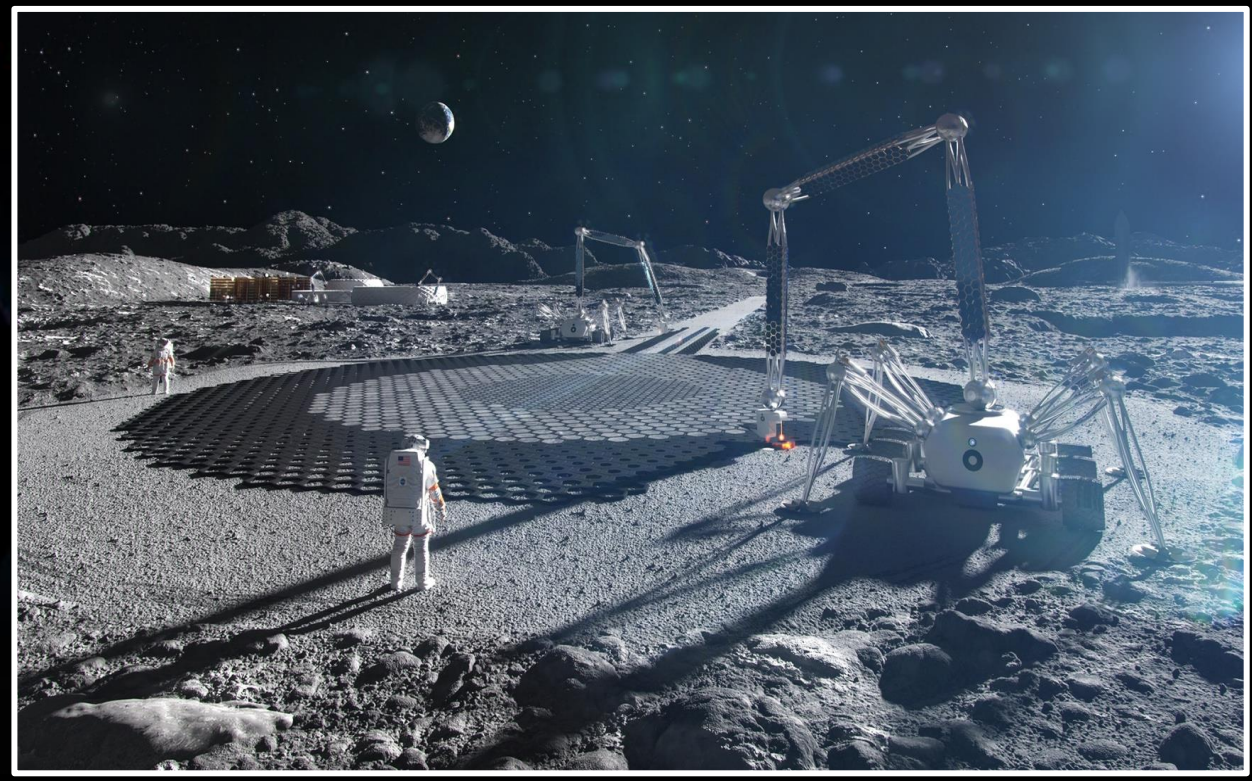
Accelerating Materials Discovery for National Security



National Security Challenges Panel

JHU/APL September 5, 2024

Dr. Corky Clinton

NASA's Moon to Mars Strategy and Objectives: Manufacturing and Construction Examples
Objective-based Approach – Architect from the Right - Stick with the Plan

LI-4L: Demonstrate advanced manufacturing and autonomous construction capabilities in support of continuous human lunar presence and a robust lunar economy.

LI-8L: Demonstrate technologies supporting cislunar orbital/surface depots, construction and manufacturing maximizing the use of in-situ resources, needed for continuous human/robotic presence.

RT-5: Maintainability and Reuse: when practical, design systems for maintainability, reuse, and/or recycling to support the long-term sustainability of operations and increase Earth independence.

PPS-2LM: Advance understanding of physical systems and fundamental physics by utilizing the unique environments of the Moon, Mars, and deep space.

AS-6LM: Advance understanding of how physical systems and fundamental physical phenomena are affected by partial gravity, microgravity, and general environment of the Moon, Mars, and deep space.

TH-4LM: Develop in-space and surface habitation system(s) for crew to live in deep space for extended durations, enabling future missions to Mars.

OP-11LM: Demonstrate the capability to use commodities produced from planetary surface or in-space resources to reduce the mass required to be transported from Earth.

OP-12LM: Establish procedures and systems that will minimize the disturbance to the local environment and allow for reuse/recycling of material transported from Earth.

NASA Space Technology Mission Directorate: Advanced Manufacturing and Excavation, Construction, and Outfitting Technology Shortfalls and Rankings

ADVANCED MANUFACTURING SHORTFALLS		
SHORTFALL NUMBER	SHORTFALL TITLE	RANKING
1485	In-Space and On-Surface Manufacturing of Parts/Products from Surface and Terrestrial Feedstocks	92
1486	In-Space and On-Surface NDE and Qualification of Components for Manufacturing, Assembly, and Construction	116
1487	In-Space and On-Surface Welding Technologies for Manufacturing, Assembly, and Construction	179
1489	In-Space and On-Surface Manufacturing from Recycled and Reused Materials and Components	172
1490	Additive Manufacturing for New and High-Performance Materials	145
1488	Additive Manufacturing for Propulsion	163
1491	Additive Manufacturing of Large-Scale Components	154
1492	Materials and Process Modeling for In-Space and On-Surface Manufacturing	170
1493	Computational Materials-Informed Qualification and Certification for In-Space and On-Surface Manufacturing	184
1494	Digital Transformation Technologies for Terrestrial, In-Space, On-Surface Manufacturing, and Operations	176
1496	In-Space and On-Surface New Materials, Manufacturing, Assembly, and Repair of Composite Structures	174
1495	Advanced Manufacturing for Improved Dimensional Control of Large-Scale Space Structures	171

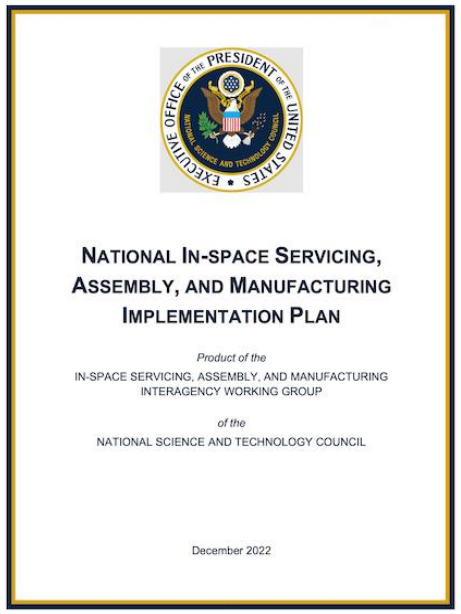
EXCAVATION, CONSTRUCTION, AND OUTFITTING SHORTFALLS		
SHORTFALL NUMBER	SHORTFALL TITLE	RANKING
369	Excavation of granular (surface) regolith for ISRU commodities production	108
384	Excavation of hard/compacted/icy material	104
385	Regolith and resource delivery system	118
662	Robotic regolith manipulation and site preparation	102
617	On-surface robotic assembly of vertical structures	148
1400	On-surface robotic assembly of horizontal structures	159
425	On-Surface In-situ Construction of Vertical Structures	145
666	On-Surface In-situ Construction of Horizontal Structures	160
1480	On-surface Outfitting of Lunar Structures	138

Space Nuclear Power and Propulsion (SNPP) Systems

- Safety, System Performance, and Mass are Design Drivers.
- Solid Fuel Nuclear Thermal Propulsion (NTP) Systems
  - Nuclear fuels capable of operating at >2500 K In the presence of hydrogen
  - Simultaneously have a high uranium loading and parasitic neutron absorption
  - Example material is UZrC.
- Liquid fuel NTP systems require
  - Materials Compatible with Liquid Uranium at >1500 K (perhaps ZrC?)
  - Materials for Regeneratively Cooled Nozzles with a Very High Heat Flux in the Nozzle Throat
  - Bearings and other components that can operate at very high (> 1000 K) temperatures.
- High performance nuclear electric propulsion (NEP) systems would benefit from
  - Closed-cycle turbomachinery capable of operating at > 1800 K turbine inlet temperature,
  - Superconducting magnets, and superconducting cables for transmitting power.
- Fission Surface Power (FSP) concepts could benefit from
  - Development of hydrogen barriers capable of preventing hydrogen diffusion at temperatures up to 1200 K.
  - Barriers could potentially be used in long-life reactors with a ZrHx or Yhx neutron Moderator
- Many SNPP systems could also benefit from
  - Development of advanced neutron reflector materials such as Be_2C.
  - Advanced manufacturing techniques - reduce the cost and hazard associated with the use of certain advanced materials.
  - High emissivity coatings capable of operating over a wide temperature range

Space/Aeronautics Manufacturing Creates

Economic Competitiveness



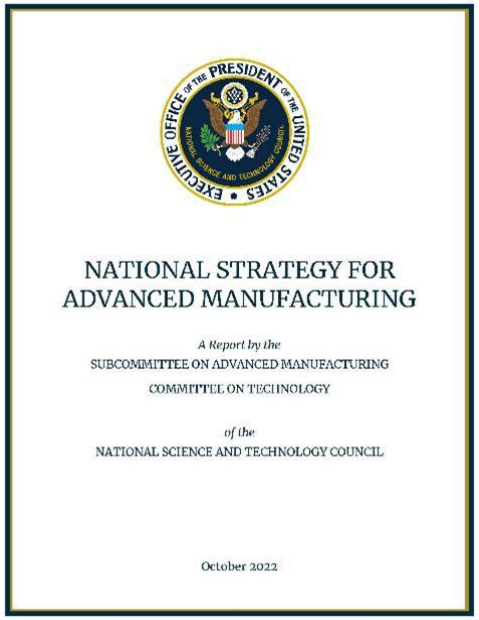
NATIONAL IN-SPACE SERVICING, ASSEMBLY, AND MANUFACTURING IMPLEMENTATION PLAN

Product of the
IN-SPACE SERVICING, ASSEMBLY, AND MANUFACTURING INTERAGENCY WORKING GROUP

of the
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

December 2022

National Security



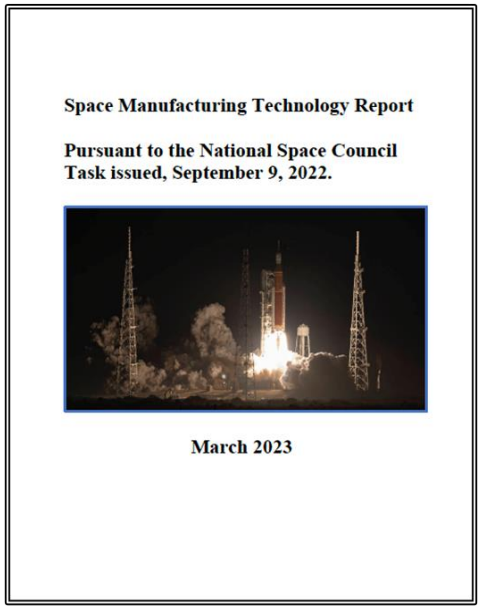
NATIONAL STRATEGY FOR ADVANCED MANUFACTURING

A Report by the
SUBCOMMITTEE ON ADVANCED MANUFACTURING
COMMITTEE ON TECHNOLOGY

of the
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

October 2022

STEM



Space Manufacturing Technology Report

Pursuant to the National Space Council Task issued, September 9, 2022.

March 2023

BACK-UP

National Space Council Space Manufacturing Technology Report:
Prioritize Investments in New and Emerging Space Manufacturing Technologies

New and Emerging Space Manufacturing Technology List:

1. Additive Manufacturing
2. Advanced Materials
3. Robotics and Automation
4. Digital Manufacturing Systems
5. Clean and Sustainable Manufacturing
6. Electronics Manufacturing
7. Hypersonics

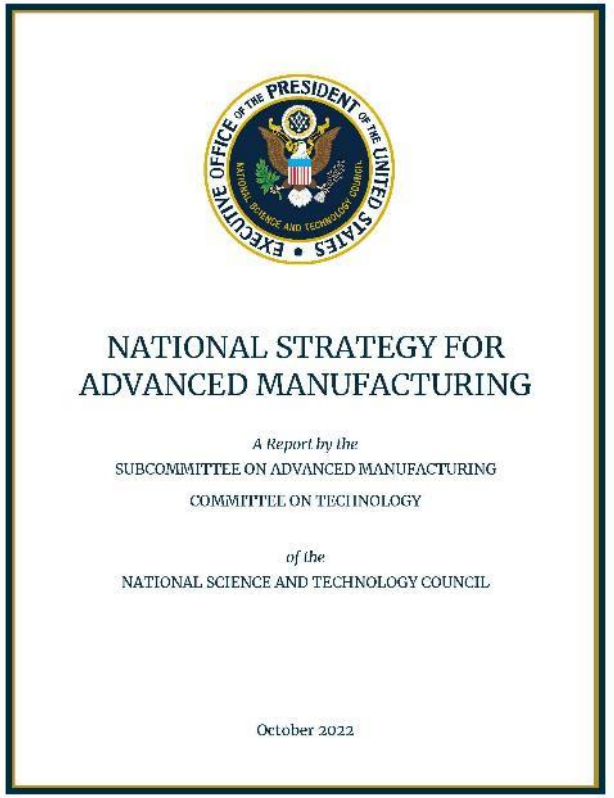
Strategic Plan Structure

Vision:

United States leadership in Advanced Manufacturing - grow the economy, create jobs, enhance environmental sustainability, address climate change, strengthen supply chains, ensure national security, and improve healthcare.

National Goals:

1. Develop and implement advanced manufacturing technologies – **5 Objectives** with **18 priorities**
2. Grow the advanced manufacturing workforce – **3 Objectives** with **8 priorities**
3. Build resilience into manufacturing supply chains and ecosystems – **3 Objectives** with **11 priorities**



Space Manufacturing Technology Report Structure

Vision:

The National Space Council - Ensuring the United States capitalizes on the rich opportunities presented by our nation's space activities

National Goals:

- **New and Emerging Space Manufacturing Technologies – 7 Priority Areas**
- **Grow the advanced manufacturing workforce – 5 Objectives, 14 Recommendations, 12 Opportunities**