National Aeronautics and Space Administration

The Space Launch System: Building a Vehicle for Sustainable Space Exploration

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September 2012

Sheri Kittredge

Deputy Manager, SLS Engines Element

NASA's Vision and SLS Missions

"To reach for new heights...

and reveal the unknown so that what we do and learn will benefit all humankind."

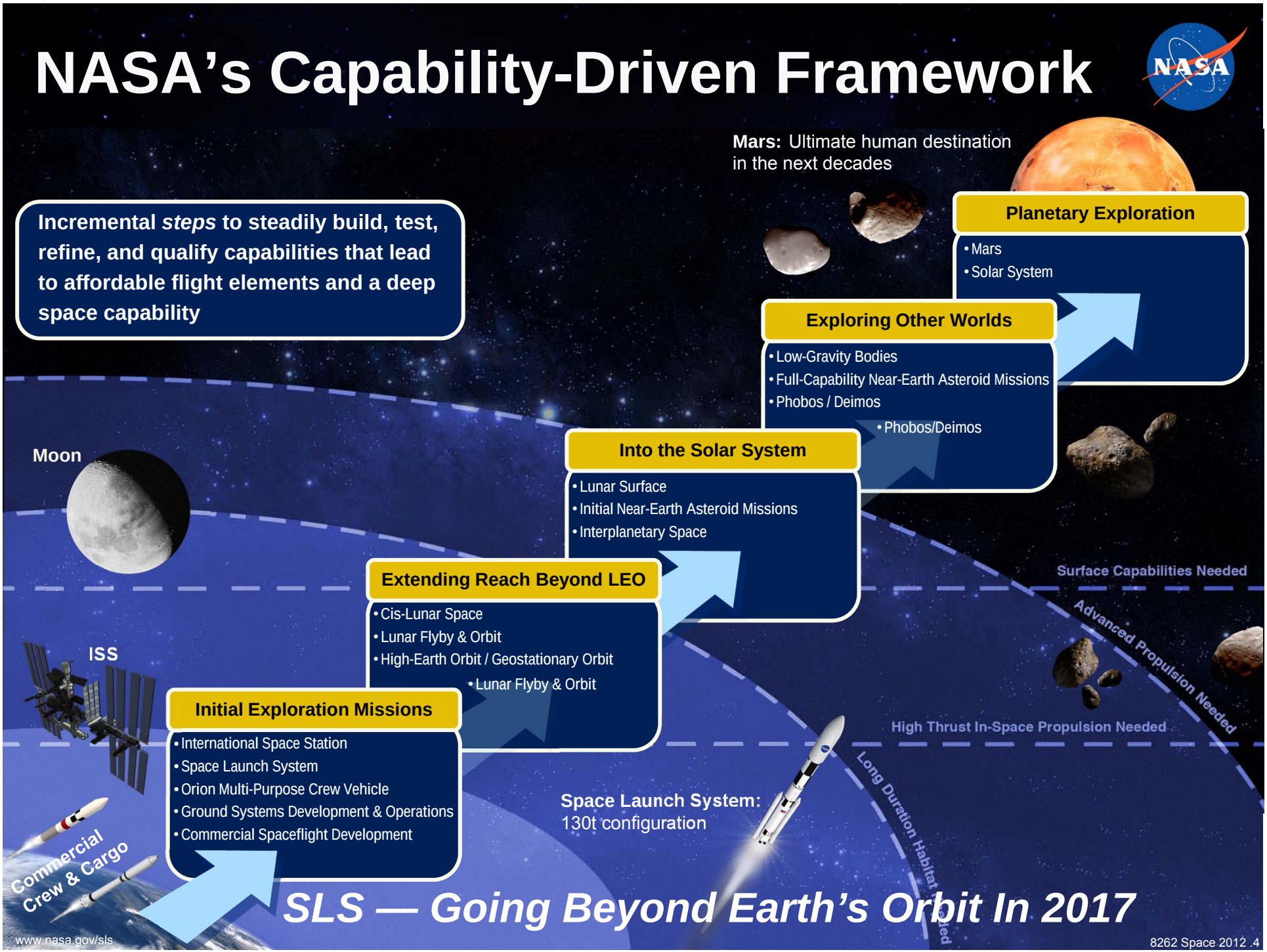
National Aeronautics and Space Administration

- 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

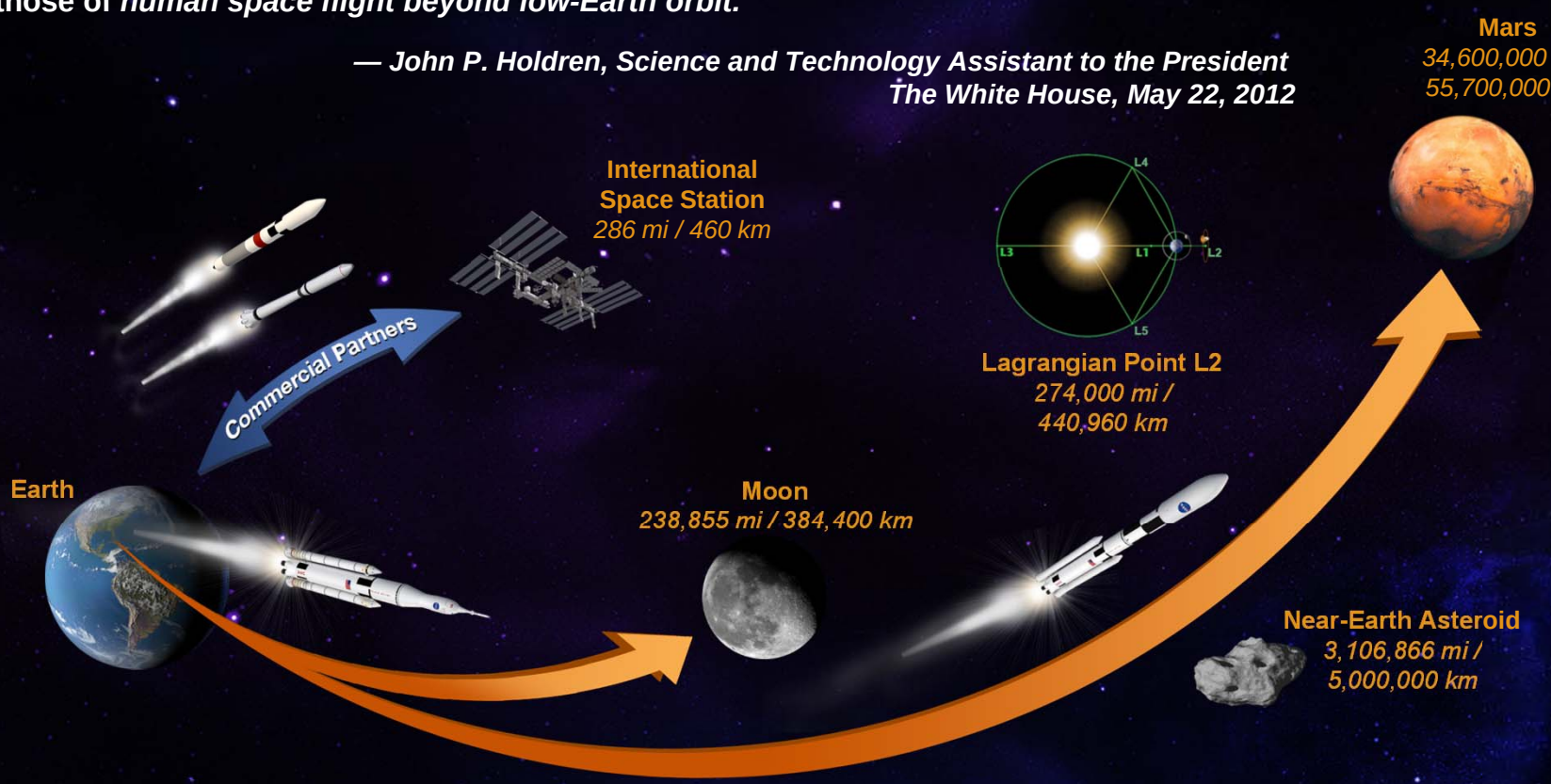
NASA's Capability-Driven Framework



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."

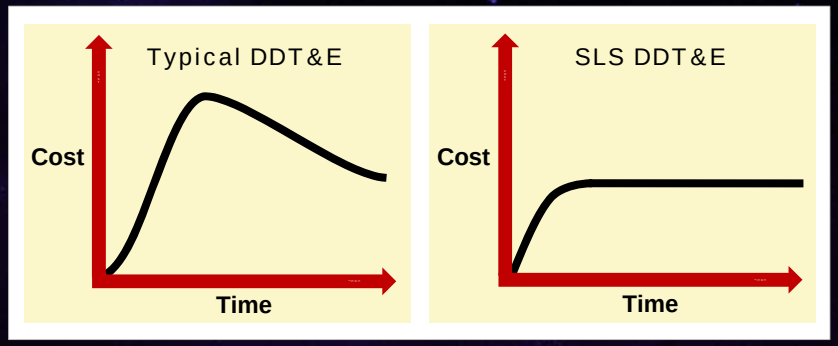
— John Grunsfeld, Associate Administrator
NASA Science Mission Directorate
Nature, Jan 19, 2012

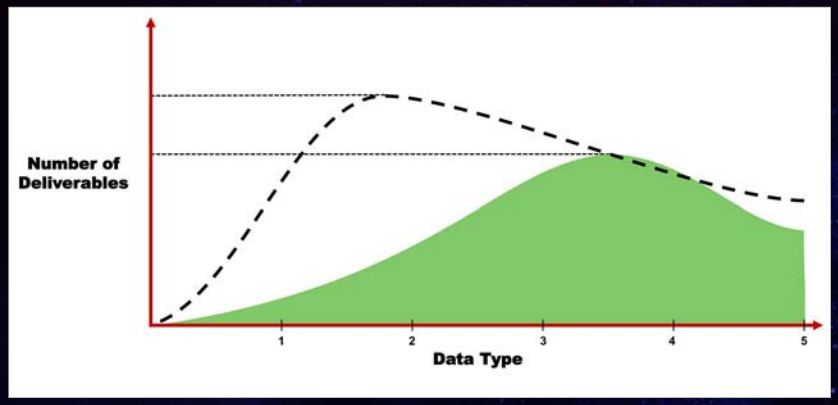
Building a National Infrastructure Asset

For Beyond-Earth Orbit Exploration

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
- Evolvable Development Approach
- Hardware Commonality





Focuses on the Data Content and Access to the Data

Sustainability through Life-Cycle Affordability

Building on Heritage Hardware and Facilities

J-2X Engine Test Firing/Space Shuttle Main Engine Testing
Stennis Space Center

Payloads
Goddard Space Flight Center

Standing Review Board
Cross-Agency

Orion Integration
Johnson Space Center

Fairing Design and Analysis
Glenn Research Center

Ground and Launch **Operations**
Kennedy Space Center

Physics-Based **A**nalysis
Ames Research Center

Manufact**uring** and Transportation
Michoud Assembly Facility

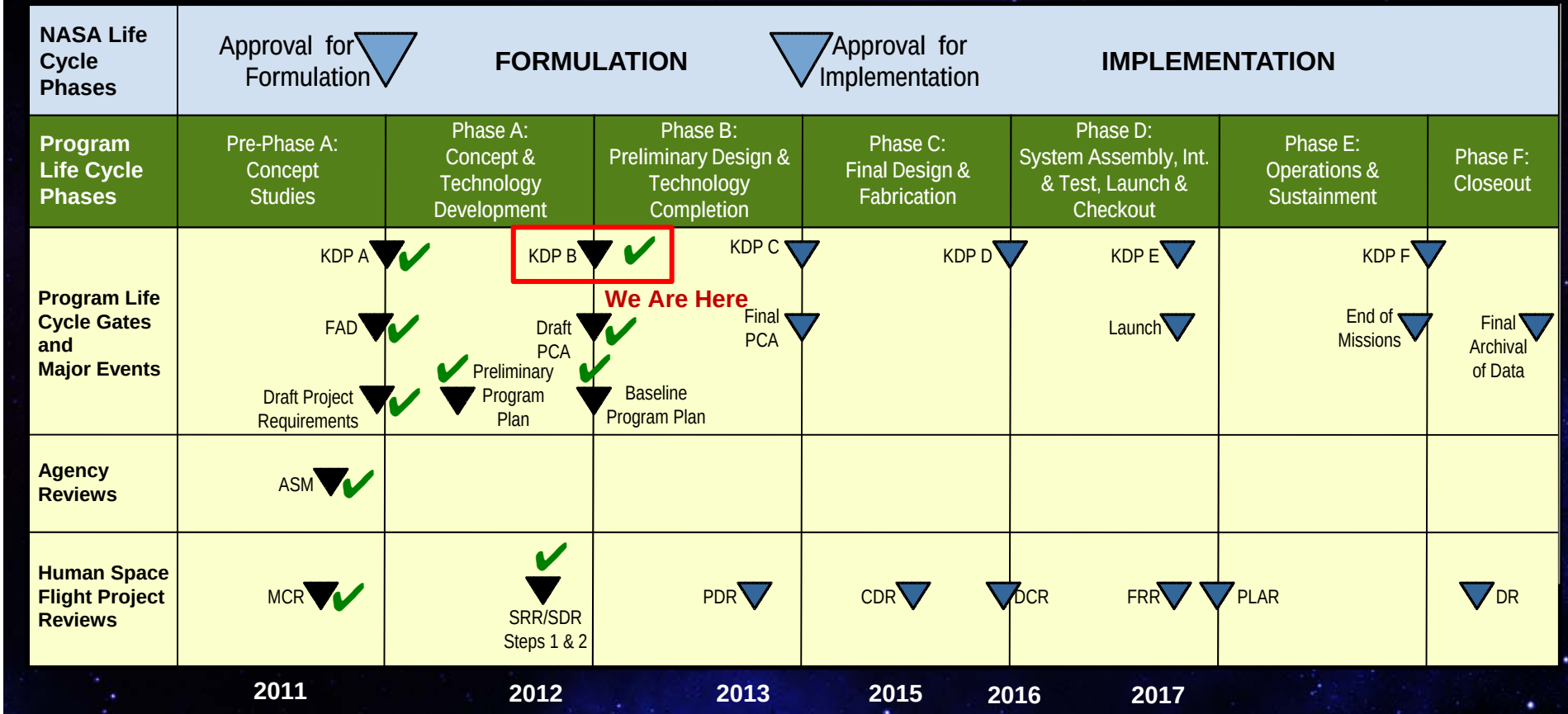
Wind Tunnel Testing
Langley Research Center

Standing Review Team
Jet Propulsion Laboratory

Upper Stage J-2X Engine Injector Firing
Marshall Space Flight Center

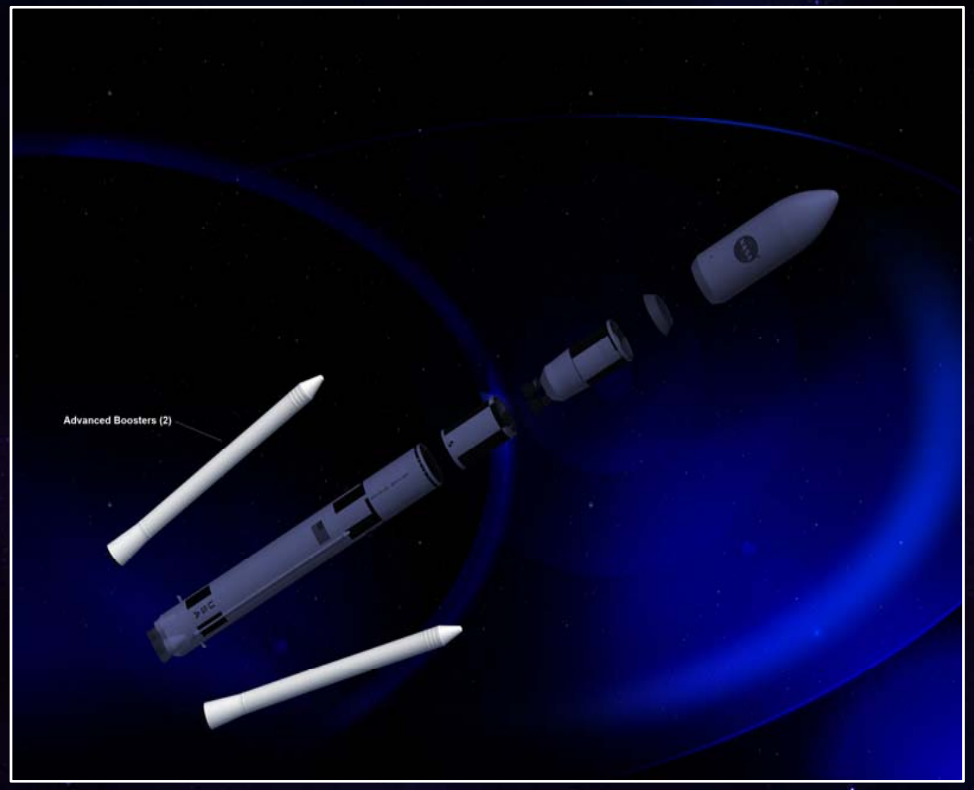
Smartly Selecting the Most Efficient Infrastructure

SLS Program Life Cycle



First Flight 2017

NASA Research Announcements (NRAs)



- **Advanced Booster Engineering and Risk Reduction**
  - Industry Day – December 15, 2011
  - Competition via NRA released - February 2012
  - Advanced Booster Proposals Received – April 2012
  - NASA Selects 6 Advanced Booster Proposals – July 2012
  - **Contract Award – October 2012**

- **Advanced Development**
  - Industry Day – February 15, 2012
  - Competition via NRA released - March 20, 2012
  - Authority to Proceed for “In-House” Work – April 19, 2012
  - Advanced Development Industry Proposals Received – April 2012
  - NASA Selects 6 Advanced Development Proposals – July 2012
  - **Contract Award – October 2012**

SLS: Being Built Today in the USA!

First ring forging prepared for Orion Stage Adapter, Cudahy, WI, April 2012.

Stages Industry Day at Michoud Assembly Facility, New Orleans, Nov 2011.

Solid Rocket Booster development motor test, Promontory, Utah, Sep 2011.

KSC is preparing Launch Complex 39B for SLS/Orion operations, 2012.

Installing the J-2X powerpack in test stand at SSC.

RS-25 Core Stage Engine in the KSC Engine Processing Facility, 2011.

J-2X Upper Stage Engine powerpack test, Stennis Space Center (SSC), MS, Feb 2012.

Meeting with Space Campers at U.S. Space & Rocket Center, Huntsville, AL, Feb 2012.

Education & Public Outreach

Pass the Torch Lecture at U.S. Space & Rocket Center
February 2, 2012

National Space Symposium with Dr. Tyson
April 16 – 19 2012

Student Launch Projects
April 19, 2012

Shuttle *Discovery* Celebration at Udvar-Hazy
April 19 – 22, 2012

Space Ops 2012
June 11 – 15, 2012

Shuttle *Enterprise* Celebration at
Intrepid with Leland Melvin
July 19 – 22, 2012

NASA's Space Launch System

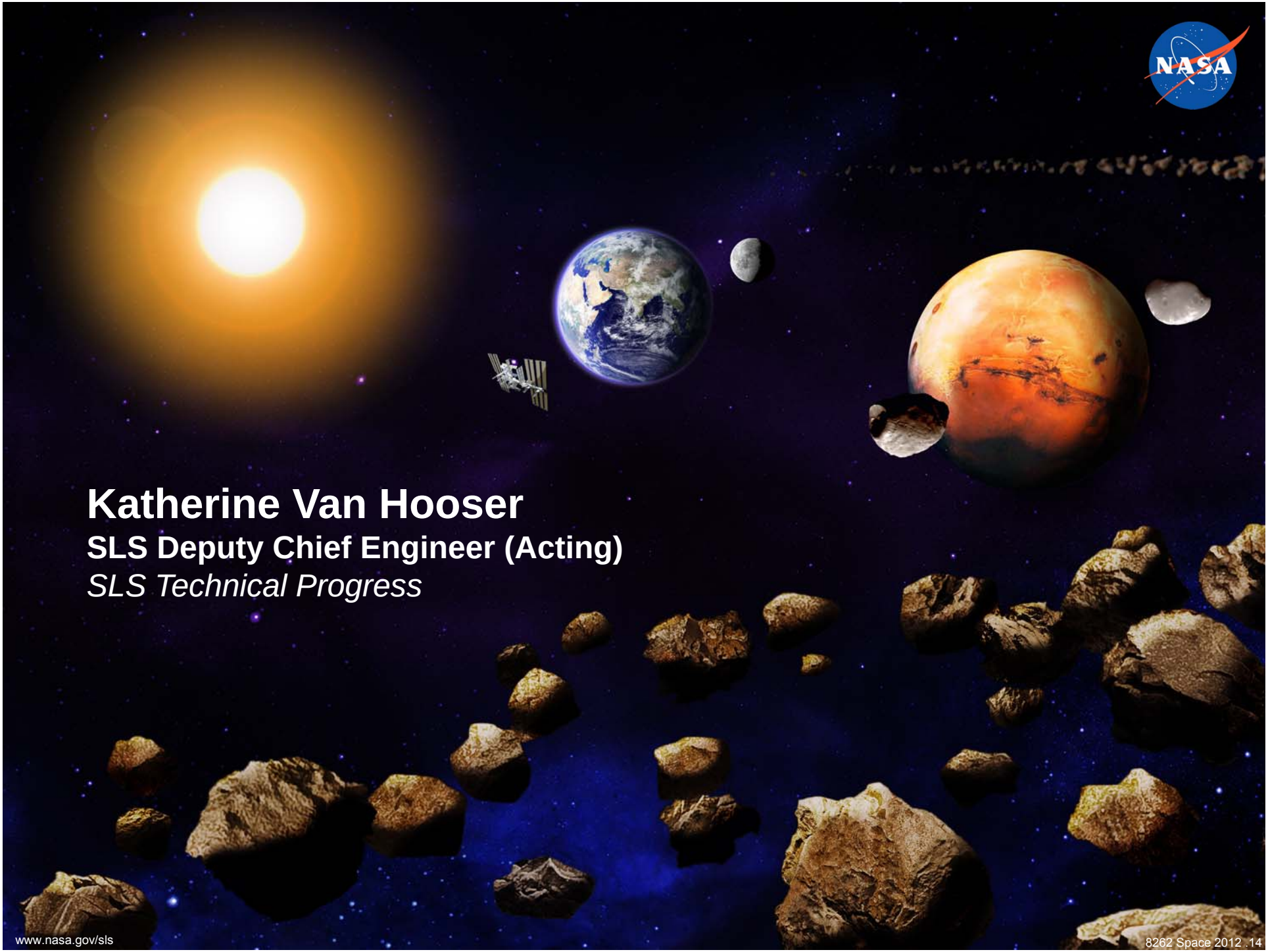
- ***Vital to NASA's exploration strategy and the U.S. space agenda***
- **Key tenets: safety, affordability, and sustainability**
- **Partnerships with NASA Headquarters, Orion, Ground Operations, and other NASA Centers**
- **Prime contractors on board, work is in progress**
- **Competitive opportunities for innovations that affordably upgrade performance**
- **Completed System Requirements Review / System Definition Review**

Preliminary Design Review 2013

Launching in 2017

For More Info:
www.nasa.gov/sls

Safe, Affordable, Sustainable



Katherine Van Hooser

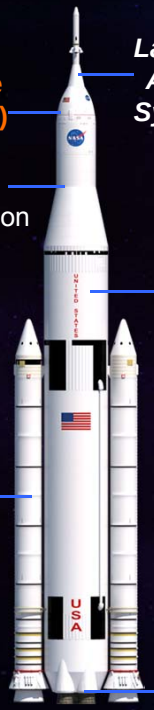
SLS Deputy Chief Engineer (Acting)

SLS Technical Progress

Building on the U.S. Infrastructure

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***

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

Avionics
- Builds on proven EELV software
- ***Boeing***

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

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***

Evolutionary Path to Future Capabilities
- **Minimizes unique configurations**
- **Allows incremental development**
- ***Advanced Development contracts to be awarded in FY13***

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 FY13***

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

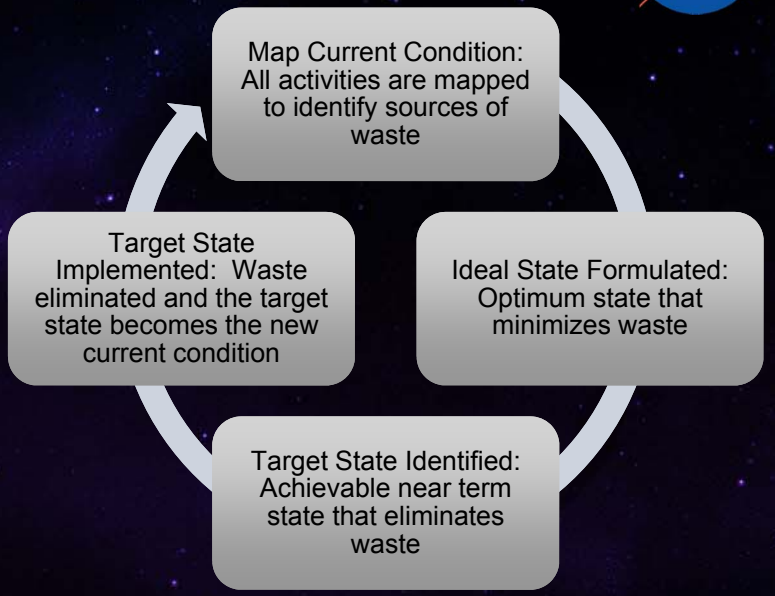
Advanced Boosters
- Competitive opportunities for affordable upgrades
- ***Risk-reduction contracts to be awarded in FY13***

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

SLS Lean Systems Engineering & Integration Model

- **Benchmarked against diverse practices**
  - Design-to-cost
  - Front-loaded product development
  - Using R&D and Knowledge Funnel approach to drive innovation and cost savings
  - Organized to balance functional expertise and cross-functional integration
  - Integrating suppliers in the product development system
  - Accelerated decision-making
  - Fewer control boards
  - Continuous Improvement
    - Contractor initiated processes to reduce contract value
    - Value-stream mapping
  - Supply Chain Management
    - Commonality
    - Simple targets and metrics for improving cost performance
  - Focus on early prototyping and testing

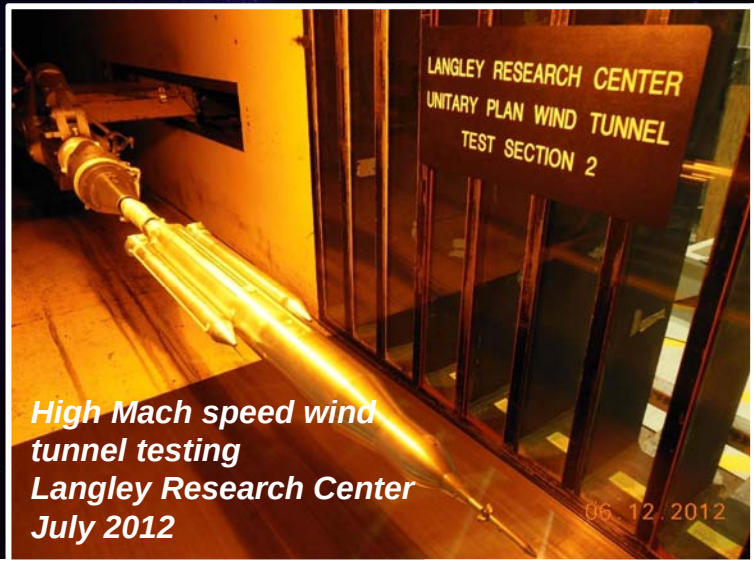
- **Benchmarked companies: 3M, ATK, Boeing, HP, IDEO, Nucor, P&G, Raytheon, Toyota, and Commercial Crew providers**



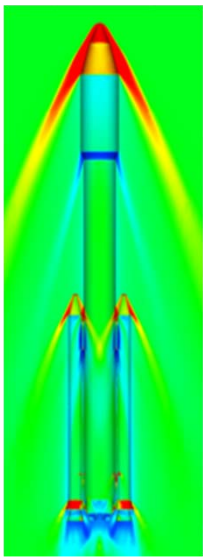
Focused on Safety, Affordability, and Sustainability

Systems Engineering & Integration

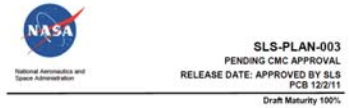
- Early wind tunnel testing completed
- Analyses and documents completed in support of SRR / SDR
- Scale Model Acoustic Testing completed for RS-25
- Environments and loads defined

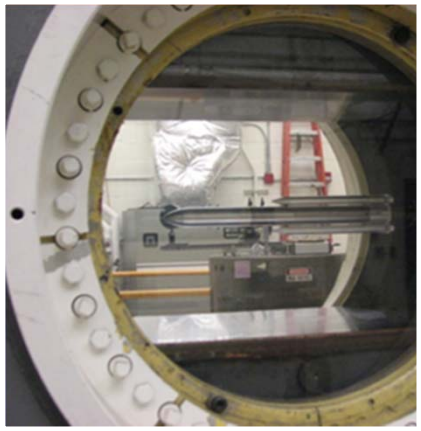


High Mach speed wind tunnel testing
Langley Research Center
July 2012

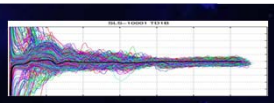


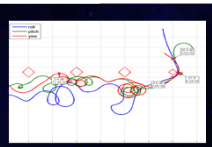
Scale model thruster acoustic testing
Marshall Space Flight Center
May 2012

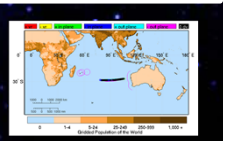




Force and moment wind tunnel testing
Marshall Space Flight Center
July 2012

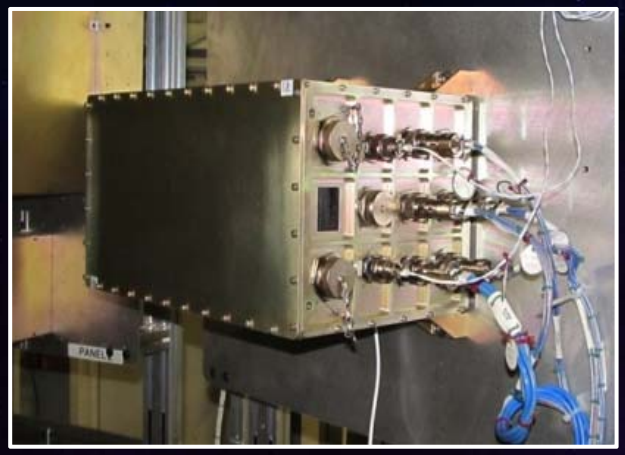






Top Accomplishments – Stages/Avionics

Stages Industry Day at MAF – November 2011

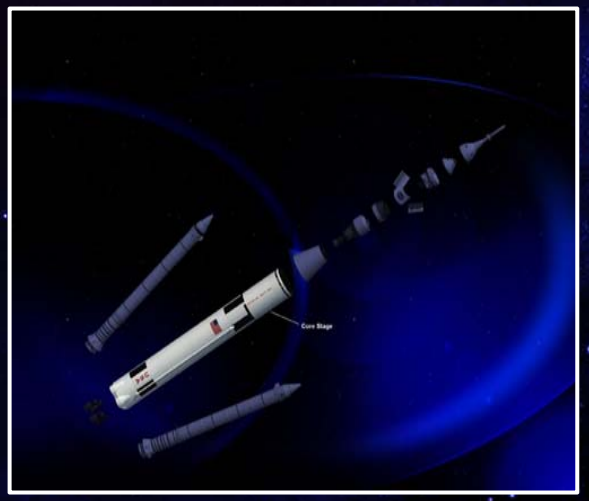


Redundant Inertial Navigation Unit – Completed initial integration with flight software – December 2011

Completed Orbiter Vehicle 103 MPS hardware removal – March 2012

Stages manufacturing demos and tooling preparation for friction stir welding – April 2012

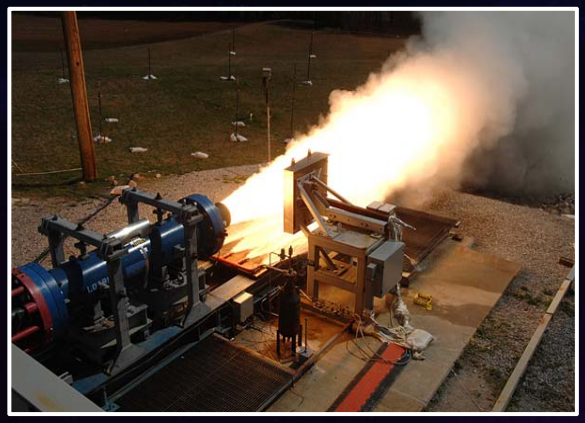
Avionics Test Beds delivered to MSFC – May 2012



Core Stage SRR completed – June 2012

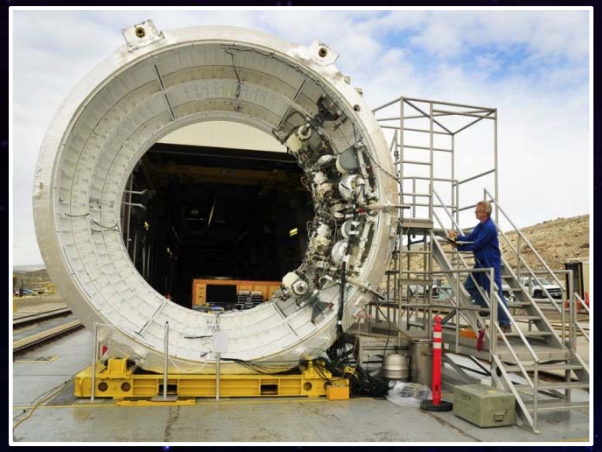
Top Accomplishments - Boosters

Development Motor Test 3
September 8, 2011
Promontory, Utah



Subscale SRM Test @ MSFC
March 14, 2012

SRM Value Stream Mapping
Completed
March 2012



Avionics Flight Control Test-1
March 2012
Promontory, Utah

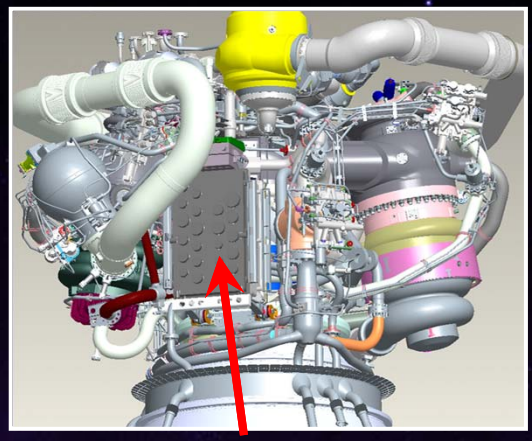
Qualification Motor First Cast
July 16, 2012
Promontory, Utah

Booster Readiness Review Completed
August 28, 2012

Top Accomplishments - Engines

J-2X PowerPack-2 testing began at SSC
February 2012

Final RS-25 core stage engines transported from KSC to SSC
April 9, 2012



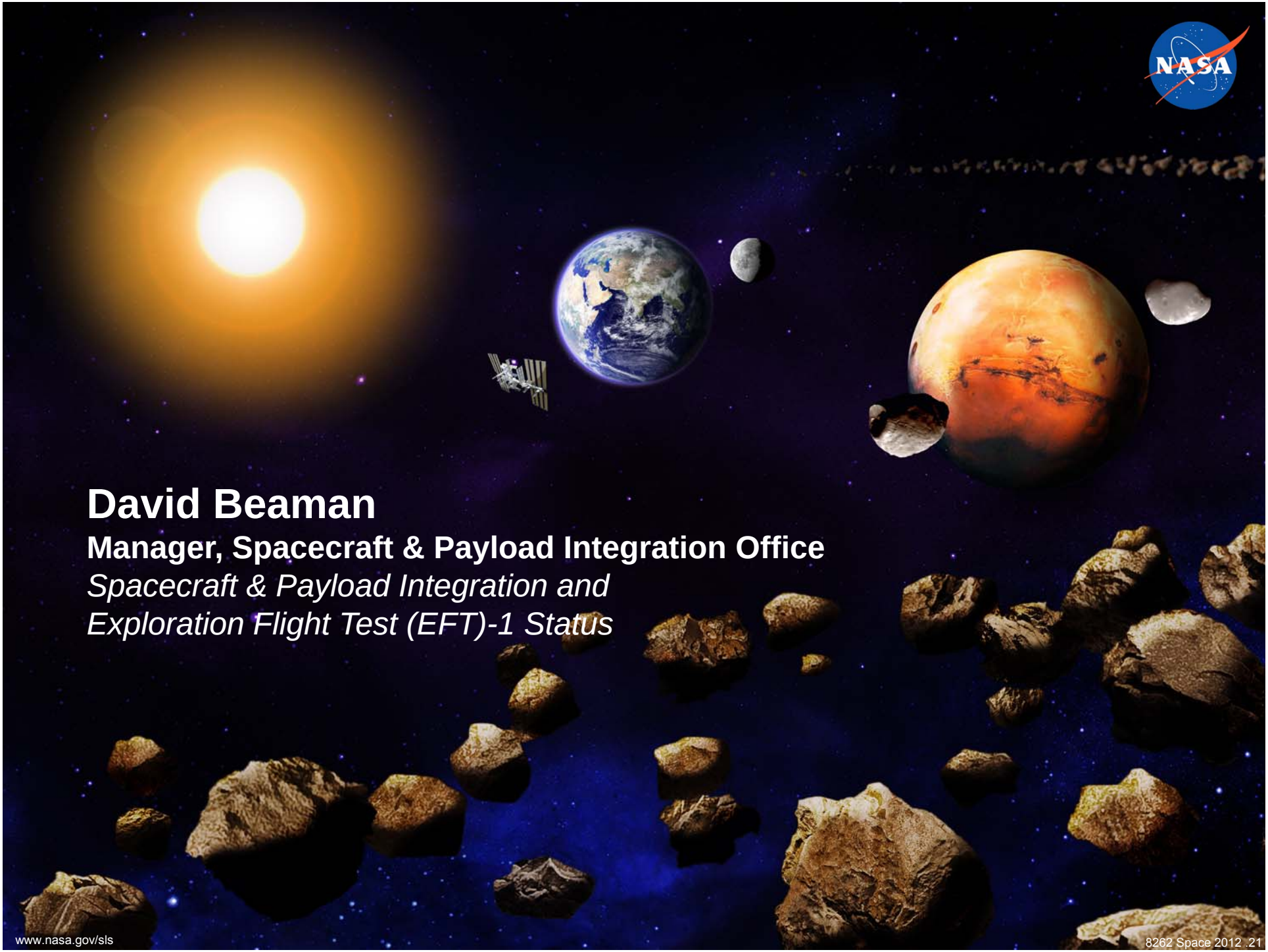
Common engine controller
SRR
May 1-2, 2012

550-sec J-2X E10001 test @ SSC
July 13, 2012

1,350 sec PowerPack-2 test @ SSC
July 24, 2012

◆ Upcoming events in FY13:

- RS-25 Engine controller unit PDR – October 2012
- Complete J-2X E10001 test series – December 2012
- Assemble J-2X E10002 – October 2012
- Assemble J-2X E10003 – December 2012



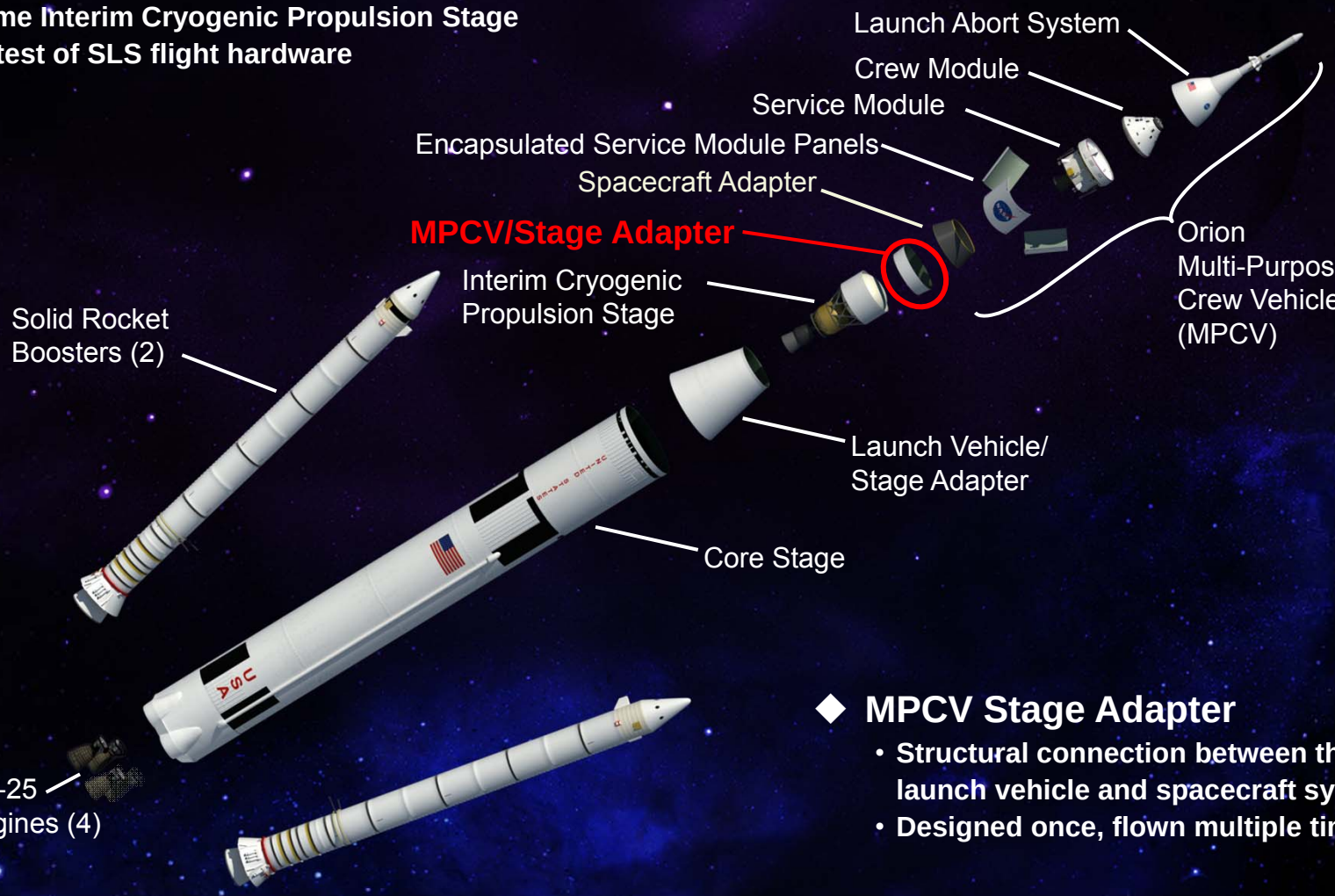
David Beaman

Manager, Spacecraft & Payload Integration Office

Spacecraft & Payload Integration and
Exploration Flight Test (EFT)-1 Status

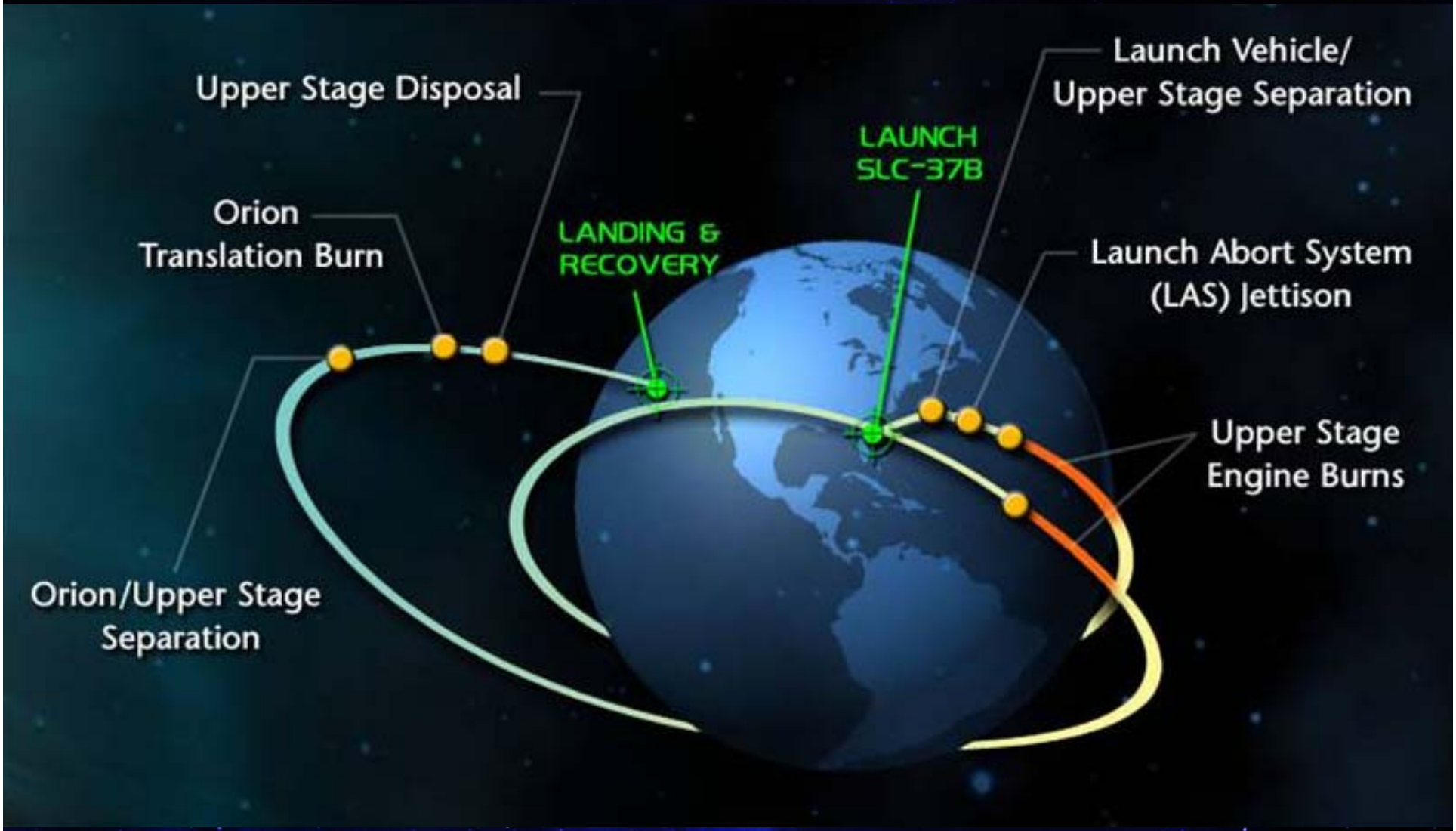
SLS 70t Expanded View

- **EFT-1**
  - **Orion boosted to high-Earth orbit by Delta Cryogenic Second Stage, which will be modified to become Interim Cryogenic Propulsion Stage**
  - **First test of SLS flight hardware**



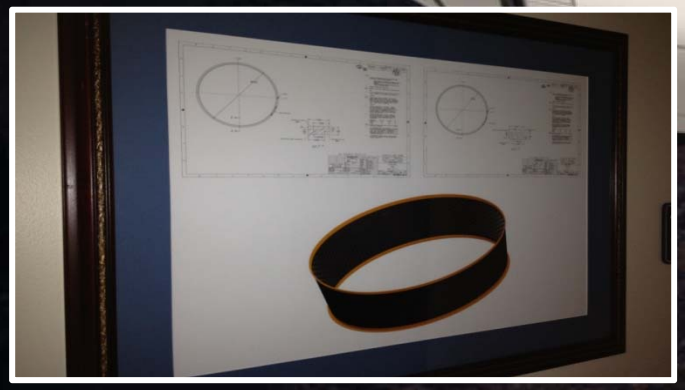
- **MPCV Stage Adapter**
  - **Structural connection between the launch vehicle and spacecraft systems**
  - **Designed once, flown multiple times**

Exploration Flight Test-1 (2014) Mission Overview



Exploration Flight Test-1 in 2014
MPCV Stage Adapter

First ring forging,
ATI/Ladish,
Cudahy, WI
April 2012



EFT-1 MPCV Stage Adapter
Design Review in March 2012


Robotic Weld Tool
NASA
4ST


WARNING
2012/06/15 13:26:06
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www.nasa.gov/sls

8262 Space 2012 .29

NASA's Space Launch System

- *On track for a 2017 first flight*
- Key tenets: safety, affordability, and sustainability
- Progress being made on all elements of the vehicle
- Prime contractors on board, work being done across the country
- Completed System Requirements Review / System Definition Review, now working toward Preliminary Design Review in 2013
- Flight hardware being tested on EFT-1 in 2014

For More Info:
www.nasa.gov/sls

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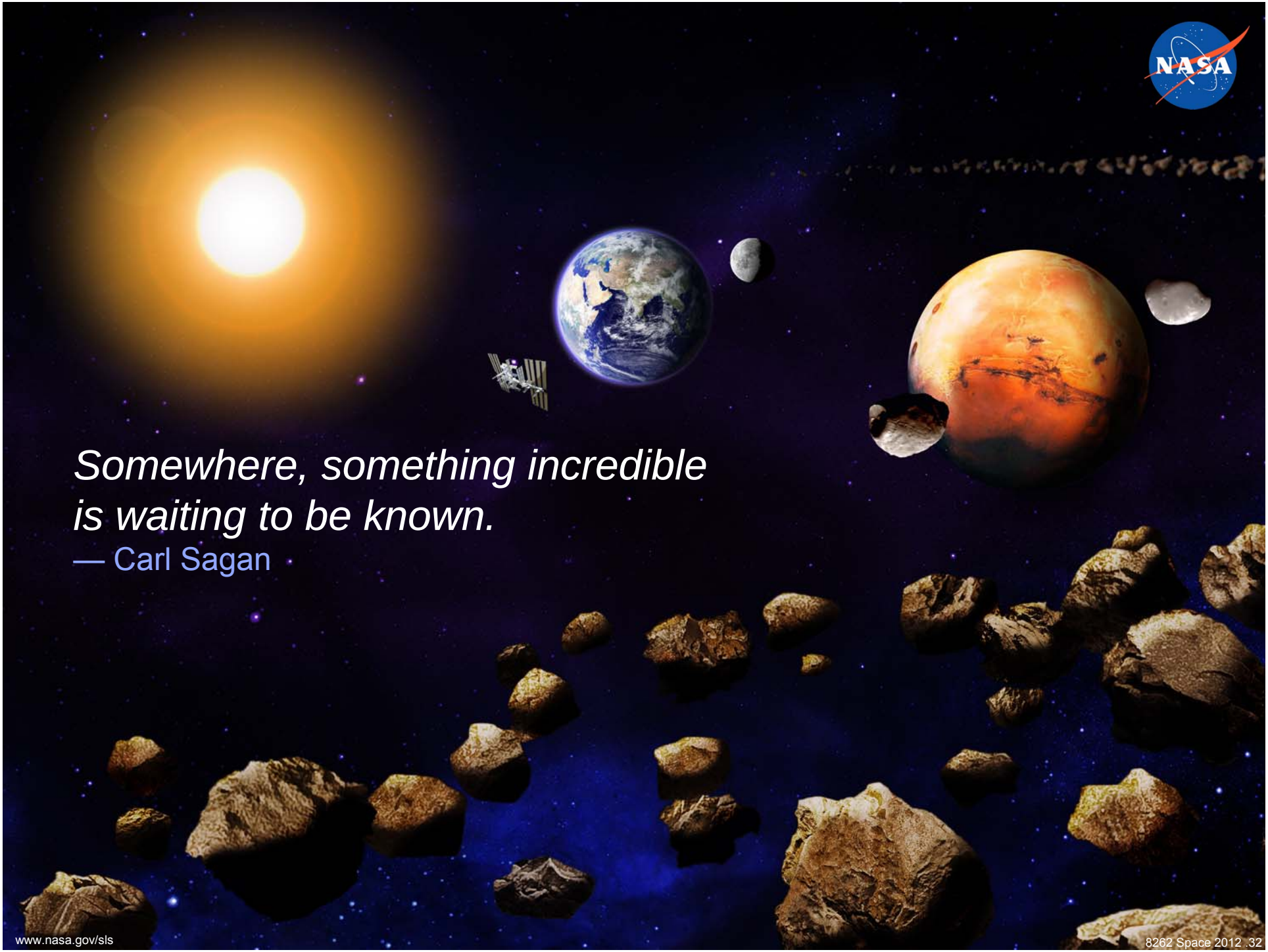
Somewhere, something incredible is waiting to be known.
— Carl Sagan