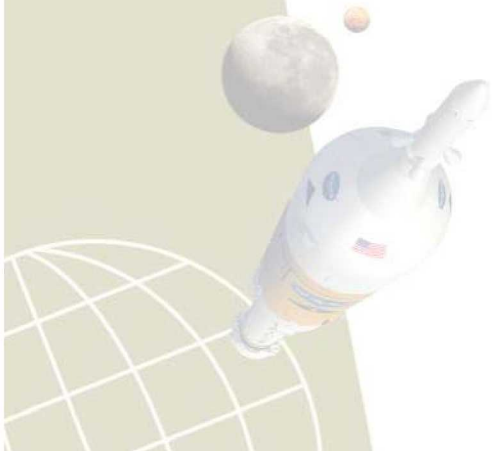
Ares I First Stage: Powering Exploration

Bruce K. Tiller
Ares First Stage Deputy

Agenda

- Introduction
- Schedules
- First Stage Progress to Date

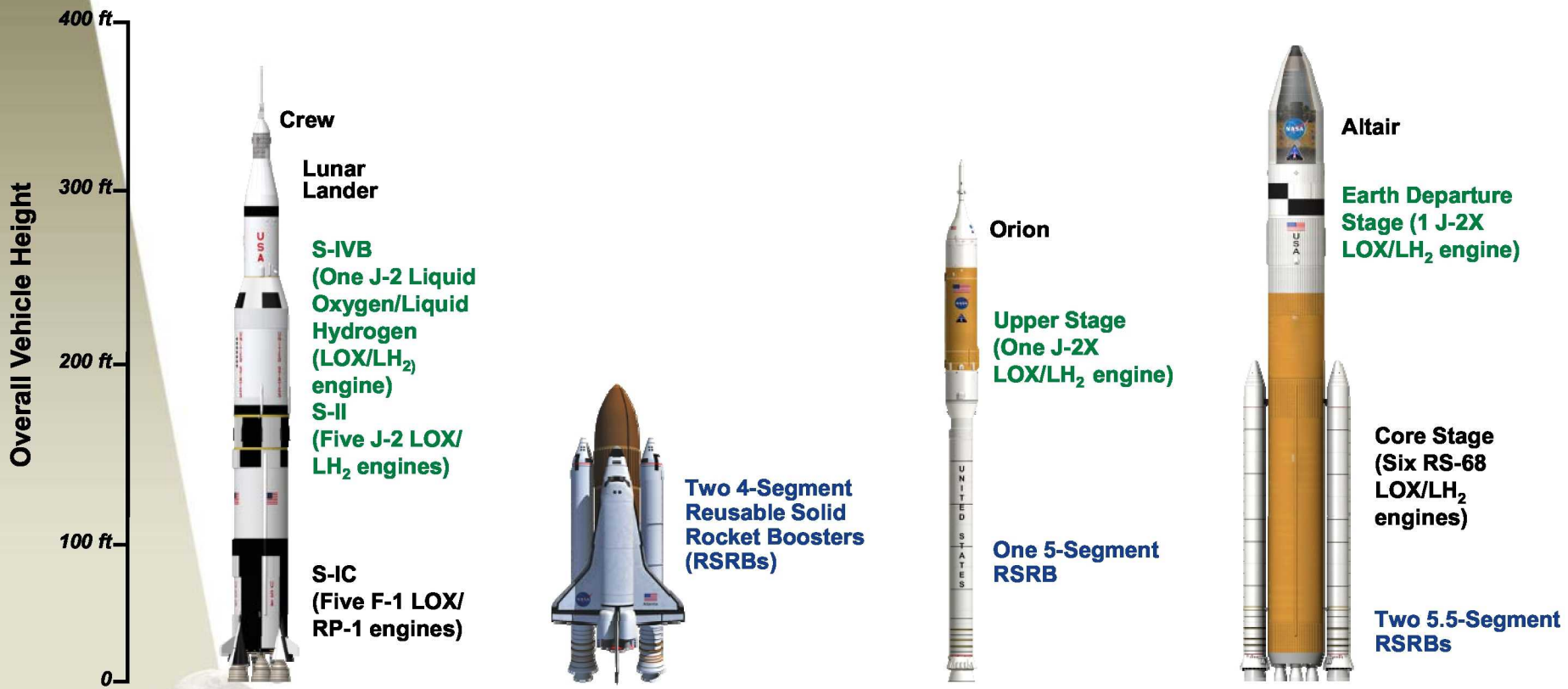


Ares Family of Launch Vehicles

- Building on the legacy of the Space Shuttle and other NASA space exploration initiatives, the propulsion for the Ares I First Stage will be a Shuttle derived reusable solid rocket motor.
- Significant progress has been made to date by the Ares First Stage Team.
- This brief status provides an update on the design and development of the Ares First Stage propulsion system.

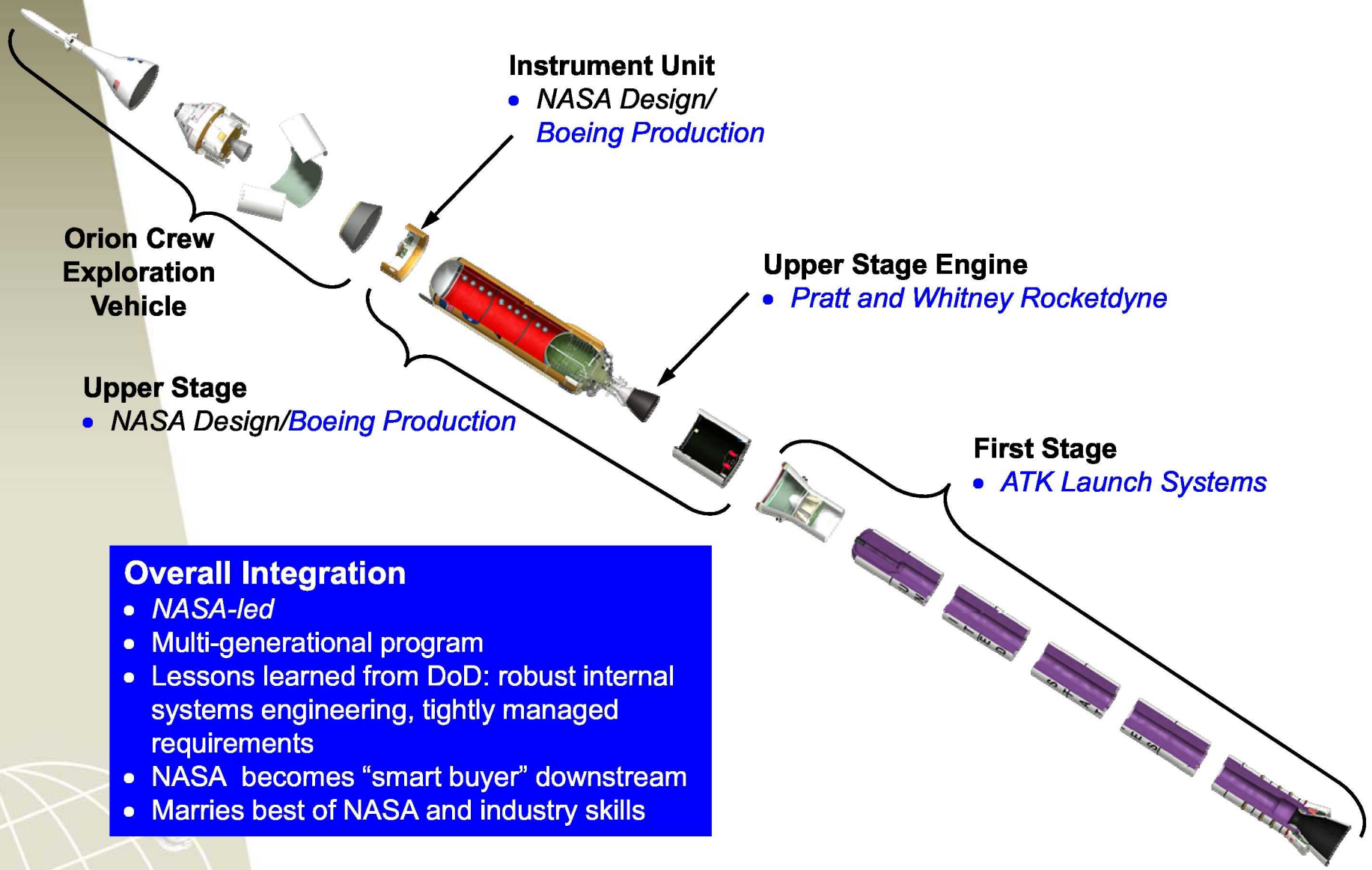
Building on 50 Years of Proven Experience

– Launch Vehicle Comparisons –



	Saturn V: 1967–1972	**Space Shuttle:** 1981–Present	**Ares I:** First Flight 2015	**Ares V:** First Flight 2018
Height	360.0 ft	184.2 ft	325.0 ft	381.1 ft
Gross Liftoff Mass (GLOM)	6,500.0K lbm	4,500.0K lbm	2,057.3K lbm	8,167.1K lbm
Payload Capability	44.9 mT Trans-Lunar Injection (TLI) 118.8 mT to LEO	25.0 mT to LEO	24.9 mT to LEO	71.1 mT to TLI with Ares I 62.8 mT to TLI ~187.7 mT to LEO

Ares I Acquisition Model



Instrument Unit
- *NASA Design/ Boeing Production*

Orion Crew Exploration Vehicle

Upper Stage Engine
- *Pratt and Whitney Rocketdyne*

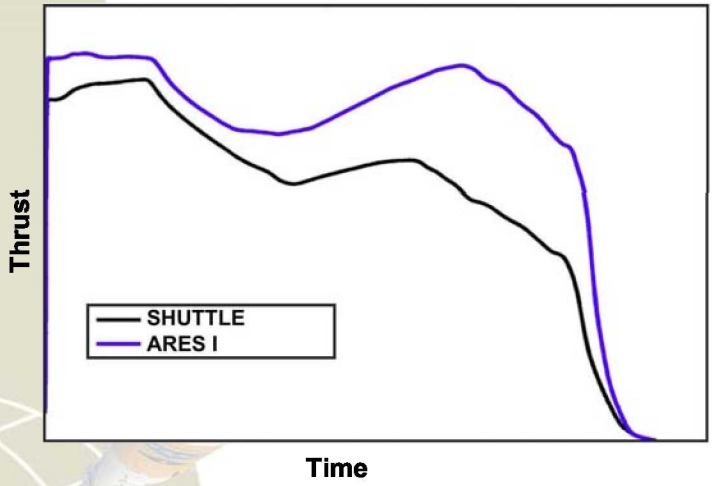
Upper Stage
- *NASA Design/Boeing Production*

First Stage
- *ATK Launch Systems*

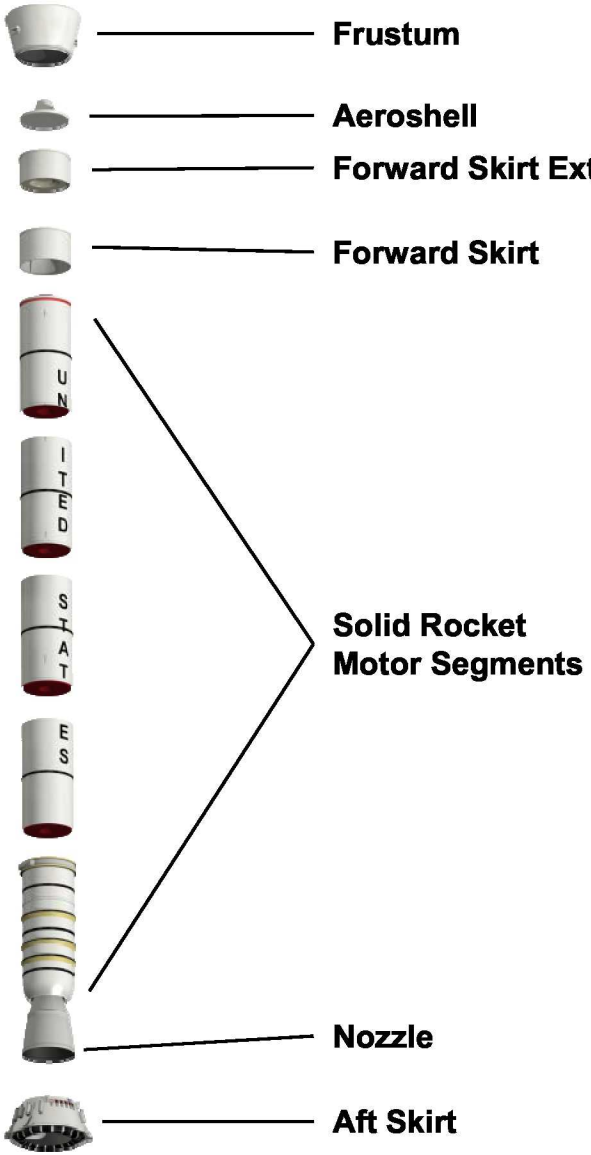
Overall Integration
- *NASA-led*
- Multi-generational program
- Lessons learned from DoD: robust internal systems engineering, tightly managed requirements
- NASA becomes "smart buyer" downstream
- Marries best of NASA and industry skills

Ares I First Stage Overview

- **Legacy motor casings, aft skirt**
- **New forward structures**
  - Forward Skirt
  - Forward Skirt Extension
  - Aeroshell
  - Frustum
- **Metal and composite materials**
- **Shuttle-derived five-segment solid rocket motor**
  - Increased performance
  - Extensibility to Ares V



Thrust trace comparison: Shuttle versus Ares I



Ares I First Stage

C-Spring isolators

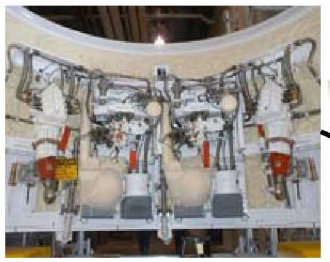
Tumble Motors (from Shuttle)

New 150 ft diameter parachutes

Asbestos free insulation/liner

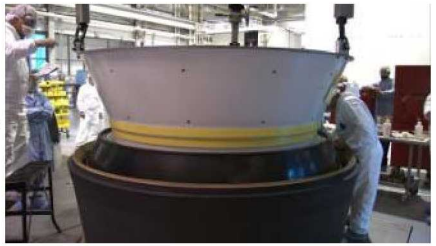
Same propellant as Shuttle (PBAN)-optimized for Ares application

Modern electronics



Same aft skirt and thrust vector control as Shuttle

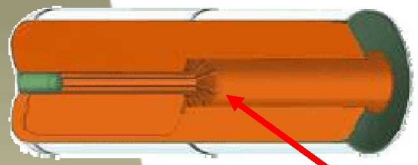
Same cases and joints as Shuttle



Wide throat nozzle

Booster Deceleration Motors (from Shuttle)

Ares First Stage Upgrades

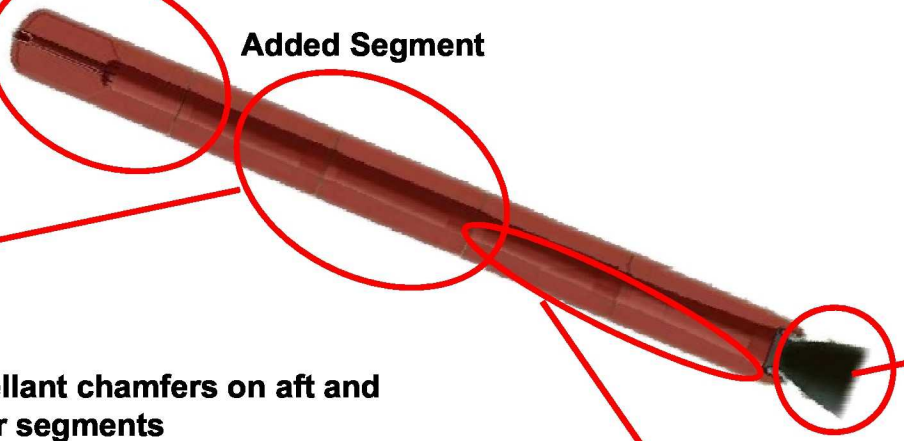


Increased number of fins from 11 to 12 in fwd segment

Burn rate lowered to meet Ares I requirements

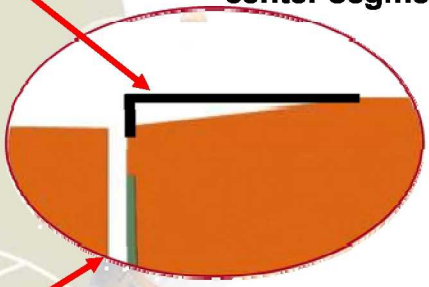
Modifications to the motor were made to:

- Improve performance (thrust)
- Improve reliability
- Eliminate hazardous materials
- Replace obsolete materials

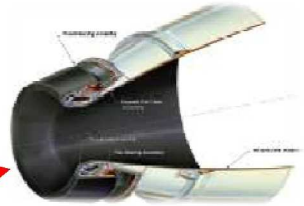


Added Segment

Propellant chamfers on aft and center segments



Modified height and thickness to prevent bore choking

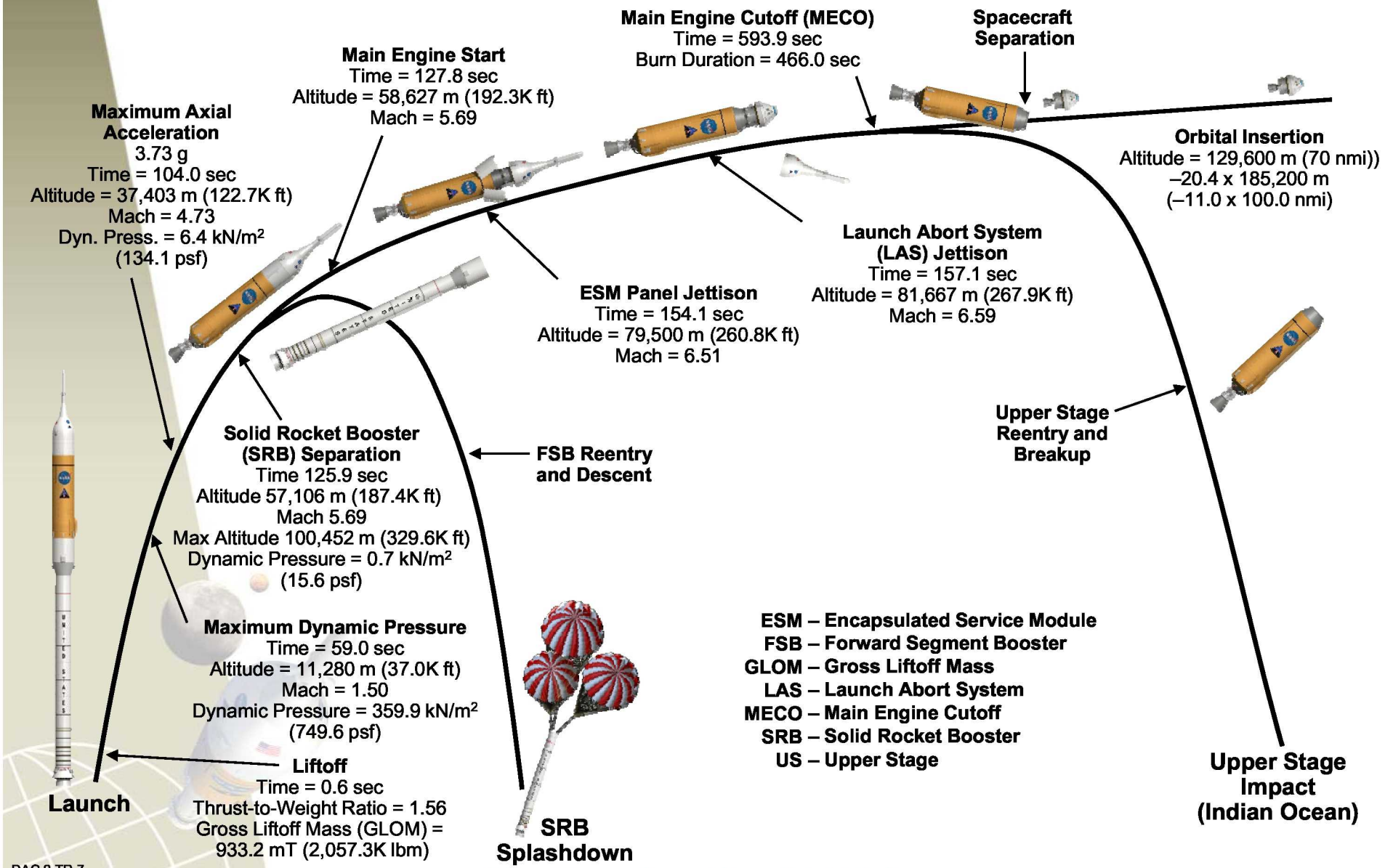


Wider throat and nozzle extension for increased mass flow

Insulation and liner formulations modified to eliminate Chrysotile fibers

Lay-up optimized to provide additional thermal protection

Ares I Lunar Mission Profile



Ares I First Stage DDT&E Schedule

	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15
ARES Milestones		SRR Dec	SDR Oct	PDR Aug	1X Aug	Ares CDR 1 Jul	Ares CDR 2 Sep		I-Y Mar, Or-1 Sep	DCR Jan, Or-2 Mar
First Stage Milestones	Pre-SRR TIM Aug	SRR Dec	PDR Jun			FS CDR Apr	QRR Apr			DCR Nov
GVT H/W Deliveries					Aft Skirts Jul	MSI/MSL Nov		Fwd Structures Oct		
Development		Commit to DM-1 Oct	Fab	DM-1 Test (N) Aug						
			Fab 1st Cast	DM-2 Test (C) Jun						
			Fab 1st Cast		DM-3 Test (H) Sep					
					Fab 1st Cast	DM-4 Test (N) Mar				
						Fab 1st Cast	QM-1 Test (N) Jun			
						Commit to QM Fab Review	Fab 1st Cast	QM-2 Test (C) Dec		
							Fab 1st Cast	QM-3 Test (H) Jun		
Ares IX & Flt Test Motors	Ares IX Design & Fab		Start Ares IX Deliveries to KSC	RSRM Mar, Aft Skt, Fwd Assy & 5SS			Ares 1Y Motor Fab 1st Cast	Ares 1Y O/D Mar		
							Orion 1 Motor Fab 1st Cast	Orion 1 O/D Dec	Orion 1 O/D Jun	
							Orion 2 Motor Fab 1st Cast			Orion 2 O/D Dec
SE&I			PDR	T.O. Checkpoint, T.O. TIM	Delta PDR	CDR				DCR
Structures						MS CD TIM				
Sep & Decel						CD Tims	Testing Complete			
Avionics						CD TIM	Qual Testing Complete			
TVC						CD TIM				
FSS						CD TIM				
HIL					HIL Development Design Rev	V&V Testing	Dev Testing Complete Qual Testing Complete			
Pyro						CD TIM				
Assembly Integration						Integ PSR	1Y Stage Assy, Or-2 Stage Assy, Or-1 Stage Assy			

First Stage Progress to Date

- **Successful Preliminary Design Review Completed in June, 2008**
- **Major Test Programs**
  - Parachute drop tests
  - Stage separation pyrotechnics
  - **Development motor (scheduled for August, 25 2009)**
- **Several Major Items Manufactured**
  - Ares I-X motor segments
  - Development motor (DM-1) Nozzle
  - DM-1 segments completed and motor installed in T-97 Test Stand
  - through insulation
  - Insulation lay-up has begun on DM-2 segments
- **Ares 1-X Support**
  - Completed all Hardware Acceptance Reviews
  - Motor segments were completed and shipped to KSC in March 2009
  - All hardware has been transferred to Ground Ops
  - Hardware being mated at KSC

First Stage Thrust Oscillation

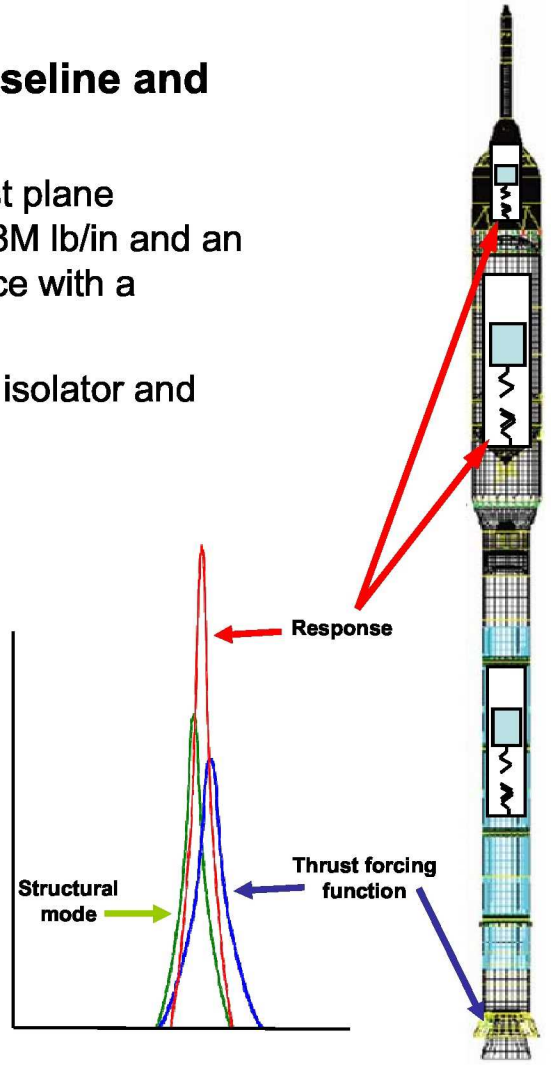
Status:

- **June Program Review was completed with decision to baseline and implement Dual Plane (DP) Isolation**
  - Baseline design established as a DP isolation system with the first plane between first stage and upper stage with a reference stiffness of 8M lb/in and an upper plane between US and Orion, on the US side of the interface with a reference stiffness of 1.2M lb/in
  - Upper Stage will begin design efforts to include the second plane isolator and coordinate interface design requirements with Orion

Four basic ways to attack problem:

- **Reduce forcing function**
- **Detune system response away from forcing function frequency**
- **Actively create an opposing forcing function**
- **Passively absorb forcing function**

◆ Mitigation Options ◆ Baseline Design

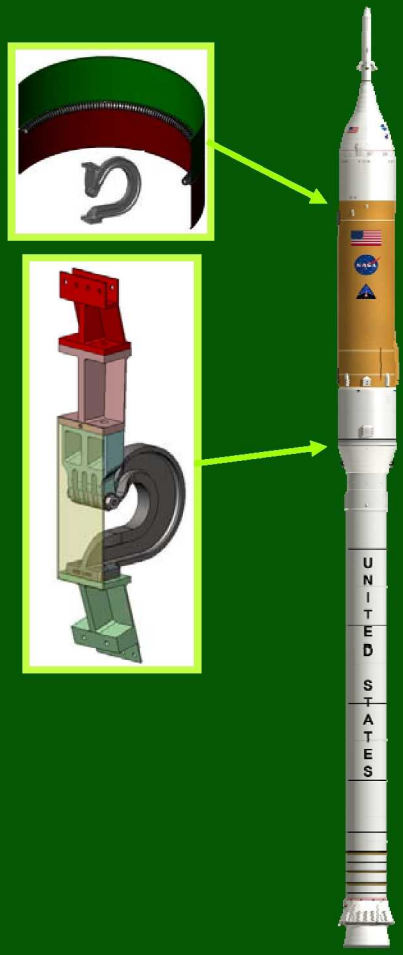


Comparison of Mitigation Options

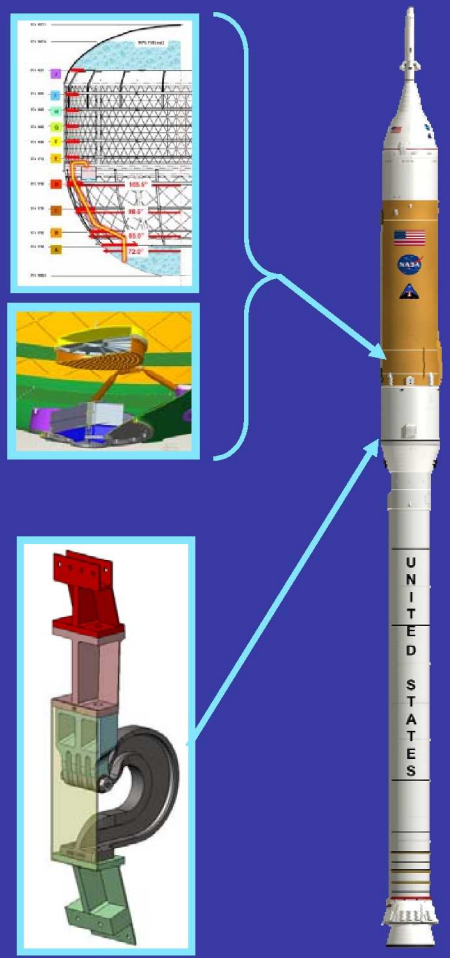
Working Baseline

Risk Mitigation Options

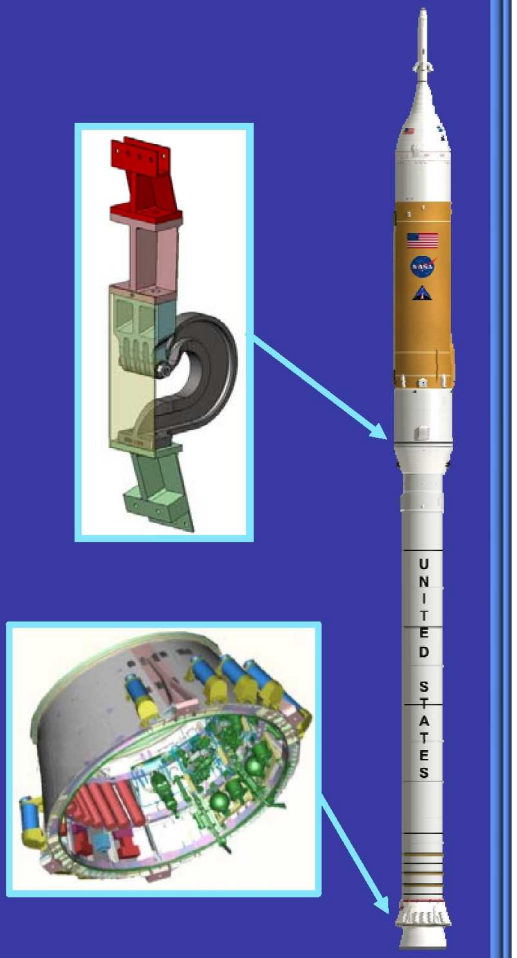
Dual-Plane Isolation



Propellant Damper Single-Plane Isolation

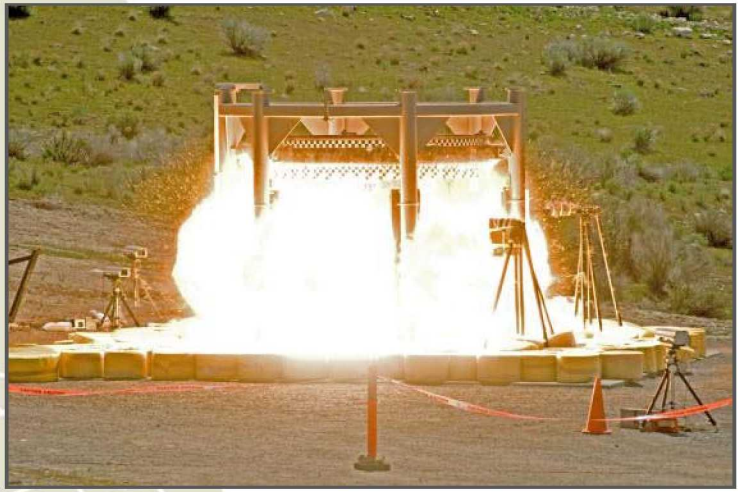


Active RMAs plus Single-Plane Isolation



Full Scale Frustum Separation Test

Promontory, UT



Cluster Drop Test (CDT)-1

Yuma Proving Grounds, AZ

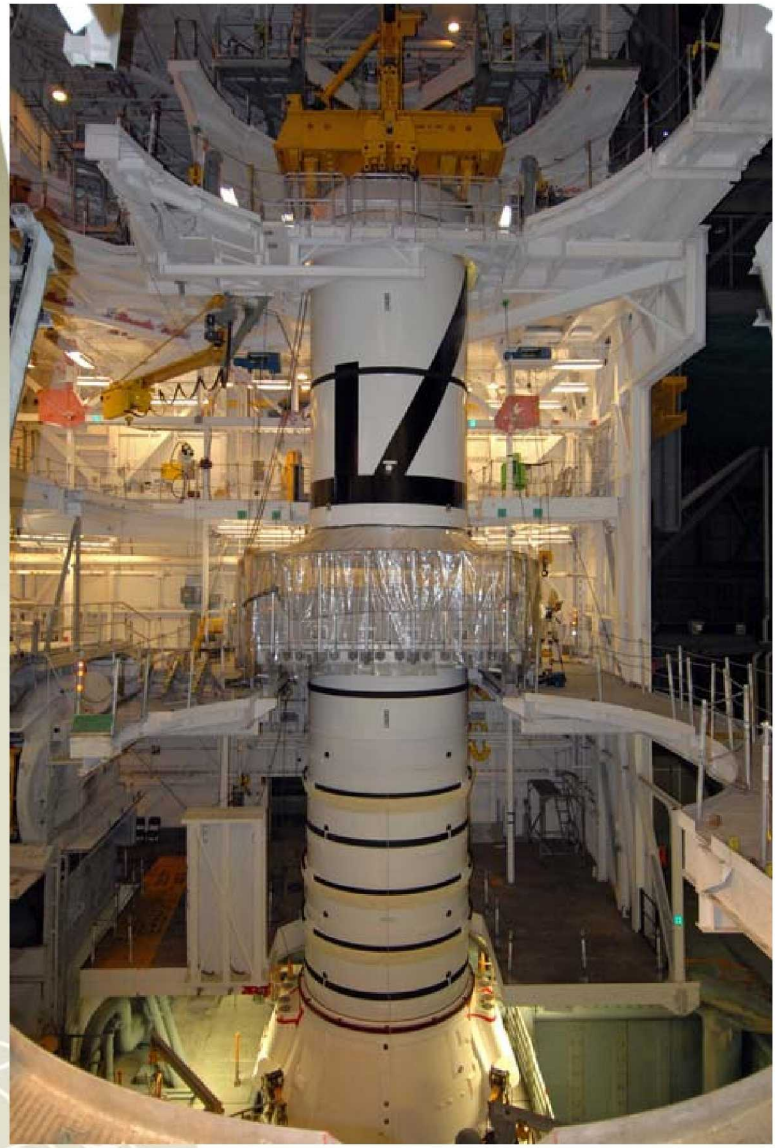
First Stage Accomplishments

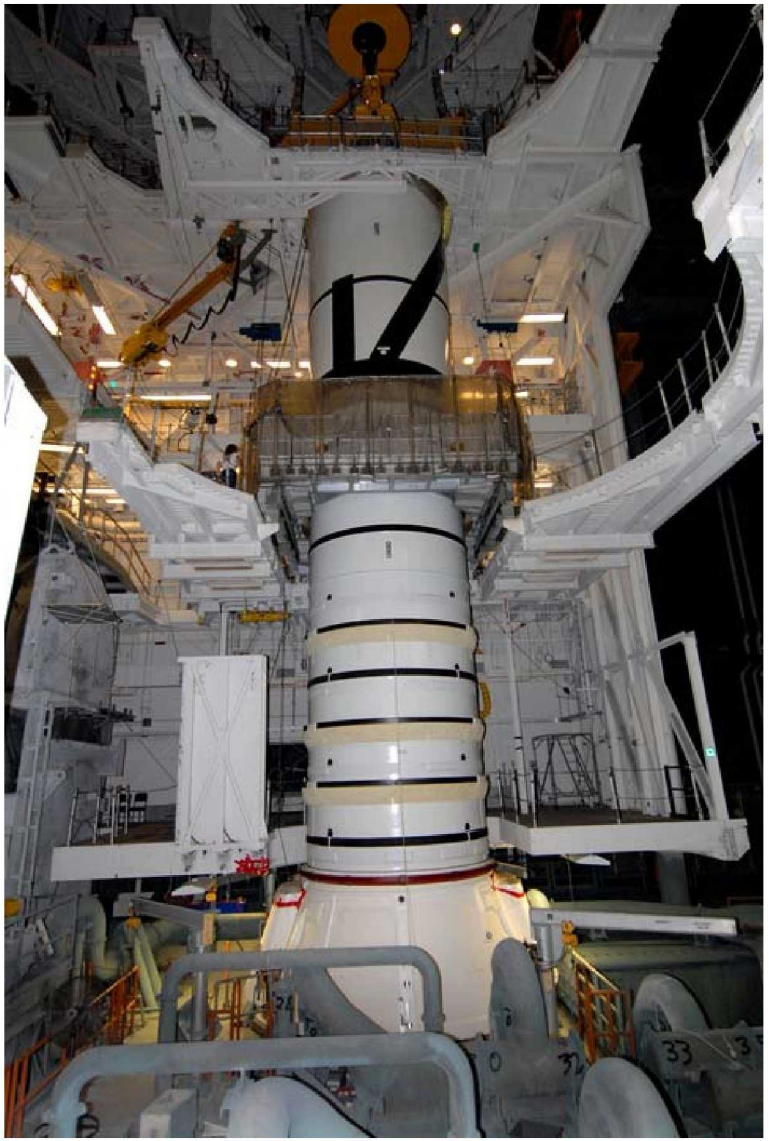
Main Parachute Drop Test
Yuma Proving Ground, AZ

Ares I-X Motor En Route to KSC
Corinne, UT

Ares I-X Super Stack
Kennedy Space Center, FL

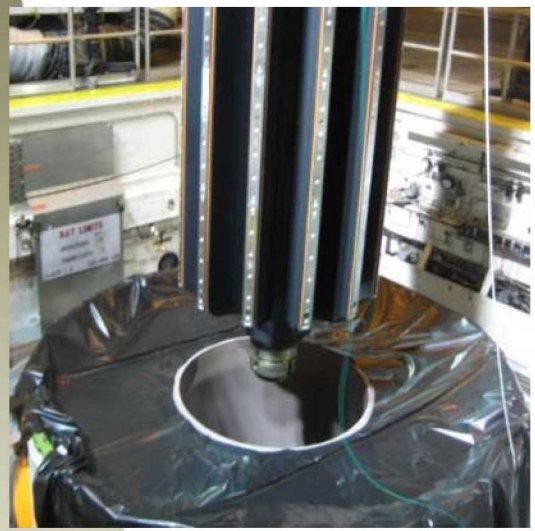
Ares I-X C/A Mated to Aft Booster on MLP



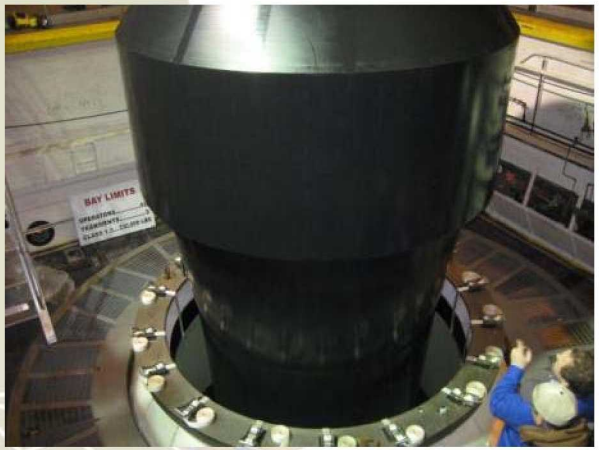


DM-1 Segment Processing

Casting/X-ray Operations



DM-1 Fwd Segment Casting
Promontory, UT

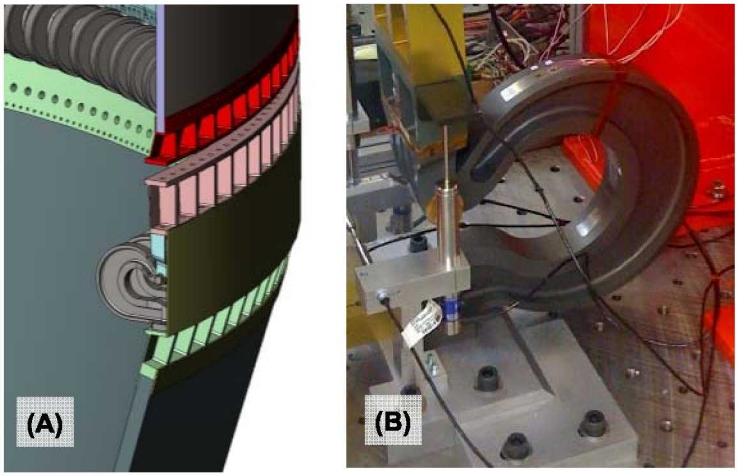


DM-1 Aft Segment Casting
Promontory, UT

DM-1 C/A Segment Casting
Promontory, UT

First Stage Accomplishments

Built-up Thrust Vector Control/Discrete Interface Module
Cincinnati, OH



Thrust Oscillation Flexure Design (A) and Testing (B)
San Luis Obispo, CA

DM-1 Igniter Test
Promontory, UT

DM-1 Installation into Test Stand
Promontory, UT

DM-1 in T-97 Test Stand

Promontory, UT

Conclusion

- **Ares First Stage design is on schedule**
  - Avionics
  - Major Structures
  - Motor
  - Deceleration System
- **Ares I-X hardware is complete and assembly at KSC is underway**
  - Launch scheduled for October 31.
- **Recovery system testing is on schedule**
  - Drogue
  - Main chute
  - Cluster
- **DM-1 static firing is scheduled for August 25, 2009**

Development Motor #1 (DM-1)

August 25, 2009

Questions