MAANA ELECTRIC

# ESA STUDY REPORT - ESR

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| CCN2 to ESA CONTRACT No. 4000125323/18/NL/MH/mg | Company: Maana Electric SA |

SUBJECT: 1MW TerraBox Phase3 Executive Summary

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ABSTRACT: n/a



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# Executive Summary

Maana Electric (herein referred to as Maana) is a Luxembourgish company operating in the space and energy sectors, aiming to provide sustainable energy solutions on Earth whilst enabling the development of a space and lunar economy.

In the last years Maana developed a proprietary ISRU system to produce fully functional solar panels using only sand (or regolith) and power from the Sun through fully automated production facilities called MaanaBoxes. The MaanaBoxes can be separated into two product lines: the TerraBox, developed for the terrestrial market, and the LunaBox, developed for a potential lunar mission to support a future Moon base. Both products are designed to carry out the same process internally – with some modifications due to the different working environments – to produce solar panels.

In anticipation of the electricity production and distribution needs that will arise from the creation of long duration lunar settlements, Maana Electric proposed to ESA to start the development of a lunar plug and socket (P/S) type connector. This P/S will distribute electrical energy to different loads for lunar surface operations, from a lunar solar power generator. Even if National Agencies had several missions to the Moon, no dedicated technical solutions have been currently developed and tested yet in lunar environment. The challenge lies on achieving long-term reliability, despite the harsh environmental conditions when operating, and easiness when being used both by astronauts and robots.

This activity aimed to develop a first concept of plug and socket that can withstand the harsh operational conditions that are posed by the lunar environment (vacuum, radiations, high thermal gradients) and by the contamination of very fine and abrasive regolith without affecting the long-term product performance.

Under this OSIP contract, Maana Electric investigated on the technical solutions that could be implemented into the lunar plug and socket system, such as a list of specific materials and dust mitigation strategies. Commercial off-the-shelf connectors, designed for high performances under challenging environments have been also used as a reference. The selection of the elements that best fitted for lunar application have been carried out by performing appropriate trade-off studies. In order to validate the results of the trade-offs, a Proof of Concept testing campaign was carried out and the outcome was used to design a plug and socket system that could sustain 150V at 50A, which is compatible with the expected user scenario with photovoltaic arrays providing power to first permanent lunar habitats.

The activity, started on 31st March 2021, and it ended on 14 November 2022, was structured as follows:

- Literature review and trade-offs.
- Proof of Concept.
- P/S breadboard design, procurement, manufacturing and assembly.
- P/S breadboard testing.

Milestones were determined as part of the project, namely:

- Preliminary Design Review (PDR).
- Detailed Design Review (DDR).
- Test Readiness Review (MRR).
- Final Review (FR).

Initially the project progressed almost in line with the schedule, with small delays experienced during the final testing campaign, at the end of which the R2D2 plug and socket concept was qualified for Technology Readiness Level 4 (as targeted at the beginning of the activity). Given this level of maturity, the R2D2 plug and socket is not ready yet to be sent on the Moon and further developments are foreseen to make sure that the maturity of the product is sufficient for being tested in an environment that has been proved to be very challenging. Therefore several aspects have been identified as potential improvement:

- Design optimization of regolith mitigation solutions.
- Design optimization of mating mechanism and implementation of improved ergonomic solutions for astronaut handling.
- General optimization of masses and volumes of the lunar P/S.
- Identification of "smart" features to incorporate into the design to improve interaction with users.
- Testing of materials in simulated operational environment (vacuum, thermal cycles, radiation, etc.).
- Definition of a family of products derived from the baseline design to serve a range of operational conditions.

In particular, for the next stages of the development, Maana Electric would like also to initiate a larger discussion at institutional level for the definition of standards for the future lunar power infrastructure. With a more mature product and the involvement of relevant stakeholders and potential users a larger discussion at institutional level for the definition of standards can be initiated and technical advancement can also benefit from this discussion.