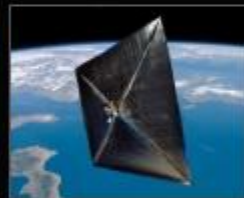




Industry 4.0 : How the New Interaction Between Man and Machine in Smart Factories Will Help Create More Intelligent Products in the Aerospace Industry

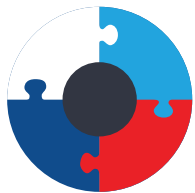
Aerospace Innovation Forum 2016

marshall





The National Additive Manufacturing Innovation Institute was launched in August 2012 as a result of President Obama's proposed need for a **whole-of-government advanced manufacturing effort.**



Mission: To accelerate the adoption of additive manufacturing technologies to increase domestic manufacturing competitiveness.



Funding: Five federal agencies - the Departments of Defense, Energy, and Commerce, the National Science Foundation, and NASA – jointly committed to invest \$45 million.

NASA contributes subject matter experts, meaningful data, and use of select facilities.

National Maker Faire June 18-19



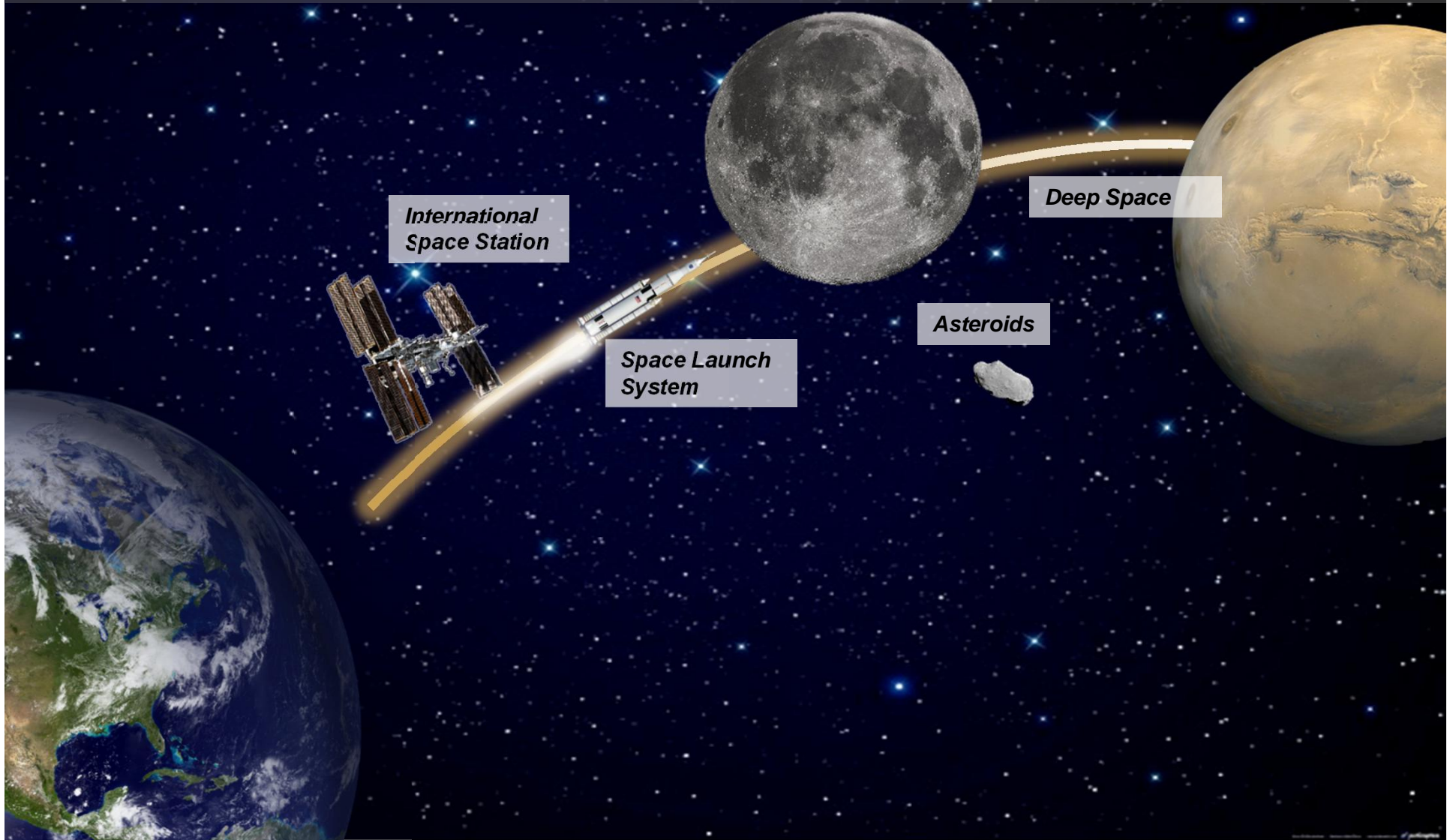
National Week of Making June 17-23

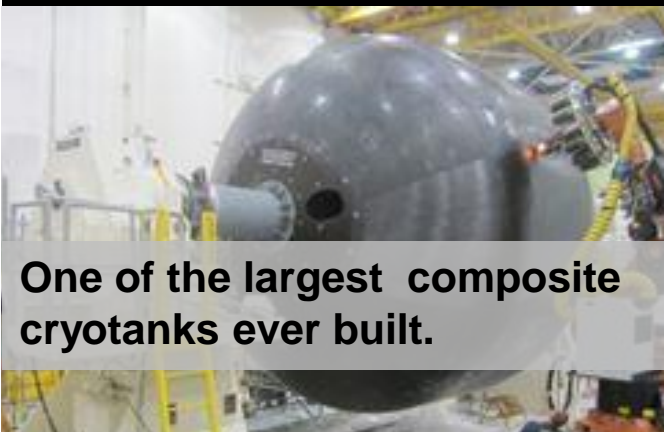
- **NASA's Role in Advanced Manufacturing**
- **In Space Manufacturing Initiative (ISM)**
- **For Space Manufacturing:**
 - **Additive Manufacturing of Liquid Rocket Engine Components**
 - **Additive Manufacturing's Role in the RS-25 Affordability Initiative**

EARTH RELIANT

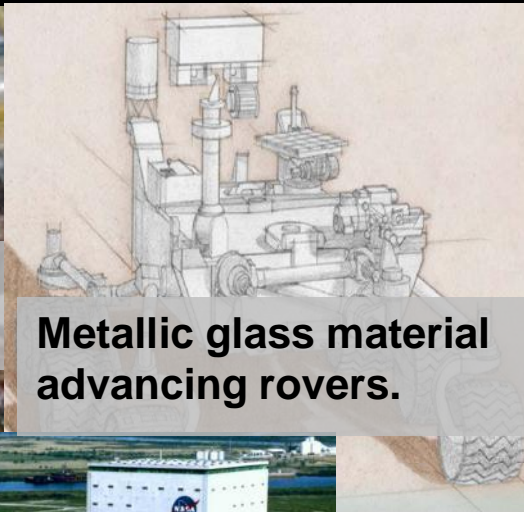
PROVING GROUND

EARTH INDEPENDENT

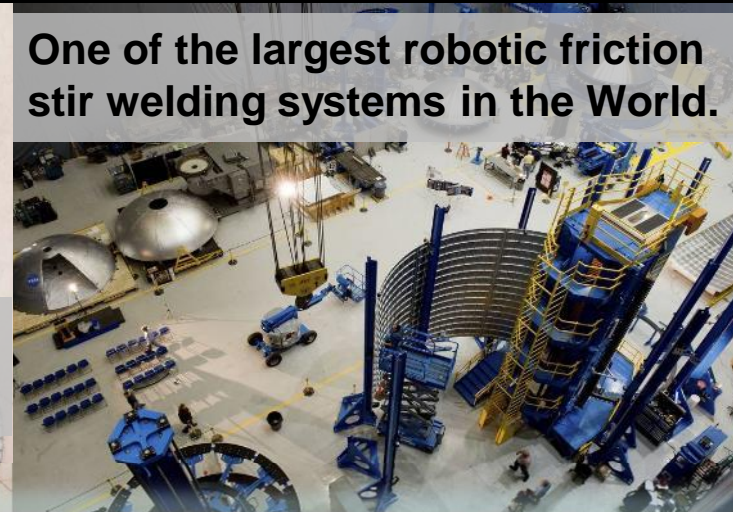




One of the largest composite cryotanks ever built.



Metallic glass material advancing rovers.



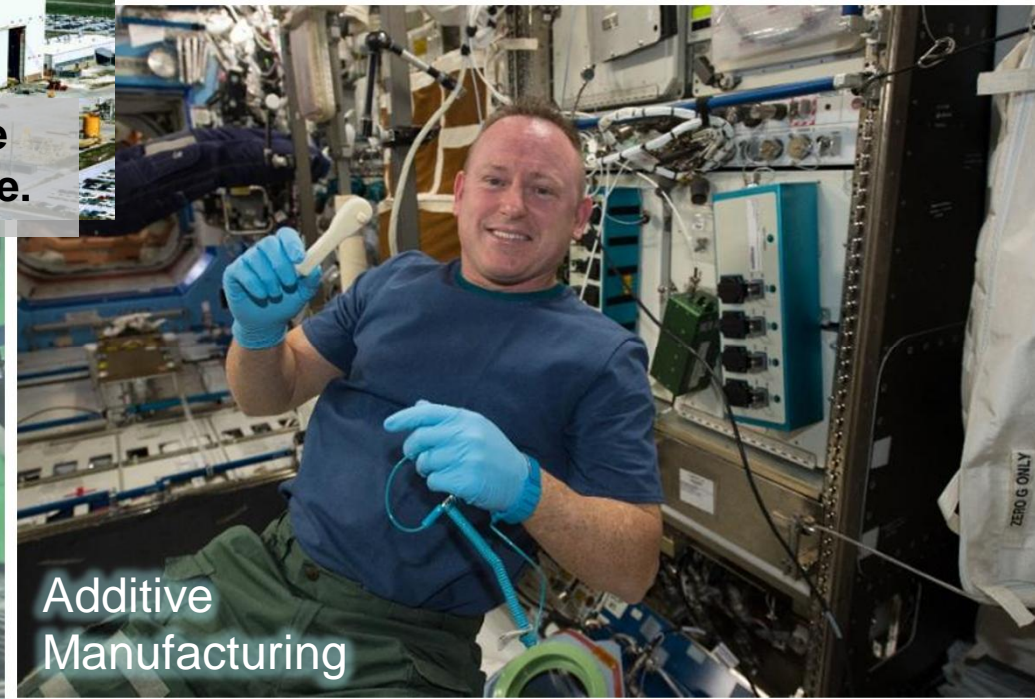
One of the largest robotic friction stir welding systems in the World.



Michoud, 43-acre facility remains one of the biggest manufacturing facilities in existence.

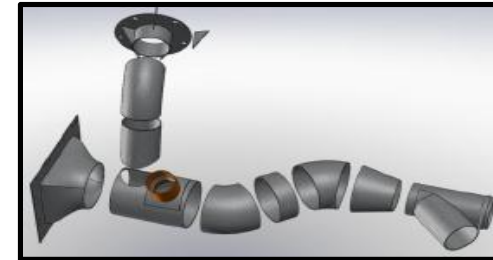


Woven composite materials provide advanced thermal protection.

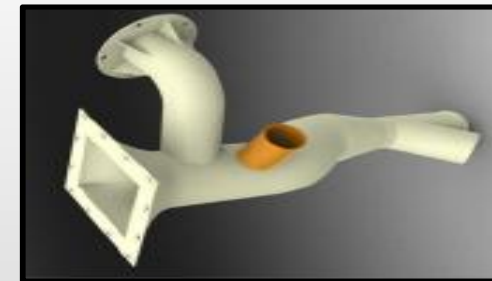


Additive Manufacturing

- Enables Mass Production and Customization
- Rapid Manufacturing: Tool-less, Extreme Cycle Time Reductions
- Enables complex designs and unitized structures
- Weight removal increases mission capabilities, saves fuel costs



Traditional Part:
*19 aluminum parts
welded together*



**Additive
Manufacturing Part:**
*1 part
30 % weight reduction
Cost and lead time
reductions*

What Was
Returned

Command
Module

Fourth Stage

Third Stage

Second Stage

First Stage

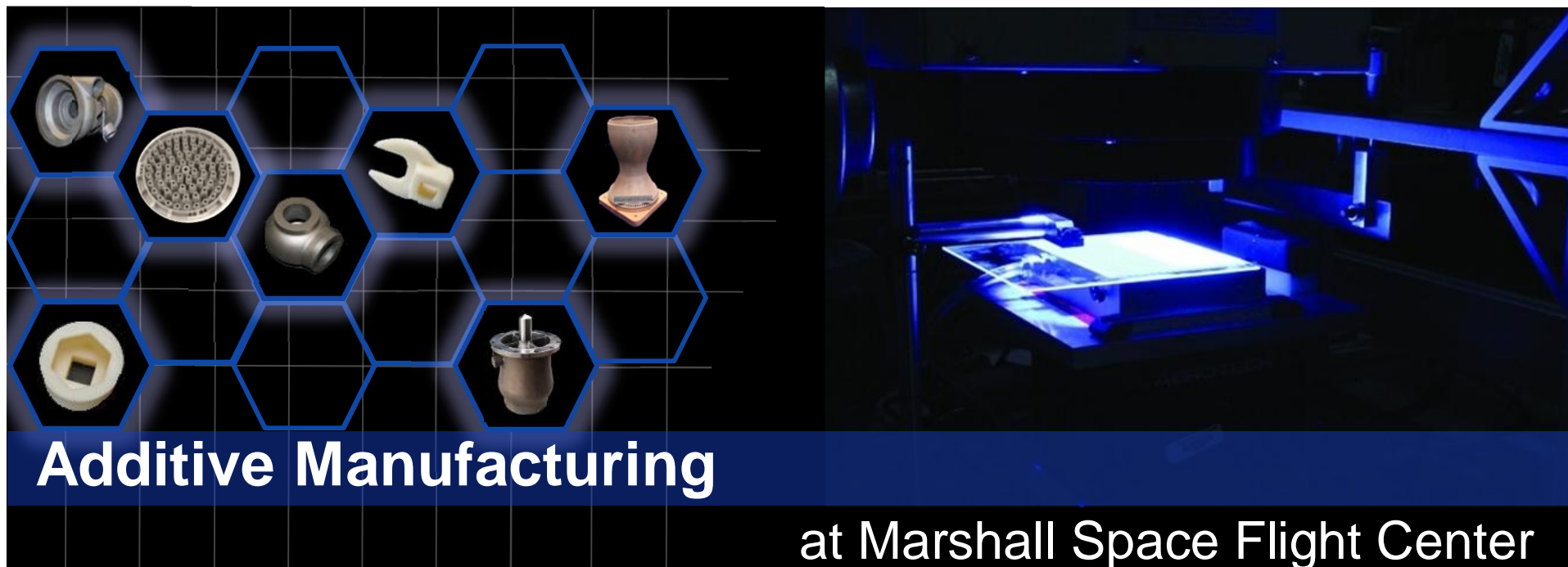
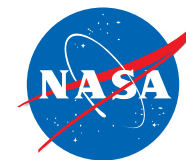
Diameter: 33 ft

Car

SATURN V

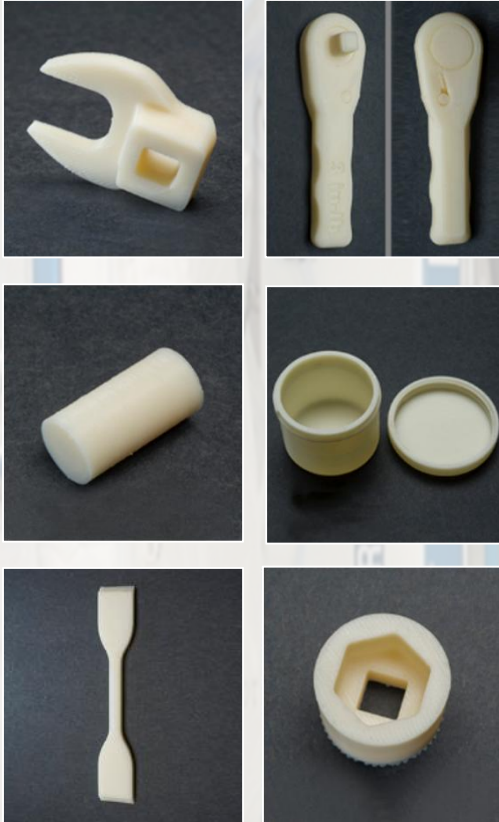
- 6.6M lbs sat on the launch pad.
- But only 12.8K lbs came back.

This is equivalent to taking a road trip in a car and coming back with just the wheels!



In Space Manufacturing Initiative

Functional Tools



To date, 21 parts have been printed.

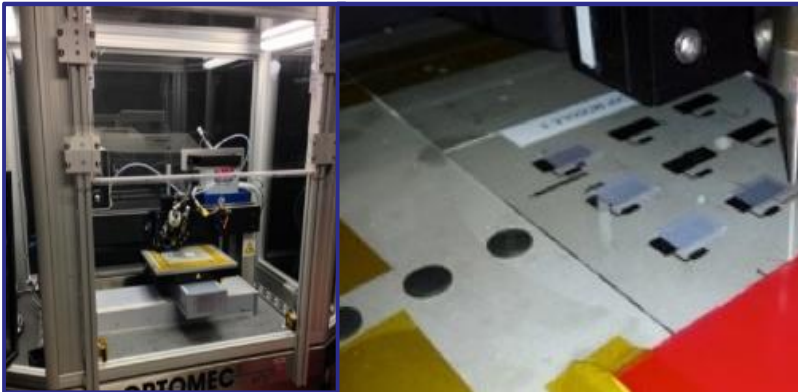


Ranked #1 in Top Ten Ways ISS is Helping NASA Get to Mars



In-space Recycler ISS Tech Demonstration Development

Phase II SBIR was awarded to Tethers Unlimited for a proposed ISS Tech Demo in 2017



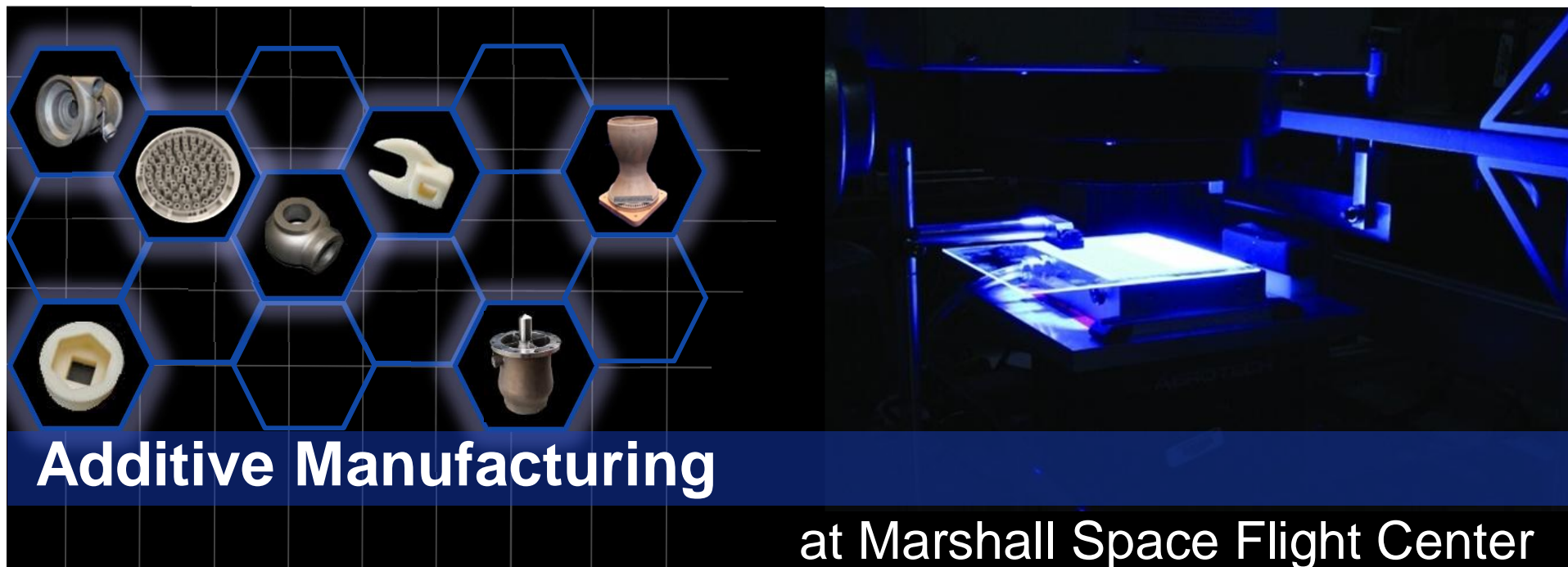
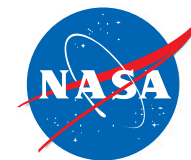
In-space Printable Electronics Technology Development

SBIR with Xerox Palo Alto Research Center (PARC), and NASA Ames Research Center, targeting future ISS Tech Demo.

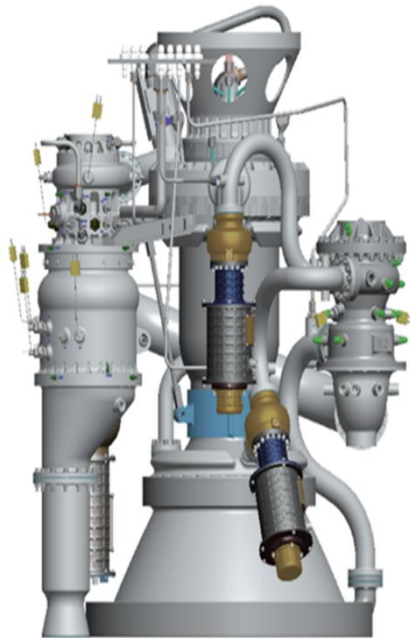


ACME - Additive Construction by Mobile Emplacement

Joint initiative with the U. S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL) Automated Construction of Expeditionary Structures (ACES) Project



Advanced Manufacturing Demonstrator - Liquid Propulsion System and Low-Cost Upper Stage Propulsion Project



Typical Engine Developments	Prototype Additive Engine
DDT&E Time	
7-10 Years	2-4 Years
Hardware Lead Times	
3-6 Years	6 Months
Prototype Costs	
\$20-50Million	\$3-5Million

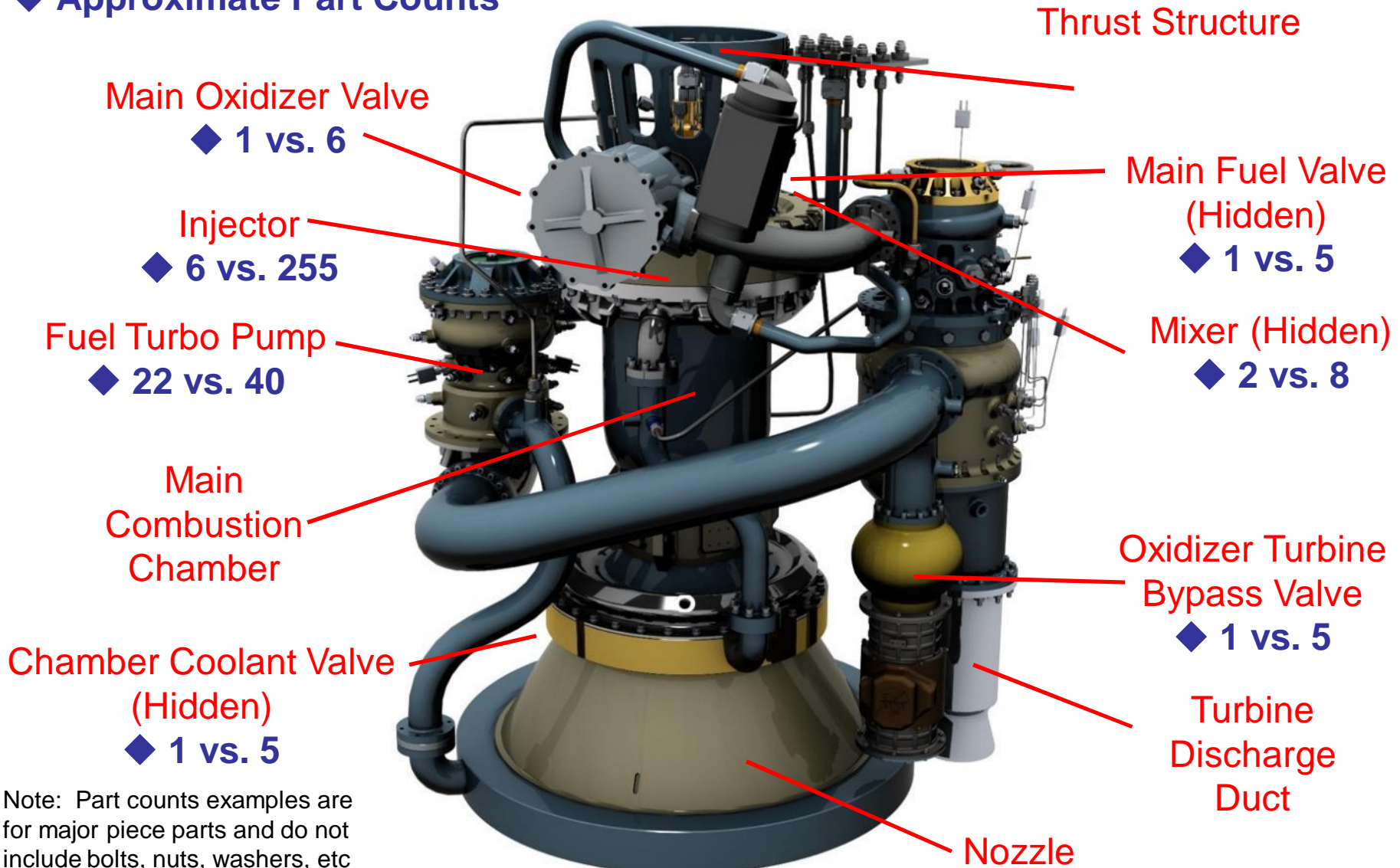


Partner with industry to design and manufacture engine parts.

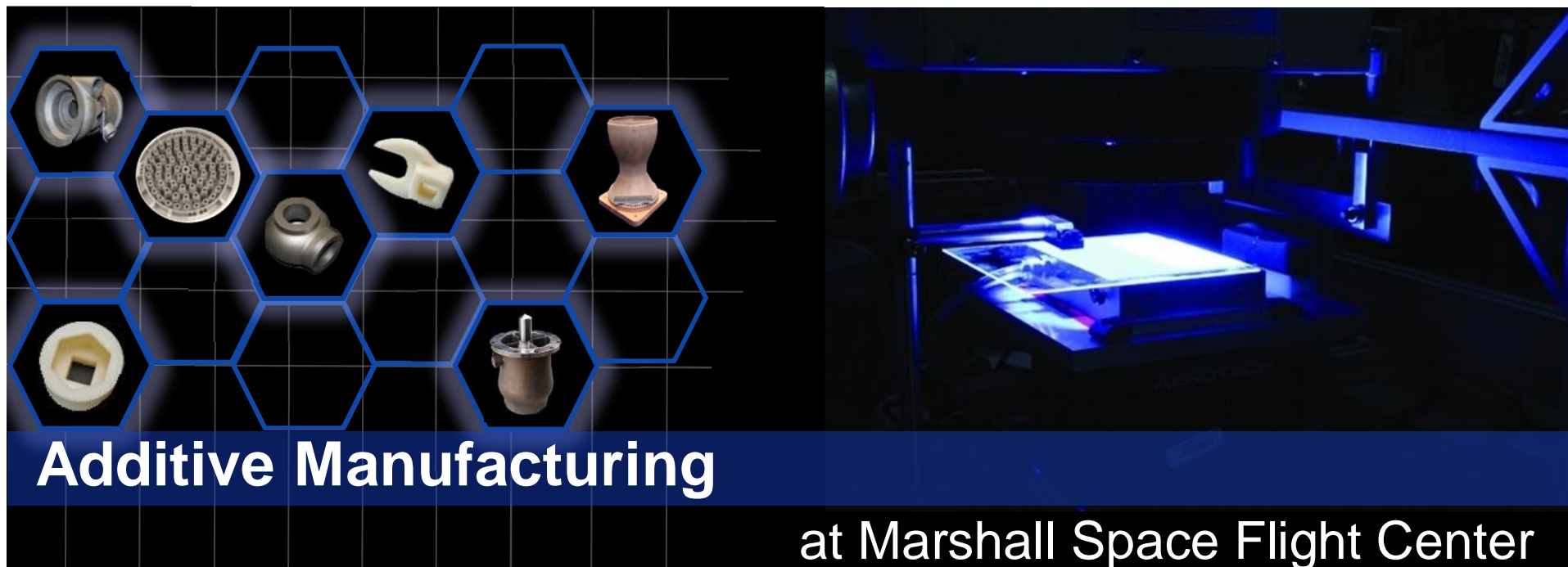
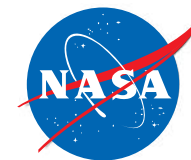


Transferring Material Property Data & Technology to U.S. Industry.

◆ Approximate Part Counts



Note: Part counts examples are for major piece parts and do not include bolts, nuts, washers, etc



RS-25 Affordability Initiative – Additive Manufacturing's Increasing Role



**33% Reduction in
Engine Cost**

**>700 Welds Eliminated
>700 Parts Eliminated**

**35 AM Opportunities
Identified for RS-25**

Working
With **AEROJET
ROCKETDYNE**



*“It is difficult to say
what is impossible,
for the dream of
yesterday is the
hope of today, and
the reality of
tomorrow.”
Robert H. Goddard*



www.nasa.gov