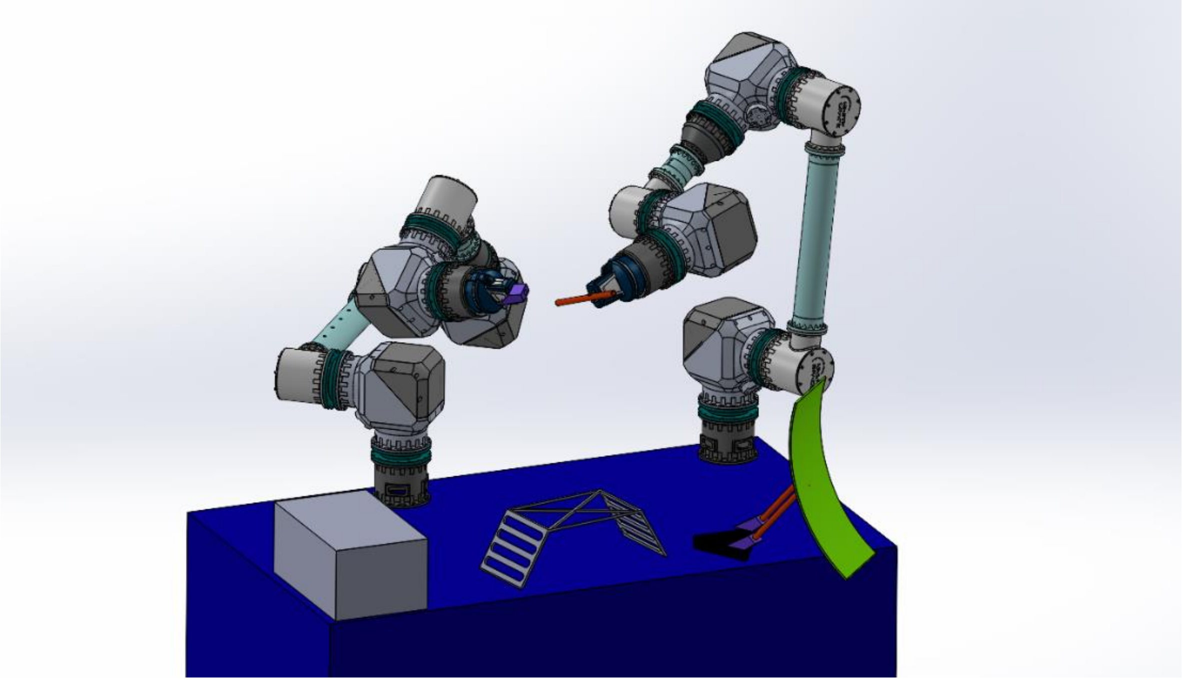
→ PREPARATION



ROBOFAB
Robotic Fabrication for Space Applications

Executive Summary
Pre-phase A system study

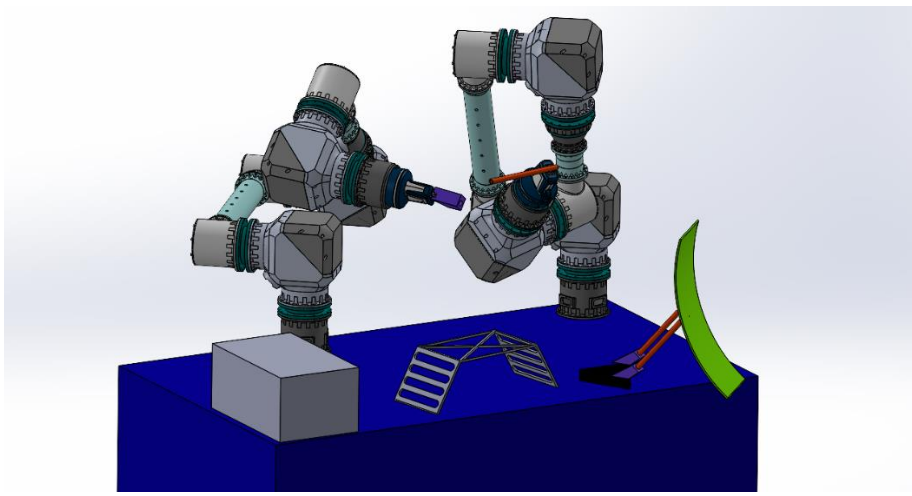
System Studies for Circular Economy in Space

Affiliation(s): Kinetik Space GmbH

Activity summary:
ROBOFAB was proposed as a mission study for redefining how large and complex structures are manufactured and assembled in orbit. Traditional methods rely on launching pre-fabricated components, which require costly, complex, and failure-prone folding mechanisms to fit within rocket fairings. ROBOFAB eliminates this constraint by enabling direct in-space fabrication. The ROBOFAB mission study analyzed the on-demand fabrication of large-scale structures in space by utilizing advanced torque-controlled robotic arms, carbon tube manufacturing using flat sections of carbon fiber polymer, and 3D printing using Fused Deposition Modeling (FDM). To enhance operational efficiency, the mission employs autonomous robotic systems, capable of executing intricate fabrication tasks with minimal human intervention.

Publishing Date: 15.02.2025
Contract Number: RCP/5-50075/24/NL/GLC/ov
Implemented as ESA Initial Support for Innovation

ROBOFAB: Robotic Fabrication for Space Applications



EXECUTIVE SUMMARY

In-Space Assembly and Manufacturing (ISAM) is a revolutionary approach to building and maintaining space infrastructure. By constructing and fabricating components directly in orbit or beyond, ISAM reduces the reliance on Earth-based manufacturing and launch constraints, as well as complicated mechanisms, offering numerous advantages for space exploration, commercial applications, and sustainability. ROBOFAB was proposed as a mission study for redefining how large and complex structures are manufactured and assembled in orbit. Traditional methods rely on launching pre-fabricated components, which require costly, complex, and failure-prone folding mechanisms to fit within rocket fairings. ROBOFAB eliminates this constraint by enabling **direct in-space fabrication**, streamlining the assembly process, and expanding the architectural possibilities for large-scale structures.

The ROBOFAB mission study analyzed the on-demand fabrication of large-scale structures in space by utilizing advanced robotic arms, carbon tube manufacturing, and 3D printing. Unlike previous space robotic systems, ROBOFAB's robotic arms incorporate torque control technology, offering superior sensitivity and adaptability for assembly and manufacturing tasks in microgravity. This approach enables precise manipulation of materials and the autonomous assembly of complex structures. The mission also introduces an innovative carbon tube manufacturing process, which forms cylindrical tubes from pre-cured flat sections of carbon fiber polymer. This technique significantly reduces launch mass while providing durable structural components essential for space infrastructure. Additionally, ROBOFAB integrates advanced 3D printing systems optimized for microgravity, allowing the fabrication of intermediate components directly in space with minimal material waste. These printers leverage proven technologies like Fused Deposition Modeling (FDM), which has been successfully tested aboard the ISS. To enhance operational efficiency, the mission employs autonomous robotic systems, capable of executing intricate fabrication tasks with minimal human intervention. By integrating shared autonomy, ROBOFAB maximizes automation for routine tasks while allowing operators to address complex challenges when necessary.

As a technological in orbit demonstration (IOD), ROBOFAB proposes a satellite endowed with a pair of robotic arms to assemble an antenna bracket. Kinetik proposes a mission where a strut is manufactured from two raw materials (carbon fiber and photopolymer resin) in space, assembled using robotic arms, and then used as a support structure for a bracket/structural member for components such as reflector antennas, solar panels, telescopes, SAR arrays.

Multiple concepts have arisen in recent years leveraging in orbit manufacturing and assembly, including for instance SOLARIS for space-based solar power, ASCEND for creating a space-based data center, PERIOD for assembly of satellites directly in space, and PULSAR for orbital assembly of a large space telescope. All these applications represent potential uses cases for ROBOFAB. Thus, ROBOFAB plays a key role in validating the technological feasibility of essential components for these missions under real space conditions, such as 3D printing, truss structure fabrication, and autonomous assembly of complex structures using a dual arm robotic system.

This mission represents a significant leap in in-space manufacturing, reducing dependency on Earth-launched components and paving the way for sustainable space infrastructure. Next stages of the study will focus on enhancing TRL for the critical elements of the mission.