for preparation of RFI responses, including context information on ISRU and space exploration, and descriptions of the ROXY process and the Mini-ROXY configuration.

1 – Global Exploration Roadmap
2 – PWC study on lunar ISRU market
3 – ROXY 2022 ICES paper
4 – ROXY 2024 TMS presentation by the Mini-ROXY team
5 – Techno-economic analysis of solar grade Si production by SOM methods
6 – Mini-ROXY White Paper (NASA NTRS link)

1- https://www.globalspaceexploration.org/wordpress/wp-content/isecg/GER_2018_small_mobile.pdf

2- https://www.pwc.com.au/industry/space-industry/lunar-market-assessment-2021.pdf

3- https://ttu-ir.tdl.org/server/api/core/bitstreams/bd80313e-3708-4f89-8df2-aced23933928/content

4- A. Seidel et al., Taking SOM to the Moon, TMS 2024 153rd Annual Meeting and Exhibition. Available at https://www.ifam.fraunhofer.de/en/Aboutus/Locations/Dresden/Cellular_metallic_materials/aerospace.html

5- https://www.osti.gov/servlets/purl/1819915

6- https://ntrs.nasa.gov/citations/20230018323

9 Instruction for RFI Response Preparation

Instructions: Include science objectives, hypotheses, and clear science justification and relevance for Mini-ROXY objectives. Describe the activity framework, technical methods and requirements, design implementation, and operational concepts. Provide information on relevant team expertise, background and prior achievements. Maximum 4000 words plus figures. Supplementary information, including bibliographic data may be provided if needed, limited to 4 A4 pages.

Ideas are requested for:

1. The preparation of the lunar demonstration mission, including activities such as experiments in terrestrial labs or under reduced gravity and modelling to address the scientific objectives.

2. The design of the demonstrator and its key elements. Possible modifications, additions, optimizations of the concept to address the scientific objectives

3. Experiment protocols for the lunar mission

4. Near-real time and post-flight data analysis

Contact

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