

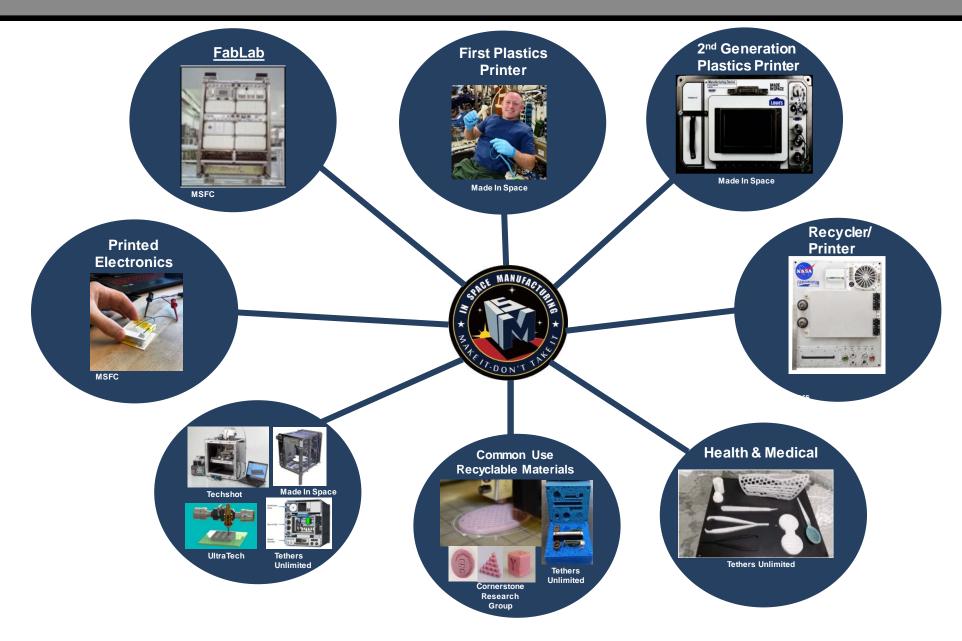
R.G. Clinton Jr., PhD Associate Director Science and Technology Office NASA Marshall Space Flight Center ISS R&D Conference July 29 – August 1, 2019 Atlanta GA



# In Space Manufacturing Path to Exploration

# Key Thrust Areas







# ISM Utilization and the Additive Manufacturing Facility (AMF): Material Characterization and Functional Parts





AMF on ISS with printed multi-purpose tool floating in front (photos courtesy of MIS)



SPHERES Tow Hitch



**REM Shield Enclosure** 



OGS AAA Adapter

- Additive Manufacturing Facility (AMF), the second generation printer, is a commercial, multi-user facility developed by Made in Space, Inc.
- Upgrades beyond 3DP include:
  - a) Print with multiple material (ABS, ULTEM 9085, and HDPE
  - b) Integral cameras/sensors for automated monitoring
  - c) Maintenance procedures reduce crew time
  - d) Leveling and calibration with on-board systems
- Materials characterization task developing baseline mechanical properties on ABS (test matrix below)

AMF Mechanical	Property Tes		ASTM #	Properties
Type, Orientation	Qty (ground)			
Tension, 0	10	10	D638	Modulus, strength, strain, Poisson's
Tension, 90	10	10	D638	Modulus, strength, strain
Compression, 0	10	10	D695	Modulus, "strength," strain
Compression, 90	10	10	D695	Modulus, "strength," strain
Tension, +/-45 (shear)	10	10	D3518	Modulus, strength, strain, Poisson's
Flatwise tension	10	10	C297	z-direction (through- thickness) tensile strength
Range coupon	2	2	n/a	n/a
EMU fan cap	1	1	n/a	n/a
Total	63	63		



## Made In Space (MIS) Archinaut – Phase II





MIS CEO Andrew Rush with a demonstration of the ArchinautOne Solar array

#### **Objectives:**

- Continue success of ESAMM and GBMASH to build ArchinautOne
  - Small satellite with best in class power capability
  - Operate in LEO
  - ESAMM unit will produce 2x 10 m beams which support 10 m<sup>2</sup> flexible solar panels each
  - Robotic arm will position vital components
  - In-situ V&V ensures quality product



ArchinautOne Small Sat

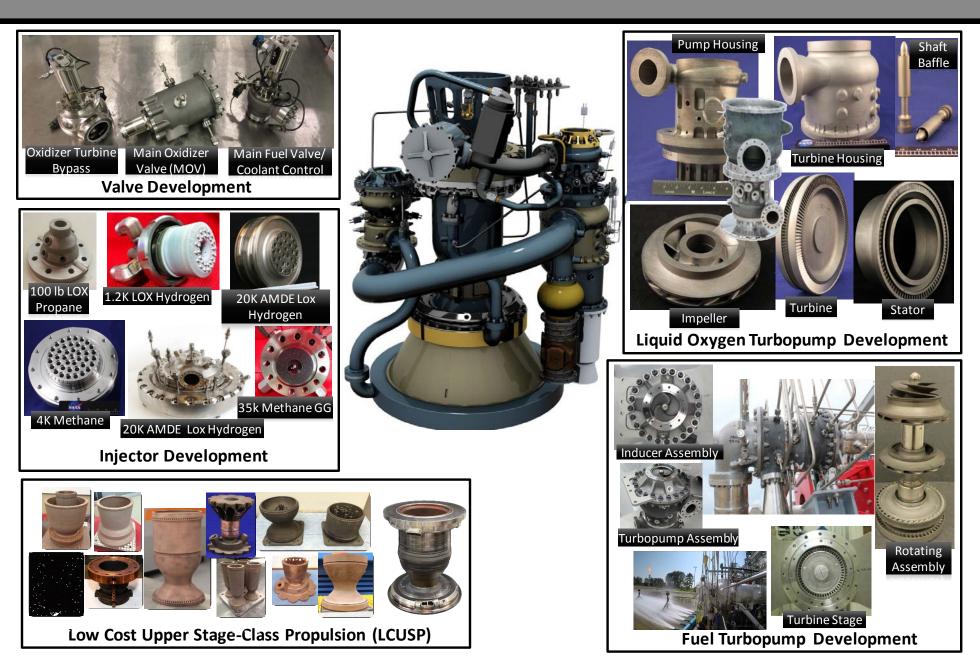
ArchinautOne Small Sat with printed solar arrays

*Demonstration of small satellite with >2kW power* 



## Additive Manufacturing Demonstrator Engine (AMDE) Development







## Rapid Analysis and Manufacturing Propulsion Technology (RAMPT) Thrust Chamber Concept



## Bimetallic Deposited Manifolds Vendor Development and Optimization

- Develops commercial supply chain
- Reduces Cost
- Optimizes weight based on selective material deposition

Integrated Large Scale Freeform Manufacturing Deposition Regen-Cooled Nozzle

- Rapid Fabrication for Increased Scale
- Reduces cost and schedule (50%)
- Removes all joints
- Increases reliability
- Reduces complexity

Design and Process Modeling Tools Enable an Integrated Optimized Design

• Reduces design cycles

**3D printed Copper Chamber** (derived from LCUSP Program)

- Proven Technology
- Advances Commercial Supply Chain

### Composite Overwrap

Thrust Chamber Assembly

- Significant weight reduction Reduces overall cost and schedule
- Increased performance
- Builds upon COPV Technology

Demonstrate Subscale and Large Scale Hot Fire testing of Multimaterial Chamber

• Allows for infusion and increases TRL

