



The BioFabrication Facility is stationed on the International Space Station to 3-D print human tissue in space

3-D Bioprinter Overcomes Gravity by Printing Living Tissues in Space

Challenge

As an enabler of innovative commercial research and technologies to improve life on Earth and beyond, NASA seeks to facilitate use of the International Space Station (ISS) to find creative solutions to unique challenges. Within the agency's Human Exploration and Operations Mission Directorate, NASA is interested in advancing biotechnology, including bioprinting—the use of techniques to 3-D print with cells to fabricate organic products. While bioprinting can be performed on Earth, the effects of gravity cause soft 3-D printed tissues, such as blood vessels and muscle, to sag and disform under their own weight if not stabilized with non-organic materials, which can be toxic to the human tissue. One approach to overcome these limitations is to bioprint in zero gravity space.

Solution

In July 2019, Techshot, Inc., a small business from Greenville, Indiana, launched its BioFabrication Facility (BFF) to the ISS on a SpaceX Dragon. Developed in collaboration with nScript, Inc., BFF is the first U.S. 3-D printing system capable of manufacturing human tissue in the microgravity of space, using bioinks—which have proteins, nutrients, and other growth factors blended with adult human cells—to construct living material that can be conditioned to grow.

Project

BioFabrication Facility (BFF) to 3-D print with living cells in zero gravity

Mission Directorate

Human Exploration and Operations

Post-Phase II and Follow-on Success

More than \$5 million external investment attributed to BFF, including \$2.5 million from ISS Program

Snapshot

Techshot, Inc., based in Greenville, IN, is the first U.S. company to 3-D print organic products on the International Space Station (ISS). The company's BioFabrication Facility (BFF), developed in collaboration with nScript, Inc., prints in space to overcome the effects of gravity on Earth, which cause 3-D printed tissues to disform under their own weight. Techshot's BFF was launched to the ISS supported by the NASA SBIR/STTR program in 2019. The company has since worked with NASA and other customers, valuing BFF's external investments at more than \$5 million, including \$2.5 million from the ISS Program.

Techshot, Inc

7200 Hwy. 150
Greenville, IN 47124

techshot.space

Techshot's BFF has ties to both the United States Army Medical Research and Materiel Command (USAMRMC) SBIR/STTR program and the NASA SBIR/STTR program. The company received its first NASA SBIR award in the 1990s for research related to avian egg incubation in microgravity conditions. Since then, Techshot has received 100+ SBIR and STTR awards from agencies including NASA, the Department of Health and Human Services, and several branches within the Department of Defense. With NASA's Johnson Space Center and Marshall Space Flight Center, Techshot expanded its portfolio in 2016 through a NASA Phase I SBIR award to mature additive manufacturing capabilities in space. Techshot's Sintered Inductive Metal Printer with Laser Exposure (SIMPLE) unit was further developed with Phase II and II-E funding from the NASA SBIR/STTR program and the NASA In-Space Manufacturing Project. In 2021, NASA awarded an SBIR Phase III to Techshot to continue development of SIMPLE under the name FabLab, with a demonstration on the ISS scheduled for 2024.



BFF was developed by Techshot, Inc. and sent to the ISS supported by funding from the NASA SBIR/STTR program

While SIMPLE demonstrated Techshot's capability to 3-D print with metal in space, the USAMRMC supported Techshot's endeavor to improve medical treatment options in austere locations. Techshot received SBIR awards through the USAMRMC in 2014 and 2016 to use the technology on Earth to improve vascular grafts for soldiers. Following success with these advanced artificial grafts, Techshot sought to combine them with bioprinted tissue, which would develop more successfully in zero gravity. In 2017, the Center for the Advancement of Science in Space, managers of the ISS U.S. National Laboratory, committed \$695,000 to prepurchase BFF services and data. In 2018, BFF crossed SBIR/STTR programs when Techshot received \$1.5 million from the [NASA SBIR/STTR Civilian Commercialization Readiness Pilot Program \(CCRPP\)](#), in addition to \$2.5 million from the ISS Program, which also included a prepurchase of BFF services and data. BFF launched to station in 2019, where federal, institutional, and commercial customers can contract with Techshot to use it.

On the ISS, BFF operates in conjunction with Techshot's Advanced Space Experiment Processor (ADSEP), which also resides on the ISS as a result of CCRPP funding through the NASA SBIR/STTR program. ADSEP and BFF complement each other to create living products: first, BFF prints an organic construct inside a "cassette" using sets of cells. The construct is then placed inside ADSEP to grow and ensure survival. Since July 2019, Techshot has successfully completed knee meniscus test prints and has printed with a large volume of human heart cells on the ISS. In summer 2022, Techshot will manufacture meniscus tissue with human cartilage cells to create the first living test print returned to Earth from the ISS.



Techshot's technology, including BFF, are available on the ISS for NASA, other government agencies, and commercial companies to access



Our company has been able to provide jobs in a rural area in a non-space state, and we really tie that back to the SBIR program.

– Richard Boling
VP of Corporate Advancement,
Techshot

Business Impact

NASA is a direct customer of Techshot through a \$49.9 million Indefinite Delivery, Indefinite Quantity contract that gives NASA and other government agencies access to Techshot's technology aboard the ISS, including BFF and ADSEP.

Techshot has also received interest from non-government clients, including the 4D Bio³ program, a collaboration between the Uniformed Services University of the Health Sciences and The Geneva Foundation, a non-profit organization supporting innovative medical research within the U.S. military.

Richard Boling, Vice President of Corporate Advancement at Techshot, remarks on the influence of the SBIR/STTR program on the company's success: "Every payload we fly to the ISS starts with an SBIR. Our company has been able to provide jobs in a rural area in a non-space state, and we really tie that back to the SBIR program. We've had 100-some odd Phase I and II SBIRs, and that success has earned NASA's confidence in us."

Techshot has hired new employees to support development of BFF and has expanded to an office in Florida at the Kennedy Space Center. In total, Boling attributes a value of more than \$7 million to the BFF program, \$5 million of which came from non-company investment. Techshot continues to improve BFF's capabilities alongside NASA in pursuit of fully functional organic constructs that could save lives and enhance life on Earth.