Space Launch System And NASA's Path to Mars

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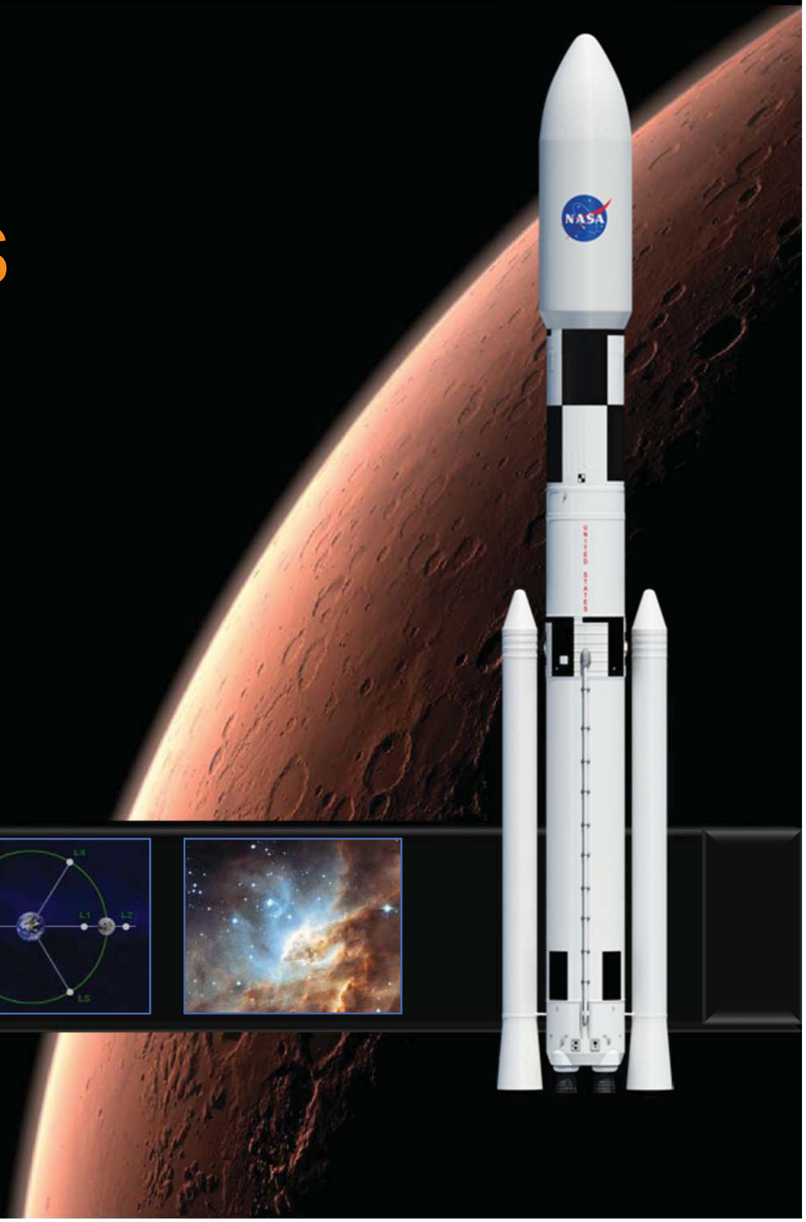
August 2014



Mars Is The Mission

launch capabilities to improve responsiveness, resiliency, and cost effectiveness for future space launch alternatives.

In support of civil space programs and activities, including human and robotic spaceflight for exploration, scientific, operational, and other civil purposes, the Administrator of NASA shall:

- Develop, in support of U.S. space exploration goals, the transportation-related capabilities necessary to support human and robotic exploration to multiple destinations beyond low-Earth orbit, including an asteroid and Mars. Such capabilities include a heavy-lift space transportation system, crew vehicles, and other related capabilities such as in-space refueling technologies and

TITLE
SPAC
NATIONAL SPACE ...
EARTH ORBIT

42 USC 18321.

SEC. 301. HUMAN SPACE FLIGHT BEYOND LOW-EARTH ORBIT.

(a) FINDINGS.—Congress makes the following findings:

(1) The extension of the human presence from low-Earth orbit to other regions of space beyond low-Earth orbit will enable missions to the surface of the Moon and missions to deep space destinations such as near-Earth asteroids and Mars.

(2) The regions of cis-lunar space are accessible to other national and commercial launch capabilities, and such access raises a host of national security concerns and economic

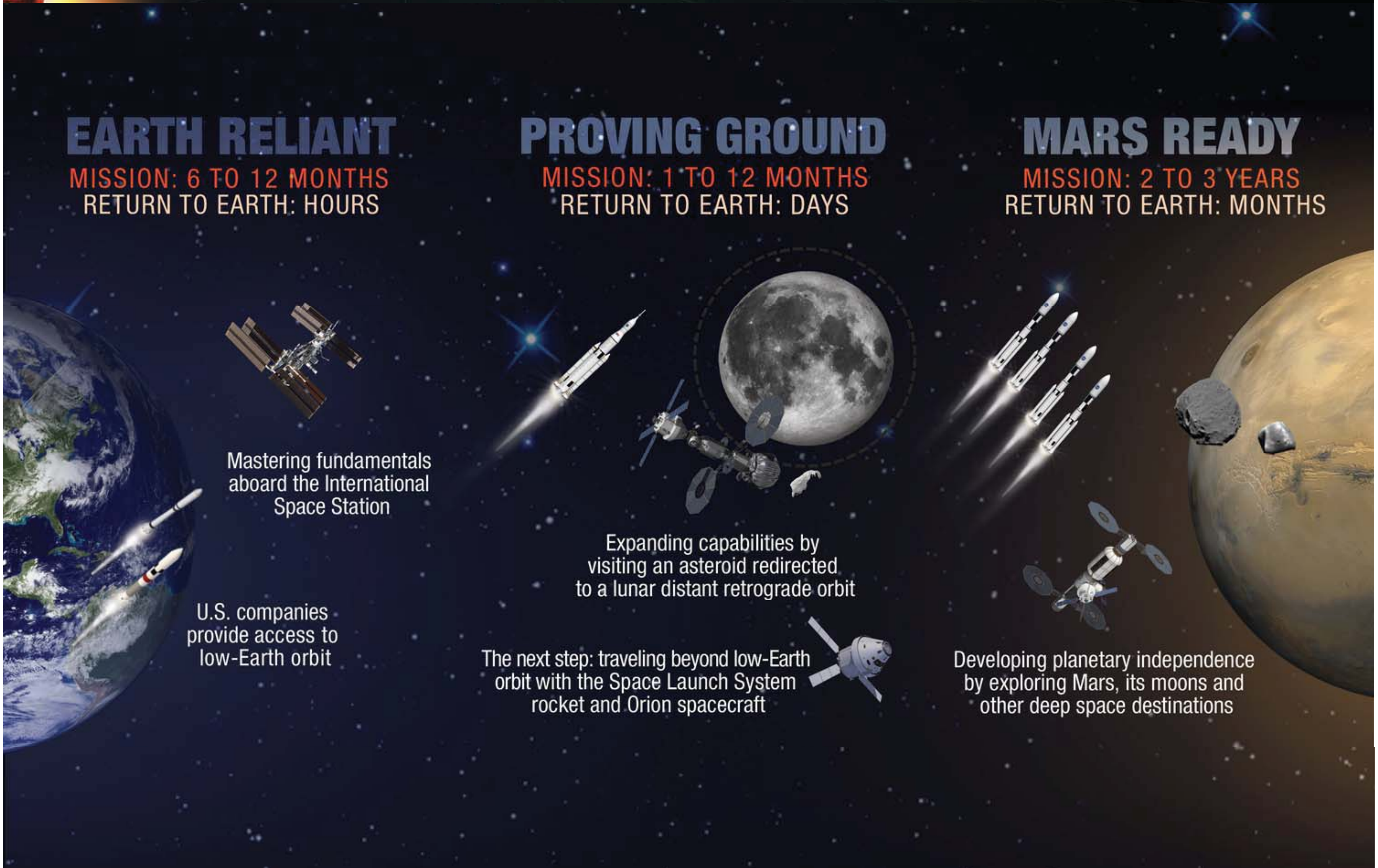
2014 Strategic Plan

space frontier for
the ISS one-of-a-kind
exploration missions
... use of the unique micro-
... academic science and research. We will work with
... to ensure a strong U.S. capability for launching crew and cargo into space. We will complete development of next-generation space systems like the Space Launch System (SLS) and the Orion Multi-Purpose Crew Vehicle to take us past low Earth orbit, and set a pathway to Mars and beyond. We will deploy the James Webb Space Telescope (JWST) to glimpse back in time to the formation of the first stars and galaxies, while our New Horizons mission will uncover knowledge

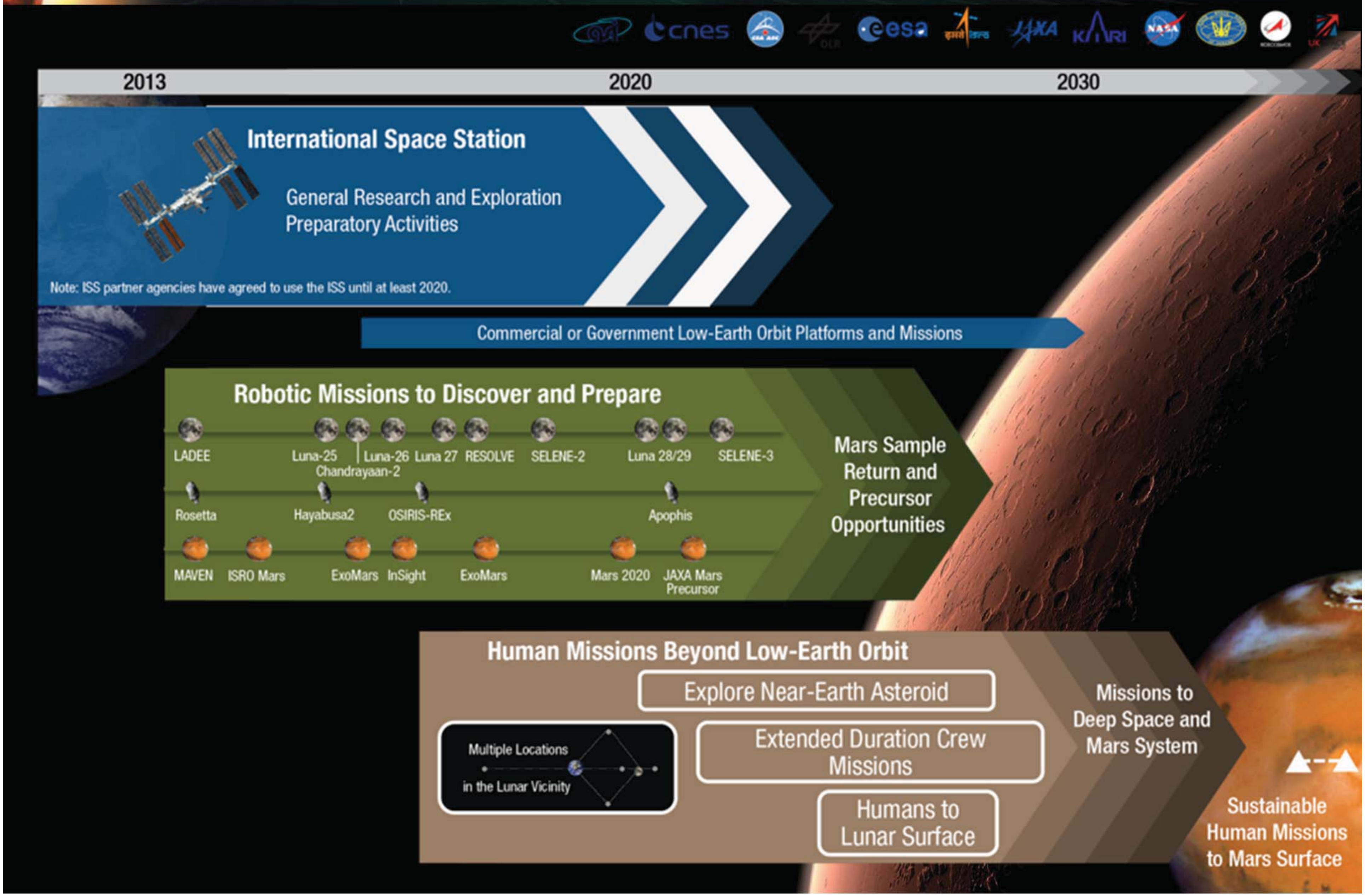
Mars: The Human Destination

Mars Landing: Heading for the High Ground
Courtesy of Dan Durda

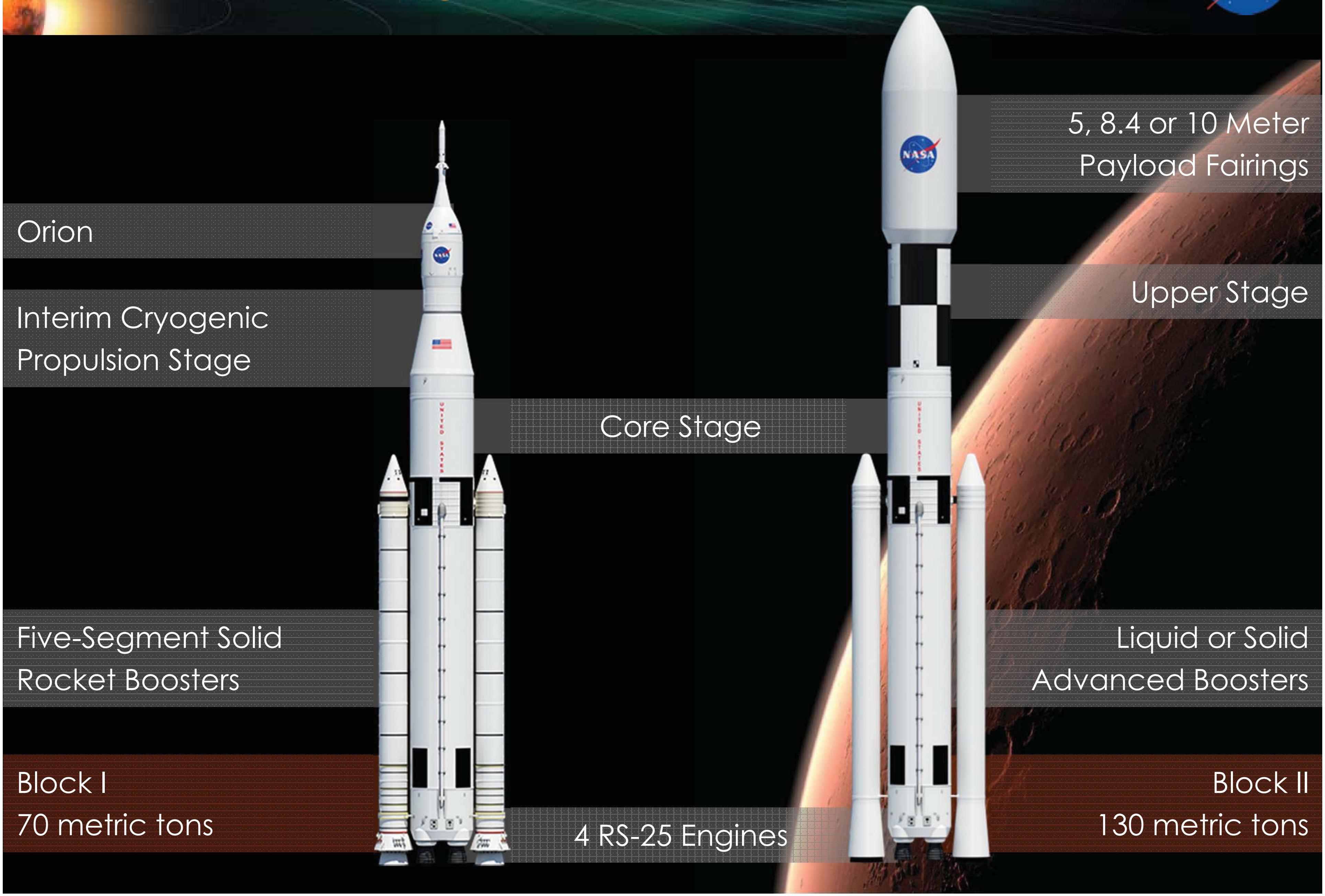
The Path to Mars



Mars Is the World's Mission

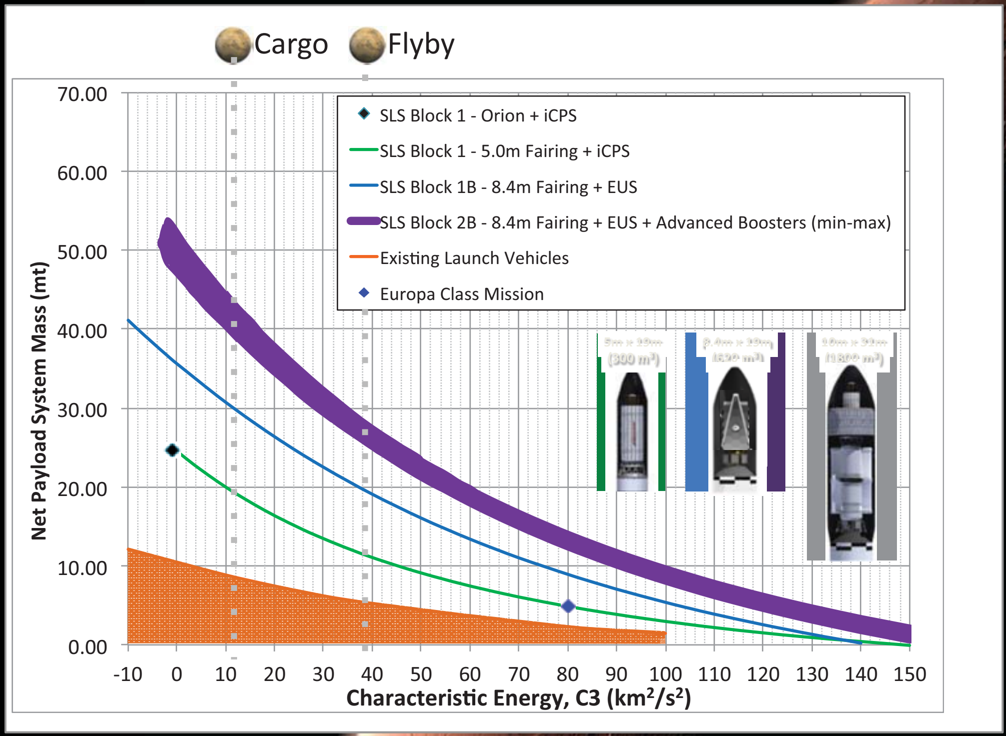


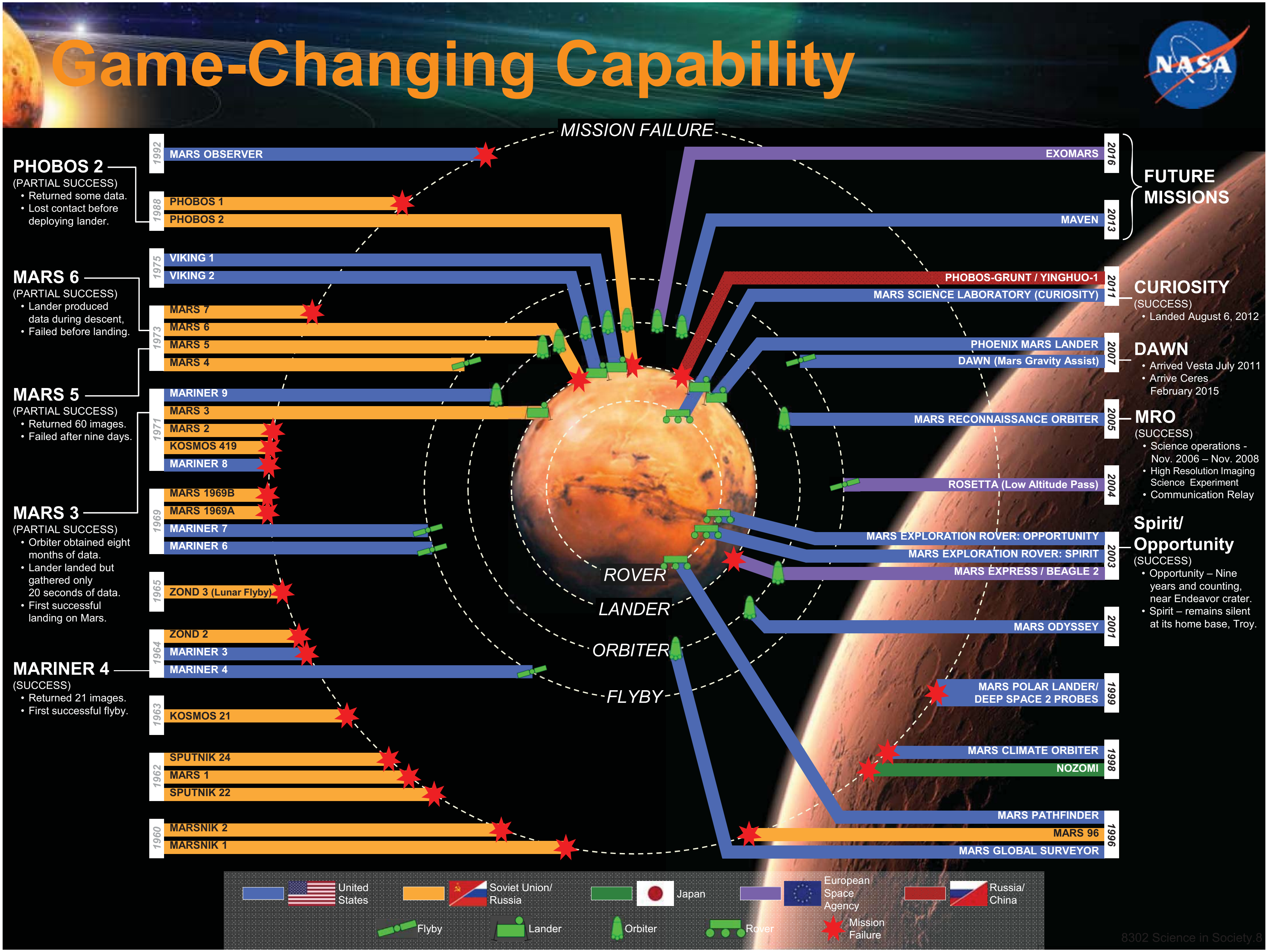
Revolutionary Evolution



Benefit: High Departure Energy

- Even the Initial configuration of SLS offers orders of magnitude greater payload-to-destination energy compared to existing launch vehicles; future configurations improve C3 performance even further.
- Higher departure energy offers more launch opportunities.
- Trade space exists between departure energy and mass capability.

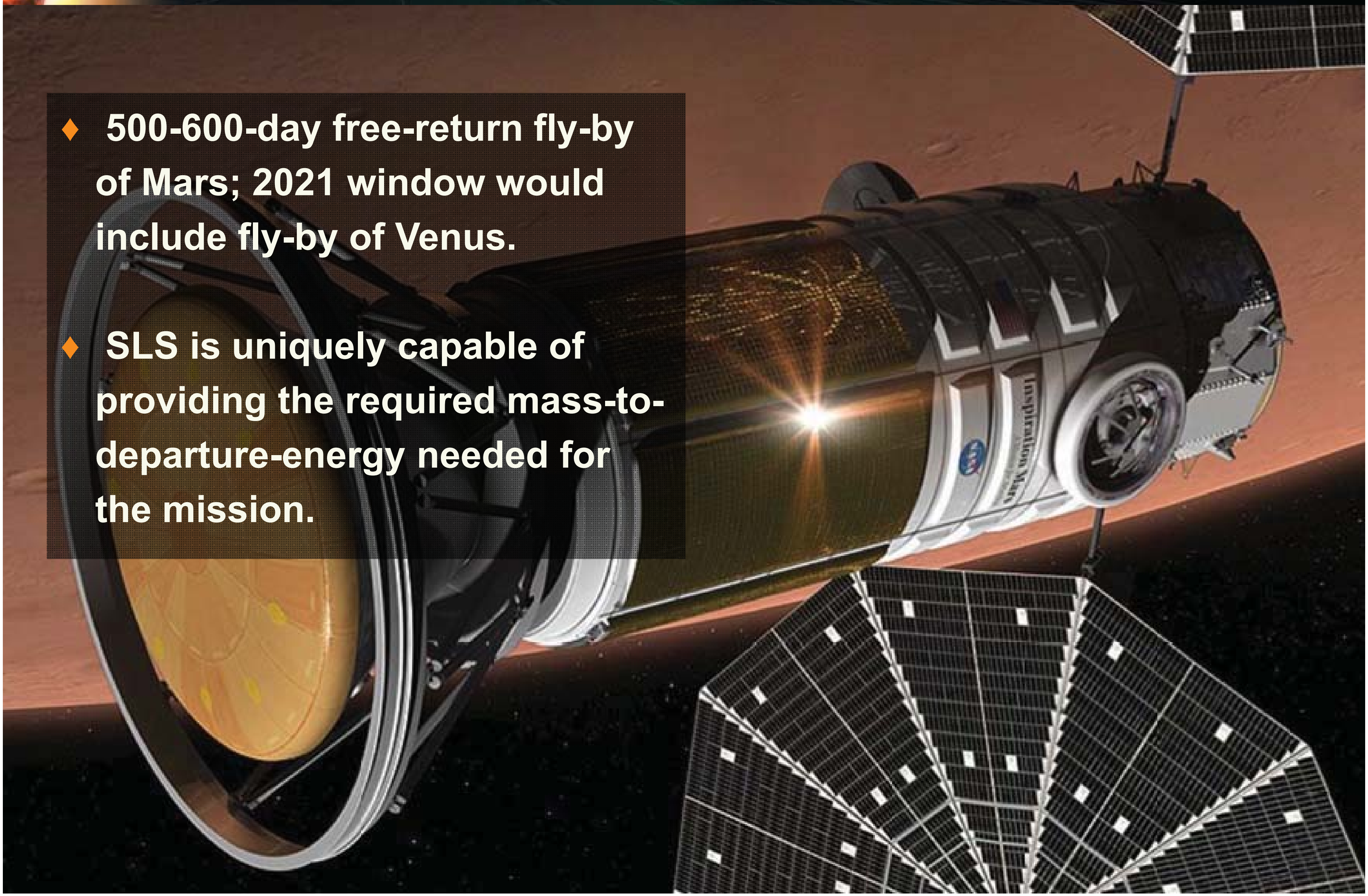




Game-Changing Capability
NASA
MISSION FAILURE
ROVER
LANDER
ORBITER
FLYBY
1992
MARS OBSERVER
1988
PHOBOS 1
PHOBOS 2
1975
VIKING 1
VIKING 2
1973
MARS 7
MARS 6
MARS 5
MARS 4
1971
MARINER 9
MARS 3
MARS 2
KOSMOS 419
MARINER 8
1969
MARS 1969B
MARS 1969A
MARINER 7
MARINER 6
1965
ZOND 3 (Lunar Flyby)
1964
ZOND 2
MARINER 3
MARINER 4
1963
KOSMOS 21
1962
SPUTNIK 24
MARS 1
SPUTNIK 22
1960
MARSNIK 2
MARSNIK 1
PHOBOS 2
(PARTIAL SUCCESS)
• Returned some data.
• Lost contact before deploying lander.
MARS 6
(PARTIAL SUCCESS)
• Lander produced data during descent.
• Failed before landing.
MARS 5
(PARTIAL SUCCESS)
• Returned 60 images.
• Failed after nine days.
MARS 3
(PARTIAL SUCCESS)
• Orbiter obtained eight months of data.
• Lander landed but gathered only 20 seconds of data.
• First successful landing on Mars.
MARINER 4
(SUCCESS)
• Returned 21 images.
• First successful flyby.
2016
EXOMARS
2013
MAVEN
FUTURE MISSIONS
2011
PHOBOS-GRUNT / YINGHUO-1
MARS SCIENCE LABORATORY (CURIOSITY)
CURIOSITY
(SUCCESS)
• Landed August 6, 2012
2007
PHOENIX MARS LANDER
DAWN (Mars Gravity Assist)
DAWN
• Arrived Vesta July 2011
• Arrive Ceres February 2015
2005
MARS RECONNAISSANCE ORBITER
MRO
(SUCCESS)
• Science operations - Nov. 2006 – Nov. 2008
• High Resolution Imaging Science Experiment
• Communication Relay
2004
ROSETTA (Low Altitude Pass)
2003
MARS EXPLORATION ROVER: OPPORTUNITY
MARS EXPLORATION ROVER: SPIRIT
MARS EXPRESS / BEAGLE 2
Spirit/ Opportunity
(SUCCESS)
• Opportunity – Nine years and counting, near Endeavor crater.
• Spirit – remains silent at its home base, Troy.
2001
MARS ODYSSEY
1999
MARS POLAR LANDER/ DEEP SPACE 2 PROBES
1998
MARS CLIMATE ORBITER
NOZOMI
1996
MARS PATHFINDER
MARS 96
MARS GLOBAL SURVEYOR
United States
Soviet Union/ Russia
Japan
European Space Agency
Russia/ China
Flyby
Lander
Orbiter
Rover
Mission Failure

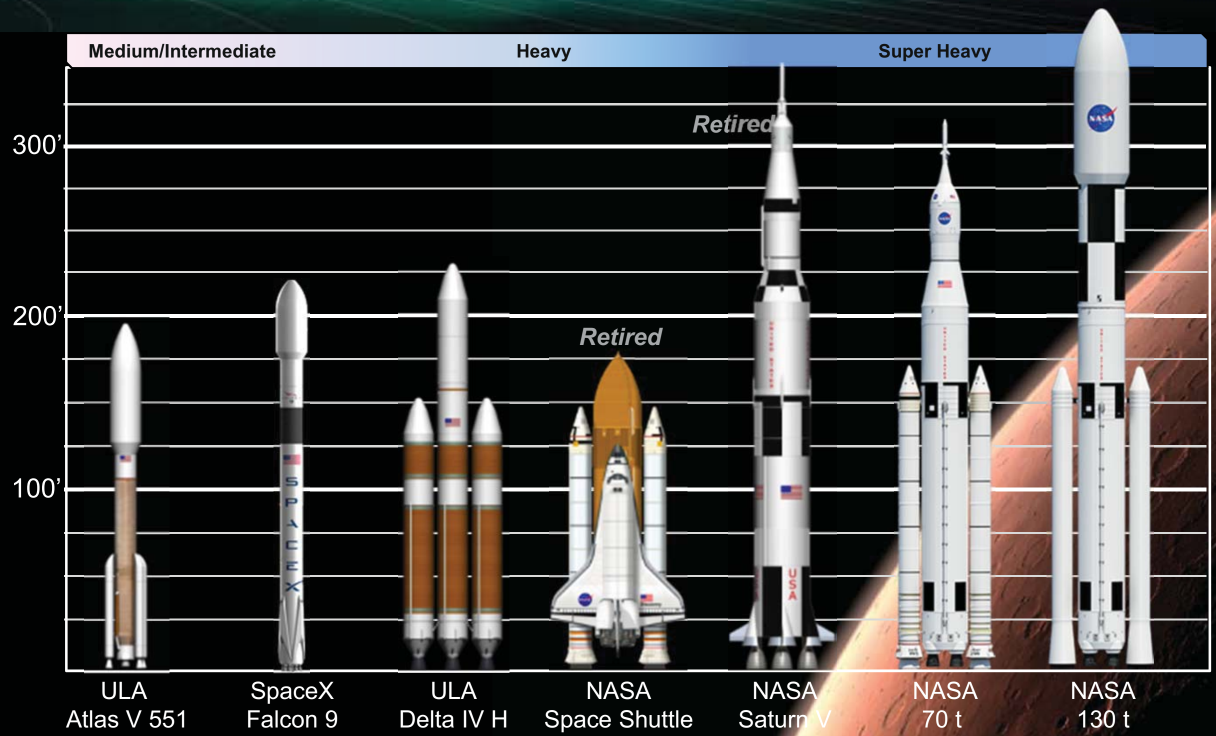
Case Study: Mars Fly-By

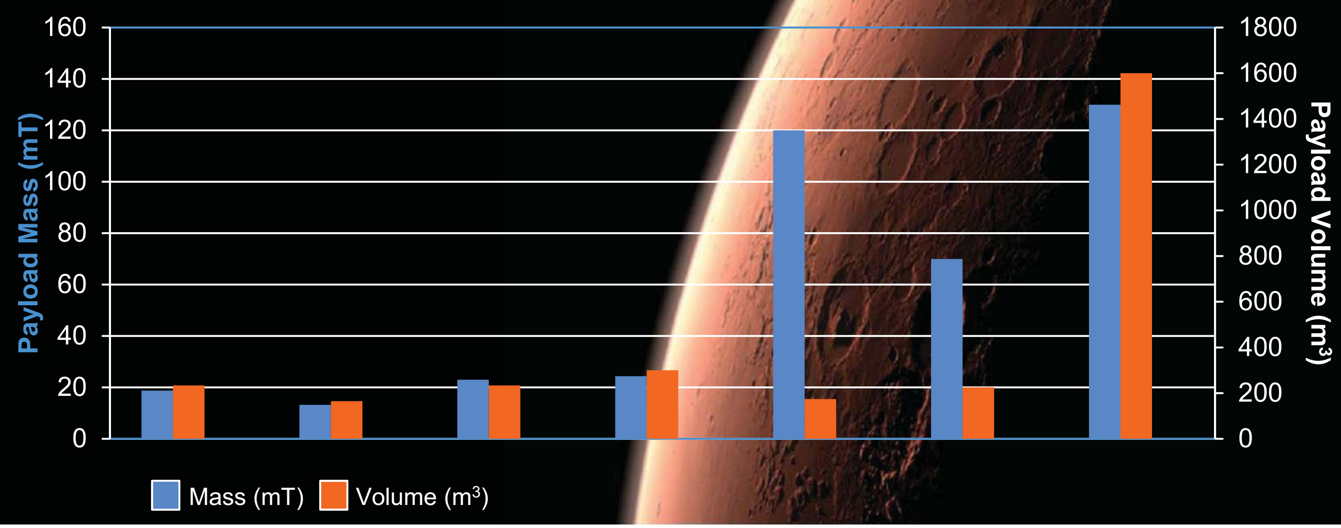
- 500-600-day free-return fly-by of Mars; 2021 window would include fly-by of Venus.
- SLS is uniquely capable of providing the required mass-to-departure-energy needed for the mission.



Benefit: SLS Mass Lift Capability

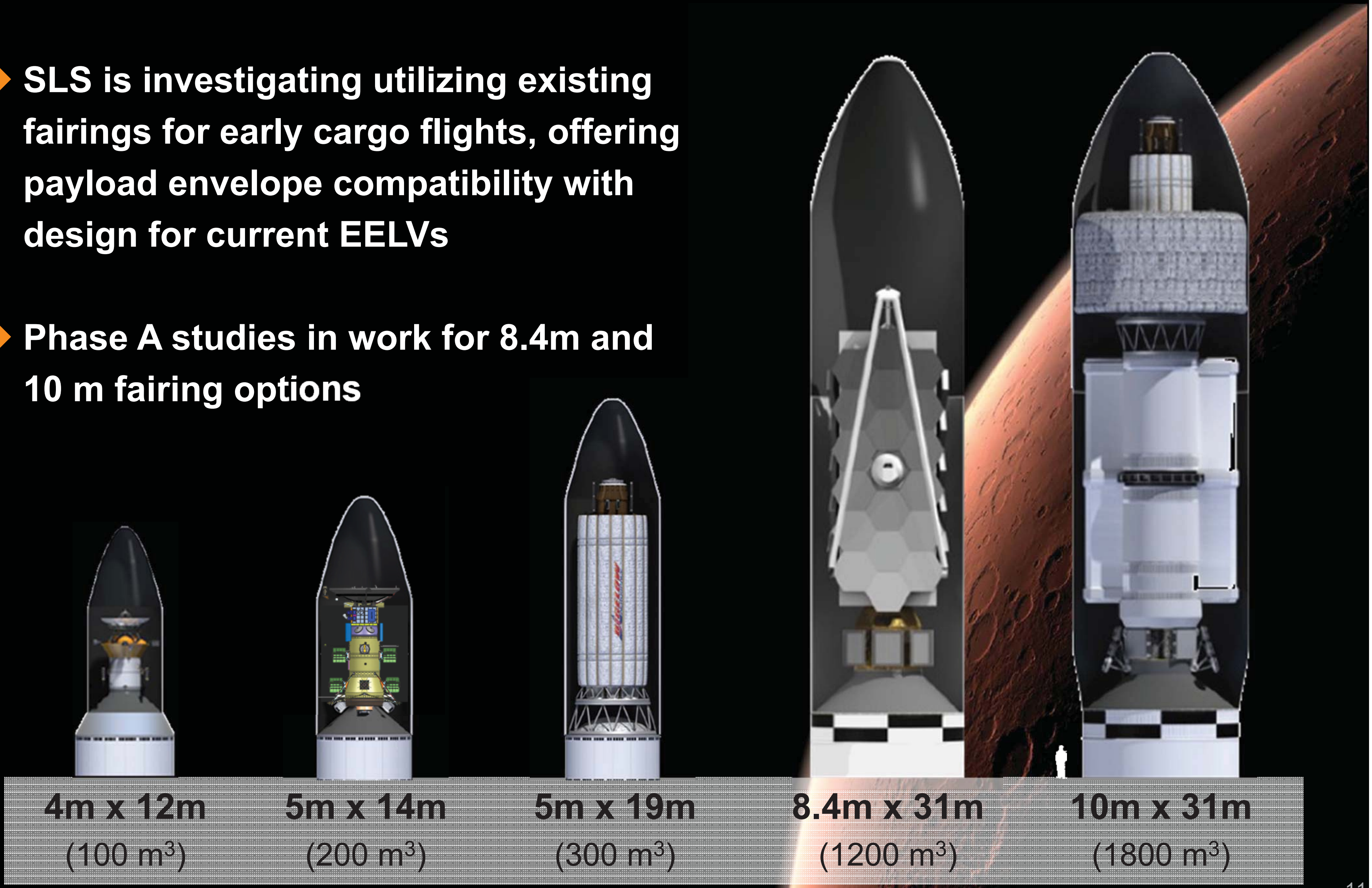
- SLS initial configuration offers 70 t to LEO.
- Future configurations offer 105 and 130 t to LEO.
- Mass capability benefits mean larger payloads to any destination.





Benefit: Unrivaled Payload Volume

- SLS is investigating utilizing existing fairings for early cargo flights, offering payload envelope compatibility with design for current EELVs
- Phase A studies in work for 8.4m and 10 m fairing options



Case Study: Mars Sample Return

Source: Mars Program Planning Group, September 2012

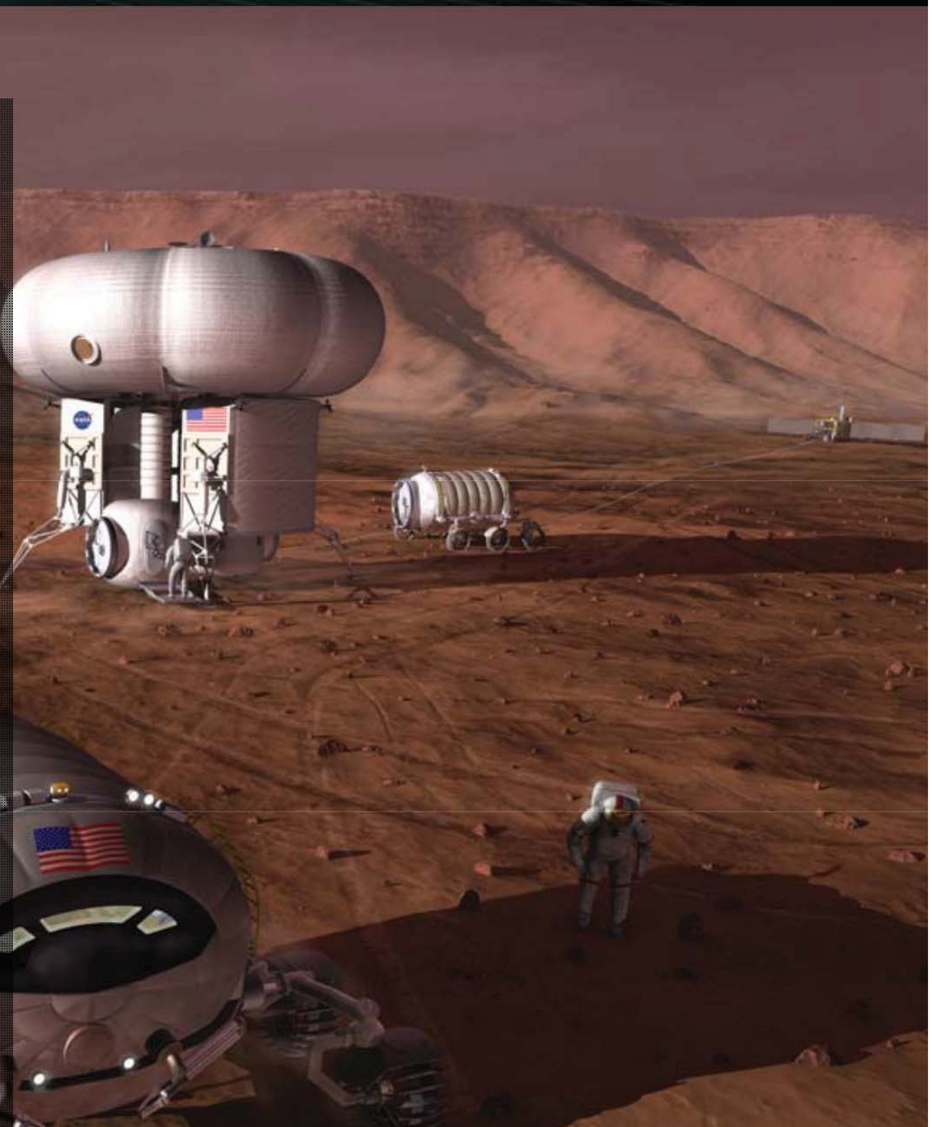
- Robotic precursor mission to return material samples from Mars
- 70-t SLS could support one-launch Mars Sample return mission with sampling rover carrying ascent vehicle and in-space return vehicle
- SLS could support two-flight sample return in conjunction with 2020 Mars science rover mission, launching ascent vehicle and in-space return vehicle

Case Study: Martian Moons

- Provides stepping-stone opportunity toward human landing on Mars
- Allows for real-time human-robotic telepresence exploration of Martian surface
- Provides ambitious Mars-vicinity target while developing Martian EDL capability
- SLS offers mass and volume capability for needed habitation and propulsion systems

Case Study: NASA DRA5

- NASA's 2009 Design Reference Architecture 5 outlines plan for 900-day human mission to Mars
- DRA5 requires 825 metric tons initial mass to low Earth orbit (almost double ISS launch mass).
- SLS exceeds DRA5 minimum 125+ t to LEO mass launch requirement
- SLS meets DRA5 minimum 10-m-diameter fairing requirement
- SLS enables crewed mission to Mars as outlined by DRA5

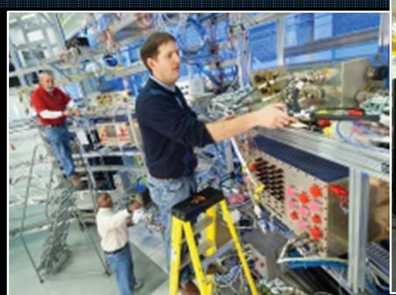


Source: "Human Exploration of Mars Design Reference Architecture 5.0," NASA Mars Architecture Steering Group, July 2009

Recent Progress

Launch Vehicle Stage Adapter: Contract awarded in February 2014.

Avionics: Avionics "first light" marked in January 2014; currently testing most powerful flight system computer processor ever.



Boosters: Forward Skirt test completed May 2014; preparations underway for QM-1.

MPCV-to-Stage Adapter: First flight hardware currently in Florida for Exploration Flight Test-1 in Fall 2014.

Core Stage: Initial confidence barrels and domes completed; Vertical Assembly Center installation to be completed in July 2014.

Engines: First RS-25 engine fitted to A-1 stand at Stennis Space Center; testing begins October 2014.

Building to Exploration Mission-1 (EM-1)

ACCOMPLISHMENTS

- 09/2011 Tested Booster Development Motor ✓
- 07/2012 Delivered RS-25 Engines to Inventory ✓
- 07/2013 Competed Preliminary Design Review ✓
- 10/2011 - 12/2013 Tested SLS Wind Tunnel Models ✓
- 07/2013 Completed First Confidence Barrel Section Welding ✓
- 10/2013 Completed Thrust Vector Control Test ✓
- 11/2013 Conducted Adaptive Augmenting Control Flight Test ✓
- 12/2013 Completed LOX Forward Dome Manufacturing Demo ✓
- 1/2014 Conducted Avionics "First Light" in Integration Facility ✓
- 02/2014 Shipped Multi-Purpose Crew Vehicle Stage Adapter for EFT-1 ✓

WHAT'S NEXT

- 07/2014 Complete Manufacturing Tooling Installation
- 07/2014-15 Test Main Engines, Boosters , & Core Stage Structure
- 07/2015 Complete the SLS Critical Design Review
- 06/2016 Assemble the Core Stage Assembly and Test Fire
- 07/2017 Stack the SLS Vehicle
- 12/2017 Transport SLS from the VAB to the Launch Pad

Man cannot discover

new oceans

unless he has the

courage to lose

sight of the shore.

For More Information

www.nasa.gov/sls

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