National Aeronautics and Space Administration

NASA's Space Launch System: A Revolutionary Capability for Science

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SLS Spacecraft/Payload Integration and Evolution

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www.nasa.gov/sls

SLS: An Evolving Capability

Launch Abort System

Orion, Multi-Purpose Crew Vehicle (MPCV- LMCO)

Interim Cryogenic Propulsion Stage (ICPS) (EELV 5m DCSS – Boeing/ULA)

Core Stage/Avionics *(Boeing)*

5-Segment Solid Rocket Booster (SRB) *(ATK)*

Core Stage Engines (RS-25) *(Aerojet Rocketdyne)*

Commonality of Payload Interfaces

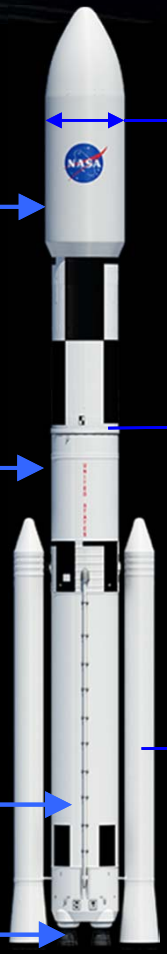
- Mechanical
- Avionics
- Software

Upper Stage & Core Stage Commonality

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

Commonality of Core Stage

Commonality of Engines



Cargo Fairing *33 ft (10m)*

Upper Stage

Advanced Solid or Liquid (i.e., RP Engines) Boosters

Block 1
Initial Capability, 2017-21
70 metric ton Payload

Evolutionary Path to Future Capabilities
- **Minimizes unique configurations**
- **Allows incremental development**

Block 2 Capability
130 metric ton Payload

SLS' Primary Mandate

HUMAN EXPLORATION

NASA's Path to Mars

EARTH RELIANT

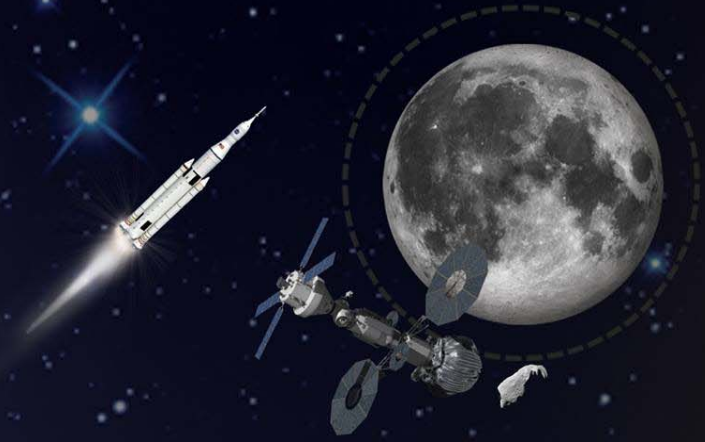
MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS

Mastering fundamentals aboard the International Space Station

U.S. companies provide access to low-Earth orbit

PROVING GROUND

MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS



Expanding capabilities by visiting an asteroid redirected to a lunar distant retrograde orbit

The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft

MARS READY

MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS

Developing planetary independence by exploring Mars, its moons and other deep space destinations

www.nasa.gov

Human Spaceflight and Space Science

SLS Availability for Space Science

- **SLS is on schedule and within budget** for to be available for launches beginning in 2017.
- **5-meter payload fairings** allow for payload envelopes compatible with current EELVs.
- **Cargo-launch variants** offer the reliability of a human-mission launch and power in excess of any launch vehicle in history.

SLS Development Milestones

2011	2012	2013	2014	2015	2016	2017
MCR ✔	SRR/SDR ✔	PDR ✔		CDR	SIR	PLAR, FRR, Launch

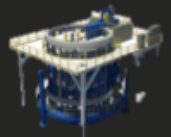
PROGRAM PROGRESS

SLS Design Chosen

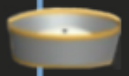
Booster Development Test

Engines Delivered to Inventory

Wind Tunnel Testing



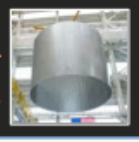
Manufacturing Tooling Installation



Production of First New Flight Hardware

Main Engine Test-Firing

Orion Flight Test

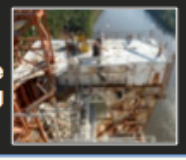


STA Production Begins

Core Stage Assembly

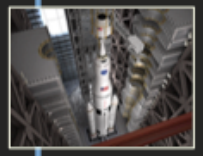
Booster Test-Firings

Core Stage Structure Testing



Core Stage Test-Firing

Booster Assembly at KSC



Vehicle Stacking at KSC

First Flight

Concept Studies	Concept & Technology Development	Preliminary Design & Technology Completion	Final Design & Fabrication	System Assembly, Integration & Test, Launch & Checkout

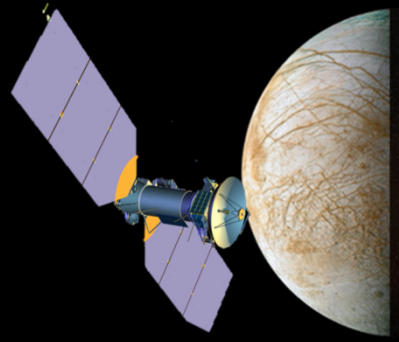
MCR: Mission Concept Review	CDR: Critical Design Review
SRR: System Requirements Review	SIR: System Integration Review
SDR: System Definition Review	FRR: Flight Readiness Review
PDR: Preliminary Design Review	PLAR: Post-Launch Asses. Review

SLS Benefits to Space Science

- **Greatest mass lift capability** of any launch vehicle in the world.
- **Largest payload fairings** of any launch vehicle produce greatest available volume.
- **High departure energy** availability for missions through the solar system and beyond.

Deep Space Telescope

Mars Sample Return



Europa Clipper

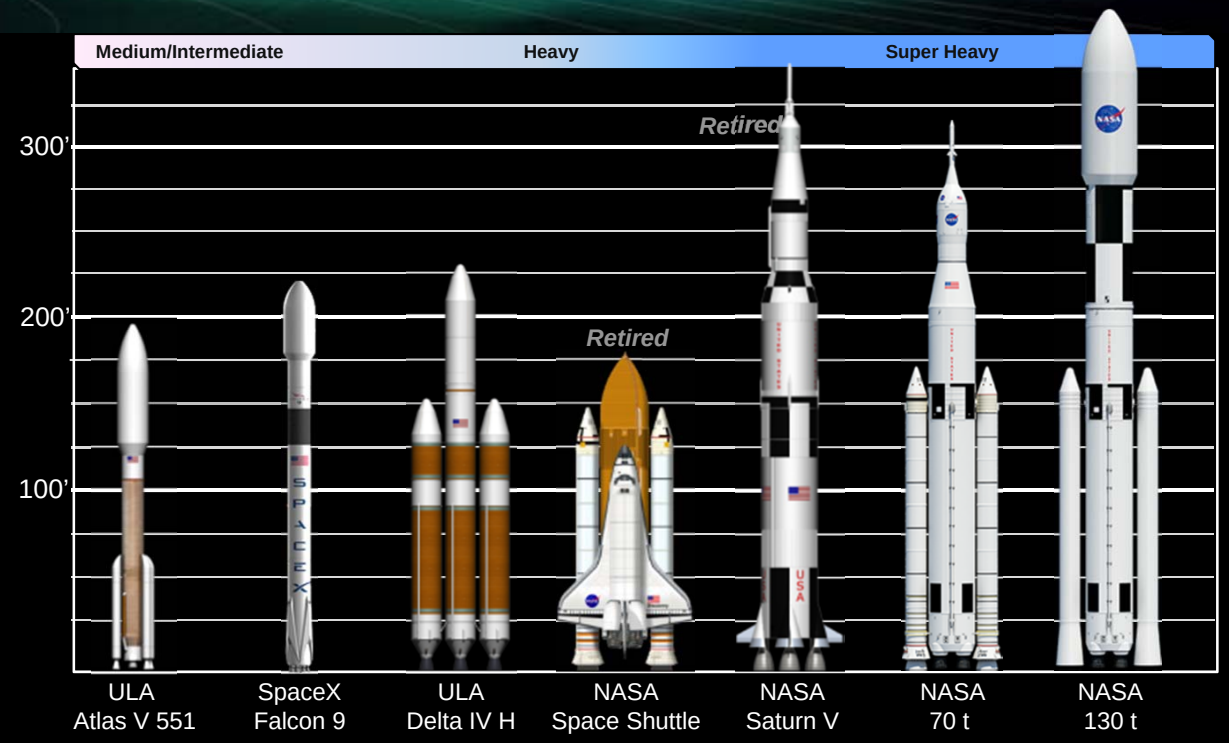
Solar Probe

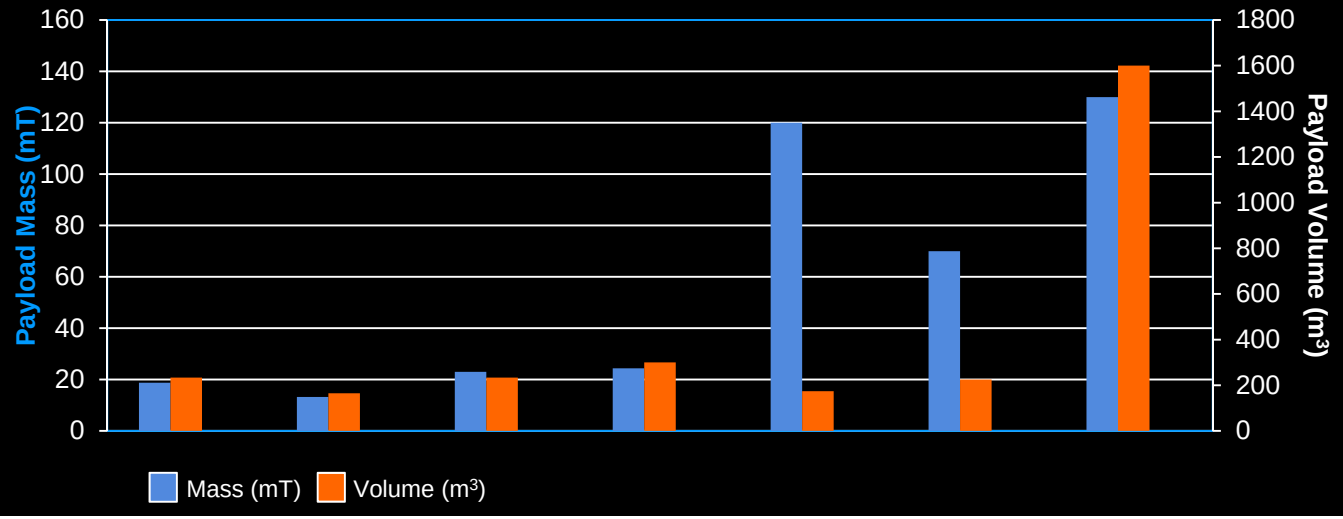
Uranus Spacecraft

Interstellar

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.



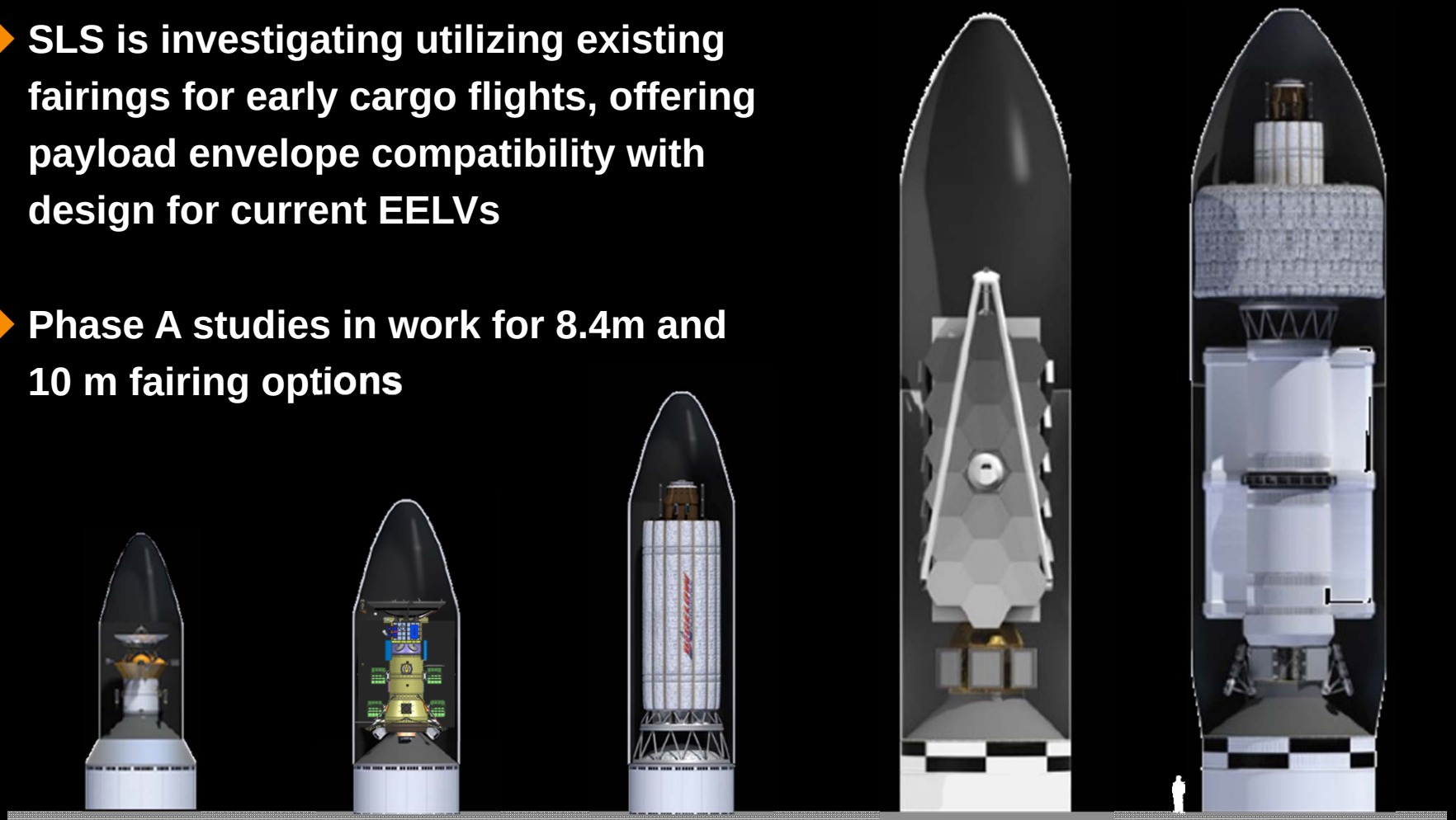


Case Study: Mars Sample Return

- **Mars Sample Return** was identified as a high priority in the “Visions and Voyages” planetary science decadal survey.
- **SLS offers single-launch option** for Mars Sample Return, versus three launches with EELVs.
- **Additional benefits of SLS** for Mars Sample Return include reduced mission time, increased sample mass, and reduced mission cost, complexity and risk**.**

Benefit: Unrivaled Payload Volume

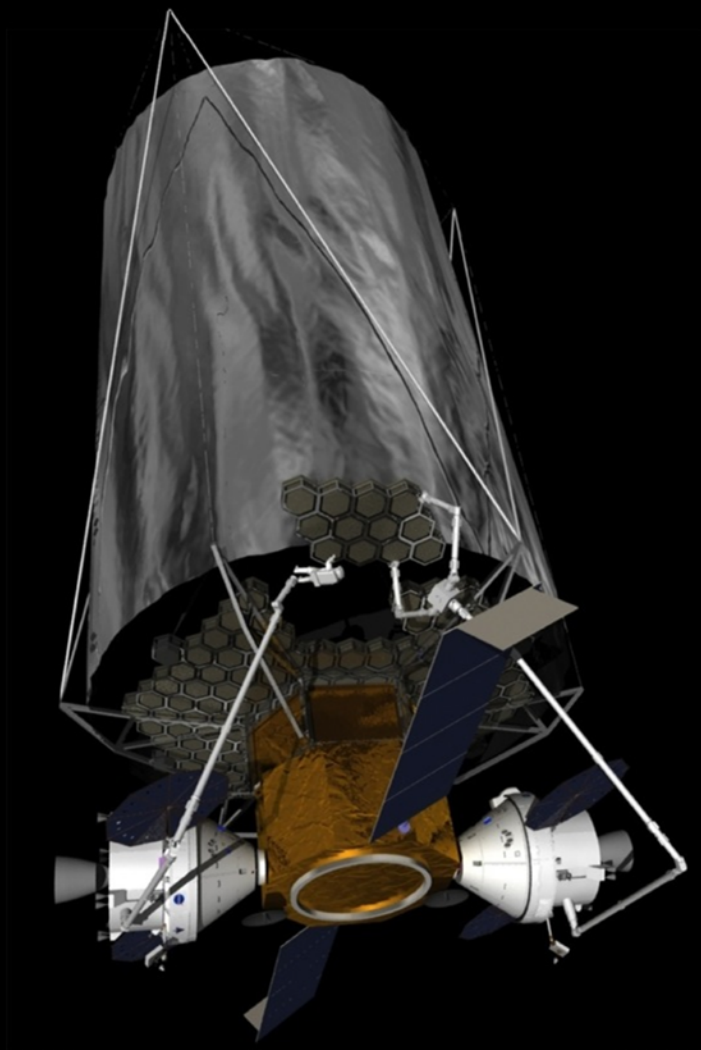
- **SLS is investigating utilizing existing fairings for early cargo flights, offering payload envelope compatibility with design for current EELVs**
- **Phase A studies in work for 8.4m and 10 m fairing options**



4m x 12m	5m x 14m	5m x 19m	8.4m x 31m	10m x 31m
(100 m^3)	(200 m^3)	(300 m^3)	(1200 m^3)	(1800 m^3)

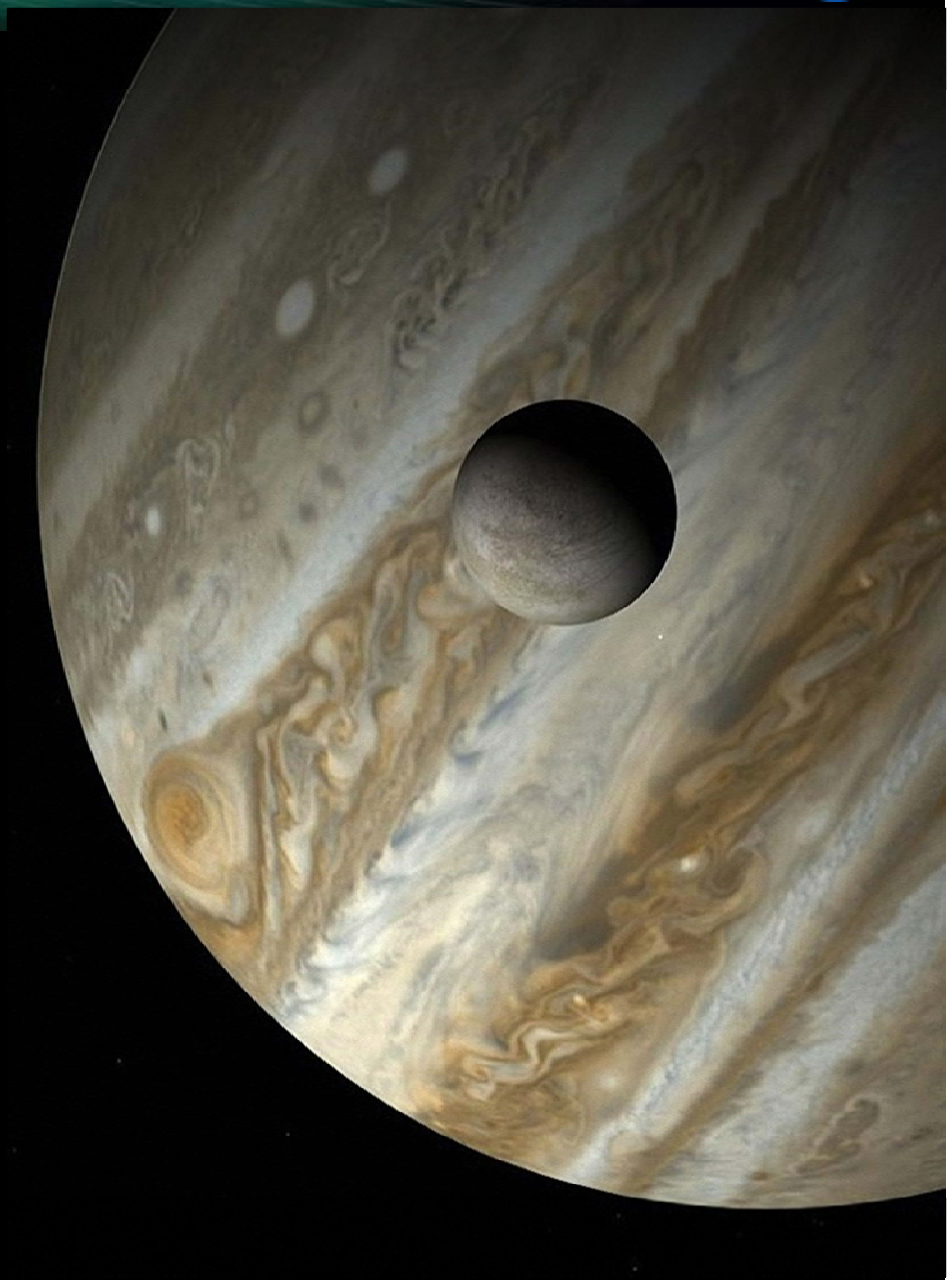
Case Study: ATLAST

- **Large-aperture spectroscopic telescope** was identified as a vital step in the “Enduring Quests, Daring Visions” astrophysics roadmap.
- **SLS is uniquely enabling** for largest-diameter telescopes due to fairing-width requirements.
- **Additional benefits of SLS** for ATLAST include opportunities for human assembly and/or servicing at deep space destinations.

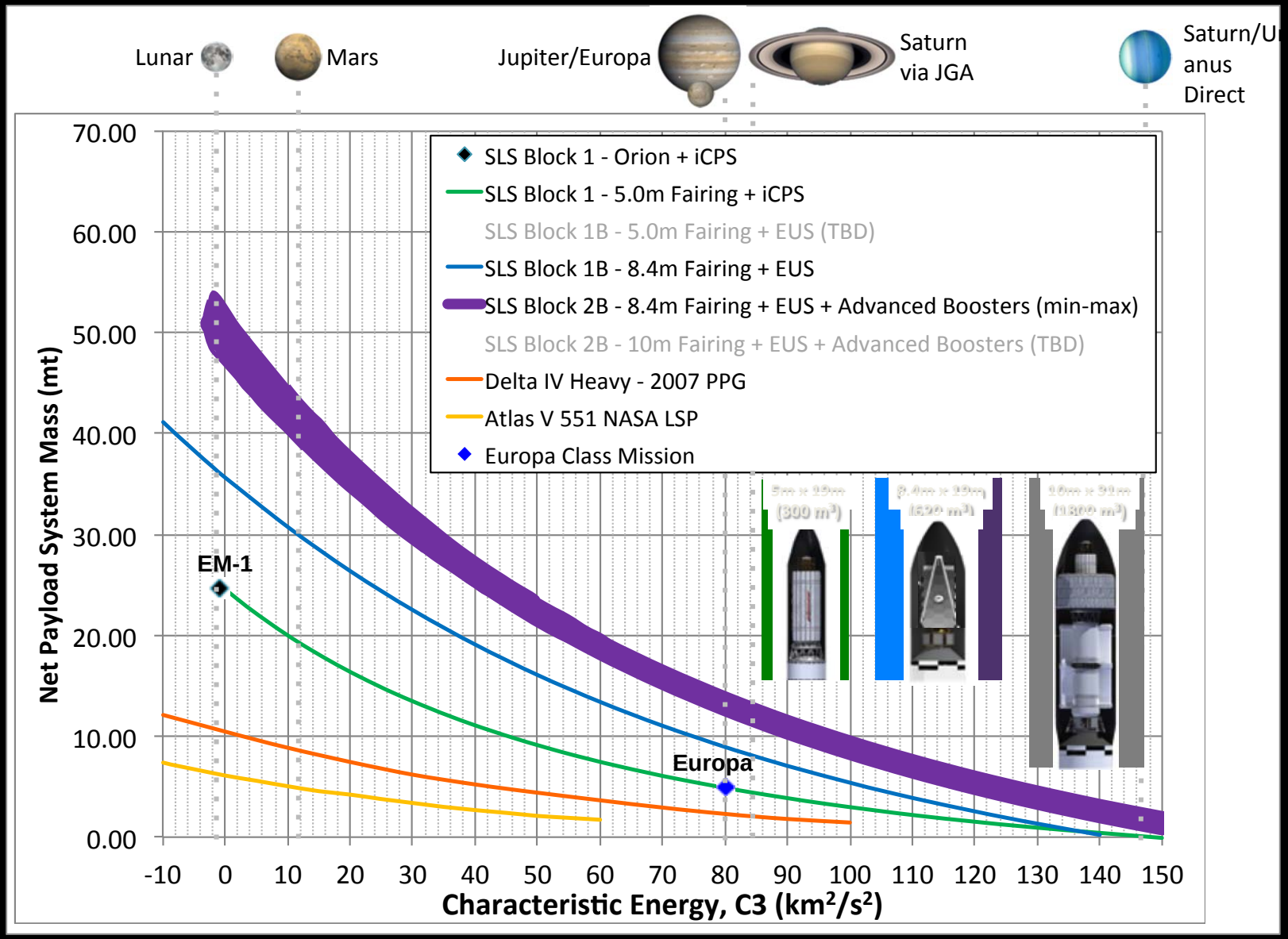


Benefit: High Departure Energy

- 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.
- Departure energy offers faster transit time to destination, including 4-7 year reduction to Saturn or 6 years to Uranus.
- Higher departure energy offers more launch opportunities.
- Trade space exists between departure energy and mass capability; a Jovian mission could see 3-year transit reduction or 13 t mass increase.

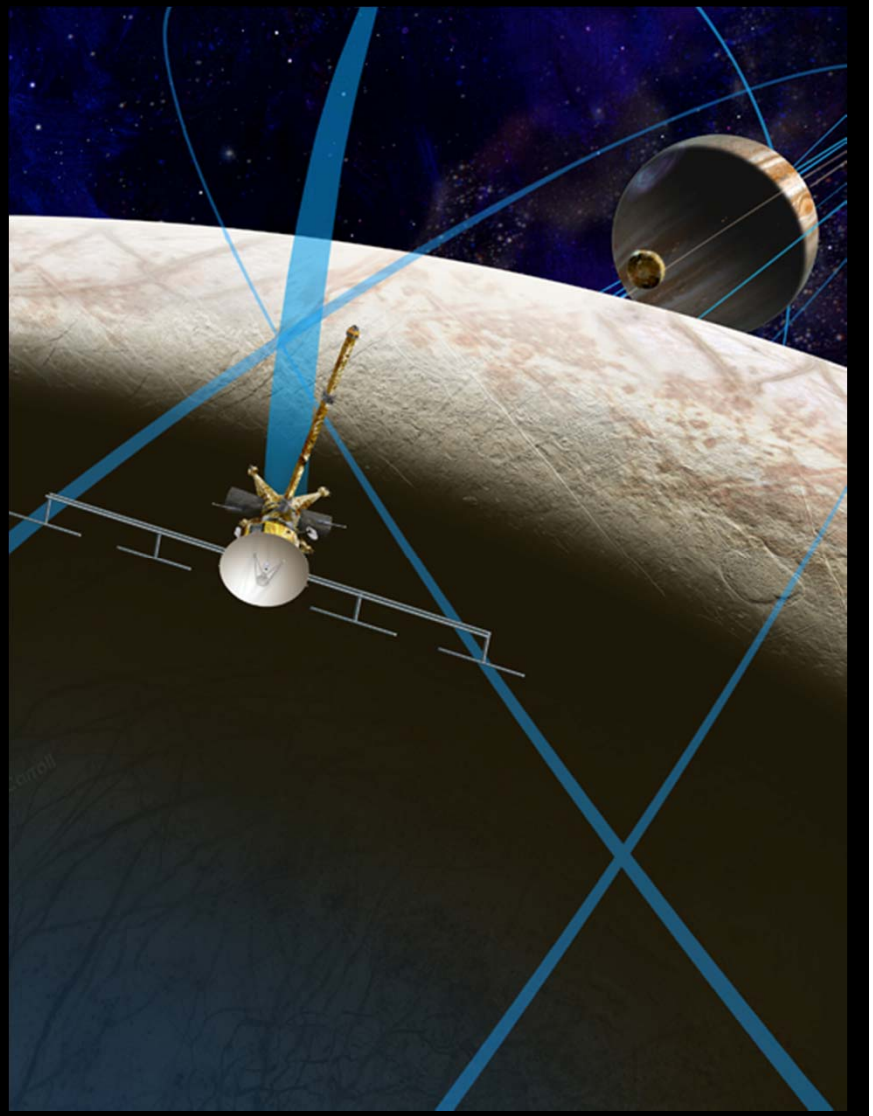


SLS Evolved Performance



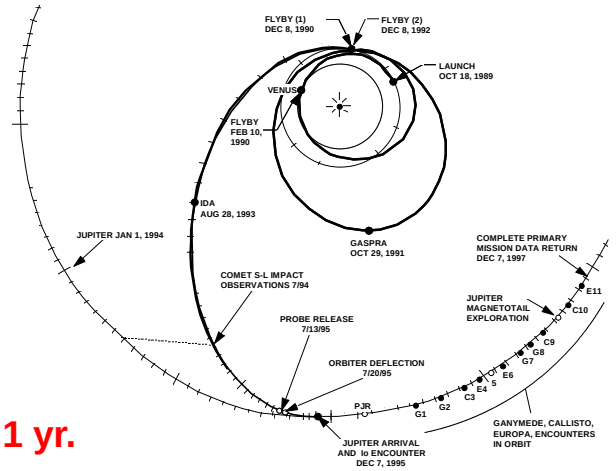
Case Study: Europa Clipper

- **Europa exploration** was identified as a high priority in the “Visions and Voyages” planetary science decadal survey.
- **SLS can provide direct injection to Jupiter,** eliminating several years of planetary gravity assists to reduce flight time to Europa from 6.3 years to 2.7.
- **Additional benefits of SLS** for Europa Clipper include reduced operational costs, reduced mission risk, and greater mass margin.



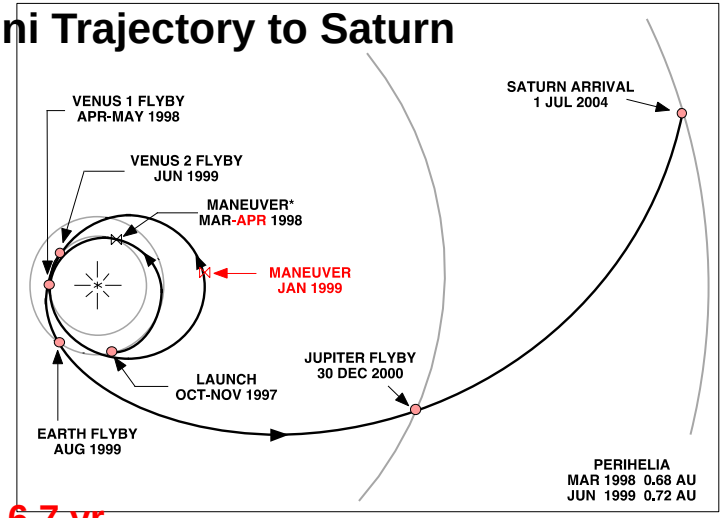
Outer Planet EELV Trajectories

Galileo Trajectory To Jupiter



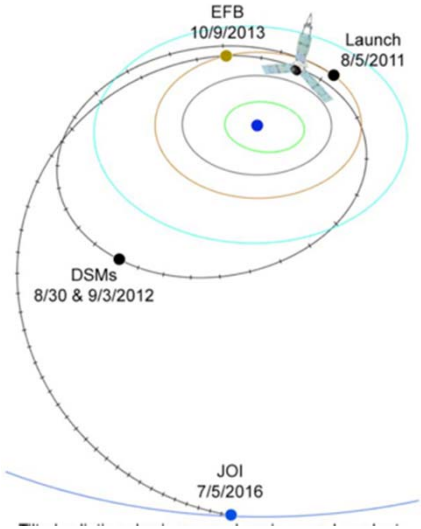
Cruise: 6.1 yr.

Cassini Trajectory to Saturn



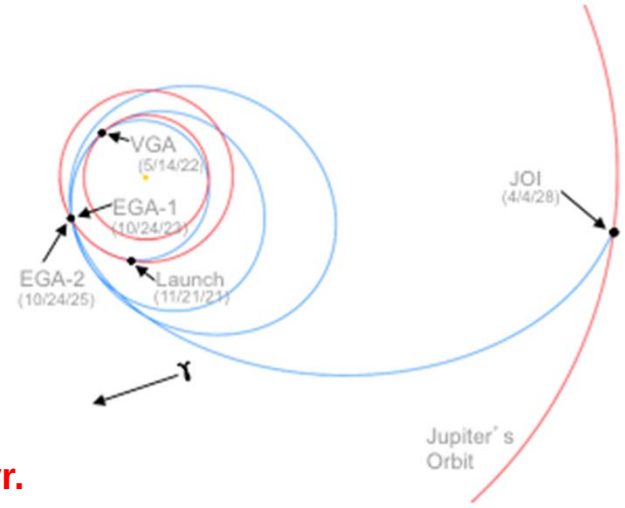
Cruise: 6.7 yr.

JUNO Trajectory To Jupiter



Cruise: 4.9 yr.

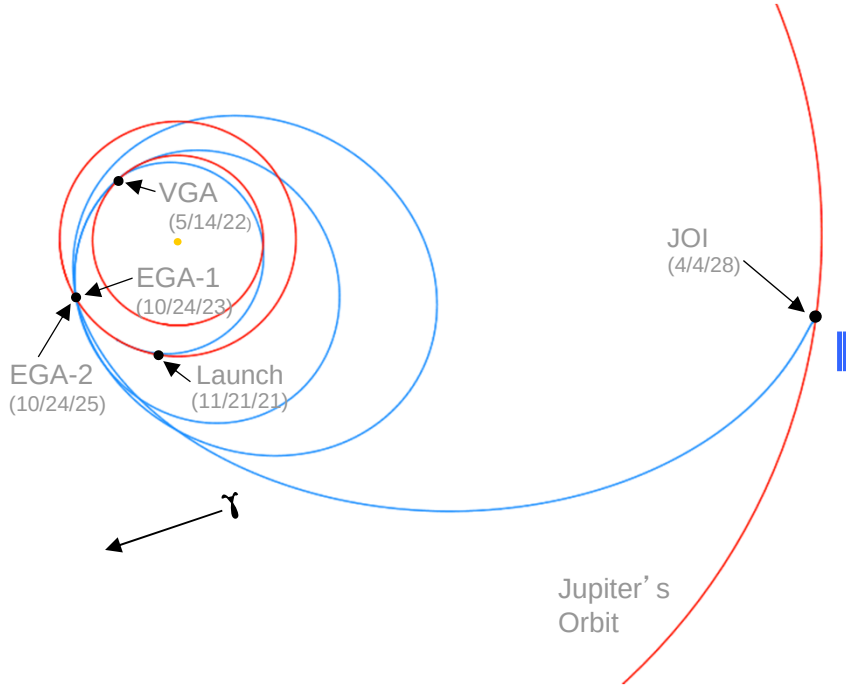
Atlas V Clipper Trajectory



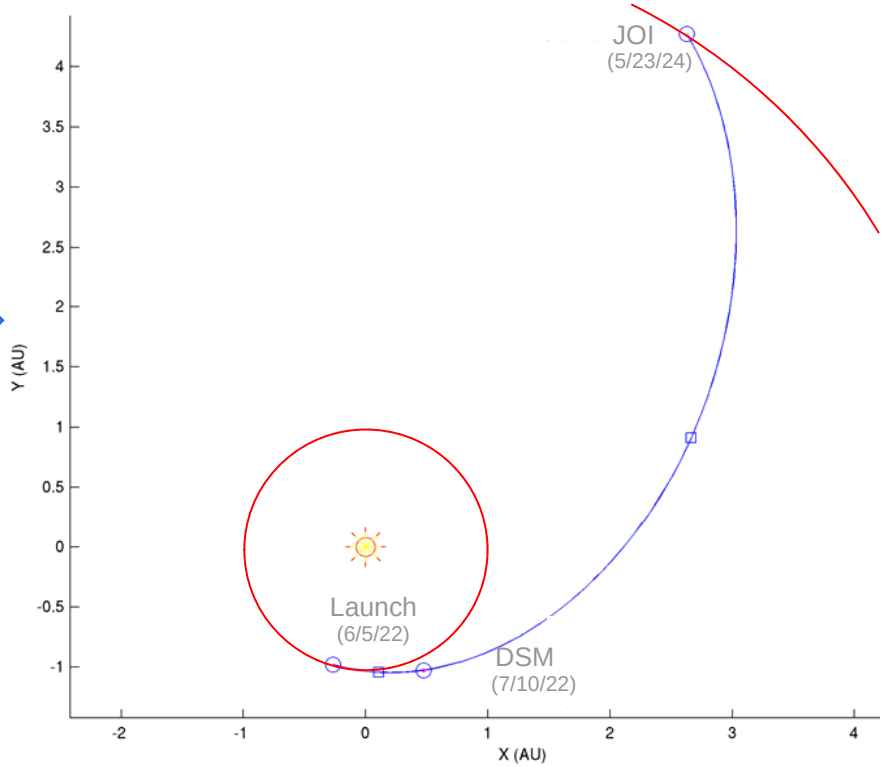
Cruise: 6.4 yr.

Europa Trajectory Comparison

Atlas V 551: VEEGA



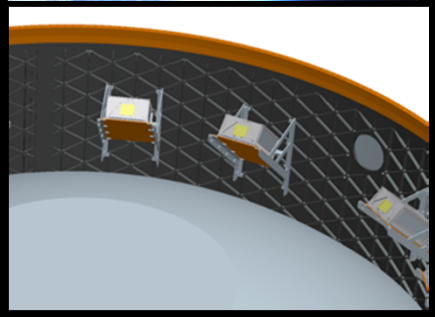
SLS: Direct



REDUCES TRANSIT TIME TO EUROPA FROM 6.5 TO 2.7 YEARS

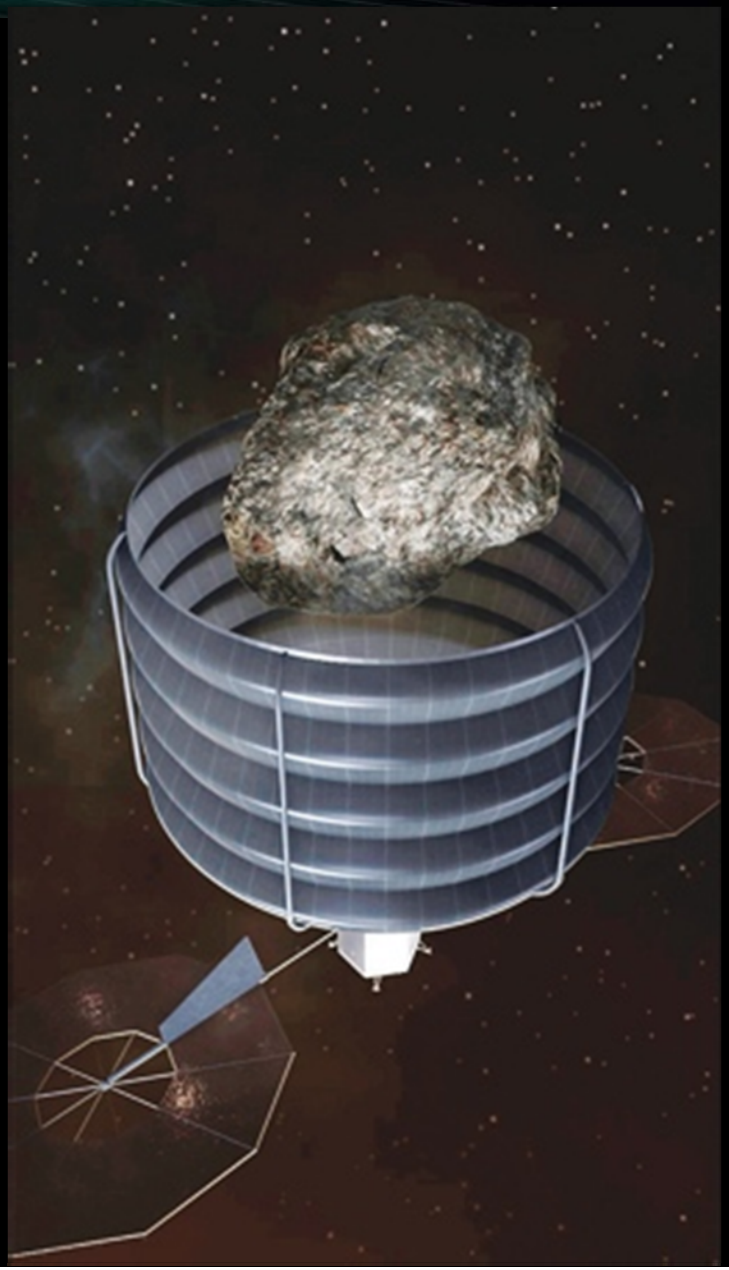
SLS Secondary Payload Capability

- SLS is providing accommodations for secondary payloads on EM-1 and subsequent launches
- Secondary payloads will be accommodated in the Orion- MPCV Spacecraft Adapter (MSA) on EM-1
- 6U equivalent volume/mass is the current standard; 12U volume can be accommodated
  - 12U mass still being evaluated
  - Additional mounting locations are being evaluated
- SLS provides secondary payload science opportunities beyond EELVs capabilities (Lunar and beyond)



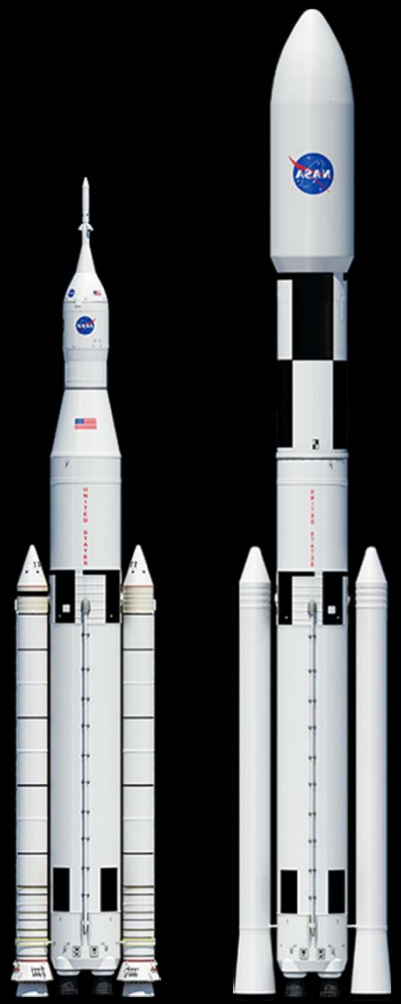
Possible Next Step: ARRM

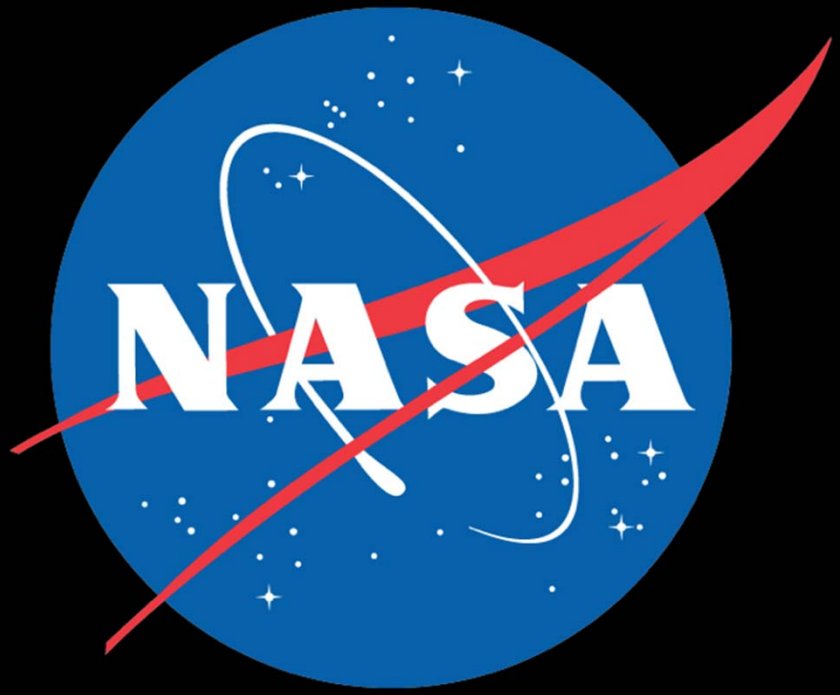
- **The Asteroid Redirect Robotic Mission** is an early step on NASA's Path to Mars.
- **SLS offers reduced transit time,** providing earlier redirection of target and/or greater launch opportunities.
- **Additional benefits of SLS** for ARRM offer the potential for redirecting a larger object and for enabling a wider variety of targets.
- SLS could launch an ARRM spacecraft as early as 2019.



Summary

- **SLS provides capability for human exploration missions.**
  - 70 t configuration enables EM-1 and EM-2 flight tests.
  - Evolved configurations enable missions including humans to Mars.
- **SLS offers unrivaled benefits for a variety of missions.**
  - 70 t provides greater mass lift than any contemporary launch vehicle; 130 t offers greater lift than any launch vehicle, ever.
  - With 8.4m and 10m fairings, SLS will over greater volume lift capability than any other vehicle.
  - Initial ICPS configuration and future evolution will offer highest-ever C3.
- **SLS is currently on schedule for first launch in December 2017.**
  - Preliminary design completed in July 2013; SLS is now in implementation.
  - Manufacture and testing are currently underway.
  - Hardware now exists representing all SLS elements.





Somewhere, something incredible is waiting to be known.

— Carl Sagan

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