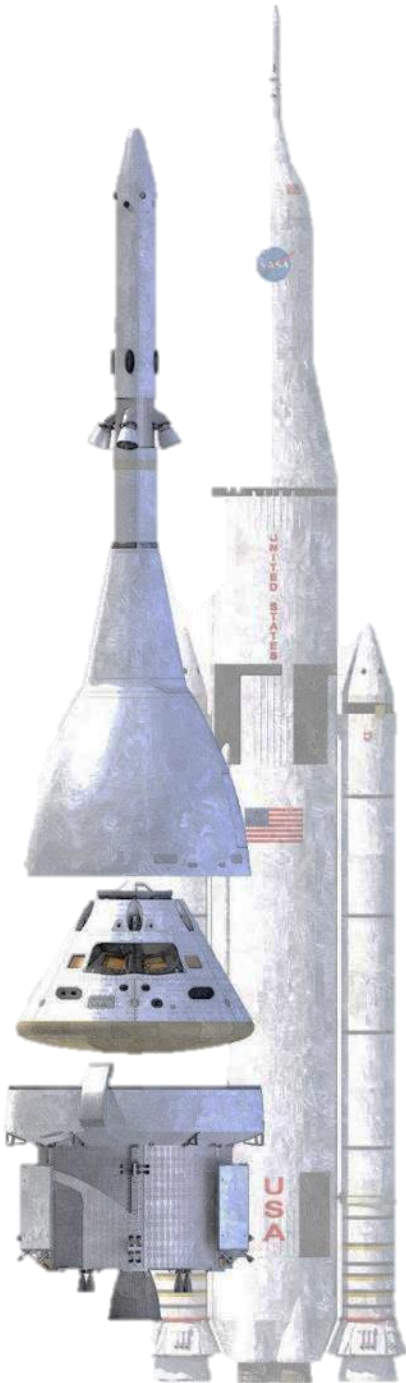




NASA Leading Human Space Exploration

August 2018

Mack McElroy, PhD

NASA Locations



NASA 2019 Projected Budget: \$19.9 billion

Human Exploration and Operations - \$10.5 Billion

Orion & Space Launch System

Commercial Crew

International Space Station

Science - \$5.7 Billion

Mars Rover 2020

James Webb Space Telescope

Earth Science, Astrophysics, Heliophysics

Space Technology - \$826 Million

Aeronautics Research - \$656 Million

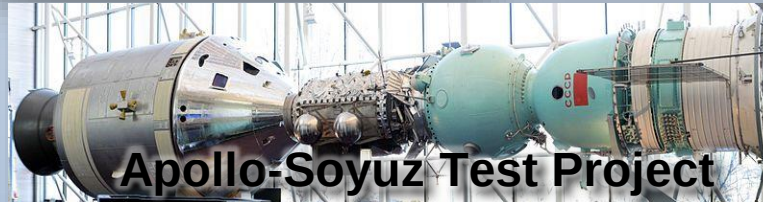
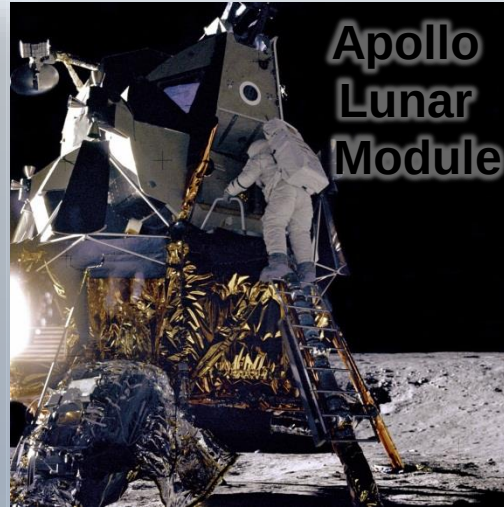
Safety, Security, Operations, Construction - \$3.1 Billion

Education - \$100 Million

NASA Johnson Space Center

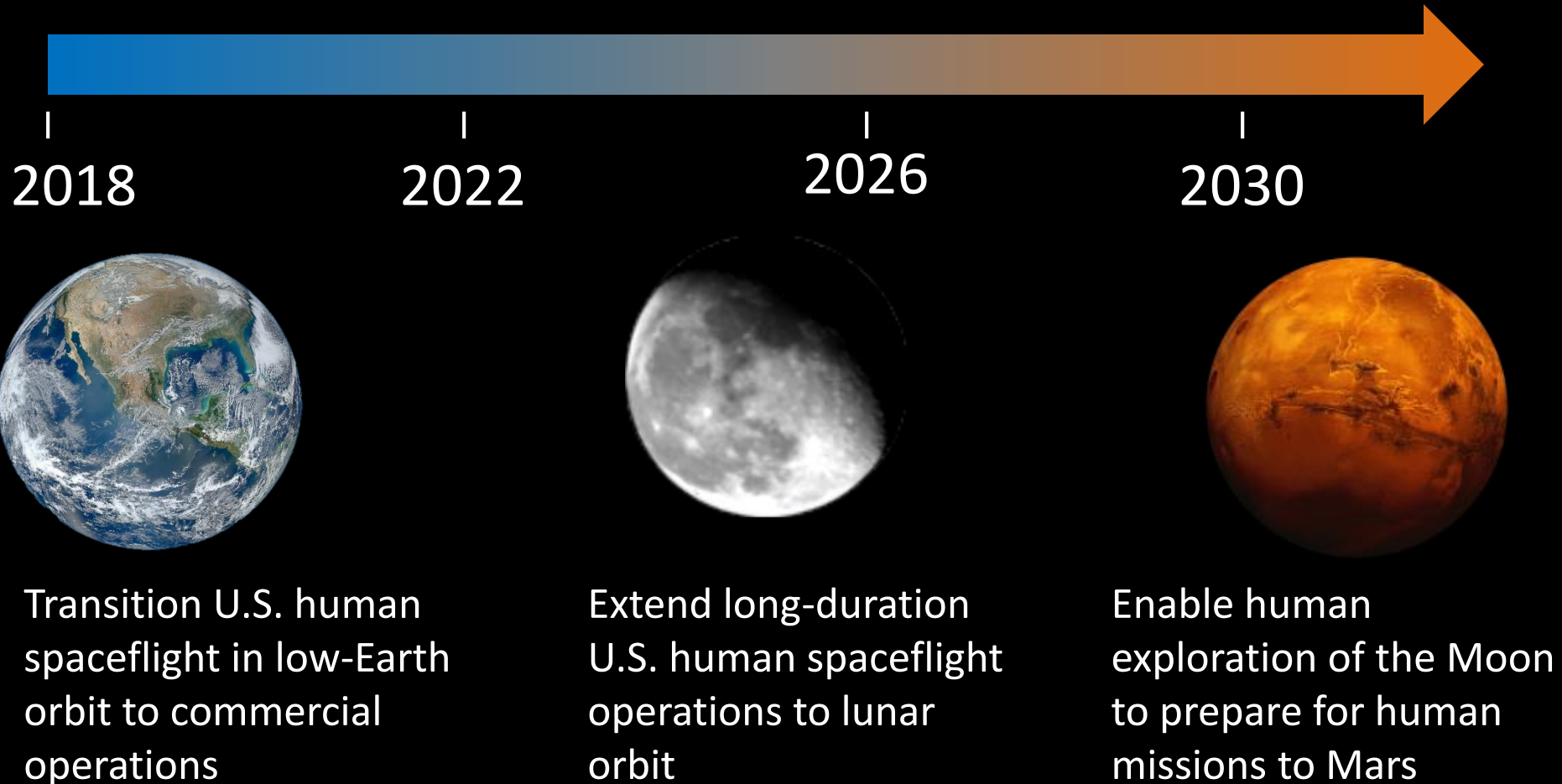


Engineering Structures Division: Systems Management on Major NASA Programs



Exploration Campaign

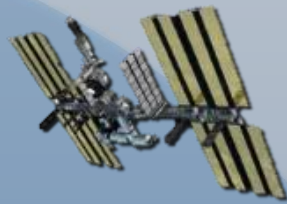
Updated December 2017



The Future of Human Space Exploration

NASA's Building Blocks to Mars

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



Learning the
fundamentals
aboard the
International
Space Station



Missions: 6 to 12 months
Return: hours

Earth Reliant

International Space Station

Began Construction: 1998

Purpose: Research

Future: Expanded commercial use

International Partners:



Canada



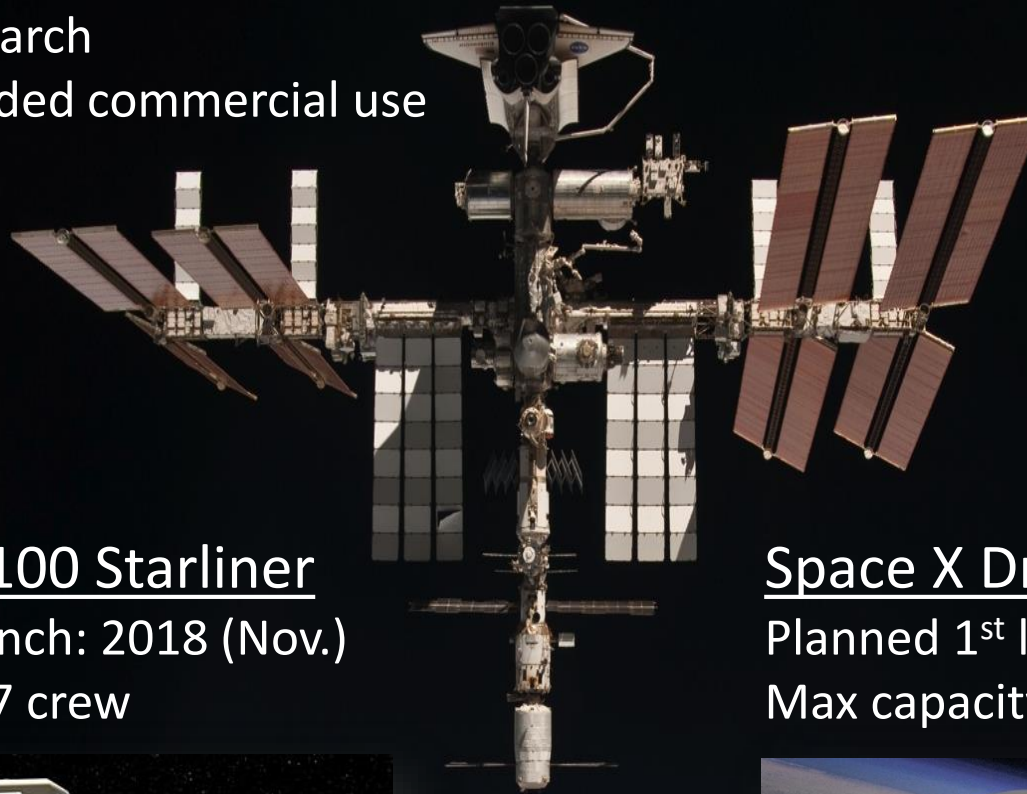
Russia



Europe



Japan



Boeing CST-100 Starliner

Planned 1st launch: 2018 (Nov.)

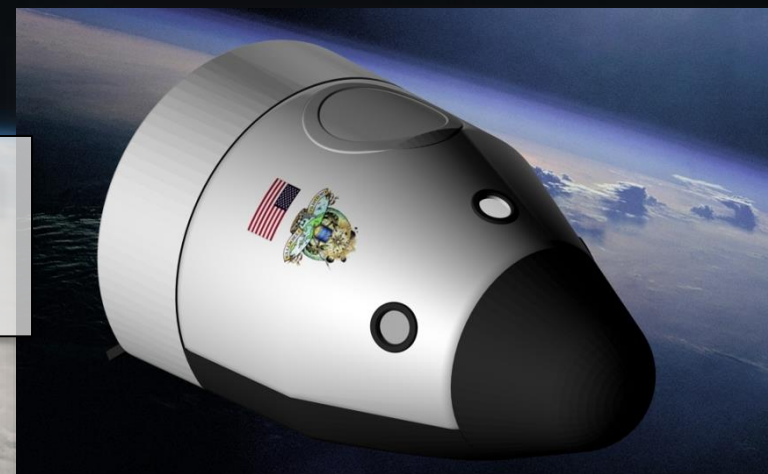
Max capacity: 7 crew



Space X Dragon Capsule

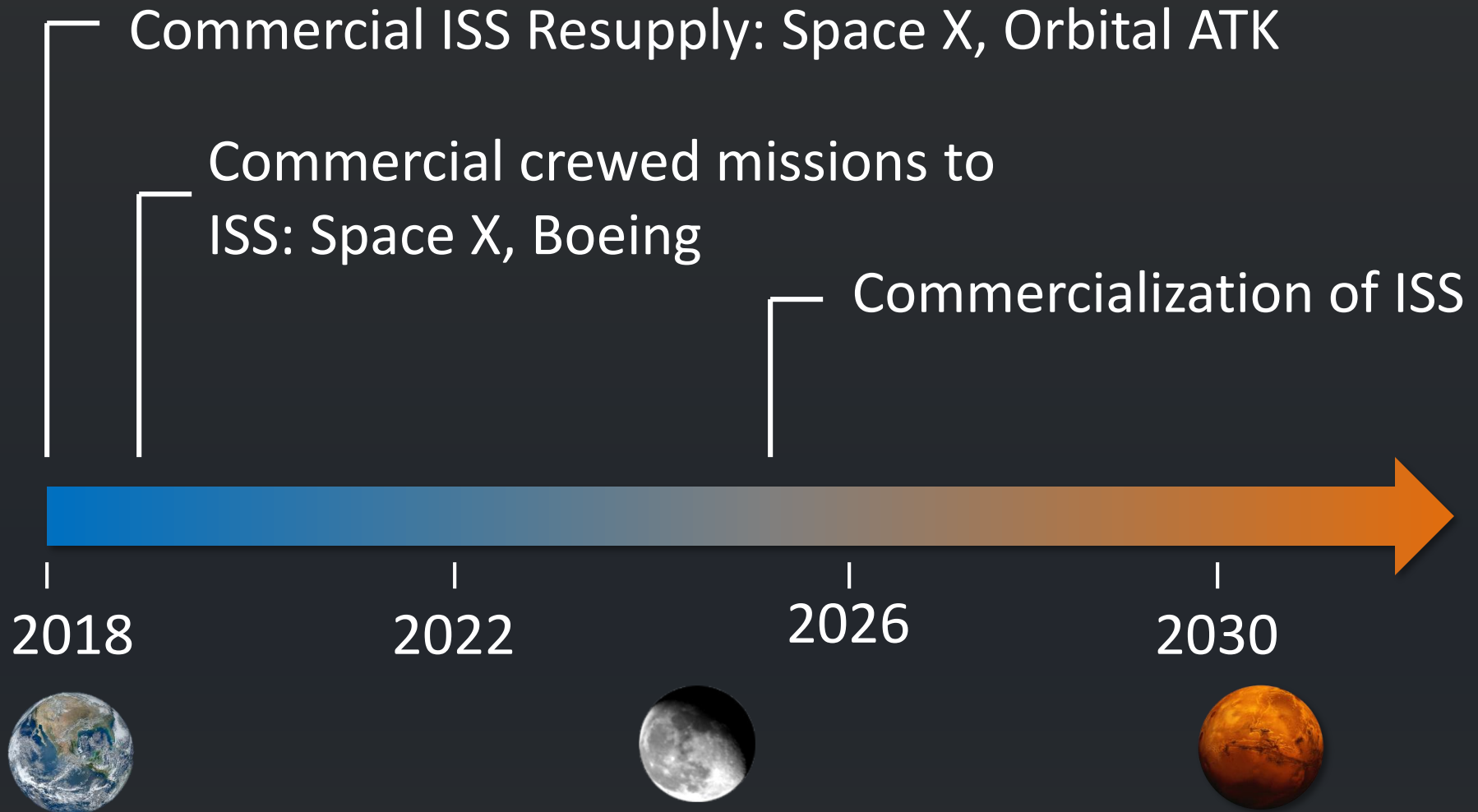
Planned 1st launch: 2018 (Dec.)

Max capacity: 7 crew



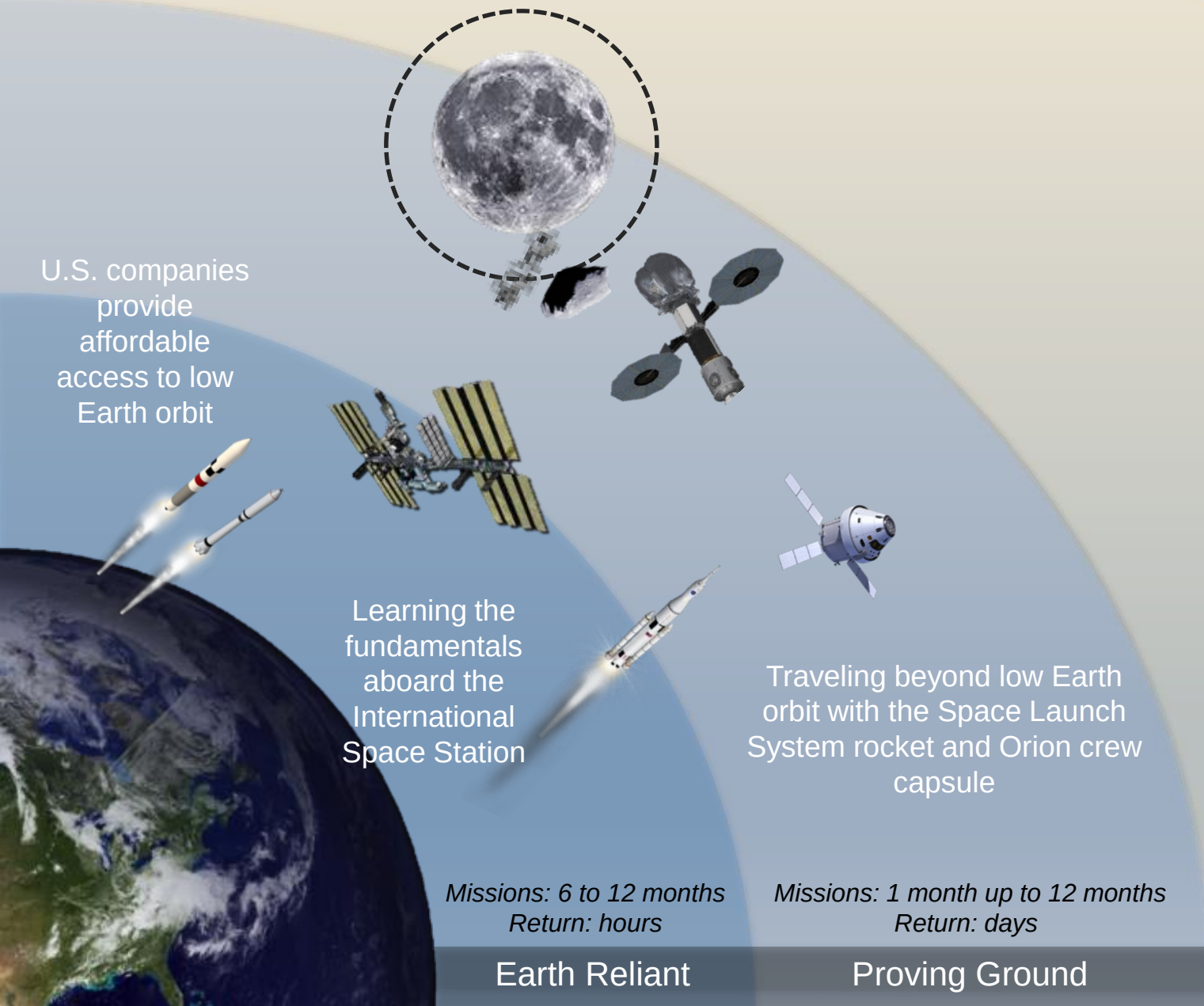
Commercial
Crew

Refocus NASA Resources from Low Earth Orbit to Deep Space Exploration



The Future of Human Space Exploration

NASA's Building Blocks to Mars



Orion

- Human capsule (5 crew max.)
- Service module (propulsion & power)
- Led at Johnson Space Center
- First test flight: 2014
- First manned flight: 2023

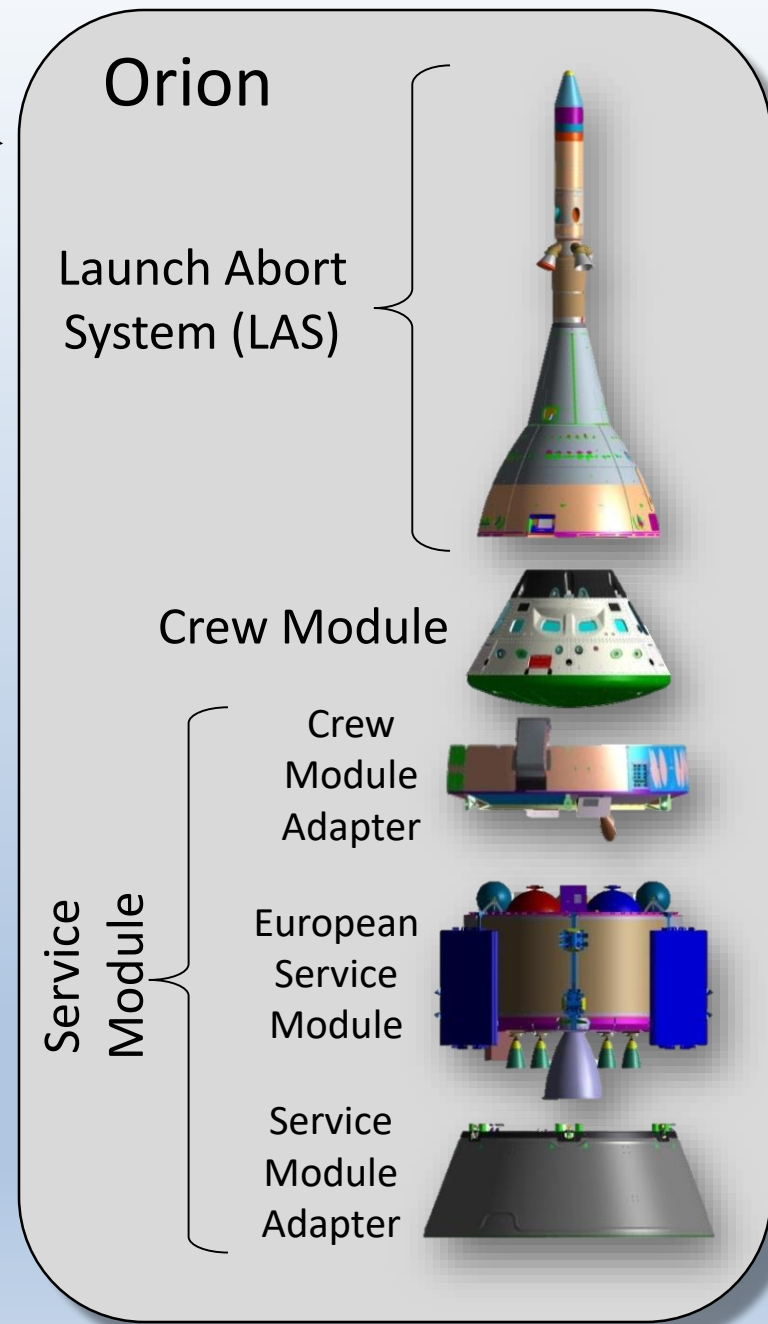
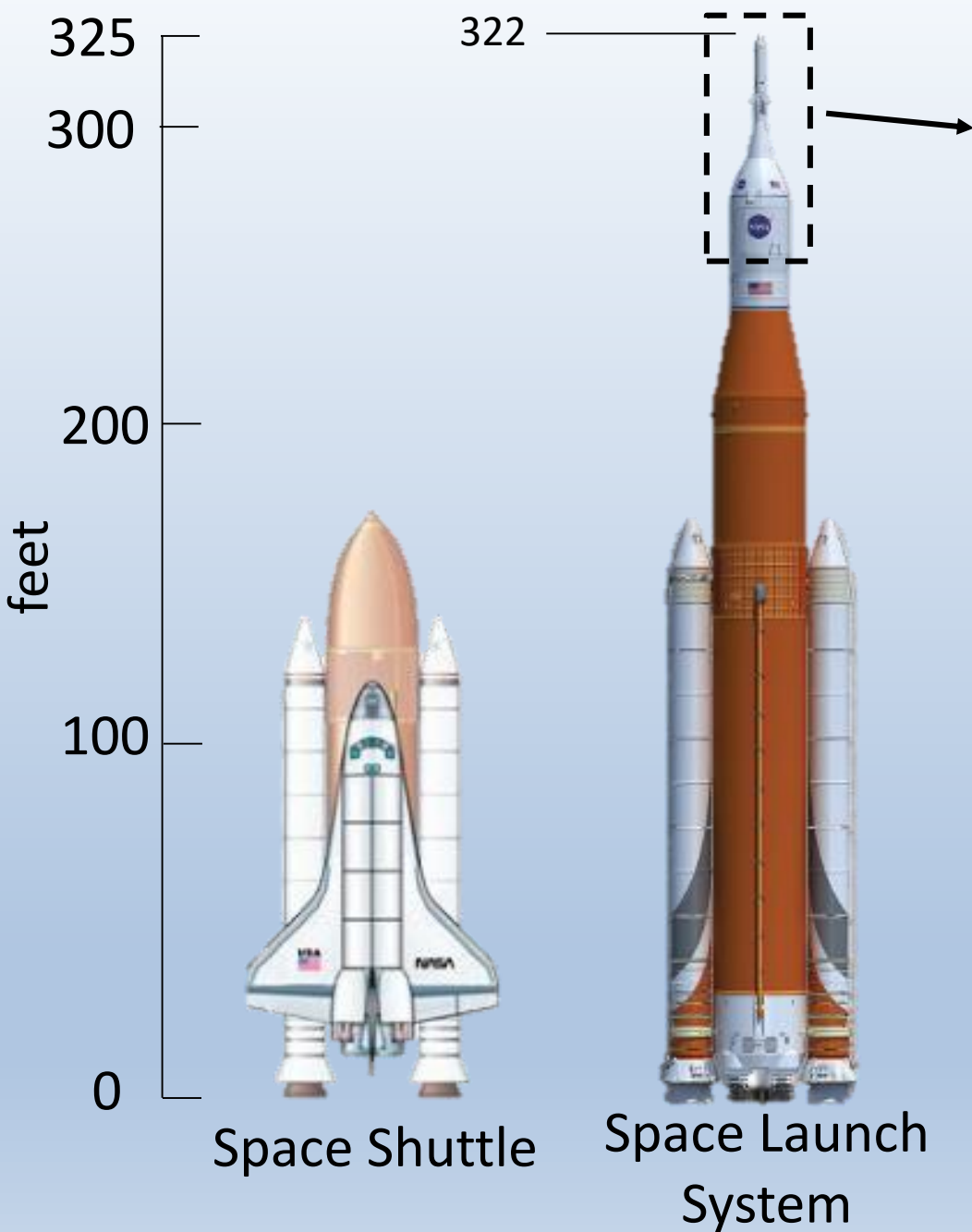


Space Launch System

- Most powerful rocket to date
- Deep space missions
- Led at Marshall Space Flight Center
- First launch: 2019

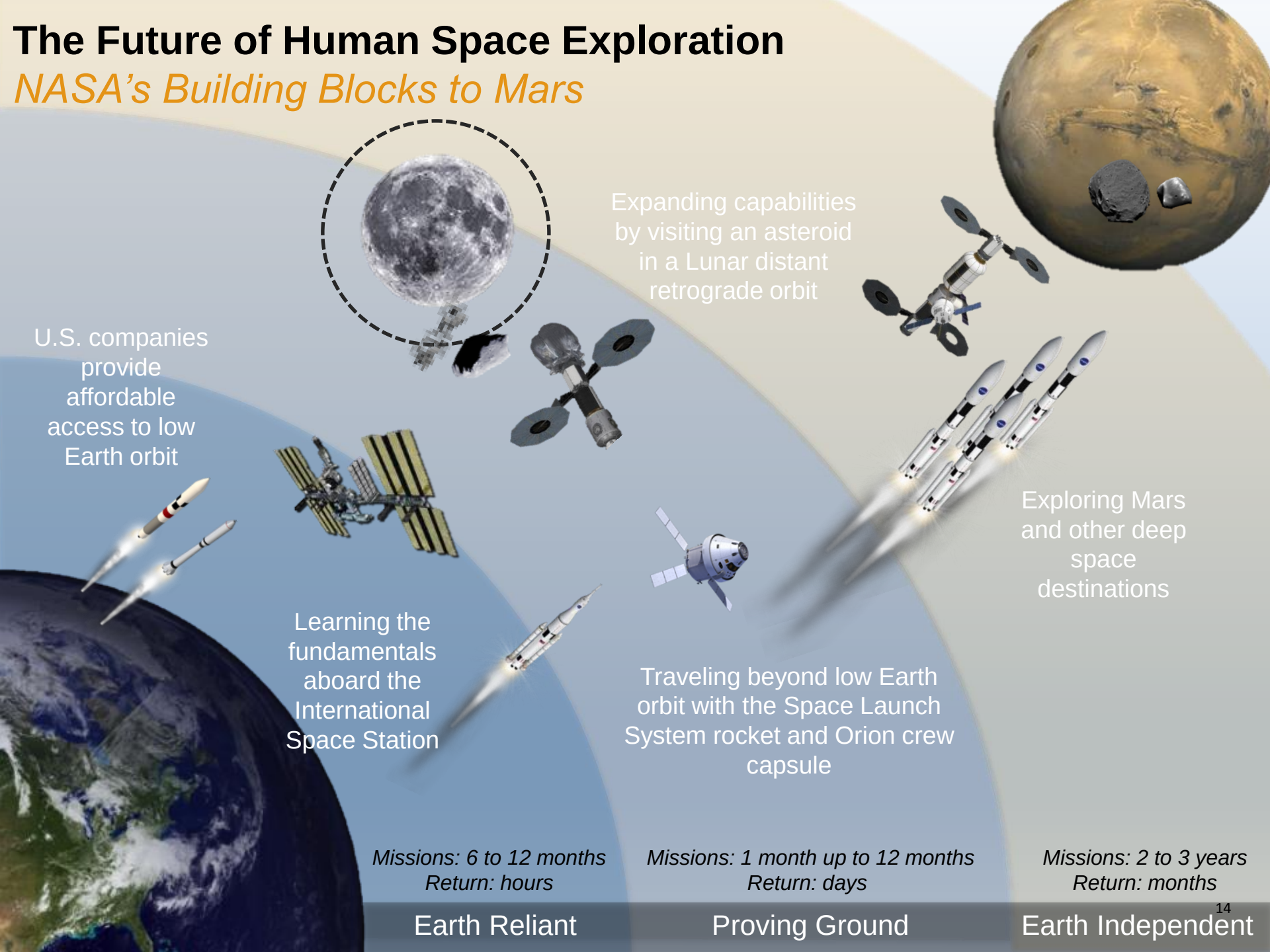


Launch site: Kennedy Space Center



The Future of Human Space Exploration

NASA's Building Blocks to Mars



Was Mars home
to microbial life? Is it today?

Could it be a safe home for
humans one day?

What can it teach us about life
elsewhere in the cosmos or how
life began on Earth?

What can it teach us about Earth's
past, present and future?

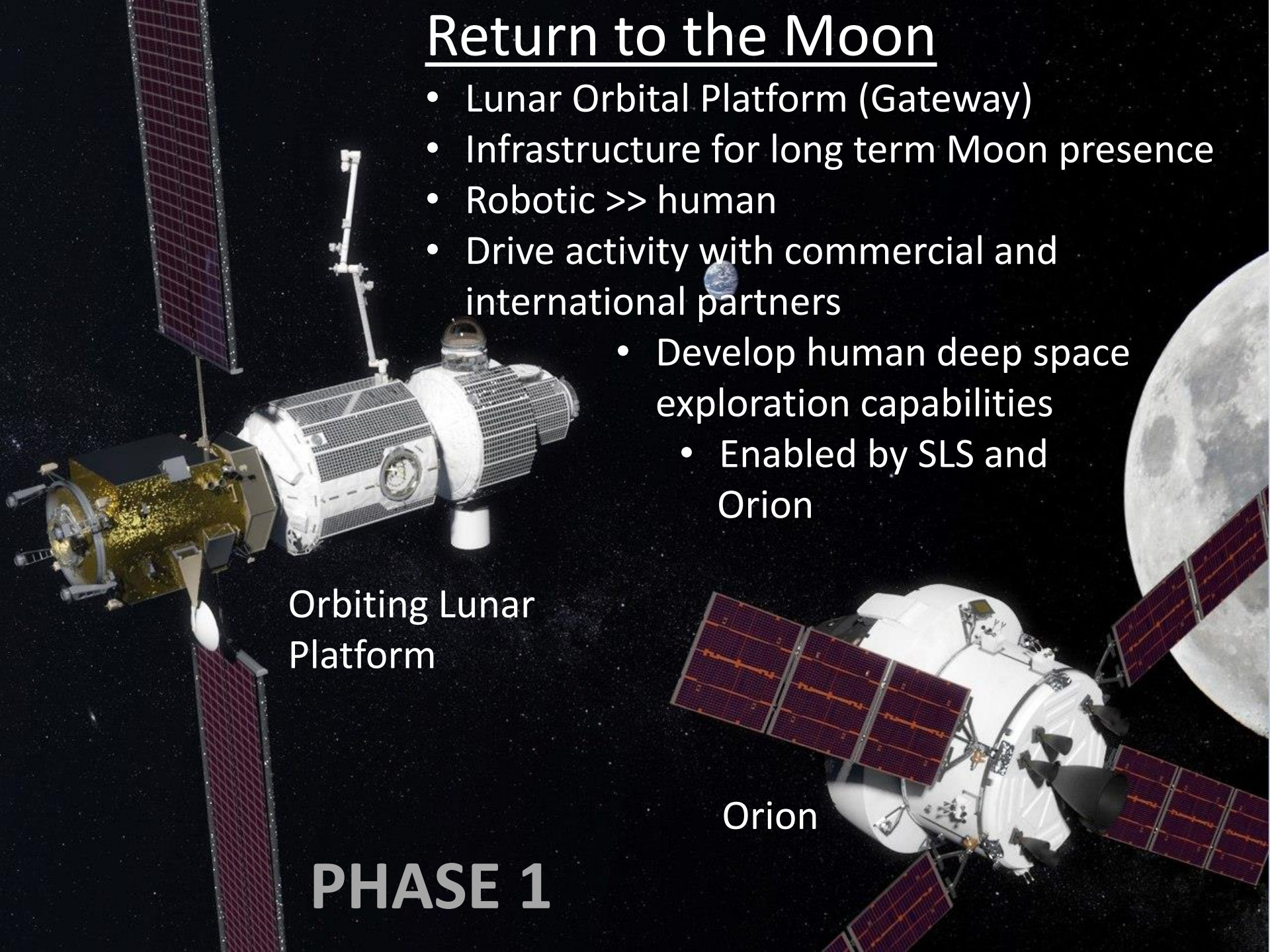
Return to the Moon

- Lunar Orbital Platform (Gateway)
- Infrastructure for long term Moon presence
- Robotic >> human
- Drive activity with commercial and international partners
- Develop human deep space exploration capabilities
 - Enabled by SLS and Orion

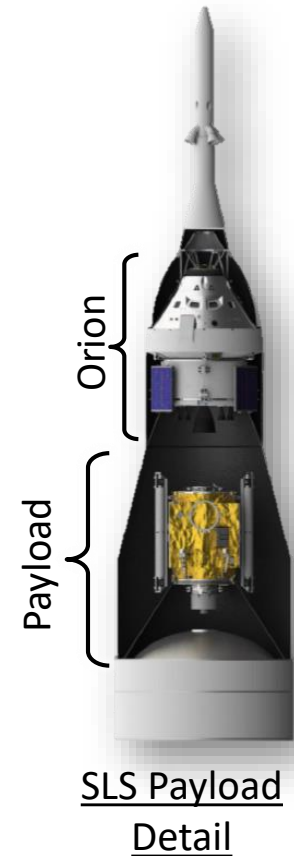
Orbiting Lunar Platform

Orion

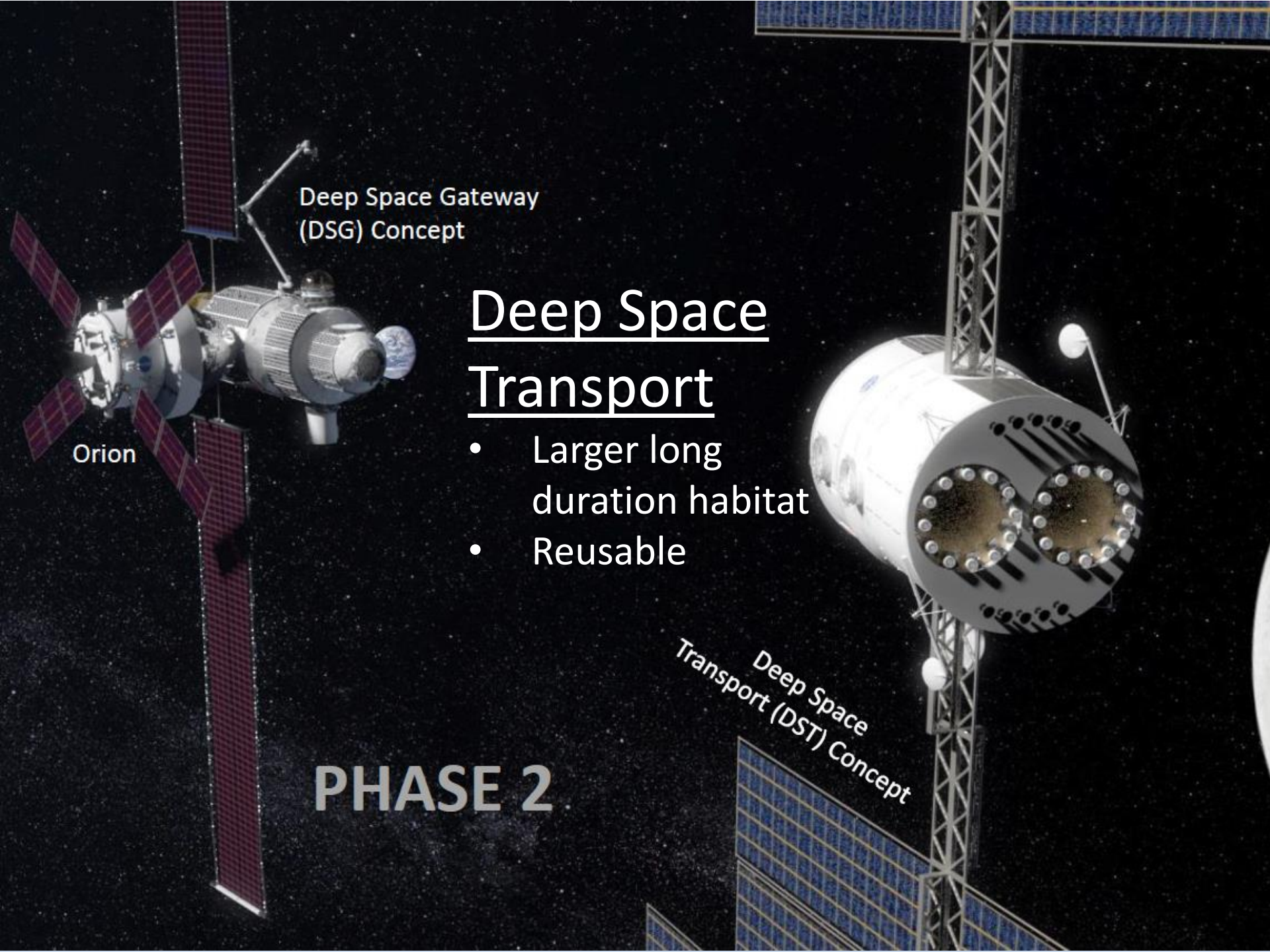
PHASE 1



Deep Space Gateway



Deep Space Gateway Buildup					
EM-1	Europa Clipper	EM-2	EM-3	EM-4	EM-5
2019 - 2025					2026
SLS Block 1 Crew: 0	SLS Block 1B Cargo Europa Clipper (subject to approval)	SLS Block 1B Crew: 4 CMP Capability: 8-9T 40kW Power/Prop Bus	SLS Block 1B Crew: 4 CMP Capability: 10mT Habitation	SLS Block 1B Crew: 4 CMP Capability: 10mT Logistics	SLS Block 1B Crew: 4 CPL Capability: 10mT Airlock
Distant Retrograde Orbit (DRO) 26-40 days	Jupiter Direct	Multi-TLI Lunar Free Return 8-21 days	Near Rectilinear Halo Orbit (NRHO) 16-26 days	NRHO, w/ ability to translate to/from other cislunar orbits 26-42 days	NRHO, w/ ability to translate to/from other cislunar orbits 26-42 days
Gateway (blue) Configuration (Orion in grey)			Cislunar Support Flight	Cislunar Support Flight	

The image shows two spacecraft concepts against a black background with stars. On the left is the Orion spacecraft, a white capsule with four red solar panels. On the right is the Deep Space Gateway (DSG) Concept, a large white cylindrical station with a complex truss structure and blue solar panels. The Earth is visible in the distance.

Deep Space Gateway
(DSG) Concept

Orion

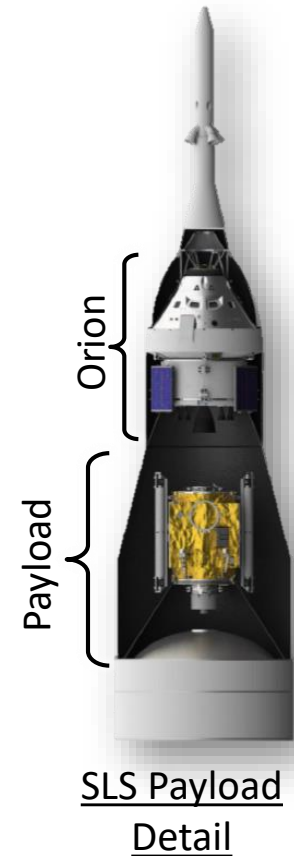
Deep Space Transport

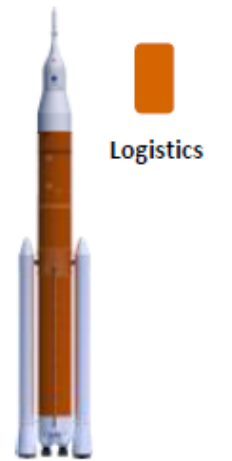
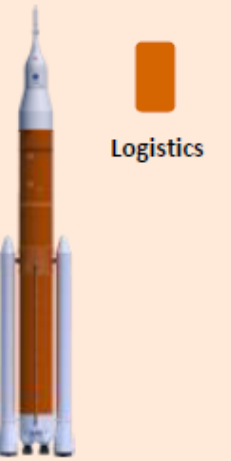
- Larger long duration habitat
- Reusable

Deep Space
Transport (DST) Concept

PHASE 2

Mars Transit



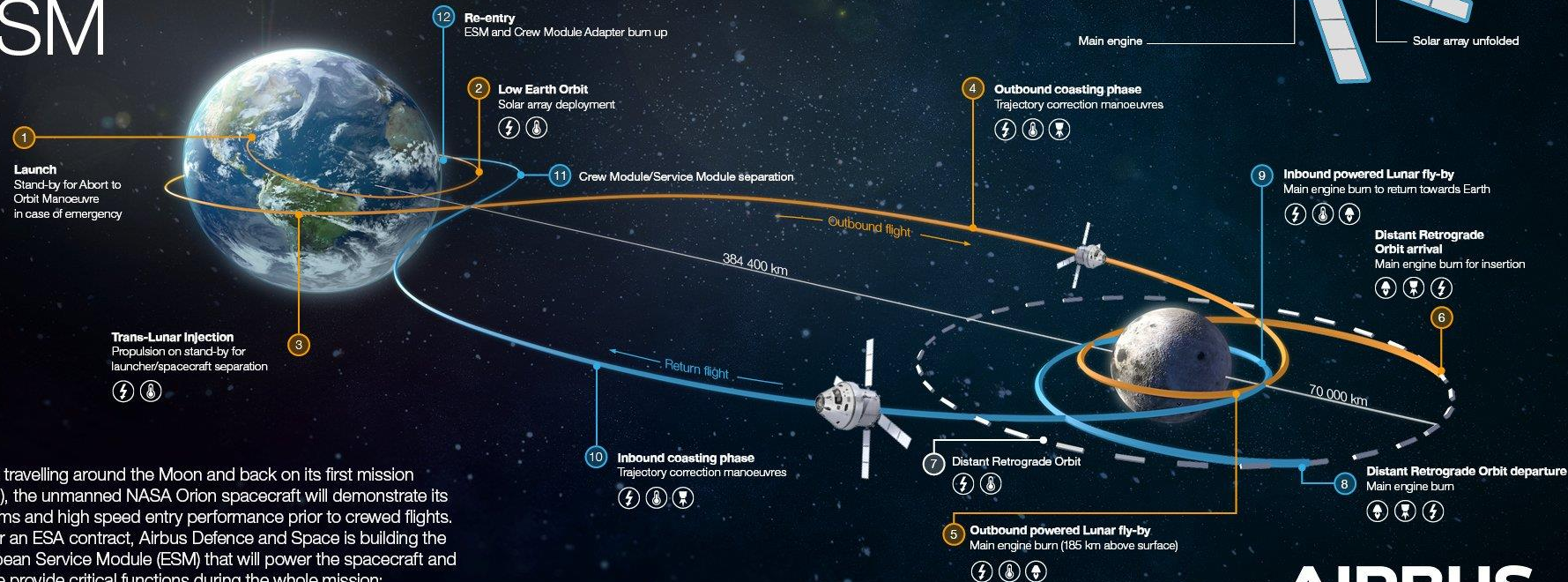
Transport Delivery		Transport Shakedown		Mars Transit	
EM-6	EM-7	EM-8	EM-9	EM-10	EM-11
2027		2028 / 2029		2030+	
SLS Block 1B Cargo P/L Capability: 41t TLI  Deep Space Transport	SLS Block 1B Crew: 4 CMP Capability: 10t  Logistics	SLS Block 1B Cargo P/L Capability: 41t TLI  DST Logistics & Refueling	SLS Block 2 Crew: 4 CMP Capability: 13+t  Logistics	SLS Block 2 Cargo P/L Capability: 45t TLI  DST Logistics & Refueling	SLS Block 2 Crew: 4 CMP Capability: 13+t  Logistics
 Cislunar Support Flight DST checkout in NRHO 191-221 days		 Cislunar Support Flight DSG: continued operations in cislunar space DST: shakedown in cislunar space with return to DSG in NRHO 300-400 days		 Cislunar Support Flight DSG: continued operations in cislunar space DST: Mars transit and return to DSG in NRHO	

Orion Exploration Mission 1 (EM-1)

- Un-crewed mission around the moon
- Launch date: June 2020



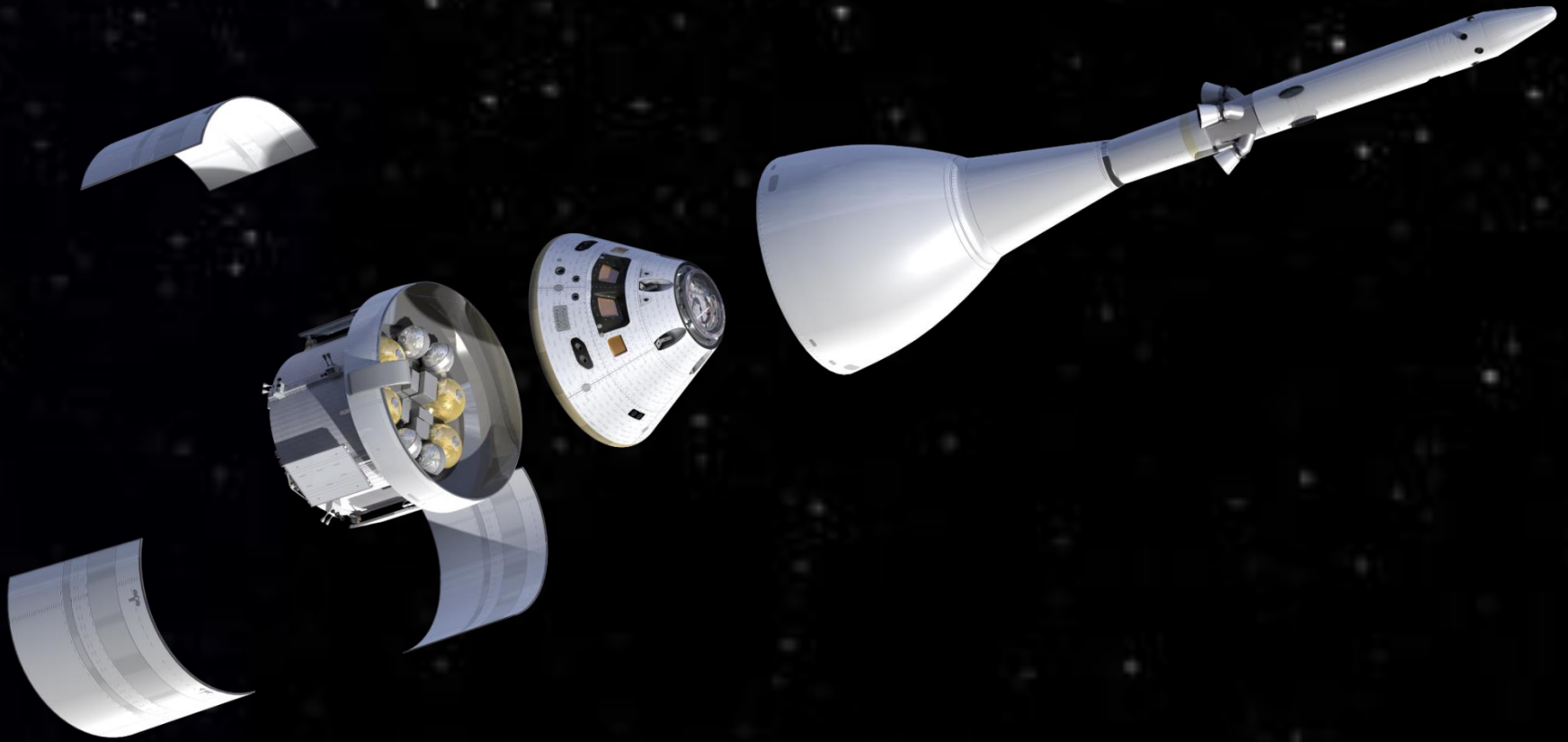
Orion: A Journey around the Moon Powered by Airbus' ESM

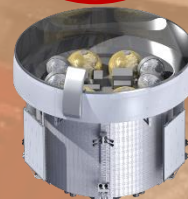


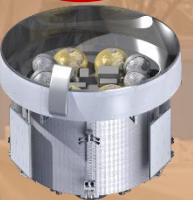
While travelling around the Moon and back on its first mission (EM-1), the unmanned NASA Orion spacecraft will demonstrate its systems and high speed entry performance prior to crewed flights. Under an ESA contract, Airbus Defence and Space is building the European Service Module (ESM) that will power the spacecraft and hence provide critical functions during the whole mission:

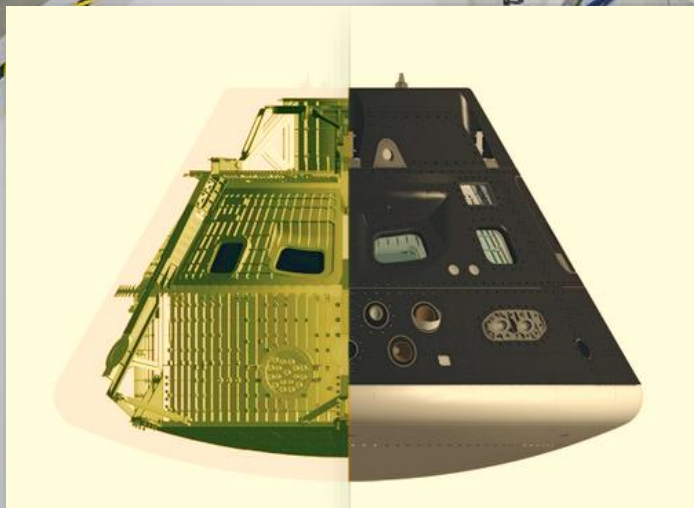
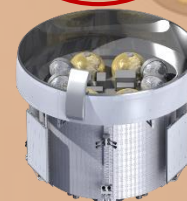
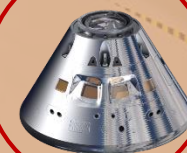
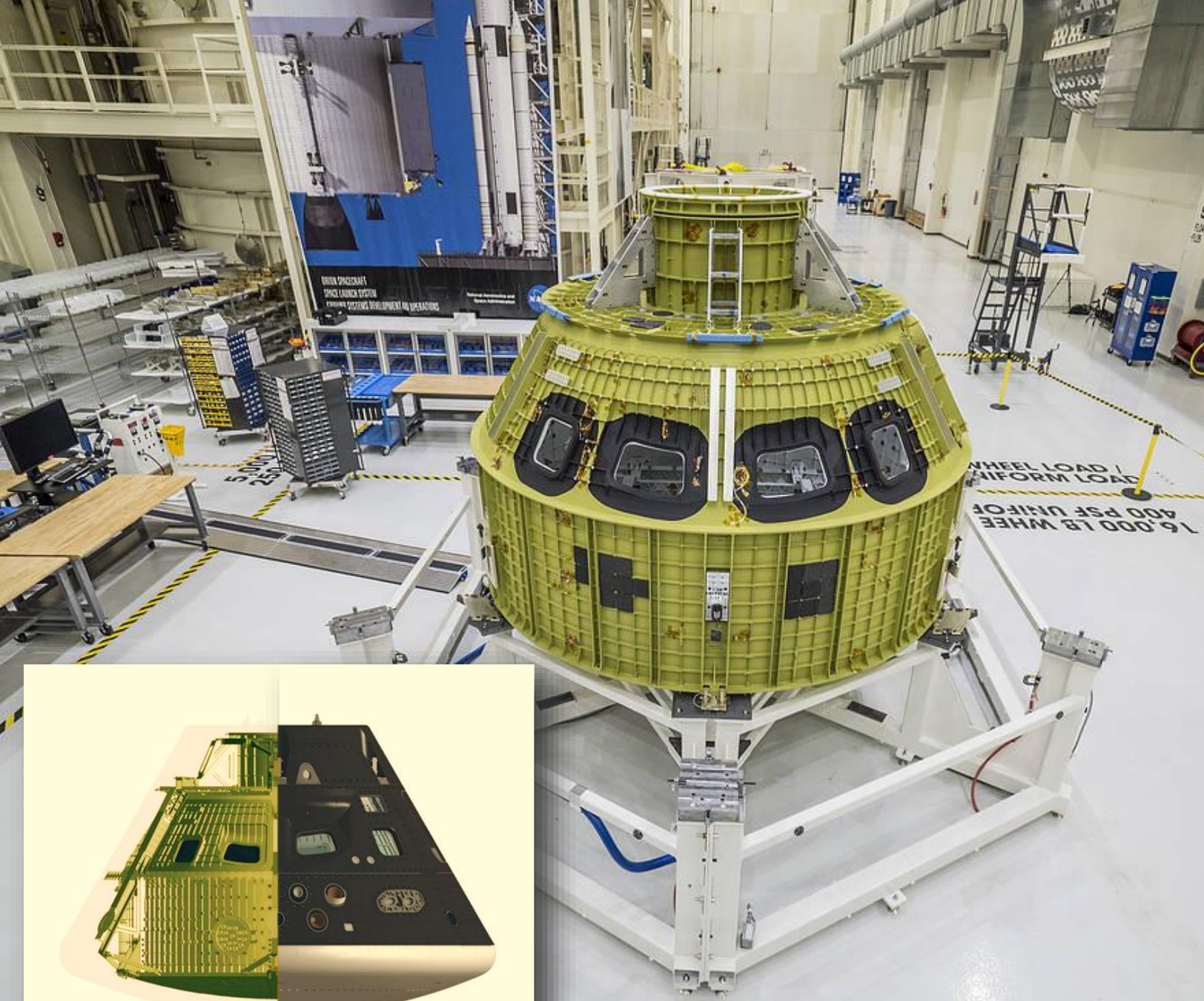
AIRBUS

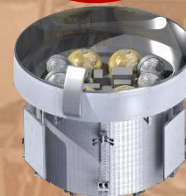
Orion Fabrication

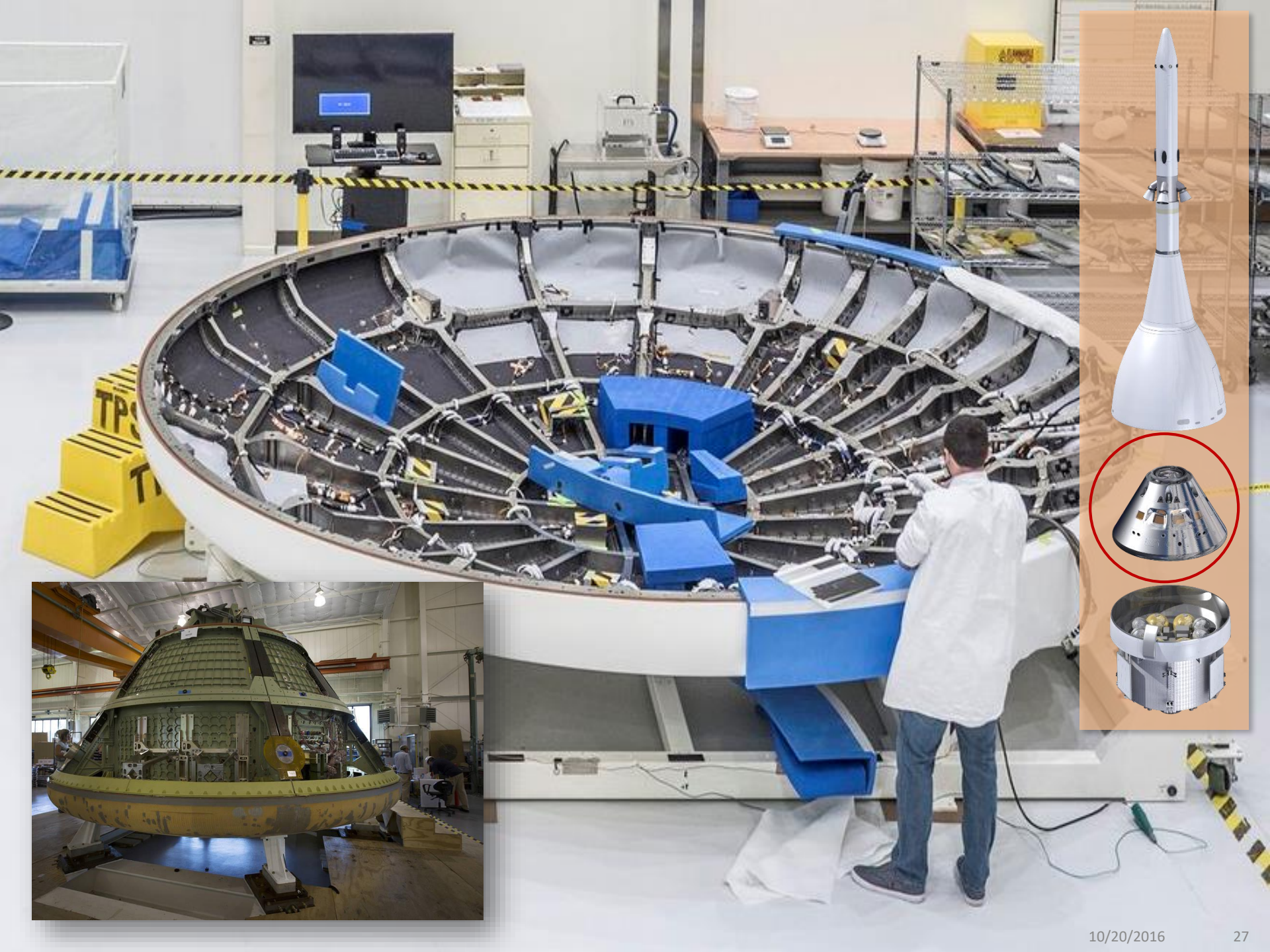


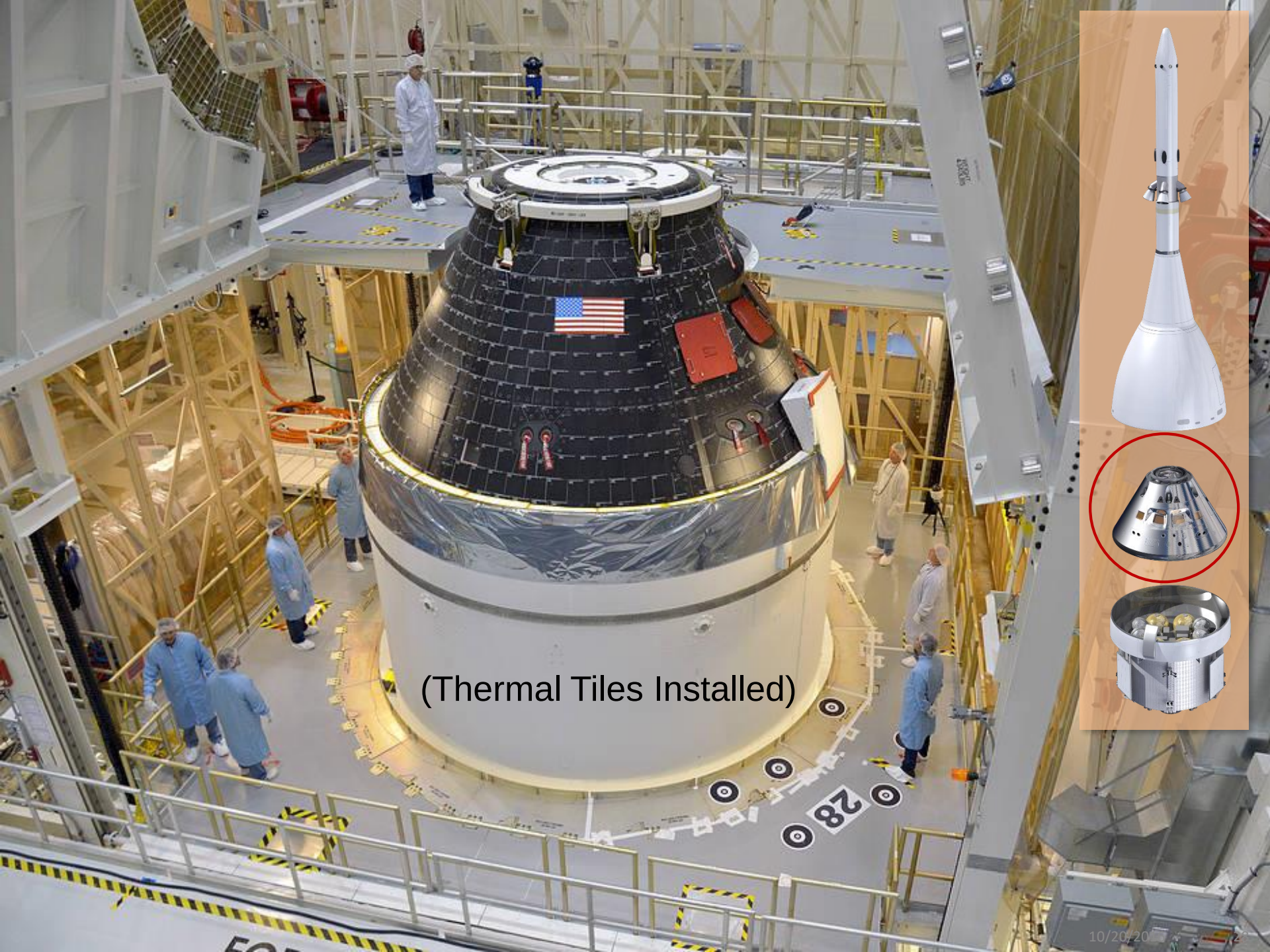




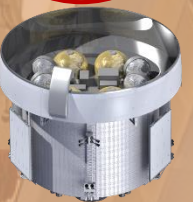


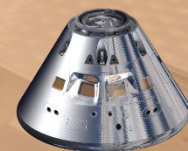
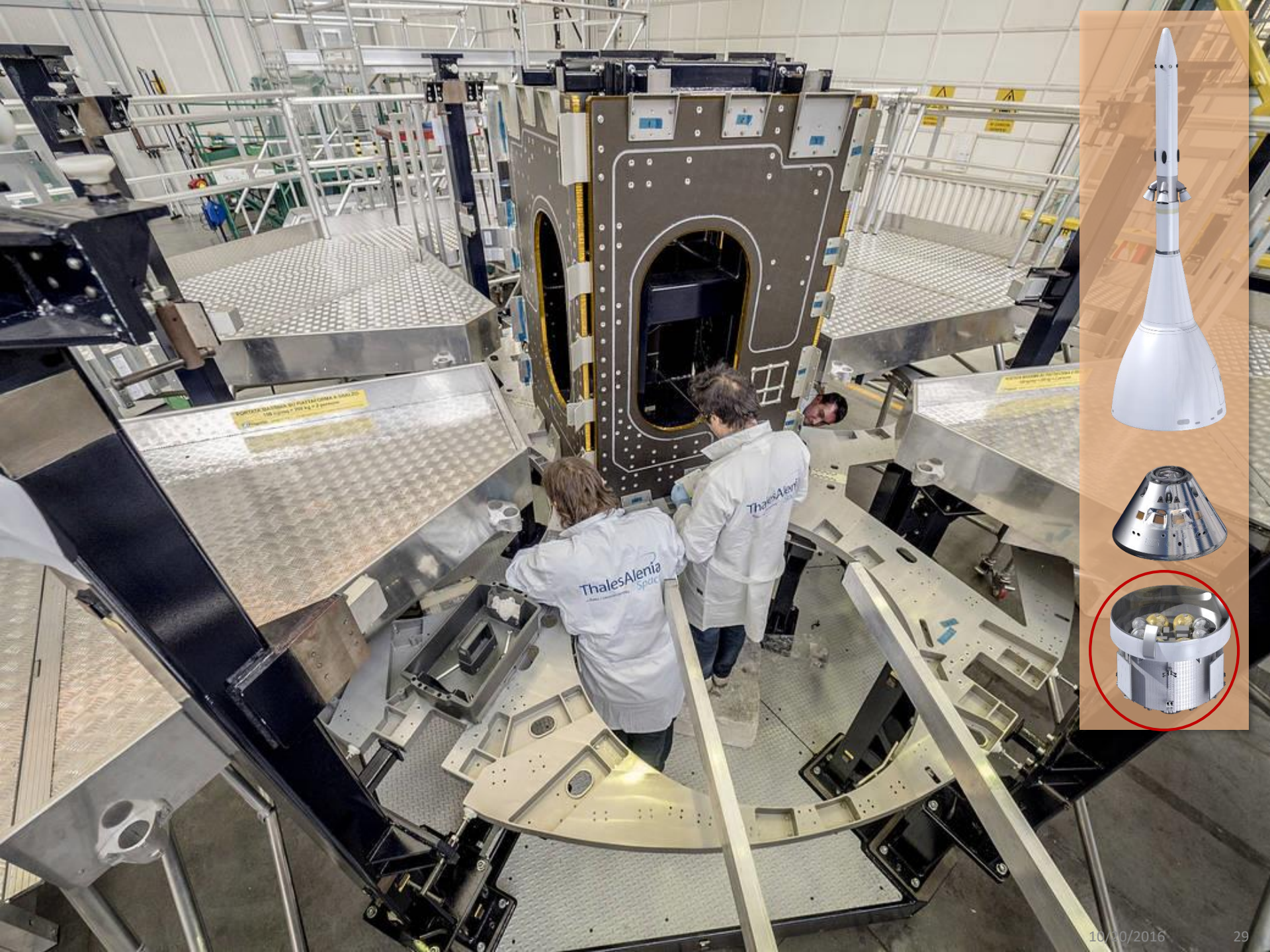


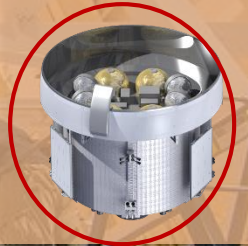
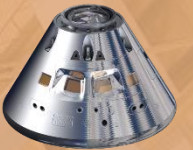




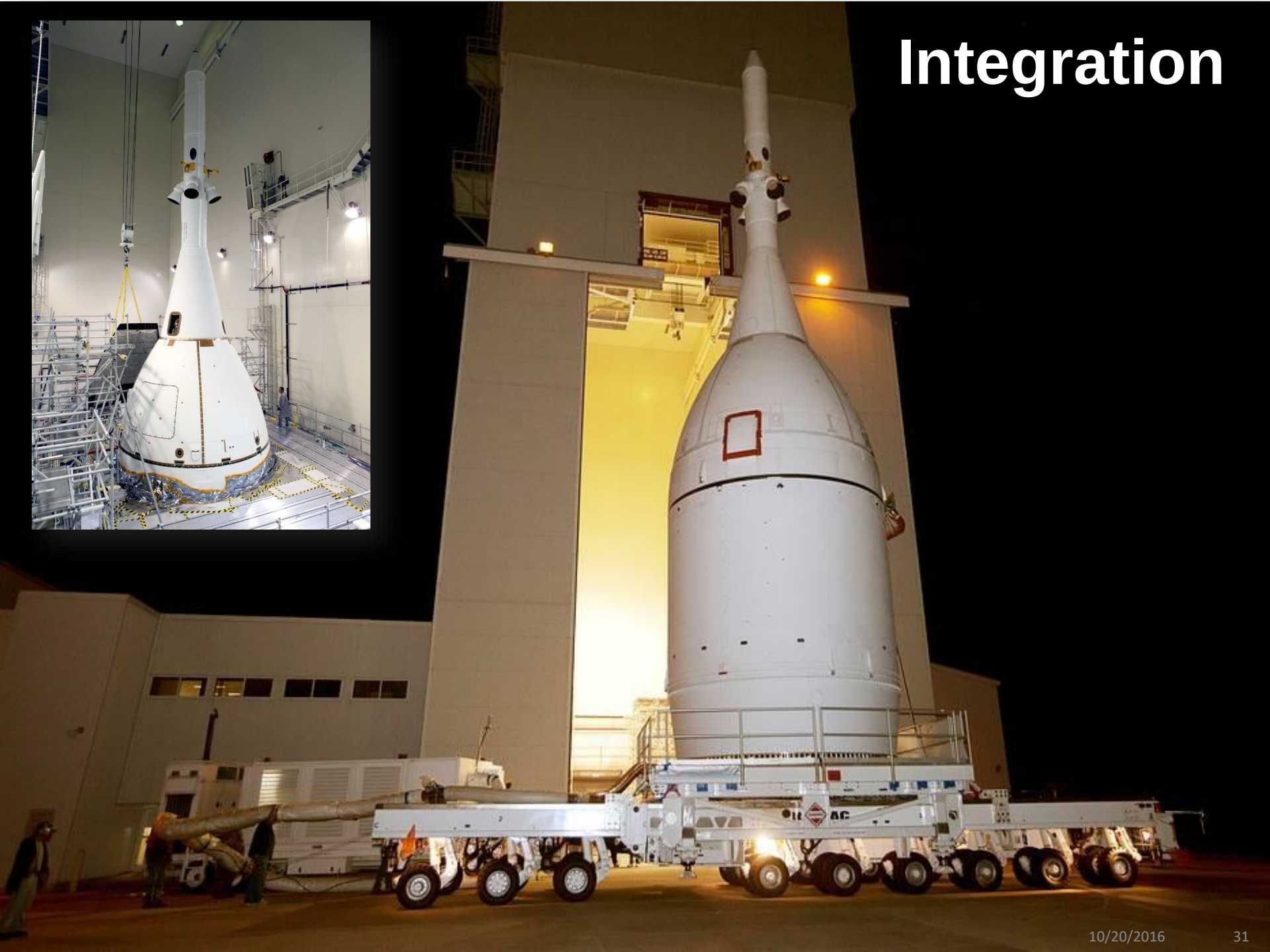
(Thermal Tiles Installed)







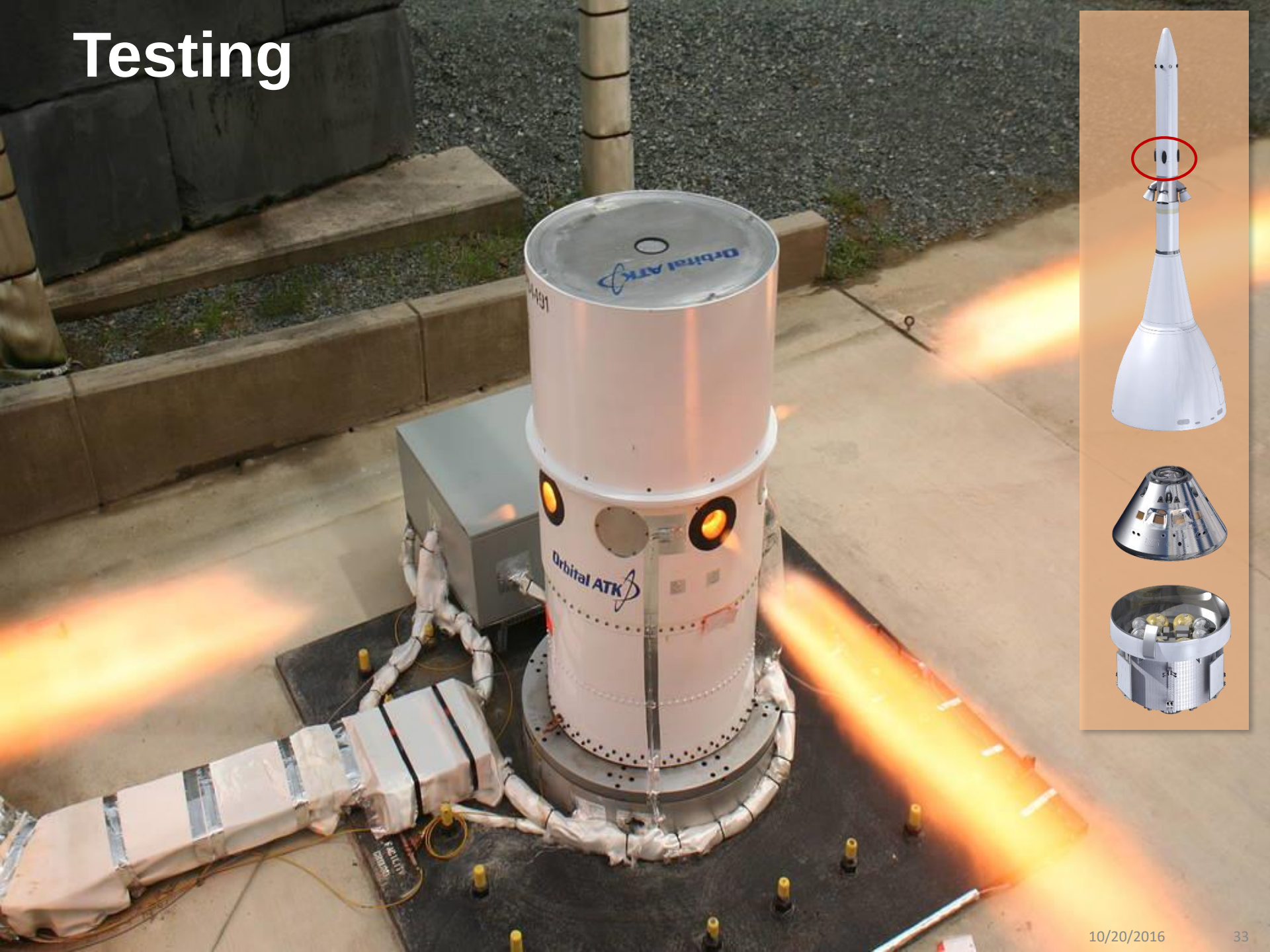
Integration



Testing



Testing



Launch



Re-entry



Recovery



Questions?

Mack McElroy, PhD
mark.w.mcelroy@nasa.gov

