National Aeronautics and Space Administration

Human Lunar Mission Design: Then & Now

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ARTEMIS

Apollo & Artemis Objectives

Then

“[The US] should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth.“

-John F. Kennedy
President, 1961

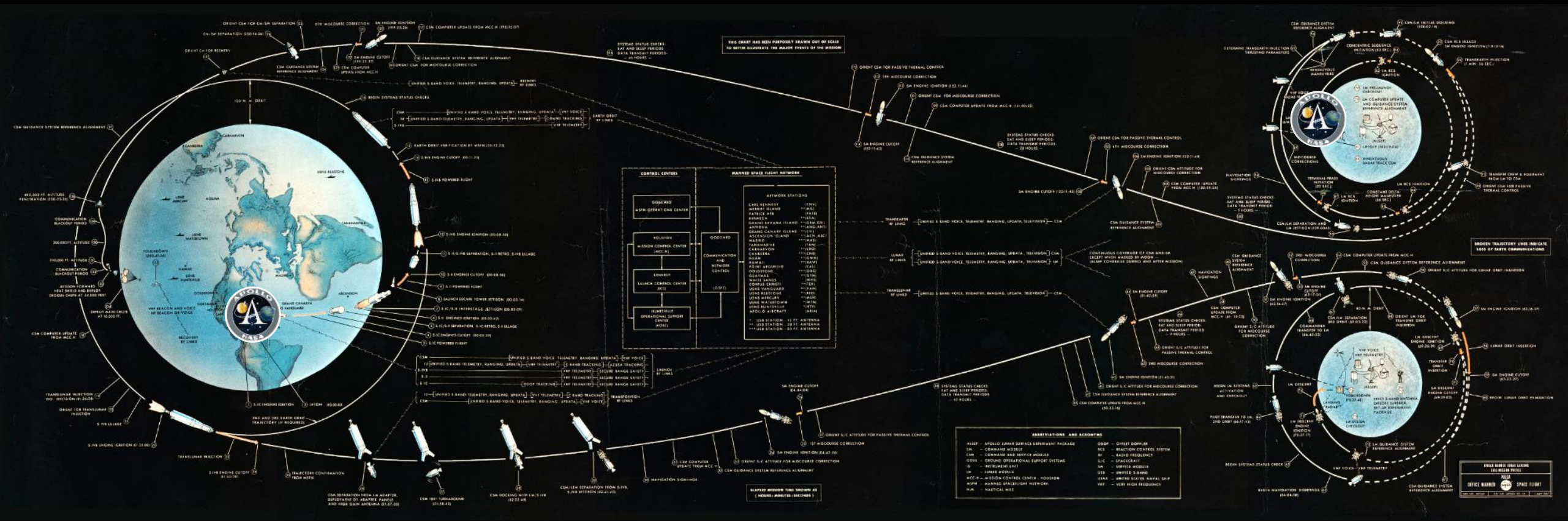
Now

“This time, when we go to the Moon, we will stay. And then we will use what we learn on the Moon to take the next giant leap - sending astronauts to Mars ”

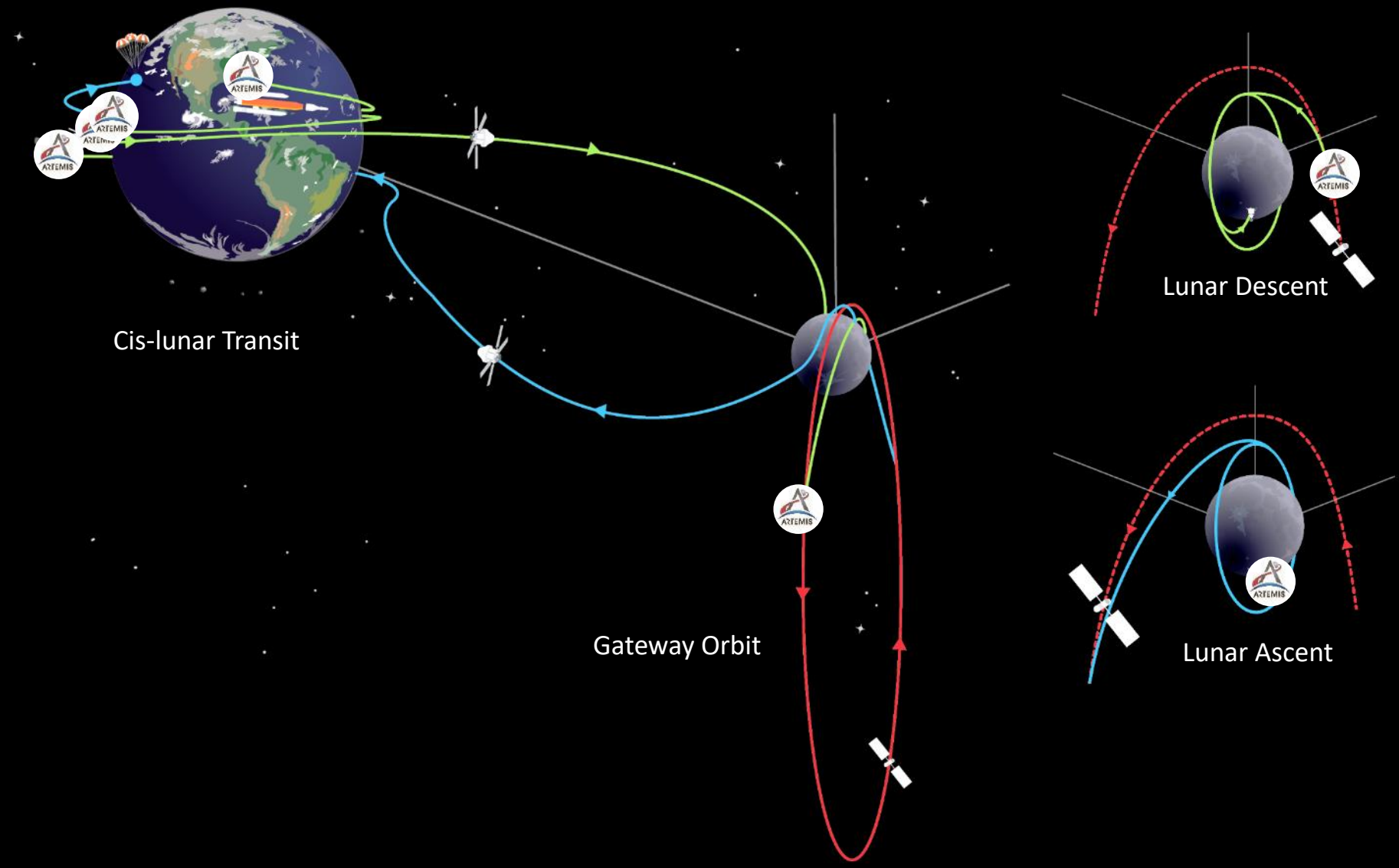
-Jim Bridenstine
NASA Administrator, 2019

Mission Design: *characteristics, constraints, and capability of a space system to meet the needs and objectives of a program*

Apollo Mission Design



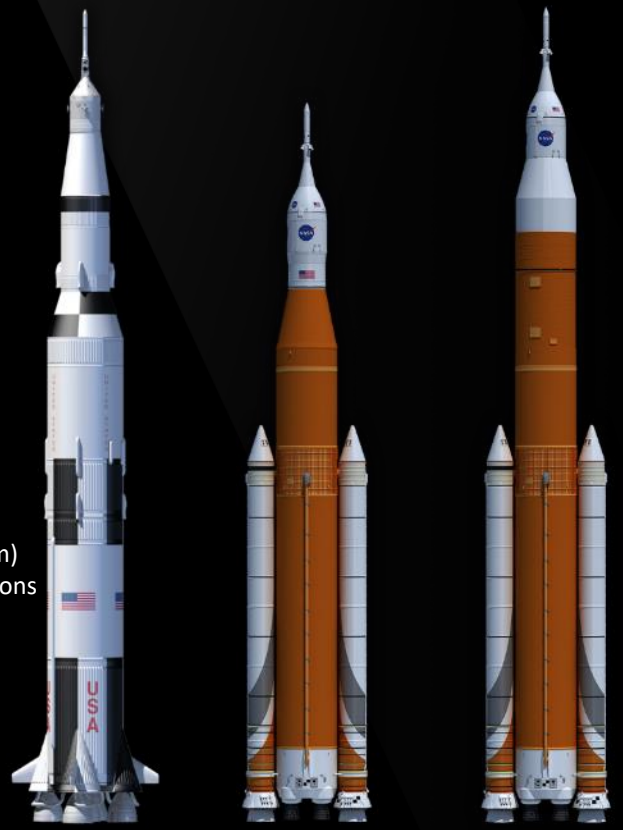
Artemis Conceptual Mission Design



Launch, Ascent, Staging Orbit

Apollo
Single Launch Direct Architecture
Daily Launch Opp (1 of 2 TLI)
26° Range Launch Azimuth
Ground, Ship, Airborne Communication

Composition	
Core Diameter	33’ (10 m)
1st Stage Engines	5 x F-1
2nd Stage Engines	5 x J-2
Max Thrust (lbf)	7.9M
Max Thrust (kN)	35,100
Launch Pad	KSC LC-39
Performance	
3rd Stage Engine	1 x J-2
Height	363’ (110.6 m)
B1 Lunar Payload	48.6 metric tons
LEO Staging Orbit	100 nmi



Saturn V

SLS B1

SLS B1B

Composition	
Core Diameter	27.6’ (8.4 m)
Engines	4 x RS-25
Boosters	**2 x 5 Segment**
Max Thrust (lbf)	8.8M
Max Thrust (kN)	39,100
Launch Pad	KSC LC-39B
B1 Performance	
Upper Stage	ICPS
Height	322’ (98.1 m)
B1 Lunar Payload	>26 metric tons
LEO Staging Orbit	100 x 1450 nmi
B1B Performance	
Upper Stage	EUS
Height	364’ (110.9 m)
B1B Lunar Payload	~37 metric tons
B1B Staging Orbit	100 nmi

Artemis
Distributed Launches w/ Aggregation Architecture
B1 ~1/2 month, 1 TLI opp B1B Daily, 2 of 2 TLI opp
~36° Range Launch Azimuth
Ground, TDRSS Communication

Advancements in space-based communication provide greater flexibility in launch range and mission opportunities

Transit and Mission Duration

Apollo
3 crew members
~39 days consumable
Fuel Cell Powered (~14day max lifetime)
Direct lunar transit of 3-4 days

Command Module

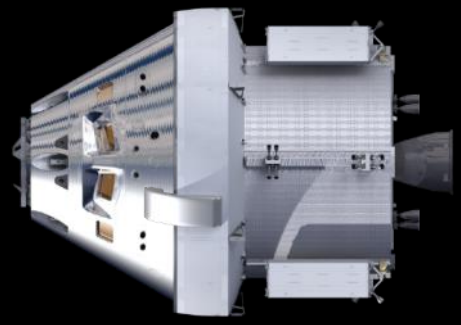
Height	10’7” (3.2m)
Diameter	12’10” (3.9 m)
Habitable Volume	210ft^3 (5.9m^3)
Launch Weight	12,392 lbm (5,621 kg)
Landing Weight	10,977 lbm (4,979 kg)

Service Module

Height	22’7” (6.9 m)
Diameter	12’10” (3.9 m)
Launch Weight	51,258 lbm (23,250 kg)

Performance

Crew	3
Habitable Volume	70 ft^3/person (2.0m^3)
Mission Support	14 days/3 crew
Power Source	Fuel Cells



Crew Module

Height	10’10” (3.3 m)
Diameter	16’5” (5 m)
Habitable Volume	314ft^3 (8.9m$^{3)}$
Launch Weight	22,900 lbm (10,387 kg)
Landing Weight	20,400 lbm (9,253 kg)

Service Module

Height	16’ (4.9 m)
Diameter	13’5” (4.1 m)
Launch Weight	34,085 lbm (15,461 kg)

Performance

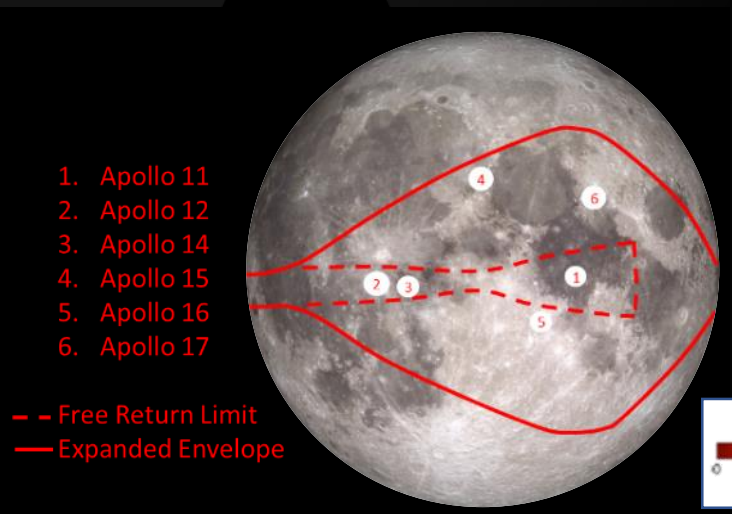
Crew	4
Habitable Volume	78.5 ft^3/person (2.2m^3)
Mission Support	21 days/4 crew
Power Source	Solar Arrays

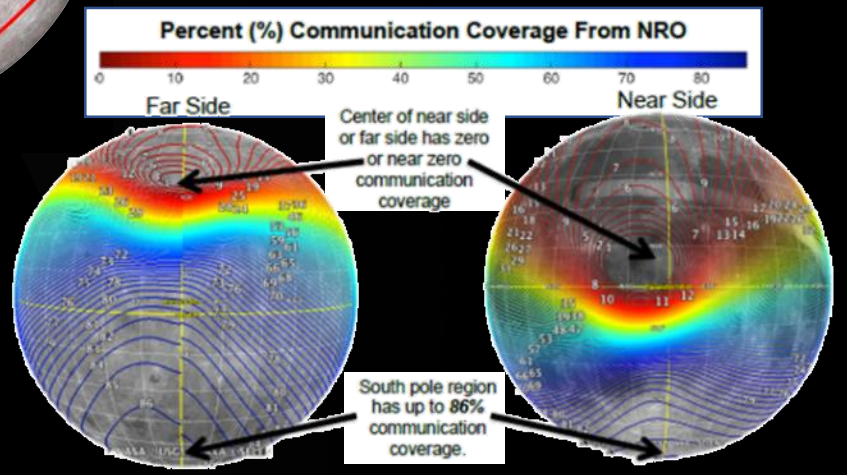
Artemis
4 crew members
~84 days consumables + Gateway w/ resupply
Solar Array Powered
Variable lunar transit 5-14 days for phasing

Transition from minimal mission durations to long-duration and flexibility in cis-lunar operations

Lunar Orbit Staging

Apollo
60nmi (100km) LLO
Earth based comm, near lunar face only
3 day max surface stay
<180 m/s available plane change delta-V



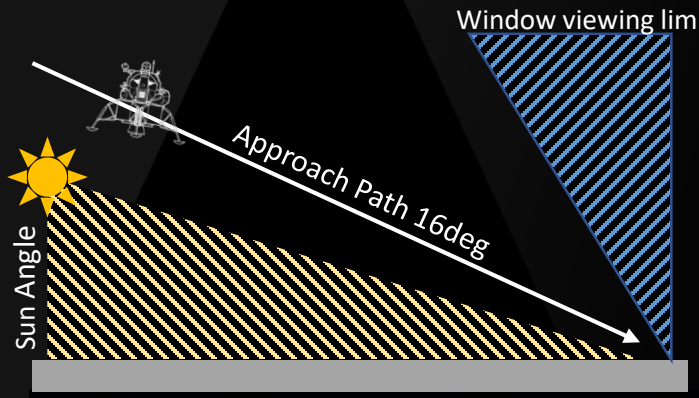


Artemis
Gateway Near-Rectilinear Halo Orbit (NRHO)
Continuous Earth based comm
Continuous solar power Min. orbit delta-V
~6 day surface increments optimized to orbit period

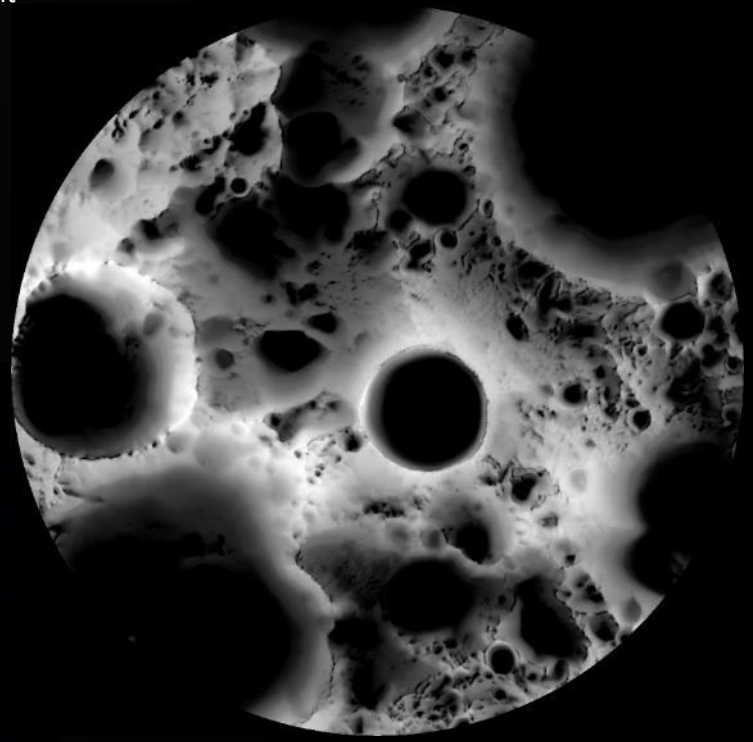
Enable polar landing opportunities and architectural evolvability through multi-mission staging

Lunar Surface Access

Apollo
Manual Piloting and Hazard Avoidance
16° Approach Angle 7-23° sun angle constraint
Solar illumination 2 weeks/month
Landing Site Availability 1 day/month



Example of Zero Phase Angle hazard washout from sun angle



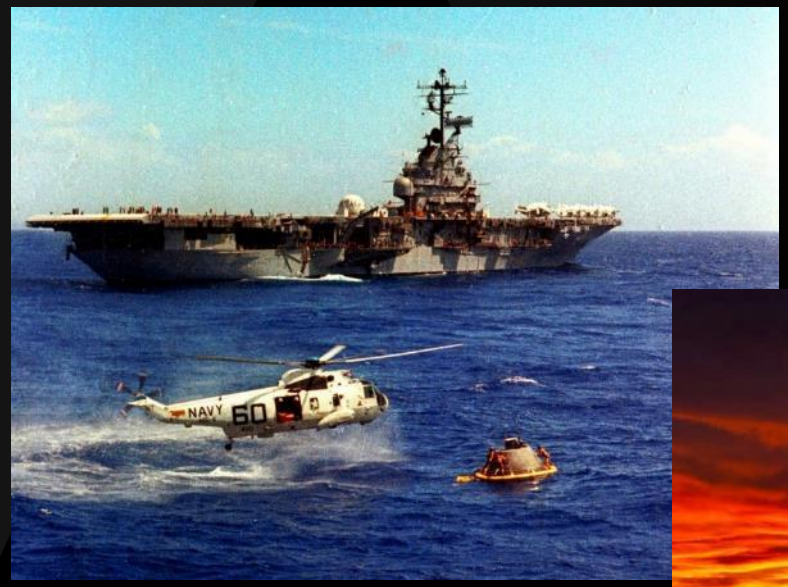
Lunar South Pole solar illumination map

Artemis
Automated/Sensor Supported Piloting
Max polar sun angle 5°
Solar illumination up to 92% of the year
South Pole Landing Site Available Weekly

Mitigation of landing site constraints through advanced automation and technology to enable South Pole opportunity

Earth Return, Landing, and Recovery

Apollo
Lunar Orbit Rendezvous With CSM
Direct Atmospheric Entry
Daylight Landing mid Pacific Ocean
486 nmi (900 km) weather divert capability



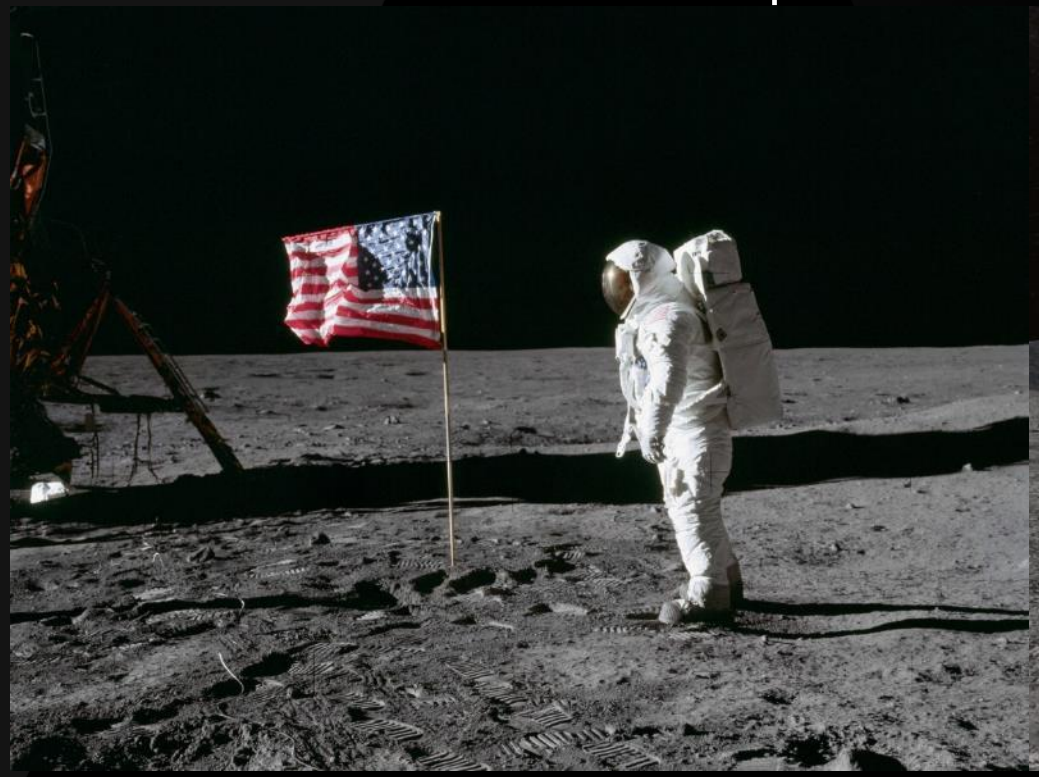
Artemis
NRHO Gateway Rendezvous with Orion
Direct Atmospheric Entry with Guided Skip
Anytime landing targeting San Diego Coast
1200 nmi (2222km) weather divert capability

Increase mission opportunities and maximize crew safety through anytime US coastal recovery

Human Lunar Mission Design: Then & Now

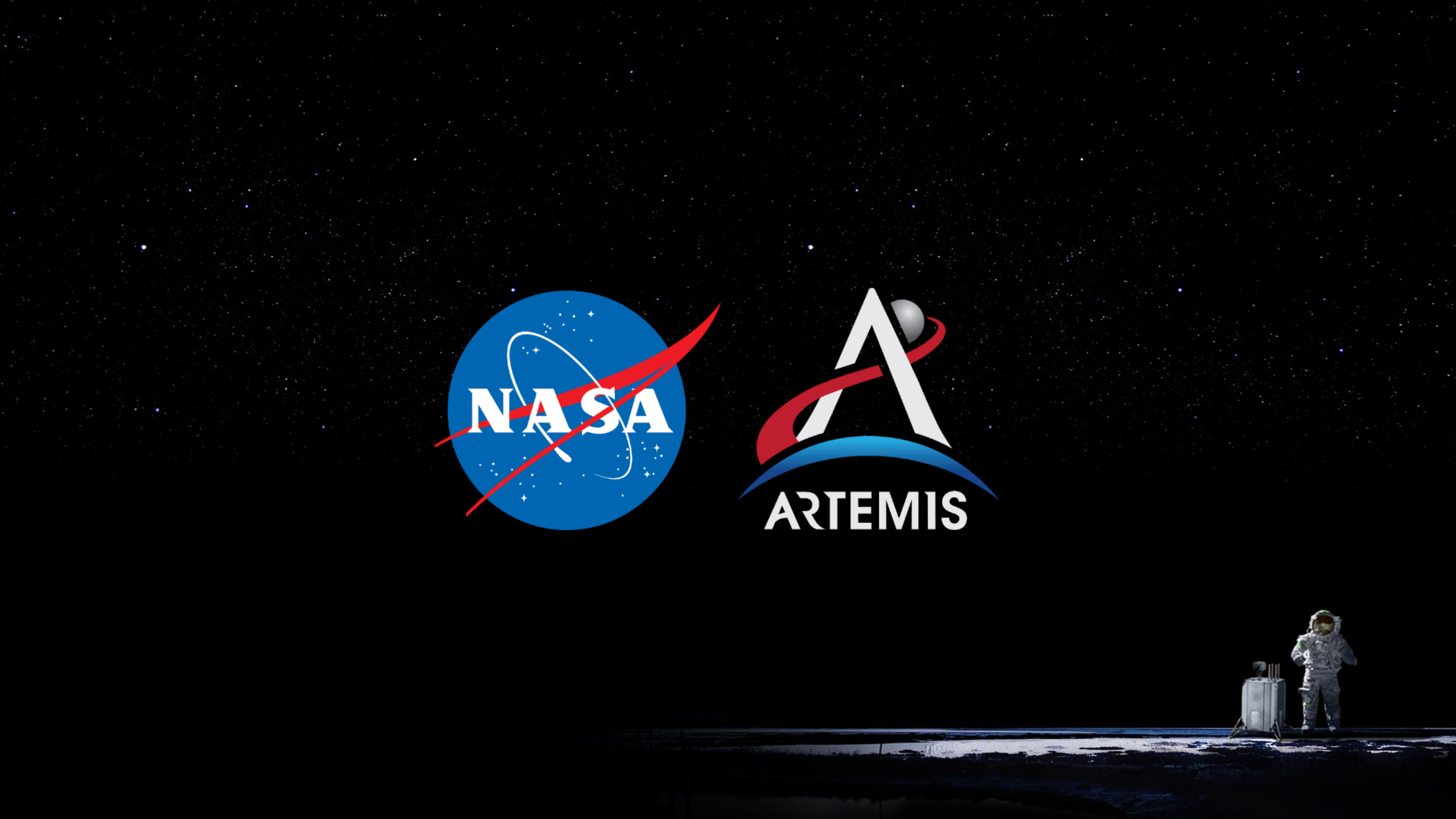
Apollo

Mission optimized to minimize performance demand and achieve surface exploration



Artemis

Mission optimized to enable polar surface mission and sustainable exploration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