
National Aeronautics and Space Administration
NASA
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Ares I Upper Stage Manager
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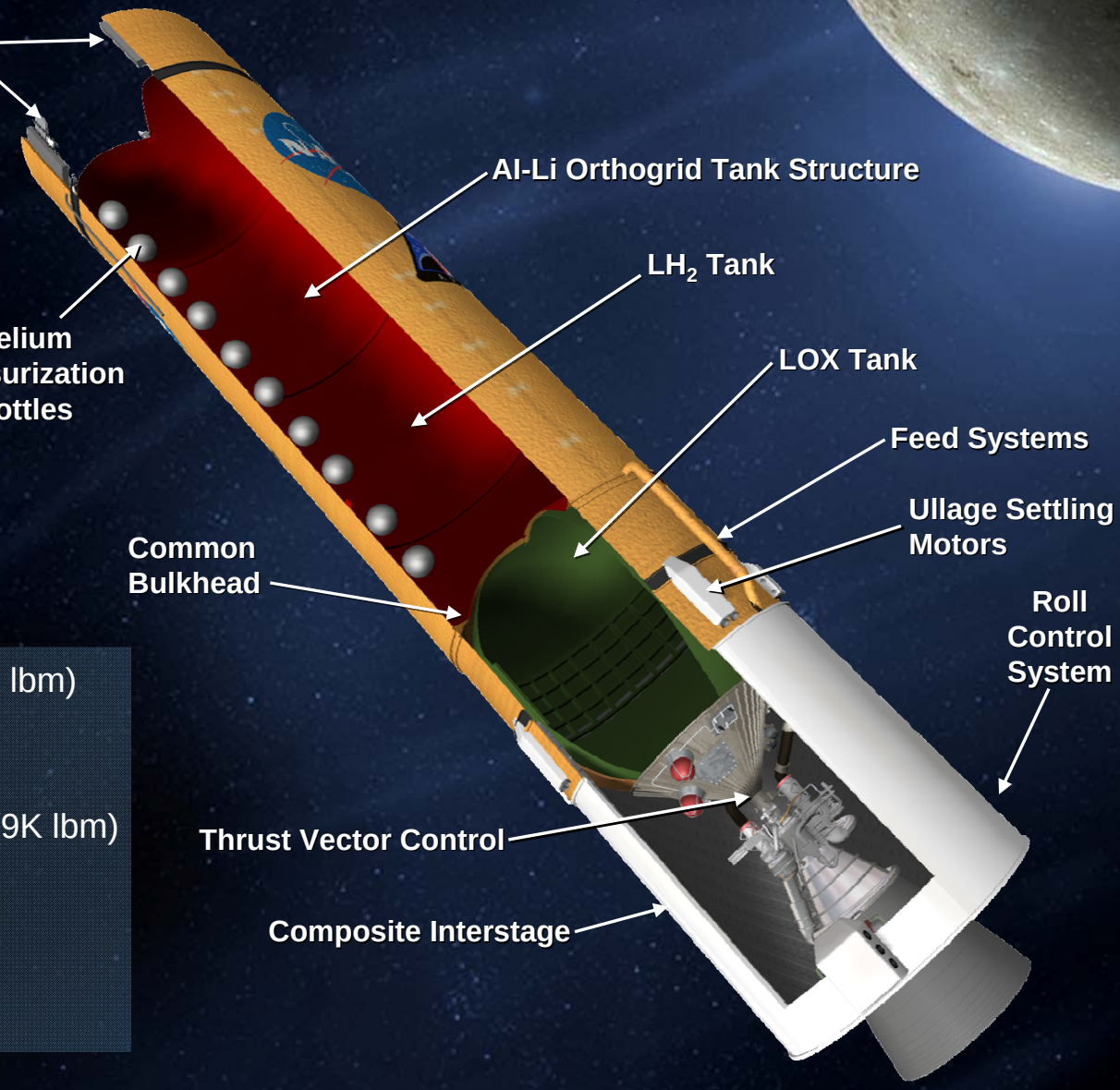
Ares I Upper Stage Update
www.nasa.gov

Upper Stage (US)

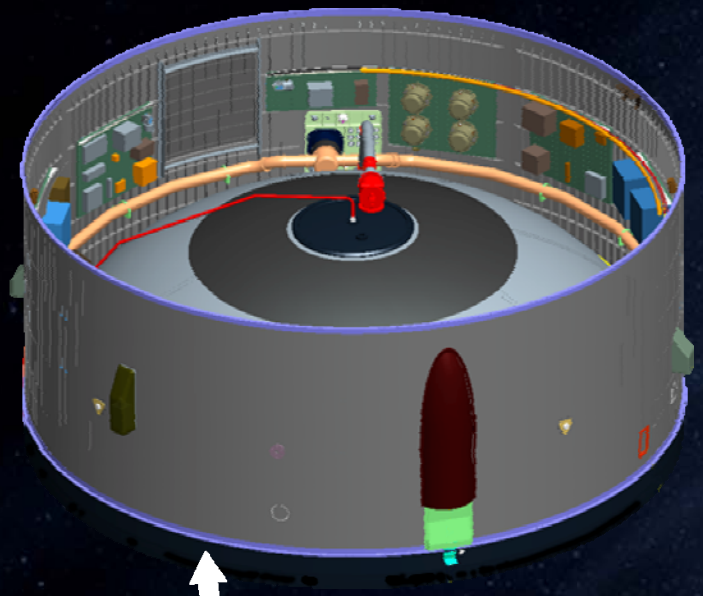


NASA Design Team

BOEING

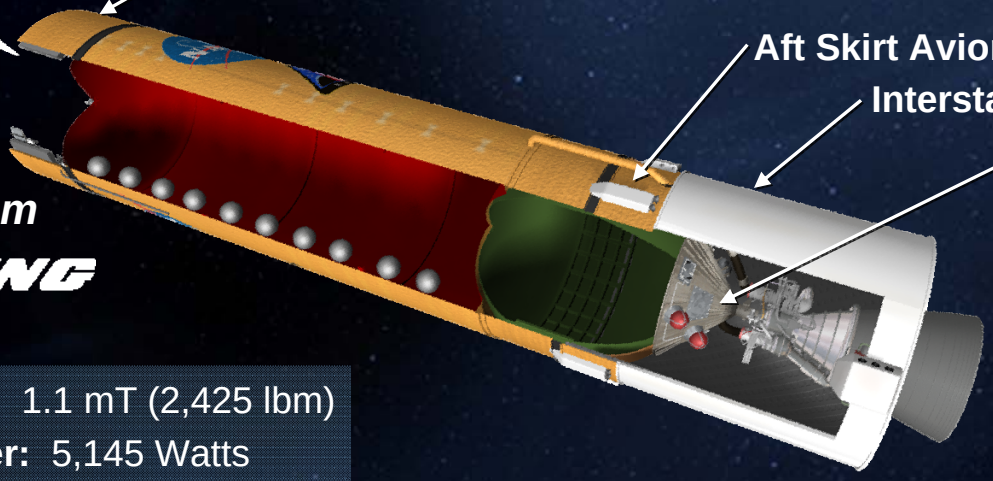
Propellant Load: 138 mT (304K lbm)
Total Mass: 156 mT (344K lbm)
Dry Mass: 16.3 mT (36K lbm)
Dry Mass (Interstage): 4.1 mT (9K lbm)
Length: 25.6 m (84 ft)
Diameter: 5.5 m (18 ft)
LOX Tank Pressure: 50 psig
LH_2 Tank Pressure: 42 psig

US Avionics



The Upper Stage Avionics will provide:

- **Guidance, Navigation, and Control (GN&C)**
- **Command and data handling**
- **Pre-flight checkout**



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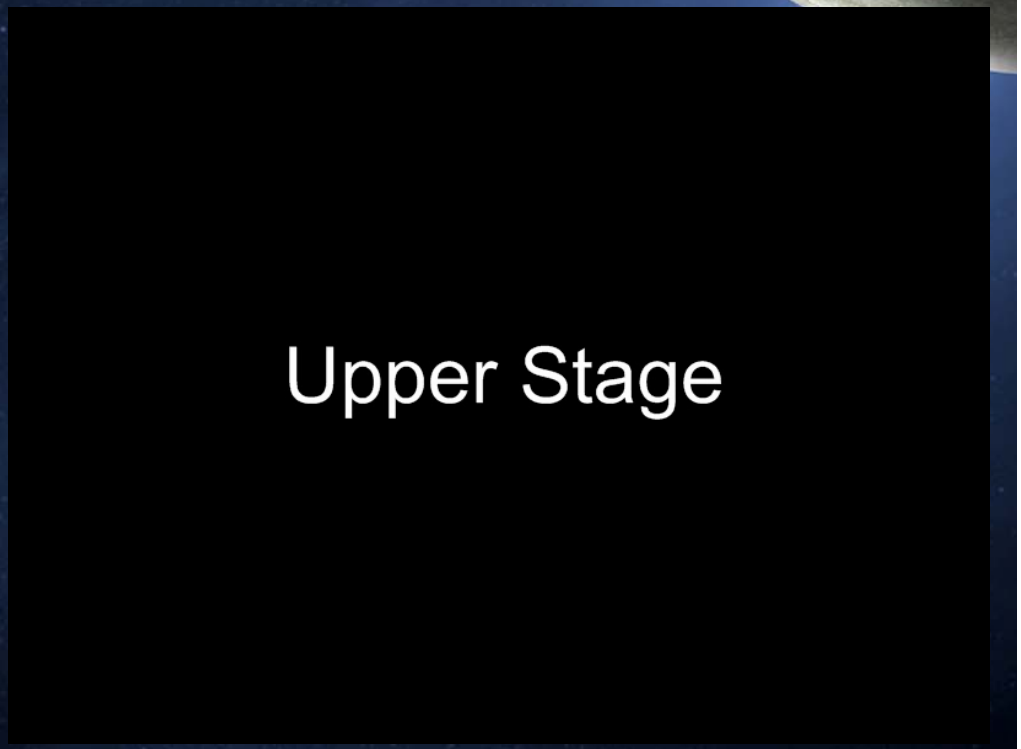
BOEING

Avionics Mass: 1.1 mT (2,425 lbm)
Electrical Power: 5,145 Watts

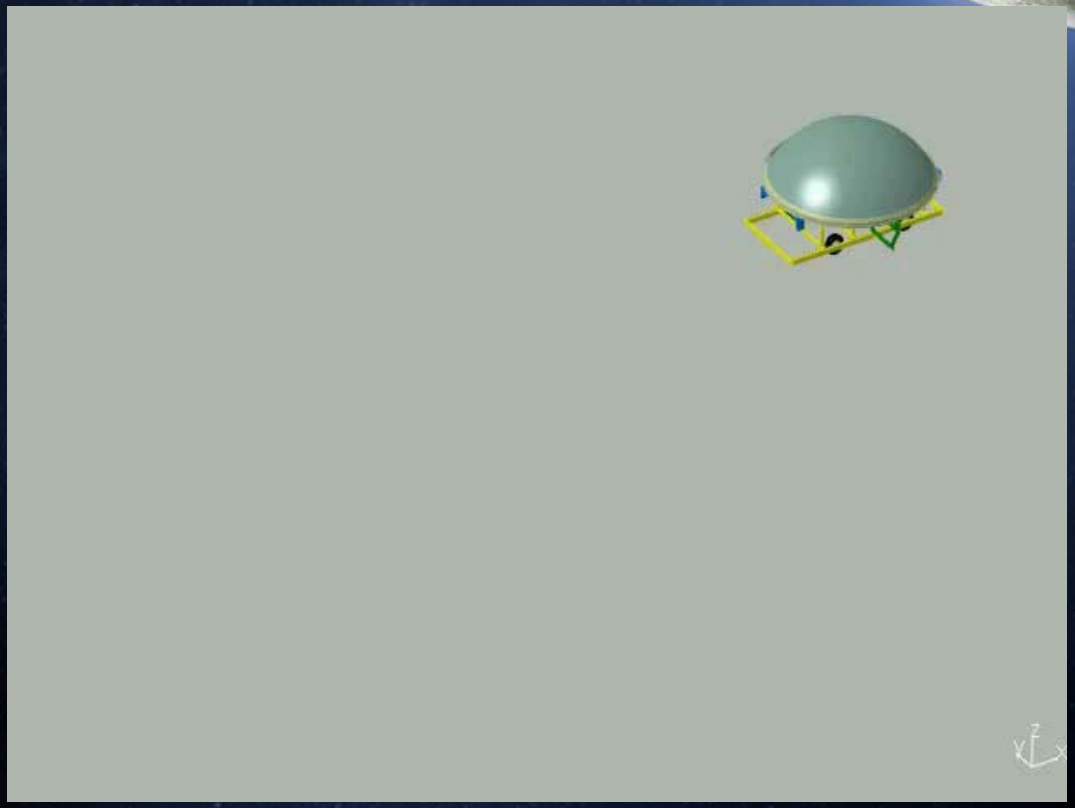
What Progress Have We Made?

- **Programmatic Milestones**
  - Upper Stage Safety Reviews
    - Constellation Safety and Engineering Review Panel reviews
  - Upper Stage Design Reviews
    - System Requirements Review
    - System Definition Review
    - Preliminary Design Review
  - Contracts awarded
    - Upper Stage Production
    - Instrument Unit Acquisition
- **Technical Accomplishments**
  - 3D Model-Based Design and Production
  - System and Process Development
    - Manufacturing
    - Avionics and Software
  - Advanced Component Development
    - Main Propulsion Systems
    - Thrust Vector Control Systems
    - Reaction Control System
    - Structures and Thermal Systems
    - Ullage Settling Motor Systems



3D CAD Model-Based Design and Production

- **CAD Model Standard**
  - Single source of engineering
  - Interface management
  - Electronic design, checking and release
- **3D Models and DELMIA software support Production**
  - Tooling Design
  - Process development
  - Electronic floor instructions
  - Supports Boeing Manufacturing Execution Software



PROCESS AND SYSTEM DEVELOPMENT

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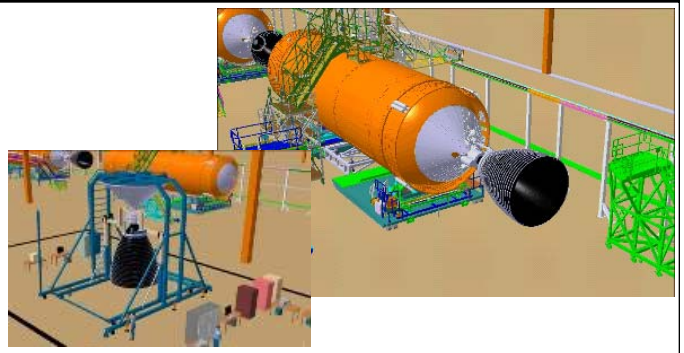
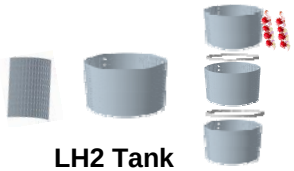
Manufacturing and Process Development

Boeing selected as Production Contractor
- Manufacturing Value Stream Mapping
- Producability Summits
- Virtual Design Reviews
- Support Component Specification development
- Tooling Design for MAF
- Support for MSFC Manufacturing

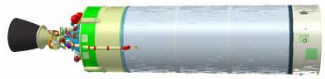




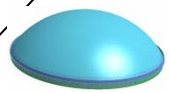
LH2 Tank

LOX Tank

Vertical Tank Assembly



Final Assembly & Integration



Common Bulkhead

Common Test Cell

VSM Metrics	
NASA Baseline	420 days
Merged VSM	320 days
With learning	<300 days

Critical Path

125.00 J2X 5.50 → TC 34 (G1) → TC 120 9.5 (G2) → CTC 110 14

177.63 ASB 32.63 → AS 145 35 → CTC

225.75 IUB 18.75 → IU 24 (G1) → IUAC 60 → IU 123 13 (G2) → CTC

217 HB1, 217 HB2, 217 HB3 → VTWB 11.00 (G1) 12

213 FD 31

246 AD 39.5

232.75 LTB 19.00 (G2) → LTB 7.00 (G1) → VTWA 5 (G1) → 201.75 VTWA 7.75 (G2) → VTWB 12.00 (G2) → 182 VTWA 6 (G3) → HT 11.5 (G1) → HT 45.5 (G2) → HT 23 (G3) → 96 INT 7 (G1) → INT 11 (G2) → INT 7.5 (G3) → INT 33.5 (G4) → INT 37 (G5)

312.50 OFD 12.75 → CB 32 (G1) → CB 66 (G3)

288.50 HAD 12.75 → CB 8 (G2) → CB 66 (G3)

84 TN 13 → 84 IS 46.5

Boeing, Working with NASA, Reduced Assembly Flow Over 100 days

Weld Tool Development

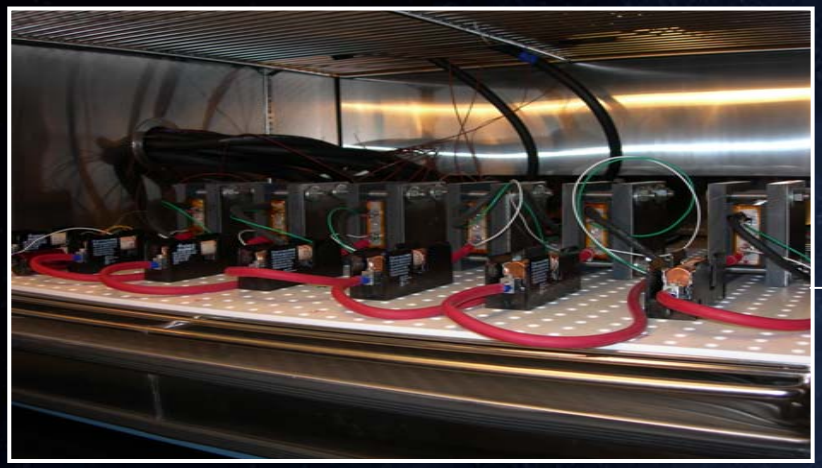
Robotic Weld Tool

Friction Stir Weld (FSW) of two sample Space Shuttle External Tank domes gores

- **Manufacturing Demonstration at MSFC**
  - Dome Development
  - Common Bulkhead Fabrication demonstrations
  - Barrel Panel Development
  - Thermal Protection System (TPS) Development
- **The Robotic Weld Tool, the largest welder of its kind in the United States, will be used to develop the manufacturing techniques required to fabricate the tanks of the Ares I US.**

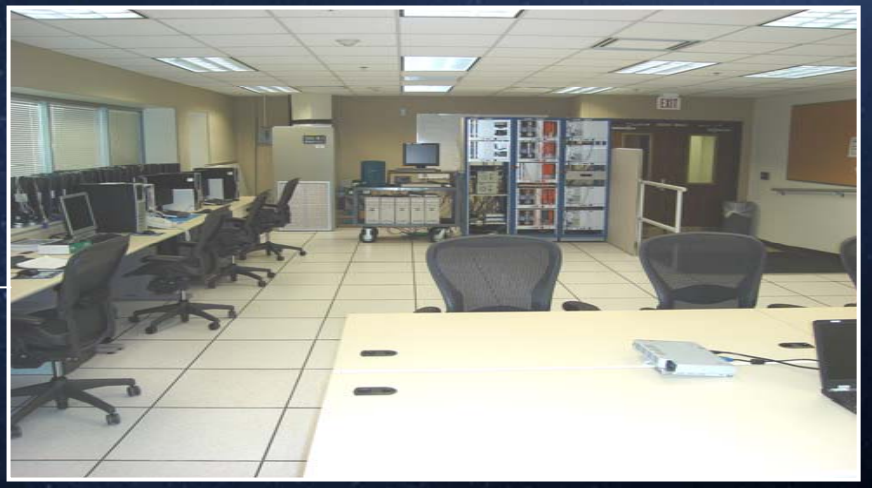
Vertical Weld Tool

US Avionics and Software Development



Lithium-ion Cell Testing

These tests are being performed to provide data in support of thermal model development for the battery assemblies.



US Flight Software Development Facility

Software Development Facilities for US Flight Software (FSW) for Flight Computer and Command/Telemetry Computer.

US Risk Reduction Laboratory

Four upgraded Network Element Cards were successfully integrated into a quad-voting architecture computer test bed and run through initial boot and built-in-test for the US Risk Reduction Laboratory.

Logistics and Operations Systems

- **Integrated Logistics supports Design Process**
  - Supportability Analysis for each design cycle
- **Human Engineering Analysis developed**
  - Physical Mock-Ups in place and used for analysis
  - Digital Mock-Ups developed
- **Maintenance Concepts developed**
- **Availability and Cost Models developed**

Facility and Transportation Systems

Digital Mock Up

Design Demonstration Units – IU and Aft Skirt

COMPONENT DEVELOPMENT

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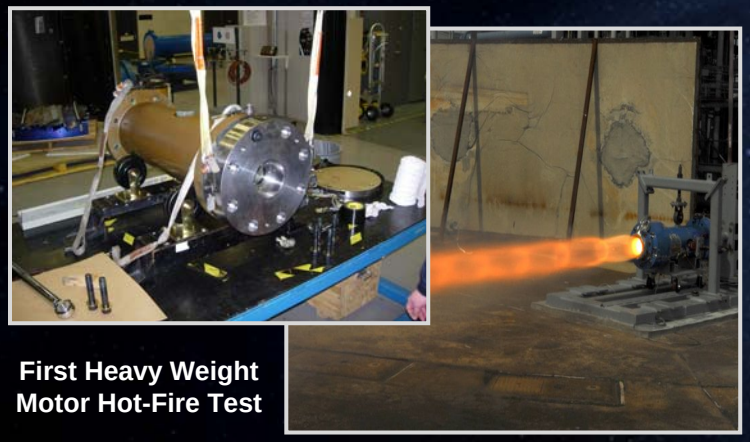
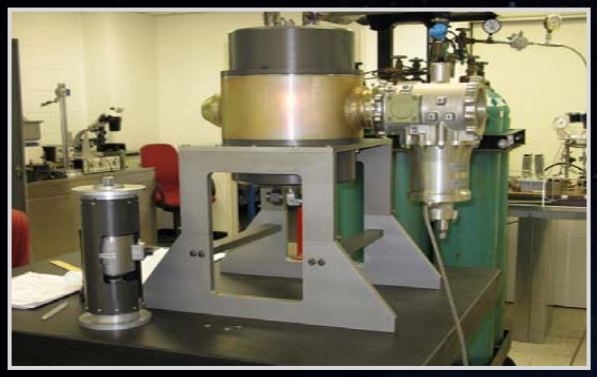
Advanced Component Development

- **Advanced Development Activities**
  - Ullage Settling Motors (Heavy Weight Motor Test, Igniter Test)
  - MPS (Cryogenic-Regulator, Pre-valve, and Vent /Relief Valve Test)
  - TVC (Bread-board system test and full 2-axis Rig Testing)
  - RCS (Thrusters, valves, regulators, and Integrated Test)
  - Structures (Panel Test, Integrated Test, Thermal and Purge)



First Heavy Weight Motor Hot-Fire Test

TVC Breadboard and 2 Axis Rig



MPS Pre-Valve on the Test Stand

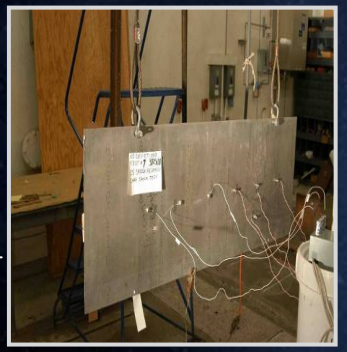
RoCS Thruster Valve

Current US Development Testing

Forming test on 52” x 52” Orthogrid and Isogrid panels
Results demonstrated the ability to form AL-Li panels to the US diameter

Small panel buckling tests
Used to anchor analytical modeling techniques

Shock Characterization
Used to improve prediction of separation shock transmission



Purge and Haz Gas Testing (GRC)
Used to improve modeling of the purge system

Range Safety Linear-Shaped Charge (LSC) testing
Determined correct standoff for best tank wall cut depth; Determines how LSC is mounted in Systems Tunnel

Umbilical Plate Testing (KSC)
Quick Disconnect performance at anticipated rotational angle; Results of the test showed the need to modify the ground side of the umbilical plate

Ares I Upper Stage Summary
PMR 08 Rev 1 Re-Plan Preliminary

	FY07	FY08	FY09	FY10	FY11	FY12	FY13
Design							
Mfg Process Develop/Demo							
Mfg Demo			CB Complete				
CB Mfg Demo				Proof Test & NDE			
CB Dev Art / Test							
Engine Delivery					✓ISTA	✓Orion-1	✓Orion-2
MAF Construction/Activation							
Long Lead / Fab Test Stage @ MAF / Testing at MSFC							
Long Lead / US-00 (Orion) M&A / TT							
Long Lead / US-01 (Ares 1-Y) M&A							
Long Lead / US-02							
US Milestones	US SRR	USPC Award, US SDR	IUAC Award, US PDR		US CDR		(Ares 1-Y) M&A, Ares 1-Y

Shift from MSFC to MAF

USP/AP provides first Flight Design at MAF

Ares 1-Y US-00 on Dock @ KSC

Conclusion

- **Building on the heritage of the Apollo and Space Shuttle Programs, the Ares I US team is utilizing extensive lessons learned to place NASA and the United States into another great era of space exploration**
  - Engineering Rigor
  - Materials and Processes
- **The NASA Design Team is using the best from the past along with State of the Art Engineering and Manufacturing Processes**
  - Advanced 3D Model-Based and Production
  - Lean Manufacturing Techniques
- **NASA and Boeing US teams are now integrated, working together, and making good progress**
  - Safety First
  - Performance
  - Affordability

"This Nation has tossed its cap over the wall of space, and we have no choice but to follow it."

-- President John F. Kennedy, 1962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