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NASA Flight Opportunities
From Suborbital Flight to the International Space Station
Dmitry Starodubov, Ph.D., FOMS, Inc.
Steve Huning, NASA's Johnson Space Center
Kevin Engelbert, NASA's Johnson Space Center
Community of Practice Webinar Series – April 6, 2022
Session will start at 10 a.m. PT – Please mute your microphone and turn off your camera
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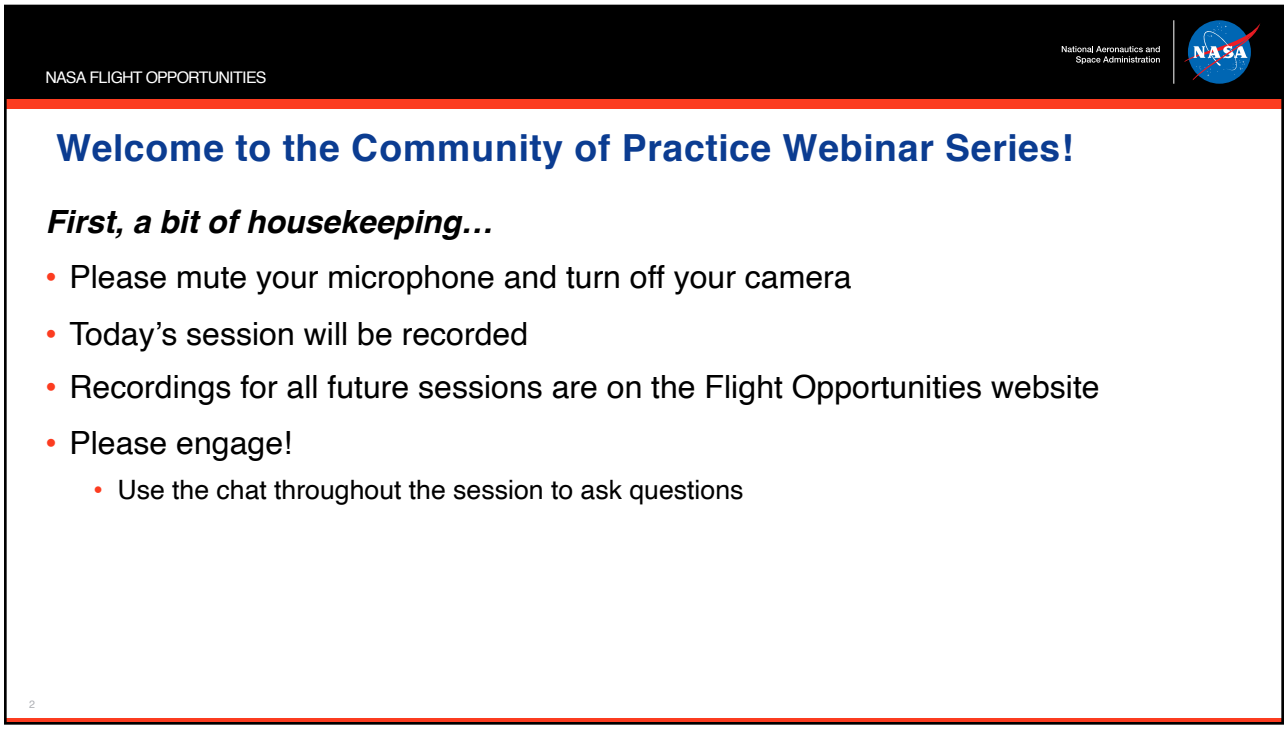
1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Welcome to the Community of Practice Webinar Series!
First, a bit of housekeeping…
• Please mute your microphone and turn off your camera
• Today's session will be recorded
• Recordings for all future sessions are on the Flight Opportunities website
• Please engage!
• Use the chat throughout the session to ask questions
2

2

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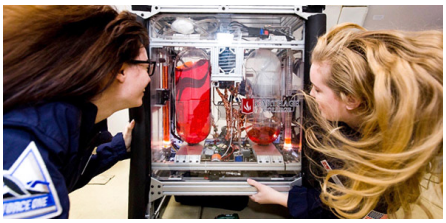
Flight Opportunities Mission

The Flight Opportunities program facilitates **rapid demonstration** of promising technologies for space exploration, discovery, and the expansion of space commerce through **suborbital testing with industry flight providers**.



3

3

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Join us for future Community of Practice webinars!

Subscribe to our newsletter to see next month's topic!

Future webinars

- Webinars are held 1st Wednesday of each month at 10 a.m. PT
- Topics will be announced in the Flight Opportunities newsletter and website
- Session recordings will be posted on the Flight Opportunities website
- Let us know session topics you would like to see covered

4

4

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Upcoming Opportunities

NASA TechLeap PRIZE

NASA TechLeap Prize - Nighttime Precision Landing Challenge No.1

Seeking proposals for sensing systems that can detect hazards from an altitude of 250 meters or higher and process the data in real time to help spacecraft land safely in the dark

- Open to researchers from qualified commercial businesses and academic institutions, as well as individual entrepreneurs and other innovators
- Key Dates
  - Q&A on April 12, 2022
  - Register by May 5, 2022
  - Applications due May 19, 2022

TechFlights – Coming Soon!

Awards funding for promising space-based innovations to researchers from U.S.-based industry, academia, and other non-NASA organizations. Awardees purchase flights directly from any eligible U.S. commercial flight provider that best suits their technology demonstration.

5

5

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Today's Speakers

Dmitry Starodubov, Ph.D.
Chief Scientist
FOMS, Inc.

Steve Huning
Research Portfolio Manager
NASA's Johnson Space Center

Kevin Engelbert
Commercial Portfolio Manager for In Space Production Applications
NASA's Johnson Space Center

6

6

7

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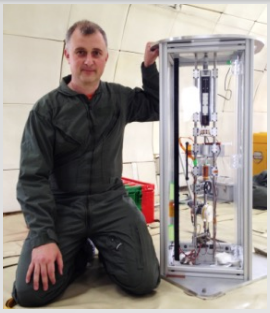
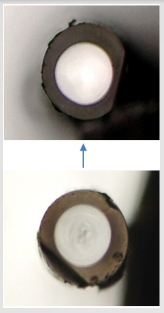
Motivation: Space Manufacturing





Market Opportunity	Year						
	2024	2025	2026	2027	2028	2029	2030
In-space services (CAGR 17%)	2.9	3.4	4	4.7	5.5	6.4	7.6
Countermeasure (CAGR 5.2%)	13.5	14.1	14.9	15.7	16.5	17.3	18.3
Fiber preforms (CAGR 23%)	8.7	10.7	13.2	16.3	20	24.6	30.3
Endoscopy (CAGR 7.5%)	34	36.6	39.3	42.3	45.4	48.8	52.2
Wafers (CAGR 4.8%)	20.6	21.6	22.6	23.7	24.9	26	27.3
Total addressable market, $B	79.7	86.4	94	102.7	112.3	123.1	135.7

- 2012, *D. Starodubov et al., Air Force SBIR, Space Test Program: Demonstration of improved ZBLAN optical fiber draw on parabolic flight

- **$100B market opportunity on Earth for space manufacturing products**
- **Low-loss fiber promise for future optical fiber communications**
- **High value to mass ratio products: $1M/kg optical fibers and fiber preforms**

*D. Starodubov, S. Mechery, D. Miller, C. Ulmer, P. Willems, J. Ganley, and D. Tucker, "ZBLAN Fibers: From Zero Gravity Tests to Orbital Manufacturing," in Imaging and Applied Optics 2014, OSA Technical Digest (Optical Society of America, 2014), paper AM4A.2.

8

8

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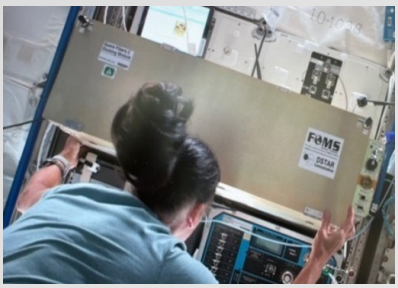
Approach: ISS Space Factory ™



- **Unique double-locker docking EXPRESS facility on ISS**
- **Ground center for remote control of manufacturing process**
- **Modular fabrication unit design with crew access for loading of materials**
- **Fully automated fiber manufacturing capability for SpX25 flight mission (06/22)**

D. Starodubov, K. McCormick, M. Dellosa, E. Erdelyi, and L. Volfson, "Microgravity Fiber Processing for Future Optical Networks," WSOF 2019, SPIE Proc. 11206, paper 11206-70.

9

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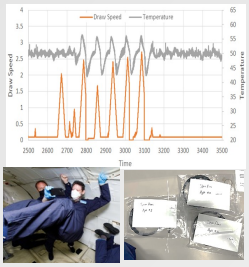
Space Fibers 3 (SpX25) Pre Flight





- **Three parabolic flights of Space Fibers 3 automated manufacturing unit**
- **Gravity-immune, continuous fiber draw through 0g and 1.7g, 3 spools of fiber**
- **Multiple design upgrades for mission success of ISS operations**
- **Verification of test protocols, safety designs and mission operations**
- **Incredible support from Flight Opportunities Program team**
- **Highly valuable inputs and guidance from NASA SBIR and ISS Utilization**
- **National Academy member, NASA employee and high school student flyers**

10

10

Low-Earth Orbit Economy

In Space Production Applications (InSPA)

Enabling U.S. Leadership of In-Space Manufacturing in Low-Earth Orbit for Terrestrial Markets – In Space for Earth!

Kevin Engelbert, ISS-OZ, NASA InSPA Portfolio Manager
Kevin.engelbert-1@nasa.gov

11

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EXECUTIVE SUMMARY

In Space Production Applications (InSPA)

- NASA's InSPA portfolio aims to **enable demonstrations** on the ISS National Lab of **in-space manufacturing** of high-value **advanced materials**, including bio-materials, **for use on Earth.**
- InSPA applies lessons from 40 years of microgravity (uG) research and nearly $40M in prior NASA ISS NRA awards to develop applications that benefit the nation, humanity, and the LEO economy over the next 10 years.
- The **focus** is on **scalable applications** that have a **sustainable impact** on the LEO economy and that will ensure **U.S. leadership** in the use of microgravity for manufacturing.
- The goal is to assist as many InSPA technologies through **two "Valleys of Death" (Technology and Manufacturing) before ISS transition** so that public/private investment takes over. The science is sound, but manufacturing control must be proven in uG and **it takes a lot of practice**!
- The InSPA portfolio has benefited from a **partnership** with the Flight Opportunities Program to utilize **parabolic flights** for testing of InSPA prototypes as **risk mitigation** and to develop **team expertise**.
- NASA expects **continued use** of parabolic flights and possible **expansion into Suborbital** flights to **validate hardware and procedures** prior to launch to ISS to make the best use of **constrained ISS resources.**

12

12

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Why In Space Production? Why Microgravity?

- Microgravity removes convection, sedimentation, and buoyancy that warp and disrupt physical and chemical processes on Earth in 1g
- In Microgravity (uG), diffusion is the dominant process, a gentler mixing that enables more perfect, uniform, and precise structures at the level of individual molecules and groups of atoms, leading to unique alloys and formulations
- Microgravity also allows surface tension features to dominate for more precise adhesion, contact, and interaction between layers of similar and dissimilar constituents, yielding unique, more complex, and higher quality products
- ISS applied R&D shows that microgravity can assist in the development of next generation materials in multiple fields including space, defense, information technologies, communications, medicine, power, green technologies, and a wide range of next generation consumer products. They inform entire classes of new materials and products where exceptional precision and quality are sought

13

13

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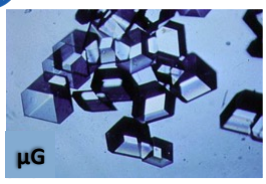
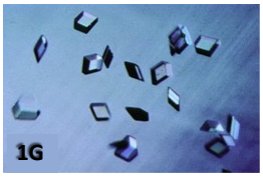
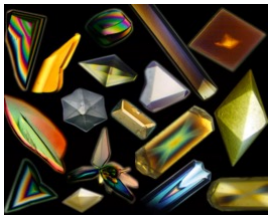
Crystals with Better Structure…

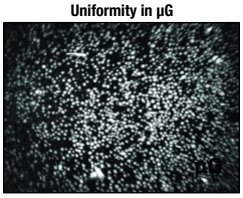


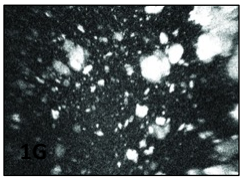


1983-now 1000+ Crystals in µG



and Much Greater Uniformity in µG

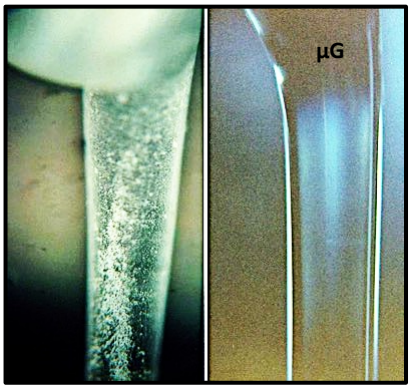




Are all caused in part by **slower crystal growth in microgravity**

Exotic Glasses and Fiber Manufacturing in Space

Use slower crystal growth in µG to prevent unwanted crystallization in exotic glasses and fibers manufacturing on commercial scales and lack of sedimentation and buoyancy to enable better glass alloys



14

14

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Summary

- The role of microgravity in materials research offers the U.S. and its partners **a competitive edge now, but global competition is increasing rapidly.**
- NASA and the ISS National Laboratory are collaborating on a strategy and set of recommended targets for rapid development of In Space Production Applications over the next ten years, with **concentration on accelerating carefully selected advances with a rapid return on investment**
- NASA is determined to **use the remaining life of the ISS to enable high-value technologies and maintain U.S. leadership** of in-space manufacturing and production.
- Use of parabolic and suborbital flight capabilities accelerates learning and increases mission success for highly valued demonstration opportunities in LEO**.**

We are in a race that has already begun and extends into the foreseeable future between nations and innovators worldwide to determine who is first and who is best in the development of space materials and products.

15

15

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Thank you!

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16 www.nasa.gov

16