Marshall Space Flight Center
Science and Technology Overview
and Additive Manufacturing Special Topics
Huntsville Aerospace Marketing Association
March 11, 2016
Organizational Factoids

HAS OVER 55 PROGRAMS/PROJECTS IN ITS PORTFOLIO

INCLUDES 200 TEAM MEMBERS; ~110 CS + ~90 WYE

PROJECTS RANGE FROM < $100K TO $1B

PROJECTS RANGE FROM PRE-PHASE A TO PHASE E

INCLUDES WORK FROM THREE OF NASA’S FOUR MISSION DIRECTORATES

40% OF NASA-EMPLOYED SCIENTISTS AND TECHNOLOGISTS HOLD DOCTORATE DEGREES
Much of our budget comes from NASA’s Science Mission Directorate (SMD) and Space Technology Mission Directorate (STMD).

Much of our Science budget is competed, while all of our technology work is directed.

A large part of our science and technology budget is spent on procurement.
Providing the ability to alter orbit inclination and elevation, and control deorbit for cubesats.
Nuclear thermal propulsion offers twice the specific impulse as traditional chemical engines and reduces trip time to Mars.
Composite Technology Demonstrations

Lightweight, Composite Propellant Tank
FASTSAT (2010-2012)

MSFC/Dynetics partnership built and launched FASTSAT, a microsatellite, from which Nanosail-D, a 3U cubesat was launched.

Near-Earth Asteroid Scout, 6u Cubesat

PULSAR
Programmable Ultra Lightweight System Adaptable Radio
Additive Manufacturing Special Topic

Marshall Space Flight Center
Additive Manufacturing Path to Exploration

EARTH RELIANT

Earth-Based Platform
- Certification & Inspection Process
- Design Properties Database
- Additive Manufacturing Automation
- In-space Recycling Technology Development
- External In-space Manufacturing and Repair
- AM Rocket Engine Development, Test, and Certification
- AM for Support Systems (e.g., ECLSS) Design, Development, Test

PROVING GROUND

Space-Based Platform
- 3D Print Tech Demo
- Additive Manufacturing Facility
- On-demand Parts Catalogue
- Recycling Demo
- Printable Electronics Demo
- In-space MetalsDemo
- AM Propulsion Systems
  - RS-25
  - Upper Stage Engine
- Habitat Systems

EARTH INDEPENDENT

Space Launch System

Planetary Surfaces Platform
- Additive Construction Technologies
- Regolith Materials - Feedstock
- AM In Space Propulsion Systems
  - Upper Stage
  - Orbiters
  - Landers
- Habitat Systems
A total of 21 parts were printed on ISS, including the uplinked ratchet handle.

Inspection and testing of all articles included:
- Structured light scanning
- X-ray and CT scan
- Microscopy
- Density
- Mechanical testing

Mechanical property differences observed between flight and ground samples.

Additional ISS prints in Spring 2016 will enable additional mechanical properties data and support hypotheses evaluation.

Lessons Learned have been incorporated into the next generation 3D Printer for ISS – Additive Manufacturing Facility (AMF) by Made In Space.
Collaborative Additive Construction Projects

Additive Construction with Mobile Emplacement (ACME)

Shared Vision: Capability to print custom-designed expeditionary structures on-demand, in the field, using locally available materials.

Automated Construction of Expeditionary Structures (ACES)
Strategic Vision for Future AM Engine Systems

Defining the Development Philosophy of the Future

- Integrating Design with Manufacturing
- 3D Design Models and Simulations Increase Producibility
- Transforming Manual to Automated Manufacturing
- Dramatic Reduction in Design Development, Test and Evaluation (DDT&E) Cycles

Building Foundational Industrial Base

Building Experience “Smart Buyer” to enable Commercial Partners

Bridging the gap between the present and future projects that are coming

Enabling & Developing Revolutionary Technology

Transferring “Open Rights” SLM Material Property Data & Technology to U.S. Industry
Reduction in Parts Count for Major Hardware

- MOV Part Count (Approx): 1 vs. 6
- FTP Part Count (Approx): 22 vs. 40
- MCC Part Count (Approx): 1 vs. 5
- Injector Part Count (Approx): 6 vs. 255
- MFV (Hidden) Part Count (Approx): 1 vs. 5
- Mixer (Hidden) Part Count: 2 vs. 8
- Thrust Structure Part Count: 2 vs. 8
- OTP Part Count (Approx): 41 vs. 80
- OTBV Part Count (Approx): 1 vs. 5

Note: Part counts examples are for major piece parts and do not include bolts, nuts, washers, etc.
Reduction in Parts Count for Major Hardware

Fundamental Additive Manufacturing M&P Development

Material Properties & NDE ➔ Standards & Specs ➔ Certification Rationale ➔ Pull

Parallel & Congruent Activities

Push

Building Foundational Additive Manufacturing Industrial Base

Methane Prop. Systems

Payloads & Satellites

RP Engine

Nuclear Propulsion

MPS Components

Upper Stage Engine

LPS Prototype Engine

RS-25

CCP
Requirement choices dictate how we embrace, foster, and protect the technology and its opportunities.
Engineering and Quality Standard for AM Spaceflight Hardware

- Tailoring
- Governing standards
- AM Design
- **Part Classification**
- Structural Assessment
- Fracture Control
- Qualification Testing
- Part Development Plans
- **Process Controls**
- Material Properties
- Finishing, Cleaning, Repair Allowances
- Part Inspection and Acceptance
Technology Transfer

**Bringing NASA Technology Down to Earth**

- Free Software Release
- Patent Licensing
- Spinoffs

**NASA 398 Alloy Used in All Evinrude E-TEC Engines**

Marshall Space Flight Center Technology Transfer Office
Specific Opportunities

2016 Dual Use Technology Development Cooperative Agreement Notice (CAN) at NASA MSFC

- NNM16567212C
- Released October 9, 2015; Response Date:
- Scope: Award cooperative agreements for technology development partnerships. MSFC resource contribution awards range from $10,000 to $100,000.
- The next opportunity deadline to submit a White Paper is 4 May 2016.
- FYI: Any Cooperative Agreement projects selected for this 4 May opportunity will most likely start sometime in Oct and use FY17 funds for the MSFC contribution.

Commercial Space Technology Development RFI

- NNH16ZOA001L
- Released January 14, 2016; Response Date: February 25, 2016
- Scope: Seeking input to inform topic areas for future STMD Tipping Point and Announcement of Collaborative Opportunity solicitations.