National Aeronautics and Space Administration

NASA's Space Launch System (SLS) Advanced Booster Engineering Demonstration and/or Risk Reduction

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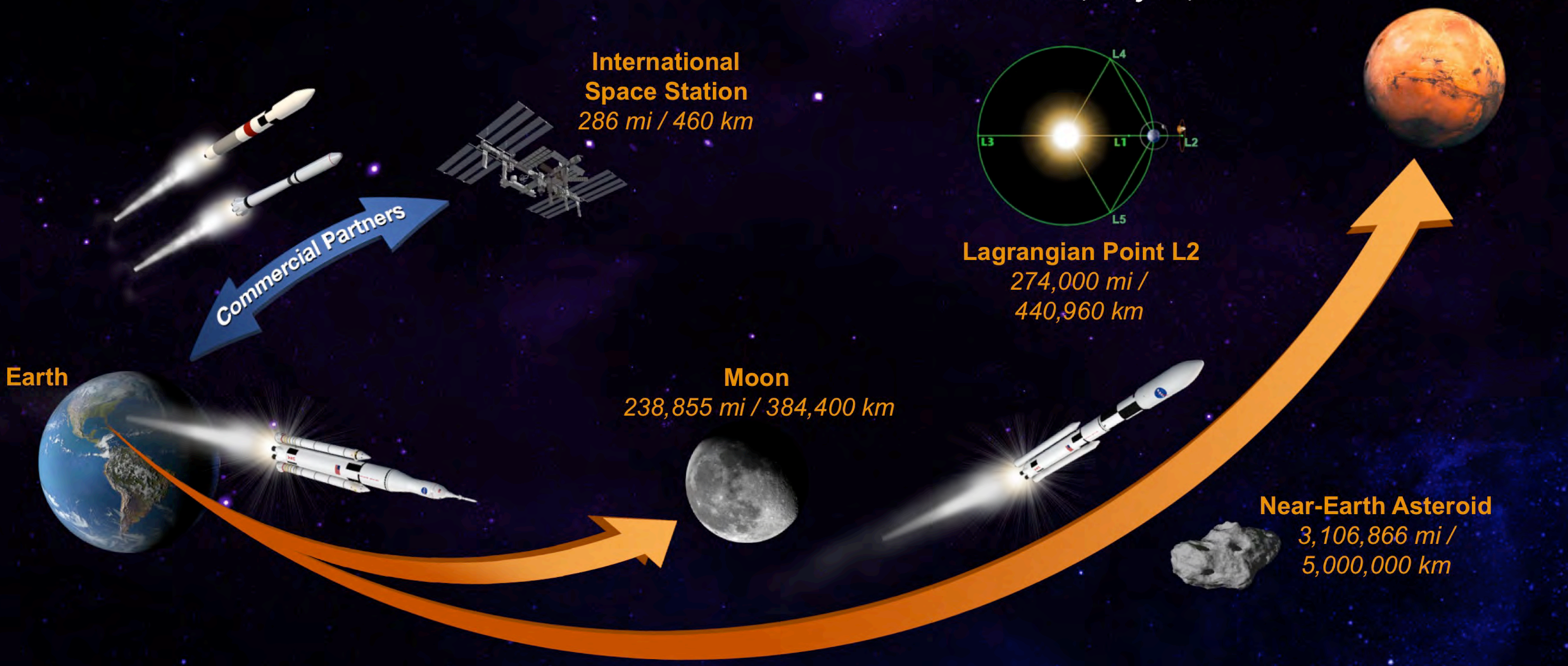
"To reach for new heights...
and reveal the unknown so that what we do and learn
will benefit all humankind."
National Aeronautics and
Space Administration
NASA
L4
L3
L1
L2
L5
• Extend and sustain human activities across the solar system.
• Expand scientific understanding of the Earth and the universe in which we live.
NASA 2011 Strategic Plan
SLS Launches in 2017
www.nasa.gov/sls
8264 Crumbly IAC.2

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

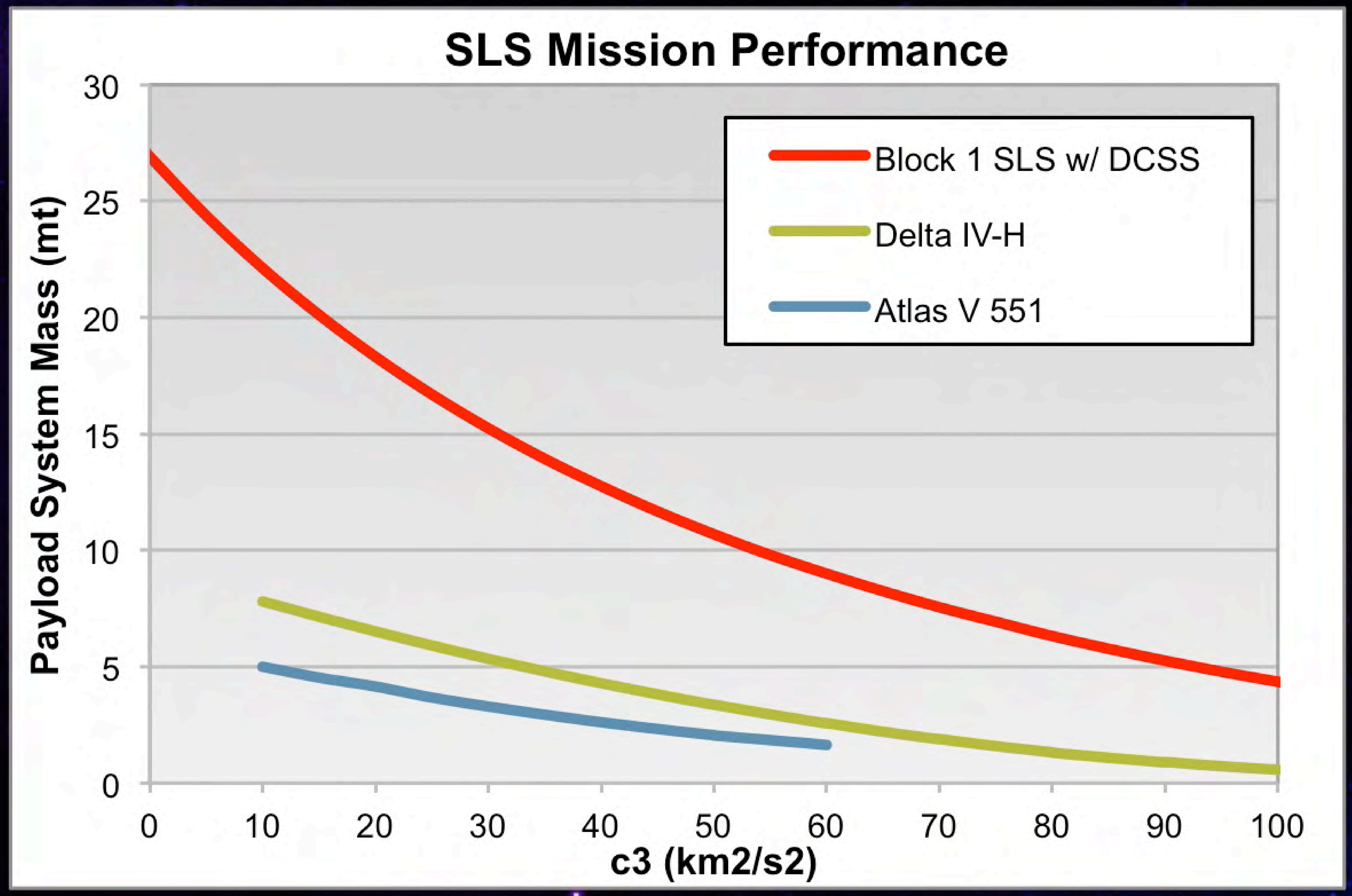


"My desire is to work more closely with the human spaceflight program so we can take advantage of synergy. We think of the SLS as the human spaceflight program, but it could be hugely enabling for science."

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

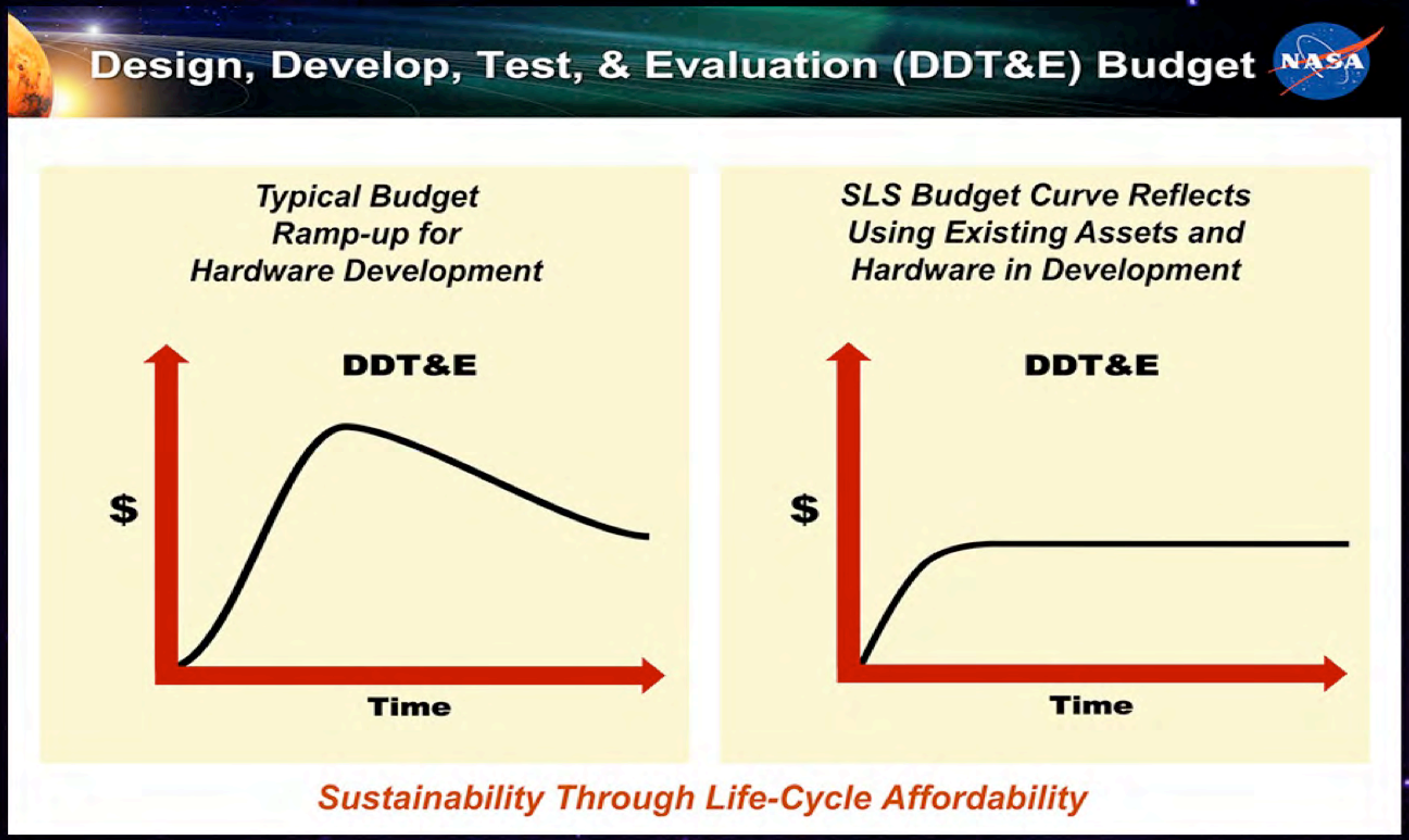
Benefits of the SLS

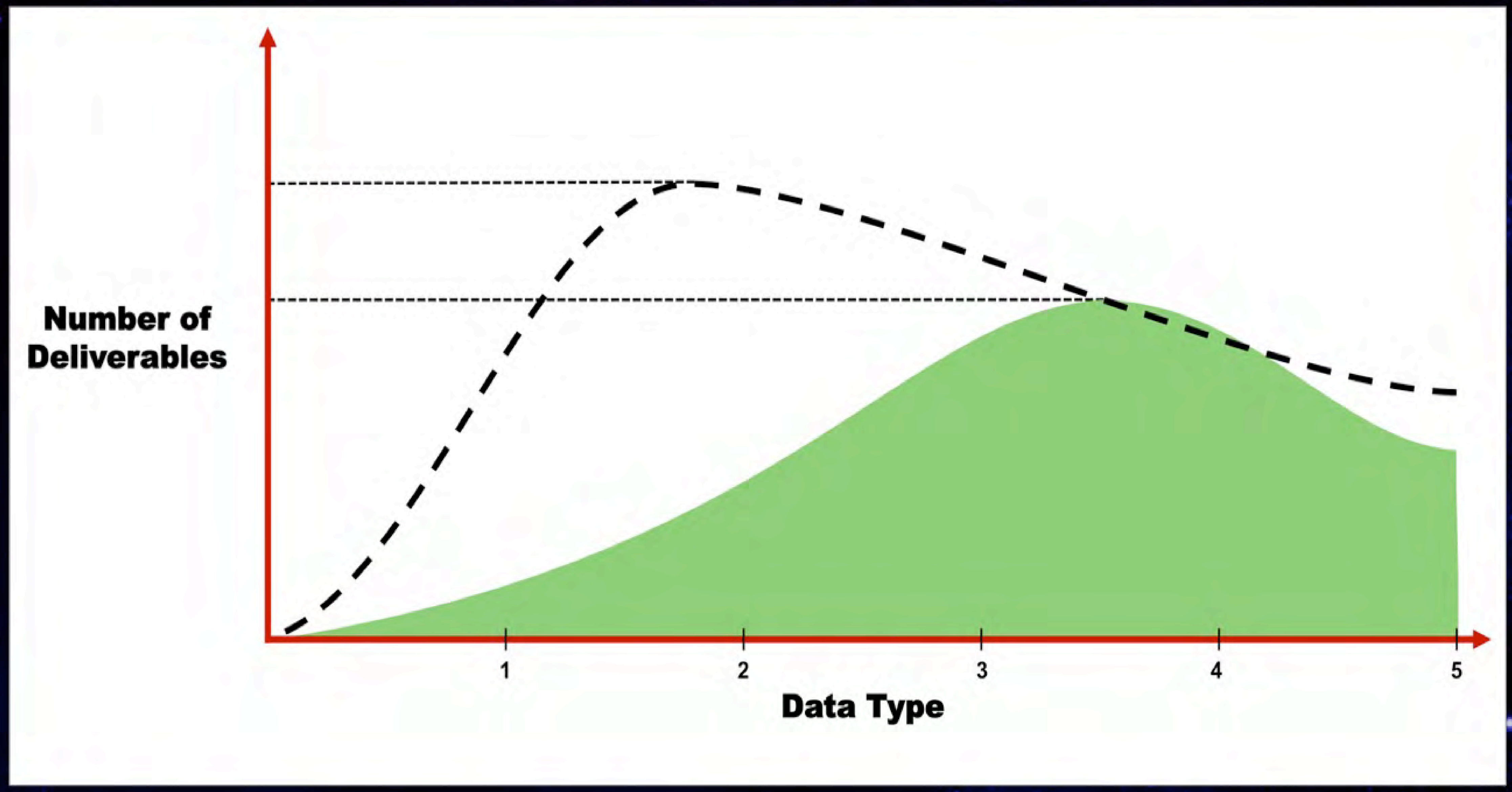
- Greater volume and mass capability/margin
  - Increased design simplicity
  - Fewer origami-type payload designs needed to fit in the fairing
- Single launch of multiple elements means fewer launches, deployments, and critical operations
  - Increased mission reliability and confidence
  - Reduced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



Pursuing Affordability Solutions

- Lean, Integrated Teams with Accelerated Decision Making
- Robust Designs and Margins
- Risk-Informed Government Insight/Oversight Model
- Right-Sized Documentation and Standards
- Hardware Commonality
- ***Evolvable Development Approach***





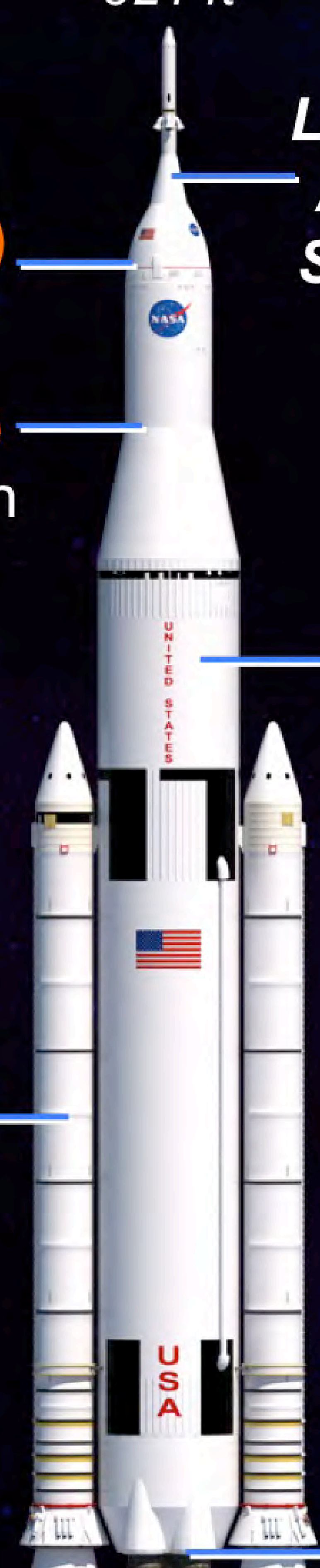
Focuses on the Data Content and Access to the Data

Sustainability through Life-Cycle Affordability

SLS Initial and Evolved Capabilities

INITIAL CAPABILITY, 2017–21

70 t
321 ft



Launch Abort System

Orion Multi-Purpose Crew Vehicle (MPCV)
- ***Lockheed Martin***

Interim Cryogenic Propulsion Stage
- Allows early flight certification for Orion
- Flexible for a range of payloads
- *Boeing*

5-Segment Solid Rocket Boosters
- Upgrading Shuttle heritage hardware
- *ATK*

Core/Upper Stage
- Common design, materials, & manufacturing
- *Boeing*

Avionics
- Builds on proven EELV software
- *Boeing*

Evolutionary Path to Future Capabilities
- **Minimizes unique configurations**
- **Allows incremental development**
- ***Advanced Development contracts to be awarded in Fiscal Year 2013***

EVOLVED CAPABILITY, Post-2021

130 t
384 ft

Fairings (27.5' or 33')
- Right-sized for the payload
- In-house design
- *Full-and-open competition Fiscal Year 2013*

J-2X Upper Stage Engine
- Builds on Apollo Saturn J-2 heritage
- *Pratt & Whitney Rocketdyne*

Advanced Boosters
- Competitive opportunities for affordable upgrades
- *Risk-reduction contracts to be awarded in Fiscal Year 2013*

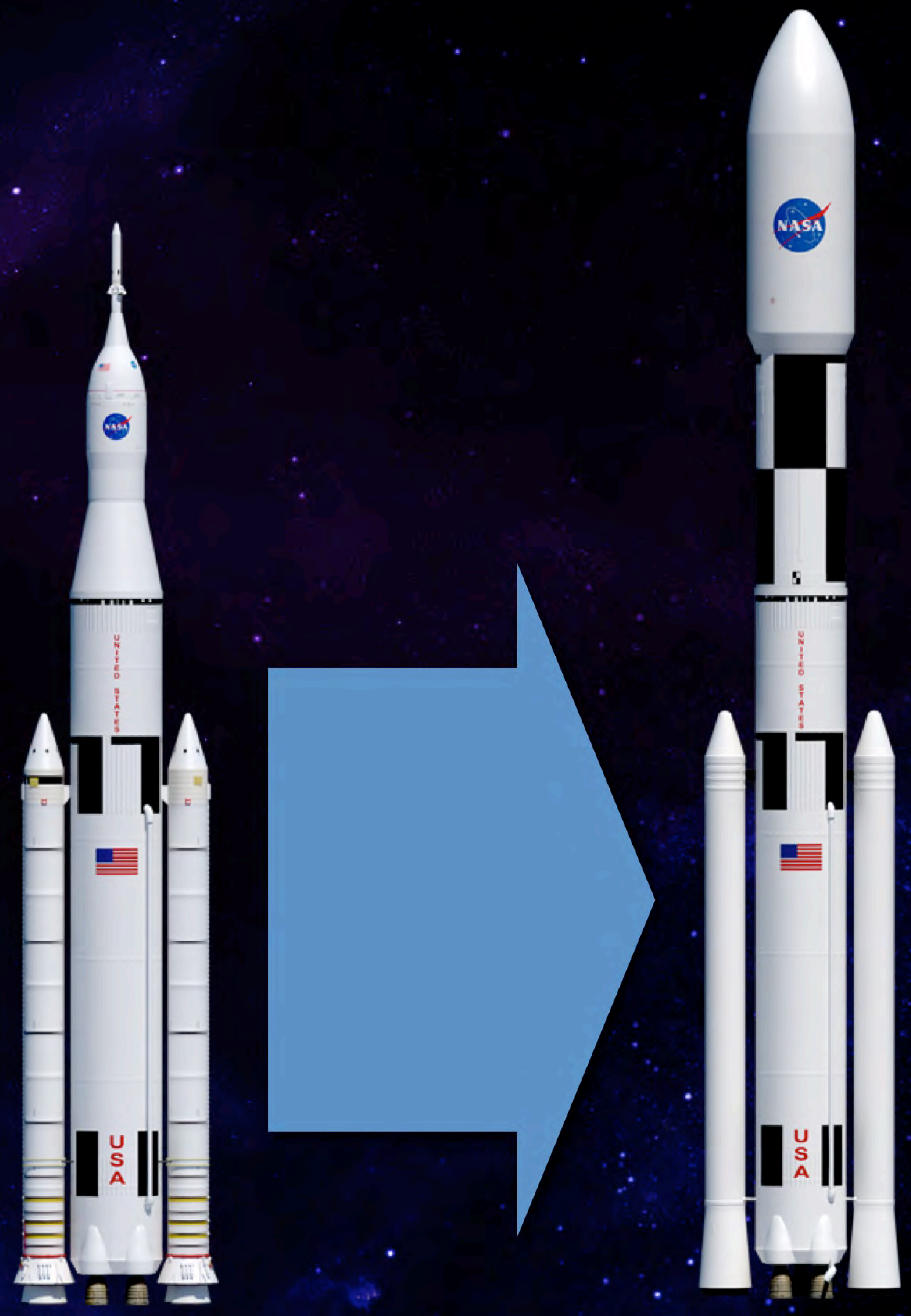
RS-25

Core Stage Engines
- Using Space Shuttle Main Engine inventory assets
- Building on the U.S. state of the art in liquid-oxygen/hydrogen
- ***Initial missions: Pratt & Whitney Rocketdyne***
- ***Future missions: Agency is determining acquisition strategy***

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

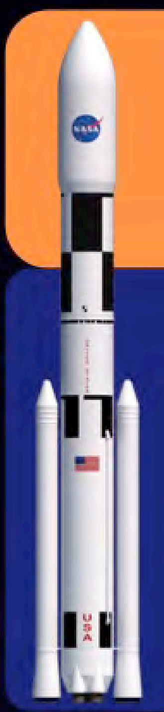


70 ton Payload (Block 1)

130 ton Payload (Block 2)

Three-Phase Booster Development Approach

Full and Open Competition



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

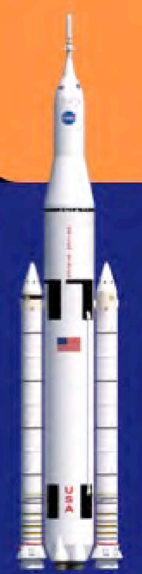
- Scope: Follow-on procurement for DDT&E of a new booster
- Date: RFP target is FY15
- Capability: Evolved at 130 t
- Contract: Full and Open Competition (Liquids or Solids)

Full and Open Competition

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



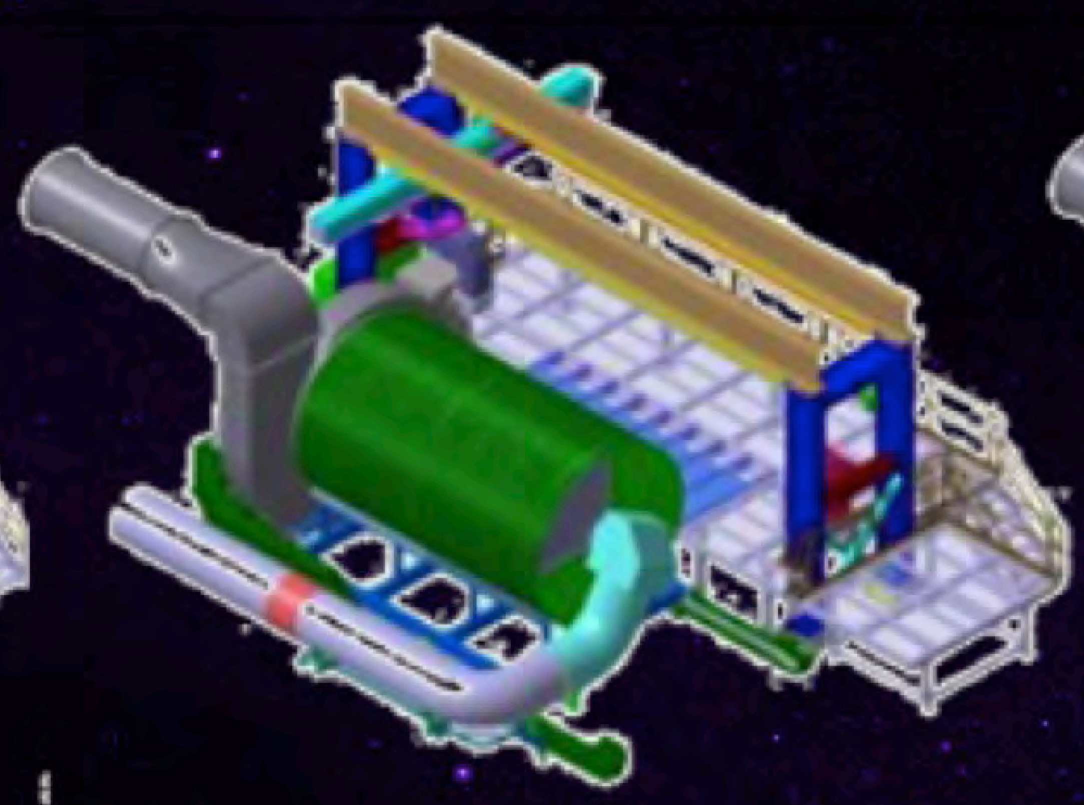
- Scope: Build two 5-segment SRB Flight Sets
- Date: In progress
- Capability: Initial 70–100 t
- Contract: Mod to Ares contract with ATK

Moving Forward from Initial to Evolved Capability

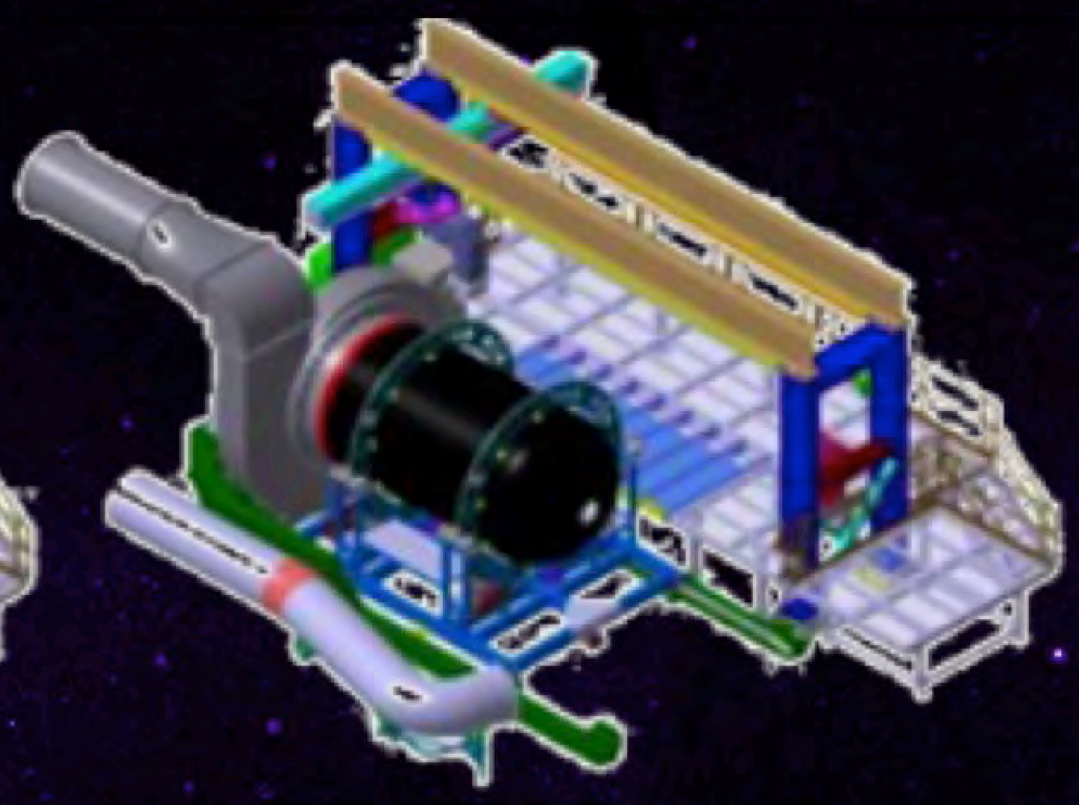
Northrop Grumman: Sub-scale Composite Tanks

- **Key Concept Attributes:**
  - Composite construction
  - Common bulkhead

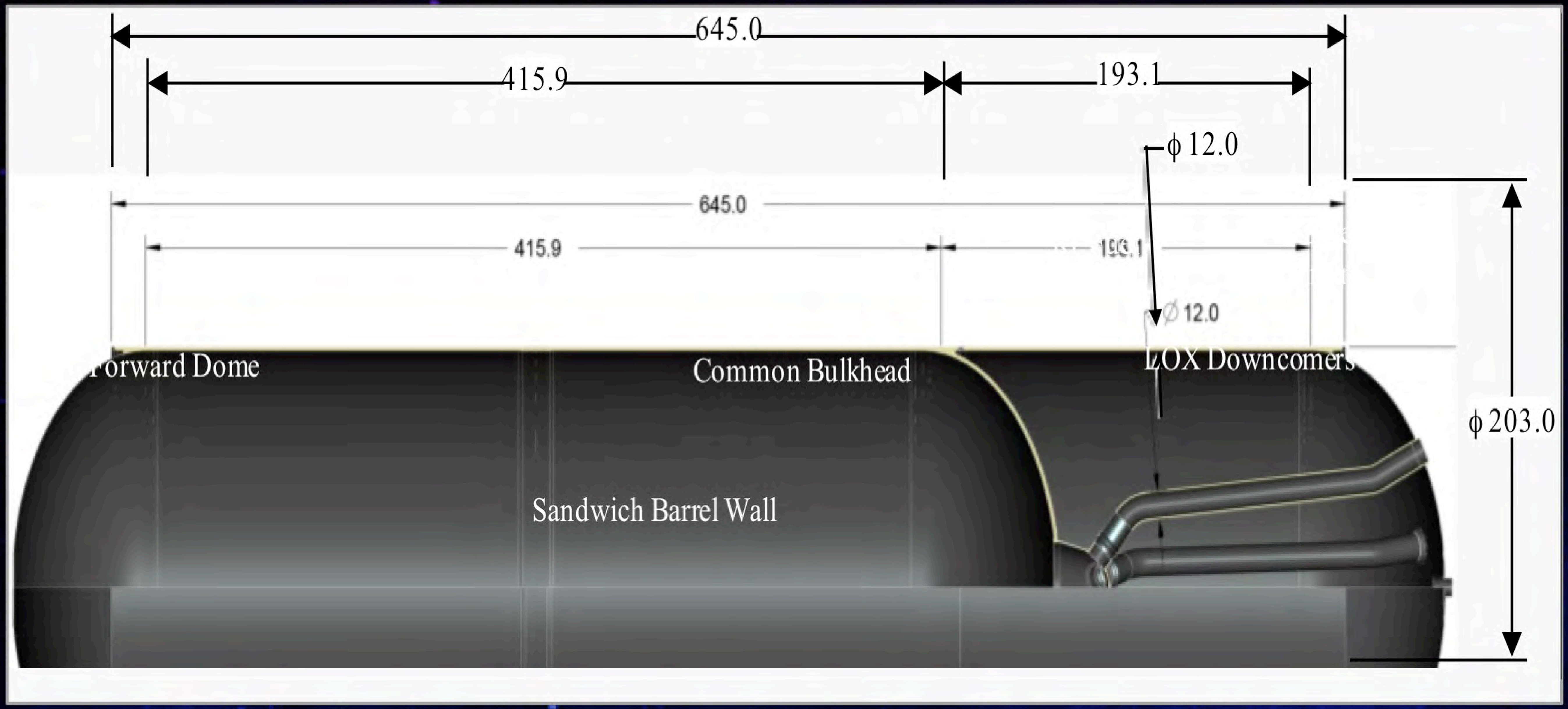
Automated Lay-up



Non-autoclave Cure



Drill, NDI and Extraction



Common Bulkhead Unitized Dome, Barrel and Skirt

Northrop Grumman: Sub-scale Composite Tanks

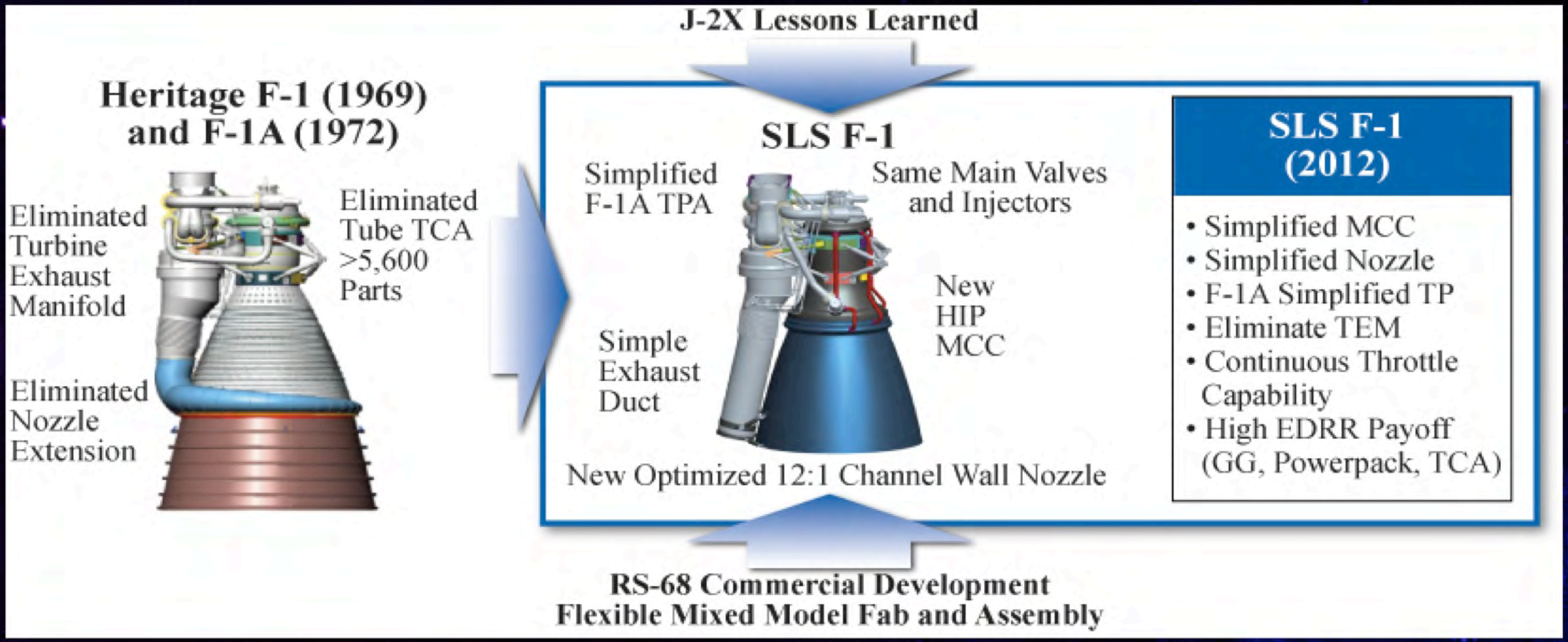
- **Concept will provide experience with composite tank/airframe manufacturing techniques:**
  - Reduced manufacturing space required – the use of an "in-situ" manufacturing process provides the ability to perform multiple processing steps (fabricate, outfit, and test) within a single facility footprint
  - Improved reliability – the tank will be manufactured as two halves, reducing the number of joints
  - Increased performance – composite structural elements help reduce weight
- **Task Scope:**
  - Design, analyze, build and test a sub-scale tank-set
  - Verify structural and thermal integrity of composite design to demonstrate reliability and performance of composite primary structures
- **Objective: development of an automated in-situ manufacturing system that utilizes out-of-autoclave curing for composite tanks**

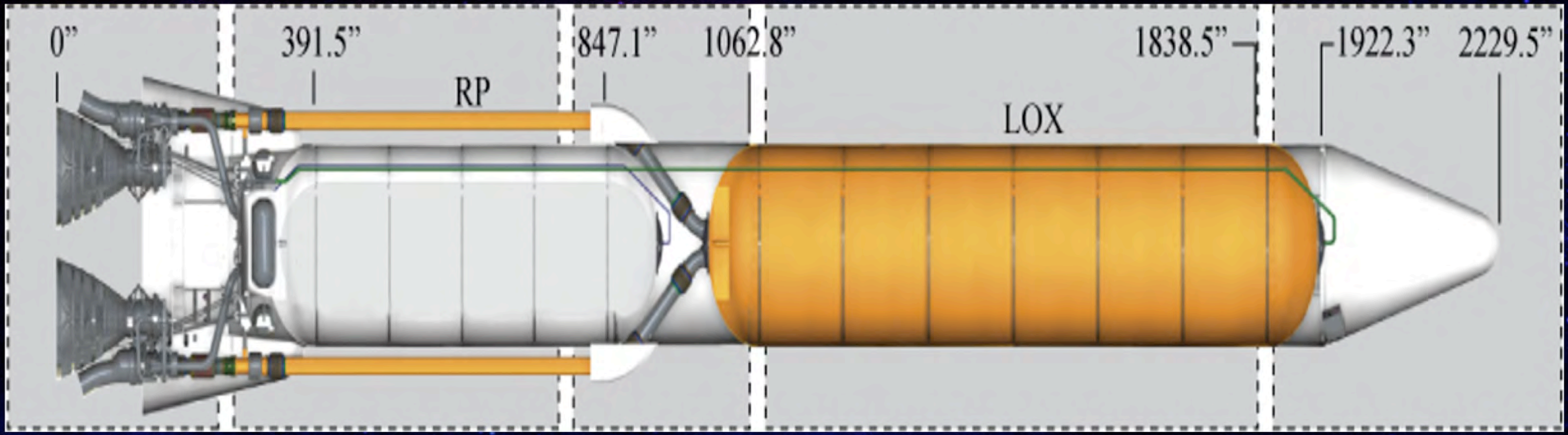
Aerojet: Full-scale Combustion Stability Demonstration

- **Concept includes a high-performance booster using an Oxygen Rich Staged Combustion (ORSC) cycle:**
  - Enhances affordability – potential synergies with other users may enhance affordability by distributing design, development, and production costs
  - Enhances performance – allows the use of a smaller booster for a given thrust level (RP allows for smaller booster due to the net density impulse of RP over hydrogen)
  - Improves operations – operational advantages of using RP are realized because it exists at ambient conditions, making handling, transportation, and storage more affordable.
- **Task Scope:**
  - Under negotiation

Dynetics Risk Reduction Tasks

- **Key Concept Attributes:**
  - 18 ft. diameter metallic (2219) tankage
  - Monocoque construction
  - 2 F-1 engines (upgraded)
  - RP-1 fueled boosters





Dynetics: F-1 Engine Risk Reduction

- **Concept includes the use of multiple modernized high-thrust class engines to yield:**
  - Lower over-all cost – modern manufacturing techniques result in fewer parts and lower production cost
  - Improved reliability – modern component designs and increased efficiency manufacturing processes replace heritage “hand-crafted” hardware and processes
  - Increased performance – e.g. continuous throttle capability for mission flexibility

Main Combustion Chamber

- **Task Scope:**
  - Gas Generator build and test
  - Turbopump build
  - Powerpack build and test
  - Thrust Chamber Assembly design

GG Injector Fabrication

- **Objectives: full-scale, production-like hardware testing validates design approach, corroborates historical data, and closes potential development issues**

Dynetics: Structures Risk Reduction

- **Concept includes simpler materials, design and manufacturing processes:**
  - Leverages the benefits of multiple higher-thrust class engines to provide sufficient performance margin to allow focus on a simpler, more robust booster tank structural design
    - Lower cost and decreased schedule risk – less costly, more robust materials enable a simpler design, manufacturing processes and tools
    - Increased performance – validates throttling capability, anchors modern models
- **Task Scope:**
  - Cryotank assembly build
  - Cryotank proof and thermal cycle test
- **Objectives: demonstrates advantage of high-thrust engines and use of underutilized advanced NASA manufacturing facilities to fabricate simpler structural designs**

MSFC Building 4755 Final Assembly

ATK: Integrated Booster Static Test

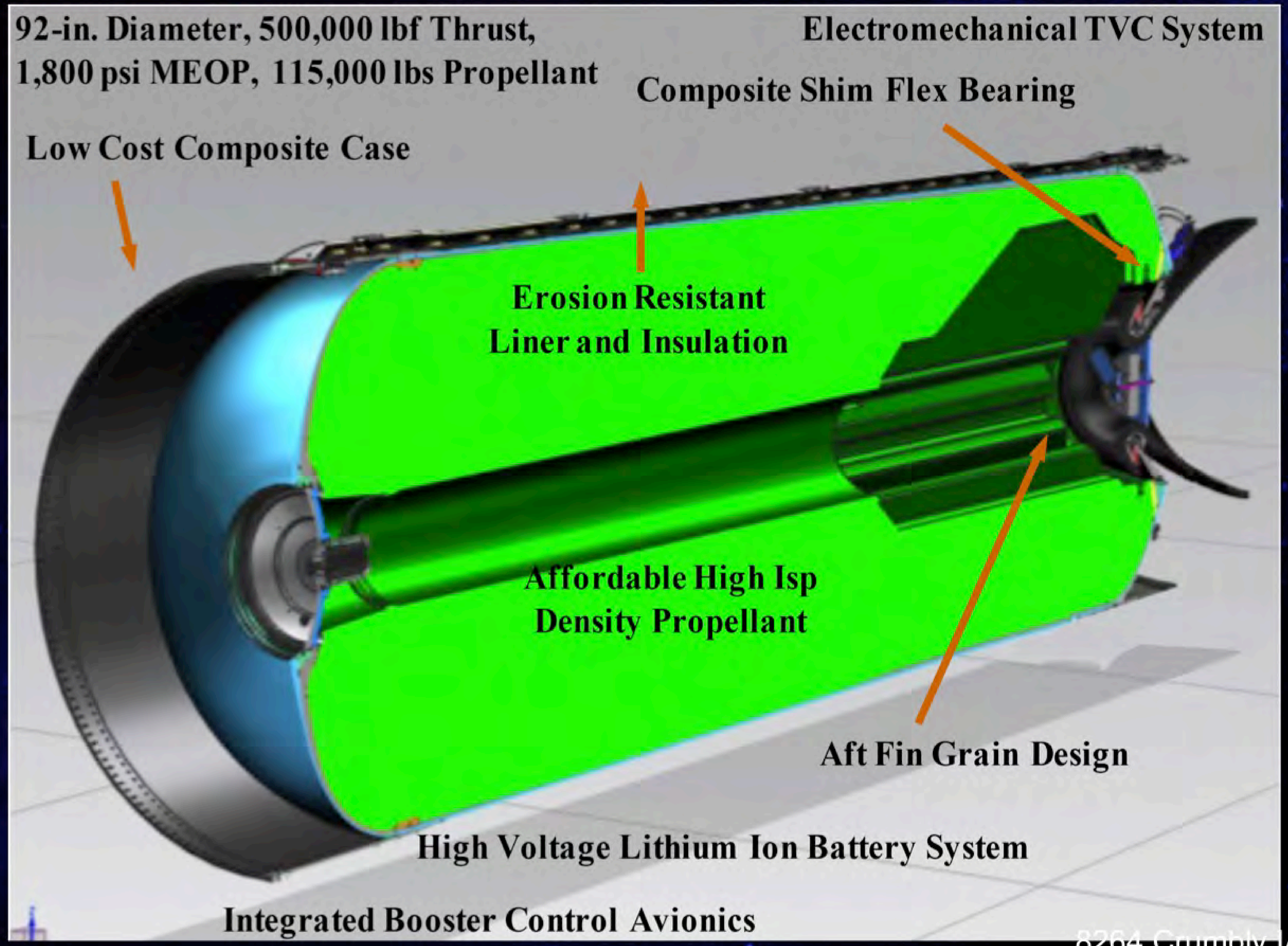
- **Key Concept Attributes:**
  - 12 ft. diameter composite case
  - 4 segment Hydroxyl-terminated Polybutadiene/ Ammonium Perchlorate (HTPB/AP) propellant
  - Automated mix & cast facility
  - 3.8M lbf thrust

ATK: Integrated Booster Static Test

- Concept includes advanced (composite) materials, redesigned forward and aft structures, and nozzle, and improved manufacturing processes:
  - The use of advanced manufacturing techniques and streamlined processes, combined with an innovative design, could result in significant cost savings over the current five-segment SRB.

- Task Scope:
  - Build, assemble, static test, and disassemble a 92 in monolithic Solid Rocket Booster (SRB) as an analog test bed for ATK's advanced booster concept
  - Activities include propellant development and characterization, nozzle design and affordability enhancement, and avionics and controls development.
  - Activities will be integrated into a 92-inch-diameter test configuration and static tested.

- Objectives: This test will allow technical challenges to be identified and addressed early in the process in order to reduce the design, development, test, and evaluation (DDT&E) schedule and cost risks.



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

For More Information

www.nasa.gov/sls