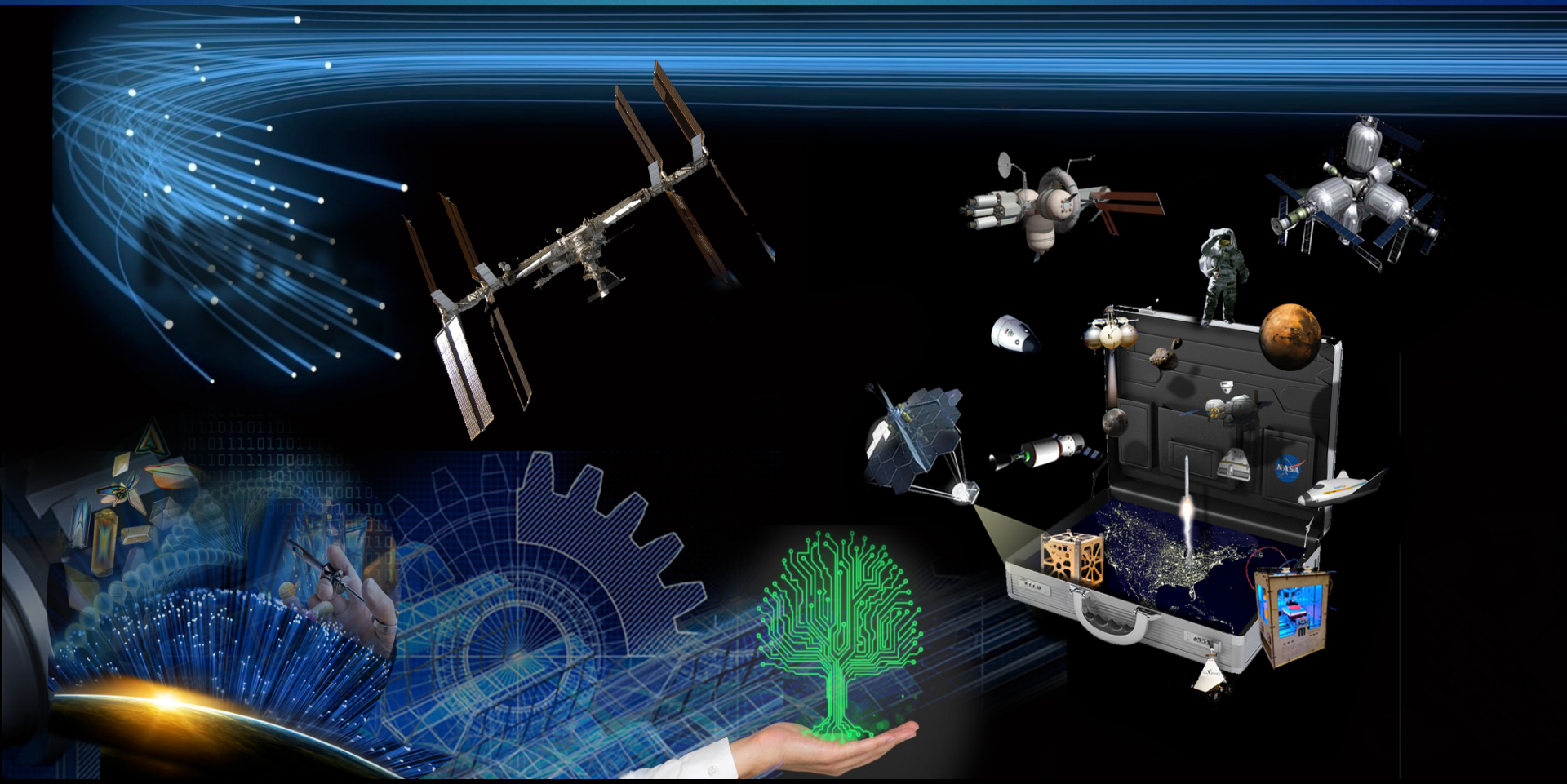
# In Space Manufacturing –
# What's Different Now?



Lynn D. Harper • Lead for Integrative Studies • Space Portal • NASA Ames Research Center

November 2020

**NASA ESO: How is gravity impeding U.S. commercial product development?**

# 2014 Demand Trends in High Tech

NO END TO THIS DEMAND IN SIGHT

- More Bandwidth
- Faster Processors
- Greater Energy Efficiency
- Better Therapeutics
- More Processing Power in Smaller Volumes
- Specific Wavelength Applications
- Performance in more Extreme Environments

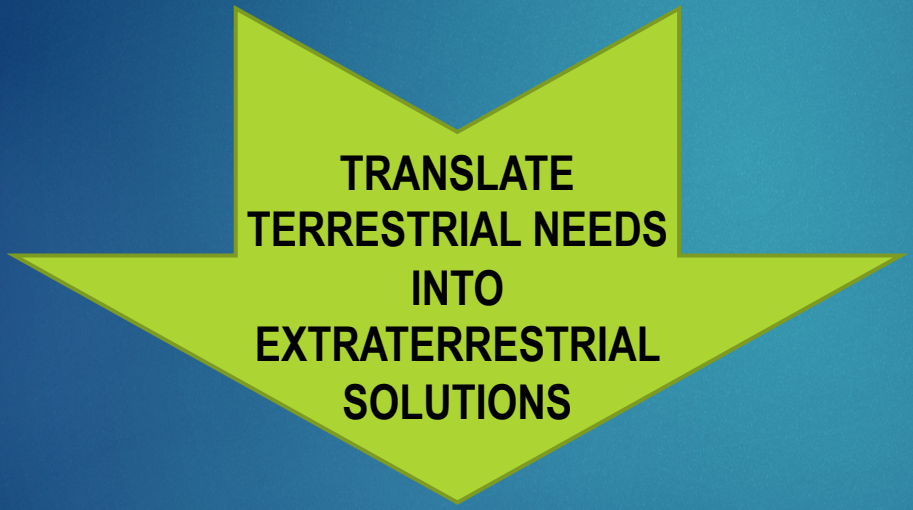
These demands push materials and processes to the point where ***defects at the atomic and molecular level matter*** …

this is where microgravity can help.

*Still true in 2020*

# **Enabling Inspace Manufacturing Success:** Can we do it?

NASA ISS Payload Utilization, ISS National Lab, SBIR, STMD Flight Opportunities




**Invisible Pathfinders:**
NASA MI&O
Integration Partners

**Rise of innovative fast agile SMALL SPACE BUSINESSES and increasing interest of large corporations in commercial space R&D**

Many cases of concept to first flight on ISS in 3-5 years

# LEARNING CYCLES
## NOT JUST TIME

Space is hard and Microgravity is weird

Developing space applications,
Finding the 'Sweet Spot'
for inspace manufacturing requires

# PRACTICE

Time does not equal learning cycles.
30 years of Space Shuttle Operations only equals about 3.5 years in space.

CAN WE GET THE PRECISION and CONTROL NEEDED for ISM?

# EXISTENCE PROOFS

**that control at atomic and molecular levels can be achieved in LEO**

| | |
|---|---|
| 1980s -now | *Significantly* better biological and non-biological crystals in space |
| 1997 | First application of Human Genome Project technologies to analysis of 3D tissue cultures in space (Space Shuttle Neurolab) |
| 2014 | First tool 3D printed in space – **INSPACE MANUFACTURING BEGINS** |
| 2016 | GeneLab – AI/ML 'OMICS' collaborative *significantly and increasingly* **amplifies value of space biosciences data -** Cell |
| 2019 | Mighty Mice in Space – **Accelerate therapeutics** development (Myostatin experiment) -- PNAS |
| 2020 | **Cold Atom Laboratory** – Extraordinary precision sustaining **quantum processes** – First Bose-Einstein Condensates in Space - known universe's coldest place |




***THIS IS THE OPPORTUNITY 'FLOOR' FOR THE NEXT DECADE***

ISSR&D Conf 2020