MAANA ELECTRIC'S TECHNOLOGIES FOR SPACE RESOURCE UTILIZATION

A European Private-Sector Perspective

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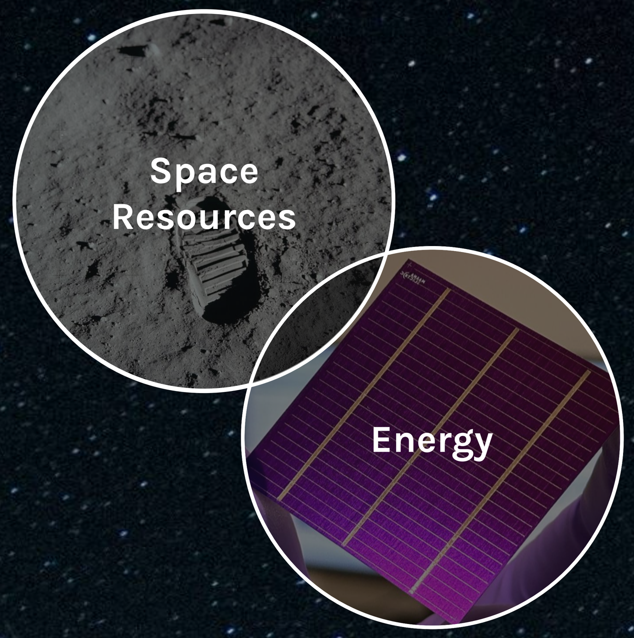
Maana Electric

Maana Electric, founded in Luxembourg in 2018, is a European private firm with the ambition of becoming the utility company of the Solar System.

Maana develops proprietary technologies at the intersection between Power and In-Situ Resource Utilization (ISRU) to accelerate the development of a viable cislunar economy and support future infrastructure across the Earth–Moon system.

We work along key steps of the ISRU value chain, from beneficiation to resource extraction and purification, focusing on (1) silicon extraction for solar energy harvesting during the lunar day, and (2) resource processing for thermal energy generation during the lunar night.



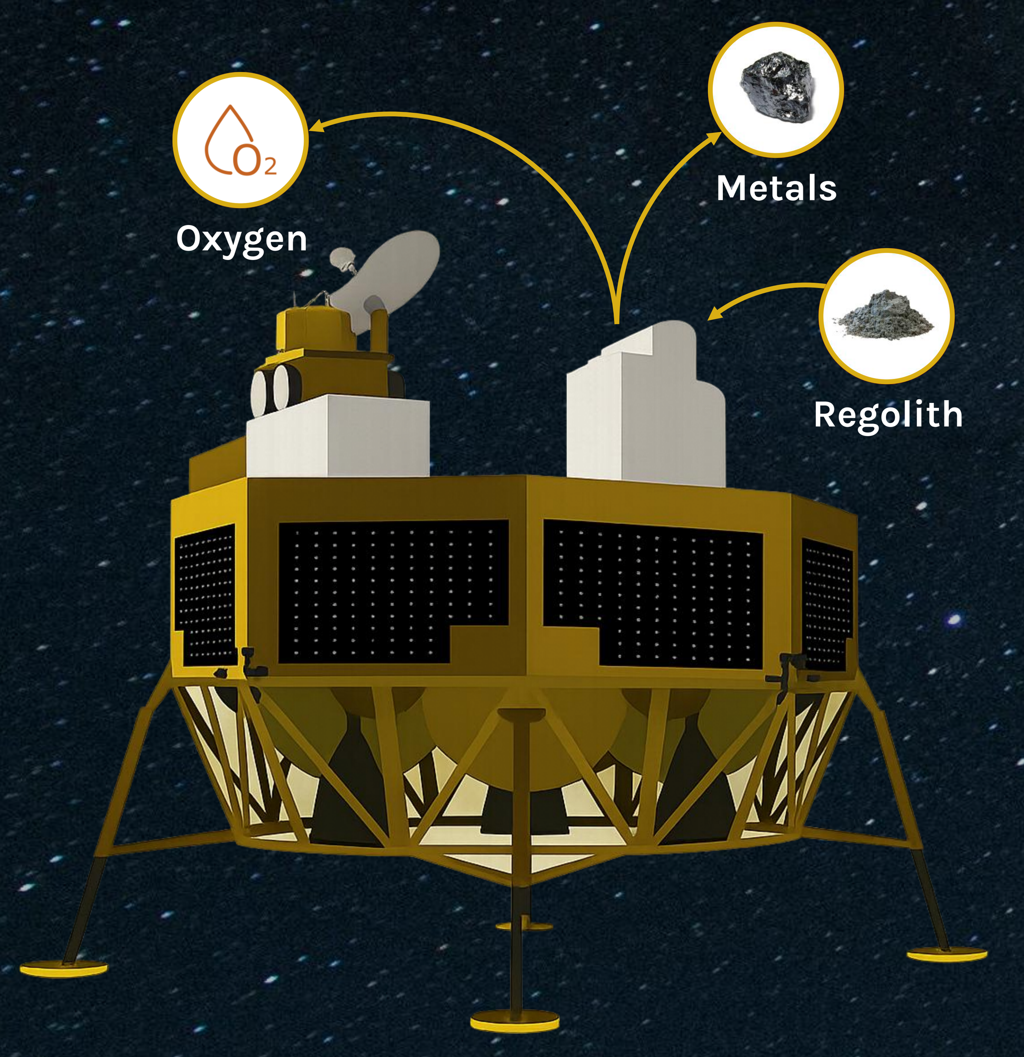
Regolith handling and beneficiation

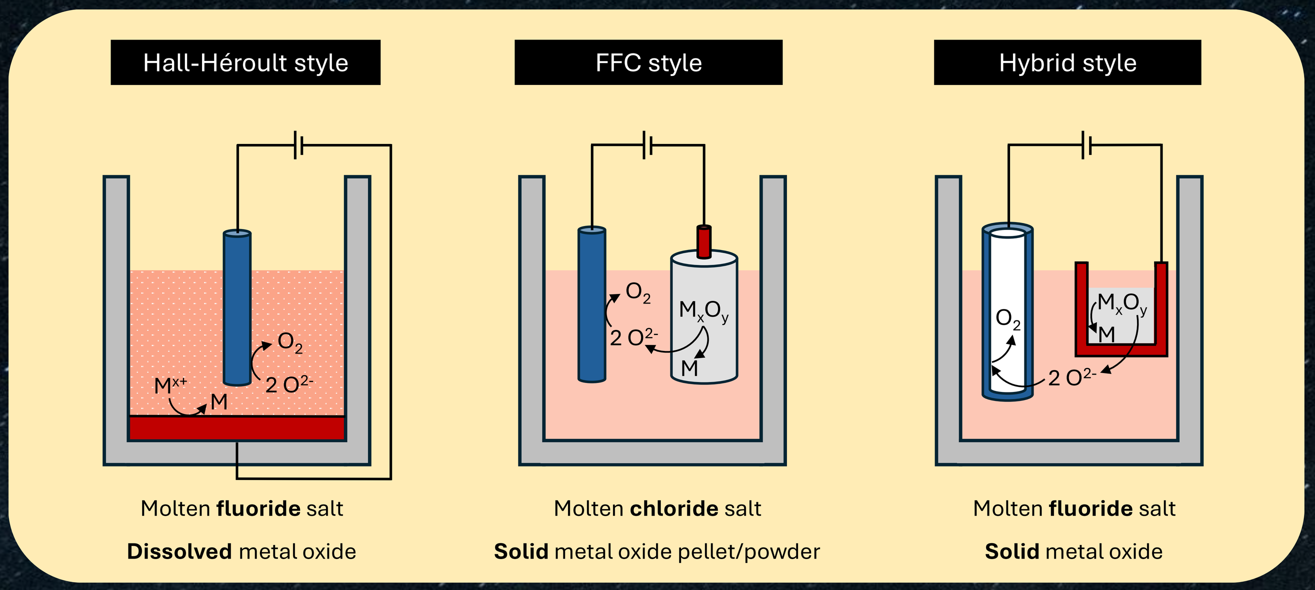
In October 2025, Maana, as part of the LuMA team, participated in the second ESA/ESRIC Space Resources Challenge, which focused on excavation and beneficiation.

Following the challenge, Maana and its Luxembourgish partners have been awarded a development contract to mature particle-size classification technologies. Maana will deliver a robust, adaptable beneficiation system capable of producing controlled regolith-size fractions tailored for various space-resource extraction and in-situ manufacturing processes. The system seeks to improve durability when in contact with abrasive regolith simulants, and to mature ancillary handling elements such as hoppers, feeders, and conveyors. We are exploring the combination of particle-size separation with complementary techniques, such as proprietary magnetic mineral concentration, to supply optimized feedstocks downstream in the ISRU value chain.

Metal and oxygen extraction from regolith

Maana's technological core, since its inception, has been the extraction of metals and oxygen from planetary regolith. Central to this effort has been the development of electrochemical processes capable of operating in molten media. Our current development strategy has prioritized Molten Salt Electrolysis (MSE) due to its low operating temperatures compared to molten regolith electrolysis, MRE, thereby reducing thermal-induced degradation and extending system lifetime [1].





We are developing processes and hardware for **two demonstration missions**.

SOURCE (Silicon and Oxygen from Unprocessed Regolith Electro-Chemical Extraction) is our flagship mission, targeting silicon extraction (alongside other metals and oxygen) from lunar soils. The process leverages principles of the industrial Hall-Héroult process by dissolving regolith in molten fluorides, and is adapted to planetary conditions by selecting low-melting electrolytes compatible with oxygen-evolving anodes and resistant to long-term bath poisoning [2].

ESA's **ISRU-DM breadboarding activities** led by OHB aim at demonstrating the FFC process on the Moon. Maana is responsible for demonstrating the feasibility of the process, including testing durable oxygen-evolving anodes and corrosion-resistant ceramics and metals [3], as well as developing an electrochemical reactor breadboard, which will be integrated and tested up to TRL5 in 2027.

Lunar night survival

Lunar night survival is a critical requirement for the development of any space resource economy on the Moon. Extreme temperature conditions compromise the ability to keep equipment operational and to ensure the continuity of surface activities.

Maana is developing a thermal solution based on **metallothermic reactions** using lunar regolith to produce heat during the lunar night. These reactions ($M_a + M_bO \rightarrow M_aO + M_b$ + Energy) are solid-state combustions, in which oxygen is transferred between two metals (M_a and M_b). The exothermic reaction occurs with the release of heat in proportion (in the ideal and adiabatic case) to the difference between the formation enthalpy of the two oxides (M_aO and M_bO).

The technology uses local regolith resources in their mineralogical form and ISRU-based metals extracted via molten salt electrolysis. Additionally, it refines metals from the reactants, which may be used for in-situ manufacturing.

The initial technology development successfully reached TRL 4 for the combustion chamber [4], demonstrating proof-of-concept for the metallothermic reaction process and the basic system configuration. The current phase is increasing the technology's maturity by building an integrated system demonstrator capable of performing the whole technological chain from sample preparation to heat acquisition and product removal. The system is based on a scalable architecture capable of delivering up to 250 kWh of thermal energy, sufficient to sustain a small lunar shelter through the night.

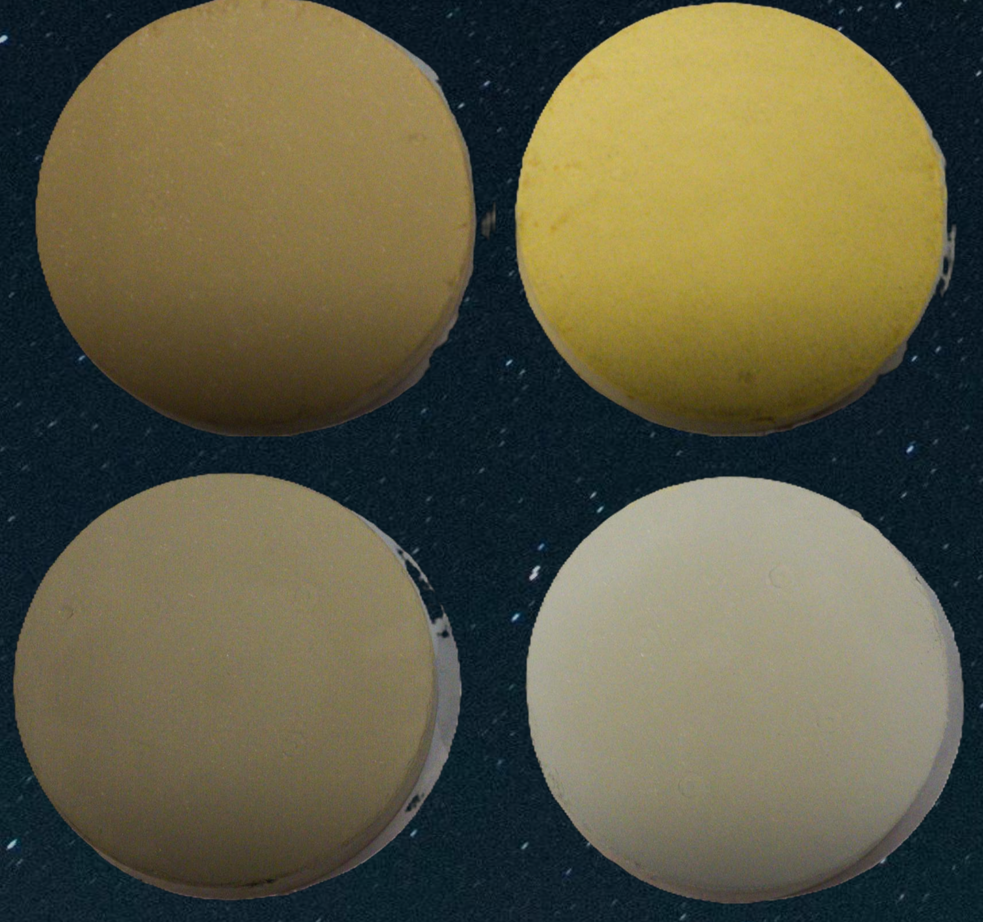
Propagation of an Aluminum/LMS-1 thermite mixture [4]

Cross-cutting technologies

Several ISRU and night survival systems operate at high temperatures, where minimizing thermal losses is essential for energy efficiency. To support these needs, Maana is developing **lightweight, high-temperature insulation** materials, characterized and tested for lunar and Martian conditions.

The development of modular Micro-ElectroMechanical System **(MEMS)-based gas compressors**, designed to provide a compact, low-mass, and low-power alternative to conventional pumping systems to meet mission-specific needs is also key for ISRU oxygen processing.

In parallel, we are advancing dust-mitigation technologies, as abrasive, electrostatically charged regolith can significantly degrade system performance. Our developments include **high-power electrical connectors** tolerant of severe dust exposure, as well as ongoing work on **Electrodynamic Dust Shield (EDS) solutions** and **optical scratch-resistant coatings** to protect critical components.



SiO_2-based microporous insulation before (left)and after (right) thermal cycling (100 cycles) from room temperature to 850 °C

Environmental testing

Maana is contributing to the development of the Dusty Thermal Vacuum Chamber (DTVC), to be hosted at ESRIC in Luxembourg, offering high-vacuum operation, temperature ranges from -180 °C to +160 °C, controlled dust deposition, and payload volumes up to 2.3 × 1.5 × 1.45 m (L × W × H).

In parallel, Maana is building additional in-house environmental testing infrastructure, including dusty vacuum chambers with internal dimensions of 1.35 × 0.85 × 1.15 m (L × W × H) to support subsystem-level development and rapid prototyping. We have developed controlled regolith deposition methodologies to reproduce relevant dust-exposure conditions and to qualify dust-driven degradation under representative conditions.

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References: *[1] Guerrero-Gonzalez F.J. et al. (2026) J. Electrochem. Soc., 173(7), 072502. [2] Guerrero-Gonzalez F.J. et al. (2025) ICES-2025-441. [3] Guerrero-Gonzalez F.J. et al. (2026) Space Resources Week. [4] Lovagnini A. et al. (2024) IAC-24-IPB, 14, x85363.*