

# Booster Obsolescence and Life Extension (BOLE) for Space Launch System (SLS)

## Empowering Deep Space Missions

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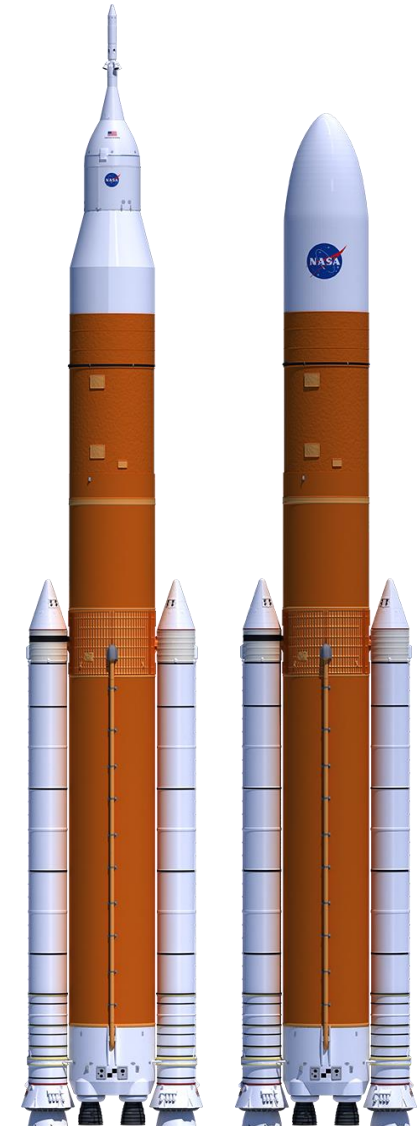
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## Booster Obsolescence and Life Extension (BOLE) for SLS

- Enables uninterrupted access to deep space by resolving obsolescence of legacy shuttle hardware
- Enables additional performance as part of larger Mars campaign

## Planned Design Improvements

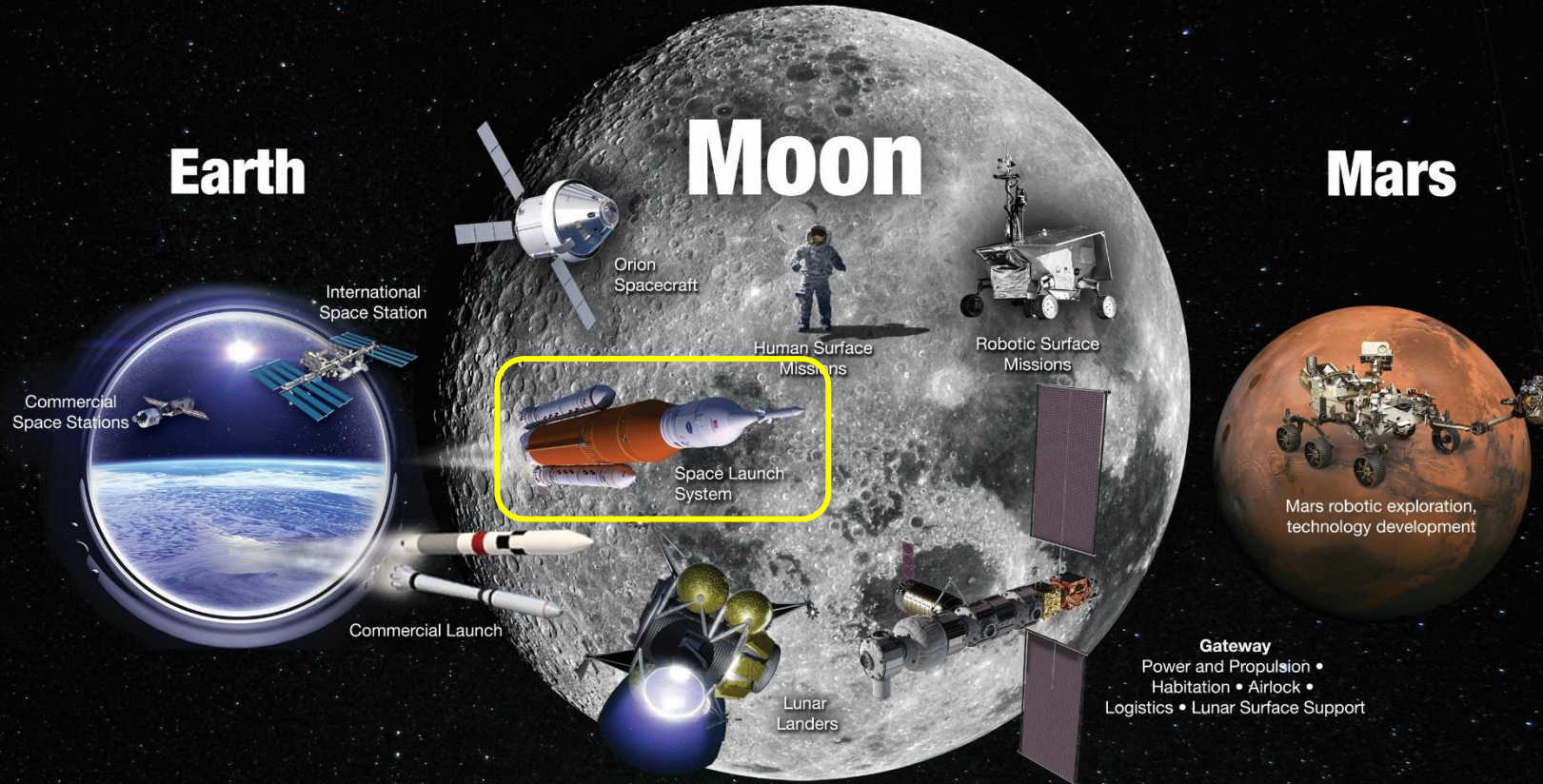
## BOLE Empowers Lunar and Mars Campaigns



# Approach to Moon and Mars Exploration

## SLS is a keystone of Moon and Mars Exploration plan

National Aeronautics and Space Administration



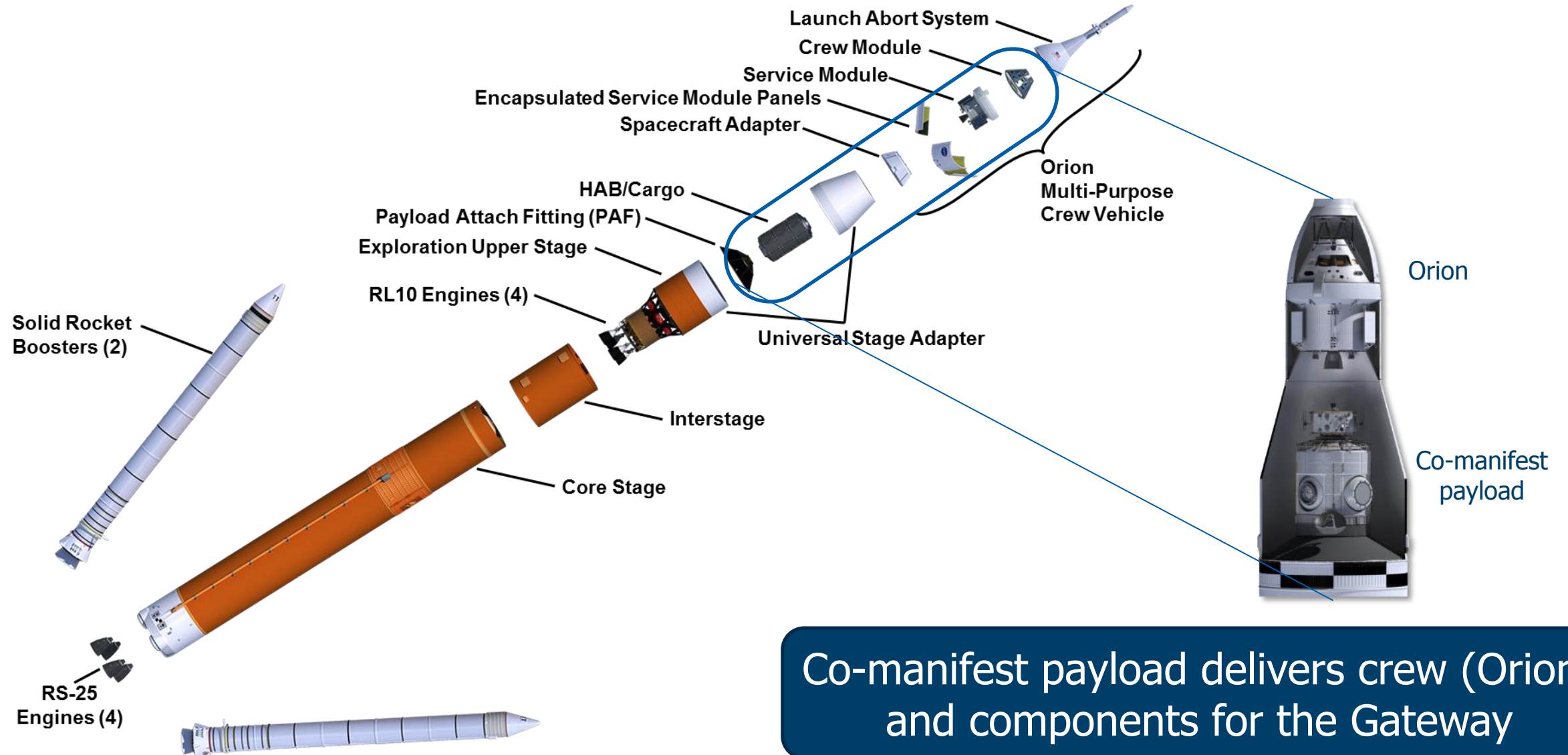
9.10.2018

**America Will Lead**  
Fly Astronauts on American Spacecraft  
Develop New Commercial Space Stations

**America Will Lead**  
Fly Astronauts Around the Moon  
Establish the First Human Outpost Around the Moon  
Return American Astronauts to the Moon for a Sustained Campaign of Exploration and Utilization

**America Will Lead**  
Return the First Scientific Collection from Mars  
Practice a Round-trip Leading to Humans to Mars

# SLS Block 1B – Expanded View



Co-manifest payload delivers crew (Orion) and components for the Gateway



# BOLE Design Changes Overview

## Forward Assembly

- Optimized forward assembly structure for mass and integration improvements
  - SLS forward attach at SLS location
    - Redesigned forward separation bolt
      - Modified avionics mounting scheme

## Integration Hardware

- SLS-like DFI
- New systems tunnel
- Newly integrated destruct charge
- SLS FSS electronics
- Titan and OmegaA style attach scheme at SLS location
- Indirect lightning electrical bonding for composites
- Proven attach and separation scheme for enhanced vehicle clearances

## Integrated Motor

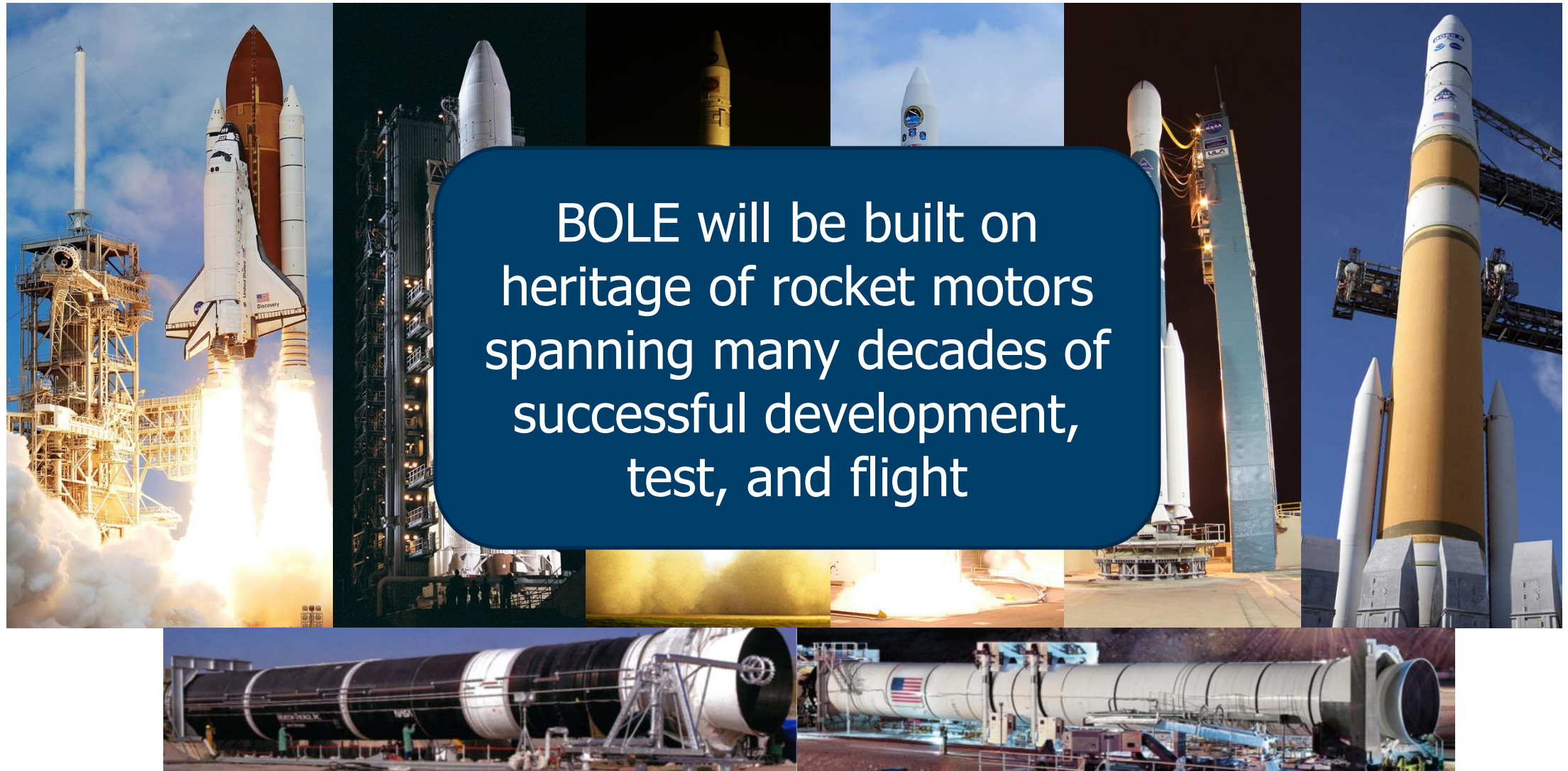
- Composite case with displacement controlled joints
  - HTPB propellant – tailored burn rate and grain design
    - Grain optimized for Mach-Q constraint
      - WEI of internal insulation
        - High expansion ratio nozzle and exit cone
          - Steel attach cylinder and domes
            - No CSA ring

## Aft Assembly

- Mass optimized aft skirt and ML interface
- Internally mounted BSMs
- New ETVC control using high voltage batteries
- External LRU pod mounting option

**BOLE changes will provide  
3 mT of additional  
payload to TLI**

# BOLE Design Leverages Heritage and Current Production Vehicles



Shuttle image from [https://en.wikipedia.org/wiki/Space\\_Shuttle#/media/File:STS120LaunchHiRes-edit1.jpg](https://en.wikipedia.org/wiki/Space_Shuttle#/media/File:STS120LaunchHiRes-edit1.jpg)  
Titan image from [https://en.wikipedia.org/wiki/Titan\\_IV#/media/File:Titan4B\\_on\\_Launch\\_Complex\\_40.jpg](https://en.wikipedia.org/wiki/Titan_IV#/media/File:Titan4B_on_Launch_Complex_40.jpg)  
Delta II image from <https://www.flickr.com/photos/ulalaunch/39206526565/in/album-72157663399219447/>

RSRMV image from [http://www.northropgrumman.com/Capabilities/SLSSolidRocketBoosters/Documents/SLS\\_Booster\\_Factsheet.pdf](http://www.northropgrumman.com/Capabilities/SLSSolidRocketBoosters/Documents/SLS_Booster_Factsheet.pdf)  
Delta IV image from <https://mobile.arc.nasa.gov/public/ieexplore/missions/pages/lsp/MobileWebsite/SubPages/DeltaIV.html>  
Athena II image from <http://solarviews.com/cap/craft/lunpros2.htm>  
Minotaur IV image from [https://en.wikipedia.org/wiki/Minotaur\\_IV#/media/File:Minotaur-4-Lite\\_HTV-2a\\_2.jpg](https://en.wikipedia.org/wiki/Minotaur_IV#/media/File:Minotaur-4-Lite_HTV-2a_2.jpg)



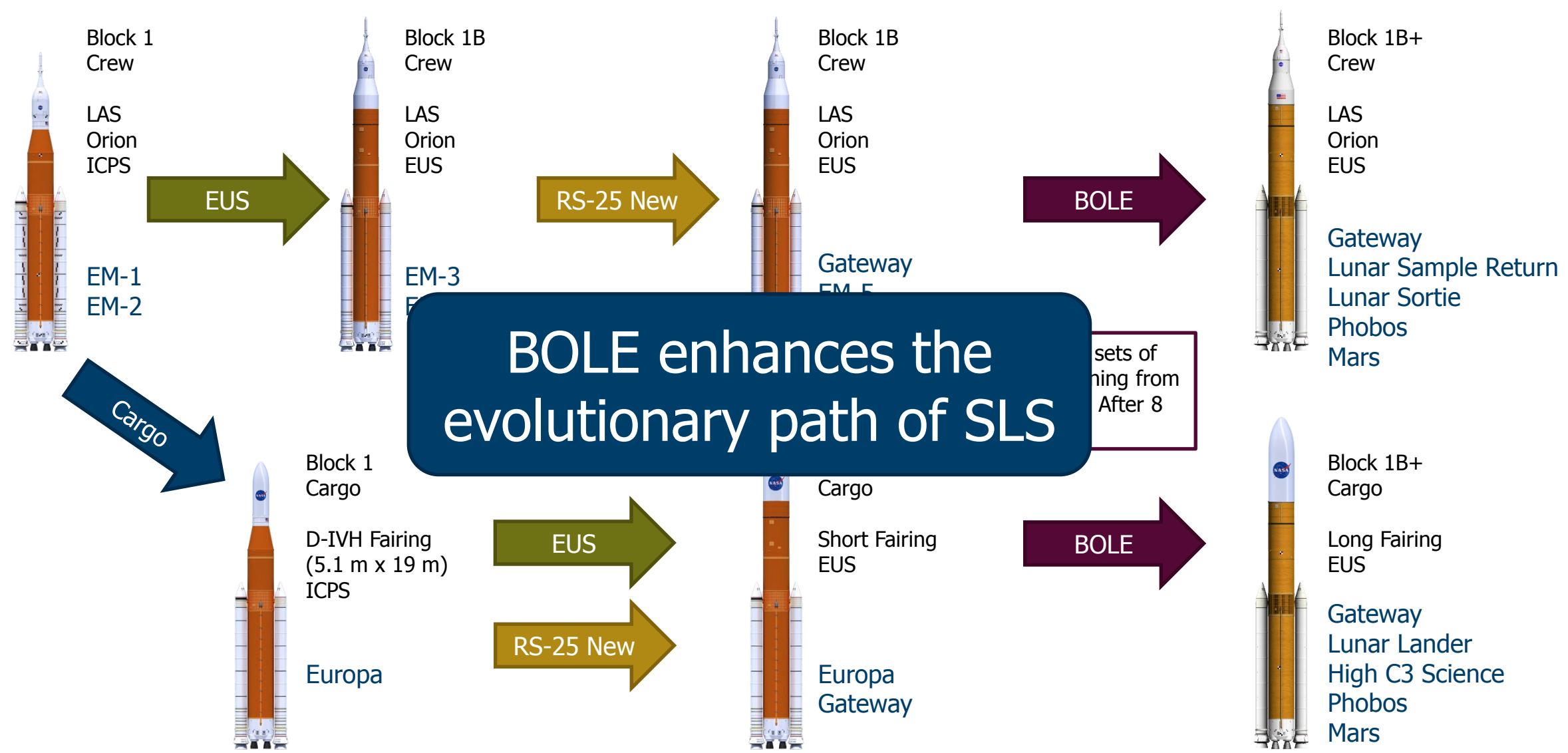
# BOLE Design Leverages Heritage and Current Production Vehicles



BOLE leverages  
significant recent  
investments in  
OmegA™

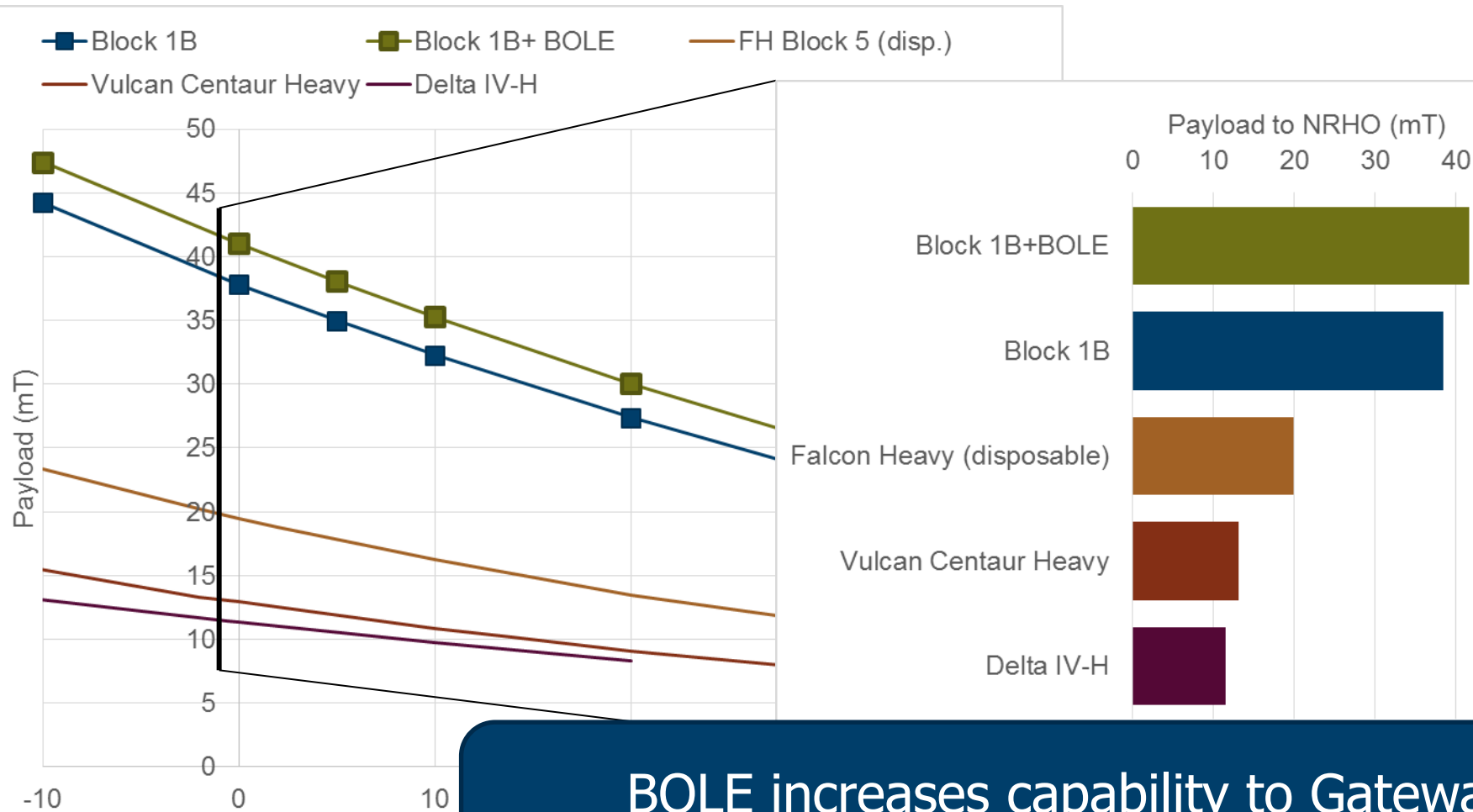


# SLS Configuration Evolution

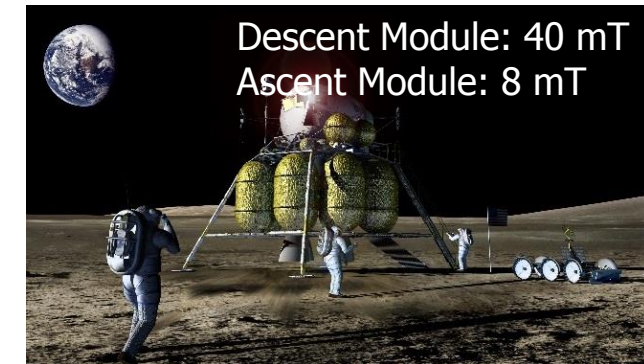




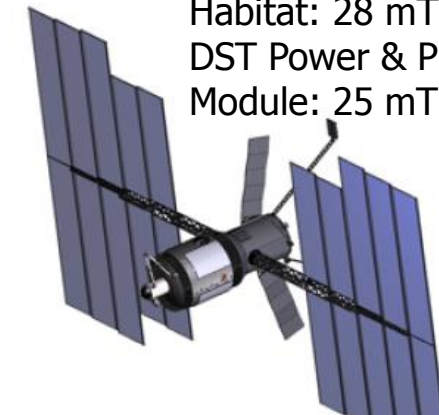
# BOLE Empowers Future Exploration Missions



## Possible payloads



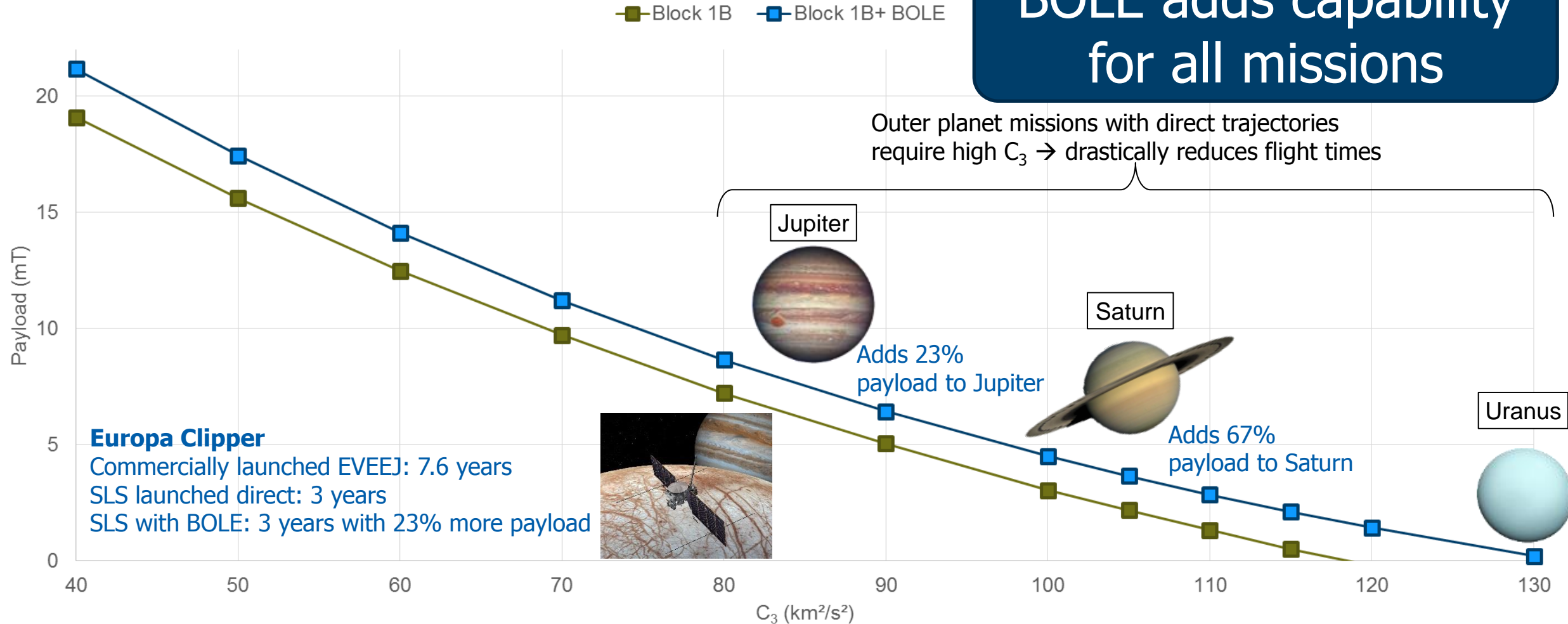
Deep Space Transport (DST)  
Habitat: 28 mT (empty)  
DST Power & Propulsion  
Module: 25 mT (empty)



BOLE increases capability to Gateway and allows larger components in one launch → fewer in-space assembly operations

# BOLE Empowers Future Science Missions

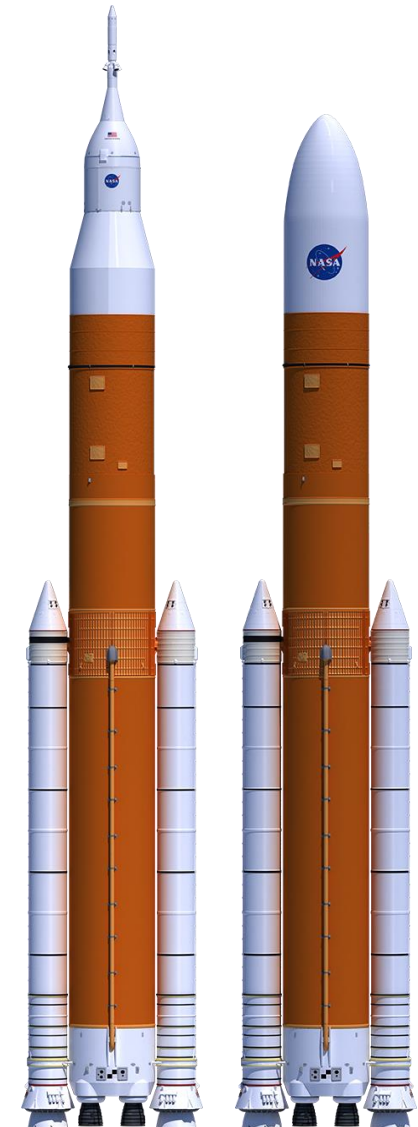
BOLE adds capability  
for all missions



BOLE program extends the life of the SLS vehicle architecture beyond the existing inventory of shuttle hardware

BOLE leverages Northrop Grumman's current investments in commercial markets for OmegaA and provides significant cost and technological synergies

The BOLE booster is one additional step on the SLS evolution path, making it an ever more capable heavy lift launch vehicle that will propel us to the moon, Mars and beyond





***THE VALUE OF PERFORMANCE.***

***NORTHROP GRUMMAN***

