ISRU ADVANCEMENTS: REGOLITH BENEFICIATION & PROPELLANT PRODUCTION OVERVIEW

DLR Institute of Space Systems, Bremen

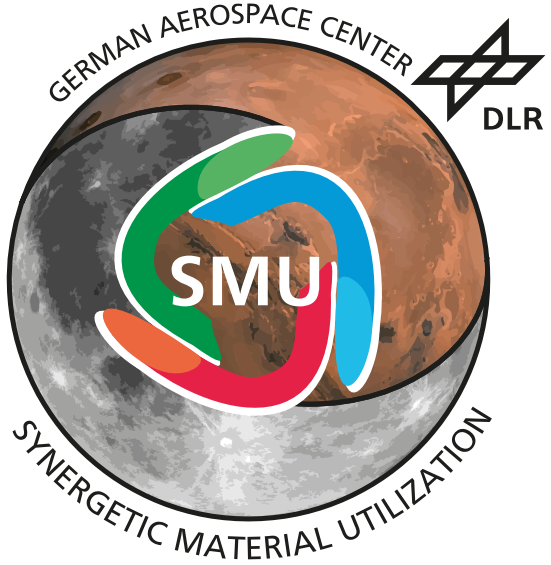
Contact: kunal.kulkarni@dlr.de

Synergetic Material Utilization research group

- Founded in June 2021 at the DLR Institute of Space Systems in Bremen.
- Focus on combining Life Support systems with In-Situ Resource Utilization (ISRU).
- Goal:

Build a small, young and innovative team to develop key technologies with a large impact in the research field.

- Combination of laboratory-scale experimental setups in relevant environment and simulations to raise the TRL to 5



Developing innovative in-situ resource utilization technologies to further advance German excellence in space exploration

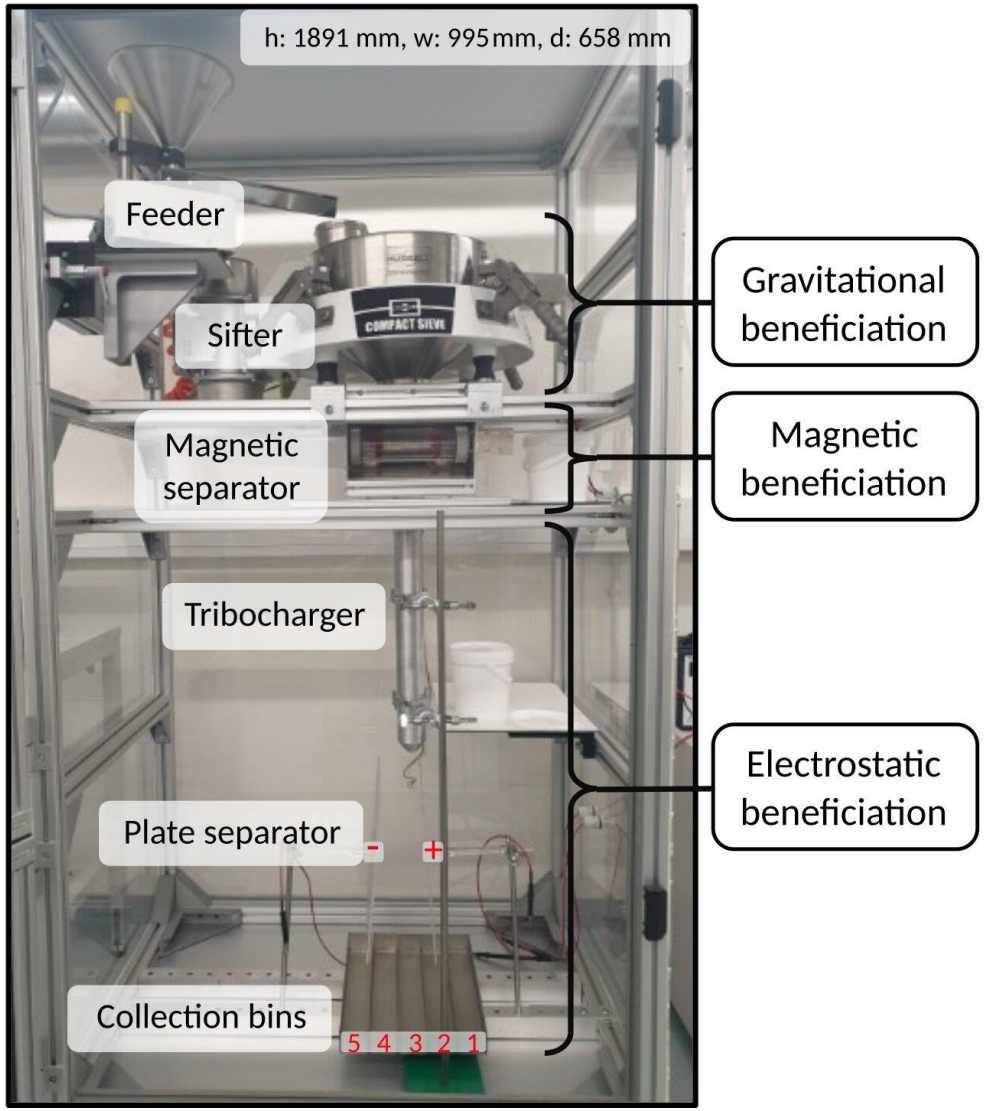
Synergetic Material Utilization research group: Ongoing research

Regolith Beneficiation and Utilization

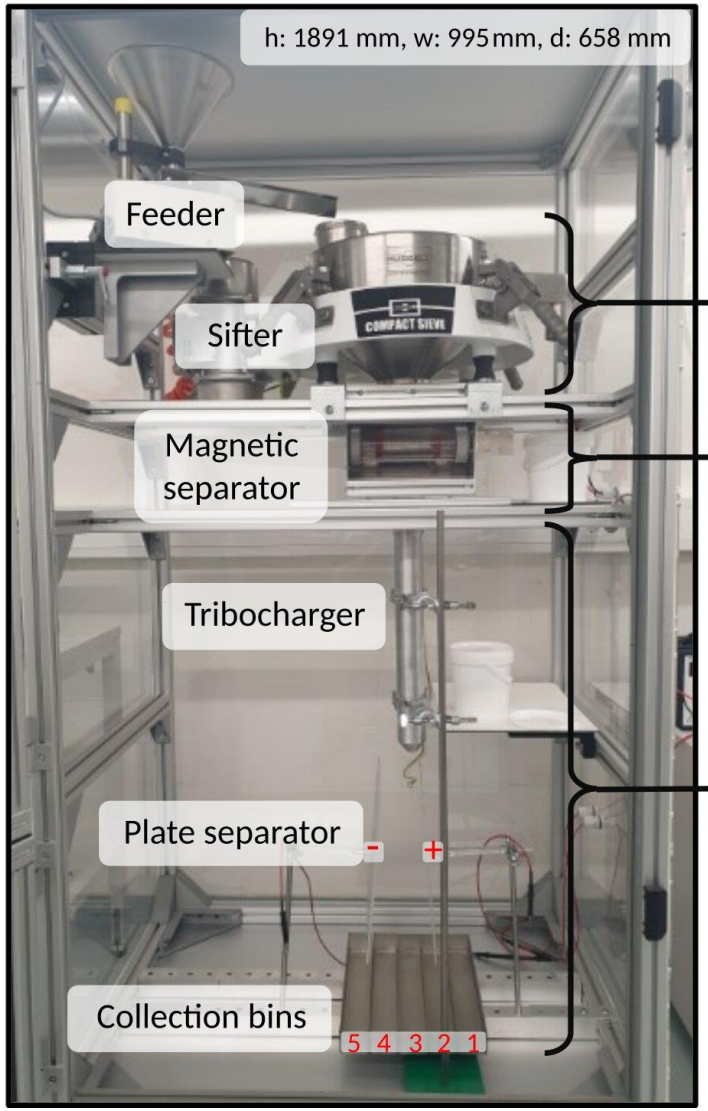
In-Situ Propellant and Consumables Production

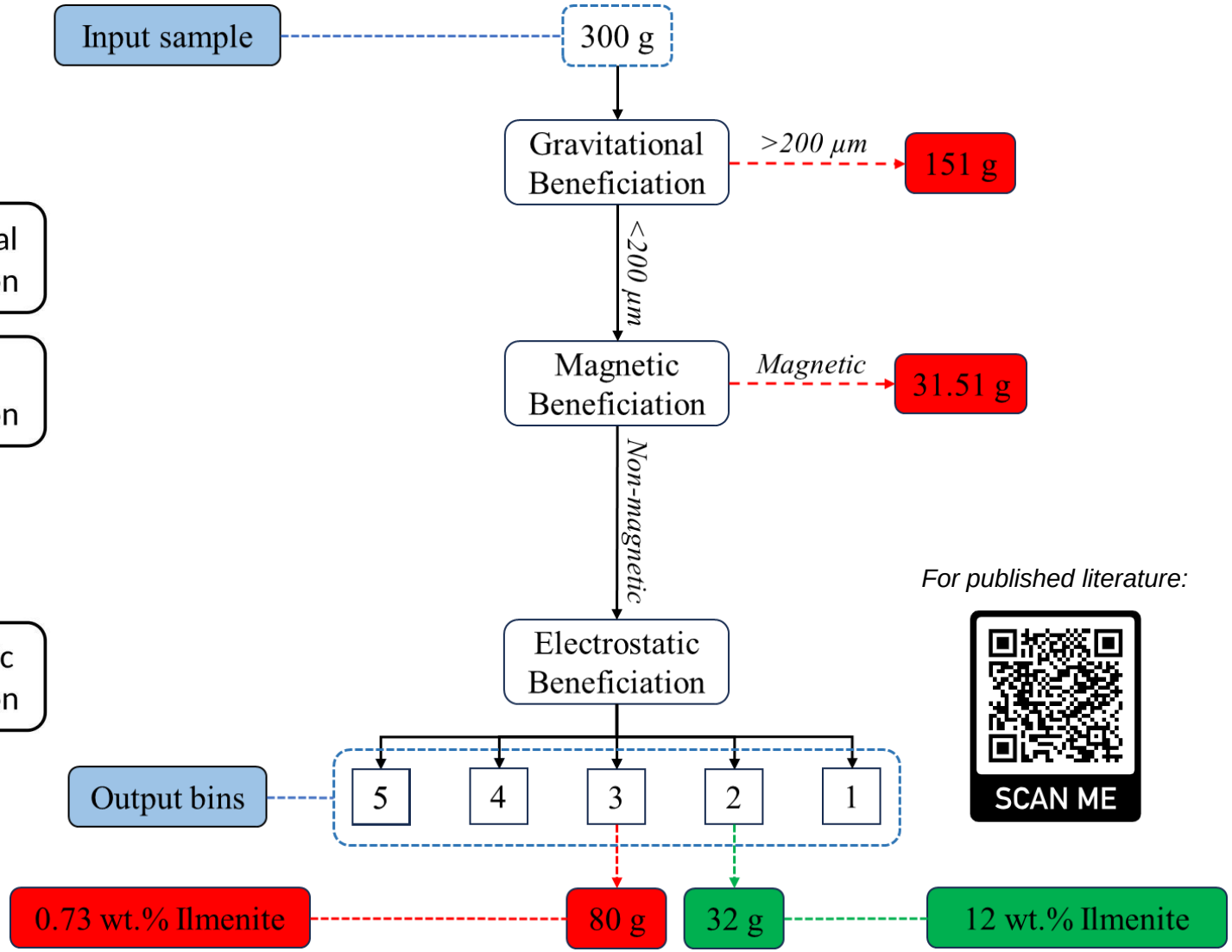
Regolith beneficiation and utilization: Current state of research

- **Gravitational beneficiation**: Remove all particles > 200 µm
  a. Vibratory feeder
  b. Horizontal vibratory sifter
- **Magnetic beneficiation**: Remove ferromagnetic agglutinates and metallic dust
  a. Permanent magnet drum separator
- **Electrostatic beneficiation**: Separate Ilmenite from tailings
  a. Tribocharger
  b. Parallel plate separator



Regolith beneficiation and utilization: Experimental results





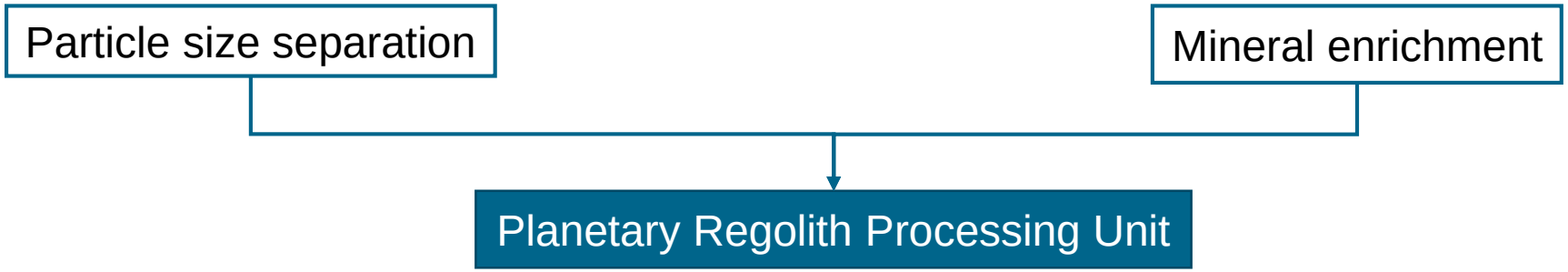
For published literature:

SCAN ME

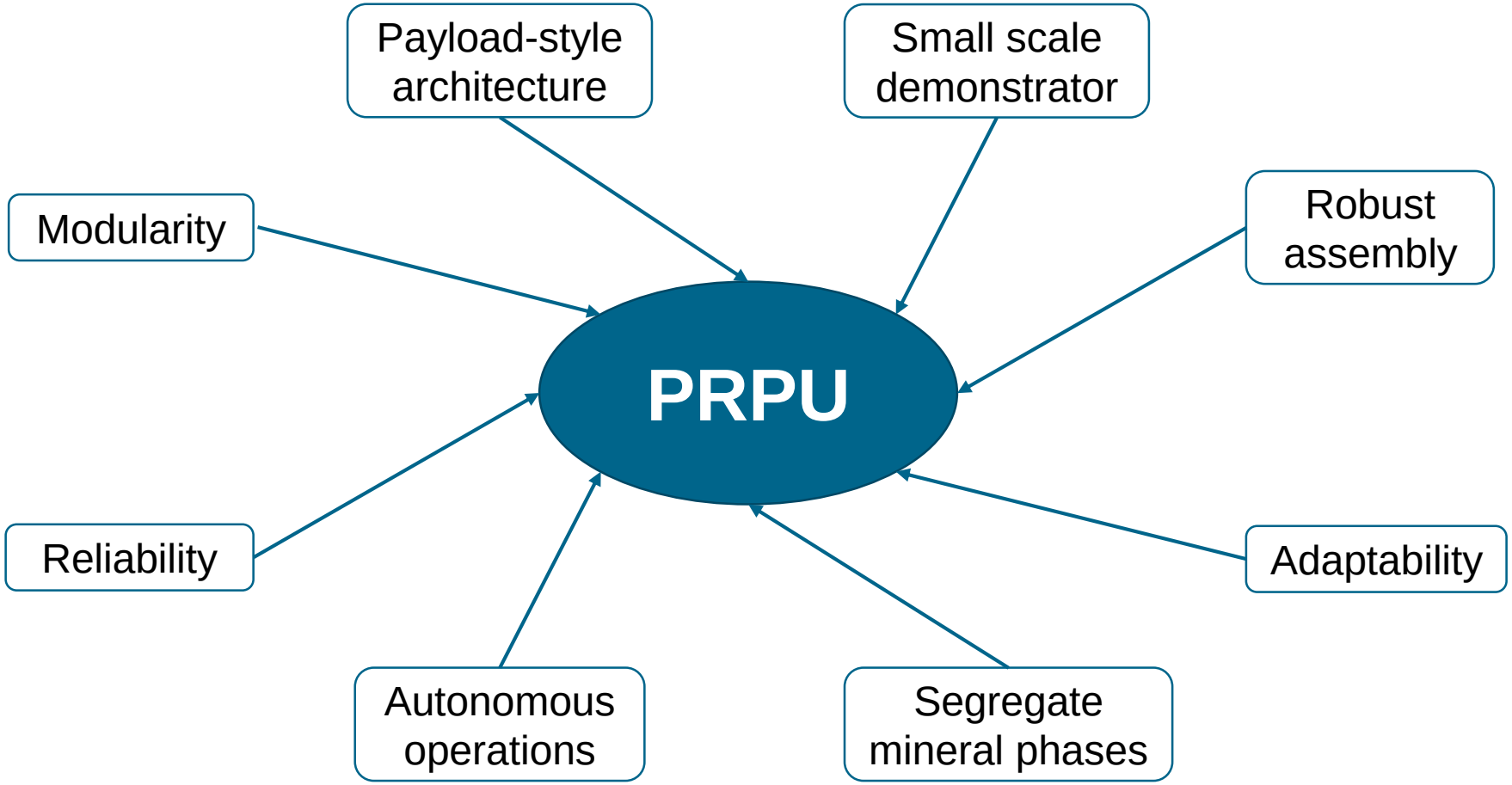
(Kulkarni, et.al. 2024)

Regolith beneficiation and utilization: Planetary Regolith Processing Unit (PRPU)

- The Planetary Regolith Processing Unit (PRPU) is a payload concept for a small scale in-situ demonstration mission
- It shall comprise of beneficiation technologies from the laboratory testbed with additional improvements as concluded from experimental trials
- The ultimate goal is to develop this payload up to a TRL 5/6 fidelity as a precursor for flight opportunities



Regolith beneficiation and utilization: Planetary Regolith Processing Unit (PRPU)



Development timeline

2024
- Research and development of the mineral enrichment stage

2025
- Development of the particle size separation stage
- PRPU assembly integration

2026
- Experimental test campaign

2027-2030
- Further development to higher fidelity
- Integration with other ISRU processes such as excavation and/or extraction systems

In-situ propellants and consumables production

LUWEX

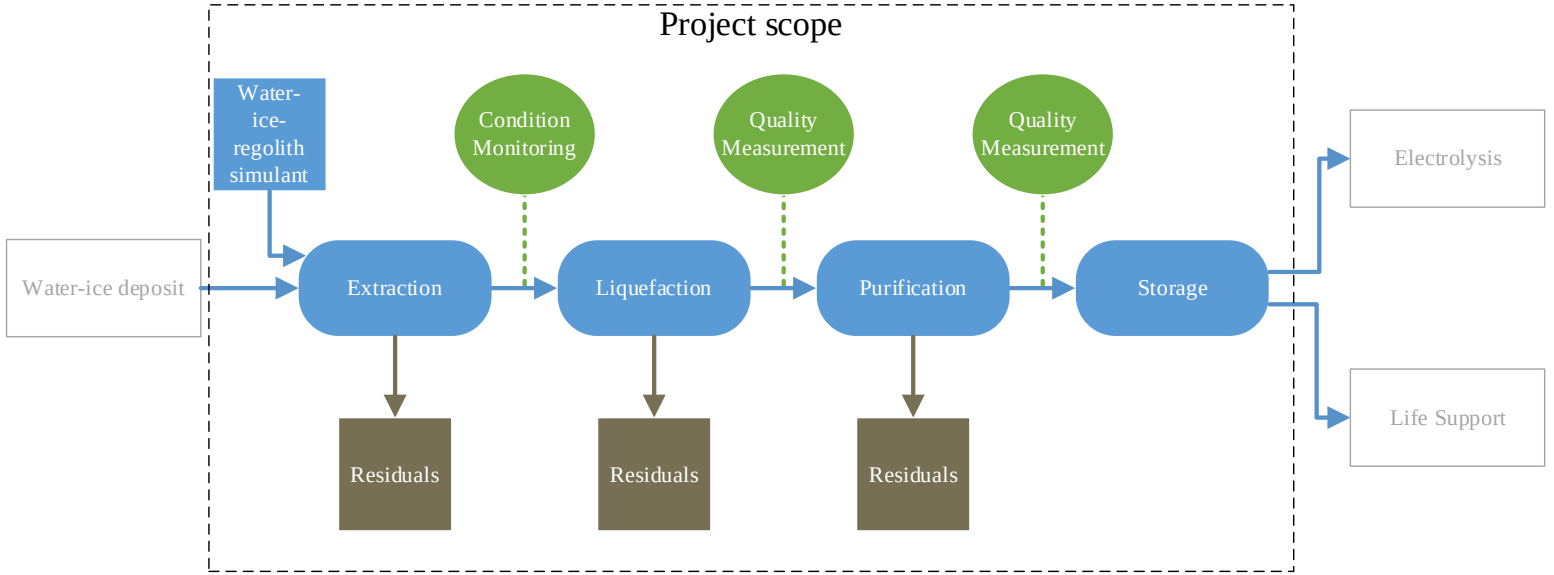
Validation of Lunar Water Extraction and Purification Technologies for In-Situ Propellant and Consumables Production

Duration: Nov. 2022 – Oct. 2024.

EU-funded with 1.5 million €

Objective

The development, integration and validation of lunar water extraction and purification technologies for in-situ propellant and consumables production for future space exploration missions



Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Technische Universität Braunschweig

LIQUIFER SYSTEMS GROUP

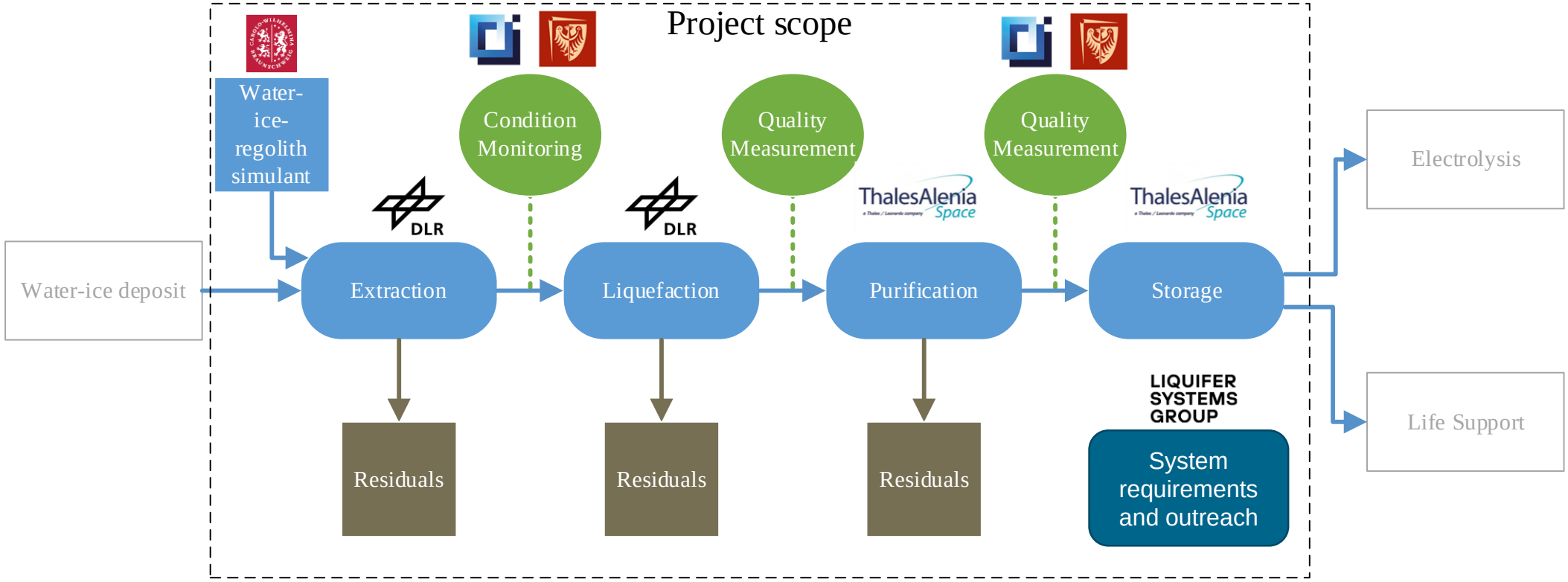
ThalesAlenia Space

Wrocław University of Science and Technology

Scanway imaging space

Funded by the European Union

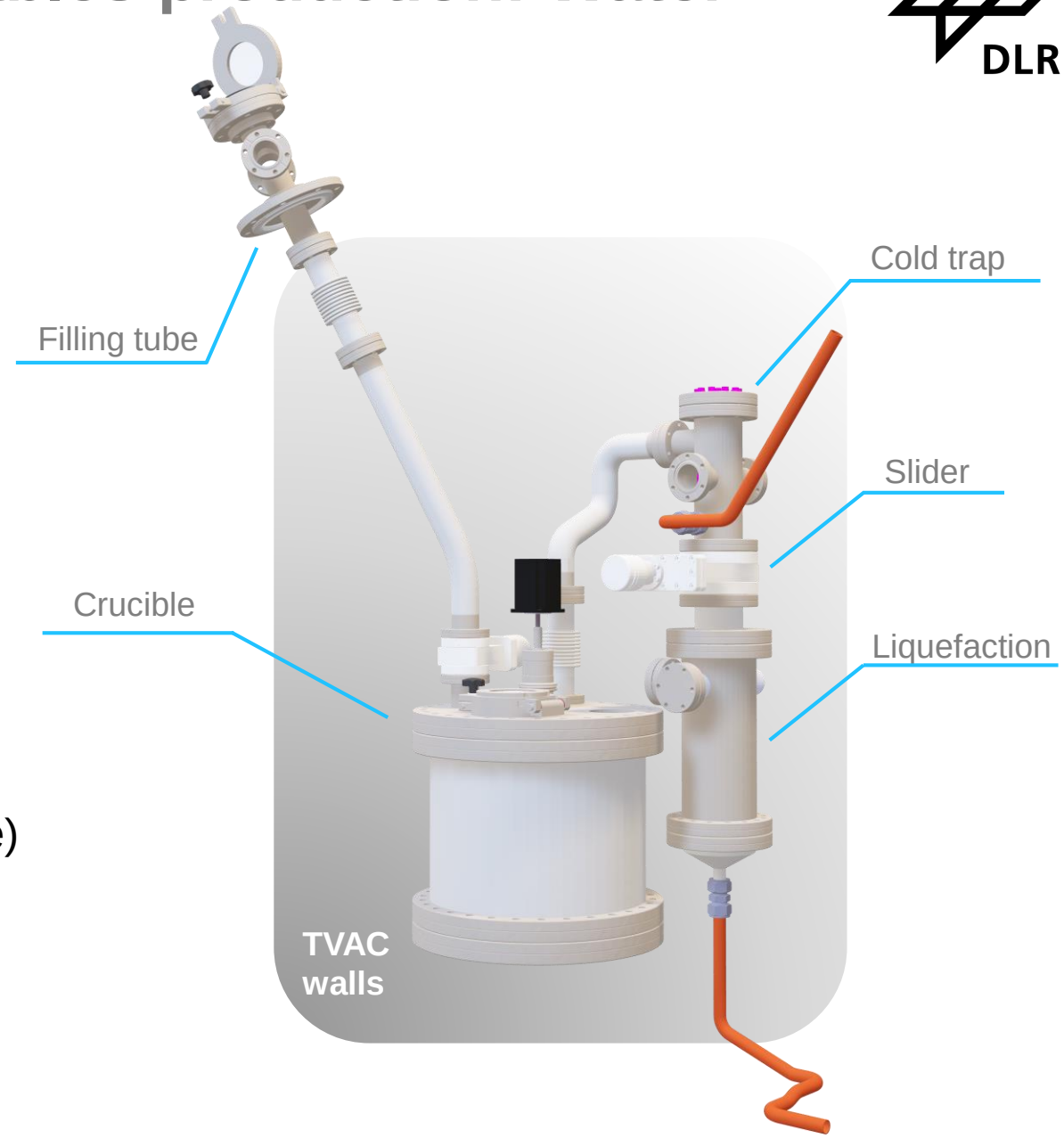
In-situ propellants and consumables production



In-situ propellants and consumables production: Water extraction and capturing

- Design for extraction and water capturing chosen using simulations and trade-offs.

- A water extraction crucible and a cold trap capturing device are placed in a “dusty” TVAC.
  - Temperature ≈ 80 – 100 K.
  - Pressure ≈ 10e-6 mbar.
  - Crucible size = ⌀30 cm x 30 cm.
  - Icy regolith simulant mass up to 15 kg.
  - Amount of water present 5 wt.%, 750 mL (baseline)
  - Presence of volatiles: CO_2 & Methanol



Systems operations: Filling

Icy regolith

Regolith

Water vapor

Water ice

Liquid Water

Heat

Systems operations: Extraction and capturing

Icy regolith

Regolith

Water vapor

Water ice

Liquid Water

Heat

Systems operations: Delamination

Icy regolith

Regolith

Water vapor

Water ice

Liquid Water

Heat

Repeat until liquefaction chamber is full

Systems operations: Liquefaction

Icy regolith

Regolith

Water vapor

Water ice

Liquid Water

Heat

Repeat until storage tank is full

Systems operations: Emptying

Icy regolith

Regolith

Water vapor

Water ice

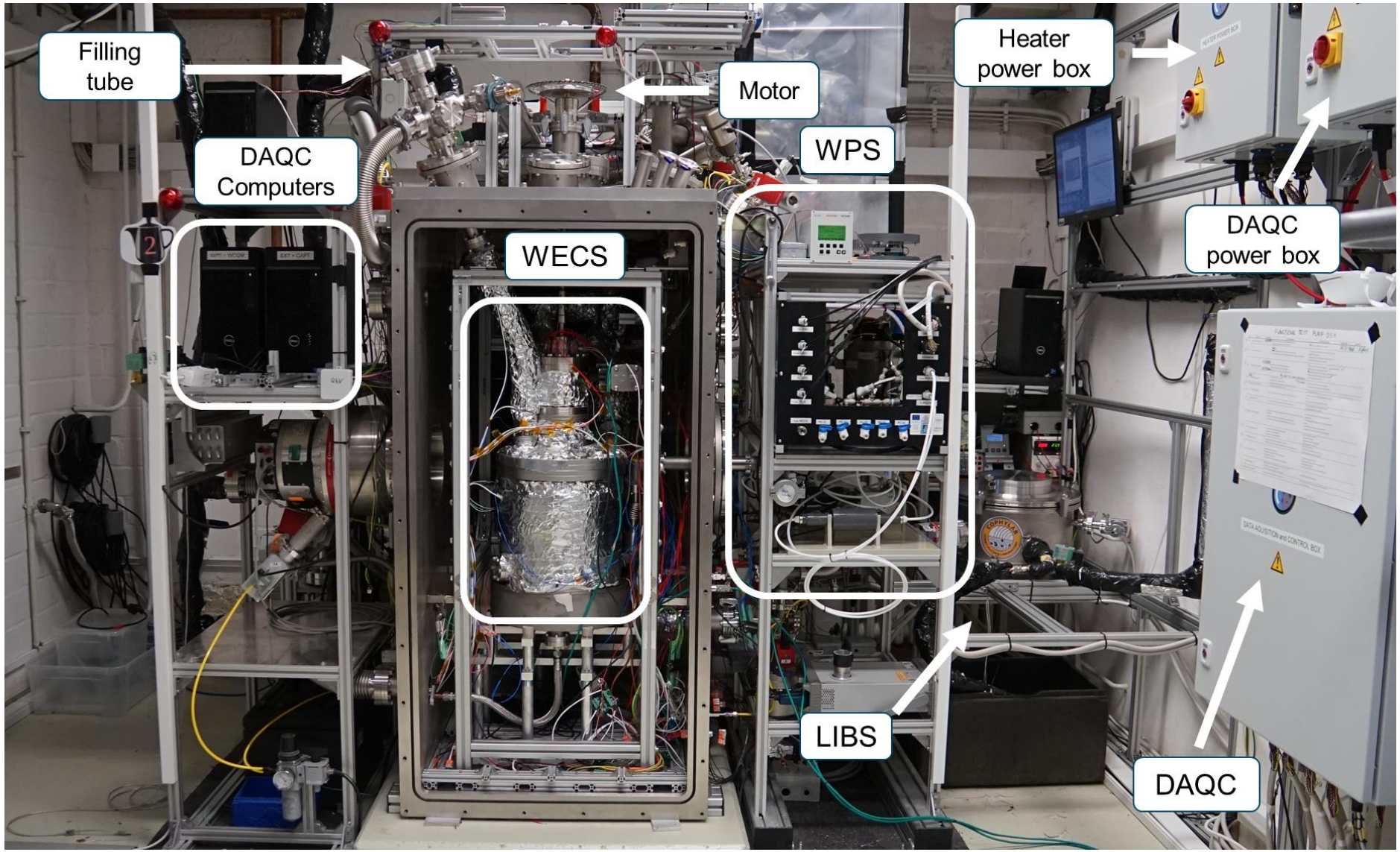
Liquid Water

Heat

For more project info:

SCAN ME

In-situ propellants and consumables production: Current state of research (LUWEX)



In-situ propellants and consumables production: Project timeline

Oct 2024

- Reach TRL 4-5.
- Tech demo concrete design with mass, power and volume

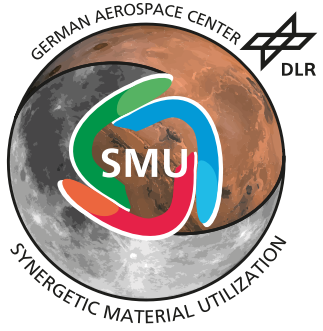
2025 - 2027

- Refined technology demonstrator design to TRL 6-7 and identifying potential flight opportunities.

2028 - 2030

- Payload delivery and launch

Research collaboration



Regolith Beneficiation and Utilization	In-Situ Propellant and Consumables Production
• Oxygen and metals production • In-situ construction • Thermal and/or radiation protection shielding • Excavation of regolith	• Water extraction from icy regolith • H2-O2 production through electrolysis • Excavation of icy regolith

THANK YOU!

Contact: kunal.kulkarni@dlr.de