National Aeronautics and Space Administration

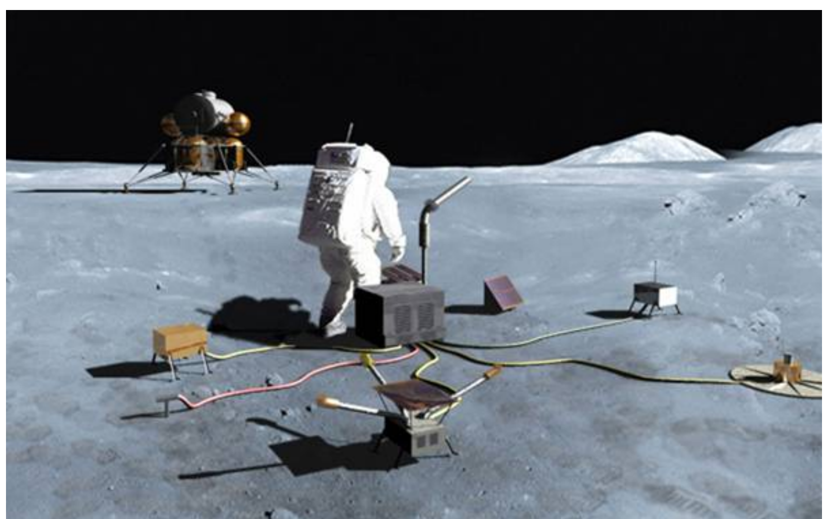
A New Heavy-Lift Capability for Space Exploration: NASA's Ares V Cargo Launch Vehicle

Daniel L. Dumbacher
Deputy Director
Exploration Launch Projects Office
Marshall Space Flight Center

AIAA Space 2006 Conference
September 2006

The U.S. Vision for Space Exploration

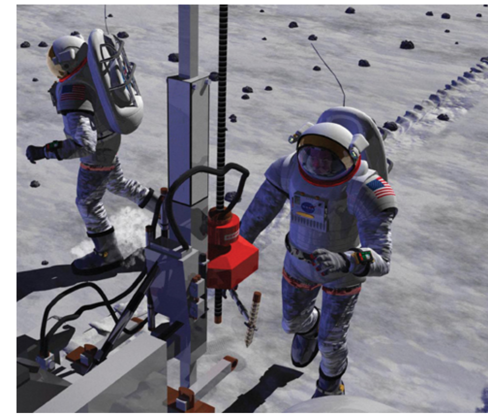
- Implement a sustained and affordable human and robotic program to explore the solar system and beyond.
- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for the human exploration of Mars and other destinations.
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration.
- Promote international and commercial participation in exploration.



Guides NASA's Missions of Scientific Discovery and Technical Achievement

The Moon –
The First Step to Mars and Beyond…

- **Gaining significant experience in operating away from Earth's environment**
  - Space will no longer be a destination visited briefly and tentatively
  - "Living off the land"
  - Human support systems



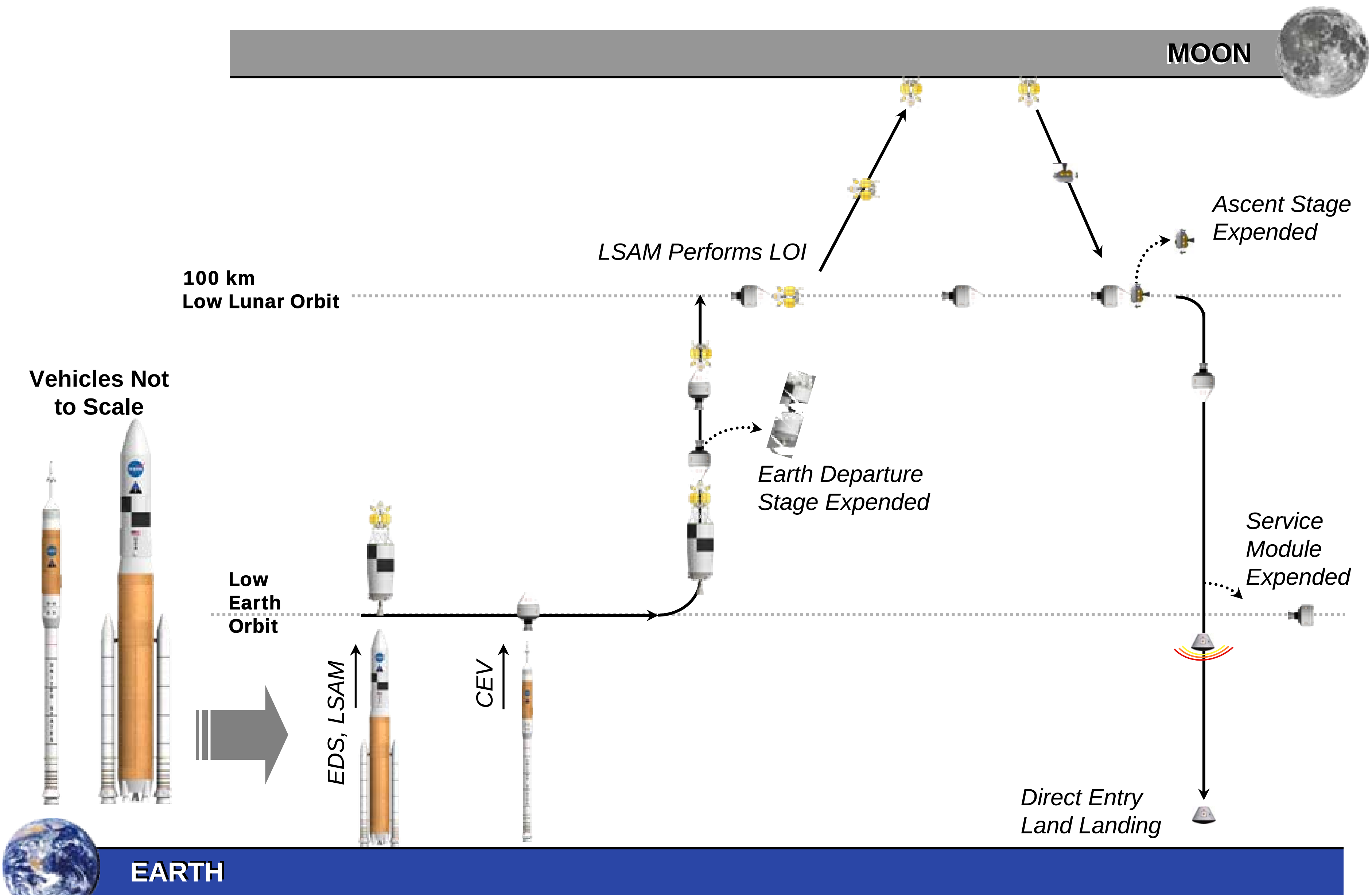
- **Developing technologies needed for opening the space frontier**
  - Crew and cargo launch vehicles (125-mt class)
  - Earth ascent/entry system – Crew Exploration Vehicle

- **Conducting fundamental science**
  - Astronomy, physics, astrobiology, historical geology, exobiology

America's Exploration of Space Promotes National Strength and Prosperity

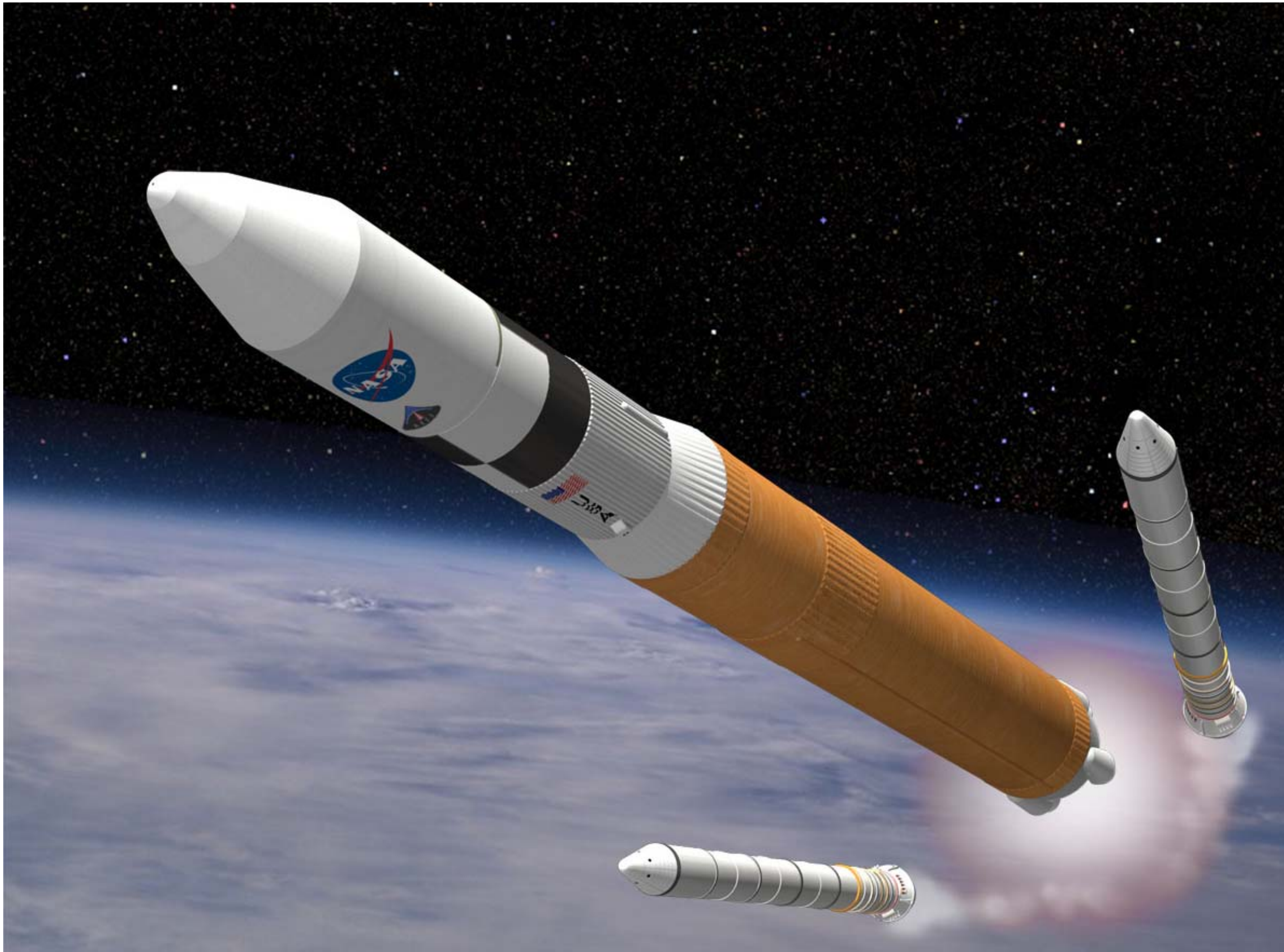
NASA's Exploration Architecture

Lunar Mission Scenario

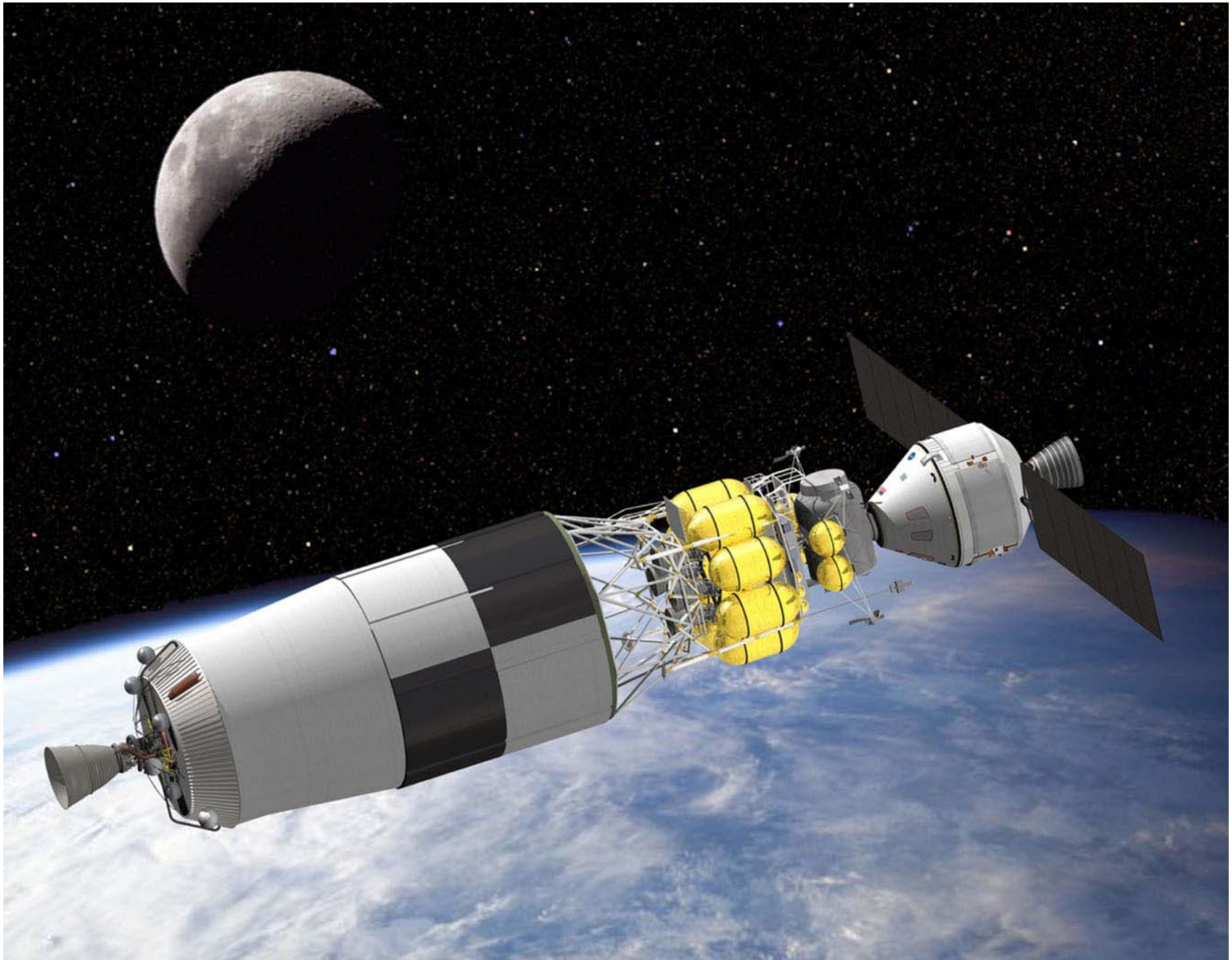


Ares I Launch Concept

Ares V Launch Concept

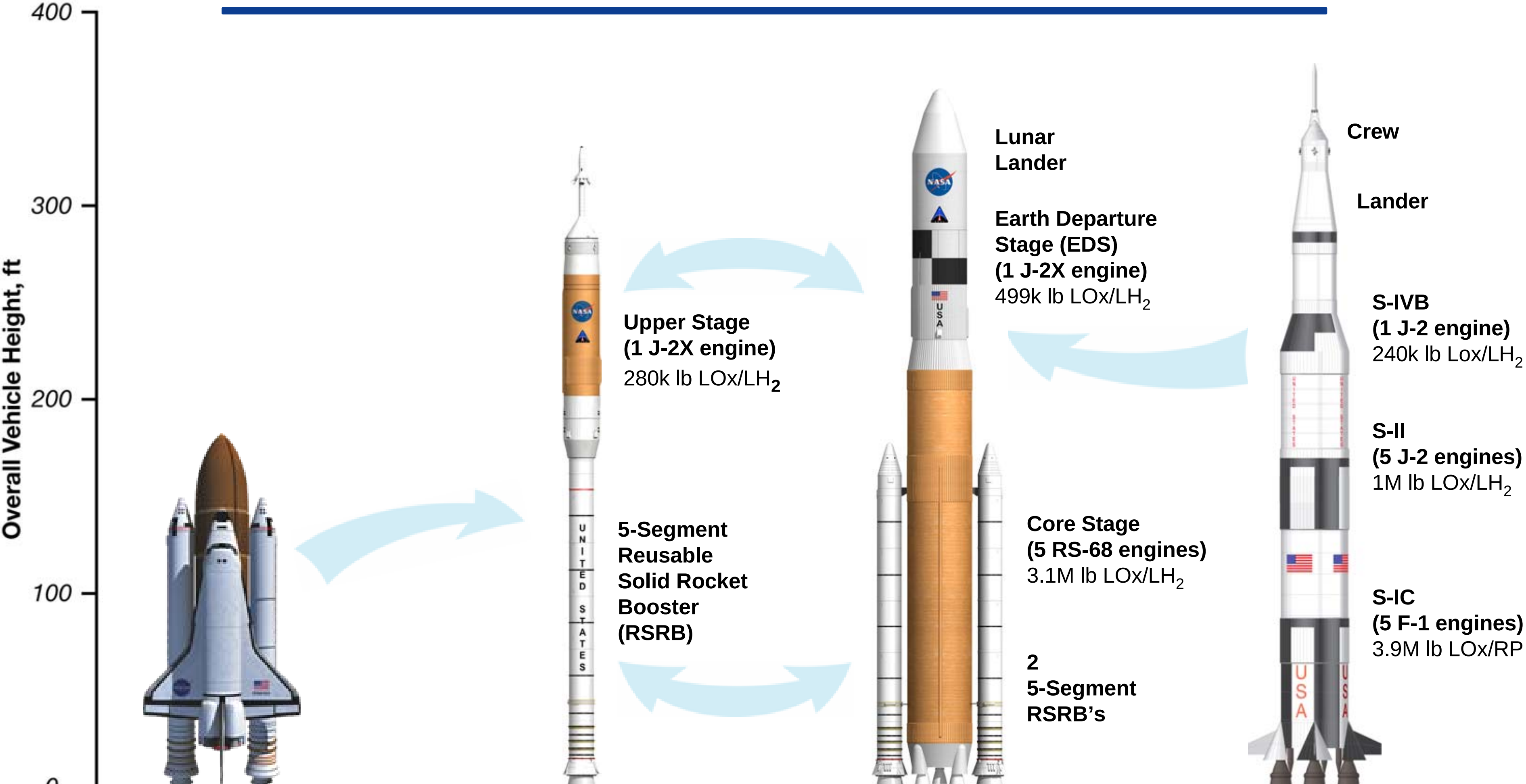


The Crew Launch Vehicle Docking with the Lunar Surface Access Module



Launch Vehicles Comparisons

(Blue Arrows Indicate Hardware Commonality)



Space Shuttle	Ares I	Ares V	Saturn V
Height: 184.2 ft	**Height:** 321 ft	**Height:** 358 ft	**Height:** 364 ft
Gross Liftoff Mass: 4.5M lb	**Gross Liftoff Mass:** 2.0M lb	**Gross Liftoff Mass:** 7.3M lb	**Gross Liftoff Mass:** 6.5M lb
55k lbm to LEO	48k lbm to LEO	117k lbm to TLI 144k lbm to TLI in Dual-Launch Mode with Ares I 290k lbm to LEO	99k lbm to TLI 262k lbm to LEO

Expanded Views of Ares I and Ares V Show Common Hardware

Launch Abort System

Crew Exploration Vehicle (CEV)
(Crew Module / Service Module)

Spacecraft Adapter

Instrument Unit

Forward Skirt

Upper Stage

J-2X Upper Stage Engine

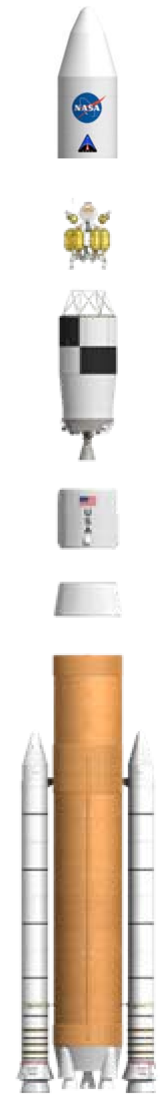
Interstage

Forward Frustum

First Stage
(5-Segment RSRB)

Ares I

48k lbm to LEO



Composite Shroud

Lunar Surface Access
Module (LSAM)

<u>Earth Departure Stage</u>
LOx/LH_2
1 J-2X Engine
Al-Li Tanks/Structures

Interstage

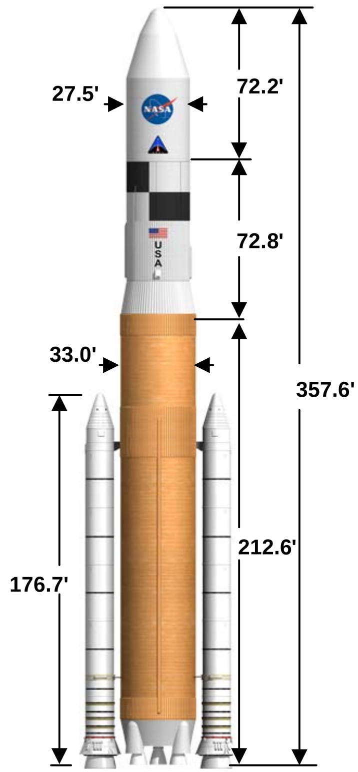
<u>Core Stage</u>
LOx/LH_2
5 RS-68 Engines
Al-Li Tanks/Structures

2
5-Segment
RSRB's

Ares V

117k lbm to TLI
144k lbm to TLI in Dual-Launch Mode with Ares I
290k lbm to LEO

Ares V Baseline Configuration

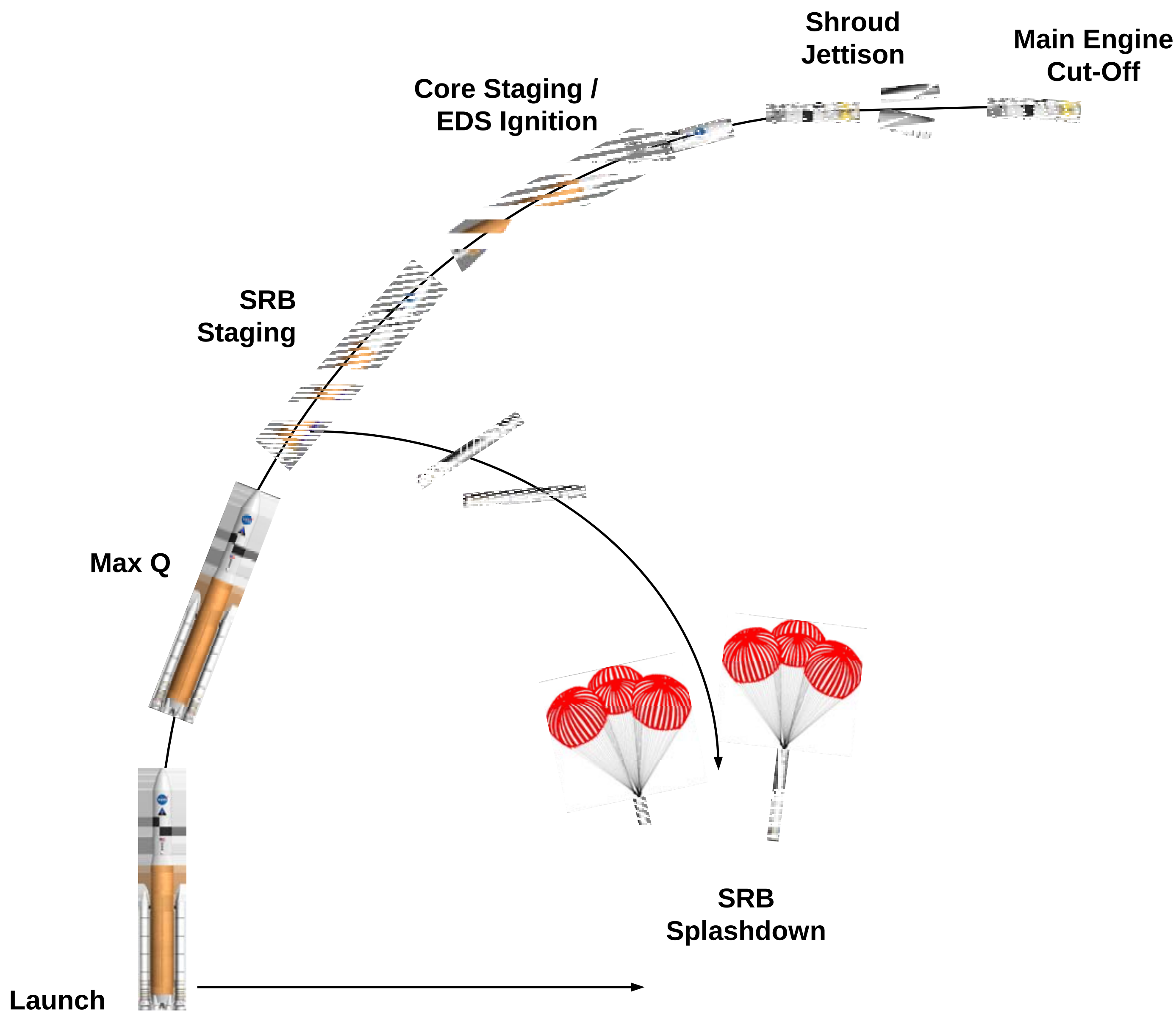


Delivery Orbit	1.5 Launch TLI (EDS Suborbital Burn)
	30 x 160 nmi @ 28.5°
Payload	144,114 lbm 65.4 mT
LSAM Earth liftoff	99,999 lbm 45.4 mT
CEV LEO rendezvous	44,115 lbm 20.0 mT
Insertion Altitude	78.0 nmi
T/W @ Liftoff	1.35
Max Dynamic Pressure	621 psf
Max g's Ascent Burn	3.86 g
T/W @ Booster Separation	1.36
T/W Second Stage	0.44
Delivery Orbit	Single Launch TLI (EDS Suborbital Burn)
	160 x 160 nmi @ 28.5°
Payload	117,206 lbm 53.2 mT
EDS Propellant Offload	6.0 %

Vehicle Concept Characteristics

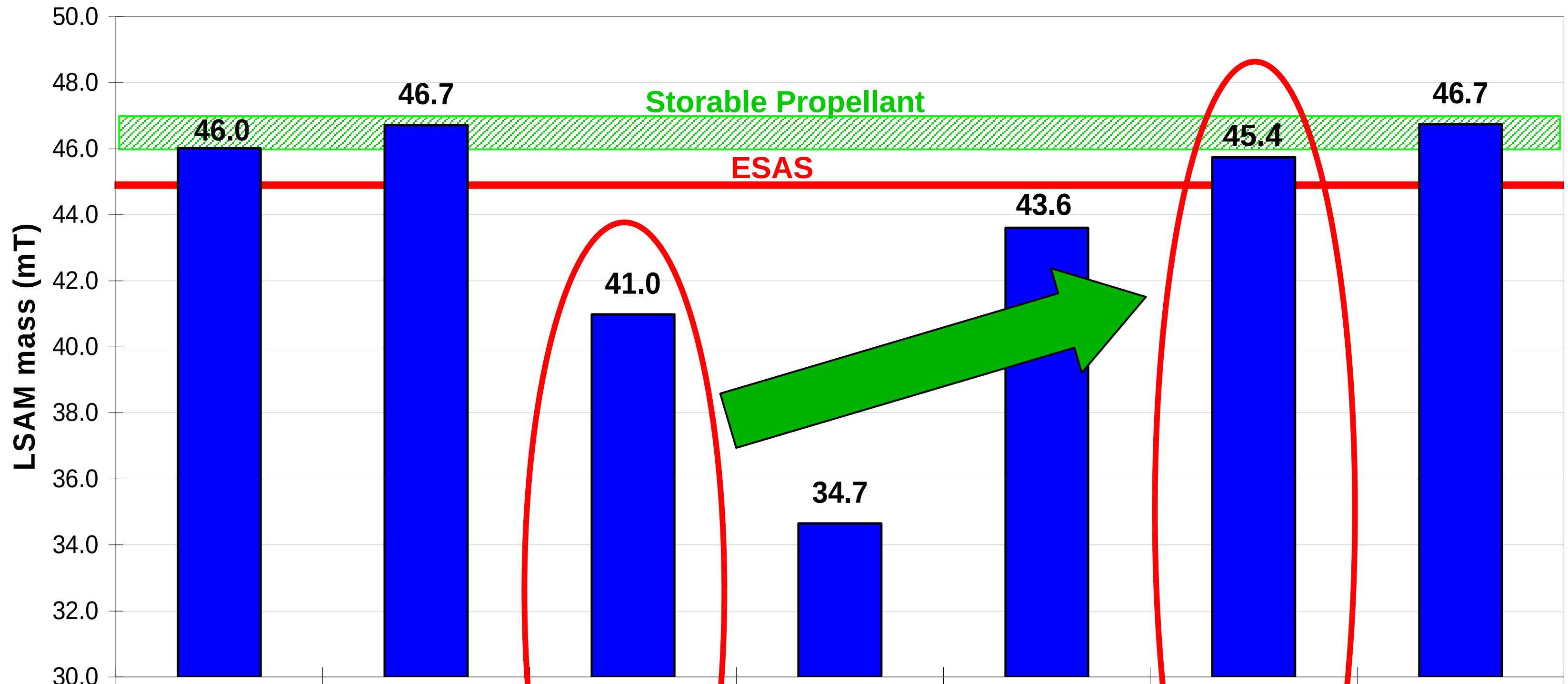
GLOW	**7,347,875 lbf**	
Payload Envelope L x D	39.4 ft x 24.5 ft	
Shroud Jettison Mass	12,868 lbm	
Booster (each)		
Propellants	PBAN (053-06 Trace)	
Useable Propellant	1,388,066 lbm	
Stage pmf	0.8566	
Burnout Mass	232,405 lbm	
# Boosters / Type	2 / 5 Segment SRM	
Booster Thrust (@ 0.7 secs)	3,484,159 lbf @ Vac	
Booster Isp (@ 0.7 secs)	265.5 s @ Vac	
Core Stage		
Propellants	LOX/LH2	
Useable Propellant	3,091,031 lbm	
Propellant Offload	0.0 %	
Stage pmf	0.8989	
Dry Mass	312,818 lbm	
Burnout Mass	347,482 lbm	
# Engines / Type	5 / RS-68	
Engine Thrust (106%)	688,693 lbf @ SL	784,000 lbf @ Vac
Engine Isp (106%)	364.3 s @ SL	414.7 s @ Vac
Mission Power Level	106.0 %	
Core Burn Time	327.0 sec	
Second Stage / EDS		
Propellants	LOX/LH2	
Useable Propellant	498,909 lbm	
Propellant Offload	0.0 %	
Stage pmf	0.9205	
Dry Mass	36,233 lbm	
Burnout Mass	43,108 lbm	
# Engines / Type	1 / J-2X	
Engine Thrust (100%)	293,750 lbf @ Vac	
Engine Isp (100%)	450.0 s @ Vac	
Mission Power Level	100.0 %	
Delivery Orbit	30 x 160 nmi @ 28.5°	
Payload	290,199 lbm 131.6 mT	
EDS Propellant Offload	41.9 %	

Ares V Notional Reference Trajectory



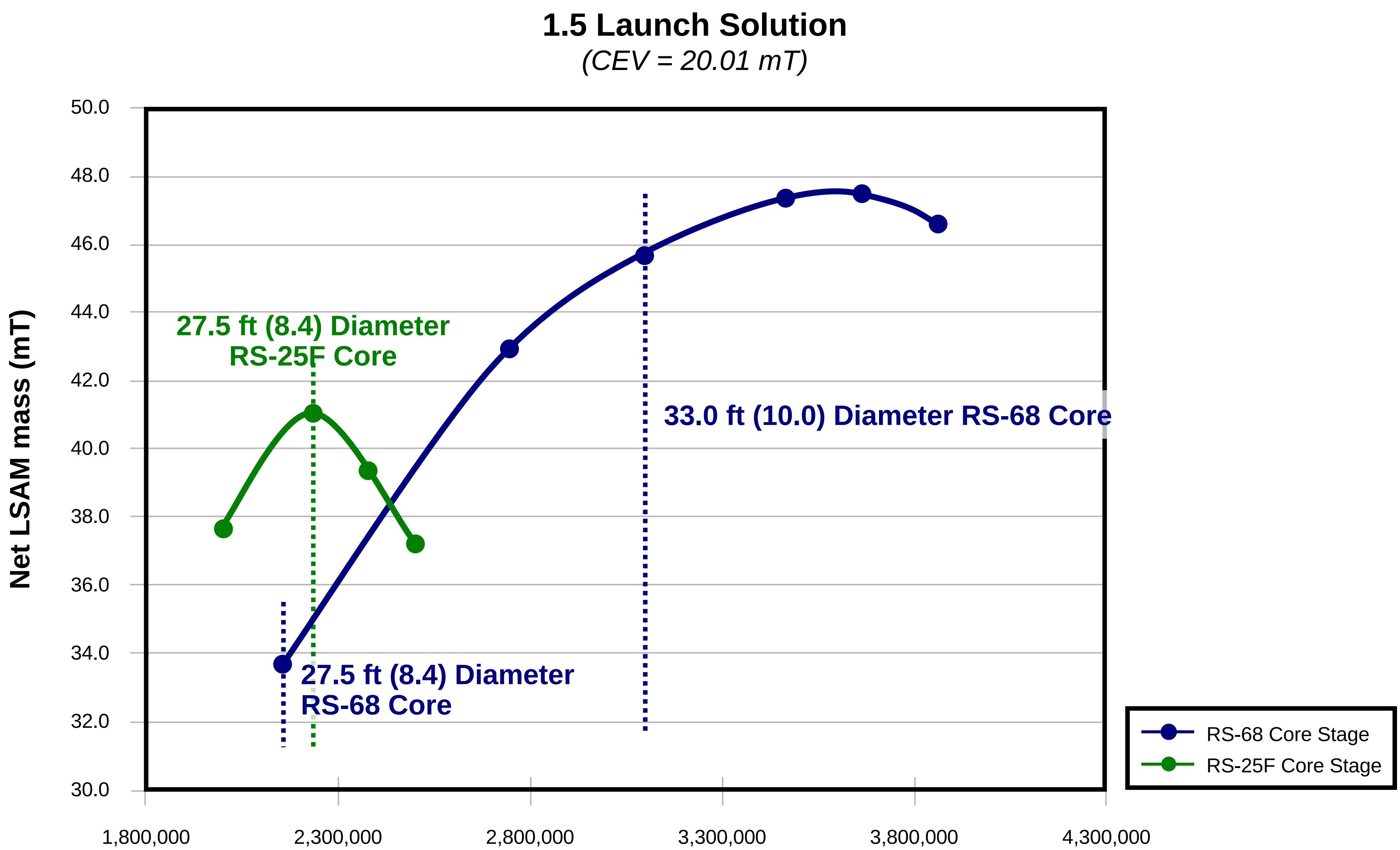
Performance Gains Are Realized Through the Ares V Configuration Evolution

1.5 Launch Solution
(CEV = 20.01 mT)



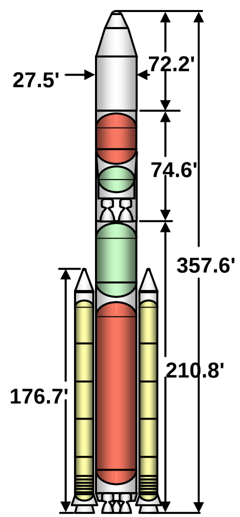
	ESAS	ESAS					
Core Eng	5xSSME	5xSSME	5xSSME	5xRS-68	5xRS-68	5xRS-68	5xRS-68
Isp (s)	452.1 Isp	452.1 Isp	451.5 Isp	409.0 Isp	409.0 Isp	414.7 Isp	414.7 Isp
Power Lvl	104.5%	104.5%	104.5%	102.0%	102.0%	106.0%	106.0%
Core Dia	27.5 ft	27.5 ft	27.5 ft	27.5 ft	33.0 ft	33.0 ft	33.0 ft
EDS Eng	2xJ-2S+	1xJ-2S+	1 J-2X				
RSRM Propellant	HTPB		PBAN *Identical Motor to CLV*				HTPB *Later Propellant-Only Change*

The Effect of CaLV Core Stage Usable Propellant on TLI Payload



Comparison of Integrated Vehicle Configurations

5 Segment SRBs with 5 SSMEs & 2 J-2S+ (ESAS 27.3)



Booster Stage (each)
2 / 5 - Segment SRM

Core Stage
5 / SSME Blk II @ 104.5%

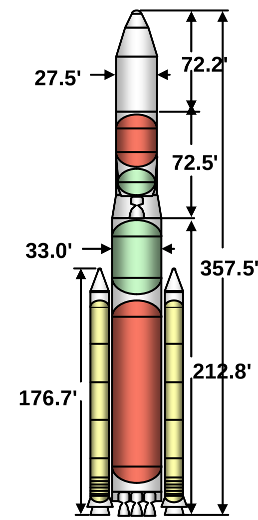
Second Stage
2 / J-2S+ @ 100%

♦ Assumptions/Conclusions

- LOM results are for ascent only
- Core engine risks dominate vehicle risk
  - **No mission continuance engine-out capability.**
- SSMEs operated with current redlines enabled and assuming a currently certified 109% PL for remaining engines in the event of an engine shutdown. (Eliminating redlines for a **cargo vehicle** would improve LOM.)

ESAS Proposal

5 RS-68 Core & 5 Segment SRB + 1 J-2X



Booster Stage (each)
2 / 5 - Segment SRM

Core Stage
5 / RS-68 @ 102.0%

Second Stage
1 / J-2X @ 100%

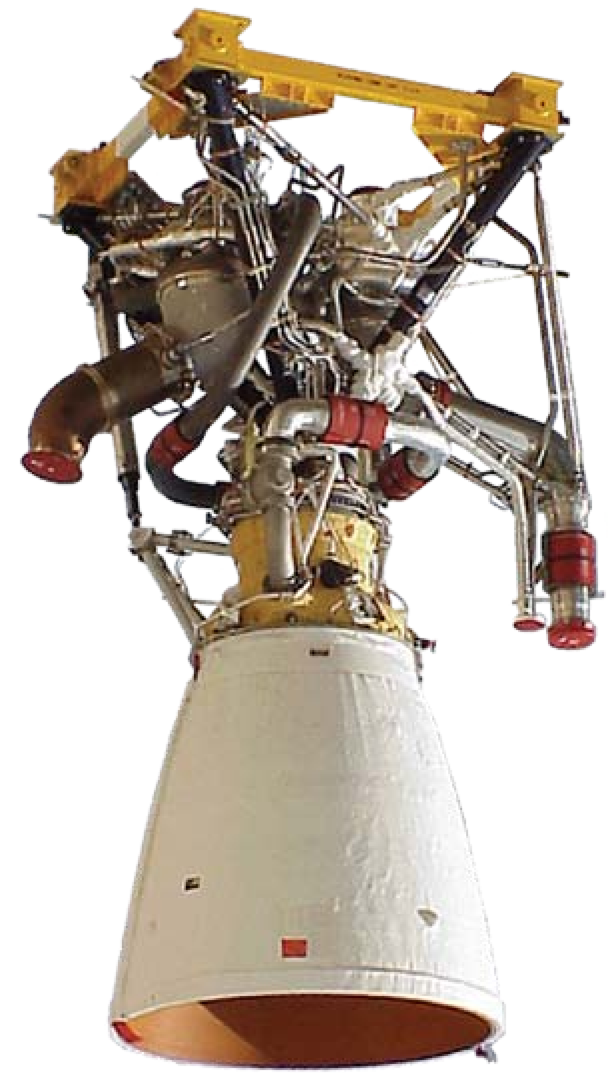
♦ Assumptions/Conclusions

- LOM results are for ascent only
- Core engine risks dominate vehicle risk
  - **No mission continuance engine-out capability.**
- J-2X was assumed to have the same failure rate as the J-2S+ for this run
- RS-68 hydrogen deflagration at start-up not considered in risk assessment

Revised Baseline

RS-68 Engine Upgrades - A Governmental Partnership (Cont'd)

- **Engine System Hardware**
  - Redesign small lines and joints to be compatible with upgrades
- **Vehicle Integration**
  - Provide engine interface requirements
  - Support trade studies on vehicle interface design solutions
  - Prepare Interface Control document

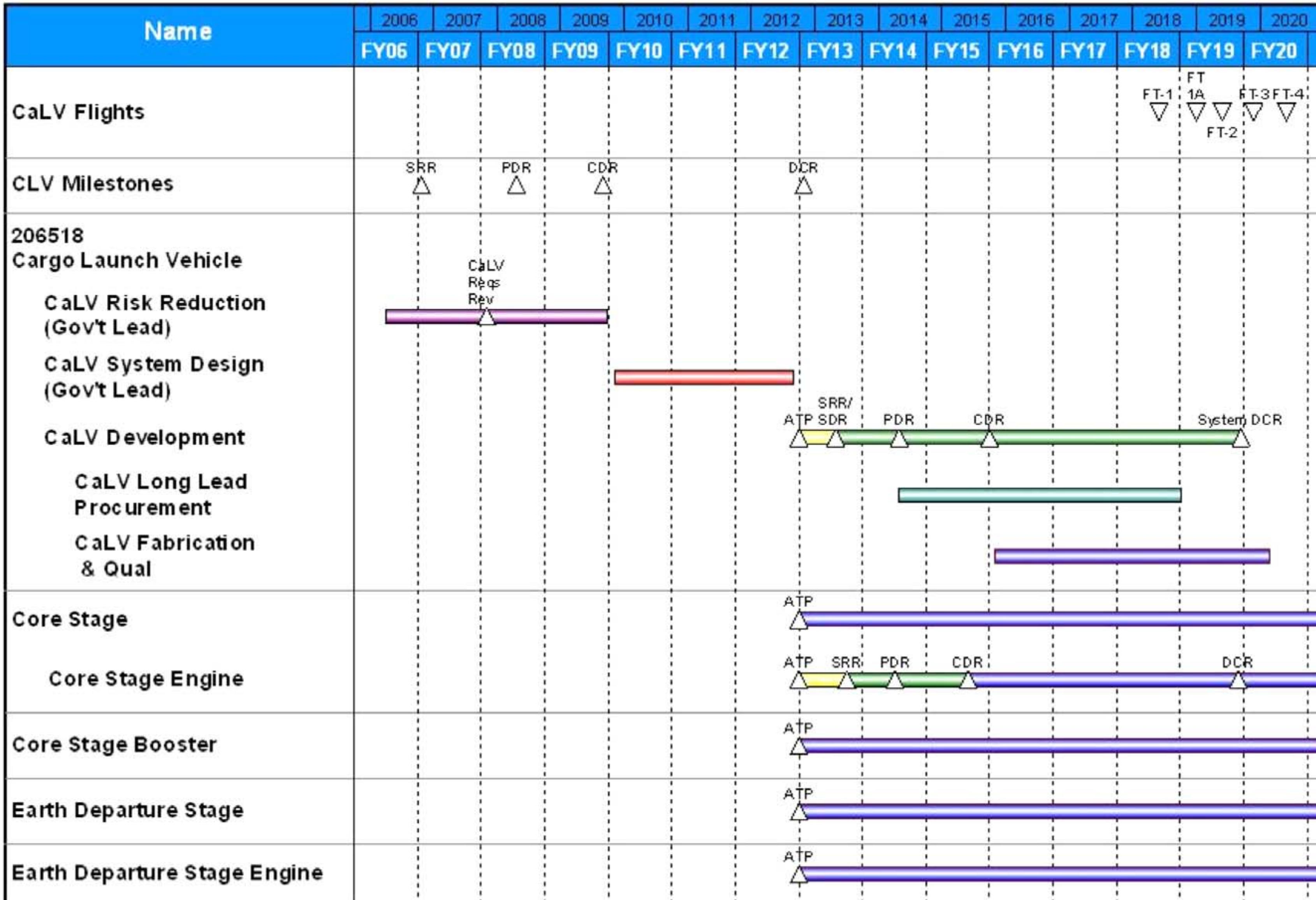


Reducing Technical, Schedule, and Cost Risks

The 33-foot-diameter Saturn V was processed at the Michoud Assembly Facility

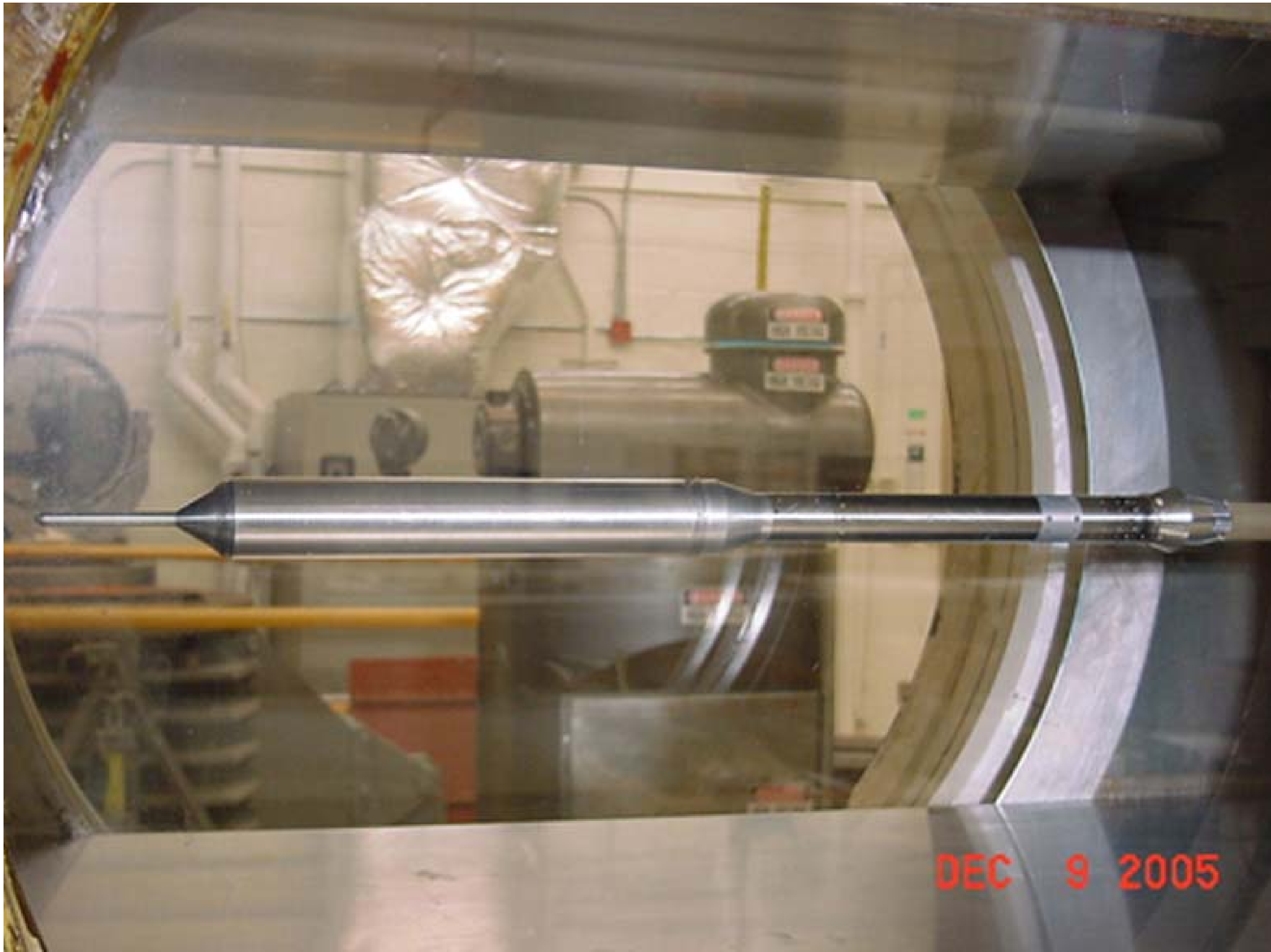
Notional Ares V Schedule

PCB B/L 5/18/06



Note: All Design Review dates are Board dates

Wind Tunnel Testing



Reusable Solid Rocket Booster Static Test Firing, April 2006

J-2X Engine Subscale Injector Performance Test

www.nasa.gov/ares