Anticipated Benefits

The capability to produce hardware on-demand will directly lower cost and decrease risk by having the exact part or tool needed in the time it takes to print. ISM is the first step towards realizing a manufacturing facility in space that is a critical enabling component of any deep space exploration mission.

Furthermore, the availability of on-demand manufacturing of electronic devices is a critical element for NASA's future in-space and planetary expeditions. Electronic devices such as sensors, communication infrastructure (cabling), printed energy storage devices, and power generation elements will all need to be manufactured on demand in an orbital or extraterrestrial habitat environment to replace failed components or manufacture new systems on long duration, earth independent missions.

Future work in outfitting and autonomous setup prior to arrival will benefit long duration missions. The ability to enable the fabrication of most infrastructure will be key to a sustainable human presence on other worlds.

The NASA ISM project utilizes mechanisms such as Cooperative Agreement Notices (CANs), and Small Business Innovation Research (SBIR) awards to work closely with industry to leverage rapid technology advances. This results in stimulating the terrestrial economy in this area, while utilizing limited NASA resources to focus on adapting these technologies for application in the environments present in space.

Summary

In-Space Manufacturing (ISM), managed out of the Marshall Space Flight Center, is working to provide capabilities for on-demand sustainable manufacturing of mechanical and electrical components during NASA Exploration Missions (transit and on-surface). ISM continues to pursue the development and evaluation of new technologies that will be applied in space for years to come.

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National Aeronautics and
Space Administration

ISM In-Space Manufacturing

Objective: Develop the technologies and processes that will enable on-demand and large scale manufacturing capabilities during long-duration space missions.

For long-duration space travel to be feasible, it is crucial for damaged or worn parts to be replaced in a cost-effective and timely manner. In-Space Manufacturing (ISM) seeks to develop technologies for these missions. ISM can provide on-demand fabrication, repair, and recycling for critical systems, habitats, and mission logistics and maintenance. ISM is developing these capabilities by using new technologies and modifying them for use in the space environment.

The International Space Station (ISS) serves as a one-of-a-kind test bed on the ISM technology development roadmap. The current ISS logistics model is heavily dependent upon Orbital Replacement Units (ORUs) for system-based (vs. component level) repair and maintenance. ISM provides an approach which will help to enable sustainable, affordable mission operations and logistics. Additionally, ISM is key to addressing significant logistic challenges for long-duration missions by reducing launch and spares mass, providing flexible risk coverage, and enabling new capabilities that are required for sustainable Exploration missions.

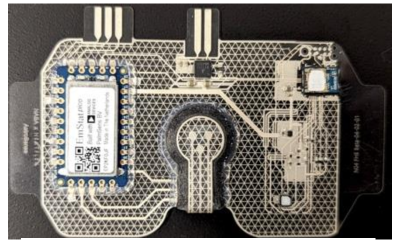
ISM Early Stages

ISM began with the 3D Printing in Zero-G Technology Demonstration, which was the first time that additive manufacturing was performed on the International Space Station (ISS) and was performed under a Small Business Innovative Research (SBIR) contract with Made In Space, Inc. (MIS), now Redwire Space, Inc. The samples were fabricated using Fused Deposition Modeling (FDM) of polymers and were returned to NASA's MSFC where they underwent extensive testing, along with the ground-printed controls, to assess if there were any differences in the parts produced in microgravity from those manufactured on earth. Results indicated that there is no significant impact of microgravity on the fused deposition modeling process. Additional testing further validated these findings.

Commander Butch Wilmore holds 3D printed container on ISS. Image from NASA.

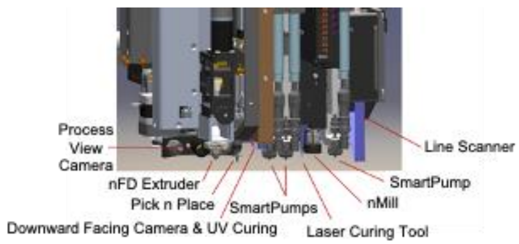
ODME *(GCD Funded through FY24)*

ODME is developing on-demand manufacturing of a wide range of electronics, sensors, and power & energy devices for manufacturing in microgravity on the ISS and on the lunar surface to support Artemis surface construction and exploration activities. The project is developing the next generation of deposition systems for printing precise patterns of electronics in microgravity and extreme environments. ODME is also developing materials and sensors to support self-powered sensor networks and replacement electronics for Logistics Reduction.



Wearable Health Monitoring Patch. Image from NextFlex.

The advanced toolplate in the ODME Printer Module is capable of the very fine printing of circuit boards and other electronic components. ISM is currently seeking opportunities to fly the Printer Module for an in-space technology demonstration.



Printer Module Advanced Toolplate. Image from Sciperio.

ODME is also leading the NASA Commercialization initiative for manufacturing semiconductors in Low Earth Orbit (LEO). ODME is developing next-generation materials, processes, and device designs to take maximum advantage of microgravity for semiconductor manufacturing to offer significant competitive advantages over terrestrial semiconductor manufacturing. The enabling of these new semiconductor technologies by ODME will also advance NASA's capability to manufacture next-generation electronics in space for exploration missions and lunar applications.

ODMM *(GCD Funded through FY23)*

The ODMM project is pursuing the development of a multi-material Fabrication Laboratory from Techshot, Inc., a subsidiary of Redwire, Inc. This payload has the potential to expand the material processing capability to multiple metals as well as polymers and electronics, with the vision of providing an adaptable capability for future missions. This adaptable capability enables long duration missions through substantial risk reduction based on the ability to fabricate parts for unforeseeable needs.

Although the ODMM project is closing at the end of FY23, it is anticipated that technologies developed will be utilized on future endeavors.

In-Space Welding *(Center & SBIR Funded)*

In addition to GCD funded activities, MSFC has pursued the development of in-space welding for both lunar surface and microgravity applications. Current work includes development of novel processes, digital twins, computational materials modeling, and parabolic/suborbital testing. ISM aims to strengthen in space welding efforts moving forward. As these efforts grow, complementary technologies including cutting, surface ablation, forming, additive manufacturing, and recycling will be pursued.