National Aeronautics and Space Administration

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SPACE LAUNCH SYSTEM

Enhanced Feasibility Assessment of Payload Adapters for NASA's Space Launch System

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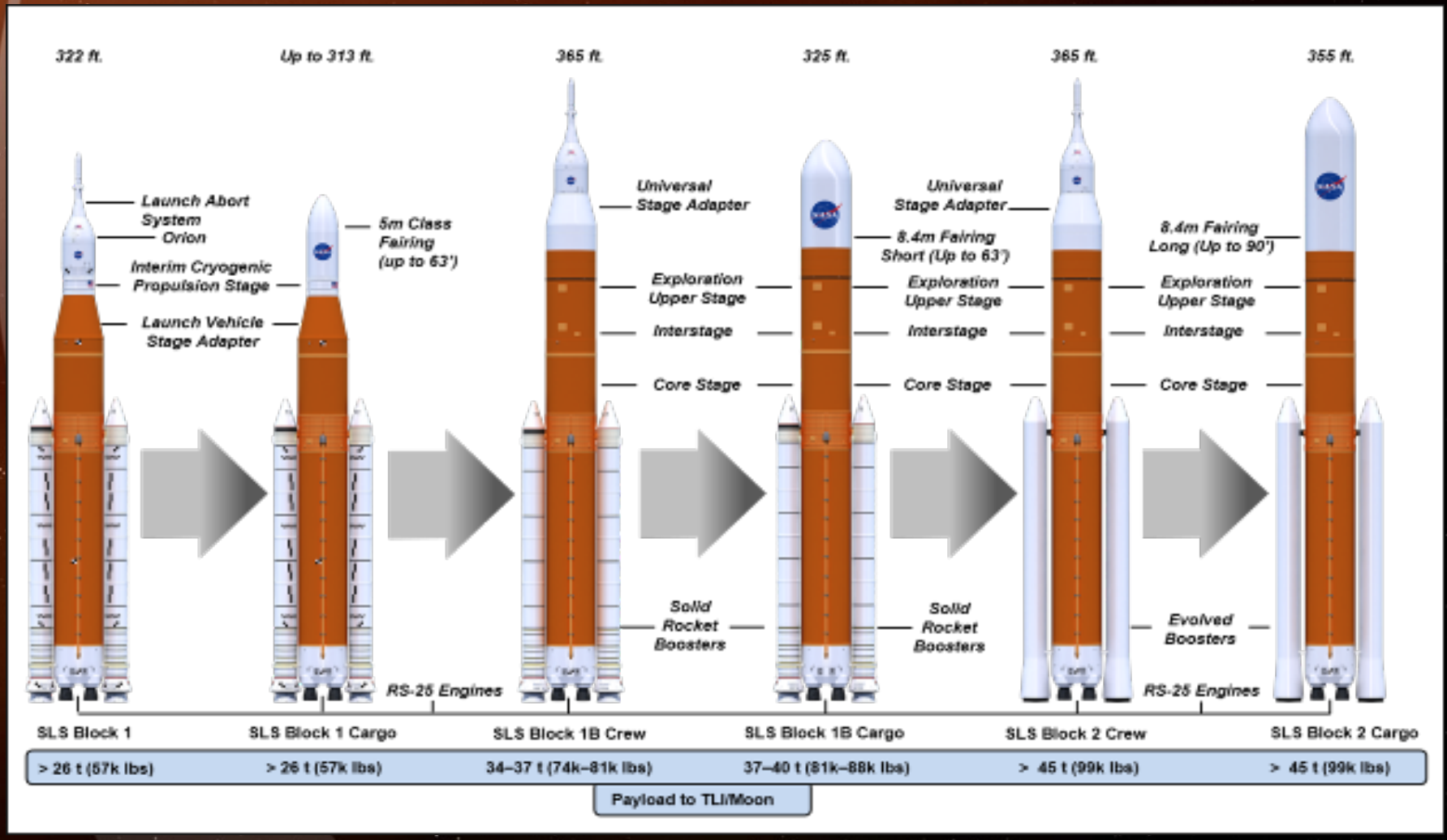
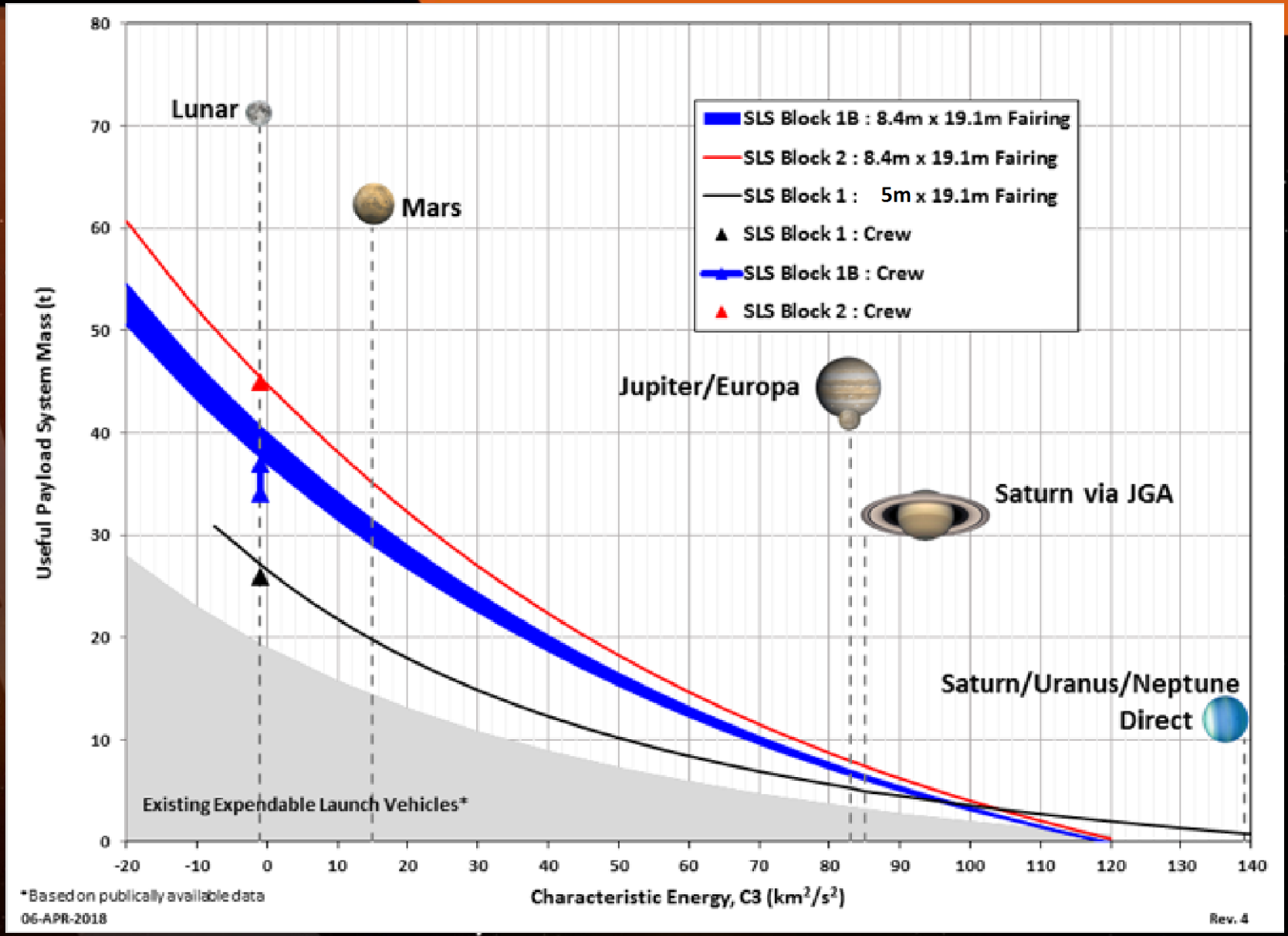
Introduction

- SLS as Cornerstone of NASA's space exploration system
- SLS Mission Opportunities
- SLS Payload Accommodations
- MBSE Pathfinder: SLS Payload Adapter Design Definition
- Next Steps

SLS Block Configurations



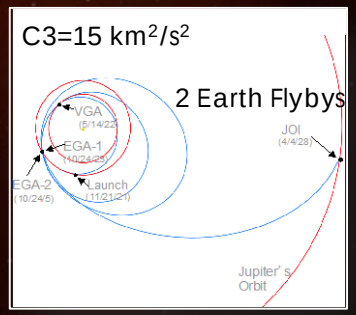
SLS Payload Mission Capture



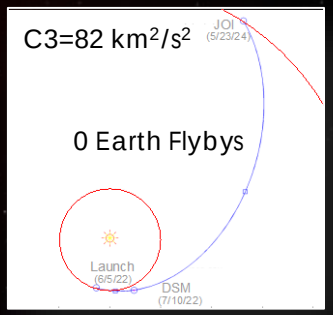
SLS Time to Destination

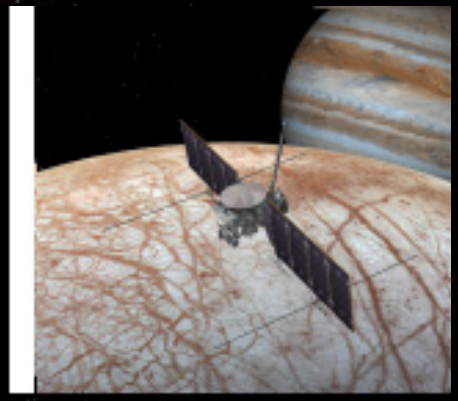
- **Shorter Transit Times to Destination**
- **Europa Clipper**
  - Desired launch date of June 2022
  - Jovian system transit time reduced by 65% over existing launch vehicles
  - Reduced mission operations cost over time

Current LVs



SLS





Earliest Launch

*Period: 6/4/22 – 6/24/22 (SLS)
*Period: 6/18/22 – 7/8/22 (Atlas)

Cruise:

2.5 Years (SLS)
7.4 Years (Atlas)

Jupiter Orbit Insertion

12/24/24 or 5/1/25 (SLS)
11/26/29 (Atlas)

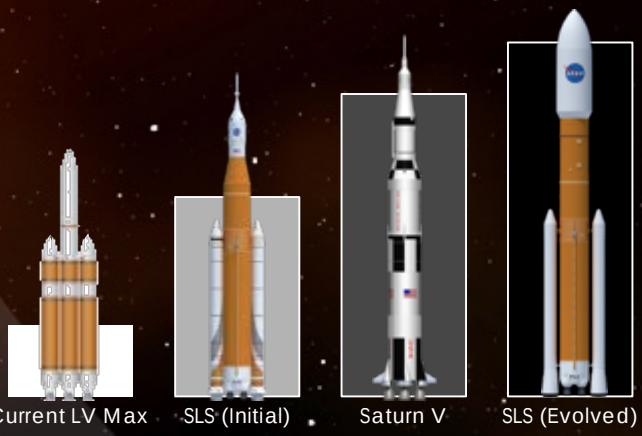
Jovian System Operations

Prime Europa Flyby
Campaign: 36 months

SLS Mass to Destination

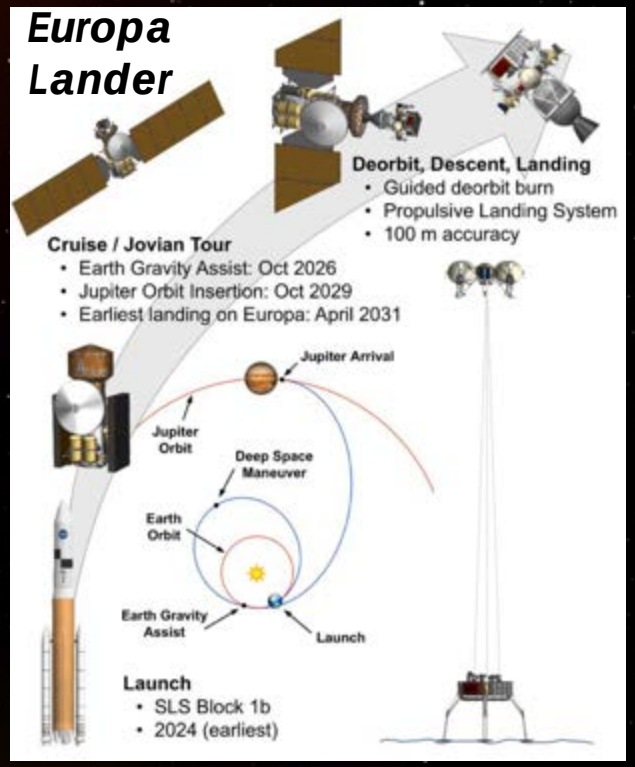
- **Up to 5 times greater mass to orbit capability than current launch systems**
  - Increases payload mass margins
  - Offers range of injection propulsion options
- **New Horizons**
  - SLS would have doubled delivered payload mass to Pluto
- **Europa Lander**
  - 16 mT delivery to outer planets (with margin)

Payload Lift Comparison



New Horizons

Europa Lander

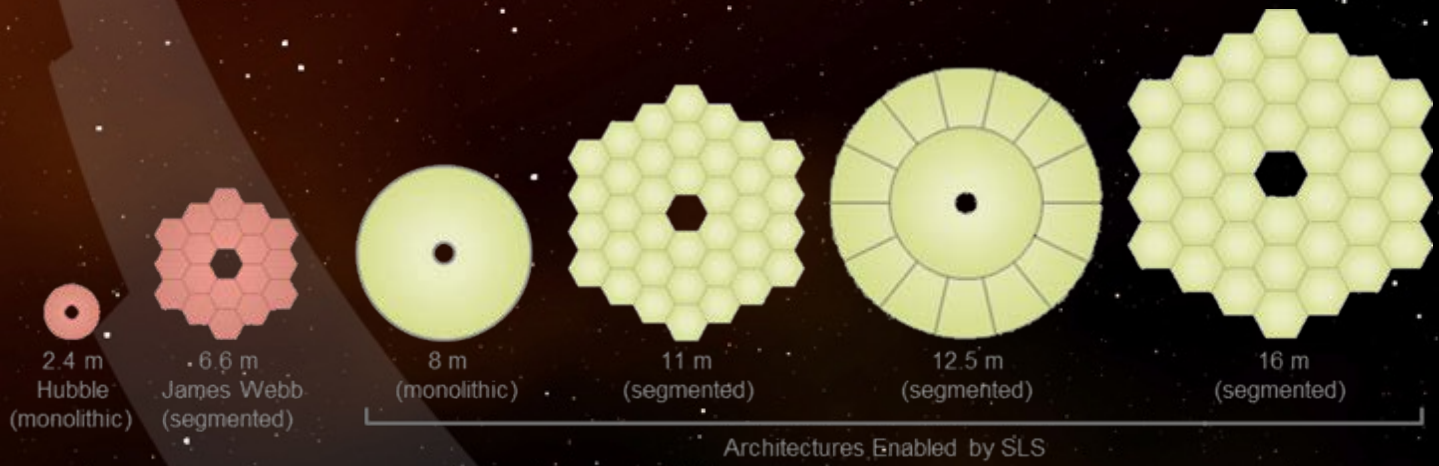


SLS Volume to Destination

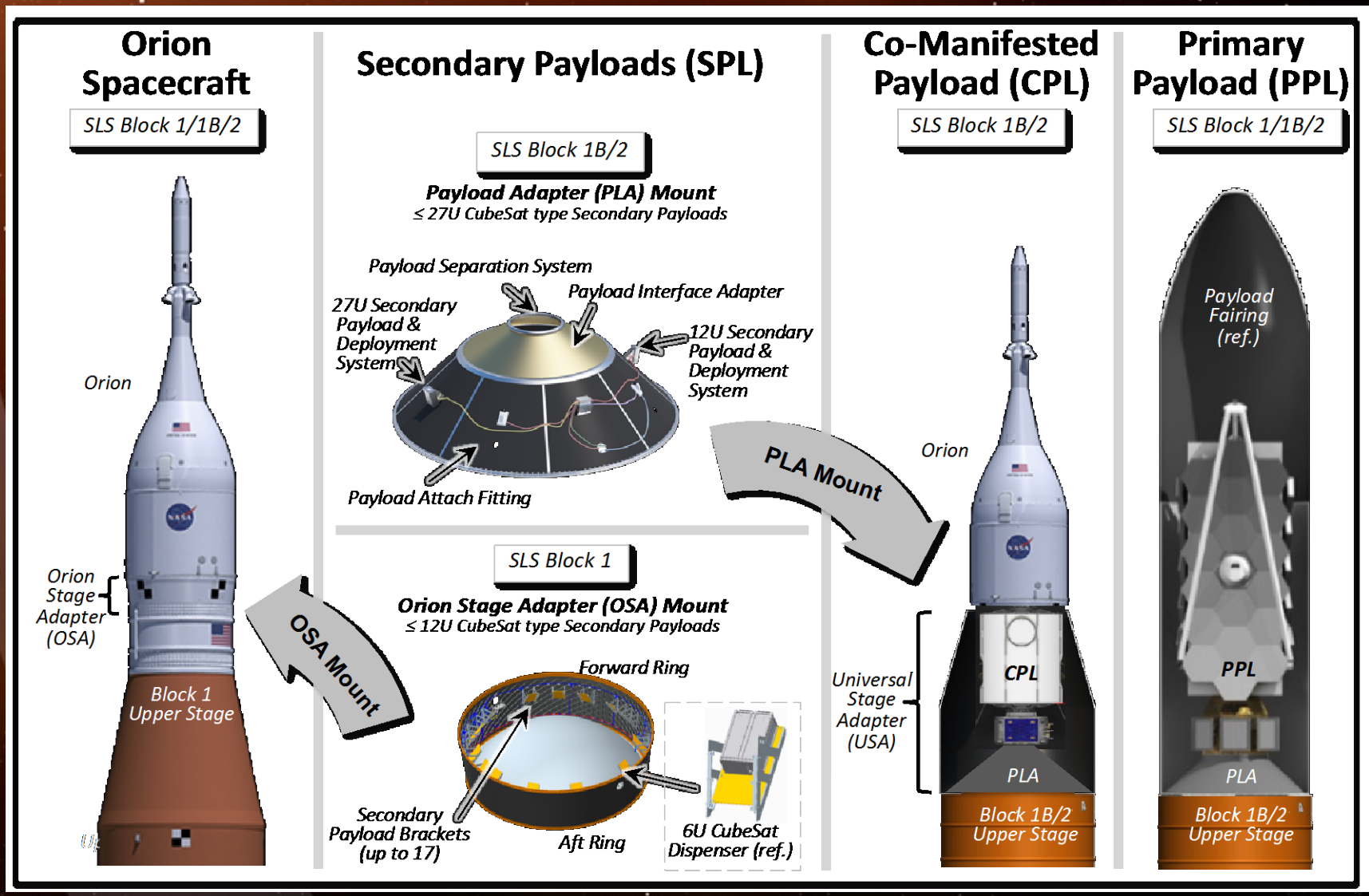
- **Up to 6 times greater volume available**
- **Multiple payload combinations**
  - Dual manifesting within fairing
  - Payload Constellations
  - More powerful injection stages
- **Telescopes**
  - Larger payloads translate into simpler orbital operations (fewer deployments)

Largest existing 5m fairing

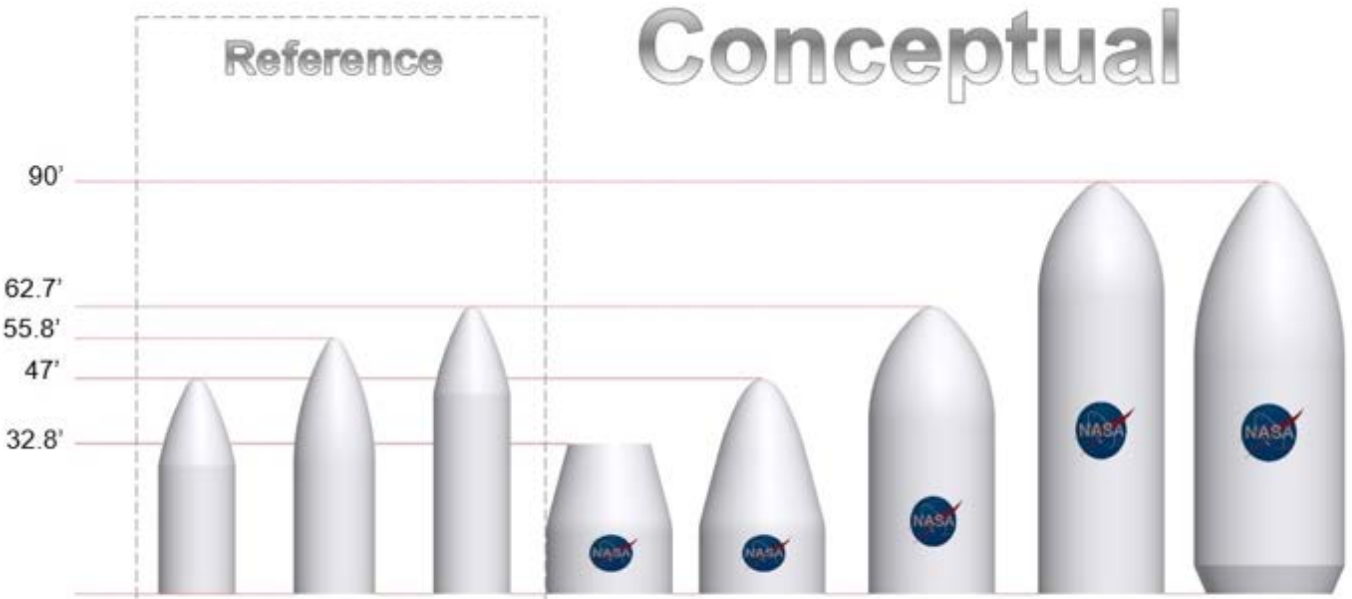
8.4m fairing with large aperture telescope



Range of SLS Spacecraft/Payload Types



Range of Payload Encapsulation



Enclosure	5.1m PLF	5.4m PLF	5.1m PLF	8.4m USA	8.4m USA PLF	8.4m PLF, Short	8.4m PLF, Long	10m PLF
Type	5m PPL	5m PPL	5m PPL	8.4m CPL	8.4m PPL	8.4m PPL	8.4m PPL	10m PPL
Length	47.0 ft	55.8 ft	62.7 ft	32.8 ft	47.2 ft	62.7 ft	90 ft	90 ft
	14.3 m	17.0 m	19.1 m	10.0 m	14.4 m	19.1 m	27.4 m	27.4 m
Diameter	16.7 ft	17.7 ft	16.7 ft	27.6 ft	27.6 ft	27.6 ft	27.6 ft	32.8 ft
	5.1 m	5.4 m	5.1 m	8.4 m	8.4 m	8.4 m	8.4 m	10.0 m
Internal Diameter	15.1 ft	15.1 ft	15.1 ft	24.6 ft	24.6 ft	24.6 ft	24.6 ft	29.9 ft
	4.6 m	4.6 m	4.6 m	7.5 m	7.5 m	7.5 m	7.5 m	9.1 m
Available Volume	6,274 ft^3	7,740 ft^3	9,030 ft^3	10,100 ft^3	11,260 ft^3	21,930 ft^3	34,910 ft^3	46,610 ft^3
	177.6 m^3	219.2 m^3	255.7 m^3	286.0 m^3	319 m^3	621 m^3	988 m^3	1,320 m^3
Potential Availability *(No Earlier Than)*	COTS	COTS	COTS	2022	2023	2023	2024	2028

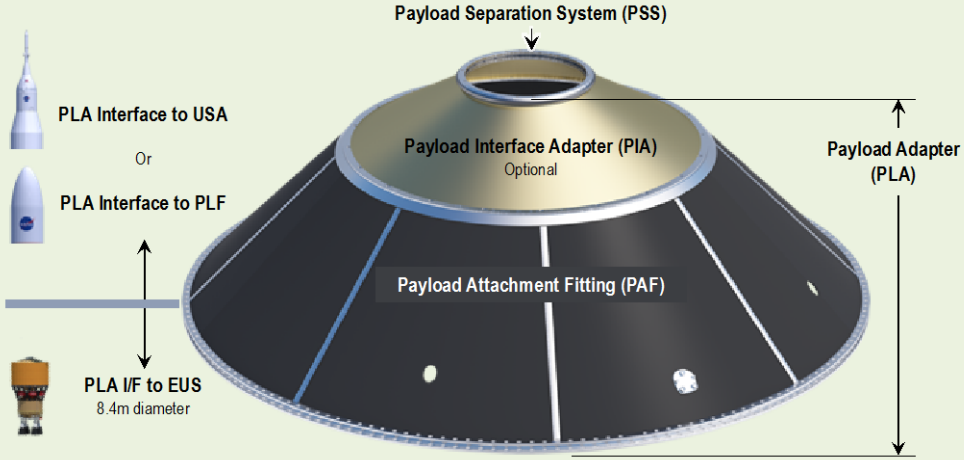
Block 1B

COTS: Commercial Off-the-Shelf CPL: Co-manifested Payload PPL: Primary Payload PLF: Payload Fairing

Block 2

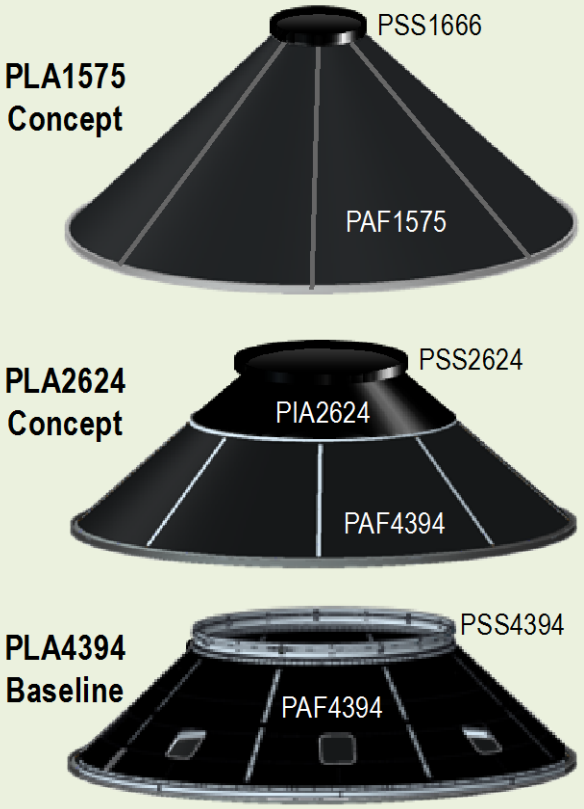
SLS Payload Adapter Concepts

SLS 8.4m Payload Adapters

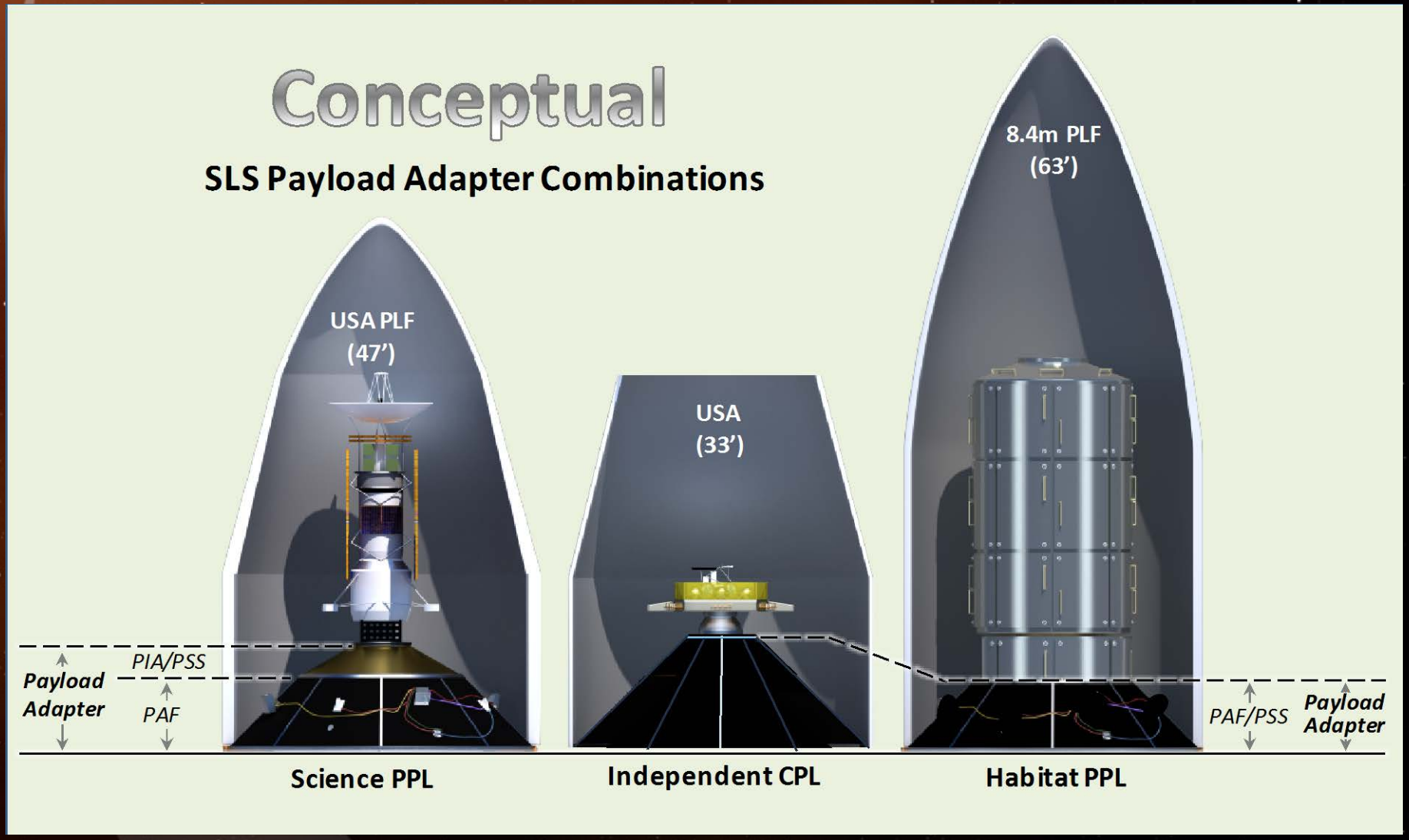


PLA Concept	PLA Interface								
	Diameter To PIA		Diameter To PSS		Diameter To Payload		Height to PSS (1)		Payload Lift
	in	mm	in	mm	in	mm	in	mm	
PLA1575	NA	NA	62.0	1,575	65.6	1,666	130.0	3,302	(2)
PLA2624	173.0	4,394	103.3	2,624	103.3	2,624	115.8	2,940	(2)
PLA4394	NA	NA	173.0	4,394	173.0	4,394	82.3	2,089	(2)

Notes: (1) Total PLA height varies based on PSS type chosen
(2) Max 19,842 lb (9.0 t) payload capability on Block 1B PLA (crew configuration)

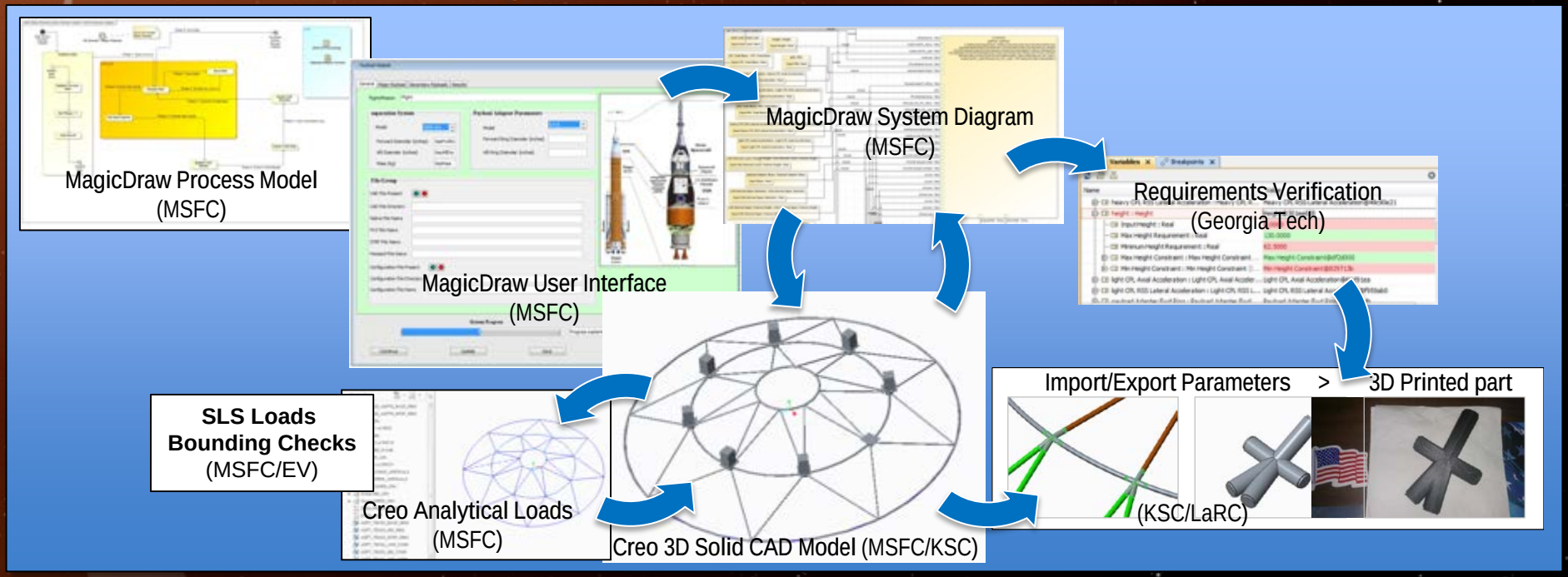


SLS Payload Adapter Accommodation Examples



MBSE Pathfinder: SLS Payload Adapter Design Definition

Integrating Rqmts/CAD/FEM/Verification to reduce changes/time to Production



Technical Challenge

SLS engineering resources insufficient to evaluate 10's-100's of optimized PL adapter options for SLS users over life of program

MBSE Challenge

Develop User Interface to feed MagicDraw parameters into CAD/analytical model and verify requirements were met by PL adapter concept

Pathfinder Findings

- **Benefits**:
  - Outward facing GUI for capture of SLS payloads
  - Automated concept design of PL integrated to SLS
  - Demonstrated MBSE to MBE for design and mfg.
  - Minimizes error from manual steps in integration
  - Matures design to higher fidelity quickly
- **Next Step**: develop front end SLS user interface within existing SLS Mission Planners Guide

Next Steps

- **SLS is a MBSE example from concept to manufacturing performed by the largest launch vehicle in history**
- **NASA is moving toward more digitally integrated solutions that span life-cycle from concept to manufacturing**
  - Opportunities arise to more efficiently tailor implementations to better balance performance, cost and schedule
  - Also working to improve NASA's smallest class of launch vehicles, by applying similar MBSE approaches
- **Looking toward how the capability best aligns with the NASA workforce at large as well as other Government Agencies and commercial providers**
  - Focus is on a 10-20 year time frame, where digital twins (digital replica of physical assets and processes) are expected to be achieved
  - Where those twins integrate engineering with programmatics, the question of "standard" engineering designs and the cost of associated change, is no longer a major consideration.