

CISLUNAR INDUSTRIES SPACE FOUNDRY LAB MODULE: A COMMERCIAL MICROGRAVITY METALLURGICAL RESEARCH SERVICE AND PRODUCTION FACILITY

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Introduction: At the Space Resources Roundtable in June 2018, CisLunar Industries introduced its concept for a Space Foundry system to enable the processing of metal in space, using recycled space debris as the first raw material. In the long run, the company remains dedicated to this vision. Over the last year, the team engaged with space industry contacts, partners, investors, advisors, and potential customers around the world. Two significant challenges emerged that face many commercial space concepts: a) dependency upon unproven technology outside the company's control; and b) the long timeframe before generating space-derived revenues and self-sustaining profits. To address these challenges, in the near-term CisLunar Industries is focusing on a technical and commercial proof of concept called the Space Foundry Lab Module (SFLM) which will lay the foundation for the rest of the company's vision.

Remove Dependencies and Accelerate Revenue:

To address these two challenges the team considered what it would take to deploy an asset in space that can also generate revenues within 3 years. To achieve this objective the company decided to refine the near-term scope of its concept to the core essentials: an electromagnetic levitation furnace with an integrated extrusion technology configured for microgravity. The company looked at options for deployment including a free-flying small satellite and hosting on the International Space Station (ISS). The power requirements and complexity of a fully autonomous spacecraft make the free-flying satellite unattractive. On the ISS, hosting options like the upcoming Airbus Bartolomeo platform provide a readily-available, lower cost and lower risk opportunity as a first step with the chance of reusability, resupply, and sample return.

Use the In-Space Demo to Generate Revenue:

Because ISS hosting offers long-duration, resupply, and ample power it also creates the opportunity to configure the company's in-space demonstration as a potential source of revenue. Electromagnetic levitators have a long heritage in microgravity research going back to the 1980s [1]. The Electromagnetic Levitator (EML) facility currently on the International Space Station (ISS) has been providing valuable results since 2015 but was designed for a 5-year lifespan [1]. By the time the Space Foundry Lab Module is deployed the EML will likely be retired but the need for its unique metallurgical research capabilities will remain. This presents an opportunity for CisLunar Industries to fill this need by

offering commercial access to the SFLM as a microgravity metallurgical research service for companies, research institutions, and governments. In addition, the SFLM will be configured to produce novel metal-based products, using both the EML furnace and the integrated extrusion technology.

The Space Foundry Lab Module (SFLM): This facility will be a scaled down version of our core technology. It will consist of (a) an electromagnetic levitation induction furnace, (b) an extrusion system and (c) automated sample handling and storage systems. The SFLM will be installed on an external platform on the ISS such as the Airbus Bartolomeo platform shown here:

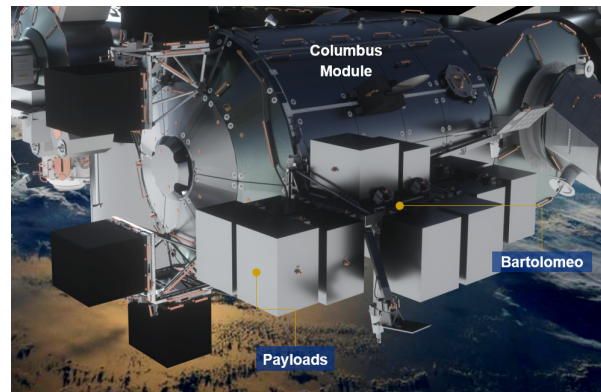


Figure 1: Bartolomeo Platform
Image credit: Airbus Defense & Space

Functions. The SFLM will provide the following 3 functions: (a) Metallurgical research: the SFLM will meet the needs of industrial researchers for the melting and solidification of metallic alloy samples under the vacuum conditions of space. (b) Production capabilities: the SFLM will be able to manufacture high-value industrial materials and luxury products for consumers to a specified form-factor. (c) Demonstration of CisLunar Industries' core technology: the integrated EML furnace and extrusion technology will be demonstrated within a microgravity environment, de-risking the technology for the company's next phase of development.

Metallurgical Research Process. The customer will contact us and reserve a position for their metal sample to be launched to our payload. The next batch of metallic alloy samples supplied by the customers will be sent to the ISS periodically along with resupply

missions. The sample cartridges from the resupply mission will be robotically installed into the SFLM. During each allocated ISS time slot, a sample will be heated beyond melting and cooled according to the protocol established by the customer. Customers will have the opportunity for multiple processing cycles with varying protocols as their research requires and in response to observed results. If the customer specifies for the metal to be extruded into a specific form-factor after study, the molten sample will then be transferred to the SFLM extrusion module.

Manufacture of Simple Products: Several form factors are being considered, including the production of (a) extruded 3D-printer wire for on-orbit manufacturing, (b) extruded scaled-down truss member for demonstration, (c) bulk metallic glasses, and more to be dictated by an on-going market survey. These capabilities will lay the foundation for scaling up the Space Foundry to be the anchor for an independent in-space manufacturing platform ultimately enabling in-situ resource utilization.

Long-term Vision: While the Space Foundry Lab Module is intended to be a self-sustaining commercial business, it is also only the first step in the company's long-term vision. The SFLM will be the proof-of-concept that enables the next stage of development: an independent, remotely-operated platform for in-space manufacturing and assembly. A full-scale Space Foundry will anchor the facility providing metal input materials and components to complementary payloads co-located to create a full in-space manufacturing value-chain.

Conclusion: Startup space companies working to make the future of space resources a reality often face the common challenges of interdependency on other parts of the value chain and long time horizons to economic sustainability. If successful, the Space Foundry Lab Module will serve as a profitable bridge for CisLunar Industries' long-range vision of enabling the utilization of space-based metal resources to support the industrialization of cislunar space.

References:

[1] Seidel A. and Stenzel C. (2011), EML - an electromagnetic levitator for the International Space Station, *Journal of Physics, Conference Series* 327.



Figure 2: CisLunar Industries Commercial Platform Concept, credit: Bryan Versteeg