My STEM Career: Materials Engineering at NASA Marshall Space Flight Center

Tracie Prater, Ph.D.
Aerospace Engineer, Materials and Processes Laboratory
NASA Marshall Space Flight Center
Huntsville, AL

Kentucky Girls STEM Collaborative

About Me

Originally from Hazard, Kentucky

B.S. Physics from EKU
M.S., Ph.D. Mechanical Engineering from Vanderbilt

Previously worked as a materials engineer at United Launch Alliance (ULA)

currently an aerospace engineer in the Materials and Processes Laboratory at NASA Marshall Spaceflight Center

Then.....


KENNEDY SPACE CENTER
TRACIE


Living and working
on the new frontier of space

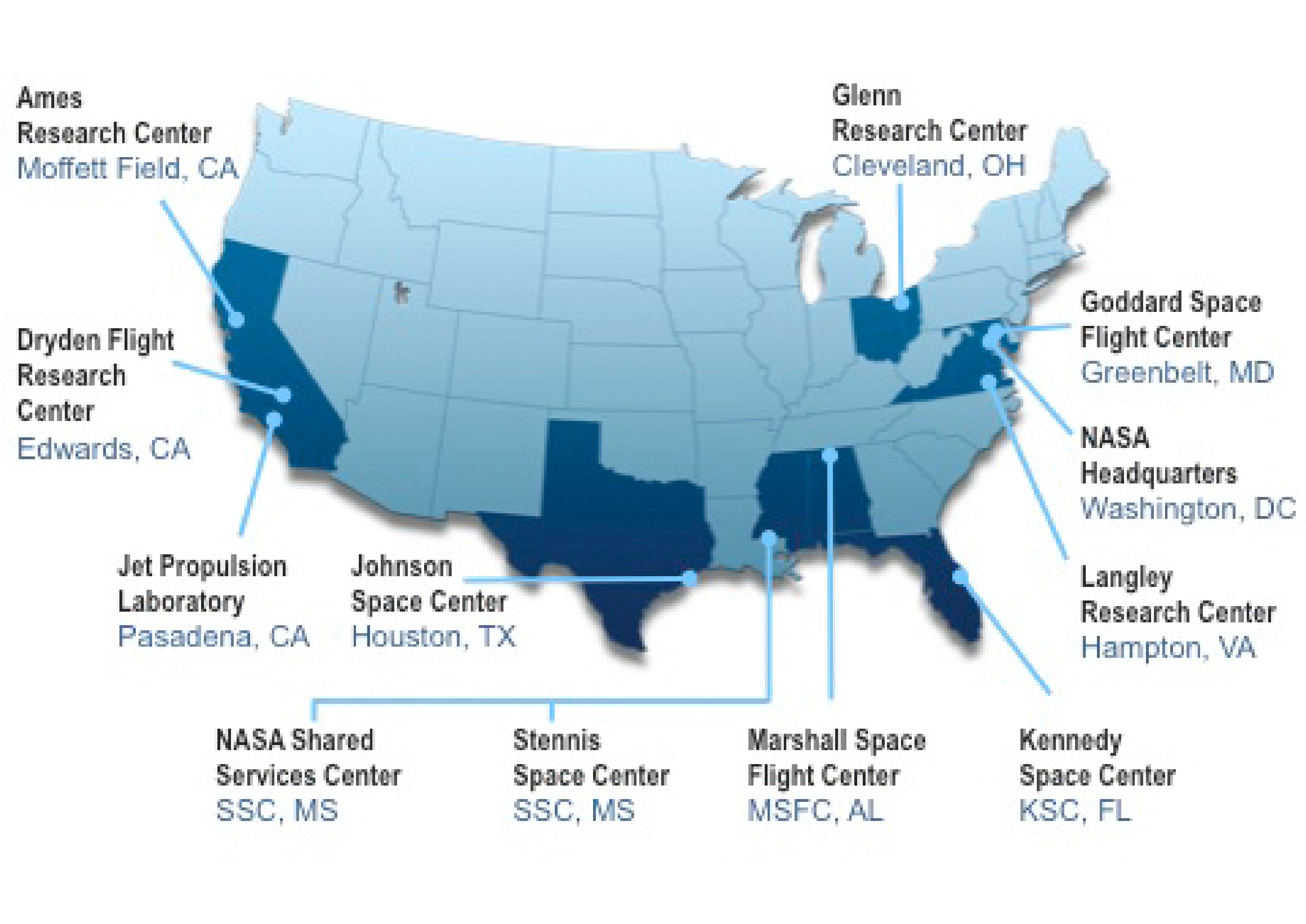
Now


FLIGHT DIRECTOR


HAROLD


GO ATLANTIS !
Space Flight Awareness
NASA

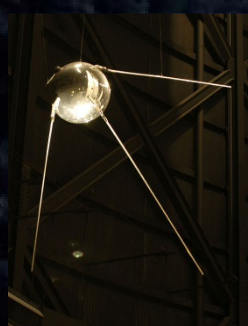
NASA Around the Country



A Brief History of NASA MSFC

1945 Project Paperclip

1950 German team moves to Redstone Arsenal to work for ABMA on development of Redstone Rocket



October 4, 1957
Sputnik launch

December 6, 1957
Vanguard explosion

January 31, 1958
Redstone Rocket puts Explorer I in orbit

A Brief History of NASA MSFC

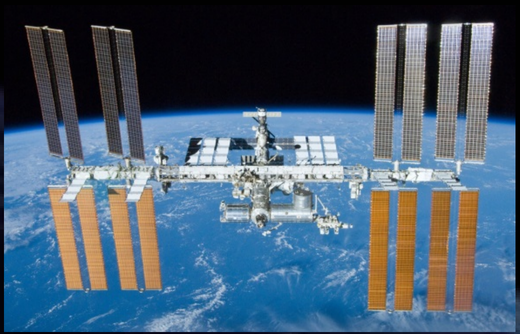
1960 Eisenhower signs act creating civilian space agency

1960-1972 MSFC develops Saturn V

1973-1979 Skylab

1981-2011 Space Shuttle

A Brief History of NASA MSFC



1998-present International Space Station

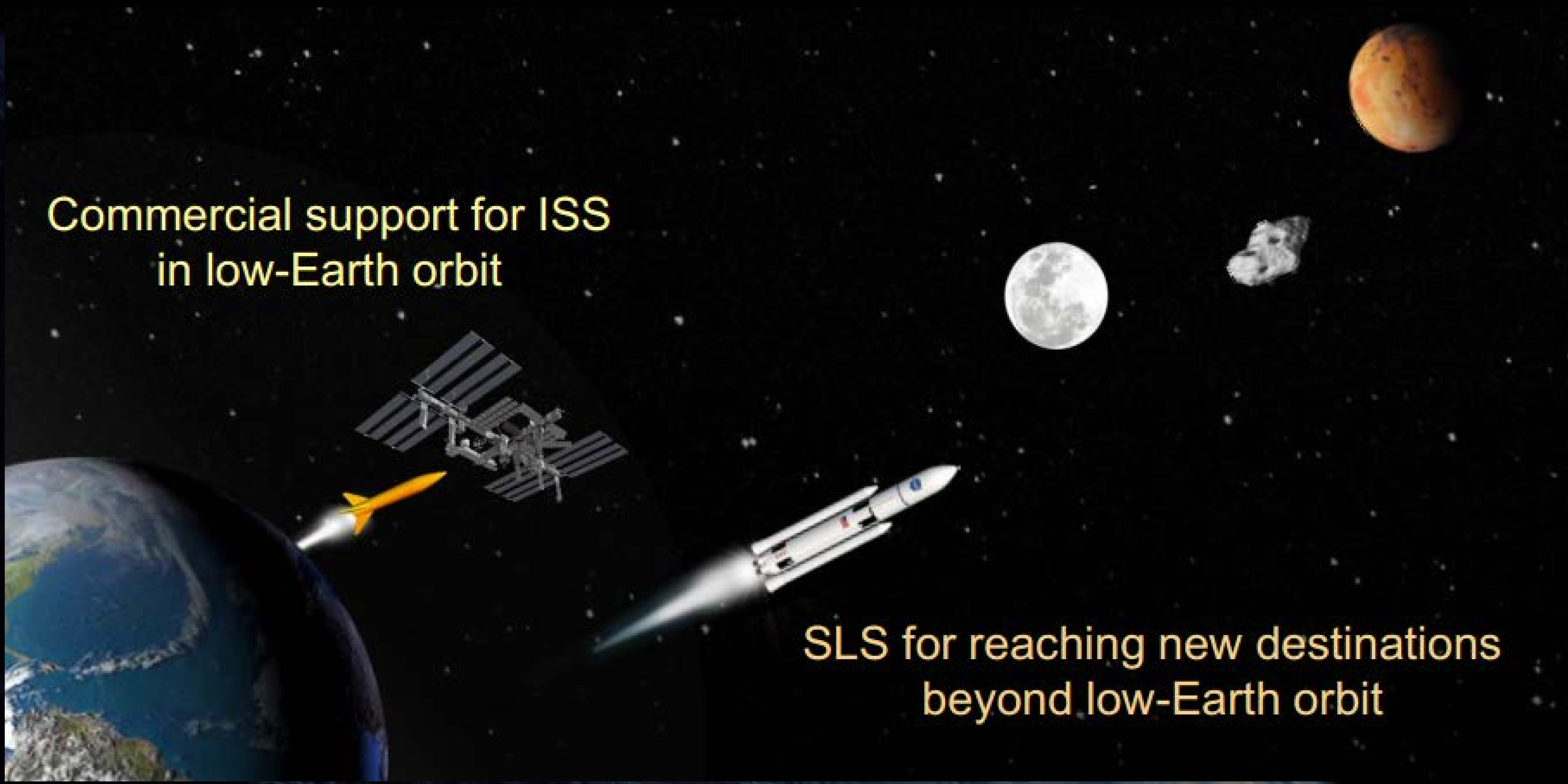
1990-present Hubble Space Telescope

Space Launch System (SLS)

James Webb Space Telescope

NASA's Four Core Mission Areas

Human Spaceflight Architecture



Space Launch System (SLS)

- Initial lift capacity of 70 MT, evolvable to 130 MT
- Carries the Orion Multipurpose Crew Vehicle (MPCV)
- First flight of SLS in 2017

Solid Rocket Booster Test

Friction Stir Welding for Core Stage

Shell Buckling Structural Test

MPCV Stage Adapter Assembly

Selective Laser Melting Engine Parts

RS-25 Core Stage Engines in Inventory

Materials Research Highlights at NASA MSFC

What materials are used for aerospace structures?

- Metals
  - -Aluminum
  - -Steel/stainless steel
  - -Titanium
  - -Magnesium
  - -Superalloys
- Ceramics
- Plastics/Elastomers
- Composites

Composite Cryotank

NASA needs an affordable, lightweight vehicle for greater payload capability to enable future exploration missions.

- Composite cryotanks could lead to rocket propellant tanks that achieve greater than 30% weight savings and 25% cost savings compared to the state-of-the-art metal tanks.
- Revolutionary manufacturing capabilities (automated fiber placement, out of autoclave cure) with innovative composite materials enable low cost, higher performance cryogenic tankage.

Friction Stir Welding

- Friction stir welding

-welding process that does not melt the material

-produces high-strength, defect-free joints

-completely robotic process

-used for almost all launch vehicle primary structures and habitable modules

-largest vertical weld tool ever constructed for SLS barrel panel welds at MAF



Friction Stir Welding at Michoud Assembly Facility for SLS



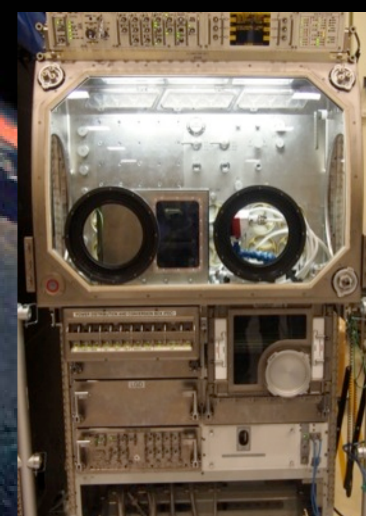
Additive Manufacturing

For Space

Near-Term

Long-Term

In-Space



Why Additive Manufacturing?

Affordability
-reduced part count
-fewer critical welds and brazes
-reduced tooling
-schedule and cost savings

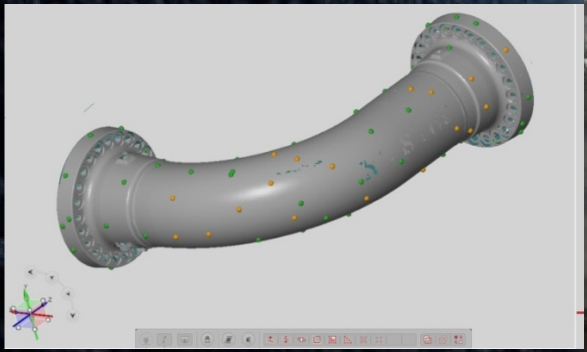
Performance
-Optimized internal flow passages
-Minimized leak paths
-Lower mass

Additive Manufacturing: Metals

- Propulsion components manufactured using Selective Laser Machining (SLM)

  atomized metal powder fused by laser

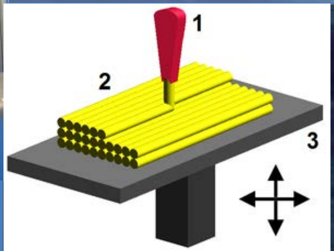
  -Inconel, Titanium
- Hot fire testing and burst testing for validation
- Immense potential to reduce cost and development life cycle for propulsion systems
- Uncertainty in how additively manufactured parts compare to conventionally manufactured counterparts
- MSFC’s role is primarily development of certification path and standards



3D Printing in Space

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

Potential Mission Accessories

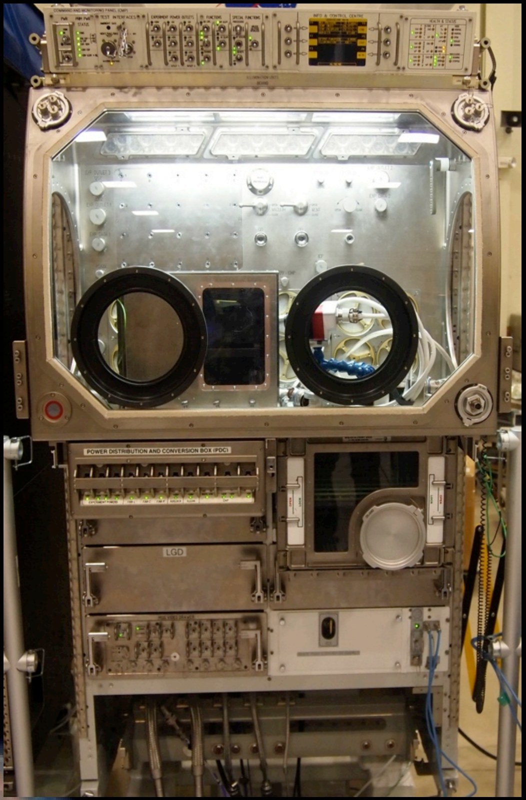


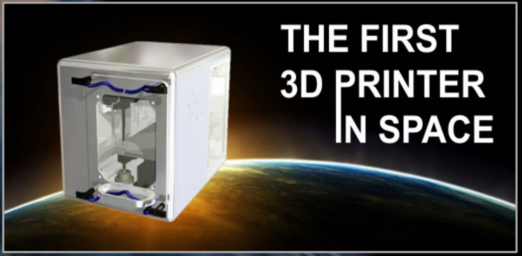
Melt deposition modeling:

1) nozzle ejecting molten plastic,
2) deposited material (modeled part),
3) controlled movable table

3D Print Specifications

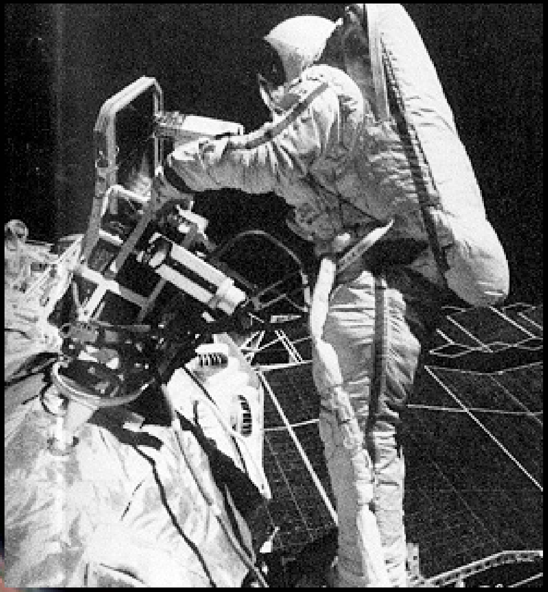
Dimensions	33 cm x 30 cm x 36 cm
Print Volume	6 cm x 12 cm x 6 cm
Mass	20 kg (w/out packing material or spares)
Est. Accuracy	95 %
Resolution	.35 mm
Maximum Power	176W (draw from MSG)
Software	MIS SliceR
Traverse	Linear Guide Rail
Feedstock	ABS Plastic



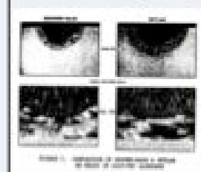
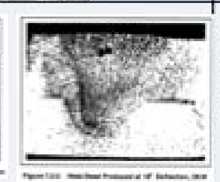
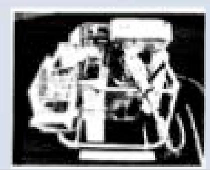


Materials Joining in Space

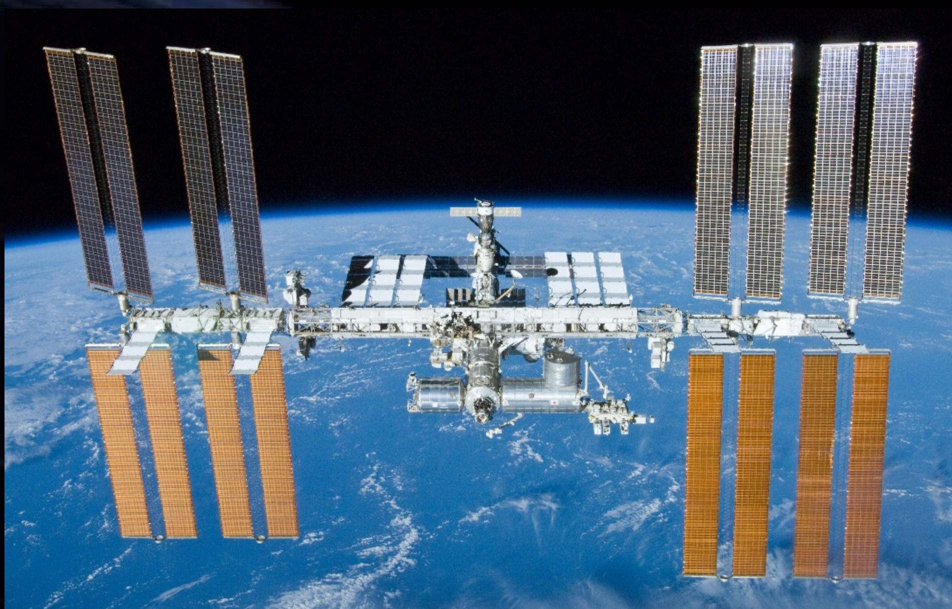
- Space structures are increasingly susceptible to micrometeroids and collisions with other hardware – current risk is low, but could be catastrophic
- Welding would enable a rapid repair capability and versatile means of on-orbit assembly
- Offers advantages over mechanical fasteners and adhesives:
  -reduced weight
  -improved mechanical properties
  -reduced stress concentrations
  -increased rigidity



A Brief History of In-Space Welding

Year	Activity	Country	Process	Vehicle	Images	Outcome
1969	Vulcan, Self-contained experiment	Russia	EB, Arc	Soyuz 6		First demonstration of on-orbit welding.
1973	M551 Materials Melting, Self-contained experiment	US/MSFC	EB	Skylab I	 	Demonstrated metallurgy of 2219-T87 welds in microgravity.
1984	First Manual Electron On-orbit Manual Weld	Russia/ Ukraine	EB	Salyut 7		Demonstrated concept and challenges of maintaining control during welding in a space suit.
1989	On-orbit Electron Beam Welding Experiment Definition	US (MSFC/ Martin Marietta)	EB	Ground Demo only	 	Demonstrated on-orbit repair concept, weld schedule, and 2219-T87 metallurgy utilizing beam deflection.
1990s	International Space Welding Experiment	US (MSFC)/ Ukraine (Paton Weld Institute)	EB	Space Shuttle (Not Flown)		Demonstrated safety challenges associated with manual EVA welding.
1995	Versatile Space Welding System Phase II SBIR	US (MSFC/ Electric Propulsion Lab)	Arc	Ground Demo Only		Developed Hollow Cathode Arc Weld System

A Vision of In-Space Manufacturing



-In-space fabrication and repair of plastics using 3D printing
-Qualification/inspection of on-orbit parts using structured light scanning
-Printable small satellite technologies
-On-orbit plastic feedstock recycling
-In-space metals manufacturing process demonstration
-Welding in space
-Additive construction using regolith

Questions

Tracie Prater, Ph.D.
Aerospace Engineer, Materials and Processes Laboratory
NASA Marshall Space Flight Center
tracie.j.prater@nasa.gov