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Future Vision for In-Space Biomanufacturing and The Role of Standards

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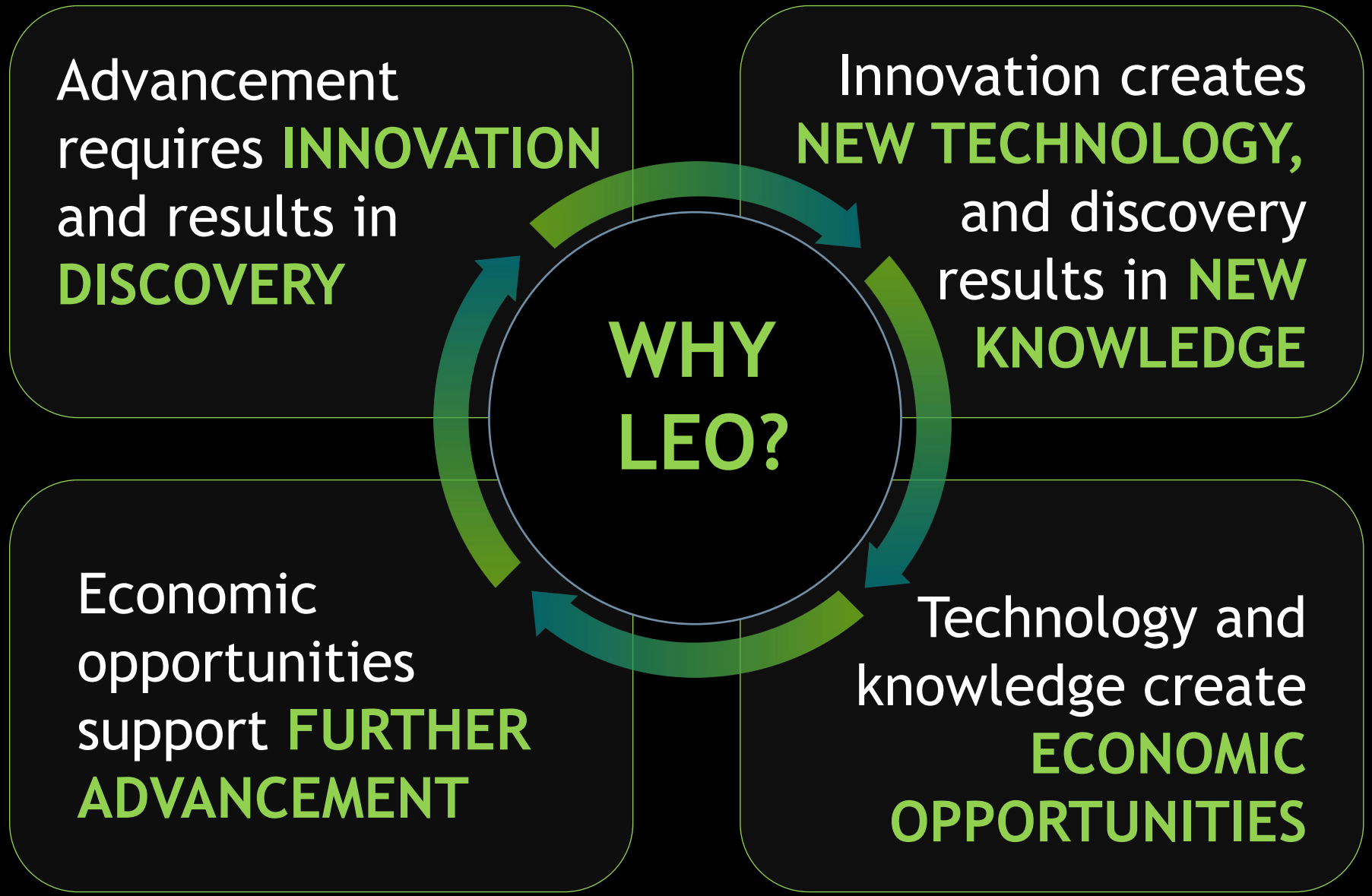
The ISS National Laboratory

Managed by the Center for the Advancement of Science in Space™, (CASIS™), a not-for-profit organization, via a Cooperative Agreement with NASA

The ISS National Laboratory

- LEO-based applied R&D microgravity applications tissue engineering &biomanufacturing technologies and products
- New business growth and capital investment
- Scalable and sustainable market opportunities
- Produce reoccurring value with the potential to generate demand for and revenue from access to space


Advancement requires INNOVATION and results in DISCOVERY
Innovation creates NEW TECHNOLOGY, and discovery results in NEW KNOWLEDGE
WHY LEO?
Economic opportunities support FURTHER ADVANCEMENT
Technology and knowledge create ECONOMIC OPPORTUNITIES

Why conduct research in space?

Persistent Microgravity

- Lack of density gradients
- No convection
- Uniform surface wetting
- Multiphase flow dynamics
- No sedimentation
- Reduced interfacial tension
- Different solidification
- Accelerated disease models

Extreme Conditions

- 500°F orbital heat cycling
- Ultrahigh vacuum
- High-energy radiation
- Atomic oxygen
- High-energy impact

Unique Vantage Point

- 250 miles above Earth
- Orbital path: 90% of population
- Spatial resolution
- Sun cycling/light conditions
- Remote sensing
- Satellite deployment

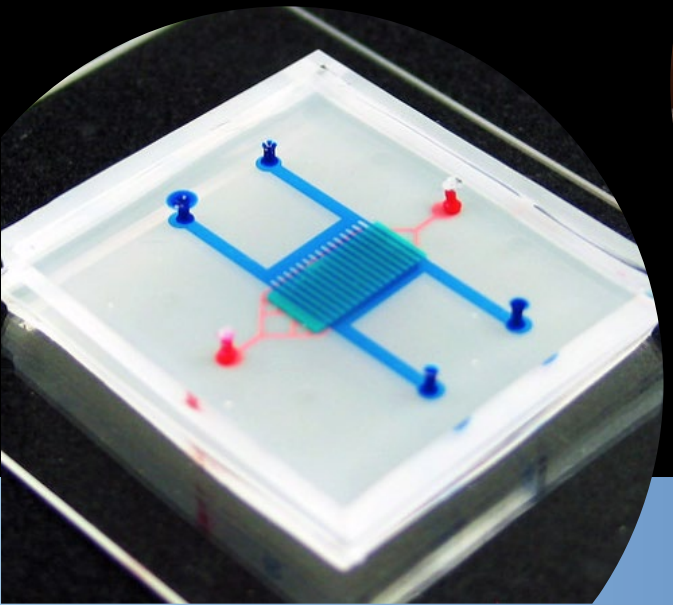
The Vision for In-Space Biomanufacturing

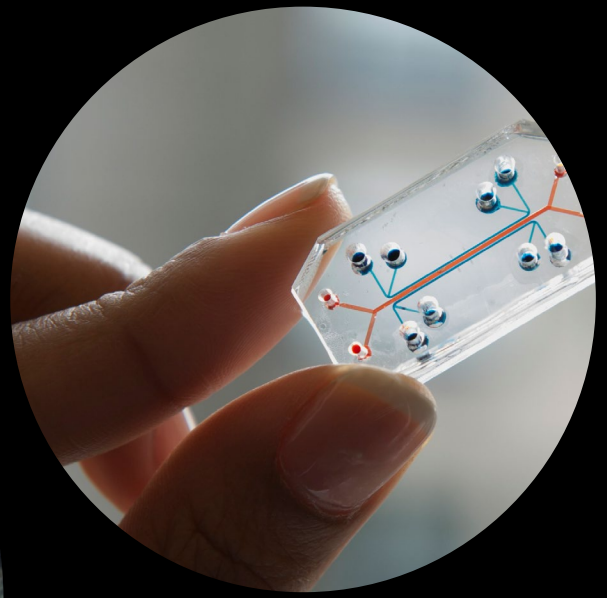
Pharmaceuticals and Biotech: Microgravity advantages for protein crystallization, tissue engineering, and more

Manufacturing facilities in LEO will pave the way for a **space-based economy**.

Collaborative, standards-driven virtual platform is essential for education, training, and shared innovation.

Vanderbilt University

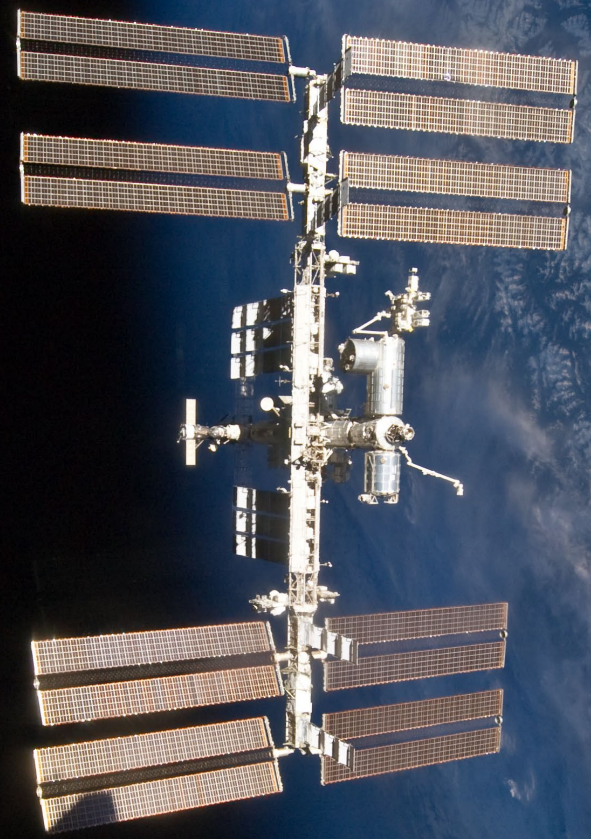




Wyss Institute for Biologically Inspired Engineering, Harvard University

The Importance of Standards for Biomanufacturing in LEO

- **Standards** create a **reliable, scalable, and safe environment**:
  Consistency: Standards ensure that processes work uniformly across different space environments.
- **Quality Control**: Standards are vital to maintaining product quality in the unique conditions of LEO.
- **Safety and Efficiency**: Standards provide the guidelines to mitigate the risks involved in space-based production.
- Efforts are being made by different oragnizations, including the ISSNL in laying foundational standards for space manufacturing..



The Importance of Standards for Biomanufacturing in LEO

- **Adaptation of Terrestrial Standards**: Existing standards for Earth-based manufacturing require adaptations for space applications.
- **Interoperability**: Standards enable different organizations and systems to work seamlessly in space.
- Importance of **collaboration across industries** to shape these standards, ensuring they meet diverse needs, and create sustainability

Virtual Platforms for Biomanufacturing Ecosystem in LEO

Virtual platform to bring together the space community

- **Education**: basics, standards, and compliance.
- **Training**: Hands-on virtual simulations using digital twins.
- **Collaboration**: Real-time collaboration spaces for knowledge-sharing and feedback.
- **Standards Implementation**: Tools to support adherence to and adaptation of standards for In-Space Biomanufacturing.

The Role of Digital Twins

- **Digital twins** create virtual replicas of manufacturing systems for simulating **manufacturing processes** in a microgravity environment.
- Adapting Earth-based processes to **space conditions**.
- Ensuring **efficiency and reliability** of processes before deploying in space.
- **De-risk ventures** by providing a controlled environment for experimentation.

How to Join Our Growing Research Community

- Submit a concept review for an open solicitation
  - Both NASAand ISS National Lab put forth a variety of funding opportunities
  - National Science Foundation annual research announcements
  - Other funding opportunities like Technology in Space Prize
- Work directly with a Commercial Service Provider who can assist in the development of your concept

Questions for The Audience

1. To create an ecosystem to build an in space biomanufacturing economy we are seeking to develop a virtual platform for education, training, collaboration, and standards implementation. One facet of this platform will use digital twins for manufacturing processes developed terrestrially and seek to use standards and in space requirements to adapt these manufacturing processes to LEO. What are design features you would want to see in such a virtual platform?

2. Would you be interested in learning more about this platform and providing input?

3. Would you be interested in a workshop on adapting potential technology used for in-space commercialization and standards?

Magazine of the ISS National Lab

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