The National Space Exploration Campaign Update

for the
National Space Council Users' Advisory Group

November 15, 2018

EXPLORE
HUMANS *in* SPACE

FOR ALL HUMANITY

Space Policy Directive-1

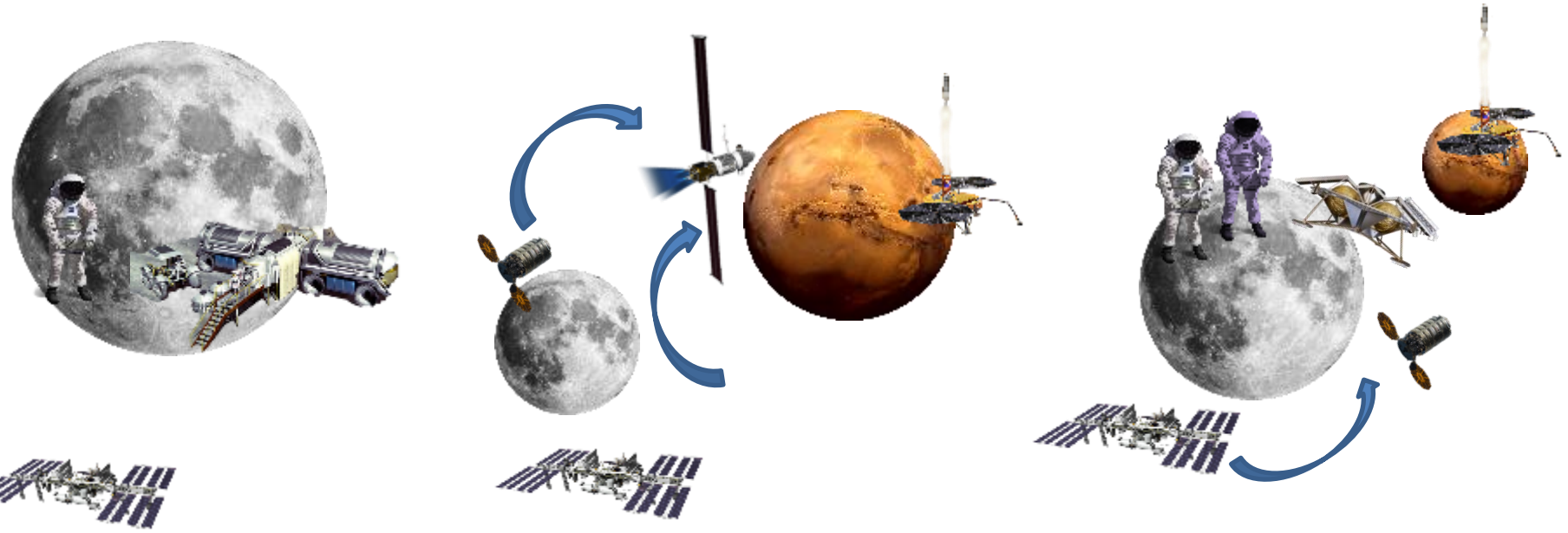
“Lead an ***innovative and sustainable*** program of exploration ***with commercial and international partners*** to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities.

Beginning with missions beyond low-Earth orbit, ***the United States will lead the return of humans to the Moon for long-term exploration and utilization***, followed by human missions to Mars and other destinations.”

Last Year: Three Implementation Approaches Studied

COMMON ELEMENTS

Greater use of ISS and commercial LEO in near-term. Americans around the Moon to follow in 2022, first beyond LEO since 1972. Commercial robotic lunar cargo and early emplacement of small payloads by 2020. Initial Cislunar presence for U.S. leadership by 2022.



APPROACH #1: Moon to Stay	APPROACH #2: Moon-Mars in Parallel	APPROACH #3: Cislunar Campaign
Focus on the lunar surface	Focus on firsts to/from Mars	Focus on cislunar infrastructure and exploration, with Mars as the horizon goal

Permutations exist for each approach, based on Acquisition, Partnering, and Programmatics

National Exploration Campaign – Five Strategic Goals

1) Transition U.S. human spaceflight in LEO to commercial operations that support NASA and the needs of an emerging commercial economy.

2) Lead the emplacement of capabilities that support lunar surface operations and facilitate missions beyond cislunar space.

3) Foster scientific discovery and characterization of lunar resources through a series of robotic missions.

4) Return U.S. astronauts to the surface of the Moon for a sustained campaign of exploration and utilization.

5) Demonstrate on the Moon the capabilities required for human missions to Mars and other destinations.

Low Earth Orbit & the International Space Station

- Over ***30*** Commercial payload facilities have launched and operated on the ISS through the National Lab
- Participation from ***40*** different commercial companies across the globe
- 2 Unique Crew Vehicle designs flying to ISS 2019

International Participation from 103 Nations Across the World

Cis-lunar Space: A Deep Space Harbor for Expanded Human Presence

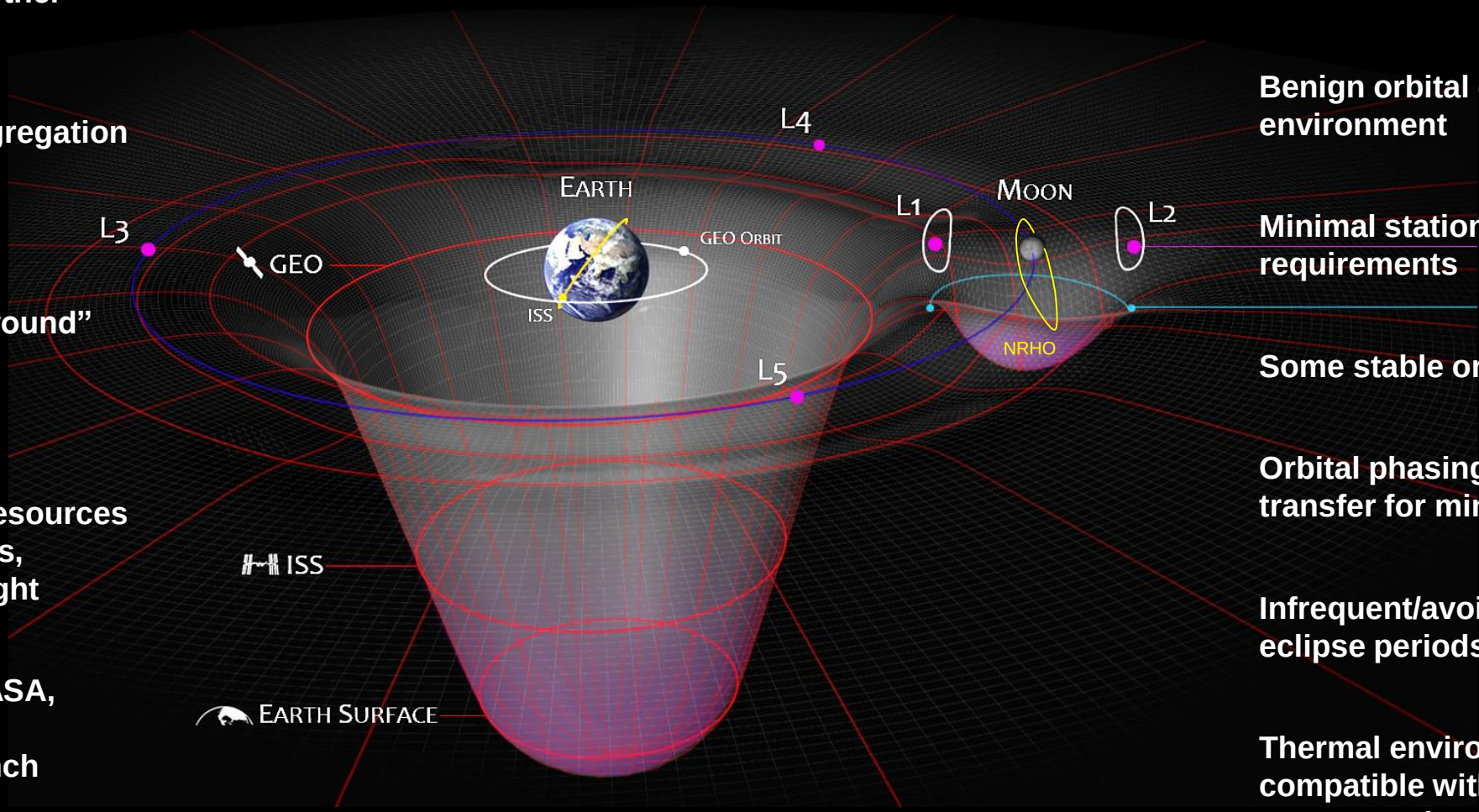
Only ~3 to 5 days away from Earth yet farther than Apollo went

Ideal mission aggregation location

The next “high ground” beyond GEO

Access to local resources including volatiles, gravity and sunlight

Accessible by NASA, commercial, and international launch systems



True deep space radiation environment

Benign orbital debris environment

Minimal station keeping requirements

Some stable orbits

Orbital phasing and transfer for minimal energy

Infrequent/avoidable eclipse periods

Thermal environment compatible with cryogenic oxygen and methane

GATEWAY

A homeport for human and robotic Exploration of the Moon and beyond

HUMAN ACCESS TO & FROM LUNAR SURFACE

Astronaut support and teleoperations of surface assets.

U.S. AND INTERNATIONAL CARGO RESUPPLY

Expanding the space economy with supplies delivered aboard partner ships that also provide interim spacecraft volume for additional utilization.

INTERNATIONAL CREW

International crew expeditions for up to 30 days as early as 2024. Longer expeditions as new elements are delivered to the Gateway.

SAMPLE RETURN

Pristine samples robotically delivered to the Gateway for safe processing and return to Earth.

SCIENCE AND TECH DEMOS

Support payloads inside, affixed outside, free-flying nearby, or on the lunar surface. Experiments and investigations continue operating autonomously when crew is not present.

COMMUNICATIONS RELAY

Data transfer for surface and orbital robotic missions and high-rate communications to and from Earth.

SIX DAYS TO ORBIT THE MOON

The orbit keeps the crew in constant communication with Earth and out of the Moon's shadow.

A HUB FOR FARTHER DESTINATIONS

From this orbit, vehicles can embark to multiple destinations: The Moon, Mars and beyond.

GATEWAY SPECS

- 50 kW Solar Electric Propulsion
- 4 Crew Members
- 30-90 Day Crew Missions
- 125 m^3 Pressurized Volume
- Up to 75 mt with Orion docked

ACCESS

384,000 km from Earth

Accessible via NASA's SLS as well as international and commercial ships.

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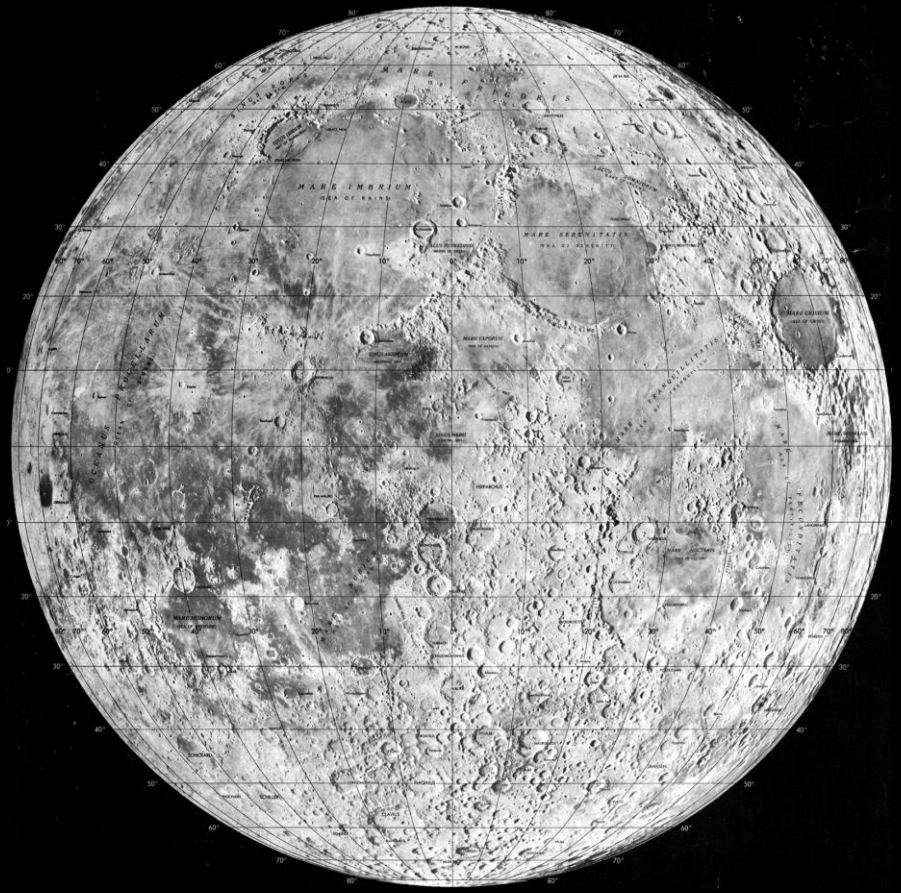
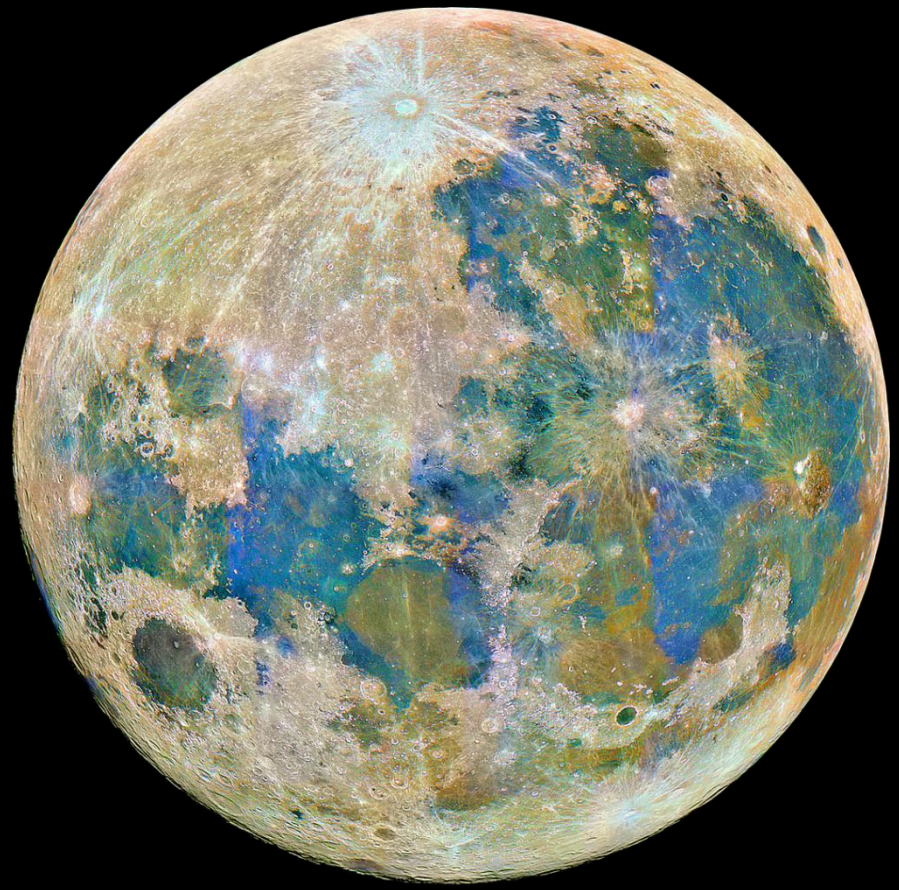
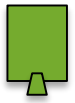
50 Years of Lunar Knowledge





Three Stage Lunar Architecture

Available launch vehicles and physics are what has driven the three stage lunar architecture:



Ascent Element: Based at Gateway and reusable and refuelable. Carries a crew of 4.

Descent Element: Performs descent propulsion and serves as a cargo lander.

Transfer Vehicle: Transfers ascent and descent elements (if applicable) from Gateway orbit to lower orbit for landing. Potential for reusability and could be provided as a commercial service

Other Benefits

Phased Development

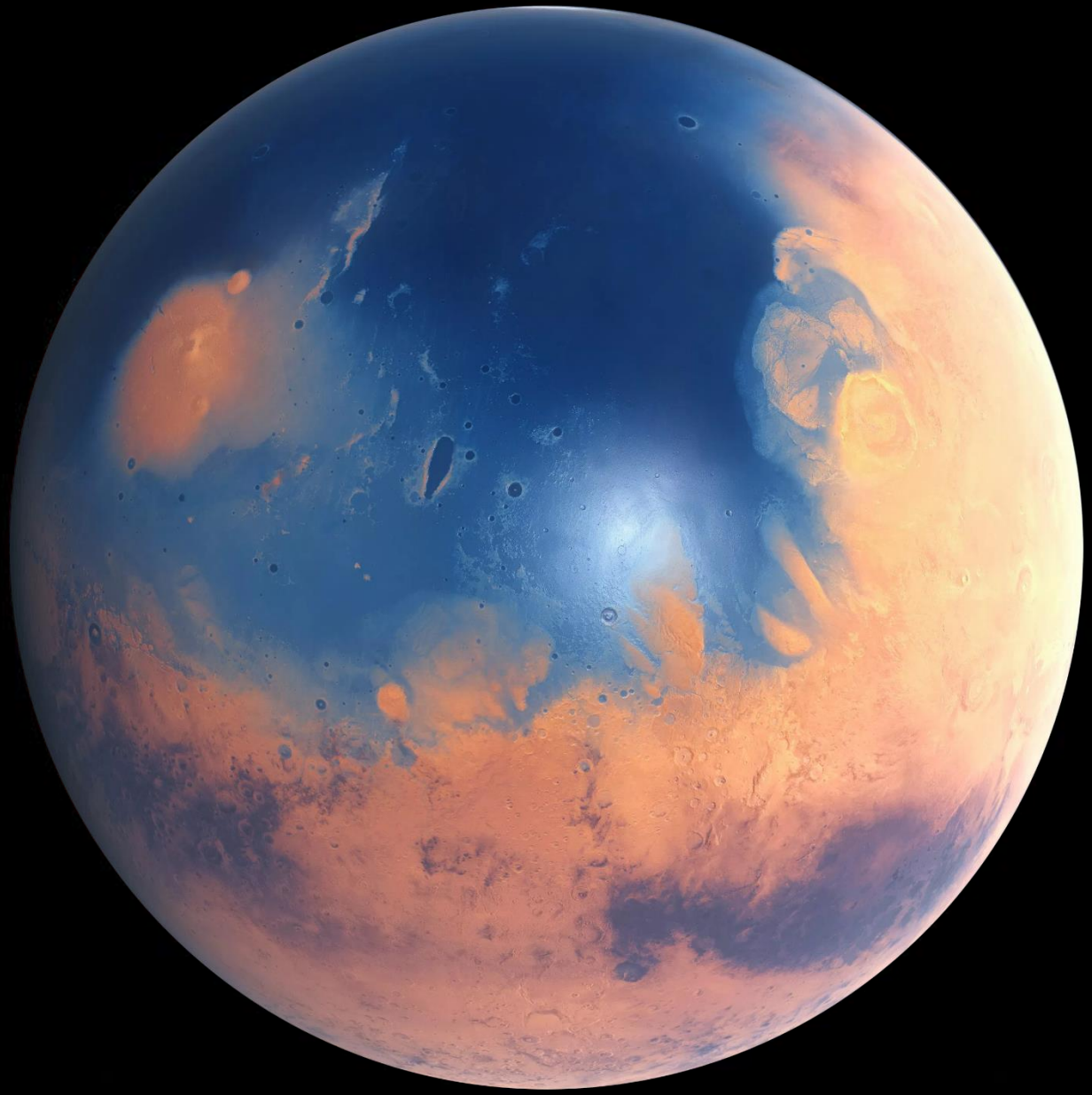
- Spreads out costs evenly, while getting a capability for landing science and exploration payloads on the moon in support of future crewed missions.
- Human rating requirements are minimal on the upfront developments, as the ascent element with its full abort capability at any crewed mission phase addresses many of the human rating requirements.

Partnering Opportunities

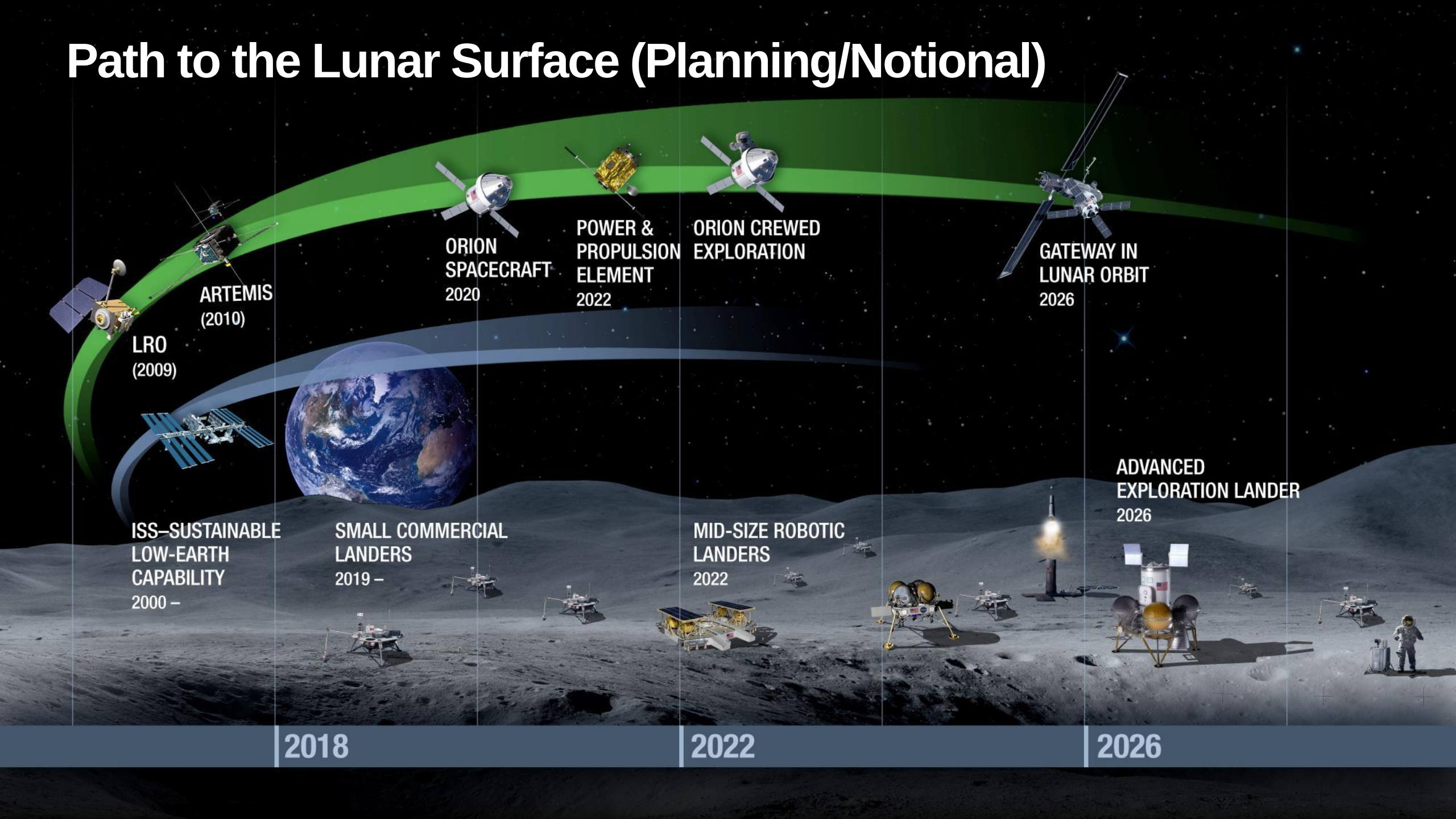
- Smaller elements, enable easier point of entry for both commercial and international partners; both now and in the future so long as interoperability standards are established.
- Industry partners can move ahead faster with the capabilities they want to build, while NASA builds and sustains its unique competencies with respect to deep space human systems on the ascent element.

Multi-use Systems

- Elements (or copies of them) can be applied to other missions to greatly increase their payload or reduce transportation time (deep space rendezvous with tug for outer planet missions, satellite maneuvering in GEO vicinity, etc)
- Alternate crewed cis-lunar missions like a NEO rendezvous, a tour of L4/L5 to see what small objects may have settled there, or missions to L1 or L2 for deploy or servicing of remote sensing systems are possible.
- The lunar elements may be partially or fully applicable to aspects of future Mars missions (common ascent systems, etc).



Path to the Lunar Surface (Planning/Notional)



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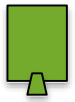

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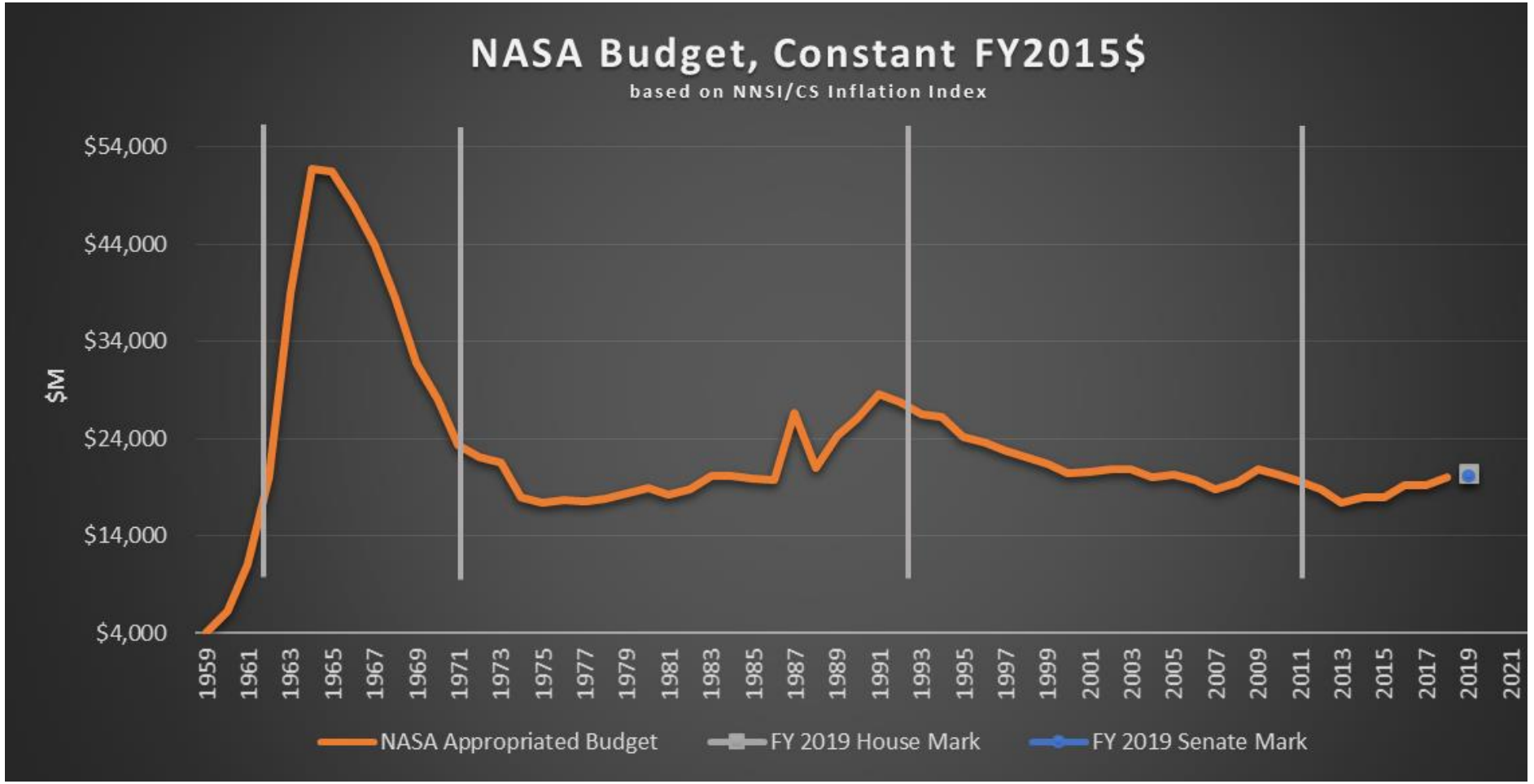
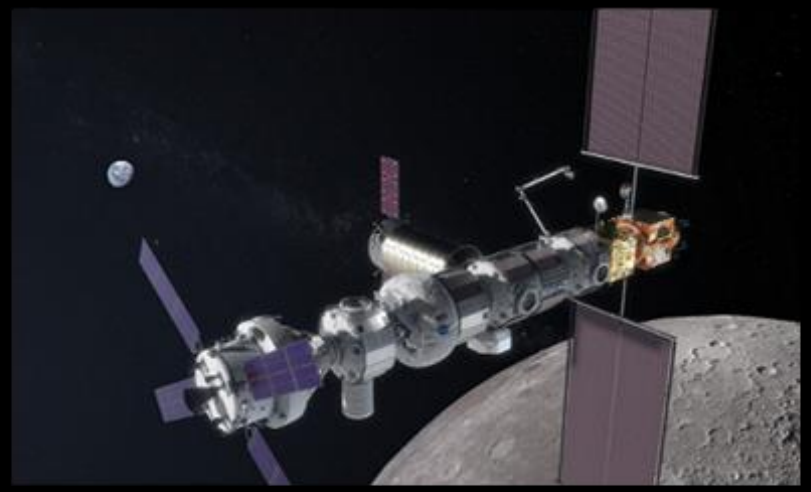
NASA Buying Power



Enabling Human Expansion Across the Solar System



Prepare

Stage

Execute