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

Center Management

Science & Technology Office

Flight Programs & Partnerships Office

Space Launch Systems Office

Daniel Schumacher, PhD
Manager

Corky Clinton, PhD
Deputy Manager

Jim Spann, PhD
MSFC Chief Scientist

Science Research Office
Jonathan Cirtain, PhD

- Earth Science
- Astrophysics
- Heliophysics & Planetary Science

Science and Space Technology Projects Office
Judy Ballance

- Science Instrument Mgmt
- X-Ray & Cryogenic Facility (XRCF)
- Chandra & JWST Management

Technology Development & Transfer Office
Mike LaPointe, PhD

- Game Changing Development
- Centennial Challenges
- Small Spacecraft Technology Development
- Technology Transfer

Center Management

Science & Technology Office

Flight Programs & Partnerships Office

Space Launch Systems Office
HAS OVER 55 PROGRAMS/PROJECTS IN ITS PORTFOLIO

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

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

Science & Technology Factoids
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.
Chandra X-Ray Observatory

Fermi Gamma-ray Burst Monitor

X-ray and Cryogenic Testing

Chandra Spots Oldest Light in the Universe 1.22.16

Advanced X-Ray Optics

SPoRT

New Mexico Wildfires and Soil Moisture Data 8.21.15

SERVIR Airds in Neapl Quake 5.4.15

Hurricane Imaging Radiometer

Lightning Imaging Sensor (ISS)

Servir

Space Weather Research

Sounding Rocket Investigations

Hinode Images Present a New Explanation of How Solar X-ray Jets Occur 8.31.15

SWEAP

HINODE

PI for NASA Lunar Flashlight

Finding Lunar Volatiles Using CubeSats

Providing the Formation Age of Rocks and Meteorites

MSFC Noble Gas Research Laboratory

NASA Lunar Flashlight
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
SmallSats

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-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

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

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

- **Injector**
  - Part Count (Approx): 6 vs. 255

- **MCC**

- **CCV** (Hidden)
  - Part Count (Approx): 1 vs. 5

- **MFV** (Hidden)
  - Part Count (Approx): 1 vs. 5

- **Mixer** (Hidden)
  - Part Count: 2 vs. 8

- **OTP**
  - Part Count (Approx): 41 vs. 80

- **OTBV**
  - Part Count (Approx): 1 vs. 5

- **Thrust Structure**

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

Push

Material Properties & NDE

Standards & Specs

Certification Rationale

Pull

Parallel & Congruent Activities

Building Foundational Additive Manufacturing Industrial Base

Payloads & Satellites

RP Engine

Methane Prop. Systems

Nuclear Propulsion

LPS Prototype Engine

RS-25

Upper Stage Engine

CCP

MPS Components
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

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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.