Danny Davis
Ares I Upper Stage Manager
October 21, 2008

Ares I Upper Stage Update
Upper Stage (US)

**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
**LH₂ Tank Pressure:** 42 psig

**NASA Design Team**

**Boeing**

**Instrument Unit**
- Modern Electronics

**Al-Li Orthogrid Tank Structure**

**LOX Tank**

**LH₂ Tank**

**Feed Systems**
- Ullage Settling Motors

**Roll Control System**
- Thrust Vector Control
- Composite Interstage

**Helium Pressurization Bottles**

**Common Bulkhead**

**DAC 2 TR 6**
National Aeronautics and Space Administration
The Upper Stage Avionics will provide:
• Guidance, Navigation, and Control (GN&C)
• Command and data handling
• Pre-flight checkout

US Avionics

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

Ares I Upper Stage
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

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

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

♦ 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.
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

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.
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

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

Shock Characterization
Used to improve prediction of separation shock transmission

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

Small panel buckling tests
Used to anchor analytical modeling techniques

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

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**

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<td>Testing at MSFC</td>
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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
www.nasa.gov/ares