National Aeronautics and Space Administration

INTERSTELLAR PROBE ON SPACE LAUNCH SYSTEM (SLS)

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NASA-MSFC

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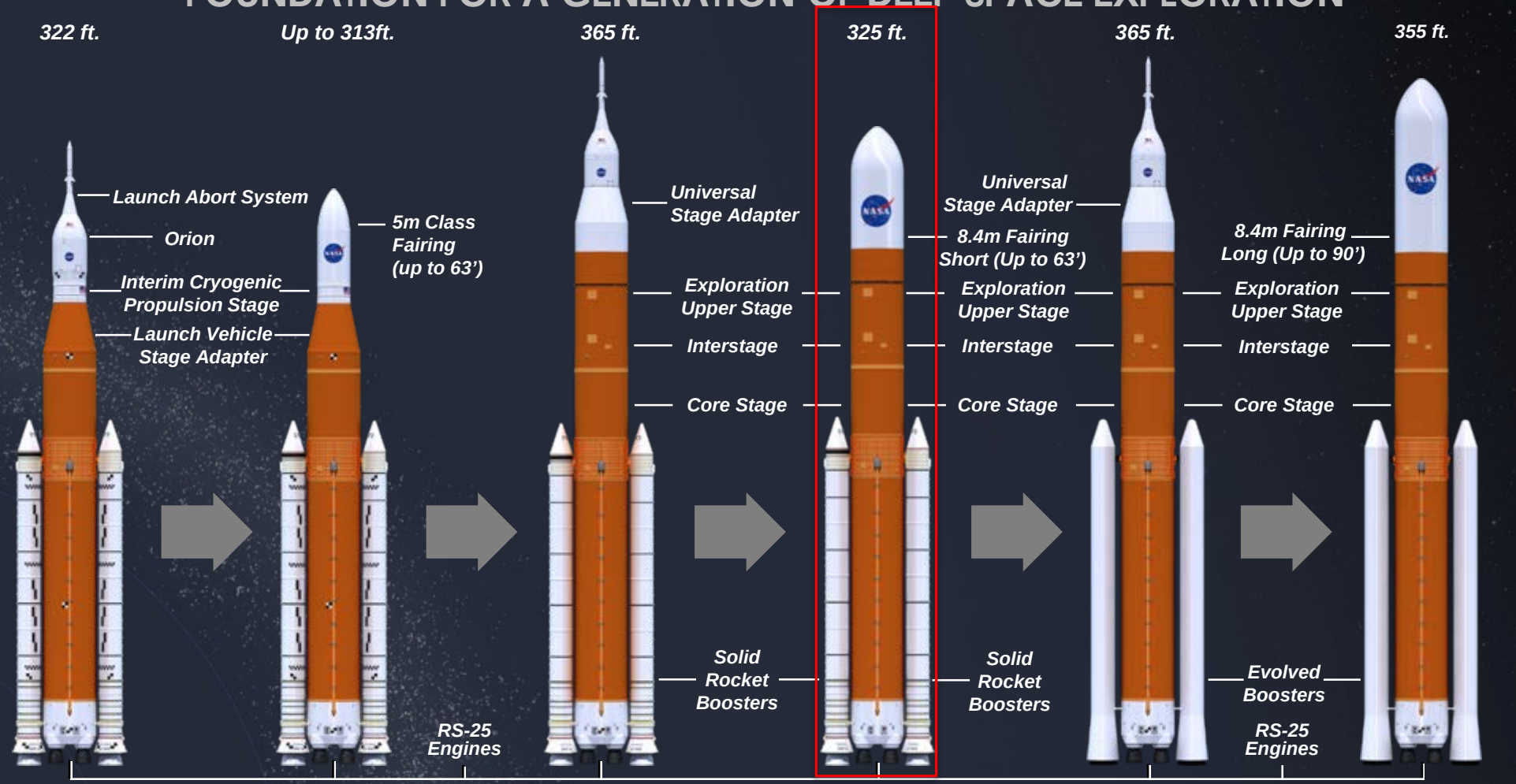
SLS EVOLVABILITY

FOUNDATION FOR A GENERATION OF DEEP SPACE EXPLORATION



SLS Block 1	SLS Block 1 Cargo	SLS Block 1B Crew	SLS Block 1B Cargo	SLS Block 2 Crew	SLS Block 2 Cargo
> 26 t (57k lbs)	> 26 t (57k lbs)	38–41 t (84k-90k lbs)	41-44 t (90k–97k lbs)	> 45 t (99k lbs)	> 45 t (99k lbs)

Payload to TLI/Moon

Launch in the late 2020s and early 2030s

IS THIS ROCKET REAL?

SLS BLOCK 1 CONFIGURATION

✓ **5 Segment S**
Boost
Northrop C
Utah,

✓ **RS-25 Engine (4)**
Aerojet Rocketdyne
California, Mississipp

on Multi-Purpose
Crew Vehicle
ockheed Martin,
ouisiana, KSC

enic
e (ICPS) ✓
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pter
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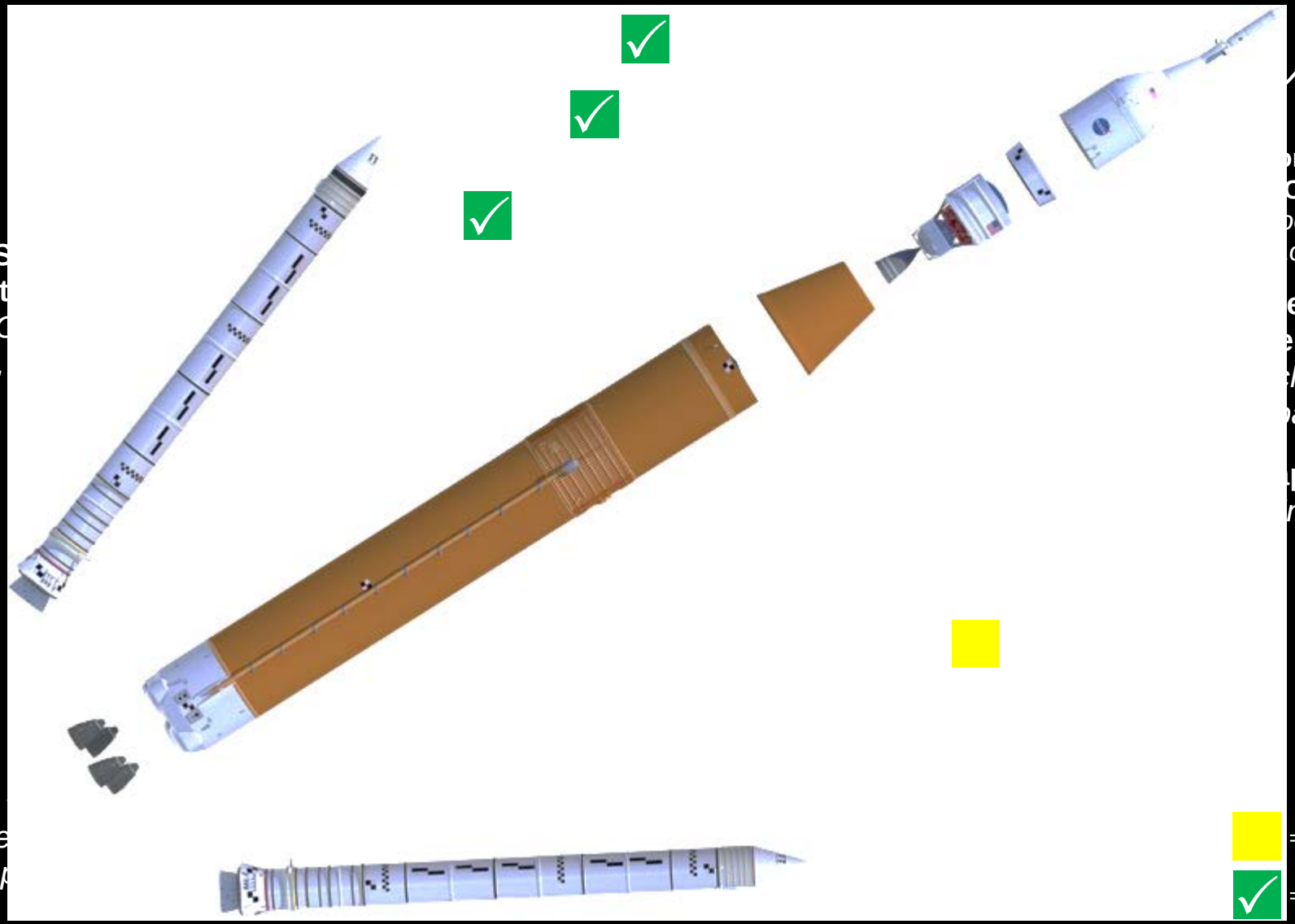


= *In Progress*

✓ = *Completed*

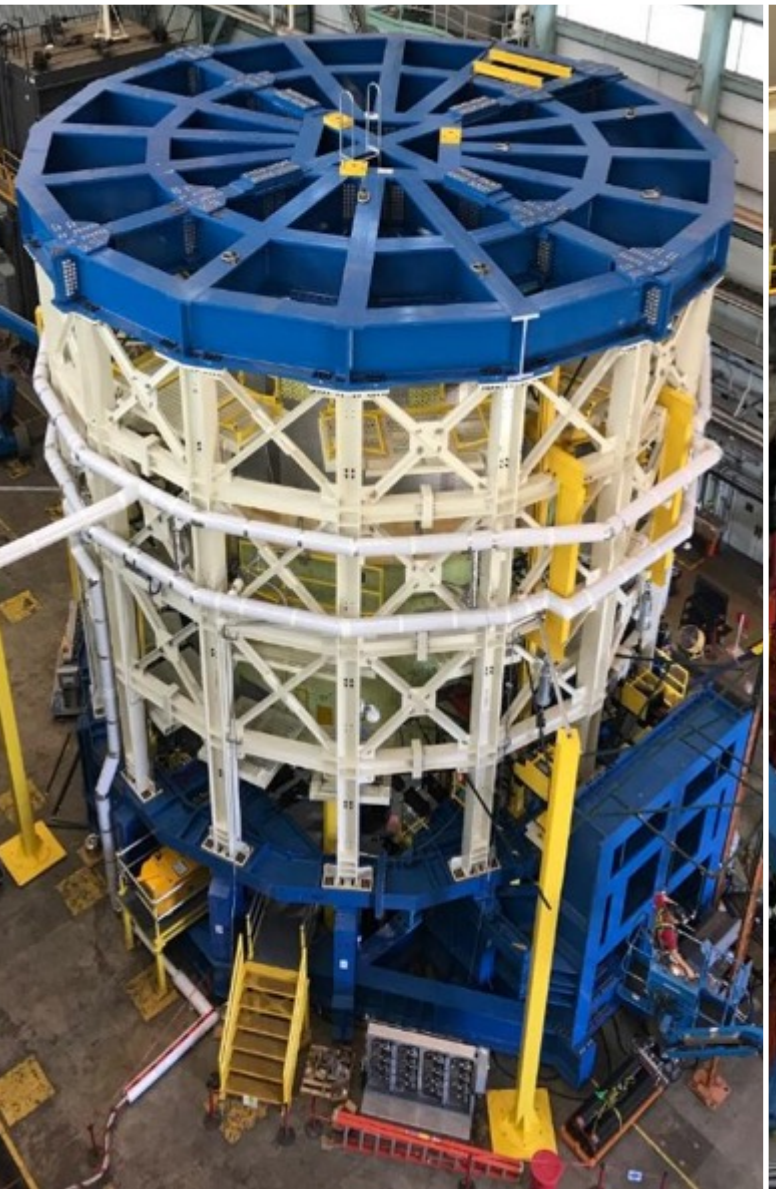
ARTEMIS I SOLID ROCKET BOOSTERS COMPLETE

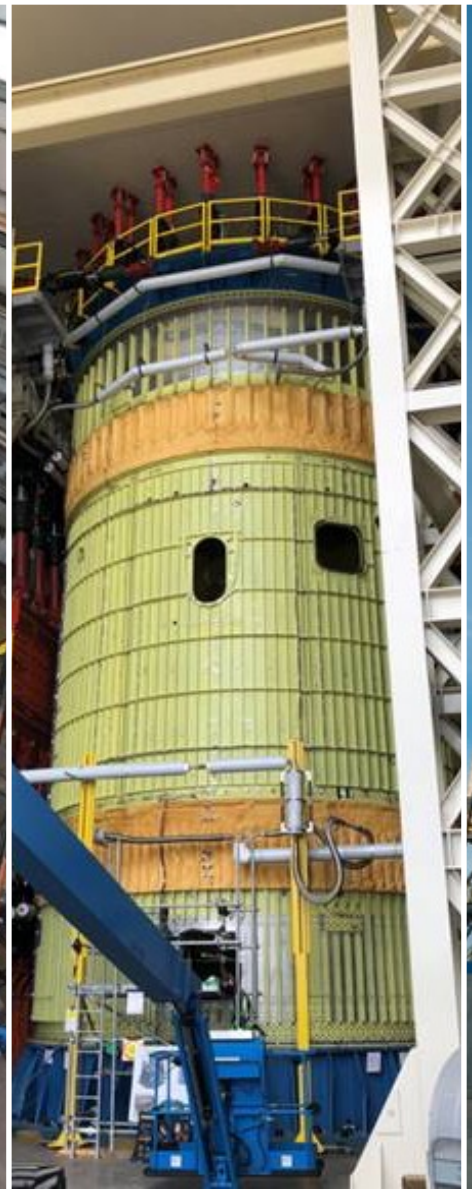
ARTEMIS I RS-25 FLIGHT ENGINES COMPLETE

SLS PROGRESS TOWARD ARTEMIS I: FLIGHT ARTICLES

ARTEMIS I CORE STAGE ASSEMBLED

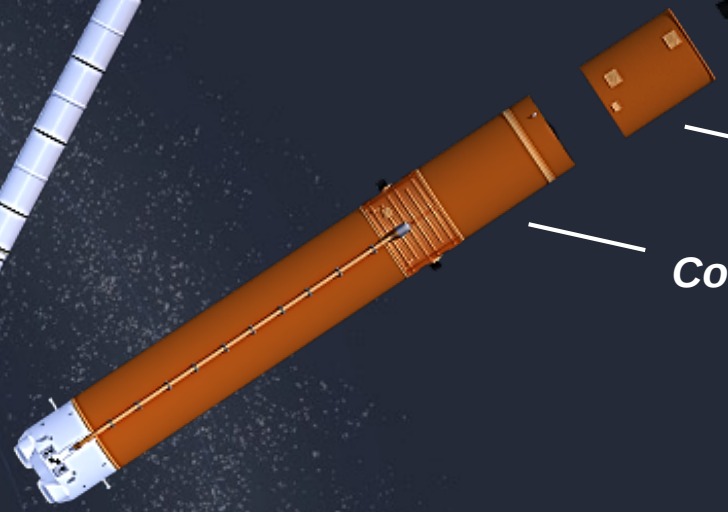
CORE STAGE STRUCTURAL TESTING

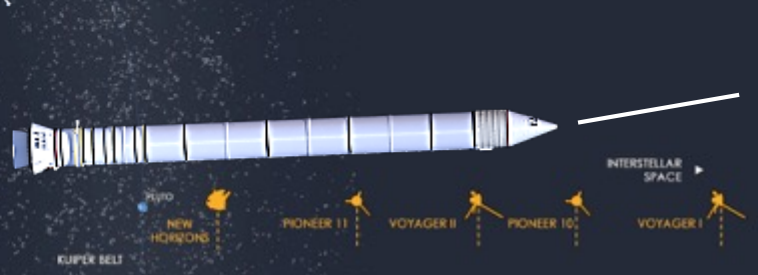




AN INTERSTELLAR ROCKET

SLS BLOCK 1B CARGO CONFIGURATION





8.4m Fairing, Short

Primary Payload

Payload Adapter (PLA)

Solid Rocket Booster (2)

RL10 Engine (4)

Exploration Upper Stage (EUS)

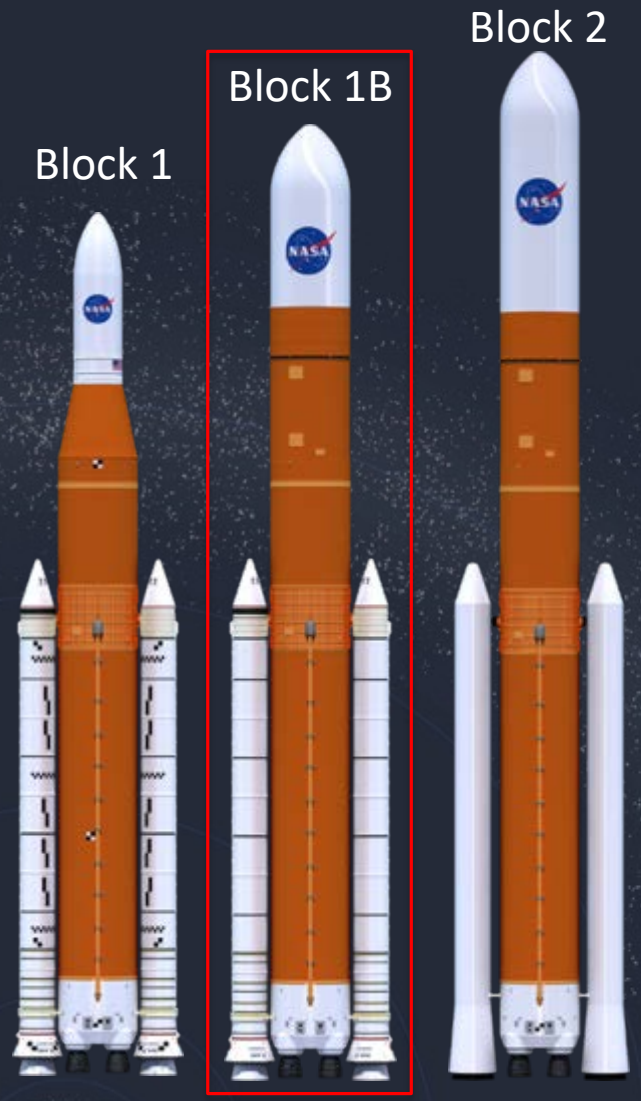
Interstage

Core Stage

RS-25 Engine (4)

Booster

SLS VEHICLE AND PERFORMANCE



Block 1B evolution path:

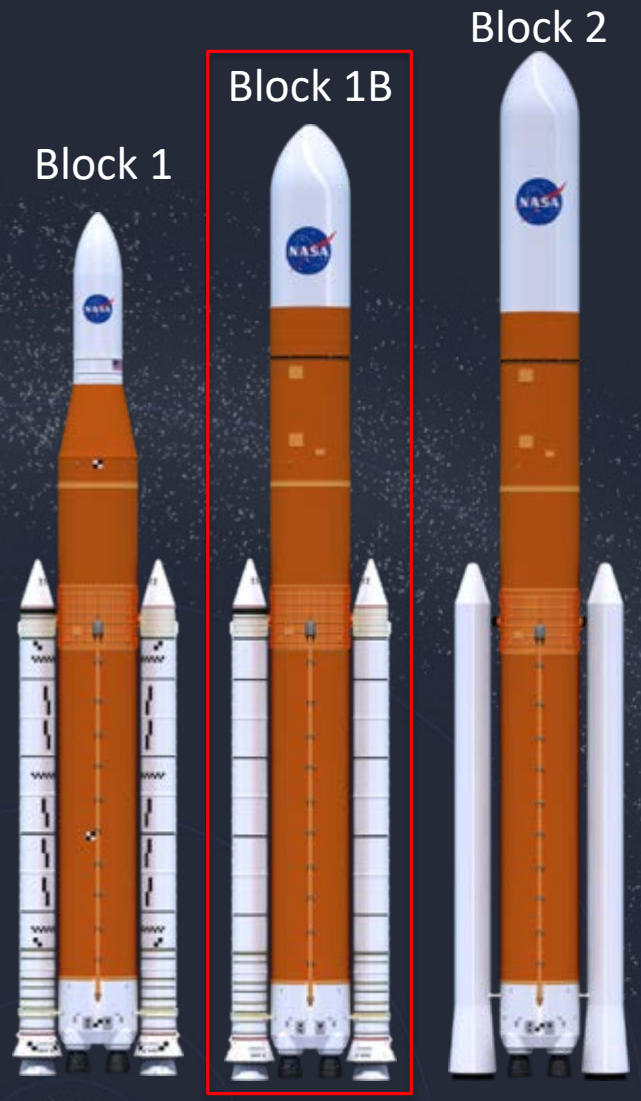
- Initial configuration (2025) – Heritage RS-25 running at 109% RPL
- Intermediate (2026-2028) – New production RS-25 engines running at 111% RPL
- Final (2029-??) - New production RS-25 engines and enhanced performance boosters

Vehicle Predicted Performance

- Predicted masses for all elements
- Nominal performance for RS25s and RL10s
- Booster performance quoted for February temperatures
- Manager's reserve is held back

SLS Block 1B future upgrades further increase performance
SLS quoted performance is conservative

RECENT DEVELOPMENTS



Block 1B vehicle updates

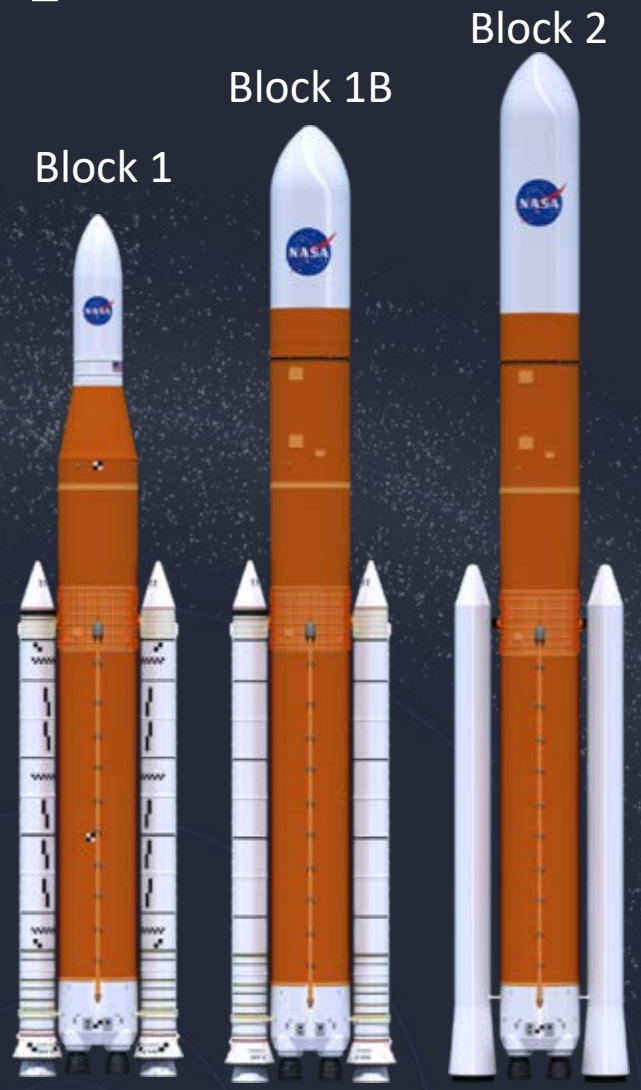
- EUS is now optimized for lunar destinations
- Additional system mass savings, flight techniques and other propulsion system enhancements were implemented
- Payload cryogenic propellant loading is currently planned for the Block 1B Mobile Launch Platform (MLP)

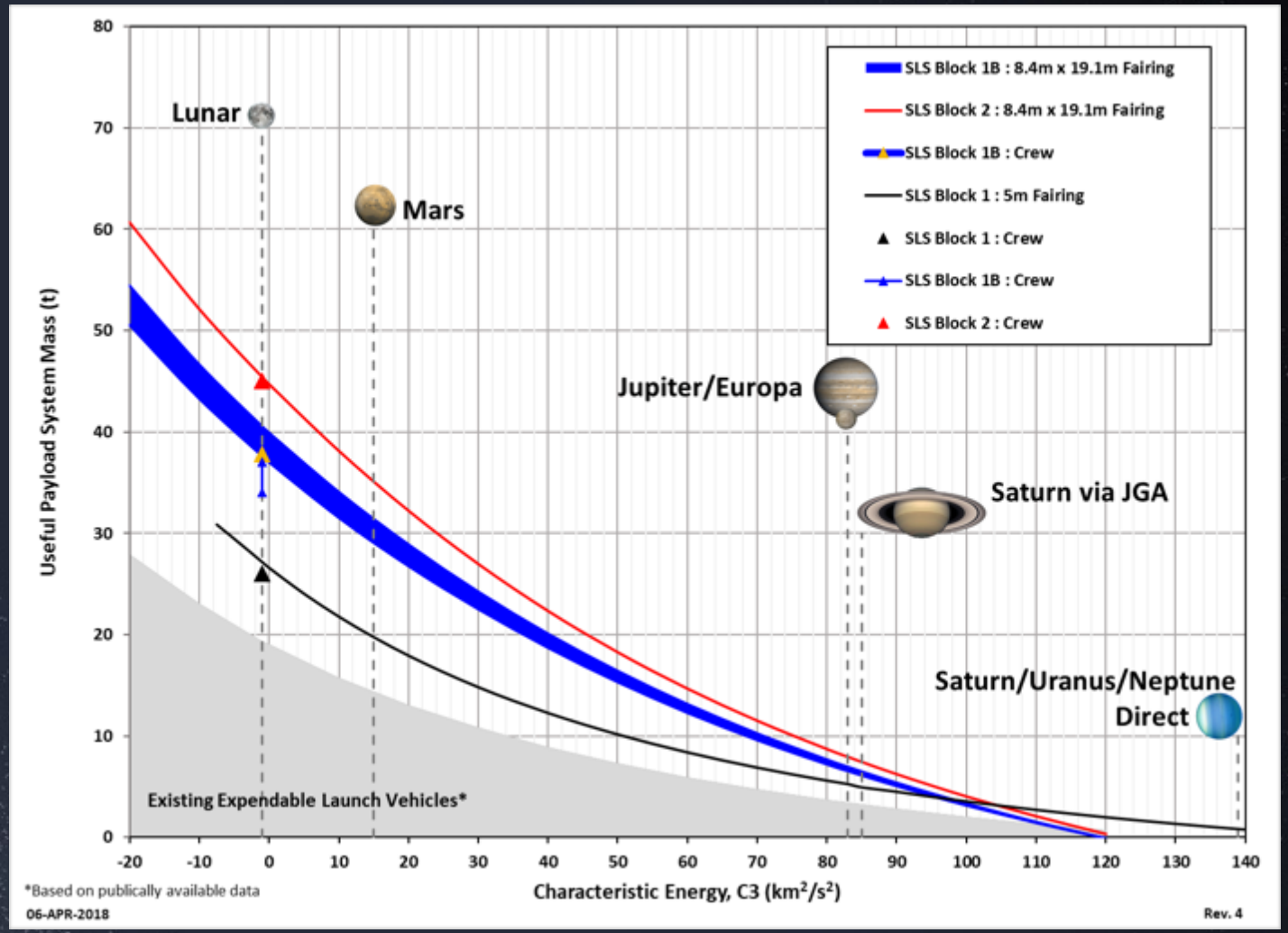
Block 1B Booster Obsolescence and Life Extension (BOLE)

- Design Analysis Cycle 1 (DAC1) is underway
- Following results reflect the updated booster design

Look for an announcement later today about SLS

SLS C3 PERFORMANCE

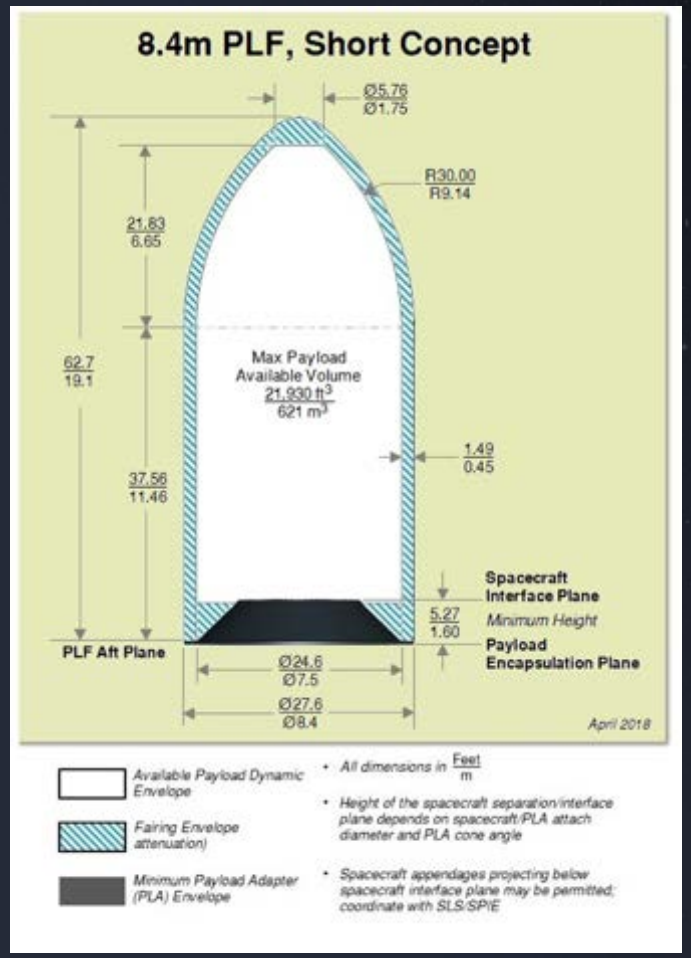




SLS performance is optimized for lunar destinations
Additional stages are needed for higher C3 destinations

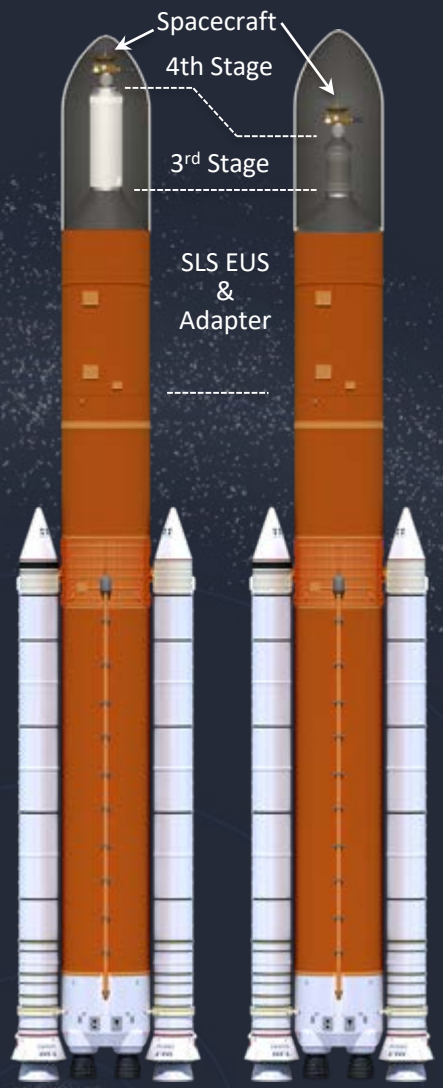
ADDITIONAL STAGES FOR HIGHER C3 DESTINATIONS

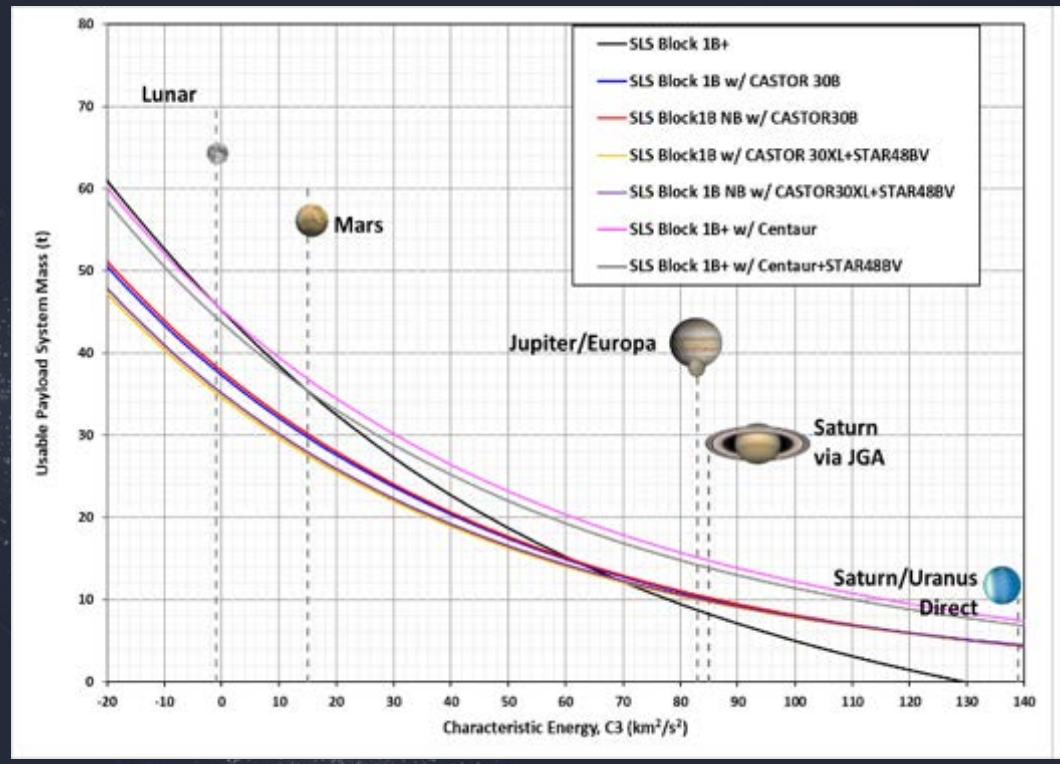
- **Manager's Reserve**
  - Allocated across all upper stages (incl. EUS) based on the stage wet mass
  - Approach preserves staging benefits at varying C3s
- **Fairing:**
  - All 3rd and 4th stages are encapsulated under the 8.4m short Payload Fairing (PLF)
  - Minimizes the risk of stage requalification
  - Removes alternate configurations for the SLS vehicle (OML changes)
- **Upper stages:**
  - Existing stages in production
  - Estimated Flight Performance Reserve
  - Solid performance nominal
  - 3rd Stages Assessed:
    - Castor 30B (NGIS provided data)
    - Castor 30XL (NGIS provided data)
    - Centaur (Government Estimate)
  - 4th Stages Assessed:
    - Star 48 BV (NGIS provided data)
    - Star48 GXV (NGIS provided data)
- **Stage adapters:**
  - Sized with NASA MSFC sizing tool, Launch Vehicle Analysis (LVA)
    - 35 years of heritage
  - Composite Adaptor (CF +Al-HC) with interface rings
  - 18% MGA

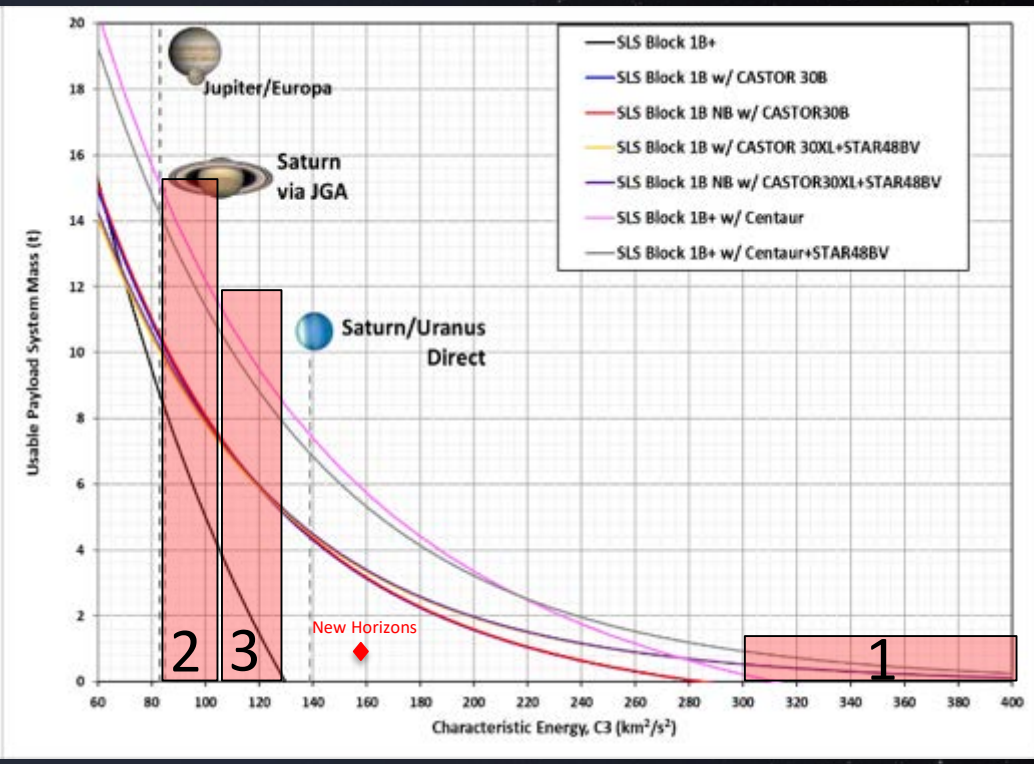


Using existing hardware and a low risk engineering approach

UPDATED C3 PERFORMANCE







Low C3 Range

High C3 Range

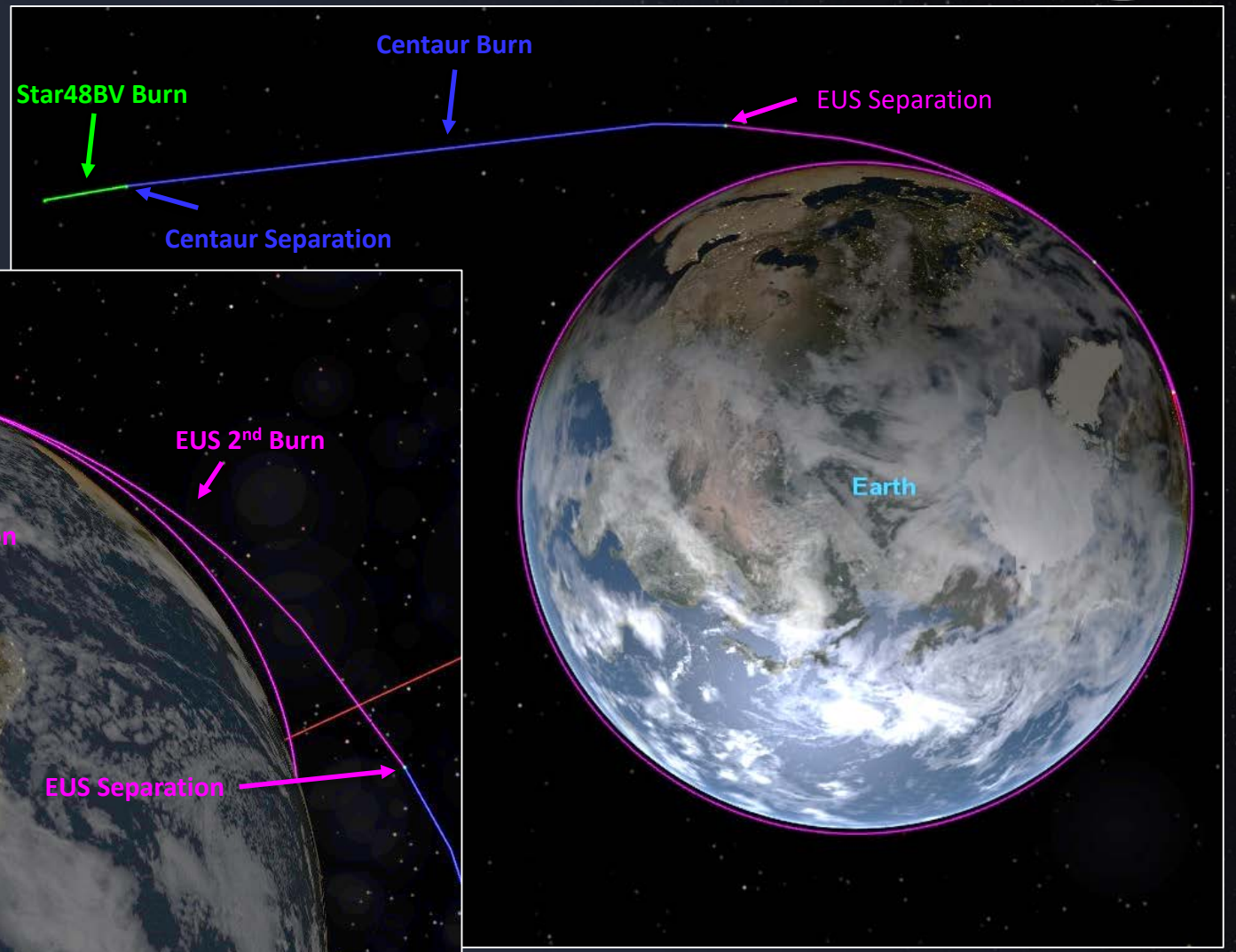
1) Passive Jupiter Flyby
2) Jupiter Powered Flyby
3) Solar Oberth Maneuver

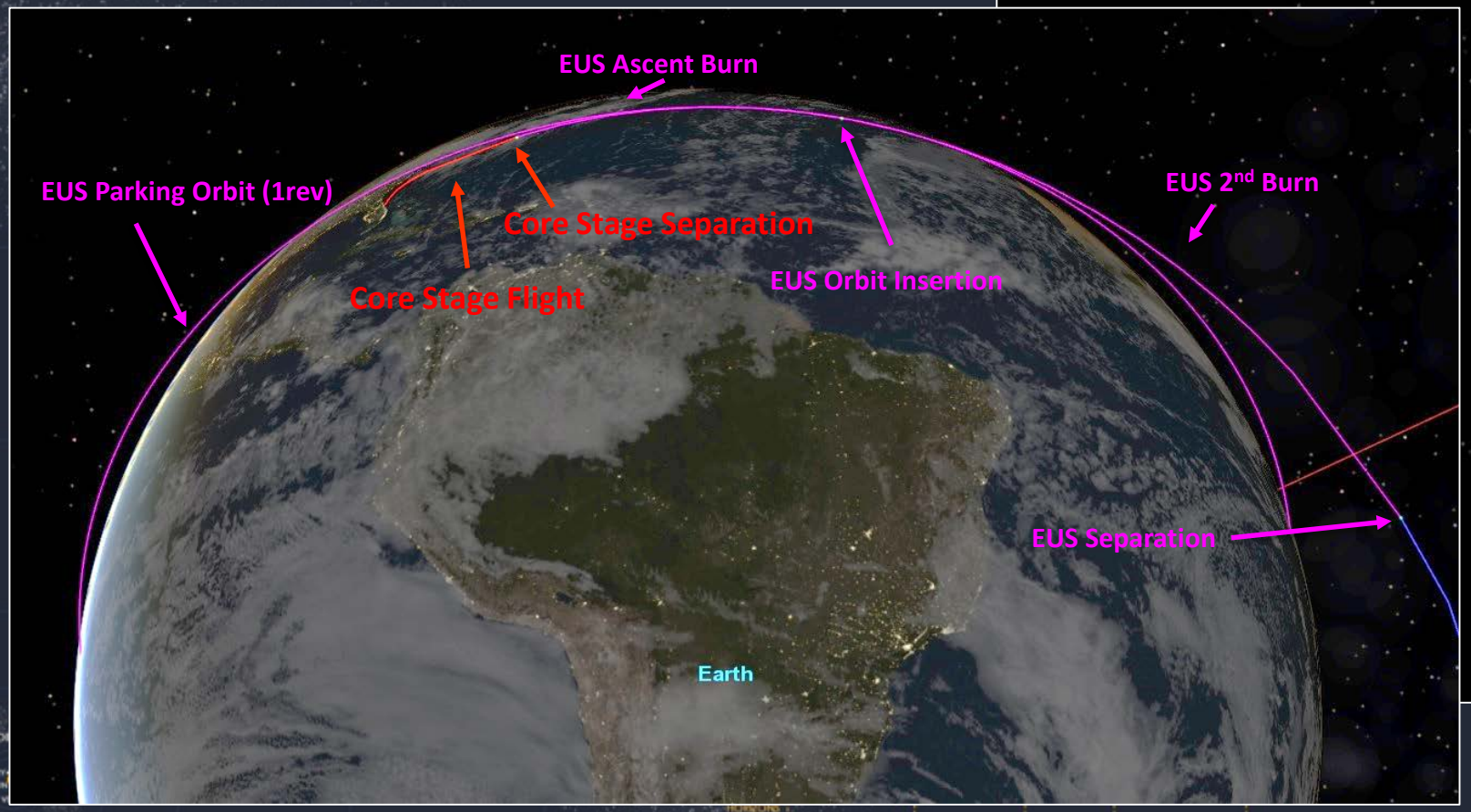
REPRESENTATIVE TRAJECTORY

Recall Specific Energy of the Orbit

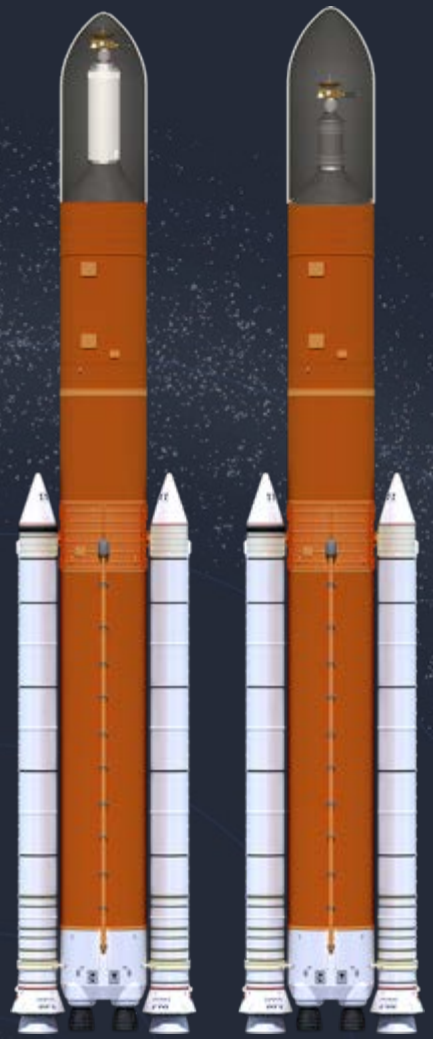
$$\mathcal{E} = \frac{(v+\Delta v)^2}{2} - \frac{\mu}{r} = \frac{C3}{2}$$

The deeper in the gravity well the maneuver the greater the increase in orbital energy (Oberth Effect)





SLS CAN ENABLE BREAKTHROUGH SCIENCE MISSIONS



- **SLS is America's heavy-lift vehicle for strategic human exploration and scientific missions**
- **Manufacturing is complete for the first flight; SLS is nearing the integration phase**
- **SLS has a flexible architecture and an evolvable upgrade path**
- **Discussions with the science community are ongoing to determine how SLS can enable breakthrough science missions, such as sending a probe to interstellar space**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