National Aeronautics and Space Administration

Marshall Space Flight Center

AIAA Technical Committee on Management

Center Overview and Additive Manufacturing at MSFC

February 18, 2014







marshall

Dr. Dale Thomas
Associate Director, Technical

www.nasa.gov

The National Aeronautics and Space Administration

Human Exploration and Operations

Space Technology

Science

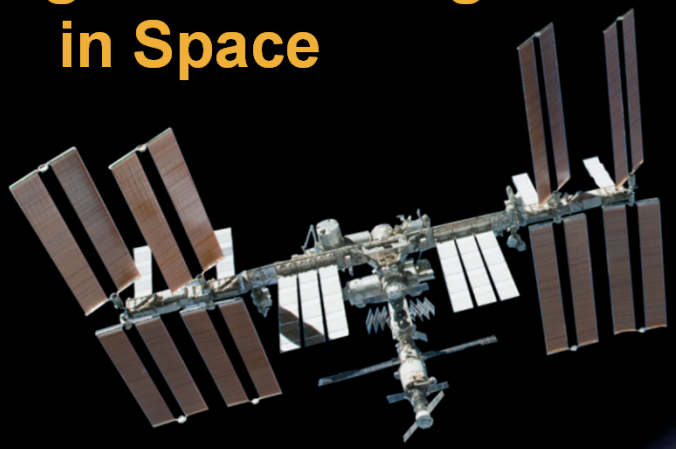
Aeronautics Research

Marshall supports three of the NASA Mission Areas.

Marshall Mission Areas

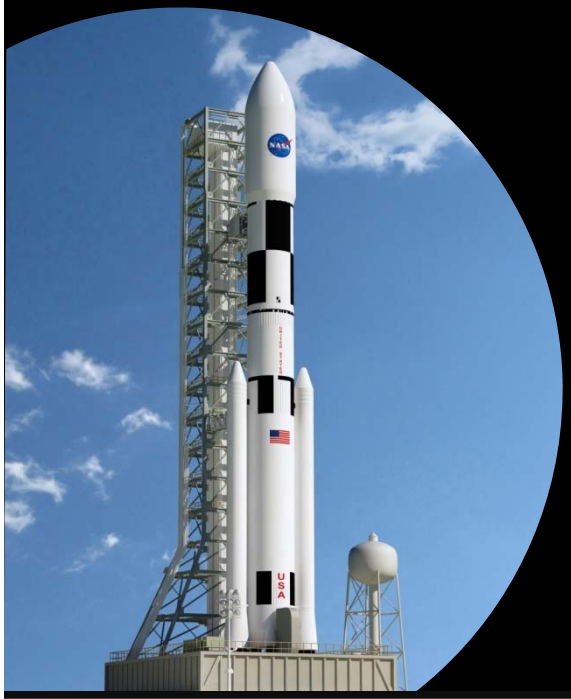
Understanding Our World and Beyond

Living and Working in Space



Traveling To and Through Space

Traveling To and Through Space



Space Launch System (SLS)

America's next human-rated heavy-lift rocket – safe, affordable, and sustainable for beyond Earth orbit exploration

Commercial Spaceflight

Partnering for success – sharing facilities and expertise

Research for the Future

New fuels, new manufacturing and test methods, and advanced concepts

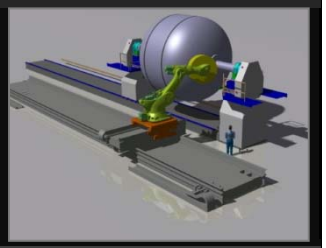
Launching SLS in 2017

Testing J2-X Upper Stage Engine

Supporting Commercial Spaceflight

Affordable Testing for Nuclear Fuel Prototypes

Collaborative Engineering Design



In-space Cryogenic Fuel Storage Concept

Marshall is leading our nation's propulsion capabilities.

Living and Working in Space

Supporting Life in Space

Supporting Scientific Research on the International Space Station

- From large space structures to life support systems and operations, Marshall supports crews in space.

Lab Training Complex

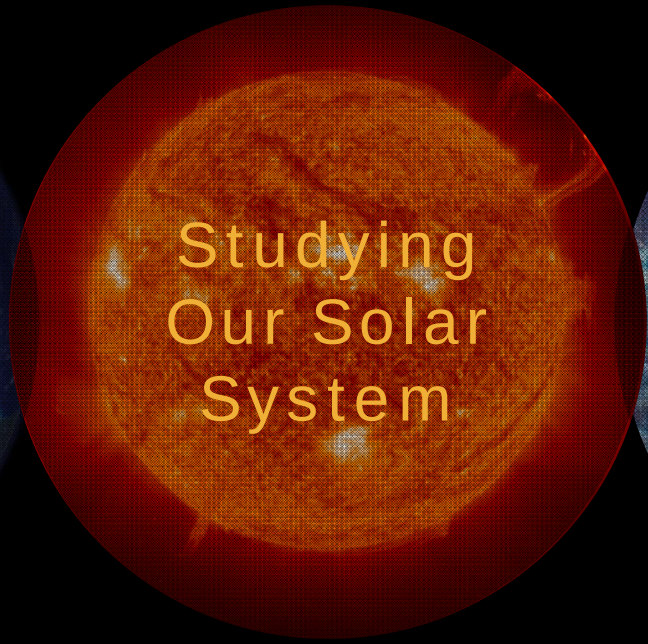
Payload Operations Center

ECLSS testing at Marshall

Microgravity Science Glovebox

ISS U.S. Destiny Lab

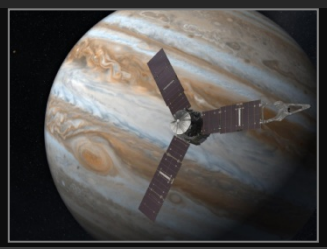
Understanding Our World and Beyond



Weather & Climate Monitoring

SERVIR

SUMI Solar Capture



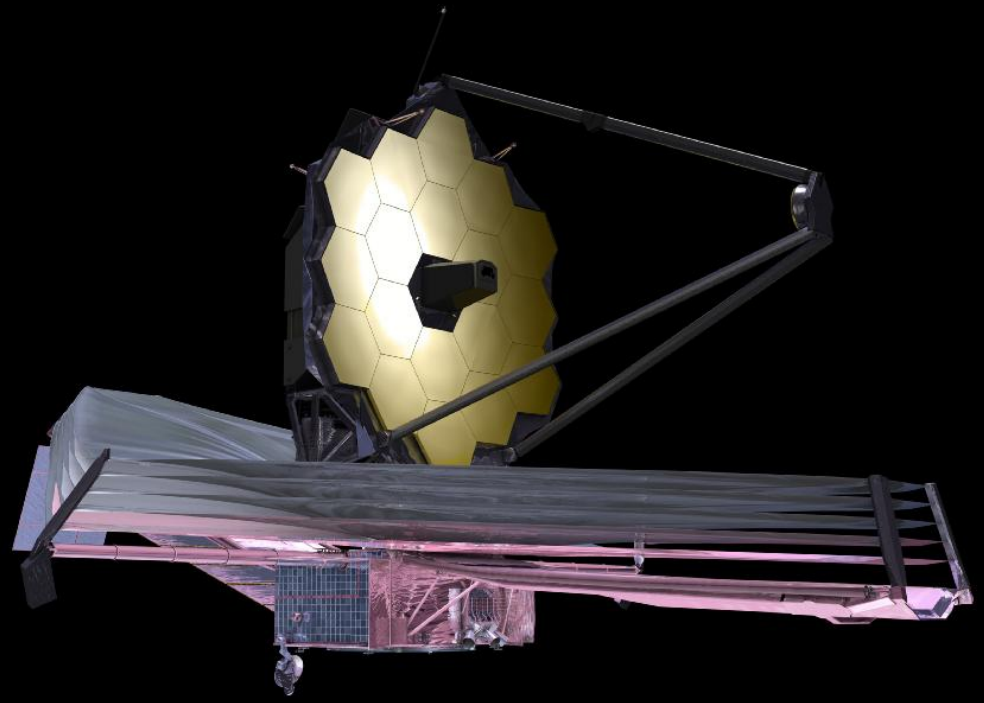
Discovery & New Frontiers

Chandra

James Webb Space Telescope

Marshall is expanding knowledge of our world and beyond.

James Webb Space Telescope



- Marshall X-ray and Cryogenic Facility used for key tests:
  - Backplane
  - Mirrors
  - Optical assembly
- Hubble successor
- 5-10 year mission
- Launch in 2018
- Search for first galaxies
- Planetary system and star evolution

Initial Mirror Testing 2008

JWST sunshield membrane

Development and Flight mirror tests in XRCF

Center of Curvature Optical Assembly tests in XRCF

Mirror backplane and wing testing in XRCF

Supporting U.S. Leadership in Propulsion Systems

NRPS
National Institute for
Rocket Propulsion Systems

Stewardship

Formulate and recommend National Policy options and strategies that promote a healthy industrial base.

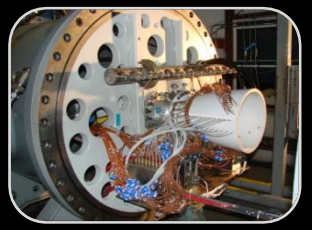
Technology

Identify technology needs and recommend technology insertions.

Solutions Facilitator

Maintain relationships and awareness across the Government and industry to align available capacity with emerging demand.





Benefitting Life on Earth – Technology Spinoffs

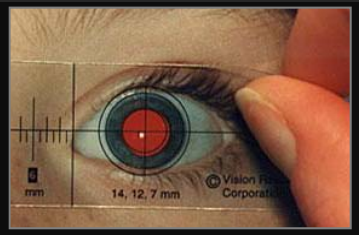
Space technology for newborns

Technologies developed at Marshall touch our lives in many ways.

Weather & Climate Monitoring

High-pressure fire hose nozzles

Kevlar™ Body Armor



Improving Vision Screening

Healing Treatments

Water Filtration Systems

Science and exploration improves our lives and our planet.

MSFC Additive Manufacturing Lab

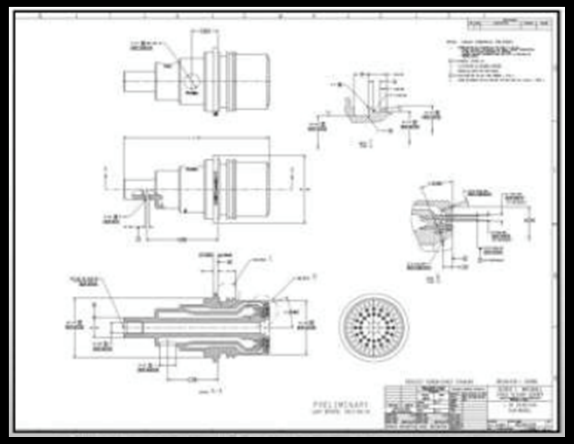
Since 1991

MSFC Additive Manufacturing Lab

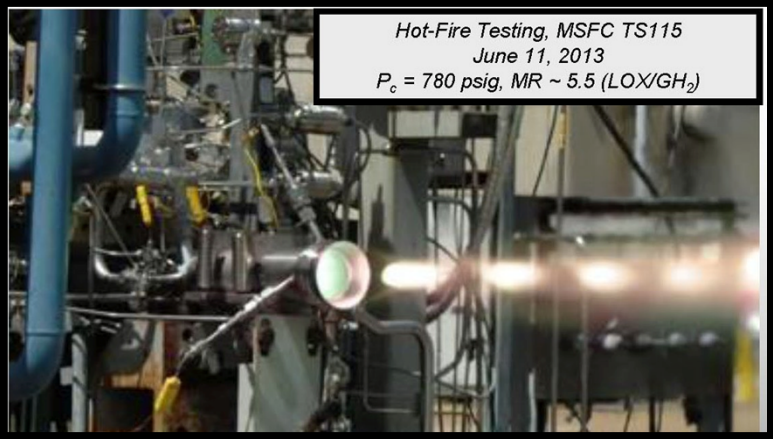
Traveling to and Through Space

Since 1991

First Hotfire One-Piece SLM Injector

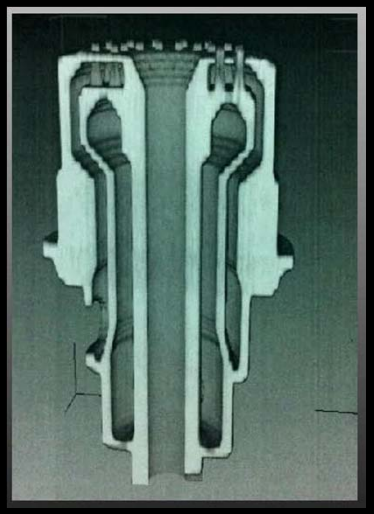


CAD File from MSFC Design/Development



Hotfire Testing

Injector fabricate at MSF-EM



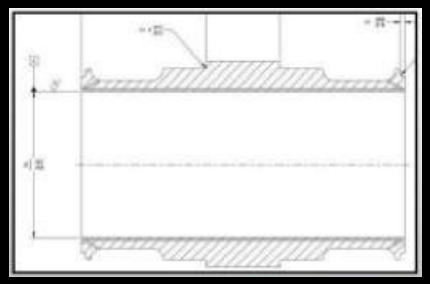
Interior CT scanned in-house

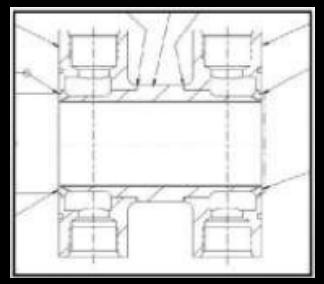
Attachment ring added, Propellant fittings welded on, Faceplate coated…

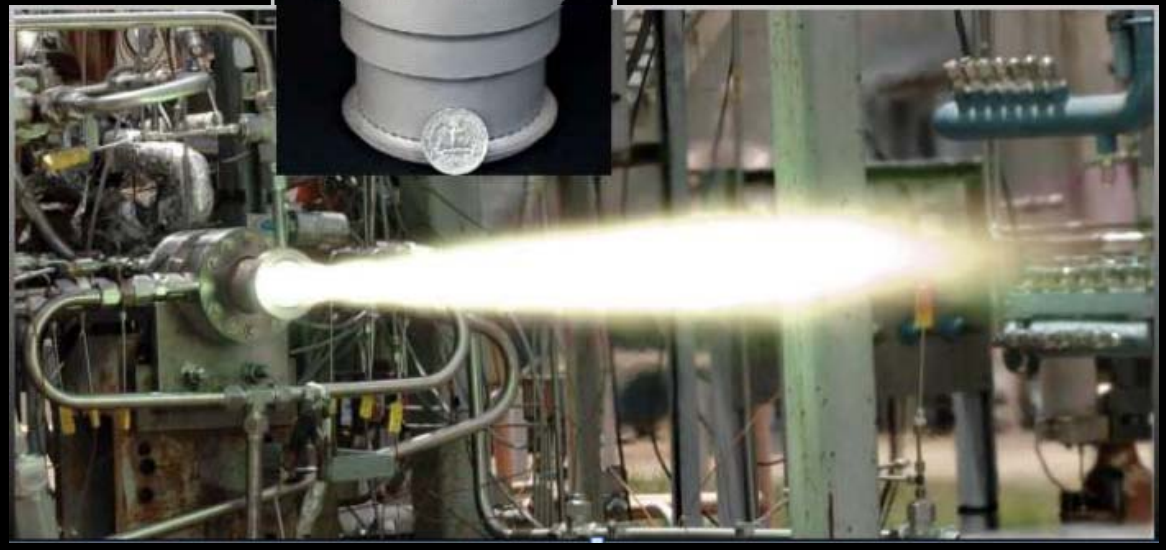
Schedule Savings: 21 Weeks … Cost Savings: 50%

SLM Inconel 718 Regen MCC

This Inconel chamber design was printed by two different vendors to determine if the SLM process could accurately reproduce small diameter slots (.030-in by .062-in) required for regenerative cooling. The chamber was successfully hotfired and heat transfer was measured at Test Stand 115 at MSFC.

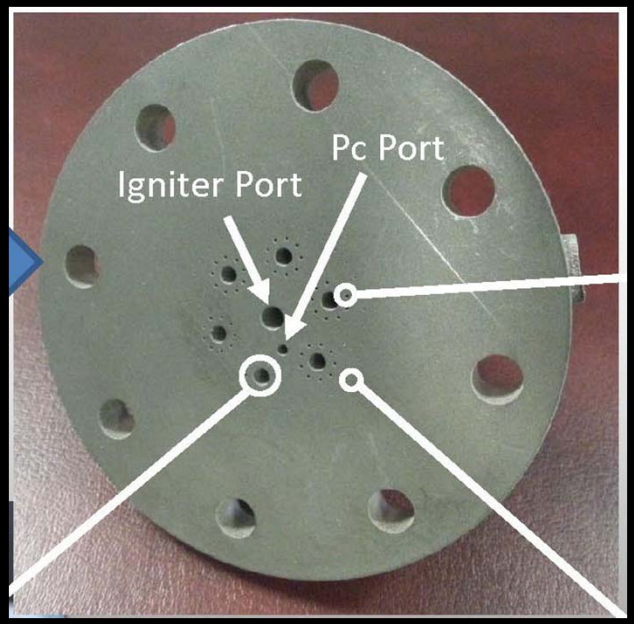






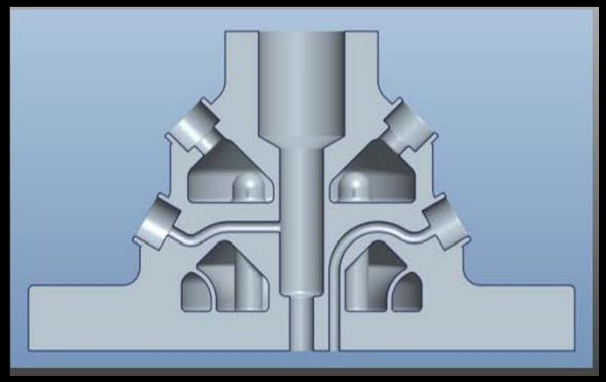
Schedule Savings: 11 weeks … Cost Savings: 30%

SLS NanoLaunch 100lb Injector



Fuel orifice water flow test

LOX swirl element water flow test



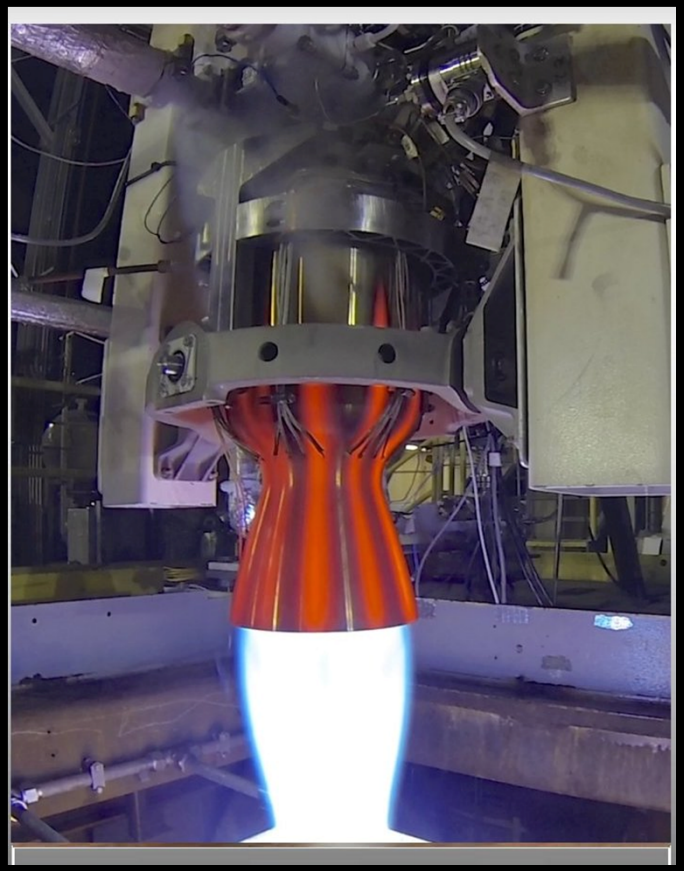
Cross-sectional view

Film coolant orifice water flow test–near limit of DMLS capability

SLM Nozzle Fabricated by MSFC for Morpheus

Inconel 625 Nozzle and tensile bar stock printed at MSFC in May 2013

White light and CT NDE at MSFC

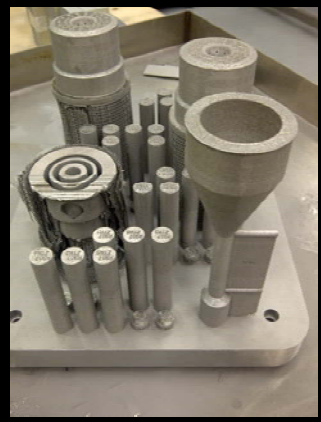


Testing at JSC, on rebuilt HD5 engine – Sept 2013

Schedule Savings: -2 weeks … Cost Savings: 5%

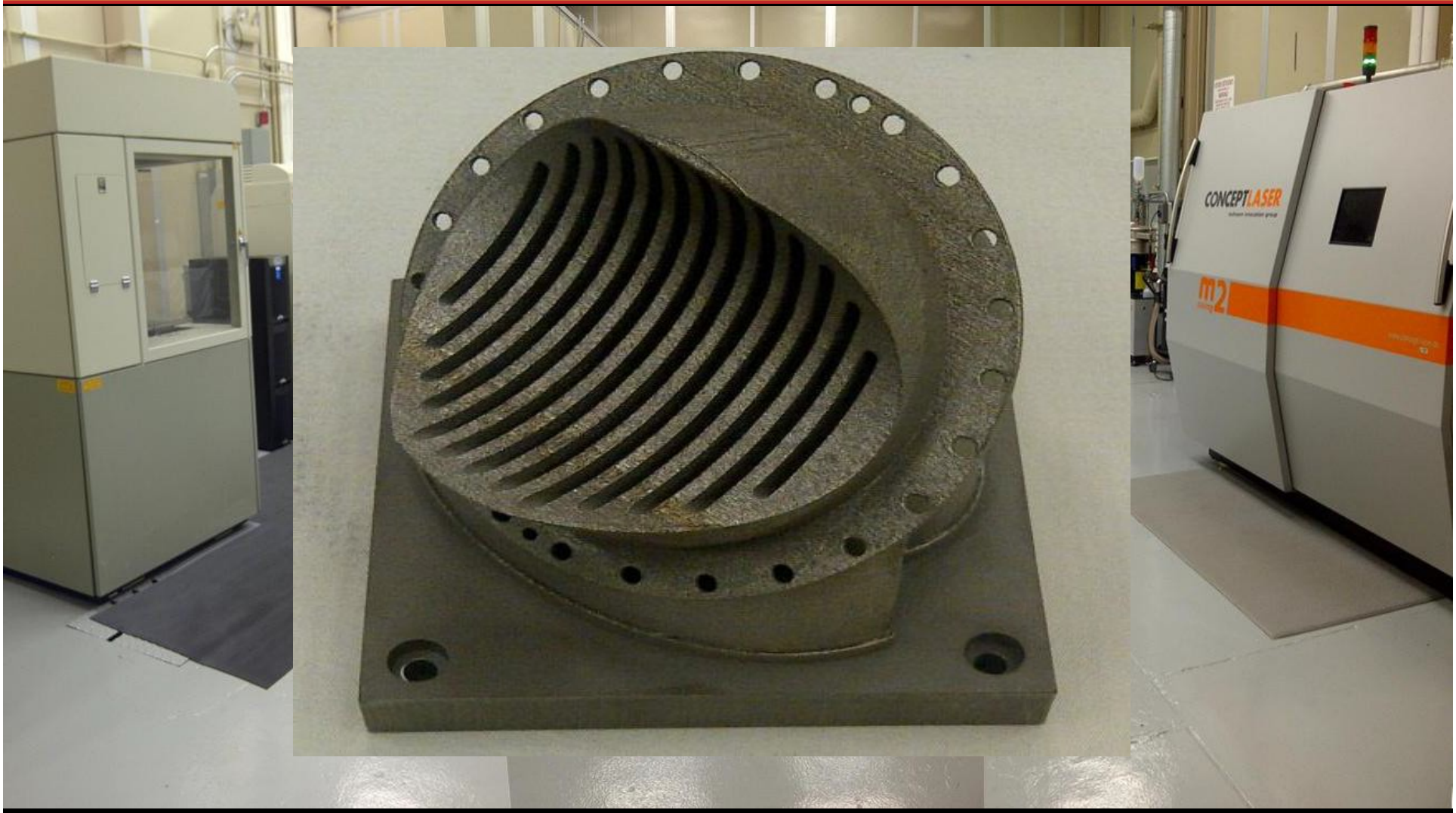
Foundational Work in Additive Manufacturing

- Working closely with NIRPS, NAMII, Academia and JANNAF
- Developing a verification protocol for flight hardware manufactured using SLM



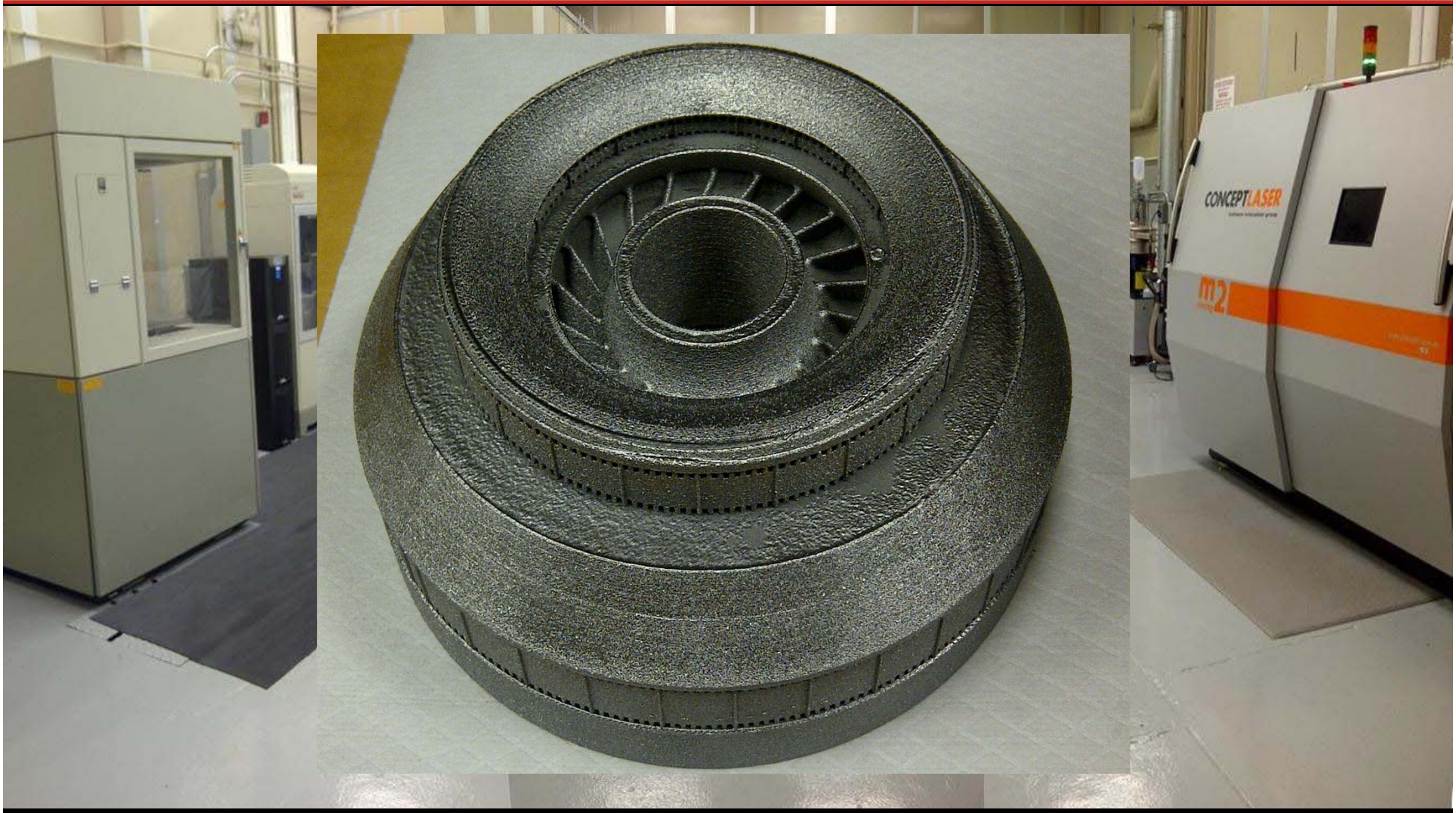
Role of government relative to SLM is to work with Industry to mature the additive manufacturing processes and to provide objective authoritative data to U.S. Industry and its partners.

MSFC Additive Manufacturing Lab



POGO Z Baffle

MSFC Additive Manufacturing Lab



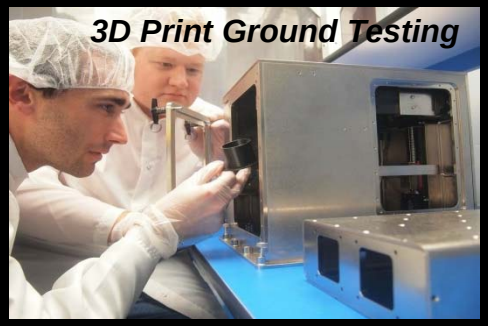
Shrouded Impeller

MSFC Additive Manufacturing Lab

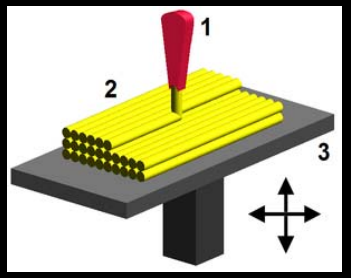
Living and Working in Space

3D Printing in Zero-G ("3D Print")
ISS Tech Demo

MADE IN SPACE

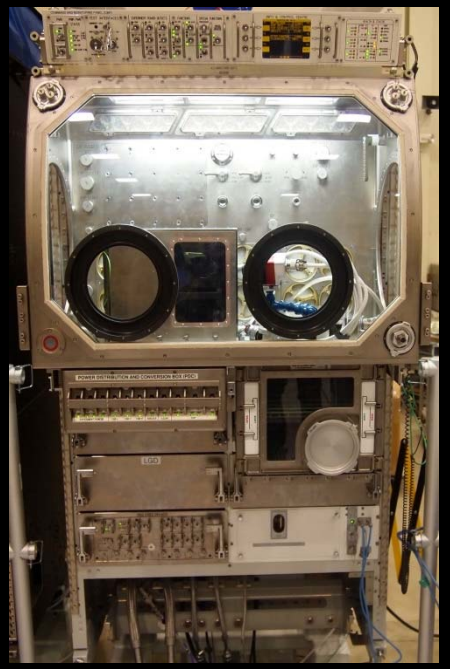


The 3D Print project will deliver the first 3D printer on the ISS and will investigate the effects of consistent microgravity on melt deposition additive manufacturing by printing parts in space.



Melt deposition modeling: 1 - nozzle ejecting molten plastic, 2 - deposited material (modeled part), 3 - controlled

3D Print in Micro-G Science Glovebox (MSG)



Potential Mission Accessories

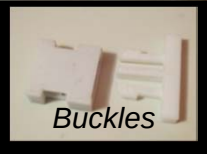

Threads


Springs


Containers


Caps


Clamps


Buckles

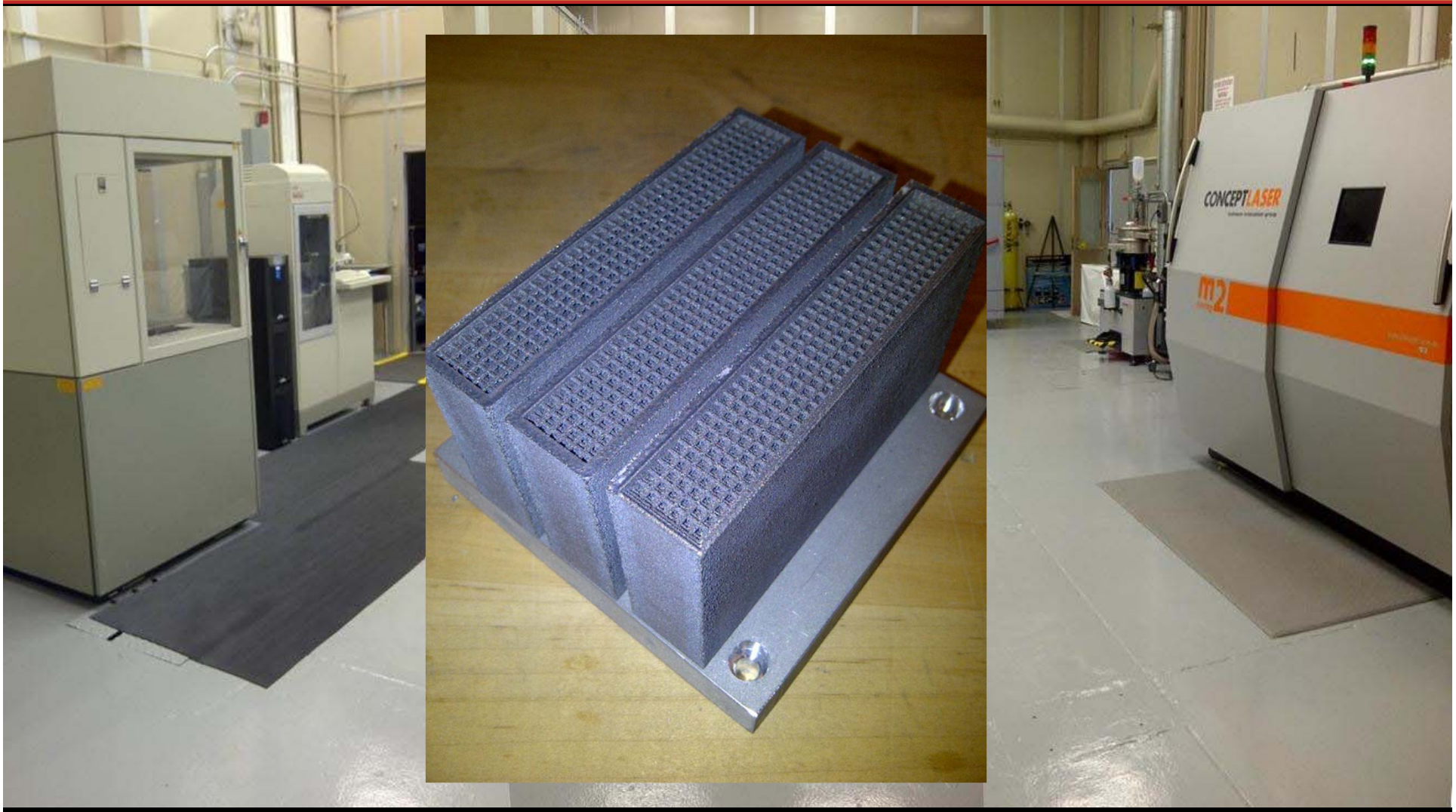
3D Print Specifications

Dimensions	33 cm x 30 cm x 36 cm
Print Volume	6 cm x 12 cm x 6 cm
Mass	20 kg (w/out packing material or spares)
Est. Accuracy	95 %
Resolution	.35 mm
Maximum Power	176W (draw from MSG)
Software	MIS SliceR
Traverse	Linear Guide Rail
Feedstock	ABS Plastic

MSFC Additive Manufacturing Lab

ISS Urine Processor Assembly

MSFC Additive Manufacturing Lab



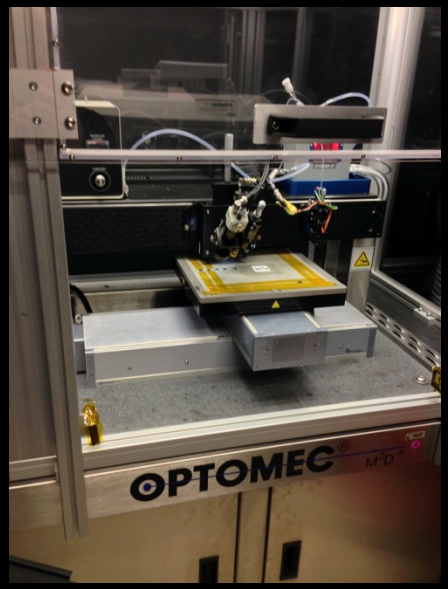
Aluminum Air Filter/Scrubbers

MSFC Additive Manufacturing Lab

Solid State Ultracapacitor to Replace Batteries

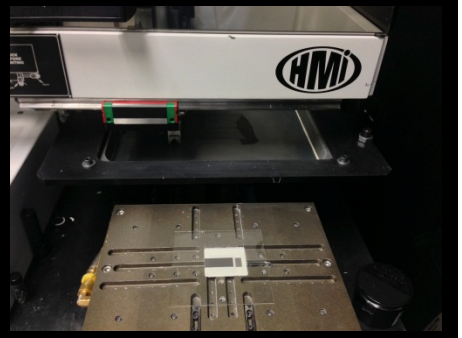
EM41 Nano-materials Development Lab

Fluidized bed treatment of high energy barium titanate powder

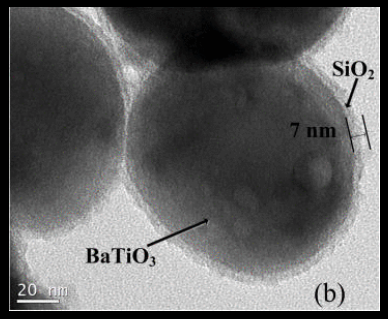


3D printing with high precision aerosol deposition

ES43 Additive Electronics Lab



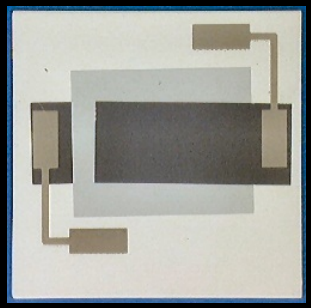
Additive printing with precision screens



ALD-coated SiO_2 on barium titanate nanoparticles

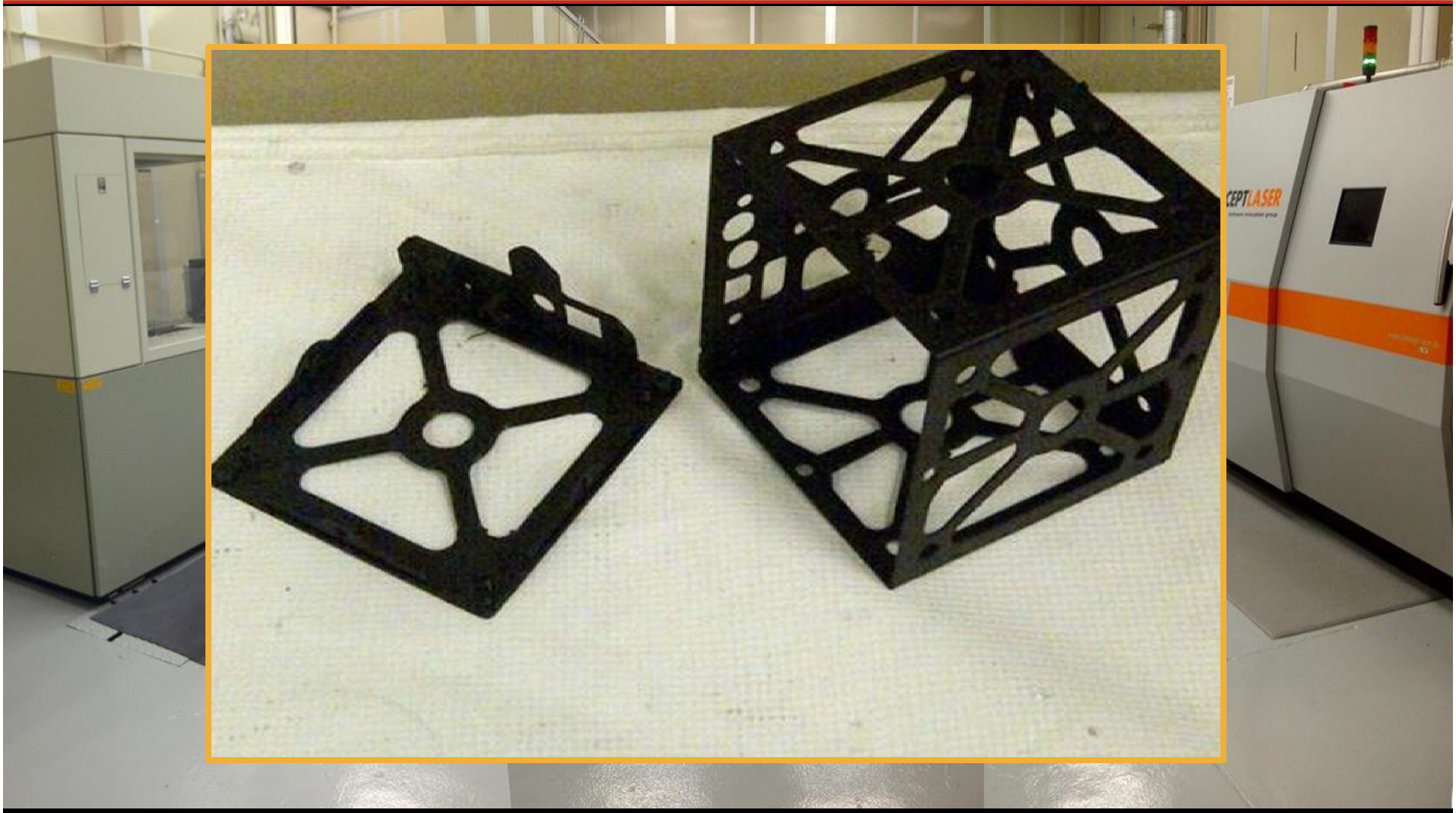
Development of a high energy storage capacitor (HESSCap) from coated barium titanate powder for a solid state device to replace current electrochemical batteries.

Device	Energy Density (J/cc)
Aerospace Battery (Li-ion/28V)	**172** (calculated from spec)
Aerospace Range Safety Battery (Ag Zn/28V)	**57** (calculated from spec)
Commercial Electrolytic Ultracap (5.9V)	**15** (provided by manufacturer)
Solid State Ultracapacitor (28V)	**80-200** (calculated from model)



HESSCap device on alumina substrate

MSFC Additive Manufacturing Lab

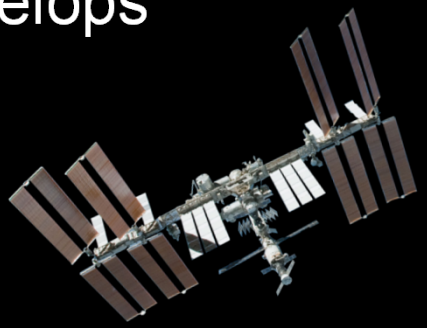


CubeSat

Marshall Space Flight Center in Summary

- Plays significant role in 3 of NASA's 4 mission areas.

- Manages projects and programs; and develops advanced technologies to:
  - Travel to and through space
  - Live and work in space
  - Understand our world and beyond.



- Studies advanced manufacturing methods—especially additive manufacturing—to accomplish challenging missions faster & more economically.

www.nasa.gov/marshall