National Aeronautics and Space Administration

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NASA

Ares V to Support Heavy Lift for U.S. Space Exploration

Industry Day Conference 2008, December 3, 2008

Ares V Cargo Launch Vehicle Introduction

Heavy Lift for Science and Exploration

- **Key transportation system for exploration beyond Low Earth Orbit**
  - Offers unique payload capabilities opening new doors to human exploration on the Moon and beyond
  - Designed for routine crew and cargo transportation to the Moon
    - **EDS + Altair to LEO**
    - **EDS + Altair + Orion to TLI**
  - Considered national asset creating new opportunities for science, national security and space business
  - Capable of transporting more than 71 metric tons to the Moon
  - Focal point for design and development located at MSFC with support across the Agency
  - Defined Point of Departure (POD) Concept from the NASA June 2008 Ares V Mission Concept Review (MCR)

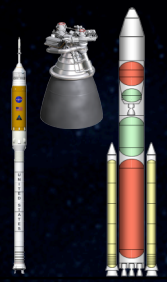
Ares V Management Approach

- **Ares V Acquisition is comprised of two Phases**
  - Phase 1 - Contractor support to NASA design efforts through SDR
  - Phase 2 - Completion of DDT&E and follow-on production contract
- **NASA owns overall Ares V Vehicle System Architecture**
  - Vehicle integration in house at NASA centers plus contractors with appropriate OCI precautions in place (separate procurement)
- **Early industry engagement to clearly define our concept of operations, requirements, interfaces, and design concepts prior to prime contractor procurement activities**
- **Competition for element prime contracts for Phase II (remainder of development and production) will be based on SRR requirements with award in SDR timeframe**
- **Phase I will focus on defining system level requirements, validating that they can be accomplished with maximum utility (cost, reliability, operability, and performance), and reducing risk for DDT&E**
  - Address historical program/project lessons learned of requirements changes and immature technical baseline as primary root causes of cost growth
- **NASA will control POD, including element definition in Phase I**
  - Industry input on risks and opportunities, requirements, and key trades
  - Exception - Upgraded booster options will be industry defined

Evolution of Ares V from ESAS to MCR

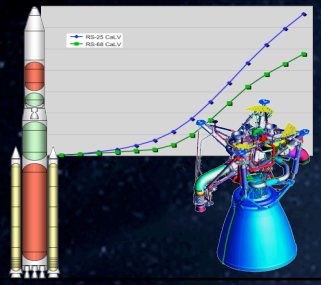
Original ESAS Capability

- *45.0 mT Lander*
- *20.0 mT CEV*
- *No Loiter in LEO*
- *8.4m OML*
- *5 SSMEs / 2J2S*



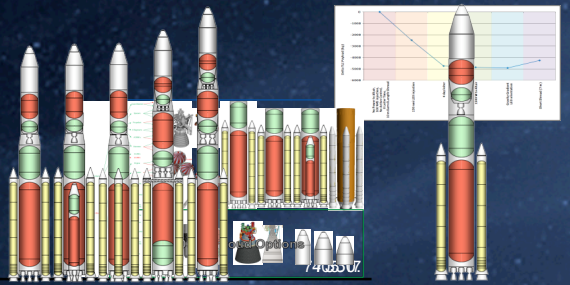
CY-06 Budget Trade to Increase

- Ares I / Ares V Commonality
- Ares I : 5 Seg RSRB / J2-X instead of Air-Start SSME
- Ares V: 1 J2-X



Detailed Cost Trade of SSME vs RS-68

- ~$4.25B Life Cycle Cost Savings for
- 5 Engine Core
- Increased Commonality with Ares I Booster
- 30-95 Day LEO Loiter Assessed

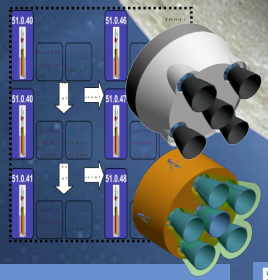


IDAC 3 Trade Space

- Lunar Architecture Team 1/2 (LAT) Studies
- Mission Delta V's increased
- Increase Margins From TLI Only to Earth through TLI
- Loiter Penalties for 30 Day Orbit Quantified

EDS Diameter Change from 8.4m to 10m

- Lunar Architecture Team 1/2 (LAT) Studies
- Lunar /Mars Systems Benefits
- Tank Assembly Tooling Commonality



Incorporate Ares I Design Lessons Learned / Parameters

- Core Engine / SRB Trades to Increase Design Margins
- Increase Subsystem Mass Growth Allowance (MGA)

Recommended Option

- *6 Core Engines*
- *5.5 Segment PBAN*

Updated Capability

- 45.0t Lander
- 20.2t CEV
- ~6t Perf. Margin
- 4 Day LEO Loiter
- Ares I Common MGAs
- HTPB Decision End of FY09

220 Concepts Evaluated

320 Concepts Evaluated

730 Concepts Evaluated

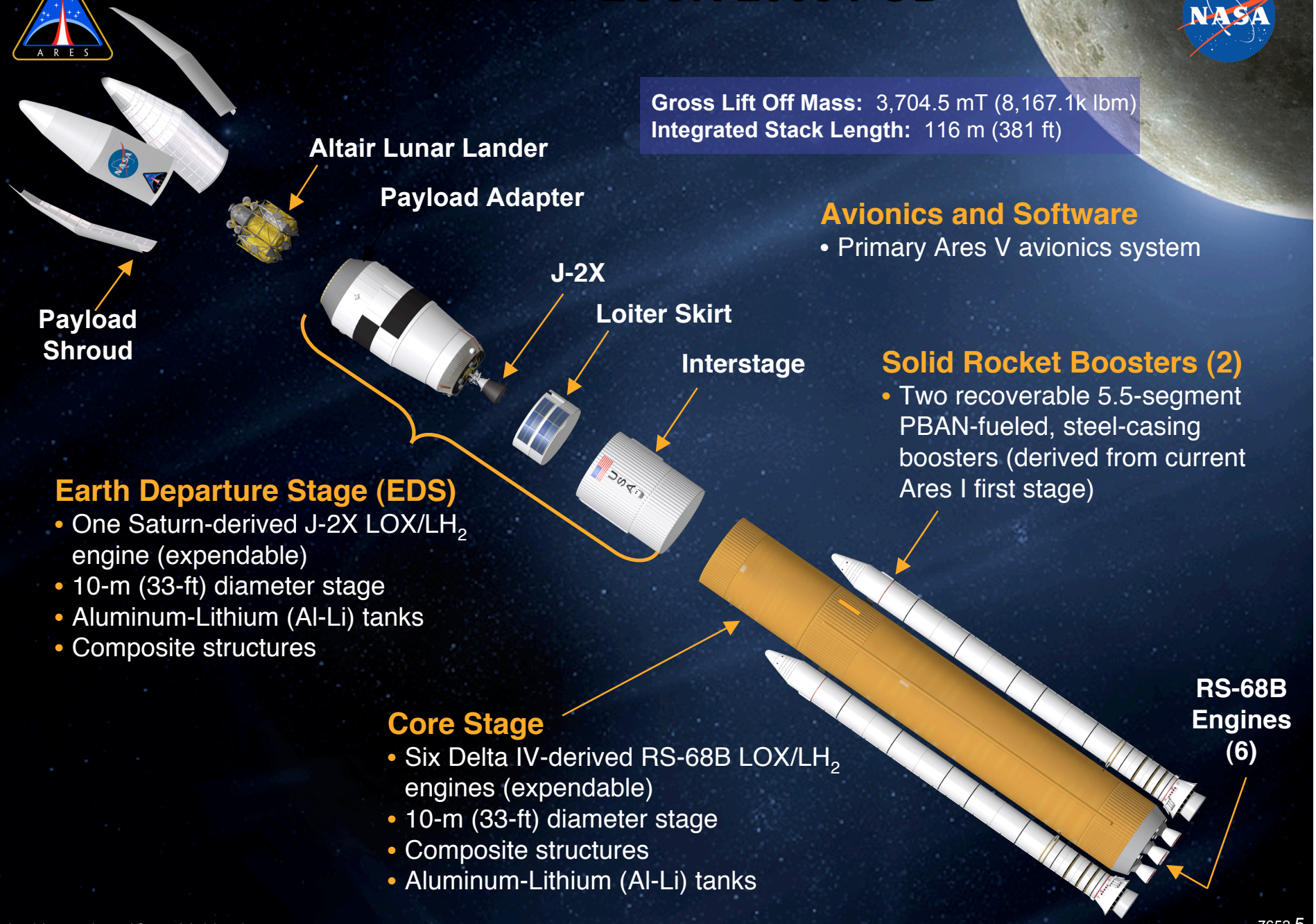
460 Concepts Evaluated

2005 | **2006** | **2007** | **2008**

- ESAS Complete
- Ares I ATP
- Orion ATP
- Ares I SRR
- Orion SRR
- Ares I SDR
- Ares V MCR

The Ares V LCCR-2008 POD

Gross Lift Off Mass: 3,704.5 mT (8,167.1k lbm)
Integrated Stack Length: 116 m (381 ft)



Avionics and Software
- Primary Ares V avionics system

Solid Rocket Boosters (2)
- Two recoverable 5.5-segment PBAN-fueled, steel-casing boosters (derived from current Ares I first stage)

Earth Departure Stage (EDS)
- One Saturn-derived J-2X LOX/LH_2 engine (expendable)
- 10-m (33-ft) diameter stage
- Aluminum-Lithium (Al-Li) tanks
- Composite structures

Core Stage
- Six Delta IV-derived RS-68B LOX/LH_2 engines (expendable)
- 10-m (33-ft) diameter stage
- Composite structures
- Aluminum-Lithium (Al-Li) tanks

Ares V Performance Requirements

Lunar Sortie Mission			
CARD Requirement	**Mass (t)**	**Mass (lb_m)**	**Derived Performance Rqt.**
Orion [CA4139]	20.2	44,500	
Crewed Lander [CA0836]	45.0	99,208	
Total TLI [CA0848]	66.9	147,575	Derived TLI > 66.9 t
	45.0	99,208	Derived ETO > 45.0 t

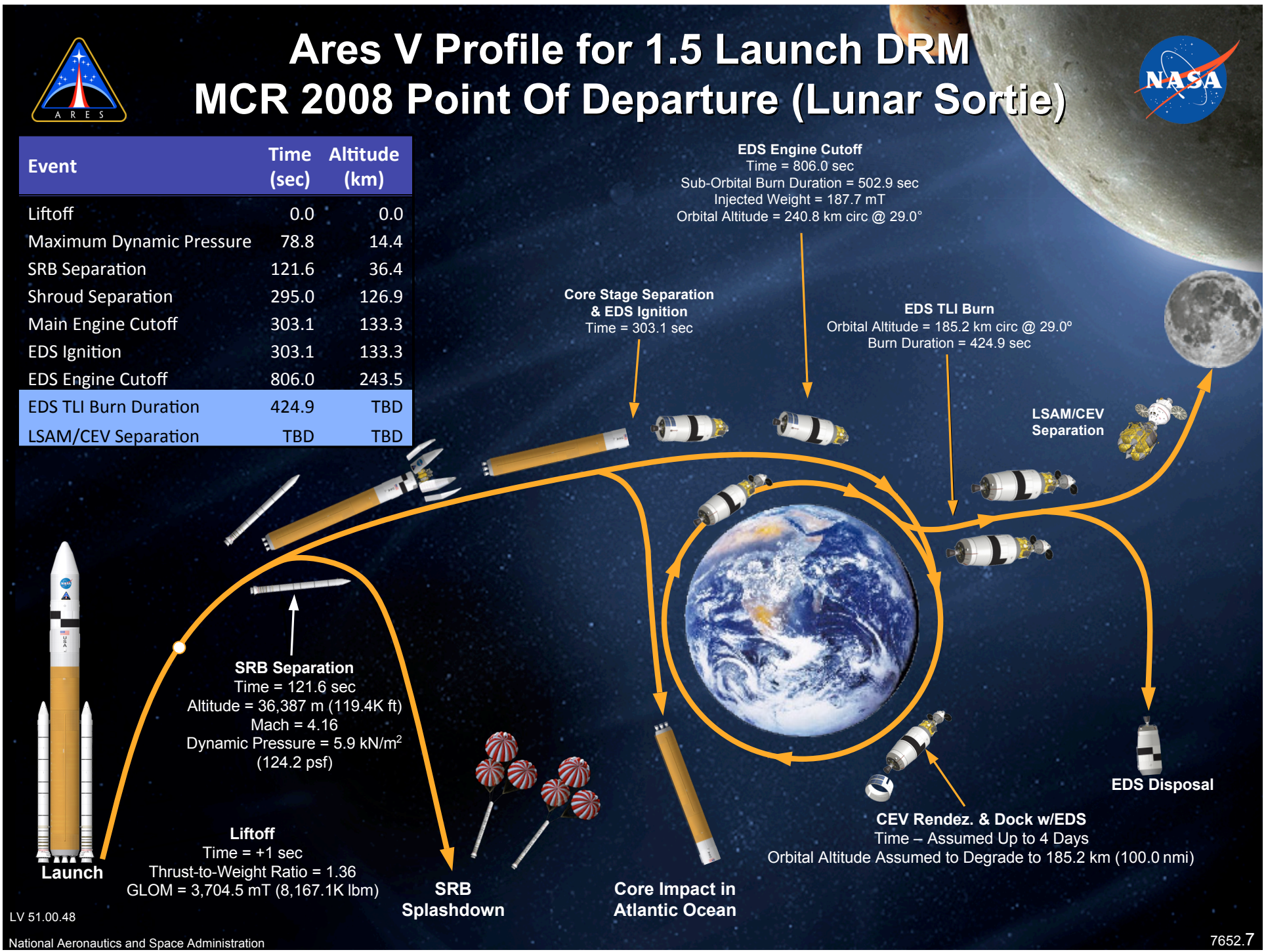
- ETO Mission Destination: 130 nmi, 29°
- Loiter Duration: 4 days
- TLI Maneuver Starting Conditions: 100 nmi, 29°
- TLI ΔV = 3175 m/s + Gravity Loss

Lunar Cargo Mission			
CARD Requirement	**Mass (t)**	**Mass (lb_m)**	**Derived Performance Rqt.**
Cargo Lander [CA5231]	53.6	118,168	
Total TLI [CA0847]	54.6	120,372	Derived TLI > 54.6 t
Total ETO Goal [CA0847]	54.6	120,372	Derived ETO > 54.6 t

- ETO Mission Destination: Phasing Orbit
- Loiter Duration: None (no loiter capability on EDS)
- Note that Saturn V TLI payload capability was 48.6 t (Apollo 17 - CM/SM/ LM/SLA)

Ares V Profile for 1.5 Launch DRM
MCR 2008 Point Of Departure (Lunar Sortie)

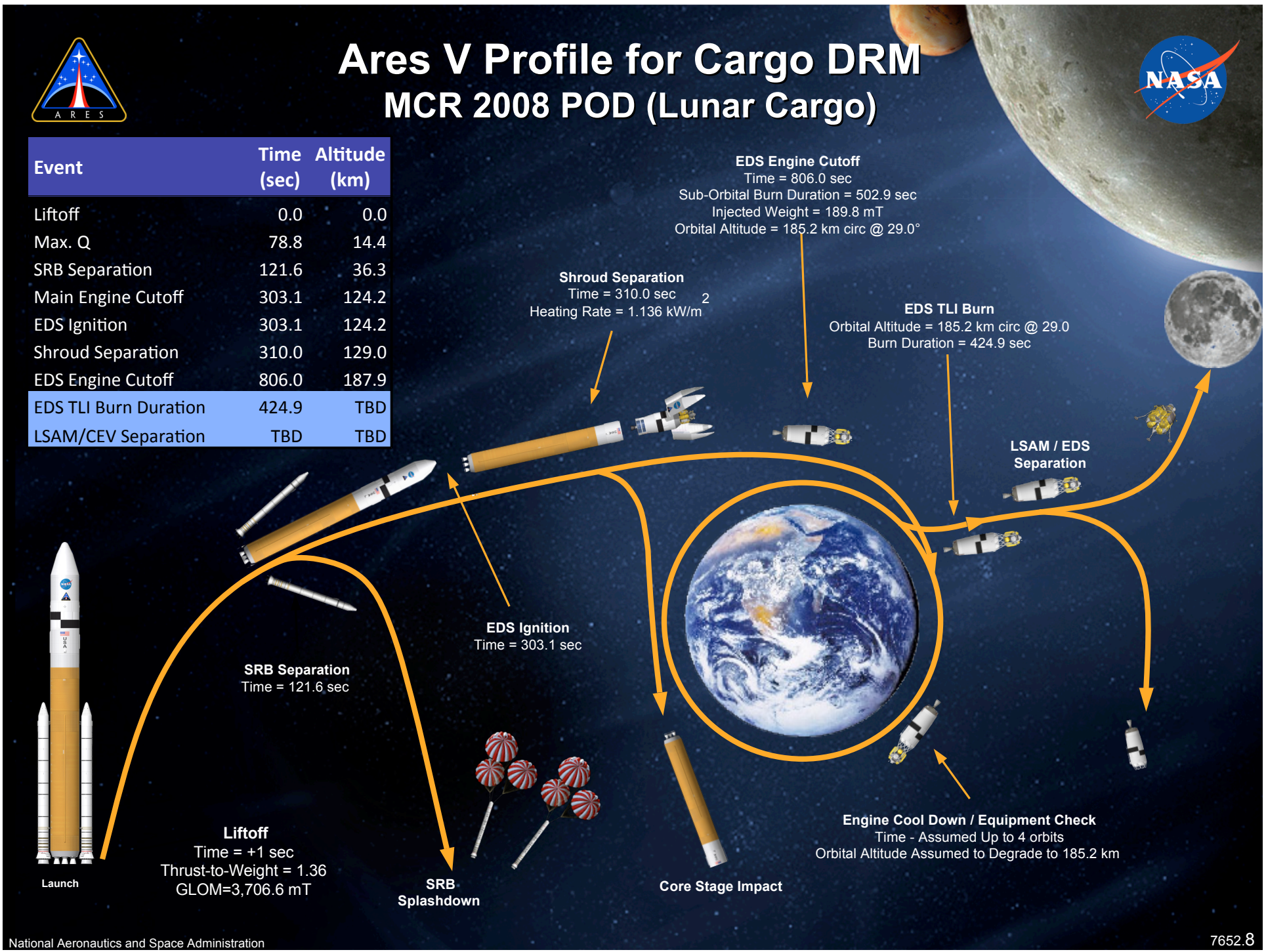
Event	Time (sec)	Altitude (km)
Liftoff	0.0	0.0
Maximum Dynamic Pressure	78.8	14.4
SRB Separation	121.6	36.4
Shroud Separation	295.0	126.9
Main Engine Cutoff	303.1	133.3
EDS Ignition	303.1	133.3
EDS Engine Cutoff	806.0	243.5
EDS TLI Burn Duration	424.9	TBD
LSAM/CEV Separation	TBD	TBD



LV 51.00.48

Ares V Profile for Cargo DRM
MCR 2008 POD (Lunar Cargo)

Event	Time (sec)	Altitude (km)
Liftoff	0.0	0.0
Max. Q	78.8	14.4
SRB Separation	121.6	36.3
Main Engine Cutoff	303.1	124.2
EDS Ignition	303.1	124.2
Shroud Separation	310.0	129.0
EDS Engine Cutoff	806.0	187.9
EDS TLI Burn Duration	424.9	TBD
LSAM/CEV Separation	TBD	TBD



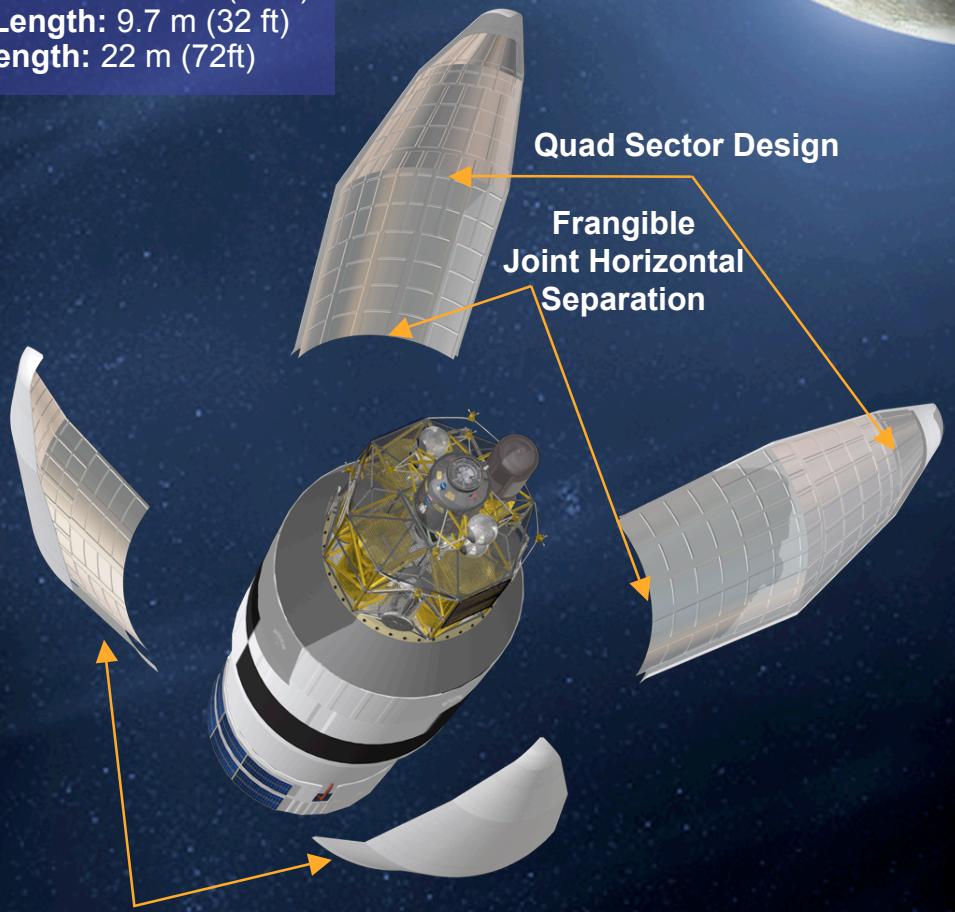
Payload Shroud Point Of Departure

Work Package 1

Point of Departure (Biconic)

Leading Candidate (Ogive)

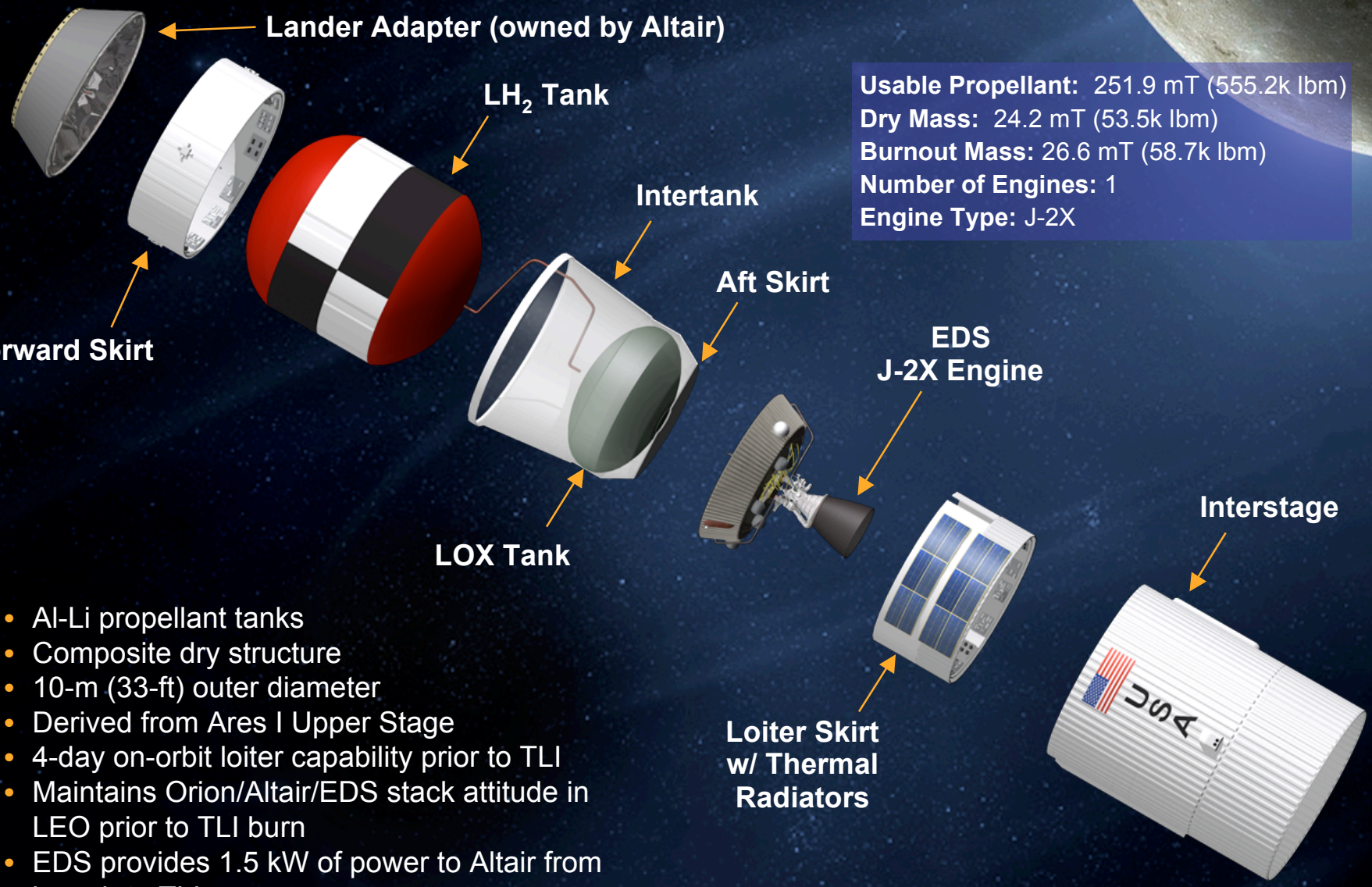
Mass: 9.1 mT (20.0k lbm)
POD Geometry: Biconic
Design: Quad sector
Barrel Diameter: 10 m (33 ft)
Barrel Length: 9.7 m (32 ft)
Total Length: 22 m (72ft)



- Composite sandwich construction (Carbon-Epoxy face sheets, Al honeycomb core)
- Painted cork TPS bonded to outer face sheet with RTV
- Payload access ports for maintenance, payload consumables and environmental control (while on ground)

EDS Current Design Concept

Work Package 2

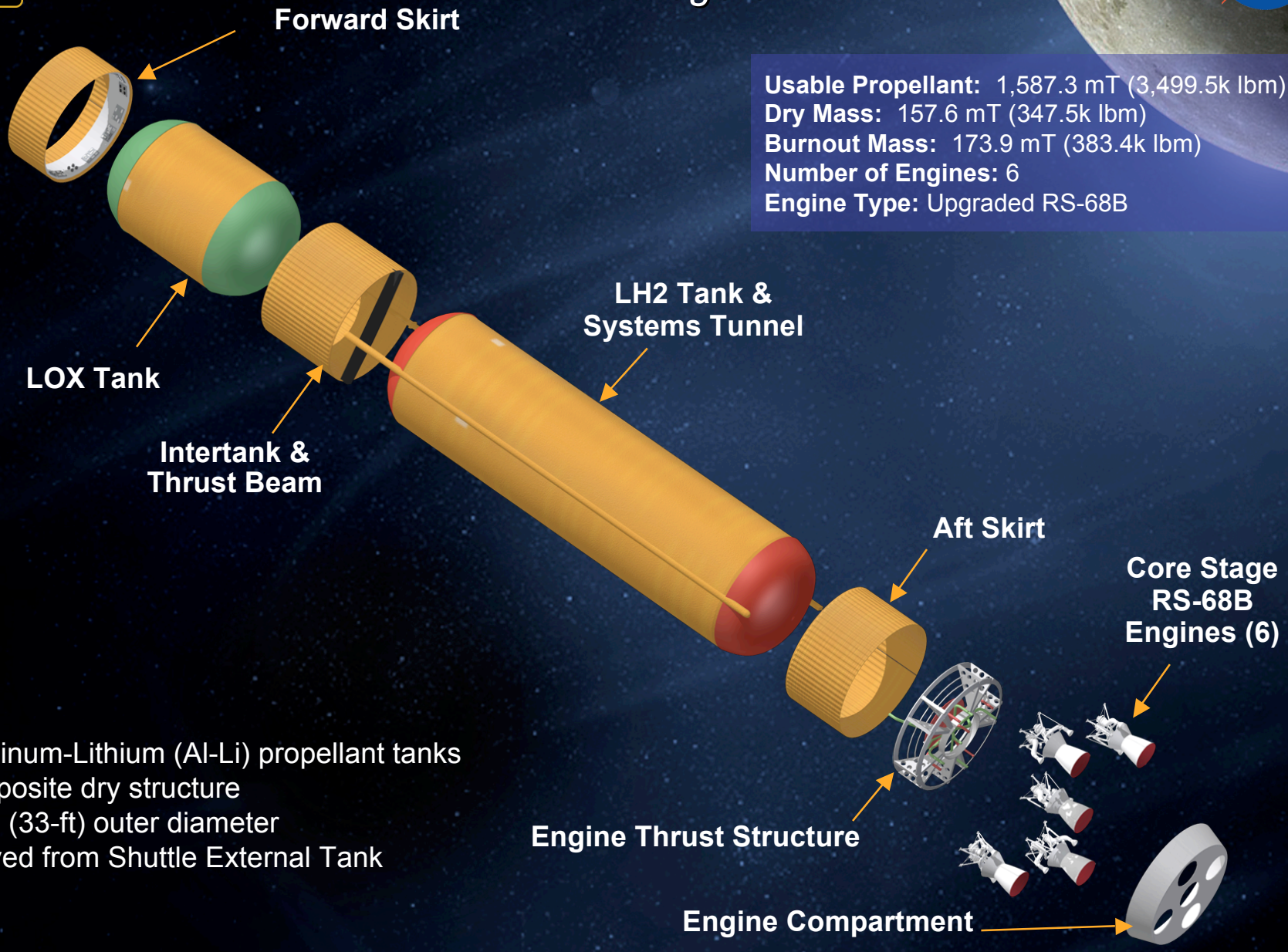


Usable Propellant: 251.9 mT (555.2k lbm)
Dry Mass: 24.2 mT (53.5k lbm)
Burnout Mass: 26.6 mT (58.7k lbm)
Number of Engines: 1
Engine Type: J-2X

- Al-Li propellant tanks
- Composite dry structure
- 10-m (33-ft) outer diameter
- Derived from Ares I Upper Stage
- 4-day on-orbit loiter capability prior to TLI
- Maintains Orion/Altair/EDS stack attitude in LEO prior to TLI burn
- EDS provides 1.5 kW of power to Altair from launch to TLI

Core Stage Design Concept

Work Package 3



Usable Propellant: 1,587.3 mT (3,499.5k lbm)
Dry Mass: 157.6 mT (347.5k lbm)
Burnout Mass: 173.9 mT (383.4k lbm)
Number of Engines: 6
Engine Type: Upgraded RS-68B

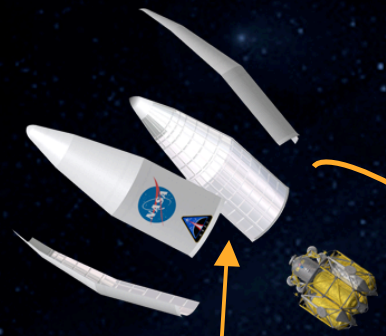
- Aluminum-Lithium (Al-Li) propellant tanks
- Composite dry structure
- 10-m (33-ft) outer diameter
- Derived from Shuttle External Tank

Avionics and Software

Work Package 4

Ares V will have a distributed avionics system across the vehicle

Avionics study contracts will assess the Ares V avionics and software for Constellation Program and the Ares V missions

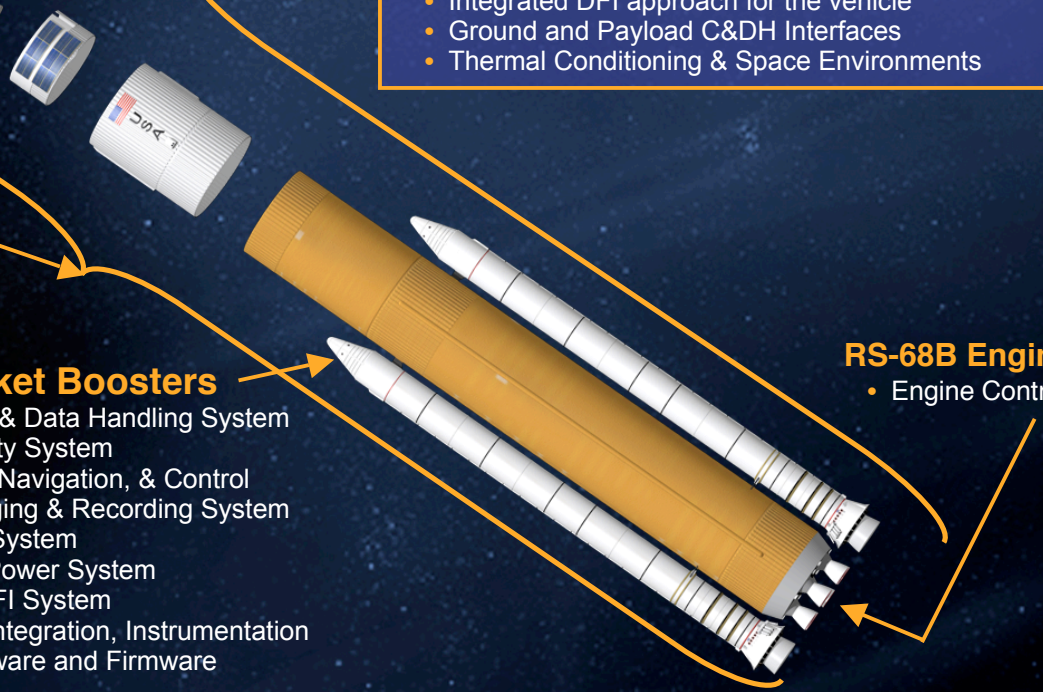


Payload Shroud & Adapter
- Shroud separation avionics

J-2X
- Engine Controller

Integrated Avionics and Software Architecture
- Integrated Fault Tolerate Architecture for the Vehicle
- Integrated Software Architecture and Approach
- Integrated Vehicle Timing Analyses
- Integrated Vehicle Avionics Reliability Analysis
- Telemetry and Data Analyses
- Common Avionics and Power systems components
- Integrated DFI approach for the vehicle
- Ground and Payload C&DH Interfaces
- Thermal Conditioning & Space Environments

Earth Departure Stage and Core Stage
- Command & Data Handling System
- Radio Freq Communication System
- Flight Safety System
- GPS System
- Guidance, Navigation, & Control
- Separation Systems
- Operational Flight Instrumentation
- Imaging System
- Electrical Power System
- Electrical Integration
- Cables
- Passive AR&D System
- Core Stage Engine system controllers
- DFI System(s)
- Flight Software and Firmware



Solid Rocket Boosters
- Command & Data Handling System
- Flight Safety System
- Guidance, Navigation, & Control
- Video Imaging & Recording System
- Recovery System
- Electrical Power System
- OFI and DFI System
- Electrical Integration, Instrumentation
- Flight Software and Firmware

RS-68B Engines
- Engine Controllers

Ares V Upgraded Booster Options

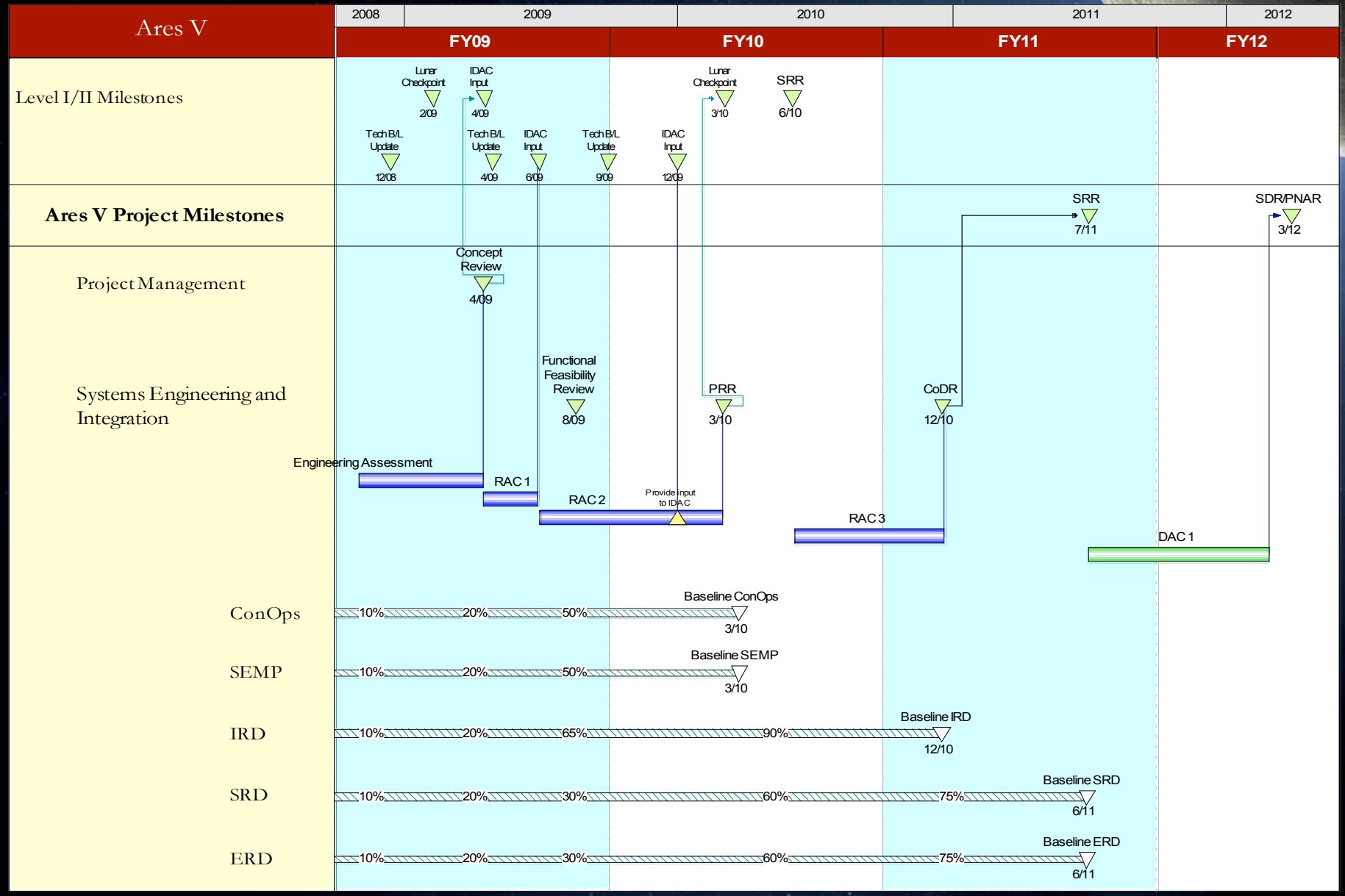
Work Package 5

- **Ares V POD booster is STS/Ares I-derived 5.5 segment**
- **LCCR instructed Ares V to investigate alternative booster options that provided upgrade performance over the POD**
- **<u>Upgraded Booster</u> work-package addresses this need**
  - Industry-led concepts that provide upgraded performance
  - Also consider cost, reliability, and long term potential for commonality with Ares I
- **Program decision on potential need for upgraded booster at Lunar SRR (currently scheduled for June 2010)**

Ares V Draft Organization

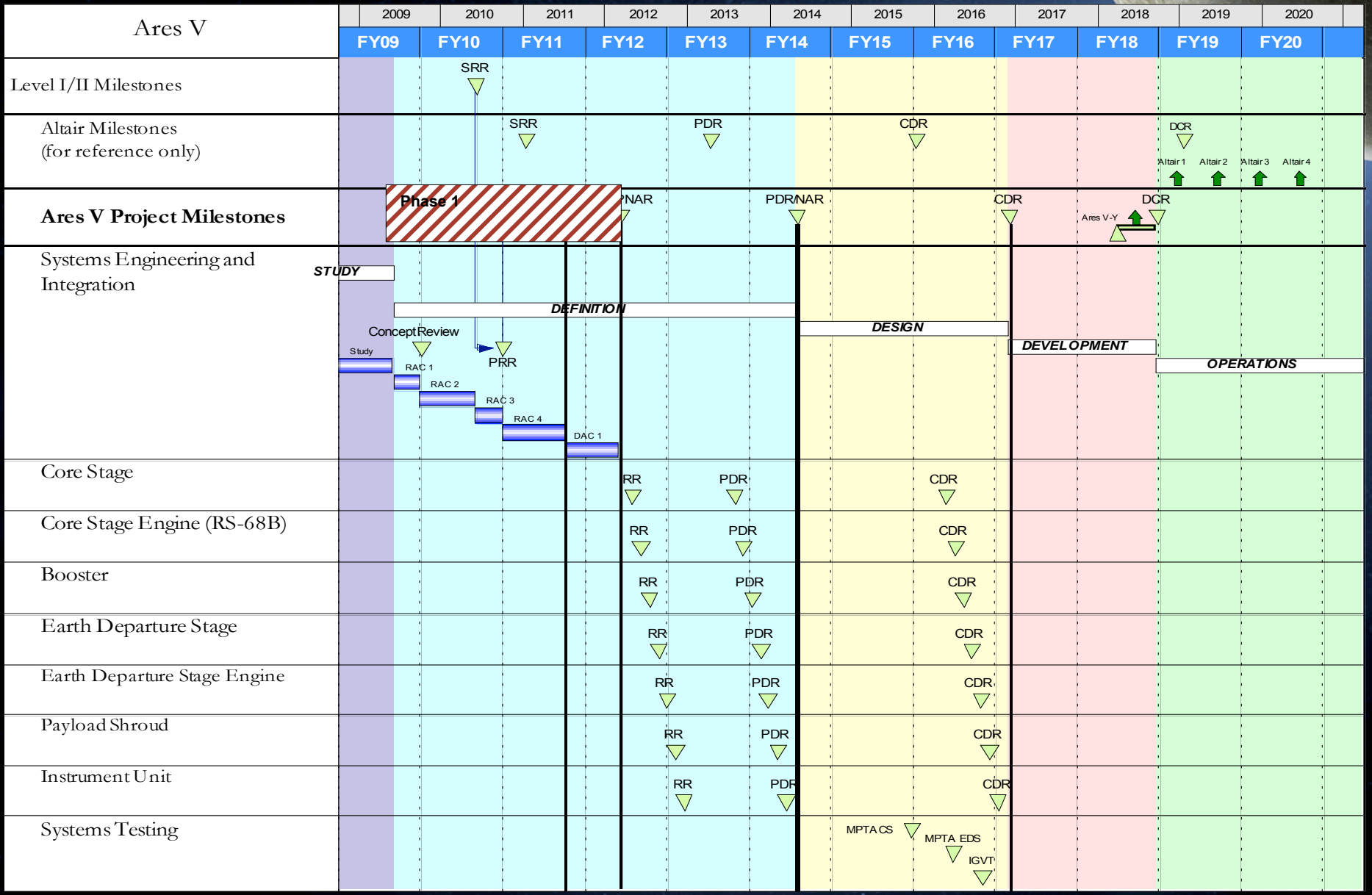
Ares V Path to SDR

DRAFT Rev 3



Ares V Summary Schedule

Rev 5b



Ares V Near-Term Reviews

- **Concept Review**
  - April 21, 2009
  - Contractor Kickoff
  - The purpose of the Concept review is to identify, capture and define the compliance of the Ares V design concept to operational, programmatic and technical KDRs and constraints and assess the POD conceptual design against the identified KDRs and constraints.
- **Functional Feasibility Review**
  - August 25, 2009
  - The purpose of the Functional Feasibility Review is to review and show consistency and feasibility between the conceptual design, the decomposed functional requirements and the existing operational plans. This includes integration of the results of the Reliability, Supportability, Maintainability, Quality, Cost, Safety and Producibility Analysis into the requirements, design and operational plans
- **Preliminary Requirements Review (PRR)**
  - March 23, 2010
  - The purpose of the Preliminary Requirements Review is to demonstrate that the preliminary set of allocated Element-level functional and performance requirements are feasible and satisfy the mission needs based on the concept design
- **Concept Design Review (CoDR)**
  - December 2010
  - The purpose of the Concept Design Review is to demonstrate that the subsystem level (5) operational, functional and design allocations are feasible and satisfy the mission needs based on the concept design
- **Level II System Requirement Review (SRR)**
- **Level III System Requirement Review (SRR)**
- **System Definition Review (SDR)**

"System Boundaries" for Ares V Procurements

Total Effort Required to Complete SRR and SDR

Phase II Procurements (Hardware Procurements)

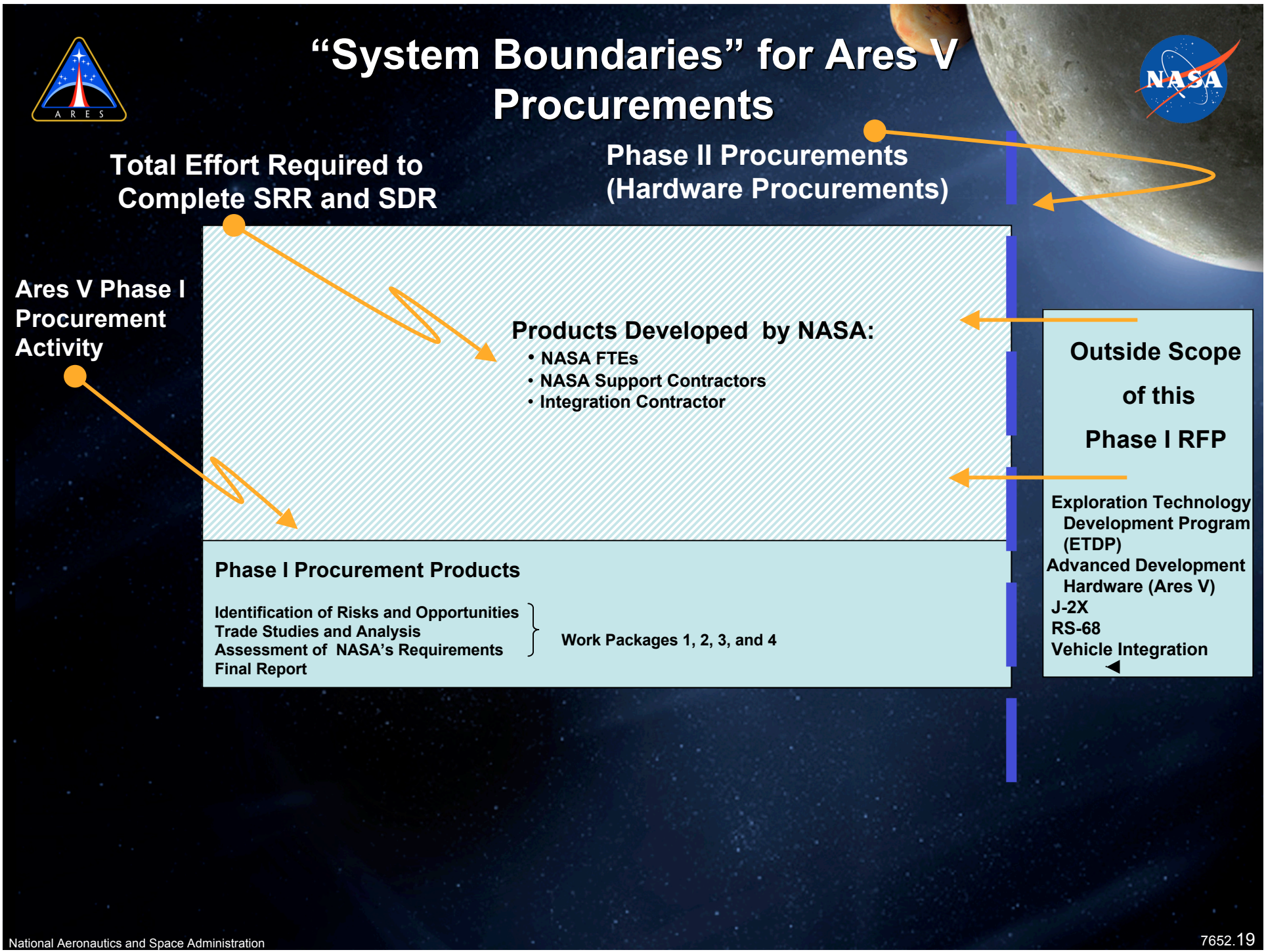
Products Developed by NASA:

- NASA FTEs
- NASA Support Contractors
- Integration Contractor

Outside Scope of this Phase I RFP

- Exploration Technology Development Program (ETDP)
- Advanced Development Hardware (Ares V)
- J-2X
- RS-68
- Vehicle Integration

"System Boundaries" for Ares V Procurements



"System Boundaries" for Ares V Procurements

Total Effort Required to Complete SRR and SDR

Phase II Procurements (Hardware Procurements)

Ares V Phase I Procurement Activity

Products Developed by NASA:
- NASA FTEs
- NASA Support Contractors
- Integration Contractor

Outside Scope of this Phase I RFP

- Exploration Technology Development Program (ETDP)
- Advanced Development Hardware (Ares V)
- J-2X
- RS-68
- Vehicle Integration

Phase I Procurement Products

Identification of Risks and Opportunities
Trade Studies and Analysis
Assessment of NASA's Requirements
Final Report

} Work Packages 1, 2, 3, and 4

"System Boundaries" for Ares V Procurements

Total Effort Required to Complete SRR and SDR

Phase II Procurements (Hardware Procurements)

Ares V Phase I Procurement Activity

Products Developed by NASA:
- NASA FTEs
- NASA Support Contractors
- Integration Contractor

Outside Scope of this Phase I RFP

Exploration Technology Development Program (ETDP)
Advanced Development Hardware (Ares V)
J-2X
RS-68
Vehicle Integration

Firm Fixed Price Contract (FFPC)

FFPC Constraints

No Level of Effort
Requires Deliverables
- Discrete
- Well Defined
- Flexibility via Technical Direction

Phase I Procurement Products

Identification of Risks and Opportunities
Trade Studies and Analysis
Assessment of NASA's Requirements
Final Report

Work Packages 1, 2, 3, and 4

Phase I

Phase I Contract Award

Level II SRR — 2010

Level III SRR — 2011

Level III SDR — 2012

2009

Phase II Contract Awards

SOW Deliverables

Work Packages 1, 2, 3, and 4

- **Assess POD Architecture and identify Risks and Opportunities Deliverable is Risk and Opportunity Matrix with mitigation/insertion plan**
- **Trade Studies and Analysis**
  Deliverables are discrete Trade Studies and Analyses
- **Assessment of NASA's Requirements**
  Deliverable is a written assessment of NASA's Requirements
- **Final Report**

Work Package 5

- **First Stage Concept for an Upgraded Solid Rocket Fueled Booster**
  Final Report for documenting contractor approach for development of an Upgraded Solid Rocket Fueled Booster

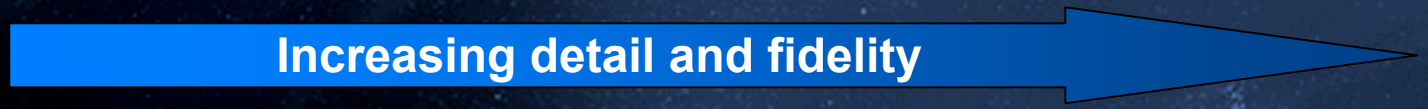
Risks and Opportunities

Base Period	Option I	Option 2 Period
Functional Feasibility Review (FFR)	Preliminary Requirements Review (PRR)	System Definition Review (SDR)
Concept of Design Review (CoDR)	System Requirement Review (SRR)	

- Submitted to NASA 60 days prior to the five reviews
- Assess the Ares V Point of Departure
- The Government will utilize the risk and opportunities identified by the Contractor to prioritize and update the trades to be performed
- Provide a risk mitigation plan for each risk identified
- Provide an independent assessment of Ares V POD opportunities

Trade Studies and Analyses

	Base Period	Option I Period	Option 2 Period
Milestones	Preliminary Requirements Review (PRR)	System Requirement Review (SRR)	System Design Review
Trade Studies and Analyses	Trade Element Concept	Trade to Mature Element Design Concept	Trade to Mature Element Design



- Trades and analyses will identify requirements and refine the concept
- NASA's intent that both deterministic and probabilistic techniques be incorporated into the trade studies and analyses
- NASA will provide Ground rules and assumptions and FOMS
- Expectation that Industry will Identify additional trades and analyses in their proposals

Requirements Assessment

Base Period	Option I	Option 2 Period
Functional Feasibility Review (FFR) • Level II Requirements (Constellation Architecture Requirements Document - CxP 70000)	**Preliminary Requirements Review (PRR)** • Level III Requirements • Level IV (EDS Element Requirements) KDRs	**System Definition Review (SDR)** • Level IV Requirements
Concept of Design Review (CoDR) • Updated Level II Requirements • Level III (Ares V System Requirements) Key Design Requirements (KDRs)	**System Requirement Review (SRR)** • Updated Level III Requirements • Level IV Requirements	

- **Submitted to NASA 60 days prior to the five reviews include the following:**
  - Flow-down of requirements
  - Impact of the requirements on the Ares V
  - Architecture (technical, cost and schedule)
  - Feasibility of implementation of the requirements
  - Verification of the requirements
  - Suggestions for remediation

First Stage Concept for an Upgraded Solid Rocket Fueled Booster

- **Propose an upgraded performance solid rocket fueled booster approach for the First Stage Element:**
  - Exceed the POD Requirements in SOW (Table 8.2)
  - Satisfy Element Physical Constraints in SOW (Table 8.3)

Base Period	Option I Period	Option 2 Period
Develop a Concept	Refine the Concept	Mature the Concept

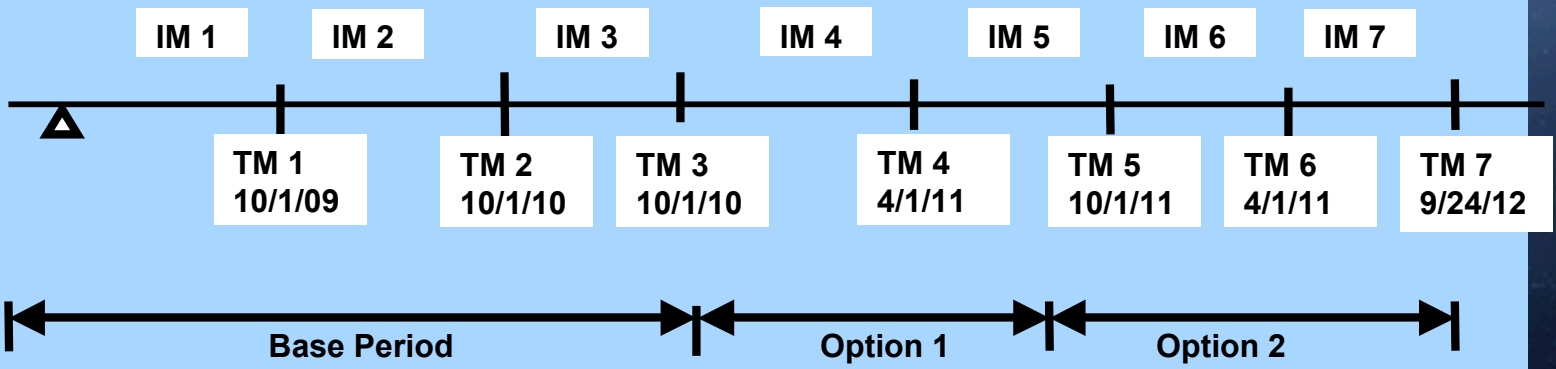
Data Requirements Description (DRDs) for Ares V Phase I Procurement

- **16 DRDs for this procurement**
  - 3 DRDs required by the FAR/NFS
    - Contract Information Technology Security Program Plan
    - Information Technology (IT) Security Requirements Compliance Documents
    - Technology Reports
  - 9 DRDs required for Project reporting and execution
    - Safety, Health, and Environmental Plan
    - Mishap and Safety Statistics Report
    - System Security Plan
    - Position Risk Designation for Non-NASA Employee
    - Badged Employee and Remote IT User Listing
    - Contractor Employee Clearance Document
    - Subcontractor and Geographic Data Collection
    - Quarterly Progress Report
    - Final Report
  - 4 additional DRDs developed due to the unique nature of the procurement
    - Risk and Opportunities Identification
    - Trades and Analyses Report
    - Requirements Assessment
    - First Stage Design Concept

Ares V Integration and Coordination

Level II Milestones			SRR 6/10			
Level III Milestones	FFR* 8/09		PRR 3/1/10	CoDR 12/10	SRR 7/11	SDR 3/12

Phase I Contract Meetings



- **TM - Technical Meeting**
  - Quarterly Meeting
  - Work Package specific review
  - Envisioned to be a virtual meeting
  - Objective - keep the NASA/Contractor Team aligned
  - Contracting Officer provide any Technical Direction Needed
- **Interchange Meeting (IM)**
  - Semi-annual Meeting
  - Ares V Integration
  - Envisioned to be a face-to-face meeting
  - Objective - keep the NASA/Contractor Team aligned
  - Contracting Officer provide any Technical Direction Needed

Planned Resource Allocation Per Contract Award

	Fiscal Year				
	2009	2010	2011	2012	Total
$ per Contractor Shroud	$0.45M	$0.9M	$2.5M	$3.0M	$6.85M
$ per Contractor EDS	$1.35M	$2.7M	$7.5M	$9.0M	$20.55M
$ per Contractor Core Stage	$1.35M	$2.7M	$7.5M	$9.0M	$20.55M
$ per Contractor Avionics	$0.45M	$0.9M	$2.5M	$3.0M	$6.85M
$ per Contractor First Stage Booster	$0.9M	$1.8M	$5.0M	$6.0M	$13.7M

Procurement Schedule

ACTIVITY	DATE
ASM Approval	Aug 22, 2008
PSM	Nov 3, 2008
Issued Draft RFP	Nov 25, 2008
Pre-solicitation Conference	Dec 3, 2008
Plan is to Synopsize RFP	Dec 19, 2008
Plan is to Issue RFP	Jan 5, 2009
Proposals Due	Feb 9, 2009
Clarification of Proposals Complete	Feb 16, 2009