

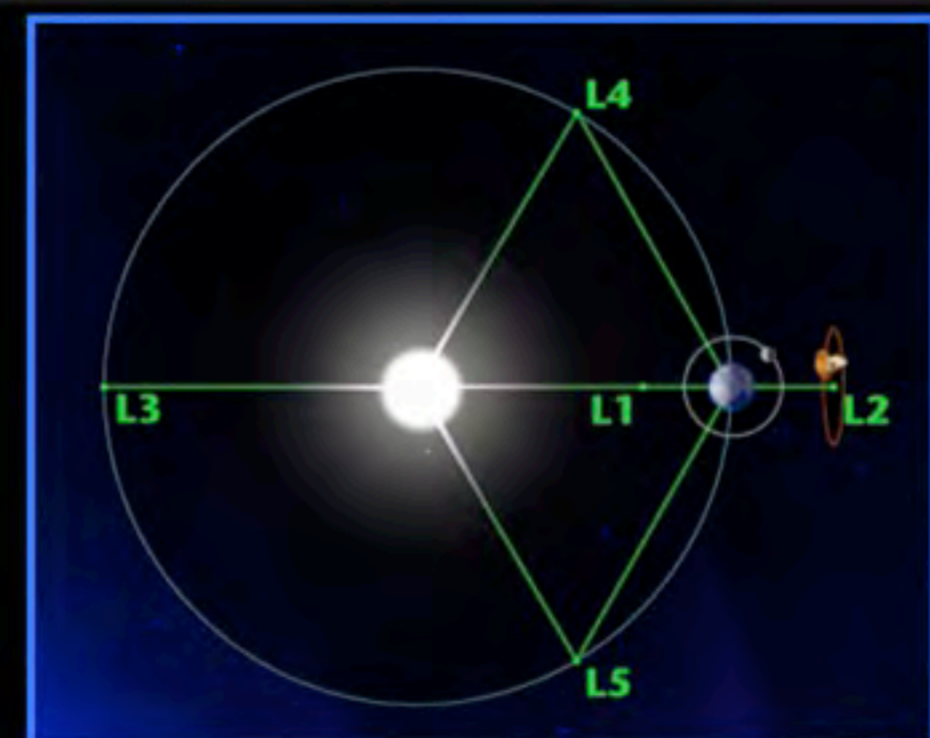
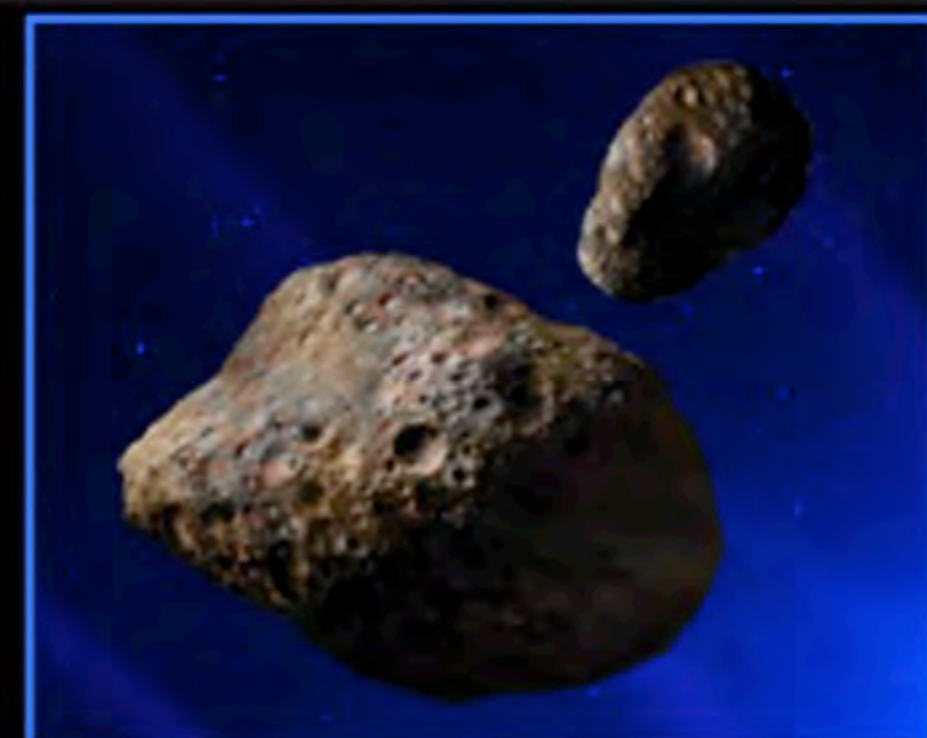


# NASA's Space Launch System Overview

*Todd May, Manager  
Space Launch System (SLS) Program  
NASA Marshall Space Flight Center*



**Space Launch System**



October 2012

# Advancing the U.S. Legacy of Human Exploration

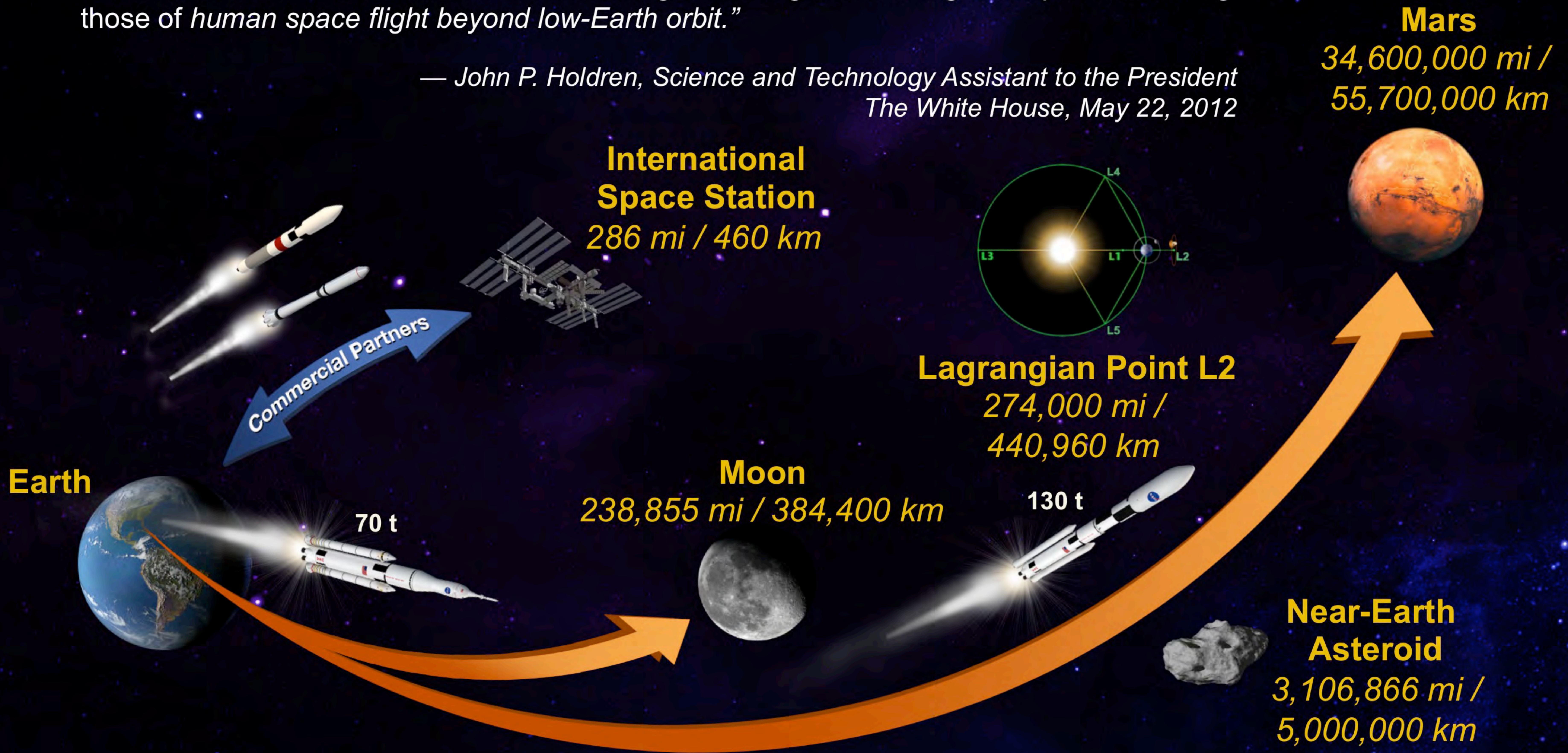


# The Future of Exploration



“This expanded role for the private sector will free up more of NASA’s resources to do what NASA does best — tackle the most demanding technological challenges in space, including those of *human space flight beyond low-Earth orbit.*”

— John P. Holdren, Science and Technology Assistant to the President  
The White House, May 22, 2012



“My desire is to work more closely with the human spaceflight program so we can take advantage of synergy. We think of the SLS as the human spaceflight program, but it could be hugely enabling for science.”

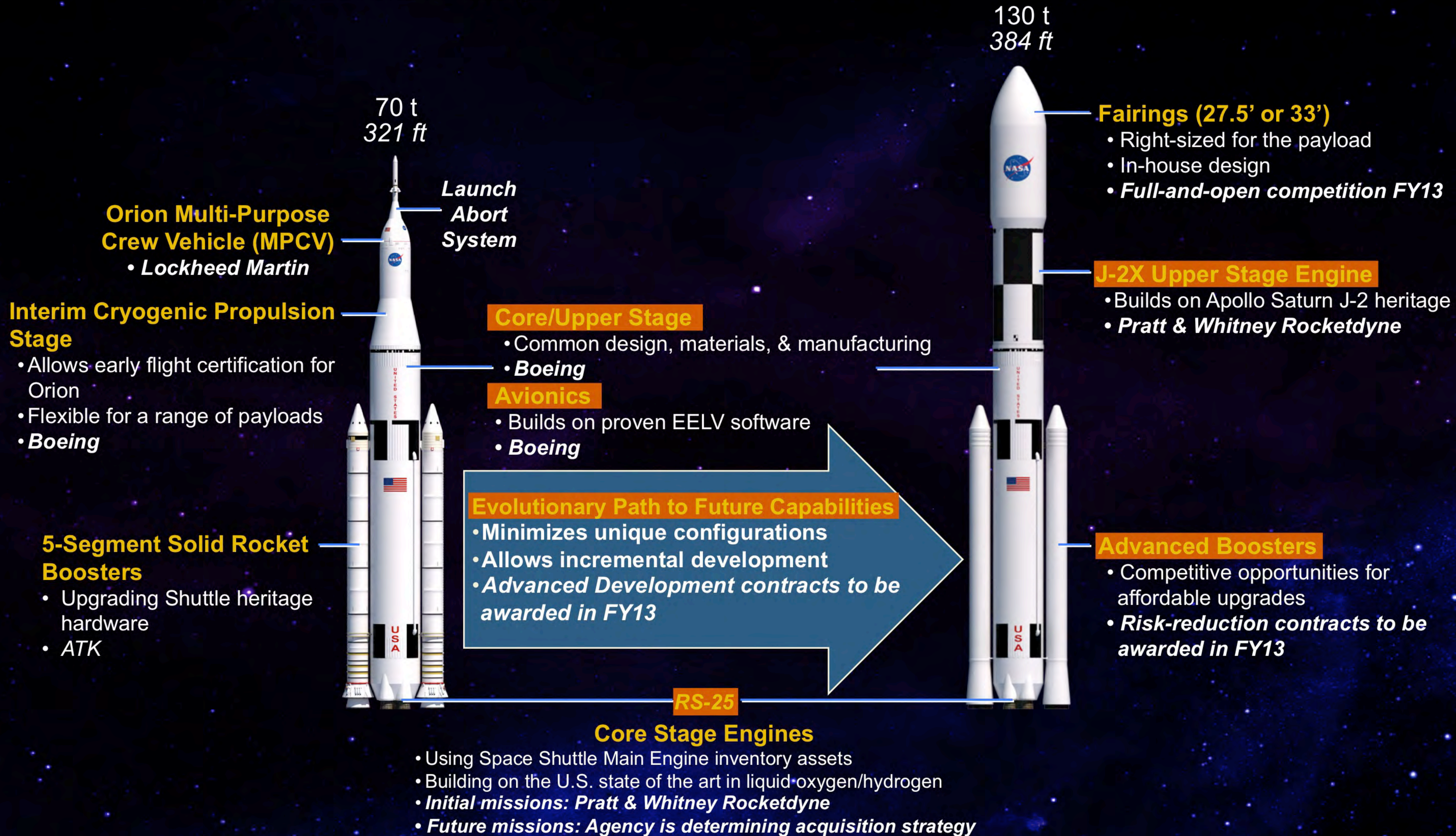
— John Grunsfeld, Associate Administrator  
NASA Science Mission Directorate  
Nature, Jan 19, 2012

# Building on the U.S. Infrastructure



**INITIAL CAPABILITY, 2017–21**

**EVOLVED CAPABILITY, Post-2021**



**Working with Industry Partners to Develop America's Heavy-Lift Rocket**

# The Road to First Flight in 2017



NASA Life Cycle Phases	Approval for Formulation ▼			Approval for Implementation ▼			
	FORMULATION			IMPLEMENTATION			
Program Life Cycle Phases	Pre-Phase A: Concept Studies	Phase A: Concept & Technology Development	Phase B: Preliminary Design & Technology Completion	Phase C: Final Design & Fabrication	Phase D: System Assembly, Int. & Test, Launch & Checkout	Phase E: Operations & Sustainment	Phase F: Closeout
Program Life Cycle Gates and Major Events	KDP A ▼ ✓	KDP B ▼ ✓	KDP C ▼	KDP D ▼	KDP E ▼ EFT-1 Launch ▼	KDP F ▼ EM-1 Launch ▼	EM-2 Launch ▼
Human Space Flight Project Reviews	MCR ▼ ✓ 2011	SRR/SDR ▼ ✓ 2012	PDR ▼ (highlighted) 2013	CDR ▼ 2015	SR ▼ 2016	FRR ▼ 2017	▼ 2021

**FOCUSED TOWARD**



CDR: Critical Design Review

EM-1: Exploration Mission 1

EFT-1: Exploration Flight Test 1

FRR: Flight Readiness Review

KDP: Key Decision Point

MCR: Mission Concept Review

PDR: Preliminary Design Review

SIR: System Integration Review

SDR: System Definition Review

SRR: System Requirements Review

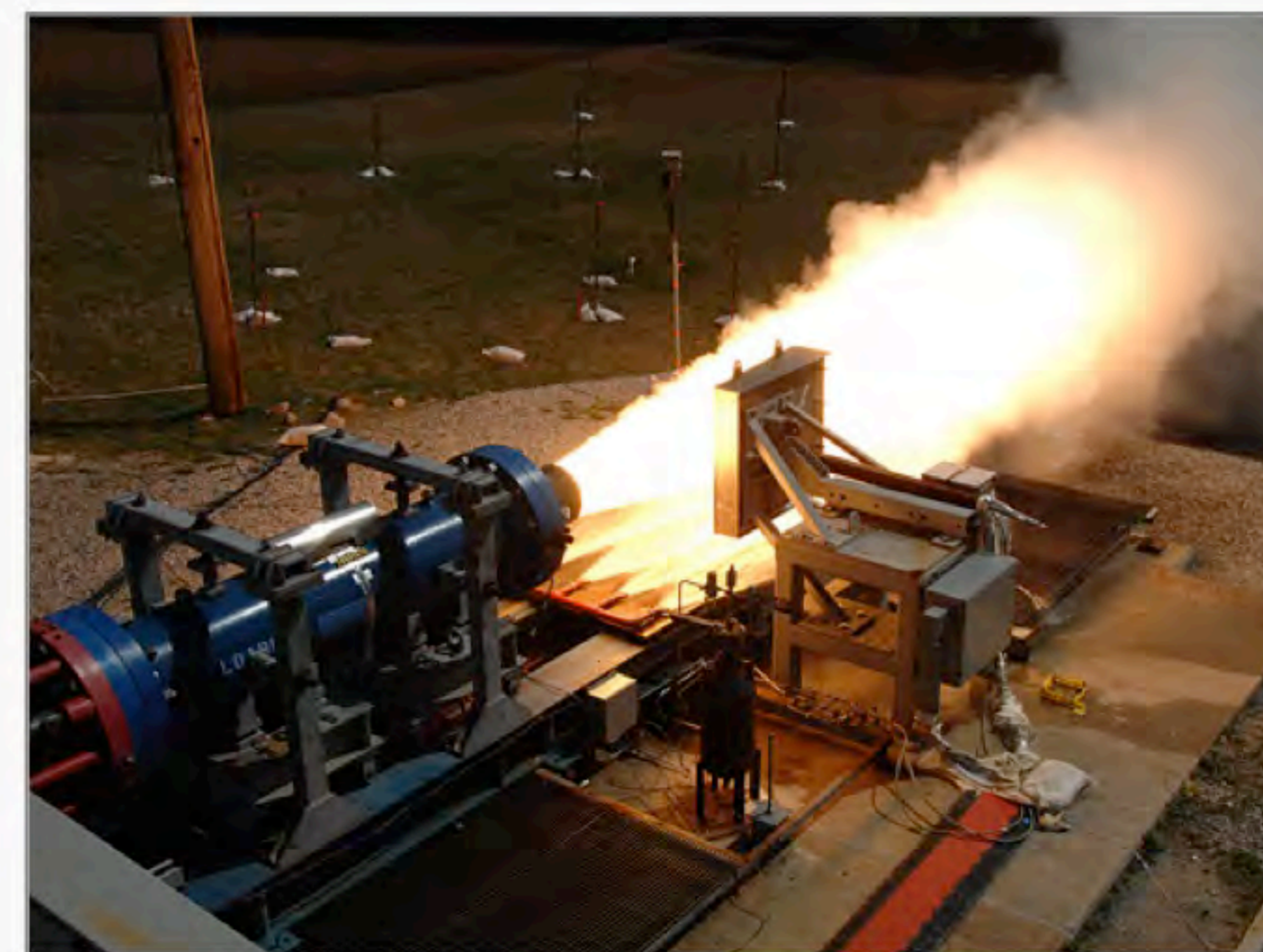
# Delivering Products and Progress Today



**J-2X Upper Stage Engine Development and RS-25 Core Stage Engine Inventory**  
Stennis Space Center, MS



**Subscale Solid Rocket Motor Firing and Avionics Testbed**  
Marshall Space Flight Center, AL



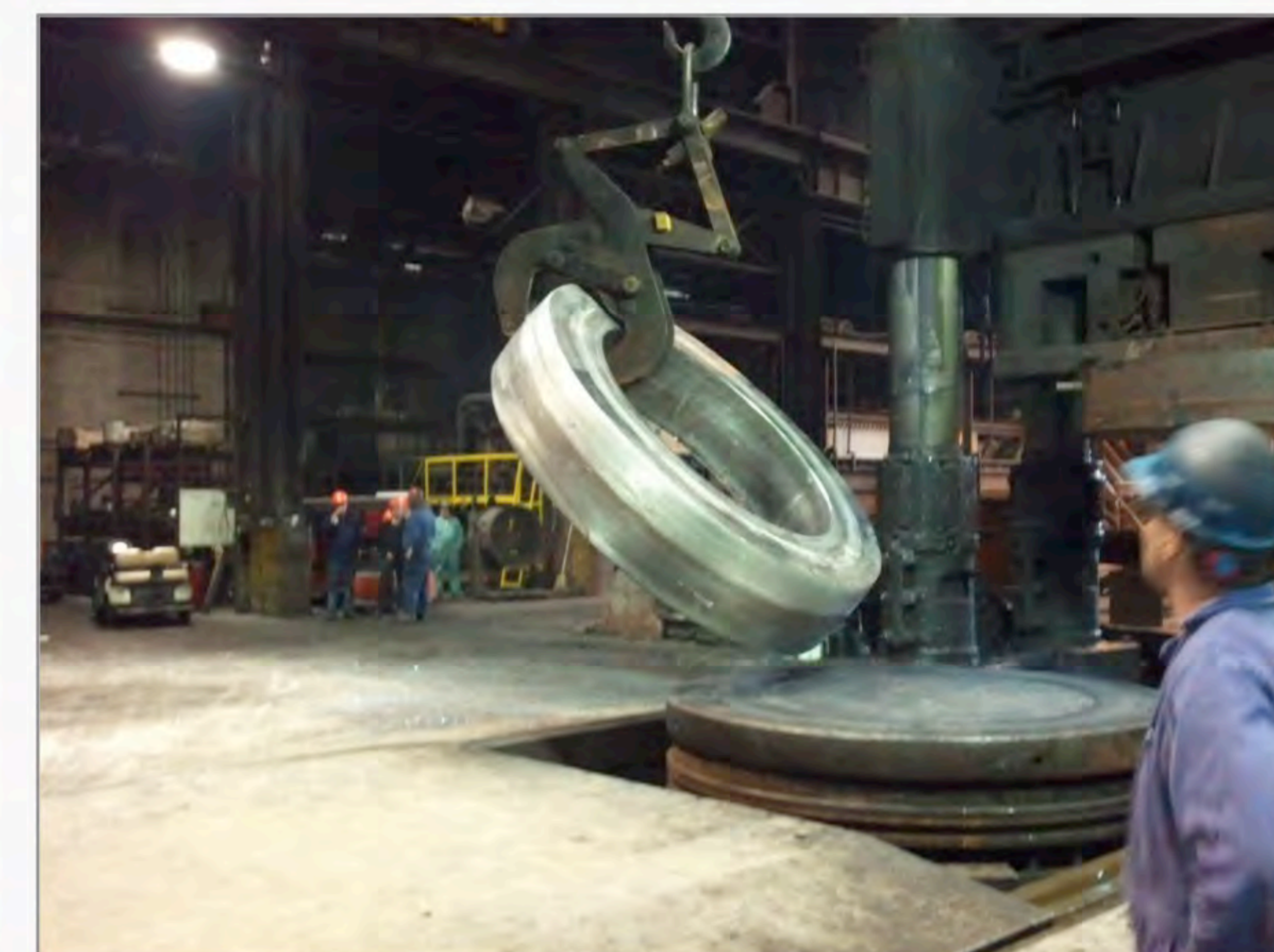
**5-Segment Solid Rocket Booster Firing, Promontory, UT**



**Stages Materials and Manufacturing Studies**  
Marshall Space Flight Center, AL



**MPCV/Stage Adapter Design and Development For Exploration Flight Test-1 in 2014**  
Marshall Space Flight Center, AL



**First Adapter Ring Forging,**  
ATI/Ladish, Cudahy, WI

# SLS Small Business Goals



- ◆ **NASA's Small Business Policy (NASA Policy Directive 5000.2C) has been assessed for SLS requirements:**
  - Stages
  - Engines
  - Advanced Booster NASA Research Announcement (NRA)
  - Advanced Development NRA
  - Interim Cryo-Propulsion Stage
  
- ◆ **Subcontracting plan goals for existing contracts are being updated via negotiations.**
  
- ◆ **SLS provides topics to the Small Business Innovation Research (SBIR) Program:**
  - Link to the NASA SBIR website is listed on all solicitations
    - <http://sbir.gsfc.nasa.gov/SBIR/SBIR.html>
  
- ◆ **For all incentive approaches, small business utilization performance is evaluated:**
  - Mentor/Protégé Program is included

***Targeting Robust Small Business Partnerships Through Various Channels***

# NASA Mentor-Protégé Agreement



July 2012

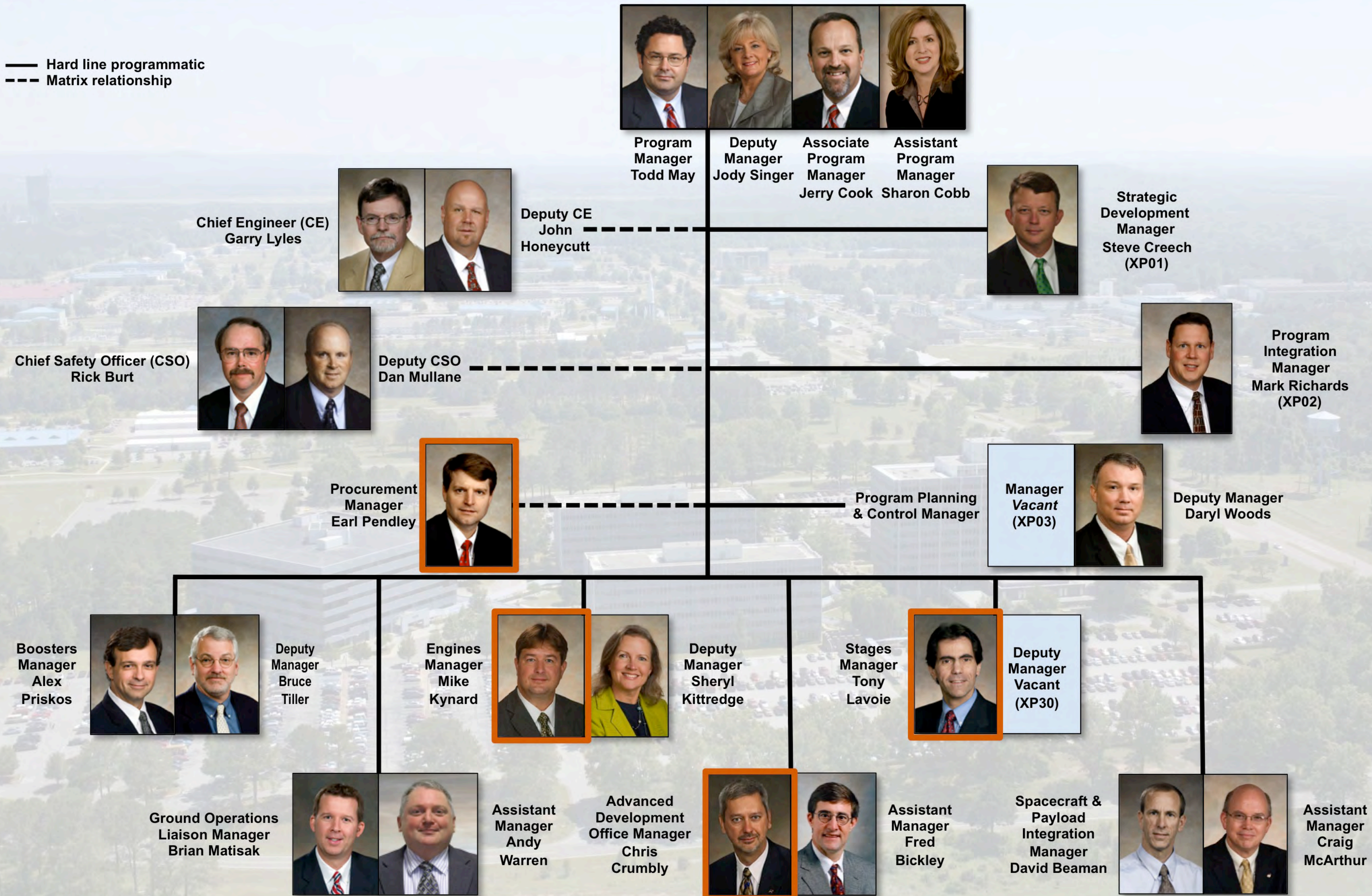


# SLS Program Office at Marshall Space Flight Center



100412

— Hard line programmatic  
 - - - Matrix relationship



# A National Infrastructure Asset



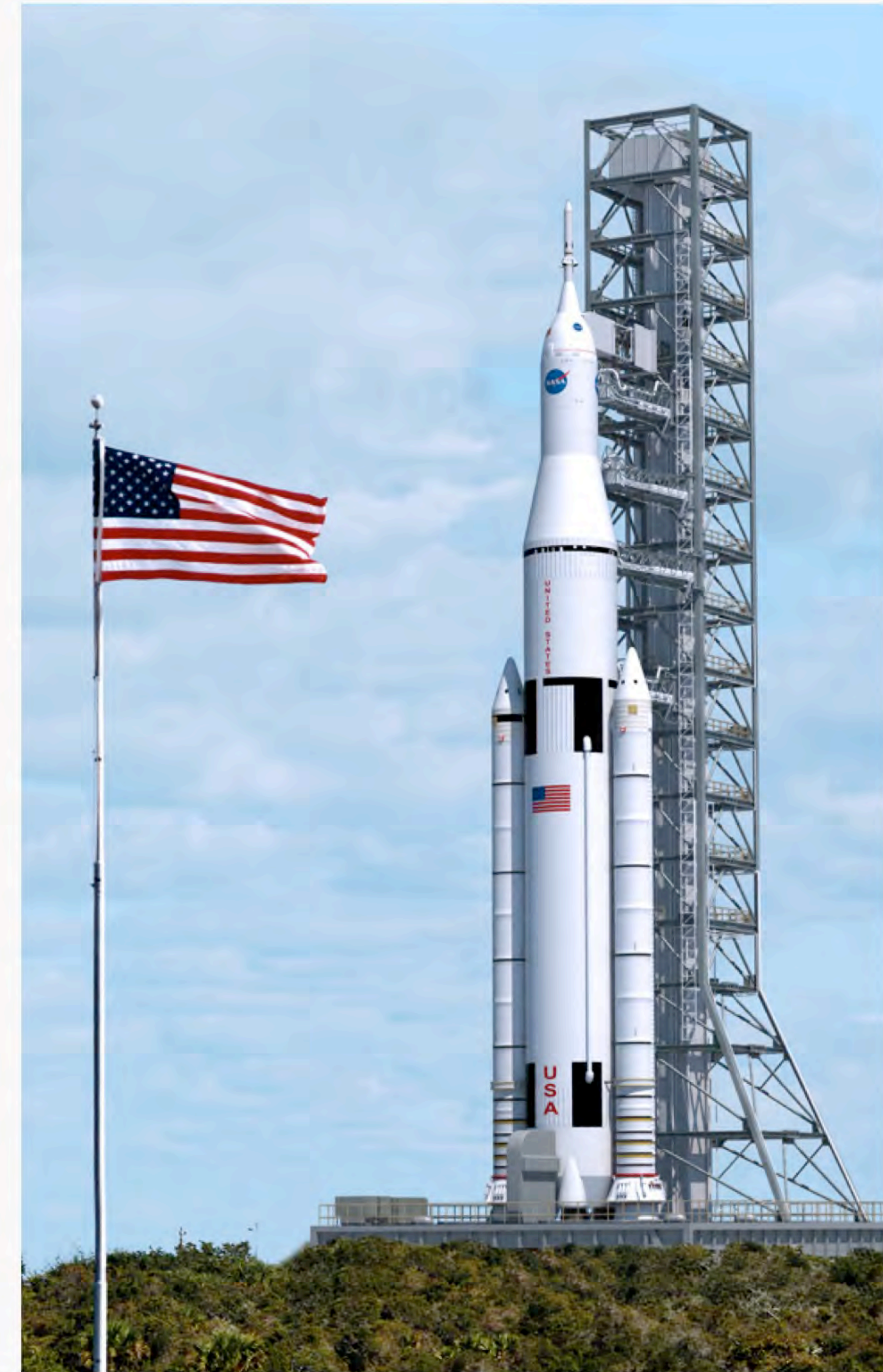
*For Beyond-Earth Orbit  
Exploration*

2017

# Space Launch System Summary



- ◆ ***Vital to NASA's mission and America's space goals***
- ◆ **Safe, affordable, and sustainable solution for space science and exploration**
- ◆ **Opens doors to discovery, technology, and economic expansion**
- ◆ **Evolvable, flexible configuration**
- ◆ **Employs available assets and advanced hardware in development**
- ◆ **Engages the Nation's aerospace experience base and unique infrastructure**
- ◆ **Offers near-term and long-range opportunities for small businesses**
  
- ◆ **Contact: Earl Pendley**
  - Phone: 256-544-2949
  - email: [george.e.pendley@nasa.gov](mailto:george.e.pendley@nasa.gov)



***Launching 2017***



***For More Information***

[www.nasa.gov/sls](http://www.nasa.gov/sls)

[www.twitter.com/nasa\\_sls](https://www.twitter.com/nasa_sls)

[www.facebook.com/nasasls](https://www.facebook.com/nasasls)



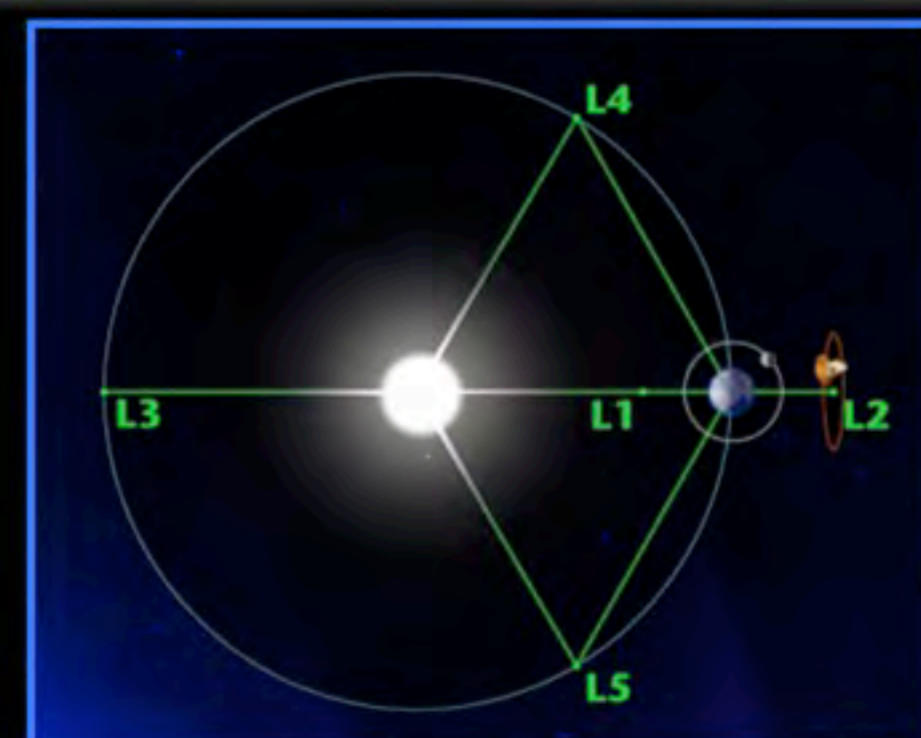
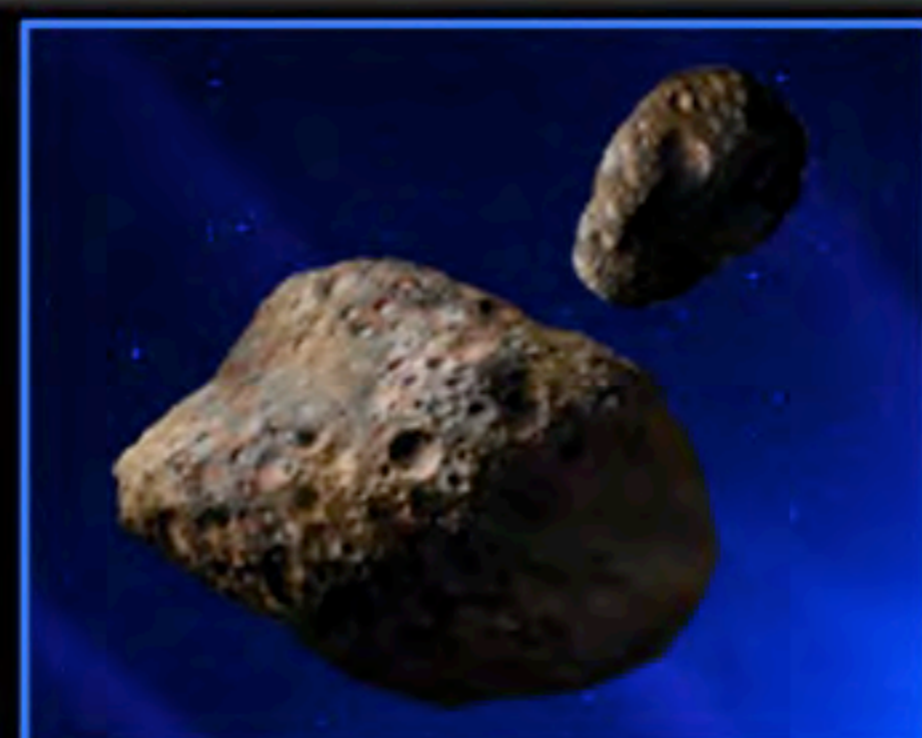


# NASA's Space Launch System Stages Overview

*Tony Lavoie, Manager  
SLS Stages Element*

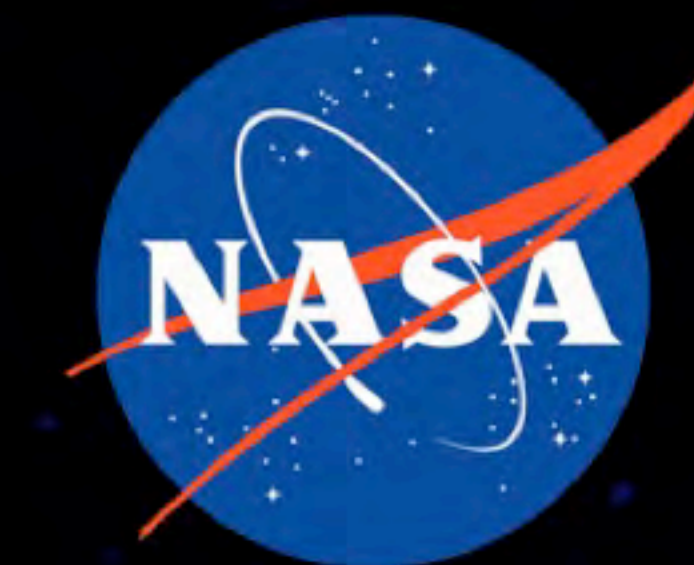
*NASA Marshall Space Flight Center*

**Space Launch System**



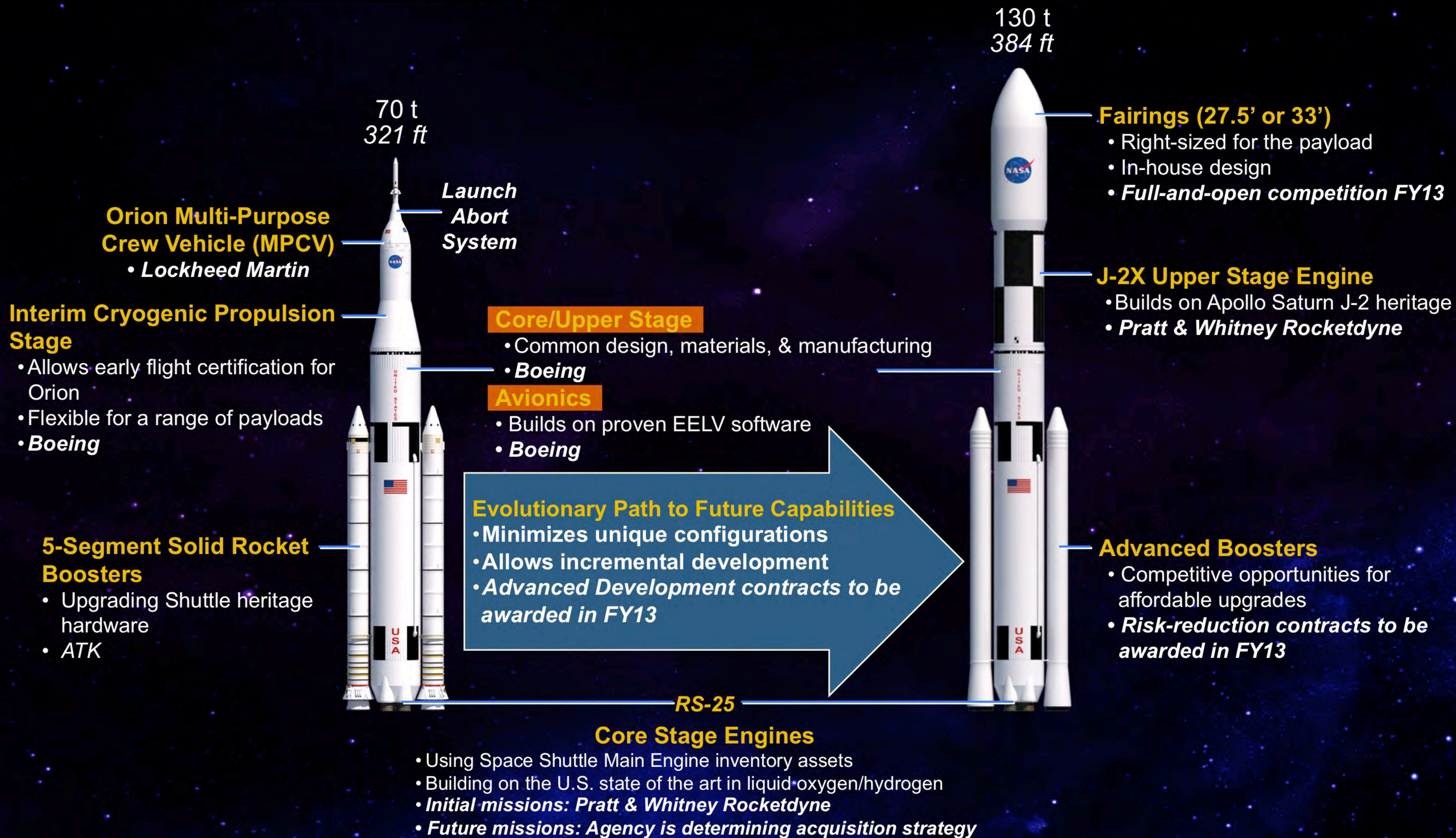
October 2012

# Building on the U.S. Infrastructure



**INITIAL CAPABILITY, 2017–21**

**EVOLVED CAPABILITY, Post-2021**



**Working with Industry Partners to Develop America's Heavy-Lift Rocket**

# SLS Commonalities



**70 ton  
Payload  
(Block 1)**



**Core Stage work directly  
applies to Upper Stage:**

- Same diameter (27.5 ft.) and basic design
- Manufacturing facilities, tooling, materials, and processes/practices
- Workforce
- Supply chain/industry base
- Transportation logistics
- Ground systems/launch infrastructure
- Propellants

**130 ton  
Payload  
(Block 2)**

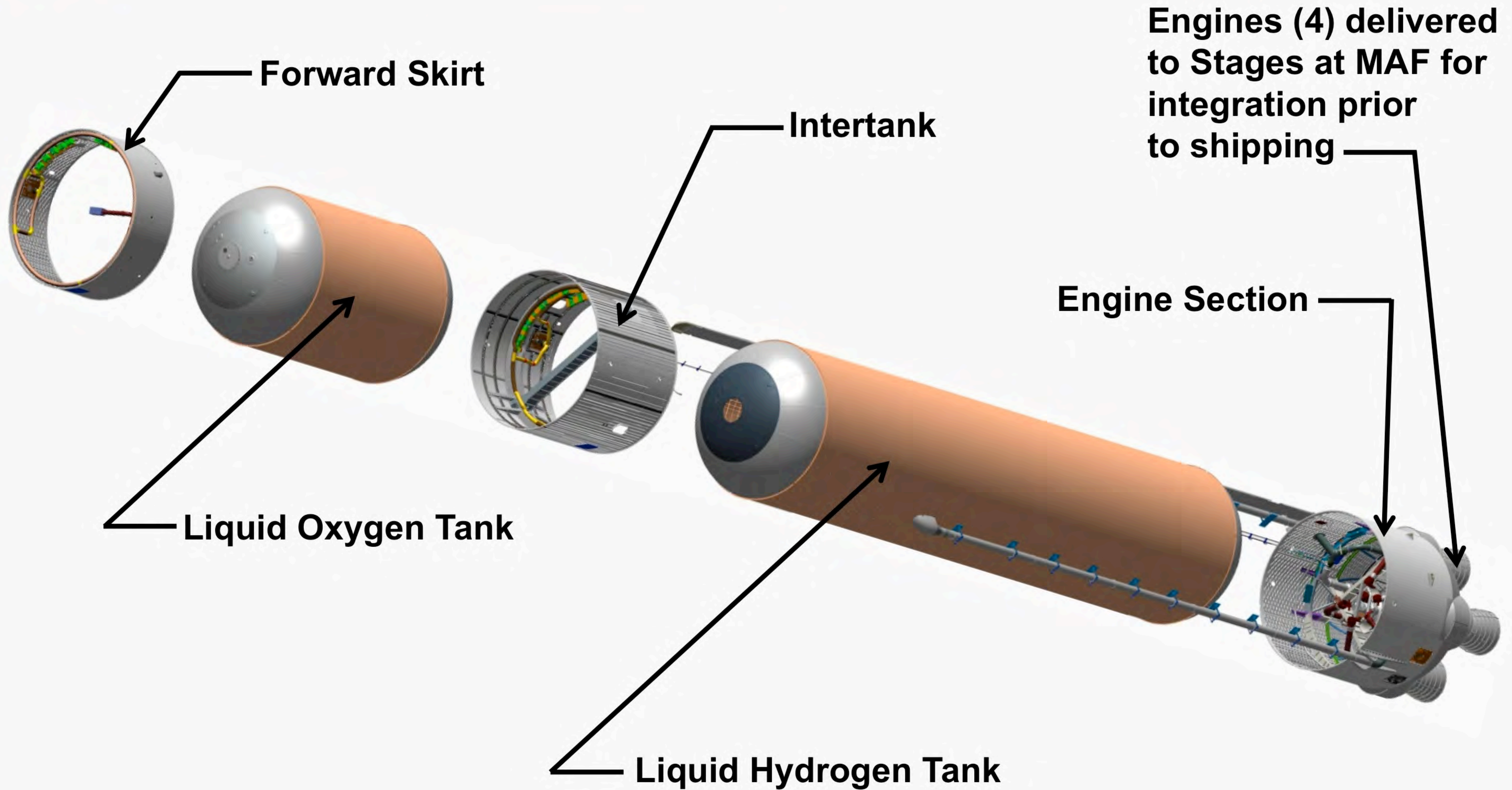


**RS-25 Core Stage  
Engines**





# Stages Element



# Stages Element



## ◆ **Manages:**

- Core Stage
- Upper Stage (as funding is available)
- Avionics
- SLS Program-level delegated integration tasks

## ◆ **Has contracted to Boeing as Prime**

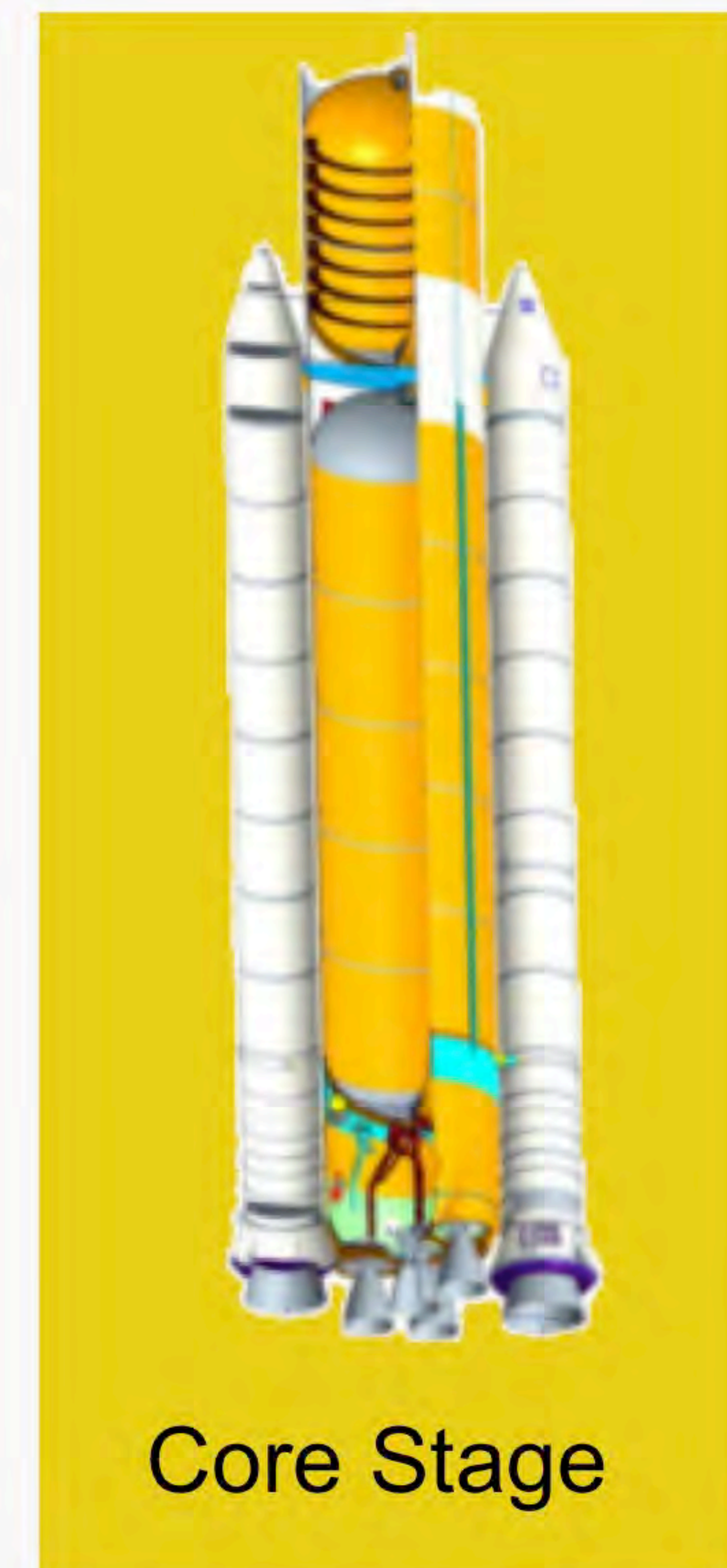
- Development (and 2 flight units) of the Core
- Scope and authority for Upper Stage (as funding is available)
- Planning and assessing Core and Upper Stage synergy for affordability
- Performs Program-level integration tasks (Element control)

## ◆ **Also manages some in-house efforts**

- Stennis Space Center B2 Stand green-run testing preps and ops
- Structural Test Article facility preps and testing (MSFC)
- Certain ground-support equipment items (transportation and handling)
- Certain avionics (Flight Instrumentation boxes, camera systems)

## ◆ **Some avionics functions are provided by the SLS Program**

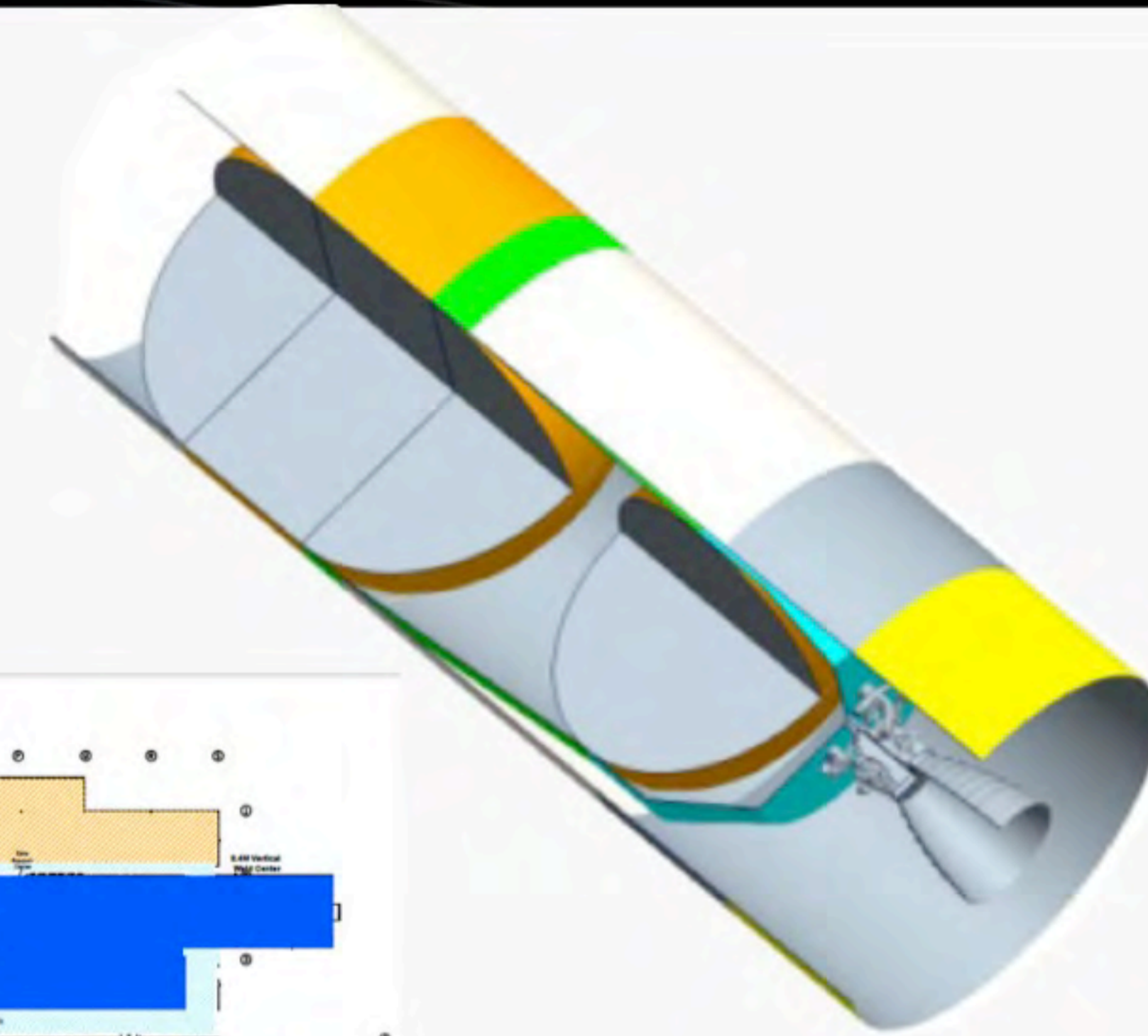
- Vehicle flight software
- System Integration Lab/Software Integration Test Facility (MSFC)



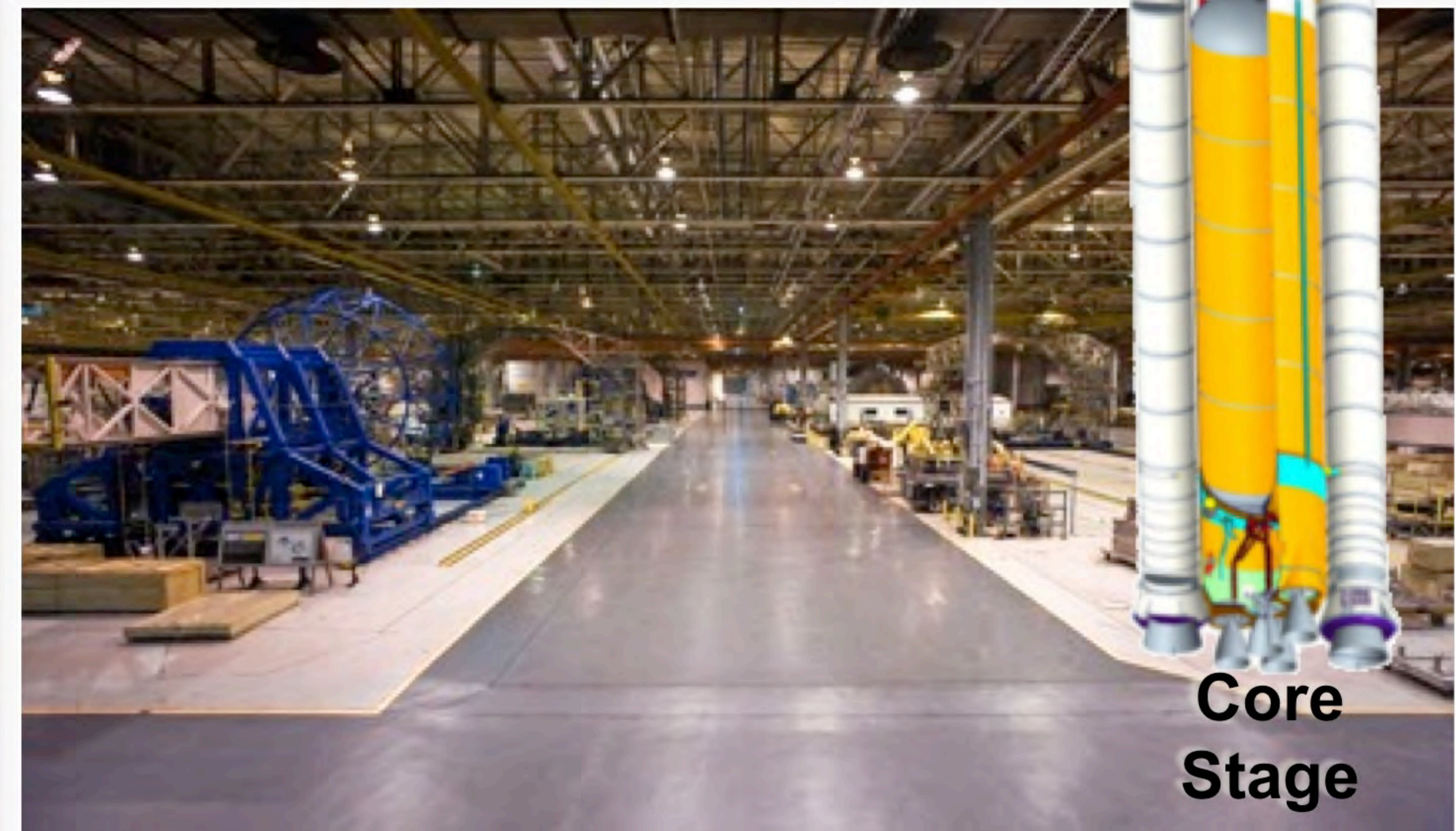
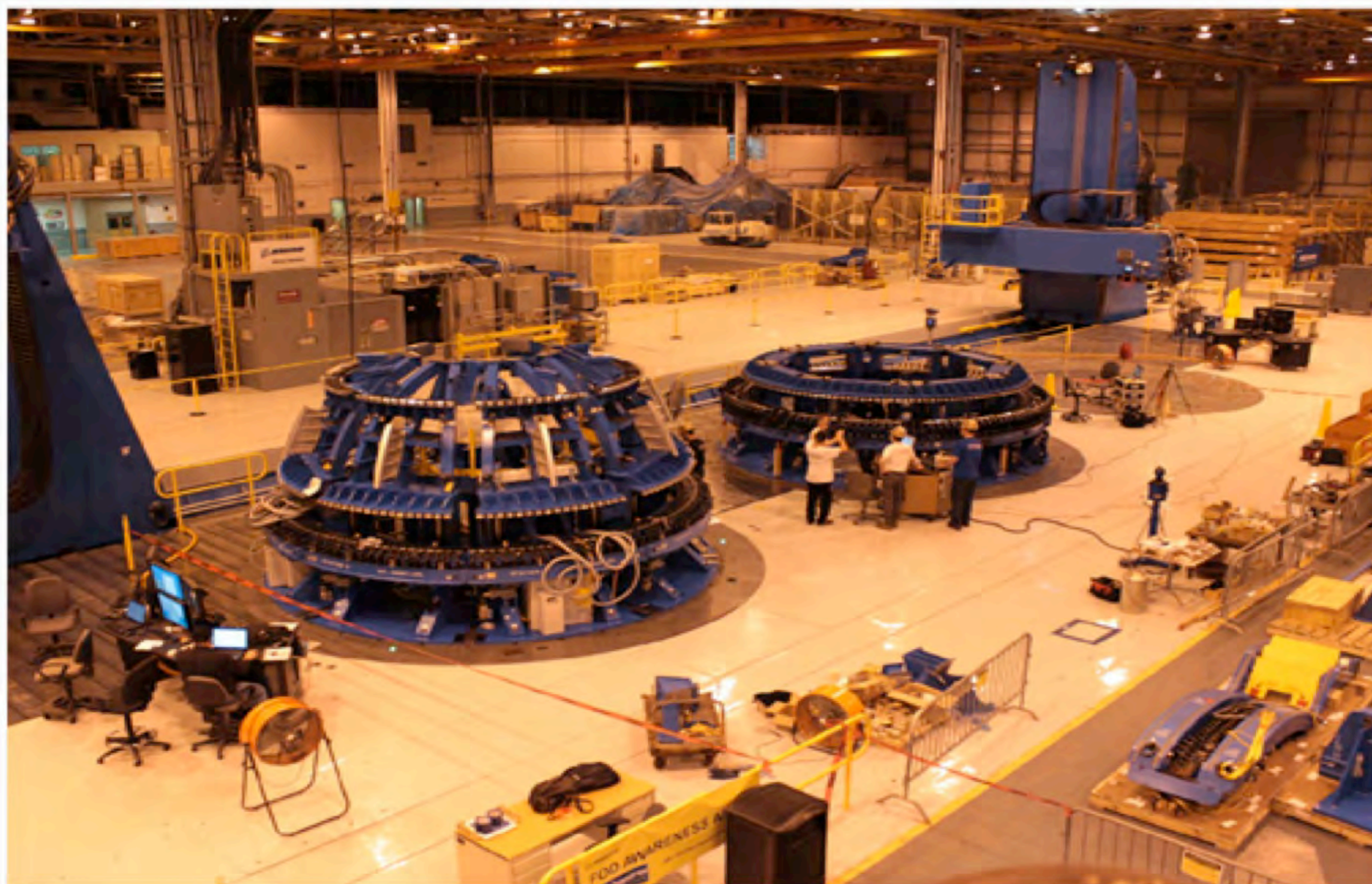
# Marshall Space Flight Center's Michoud Assembly Facility



Upper Stage



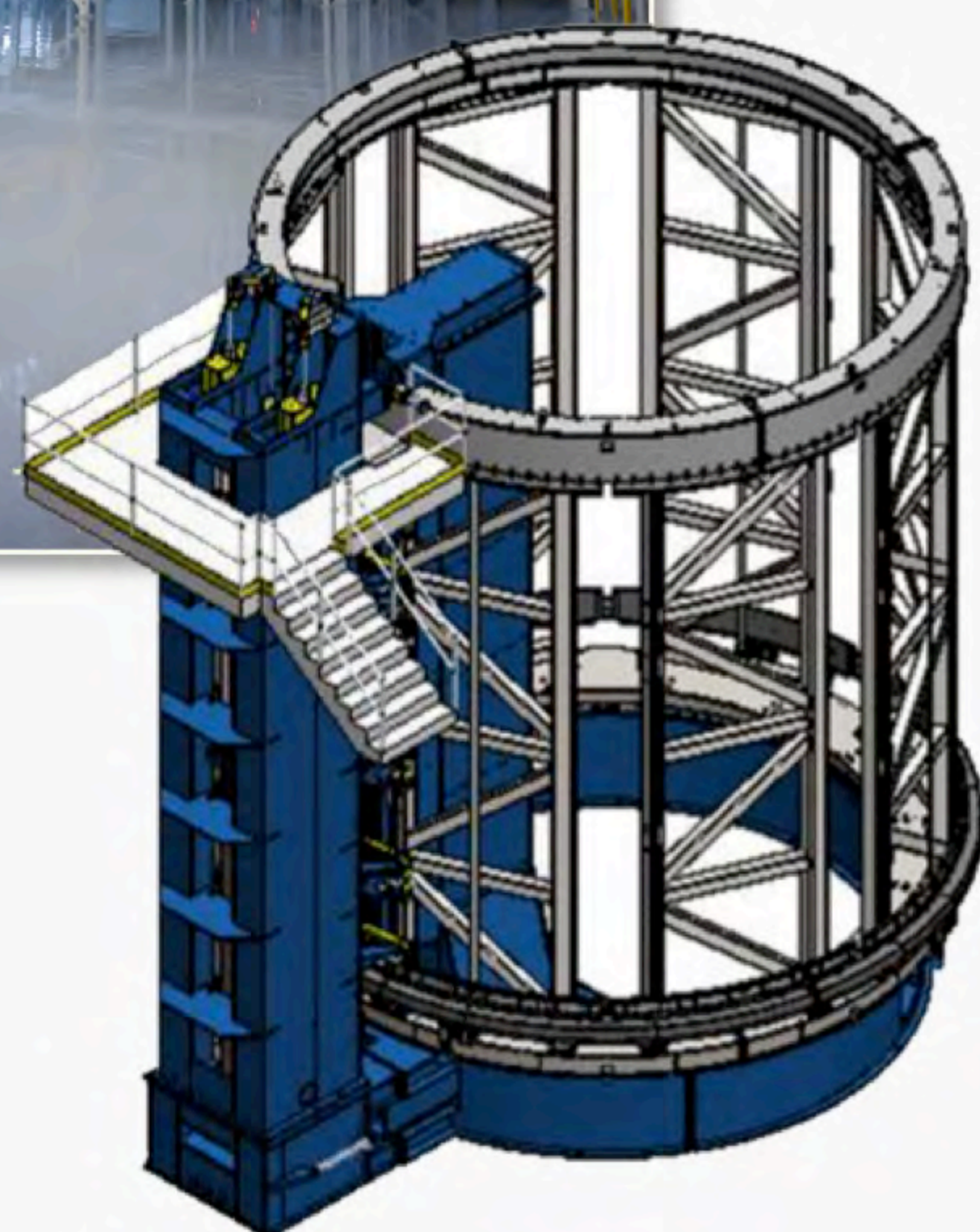
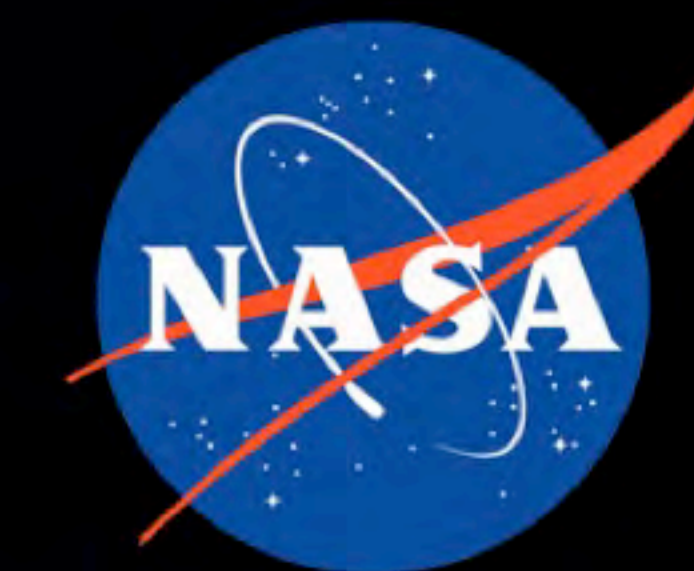
BLDG 103 MANUFACTURING PLANT LAYOUT



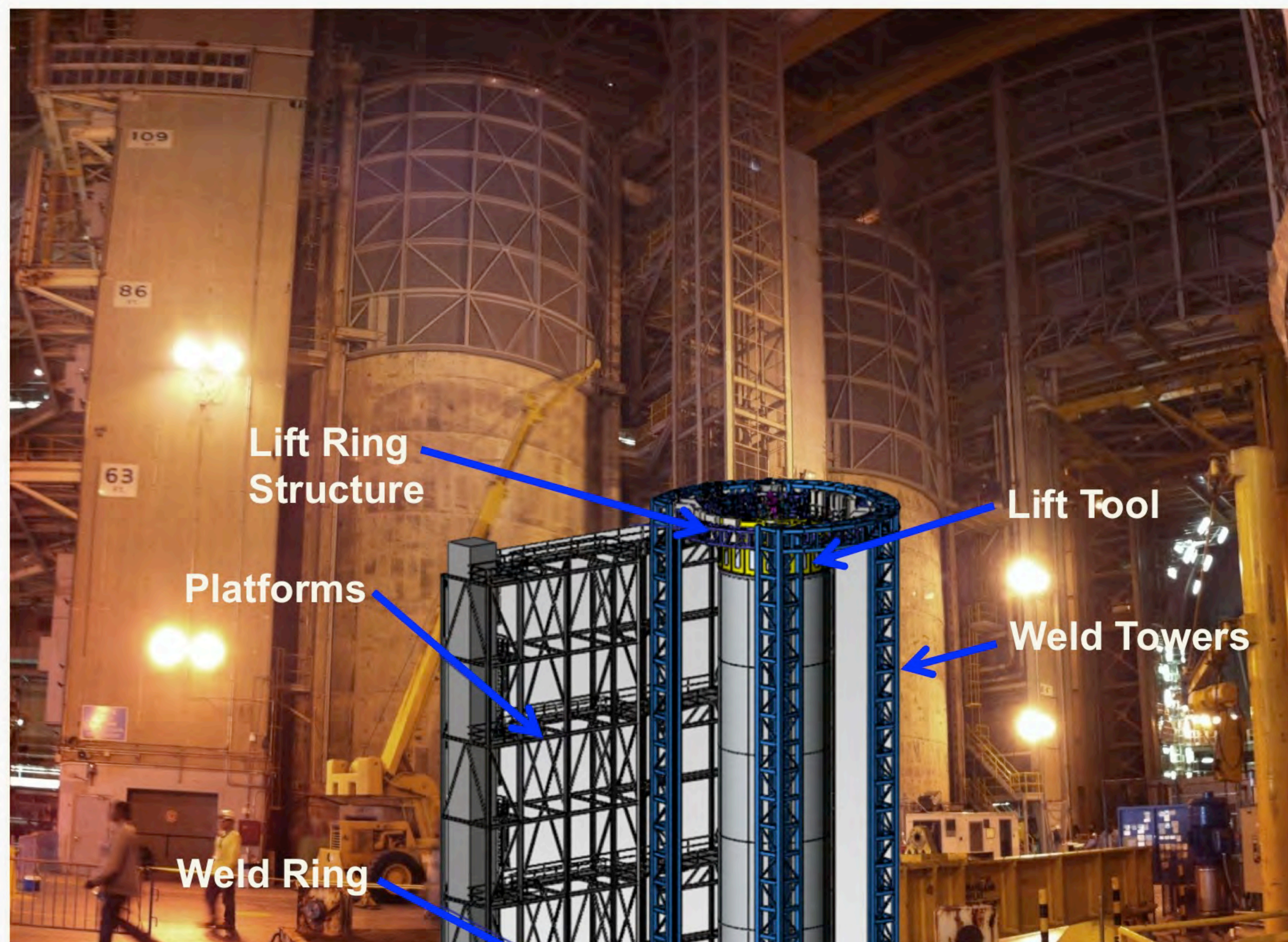
Core Stage

***One-of-a-Kind Infrastructure Asset***

# Marshall Space Flight Center's Michoud Assembly Facility



**Vertical Weld Center**



**Vertical Assembly Center**

## *Tooling and Equipment*

# Core Stage Avionics Subsystem Requirements

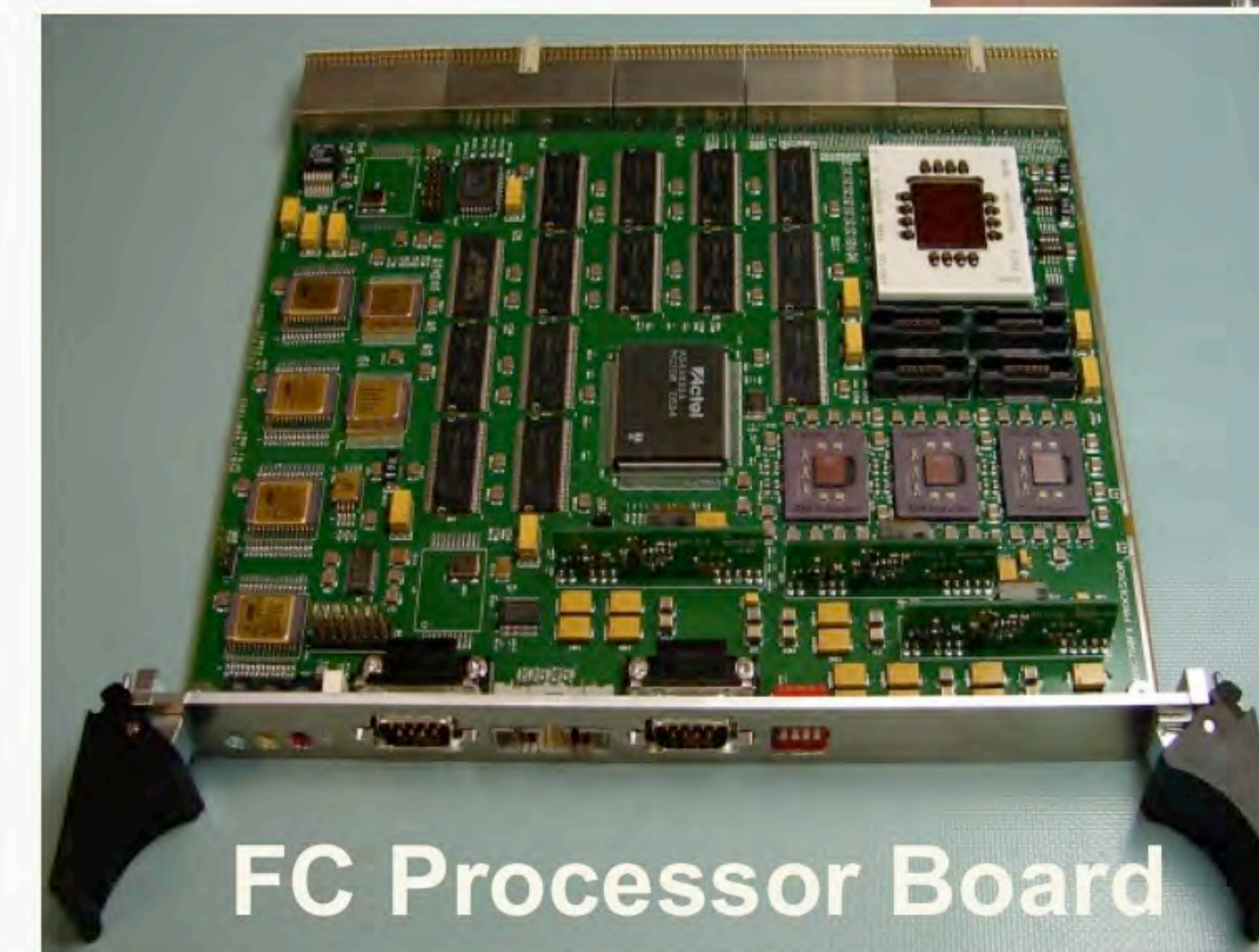
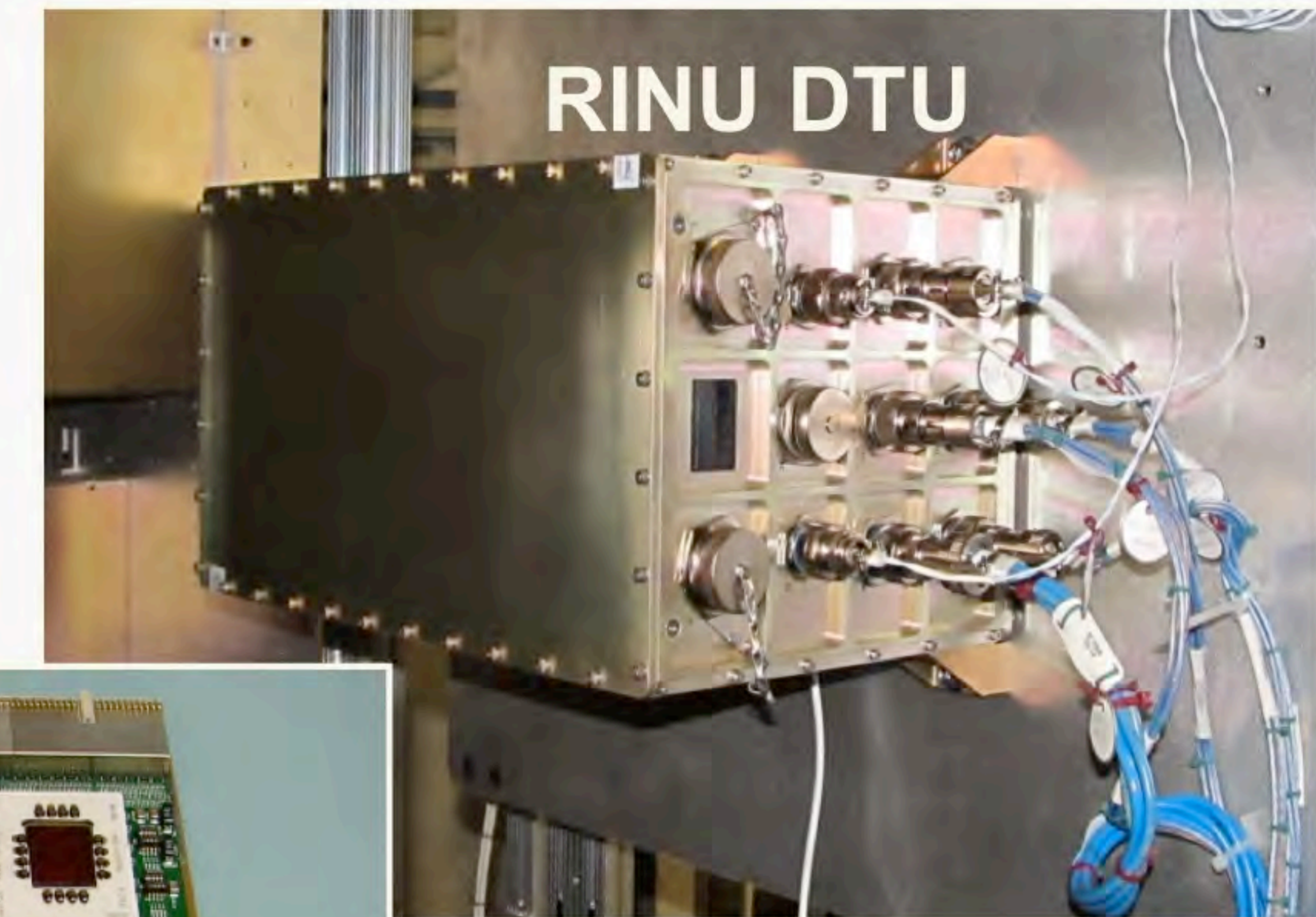


## ◆ Avionics Subsystem Allocated Functions

- Host Flight Software
- Route Data
  - GSDO to FSW, FSW to Boosters, Engines to FSW, TVC to CTN, etc.
- Store Energy
- Distribute Power
- Produce Navigation & Flight Control Data
- Produce Range Safety Tracking Data
- Execute Flight Termination commands
- Produce Motion Imagery
- Produce OFI, EFI, DFI Data
- Produce Propellant Level Measurements
- Provide Telemetry
- Accept Software Configuration Changes
- Synchronize Processes and Data
- Time Stamp Data

## ◆ 73 “Black Box” Functional Requirements

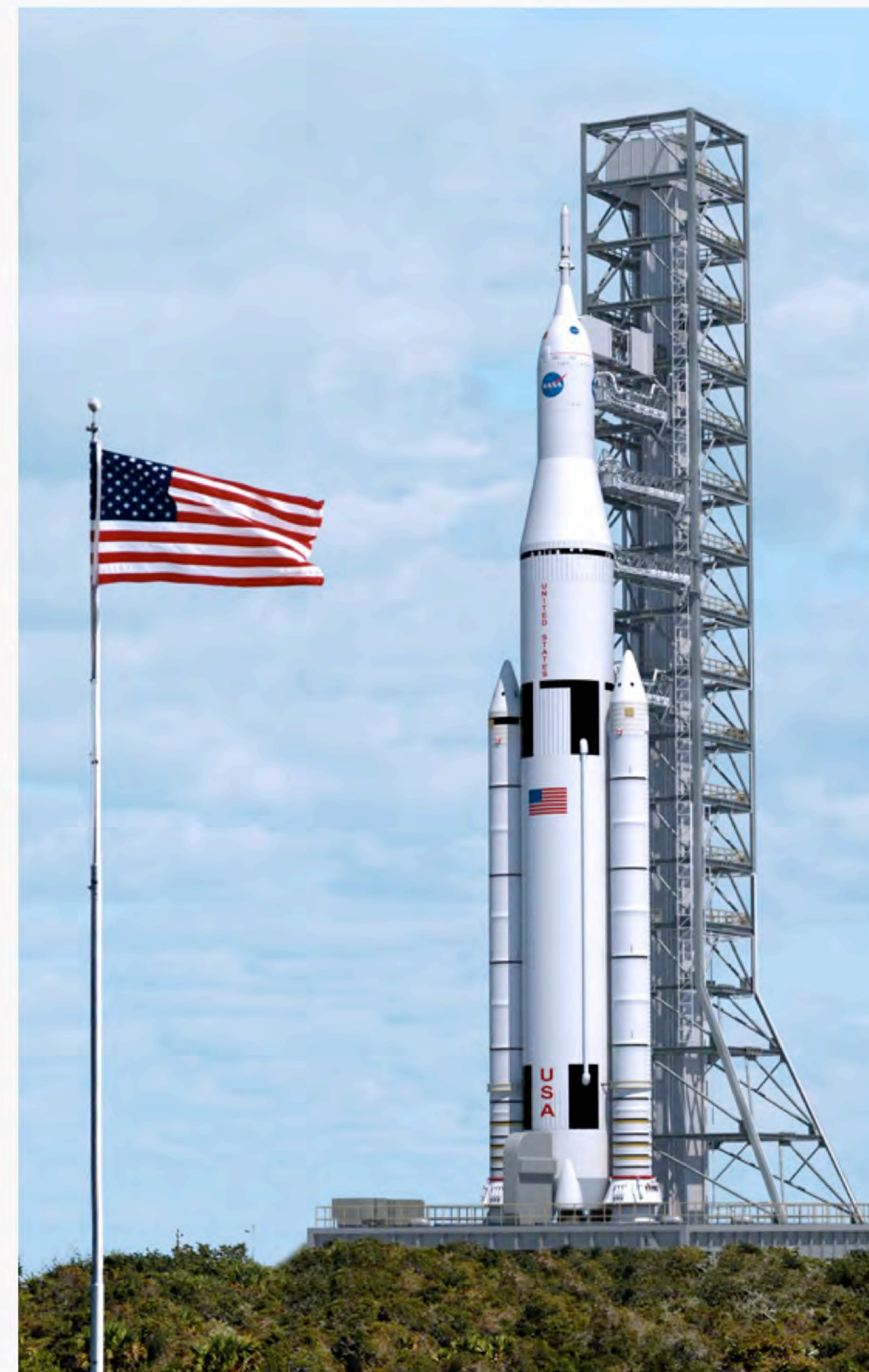
## ◆ 30 Design Constraint, 11 Environmental, 4 Suitability, 12 Interface Requirements



# Space Launch System Stages Summary



- ◆ **Managing Core Stage, Upper Stage, Avionics, and some integration tasks**
- ◆ **Prime contractor Boeing on board and making progress**
- ◆ **Pursuing affordability synergies between the core stage and the upper stage**
- ◆ **Using the unique facilities resident at NASA, such as MAF manufacturing capabilities and SSC test stands**
  
- ◆ **Contact: Earl Pendley**
  - Phone: 256-544-2949
  - email: [george.e.pendley@nasa.gov](mailto:george.e.pendley@nasa.gov)



***Launching 2017***



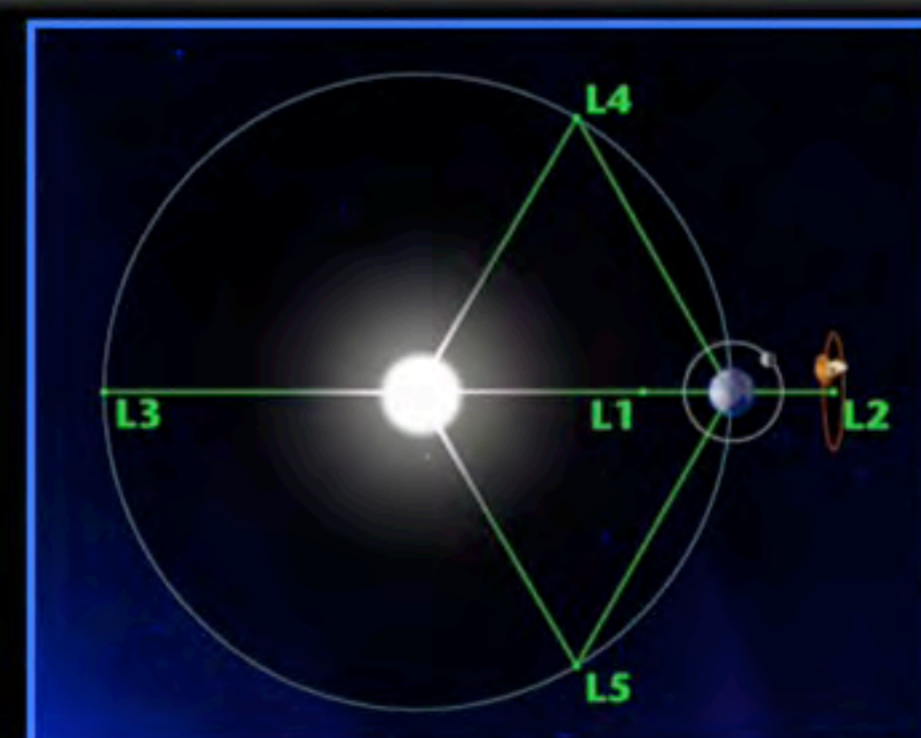
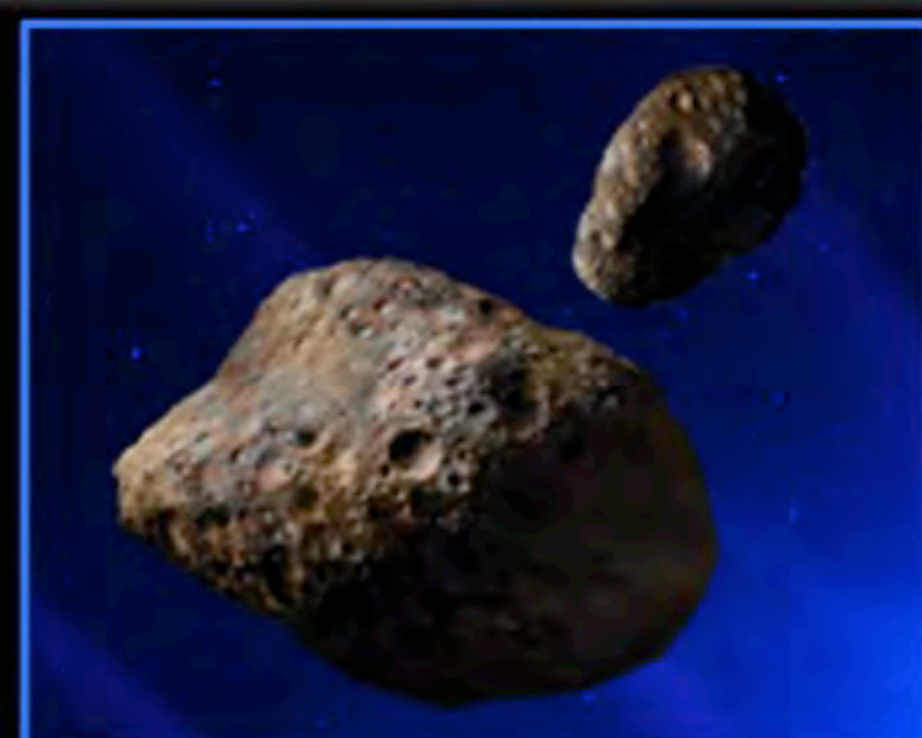
# NASA's Space Launch System Engines Overview

*Mike Kynard, Manager  
SLS Engines Element*

*NASA Marshall Space Flight Center*



**Space Launch System**



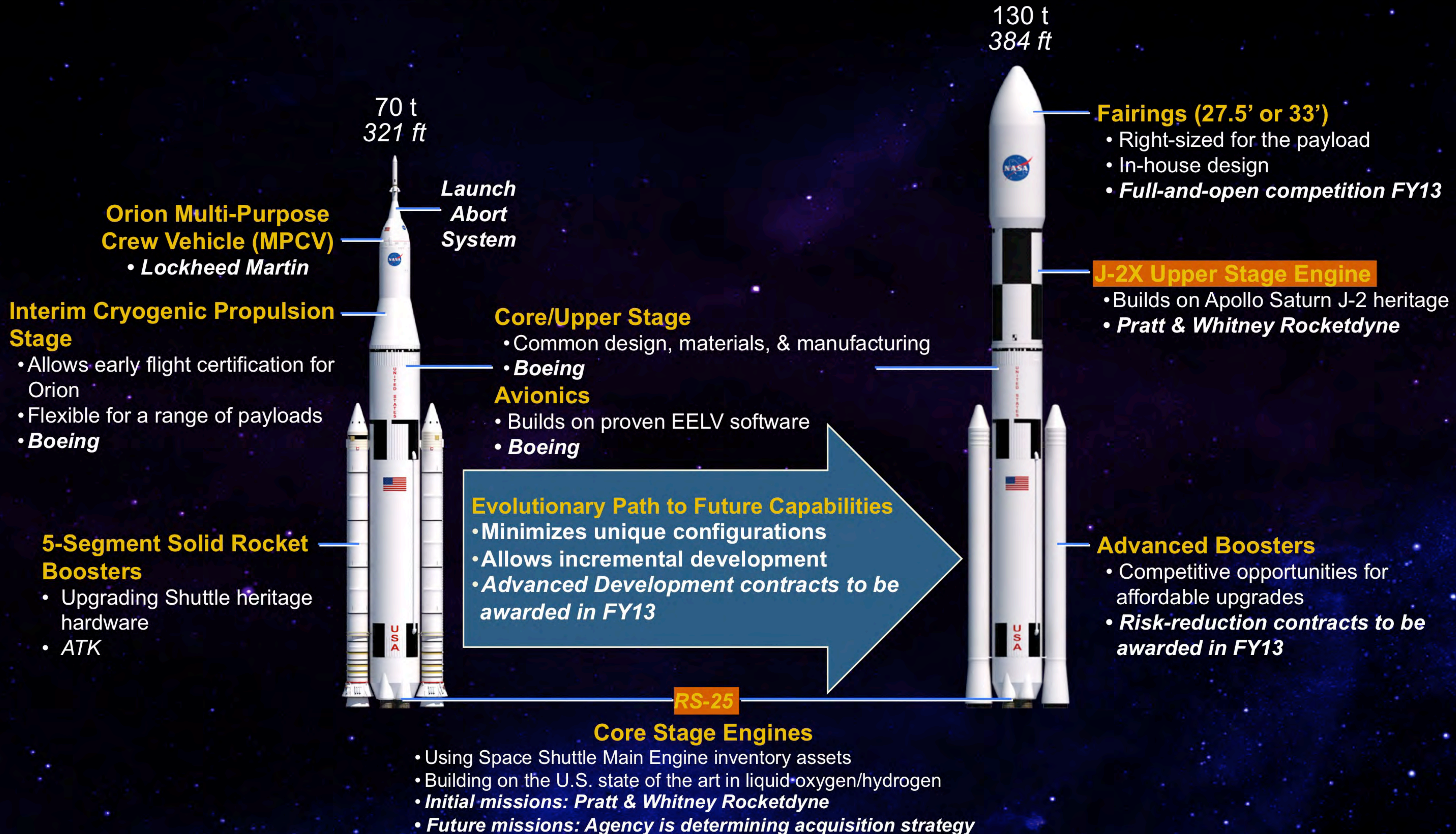
October 2012

# Building on the U.S. Infrastructure



**INITIAL CAPABILITY, 2017–21**

**EVOLVED CAPABILITY, Post-2021**



**Working with Industry Partners to Develop America's Heavy-Lift Rocket**



# RS-25 Core Stage Engine: In Stock



## RS-25 Power Level (PL) Terminology

- 104.5% Nominal existing inventory flight certified PL
- 109.0% Max existing inventory flight certified PL
- 111.0% Max existing inventory ground test demonstrated PL

<i>Core Stage Engine</i>	<i>Existing RS-25 Inventory</i>	<i>New Build RS-25</i>
Propellant	LO2/LH2	LO2/LH2
Throttle Range	65%-109% RPL	65%-111% RPL
Avg Thrust @ max power (vac)	512,185_lbs	521,700 lbs
Min Isp @ max power (vac)	450.8	450.8
Engine Mass (each)	7,816	NTE 8,156
Nom, Range MR	6.043, 5.85-6.1	6.043, 5.85-6.1
Size	96" x 168"	96" x 168"



**Stennis Space Center**

# J-2X Controller Design Reuse

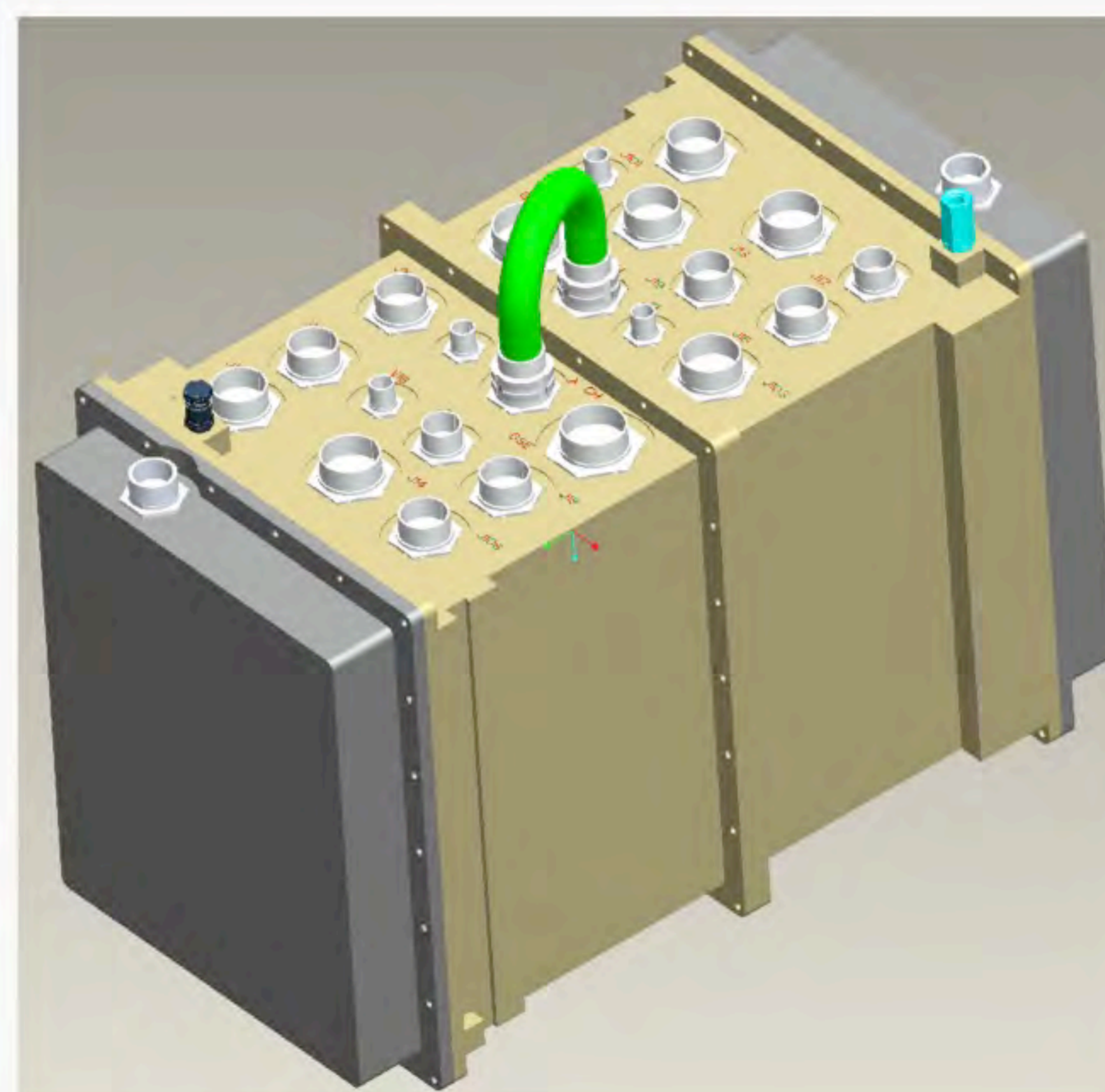


## SSME Engine Controller Unit



- ◆ Re-use of SSME software design/code approaches
  - 90% of AHMS Code
- ◆ Re-use of RTVMS accel signal cond. Circuits - 90%

*RS-25 baseline design will support electrical and mechanical interfaces for both SSME and J-2X engines.*



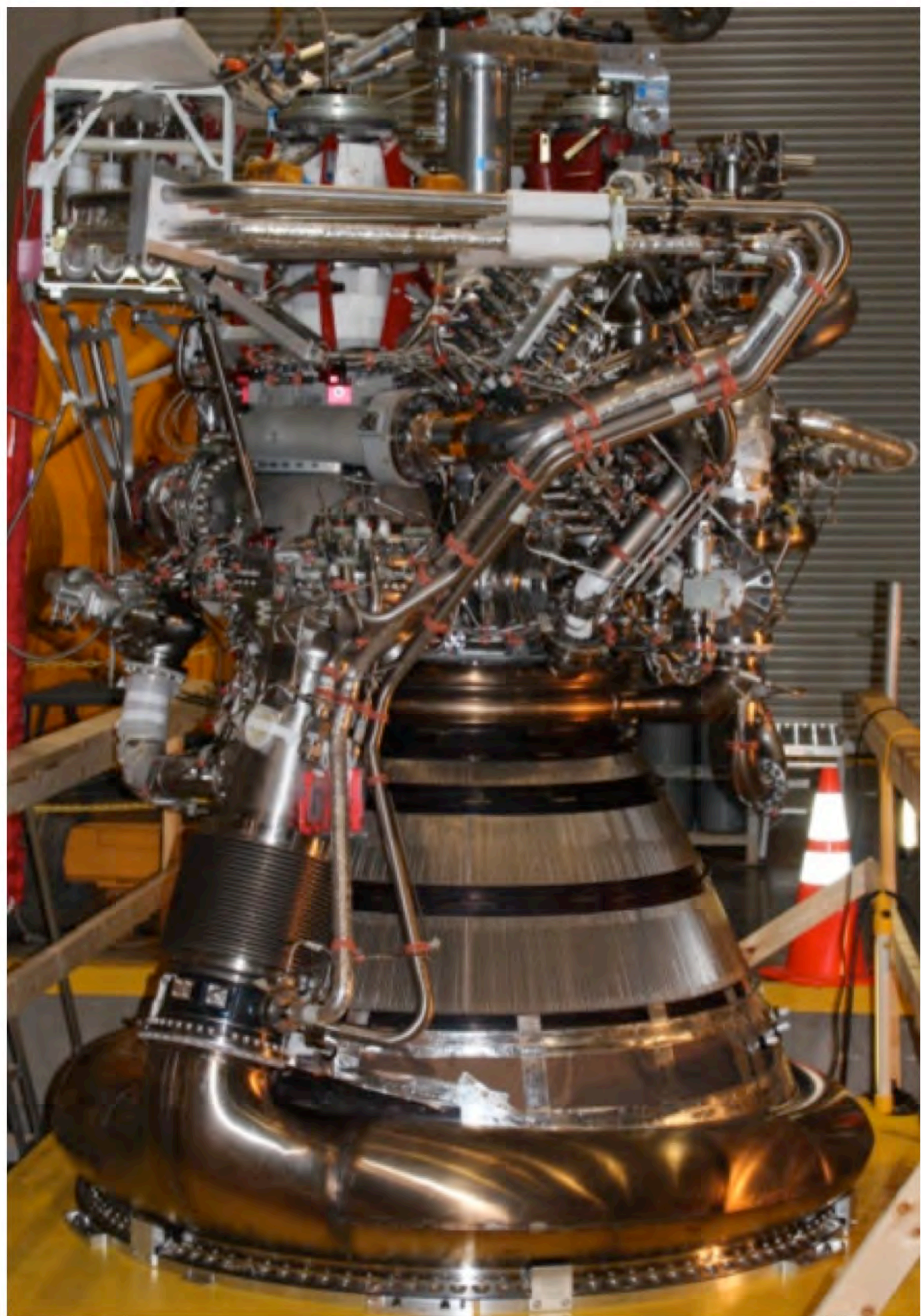
## J-2X Engine Controller



- ◆ 50-60% re-use of J-2X electrical circuit designs
- ◆ 40% re-use of J-2X software design/code

***SSME and J-2X Provide a Great Foundation for RS-25***

# J-2X Upper Stage Engine: In Development

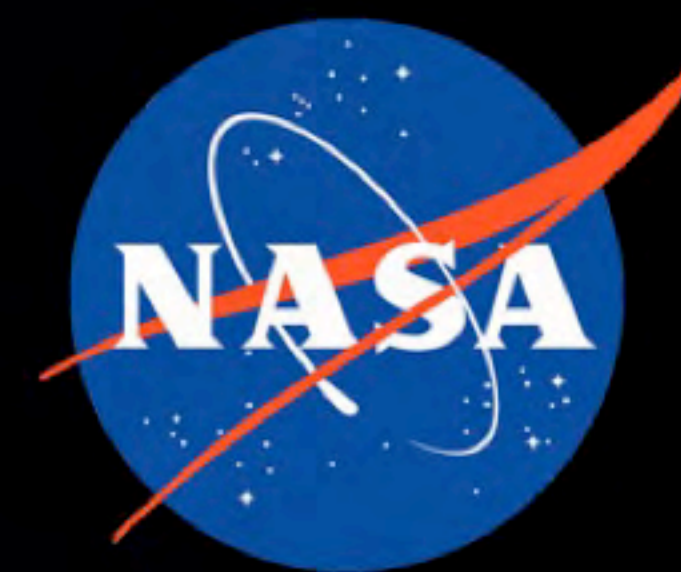


◆ Cycle	Gas Generator
◆ Thrust, vac (klbs)	294 (285K*)
◆ Isp, vac (sec)	448 (436*)min
◆ Pc (psia)	1,337
◆ Mixture Ratio	5.5
◆ Area Ratio	92 (59*)
◆ Weight (lbm)	5,450 max
◆ Secondary Mode MR	4.5
◆ Secondary Mode PC	~82%
◆ Restart	Yes
◆ Operational Starts	8
◆ Operational Seconds	2,600
◆ Length (in), Max	185
◆ Exit Dia (in), Max	120

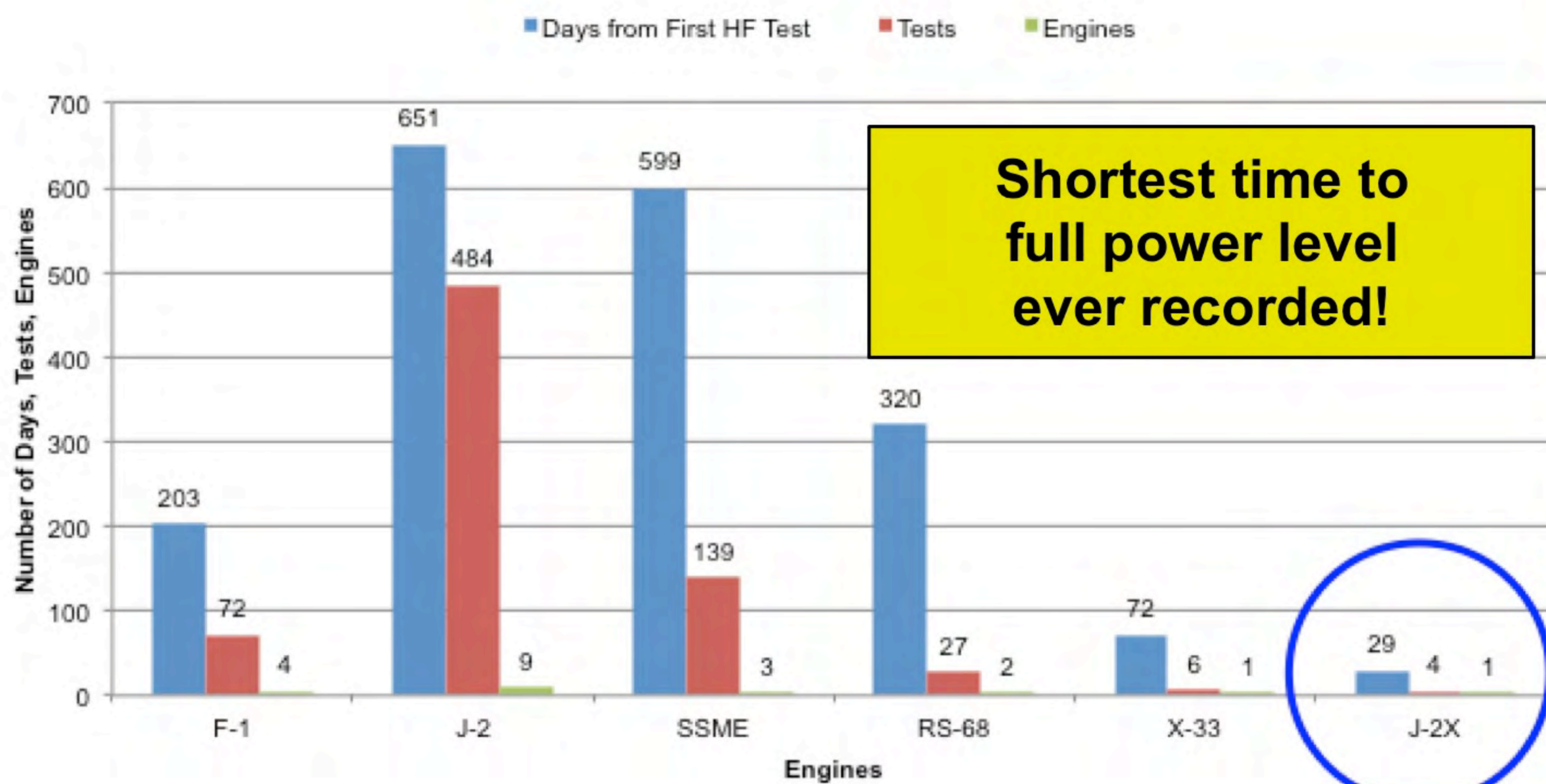
\* *With short nozzle extension*

# J-2X Upper Stage Engine Accomplishments

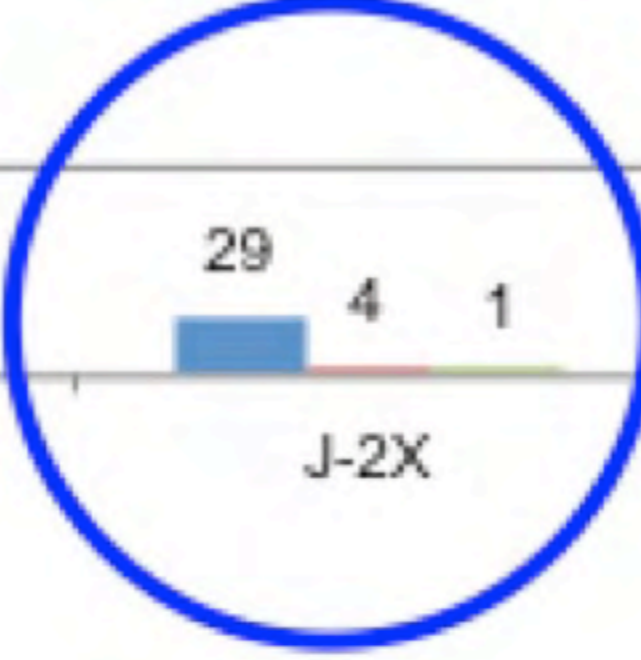
6,879 total seconds on E10001 and PPA-2



### Reaching 100% Power Level



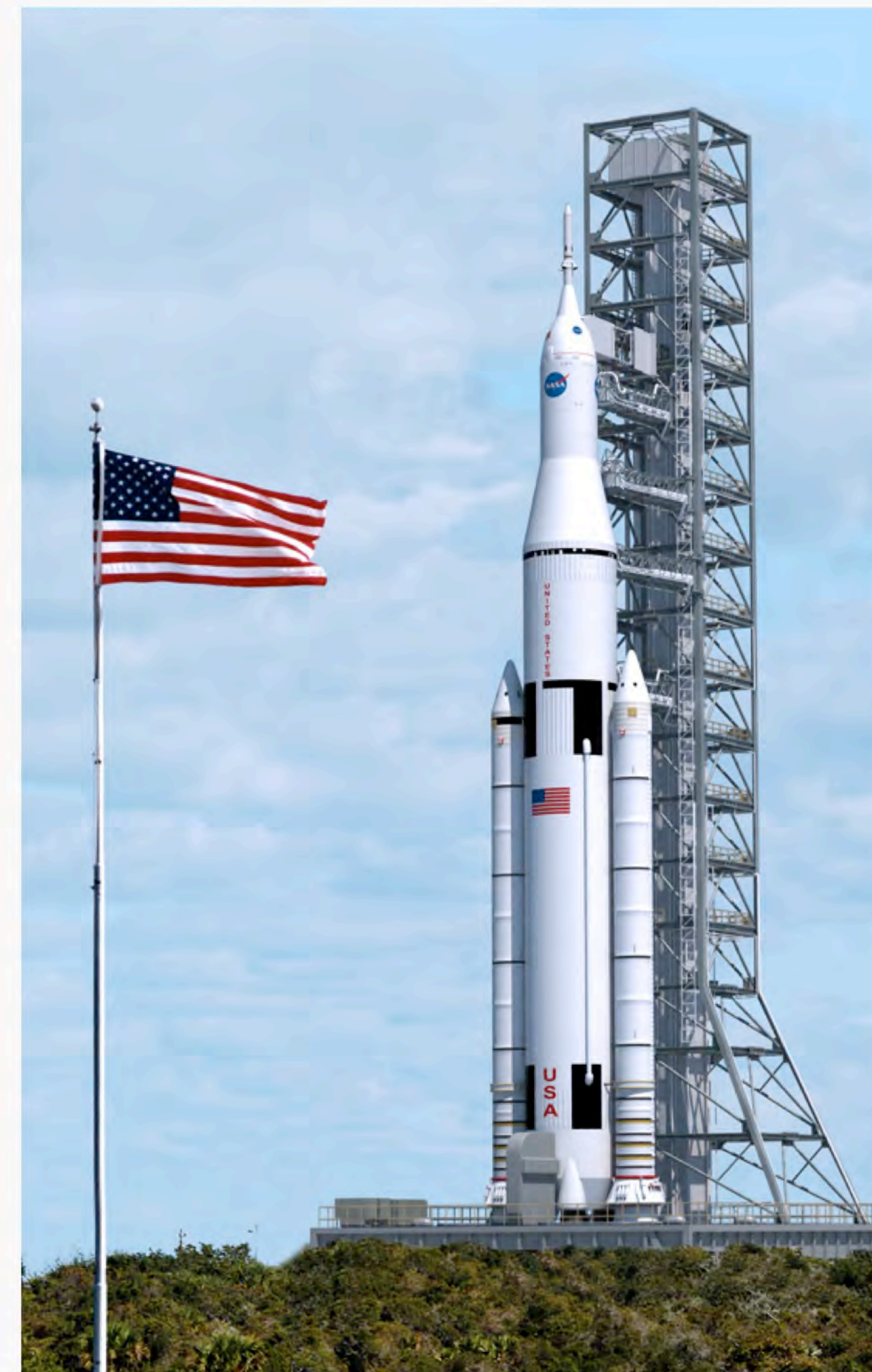
**Shortest time to full power level ever recorded!**



# Space Launch System Liquid Engines Summary



- ◆ Supporting initial and evolved SLS configurations
- ◆ RS-25 engines on hand to support first four flights, including Orion in 2017 and 2021
- ◆ J-2X testing in progress at Stennis Space Center – finishes 2015
- ◆ Common controller to integrate RS-25 engine with newer systems
- ◆ New technologies to improve testing and lower the cost of future units
  - SLM and Structured Light
- ◆ Contact: Earl Pendley
  - Phone: 256-544-2949
  - email: [george.e.pendley@nasa.gov](mailto:george.e.pendley@nasa.gov)



***Launching 2017***

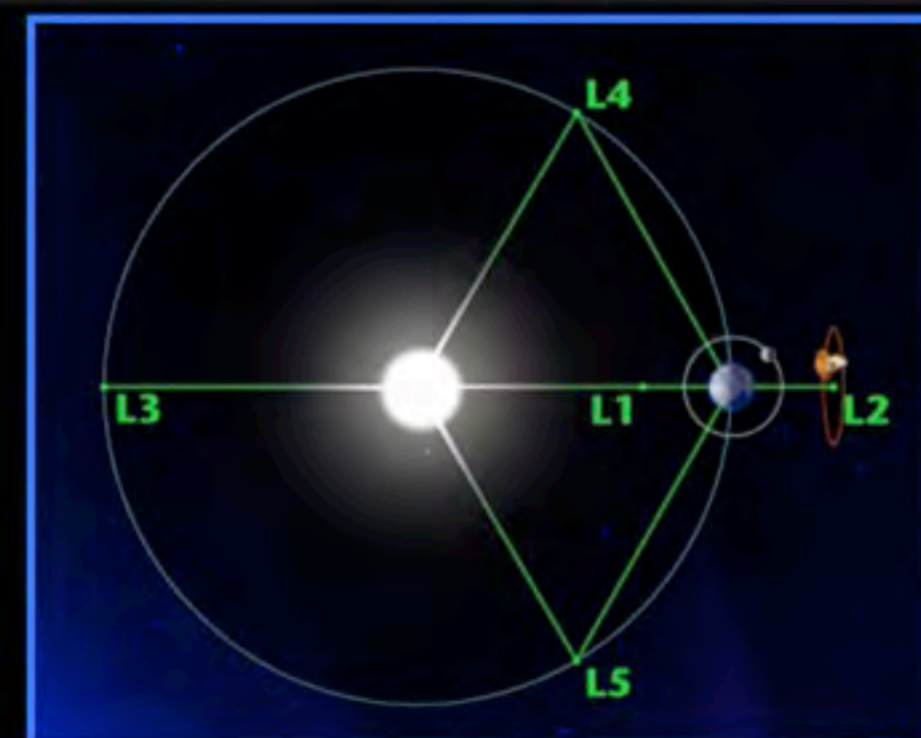
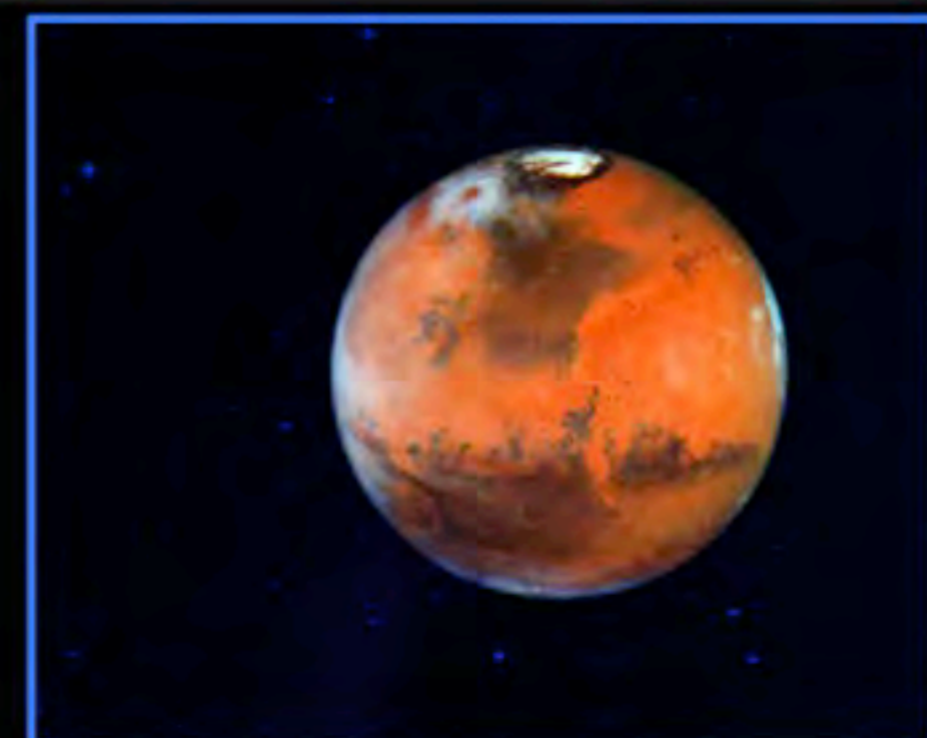


# NASA's Space Launch System Advanced Development Overview

*Chris Crumbly, Manager  
SLS Advanced Development Office  
NASA Marshall Space Flight Center*

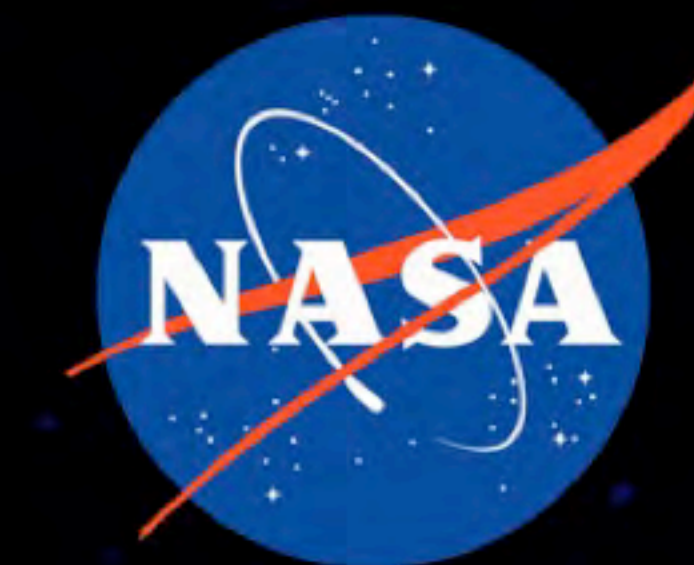


**Space Launch System**



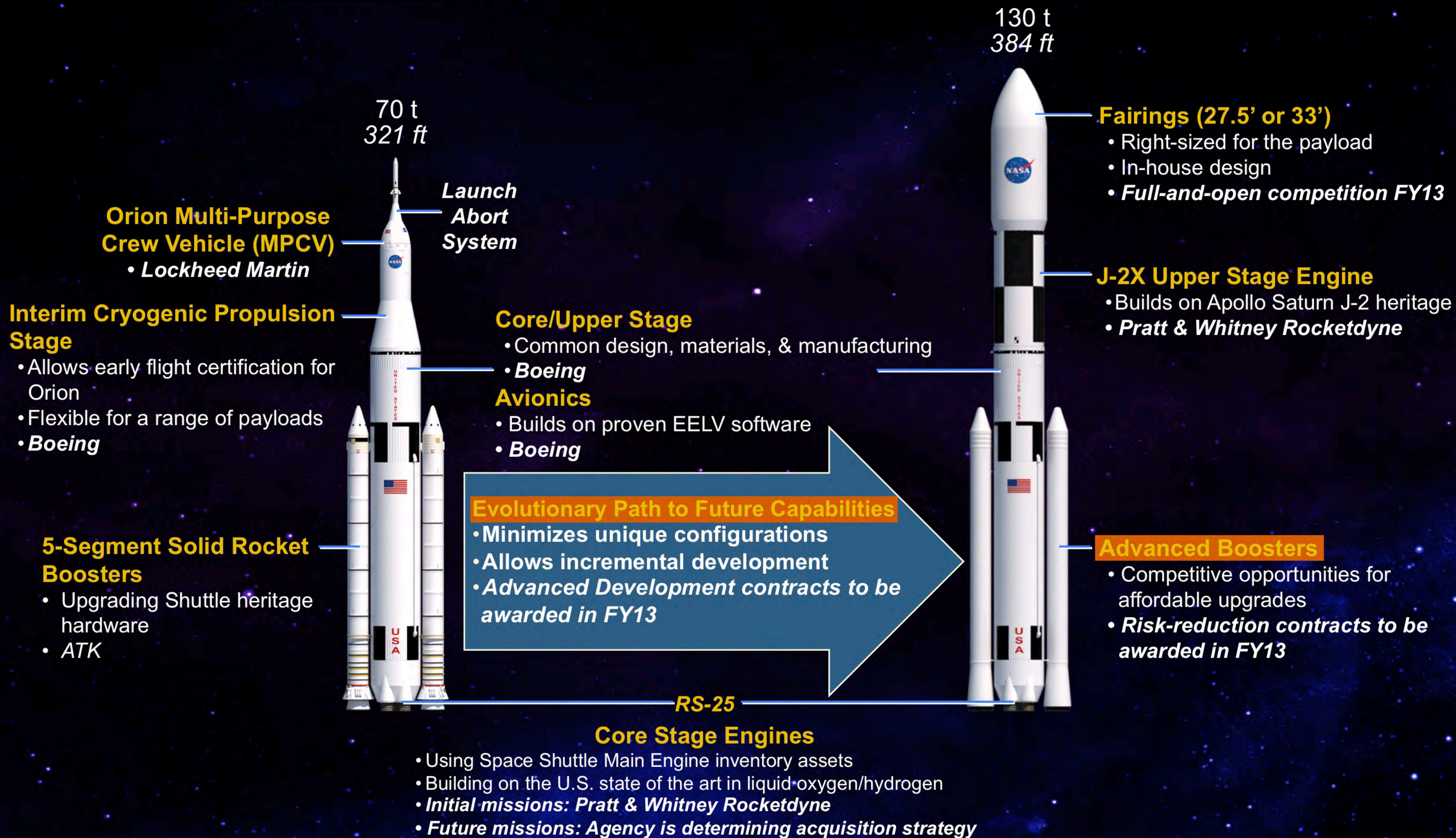
October 2012

# Building on the U.S. Infrastructure



**INITIAL CAPABILITY, 2017–21**

**EVOLVED CAPABILITY, Post-2021**

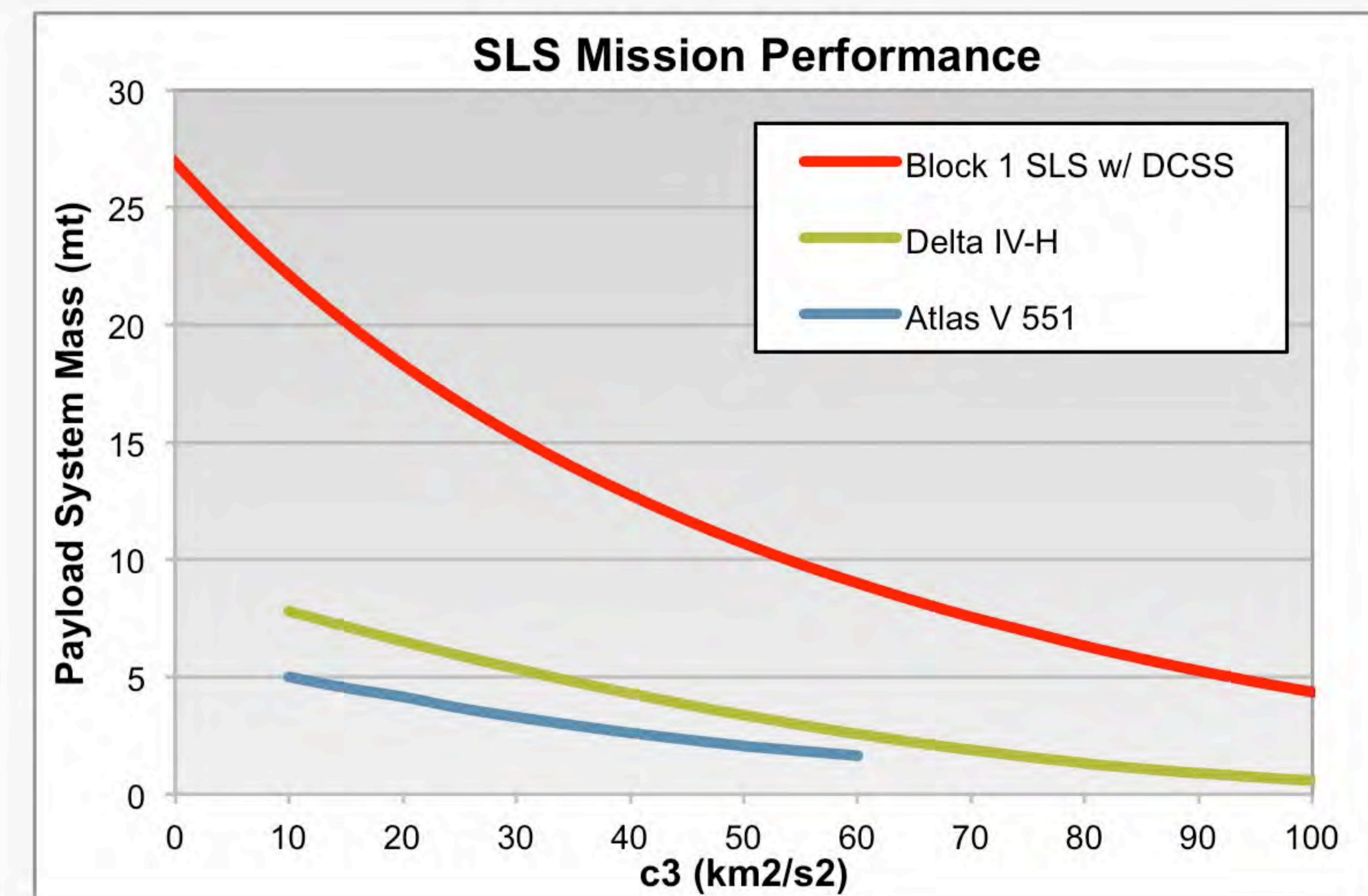


**Working with Industry Partners to Develop America's Heavy-Lift Rocket**

# Benefits of the SLS for Payloads



- ◆ **Greater volume and mass capability/margin**
  - Increased design simplicity
  - Fewer origami-type payload designs needed to fit in the fairing
- ◆ **Single launch of multiple elements means fewer launches, deployments, and critical operations**
  - Increased mission reliability and confidence
  - Reduced risk
- ◆ **High-energy orbit and shorter trip times**
  - Less expensive mission operations
- ◆ **Increased lift capacity and payload margin**
  - Reduced risk





# SLS Boosters Overview

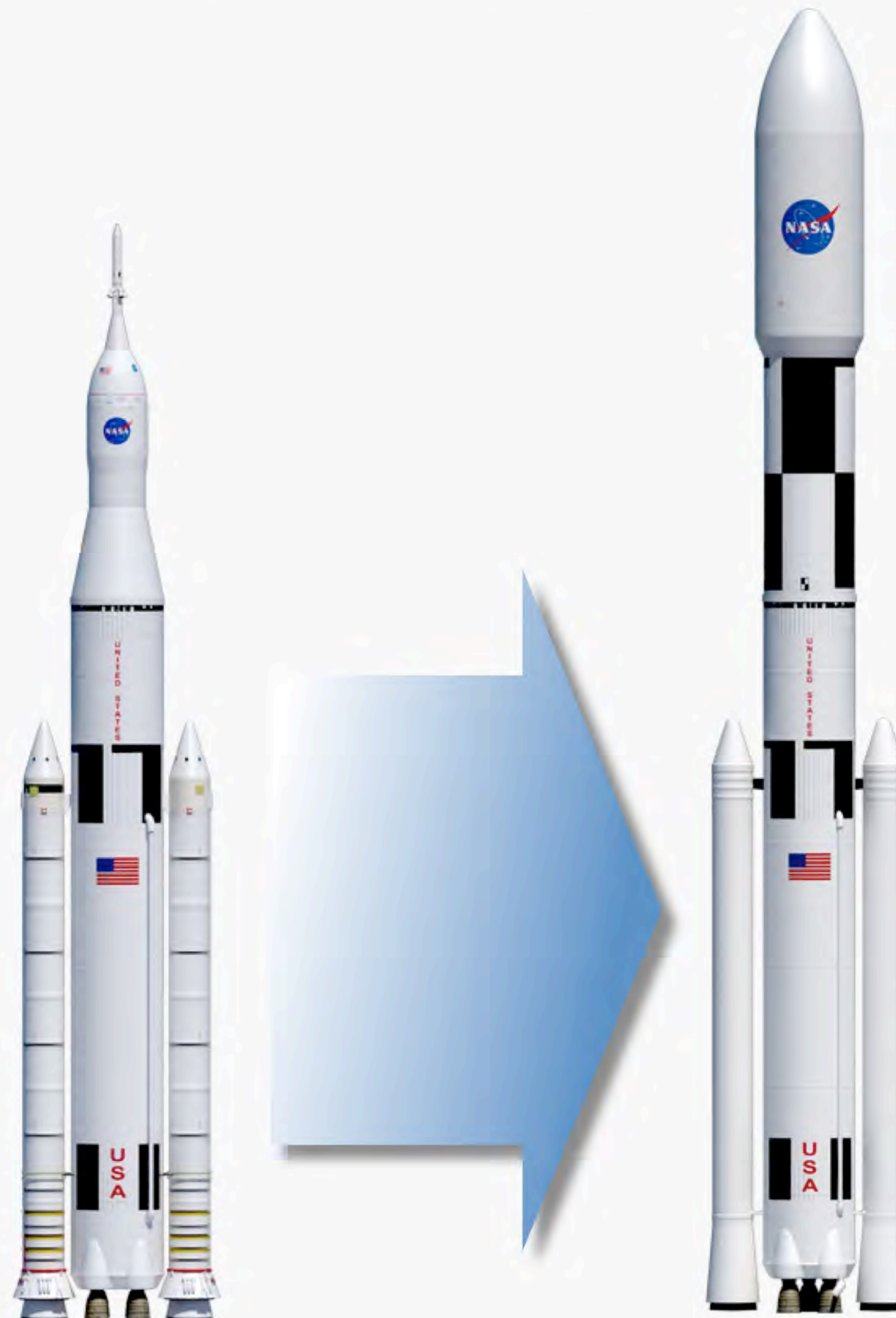


## ◆ Initial Booster Configuration

- Two flights (2017 and 2021)
- Utilizes existing hardware/contracts
  - ATK prime contractor
- Heritage hardware/design
  - Forward structures
  - Metal cases
  - Aft skirt
  - Thrust Vector Control
- Upgraded hardware/design
  - Expendable design
  - New avionics
  - Asbestos-free insulation
  - Five-segment solid rocket motor
    - Additional segment
    - Increased performance
    - Unique thrust-time profile

## ◆ Evolved Booster Configuration

- Used in flights beyond 2021
- Design, Development, Test & Evaluation (DDT&E) will be awarded by a competitive procurement
- Improved performance by either liquid or solid propulsion



# Three-Phase Booster Development Approach



### Advanced Booster Design, Development, Test, and Evaluation (DDT&E)

- Scope: Follow-on procurement for DDT&E of a new booster
- Date: RFP target is FY15
- Capability: Evolved at 130 t
- Contract: Full and Open Competition (Liquids or Solids)



### Advanced Booster Engineering Demonstration and/or Risk Reduction NRA

- Scope: Award contracts that reduce risks leading to an affordable Advanced Booster that meets the evolved capabilities of SLS and enable competition by mitigating targeted Advanced Booster risks to enhance SLS affordability
- Date: **Issue draft NRA Dec 12, 2011; award targeted for Oct 1, 2012**
- Capability: Leading to 130 t
- Contract: NRA Demonstrating Specific Technologies and Affordability Risk Reduction for Advanced Boosters
  - Liquid Rocket Boosters or Solid Rocket Boosters



### Booster Fly-out for Early Flights through 2021

- Scope: Build two 5-segment SRB Flight Sets
- Date: In progress
- Capability: Initial 70–100 t
- Contract: Mod to Ares contract with ATK

***Moving Forward from Initial to Evolved Capability***



- ◆ **Northrop Grumman: Subscale Composite Tanks (awarded)**
  - Develop an automated in-situ manufacturing system that utilizes out-of-autoclave curing for composite tanks
  
- ◆ **Aerojet: Full-scale Combustion Stability Demonstration (in negotiation)**
  - Demonstrate high-performance booster using an oxygen-rich staged combustion cycle
  
- ◆ **Dynetics: Booster Risk-Reduction Tasks (awarded)**
  - F-1 Engine: Full-scale, production-like hardware testing
  - Structures: Simpler materials, design, and manufacturing processes
  
- ◆ **ATK: Integrated Booster Static Test (awarded)**
  - Identify and address technical challenges for a composite booster with redesigned forward and aft structures and nozzle, and improved manufacturing processes

# Advanced Development NASA Research Announcement (NRA) Overview



- ◆ **Evolutionary development strategy for SLS allows for incremental progress within constrained budgets through the solicitation of innovative development concepts from both industry and academic institutions**
- ◆ **Objectives to improve affordability, reliability, or performance in several key topic areas: Concept Development, Trades, and Analyses; Propulsion; Manufacturing, Structures, and Materials; and Avionics and Software**
- ◆ **85 proposals submitted were compliant**
- ◆ **Evaluation criteria: (1) Relevance to NASA Objectives, (2) Intrinsic Merit, and (3) Price**
- ◆ **In FY13, budget negotiations will be initiated on those selections that have the highest priority**

# Sample of Proposals Selected for Negotiation

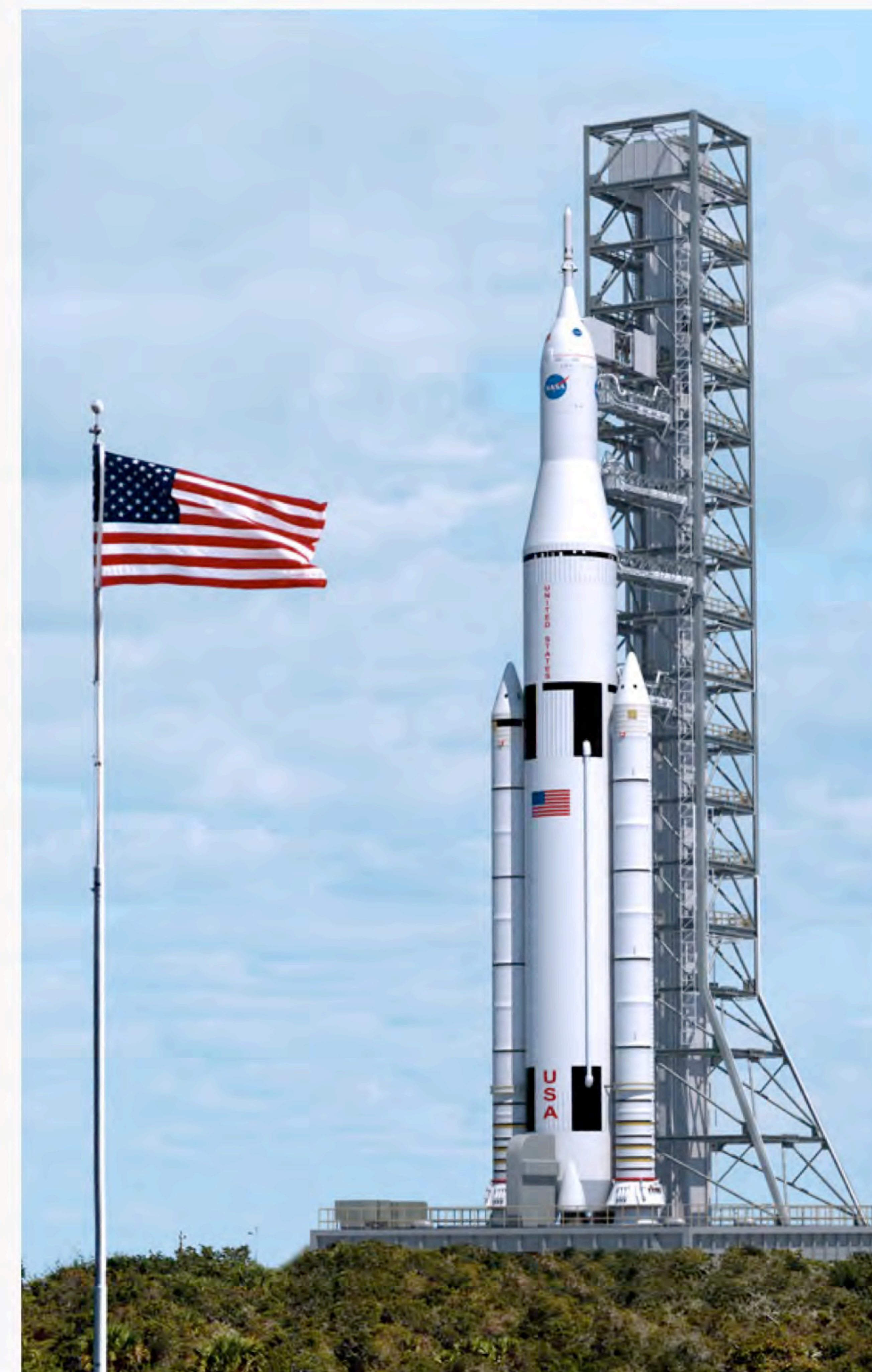


[http://www.nasa.gov/home/hqnews/2012/sep/HQ\\_12-333\\_SLS\\_Advanced\\_Development\\_Proposals.html](http://www.nasa.gov/home/hqnews/2012/sep/HQ_12-333_SLS_Advanced_Development_Proposals.html)

# Space Launch System Advanced Development Summary



- ◆ **NASA's Space Launch System is implementing an evolvable configuration approach to system development in a resource-constrained era**
  - Legacy systems enable non-traditional development funding and contribute to sustainability and affordability
  - Limited simultaneous developments reduce cost and schedule risk
  - Phased approach to advanced booster development enables innovation and competition, incrementally demonstrating affordability and performance enhancements
  - Advanced boosters will provide performance for the most capable heavy lift launcher in history, enabling unprecedented space exploration benefiting all of humanity
  
- ◆ **Contact: Earl Pendley**
  - Phone: 256-544-2949
  - email: [george.e.pendley@nasa.gov](mailto:george.e.pendley@nasa.gov)



***Launching 2017***



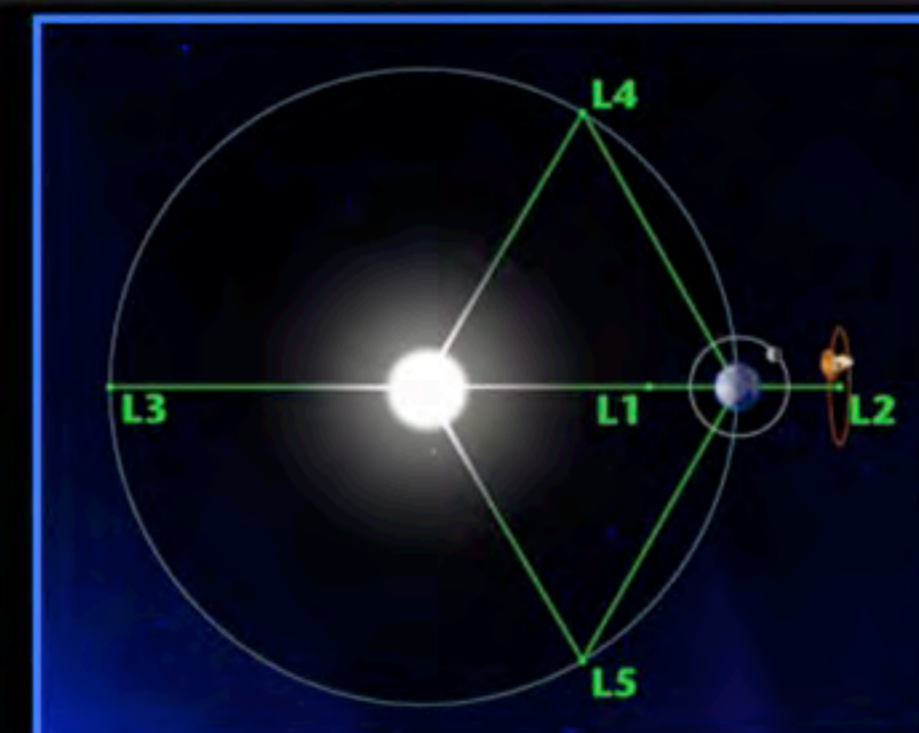
# NASA's Space Launch System Acquisition Overview

*Earl Pendley, Manager  
SLS Procurement Office*

*NASA Marshall Space Flight Center*



**Space Launch System**



October 2012

# Path to the SLS Acquisition Plan



- ◆ The NASA Authorization Act of 2010 (PL 111-267, Oct. 11, 2010) requires that NASA deliver a Space Launch System with at least 70 t of initial capability and 130 t of evolved capability.
- ◆ The President's FY12 Budget Request includes funding for SLS.
- ◆ The FY11 Appropriation Act includes funding for SLS.
- ◆ NASA selected an architecture in June 2011 to meet the Authorization Act.
- ◆ NASA conducted an Agency-level SLS Acquisition Strategy meeting in July 2011.
- ◆ NASA conducted Procurement Strategy Meetings in mid-September 2011.
- ◆ Acquisition process is proceeding.



*This rocket is key to implementing the plan laid out by President Obama and Congress in the bipartisan 2010 NASA Authorization Act.*  
— NASA Administrator Charles Bolden  
September 14, 2011



***SLS Acquisition Strategy Fulfills Legislative and Executive Branch Direction and Law***



# Key SLS Requirements



## ◆ Affordability

- Flat annual budget profile
- Existing contracts and assets used for initial capability
  - Significant hardware investments maximized
  - Significant portions of the supply chain in place
  - Work can begin earlier, engaging the U.S. aerospace workforce
  - Less design, development, test, and evaluation (DDT&E) risk and costs
  - Contract types to move to more objective incentive structures

## ◆ Performance Margin

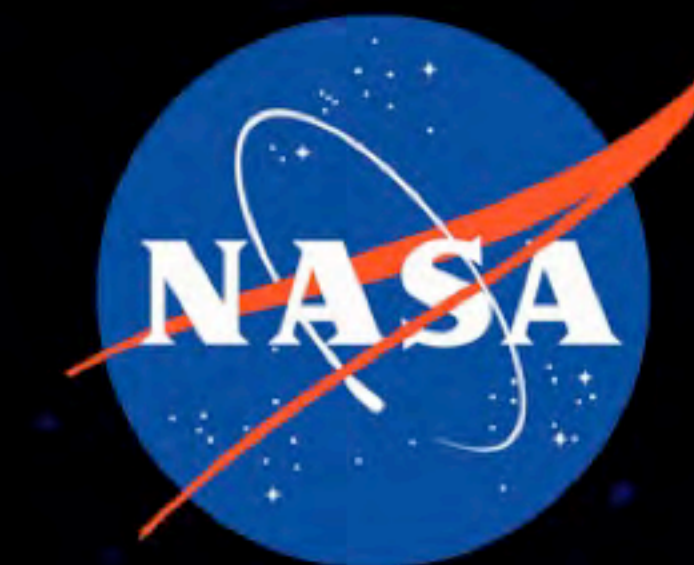
- Initial near-term capability of 70 t, evolvable to 130 t
- Modular flexible architecture that may be configured for mission needs
- Significant National capability

## ◆ Evolvable

- Competitions for technology infusions and vehicle upgrades for future capability

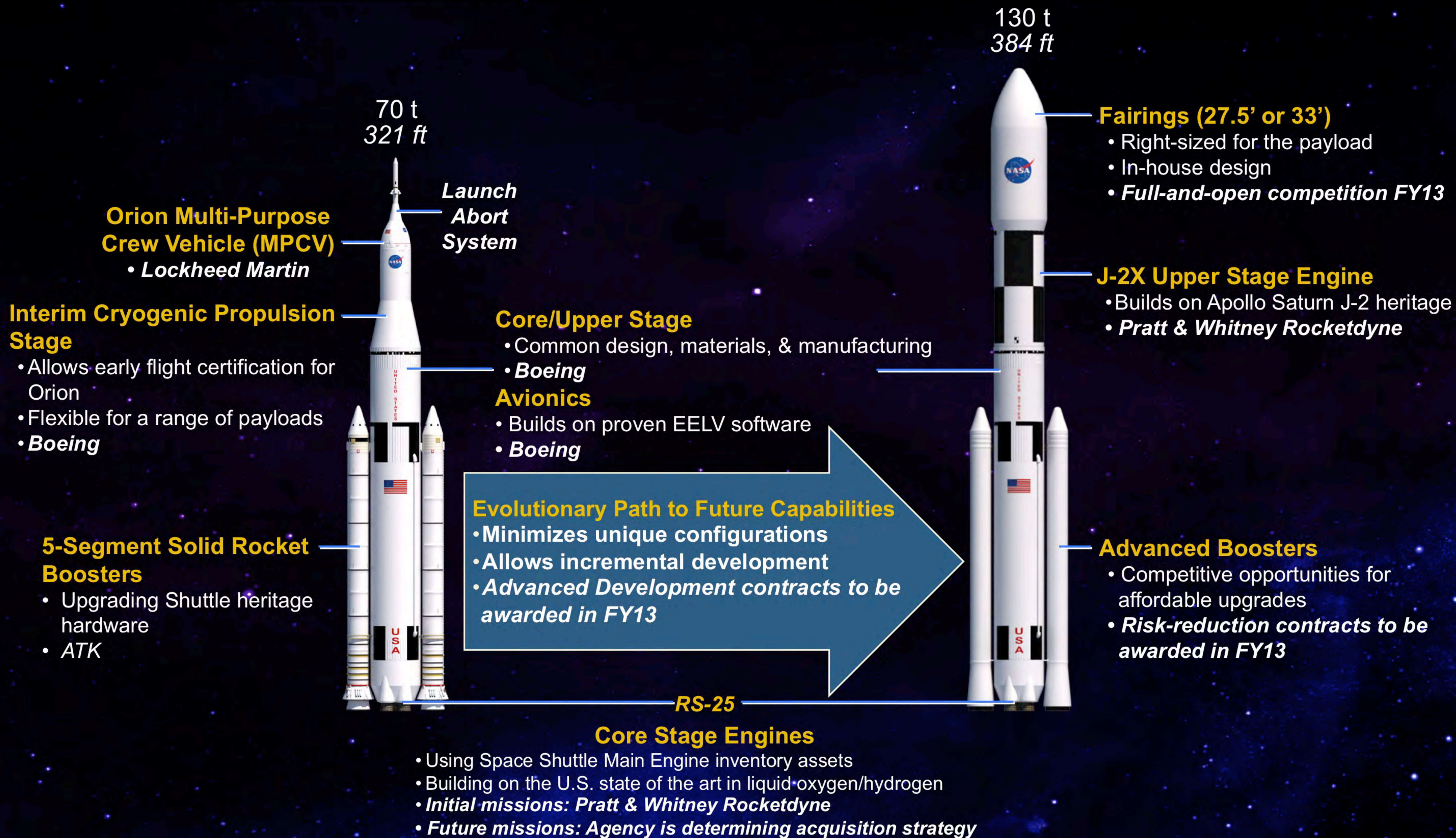
***SLS Will Be Safe, Affordable, and Sustainable***

# Building on the U.S. Infrastructure



**INITIAL CAPABILITY, 2017–21**

**EVOLVED CAPABILITY, Post-2021**



**Working with Industry Partners to Develop America's Heavy-Lift Rocket**

# Procurement Schedule



Element	FY11	FY12				FY13	FY14	FY15
	4 <sup>th</sup> Qtr	1 <sup>st</sup> Qtr	2 <sup>nd</sup> Qtr	3 <sup>rd</sup> Qtr	4 <sup>th</sup> Qtr			
<ul style="list-style-type: none"> <li>• Stages</li> <li>• Avionics</li> <li>• Booster</li> <li>• Engines - J-2X and RS-25</li> </ul>								
<ul style="list-style-type: none"> <li>• Advanced Booster Demonstration</li> </ul>								
<ul style="list-style-type: none"> <li>• Advanced Development</li> </ul>								
<ul style="list-style-type: none"> <li>• Spacecraft Adapter</li> </ul>								
<ul style="list-style-type: none"> <li>• Advanced Booster DDT&amp;E</li> <li>• Core Stage Engine</li> </ul>								

**Legend**

- PSM Conducted
- NRA Notice of Intent
- Definitization/ Contract Modification
- Solicitation
- Award

**On Track for First Flight in 2017**



## ◆ Stages

- Core and Upper Stages to be built at MAF
- Significant tooling investment in place
- Construction of Facilities work is beginning

## ◆ MSFCOC-Jacobs Engineering

- Provides operations and maintenance for MAF
- Includes robust opportunities for commercial tenants

# SLS Recent Contract Announcements



## ◆ **Advanced Booster**

- Four contractors selected
- Three contracts awarded

## ◆ **Advanced Development**

- Twenty three selections (Industry and Academia)

## ◆ **Interim Cryogenic Propulsion System (ICPS)**

- Letter contract awarded

# SLS Small Business Goals



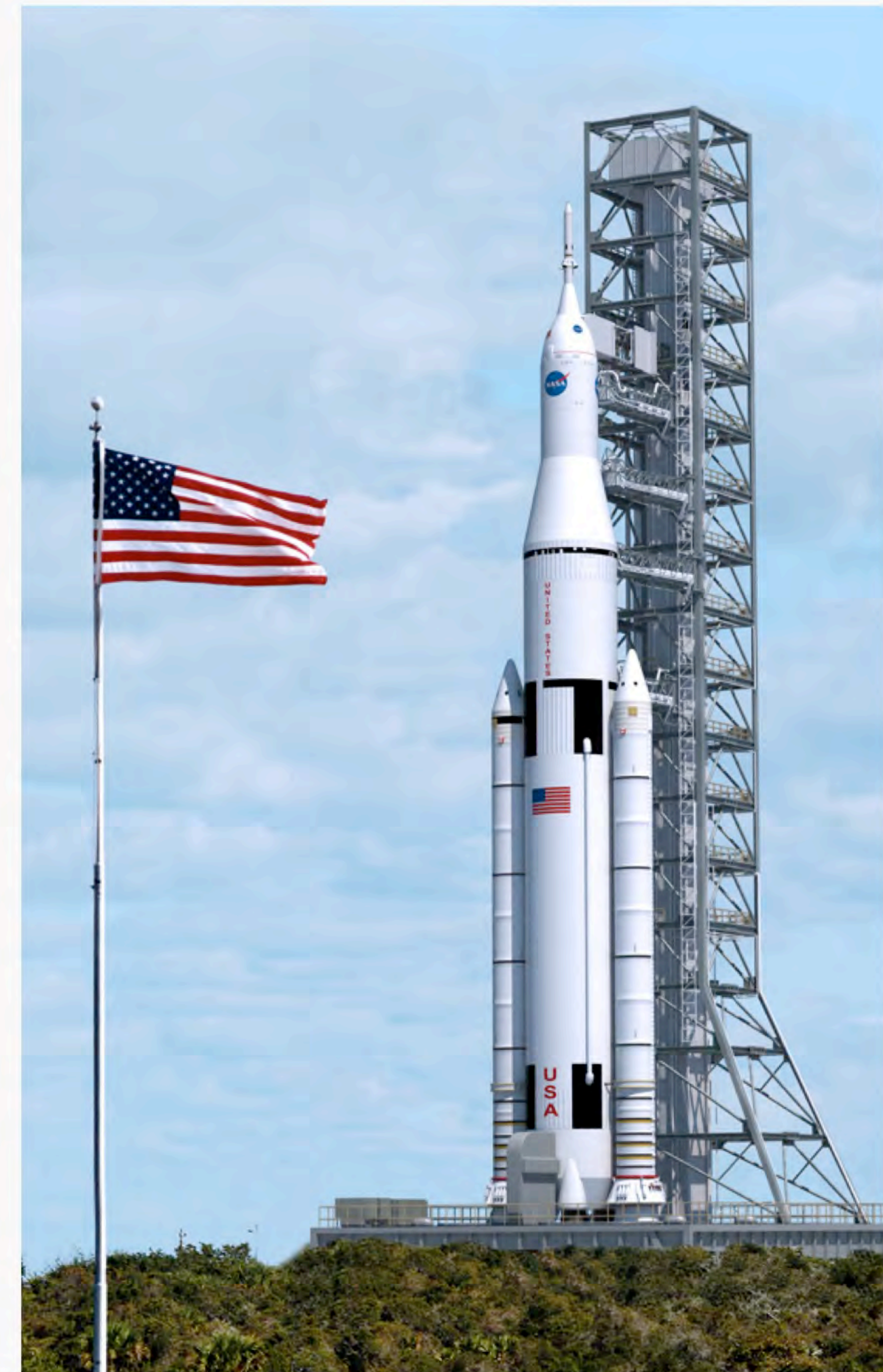
- ◆ **The NASA MSFC Small Business Specialist has performed a NASA Policy Directive 5000.2C uniform methodology assessment for the appropriate SLS requirements:**
  - Stages
  - Engines
  - Advanced Booster
  - Advanced Development
  - ICPS
  
- ◆ **Subcontracting plan goals for existing contracts will be updated via negotiations.**
  
- ◆ **Small business utilization performance is evaluated on both incentive fee and award fee contracts.**
  - Mentor/Protégé Program will be included
  
- ◆ **SLS will provide topics to the Small Business Innovation Research (SBIR) Program.**
  - Link to the NASA SBIR website will be listed on all solicitations
    - <http://sbir.gsfc.nasa.gov/SBIR/SBIR.html>

***Targeting Robust Small Business Partnerships Through Various Channels***

# SLS Acquisition Summary



- ◆ **The SLS contract activity continues to evolve per our initial acquisition strategy.**
- ◆ **The acquisition strategy meets key SLS requirements of *safety, affordability, and evolvable performance.***
- ◆ **SLS will continue to work closely with NASA's Office of Small Business Programs to maximize opportunities for all parts of the Agency's socio-economic programs.**
- ◆ **Contact information: Earl Pendley**
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  - email: [george.e.pendley@nasa.gov](mailto:george.e.pendley@nasa.gov)



***Launching 2017***