HUMAN LANDING SYSTEM

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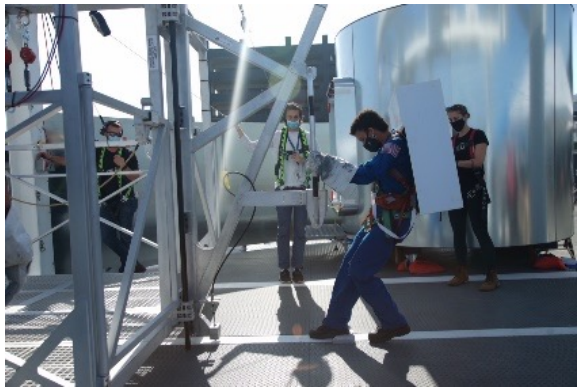
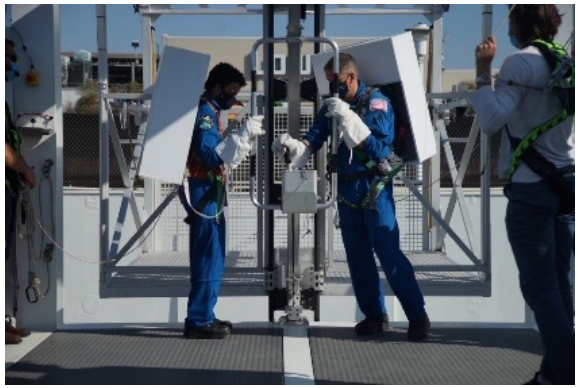
Artemis III Starship HLS Progress

Image Credit: SpaceX

Crew and cargo elevator





Crew cabin VR evaluation

Airlock

Artemis III Starship HLS Progress

Image Credit: SpaceX

Human Landing System (HLS) Procurement Path

DESIGN STUDIES, RISK REDUCTION, AND INITIAL DEVELOPMENT

Initial Lander Studies and Risk Reduction
(Appendix E)
2018-2020

- Aerojet Rocketdyne
- Blue Origin
- Boeing
- Dynetics
- Lockheed Martin
- Masten Space Systems
- Northrop Grumman
- OrbitBeyond
- Sierra Nevada Corporation
- SpaceX
- SSL

Initial Lander Development
(Appendix H Base Period)
2019-2021

- Blue Origin Federation
- Dynetics
- SpaceX

Sustainable Lander Studies and Risk Reduction
(Appendix N)
2021-

- Blue Origin
- Dynetics
- Lockheed Martin
- Northrop Grumman
- SpaceX

FULL DEVELOPMENT AND DEMONSTRATION

SpaceX Uncrewed Lunar Demo-A

SpaceX Crewed Lunar Demo-A

Full Development and Initial Demonstration
(Appendix H Option A)
2021-

Awarded to SpaceX

SpaceX only

SpaceX Crewed Lunar Demo-B

Evolution from Initial to Sustaining
(Appendix H Option B)

Company2 Uncrewed Lunar Demo

Company2 Crewed Lunar Demo

Open to all U.S. Industry except SpaceX

Sustaining Lunar Development
(Appendix P)

Parallel efforts to develop sustaining landers to deliver humans and human-class cargo

RECURRING TRANSPORTATION SERVICES

Sustaining Lunar Transport
(Future task order solicitation to deliver humans and human-class cargo)

- Contract Completed
- Contract In Execution
- Future Contract
- Lunar Demo Flight

www.nasa.gov/nextstep

“Original” Science/Utilization Requirements for Sustained Human Landing Systems

- **Downmass: 100kg**
  - Geology tools: 60-70kg
  - Camera or other sensors: 10-20kg
  - Sample return equipment: 20kg
- **Upmass: 100kg**
  - Sample return equipment: 20kg
  - Lunar samples: 80kg

Items	Qty	Mass (kg)	Storage Environment	Geometry	Length (cm)	Height (cm)	Width (cm)	Volume (m3)	Notes
Down Mass Total		**100**						**1.42**	
Science Equipment		80							
long axis of tools such as rakes or drive tubes		60-70	Pressurized or Unpressurized	box	145	165	50	1.2**	Tools, cameras and sensors will remain on lunar surface
cameras or other sensors for use in the habitable environment	2	10-20	Pressurized	box	48	38	18	0.06	Dimensions are for each container, 0.06 for both
Sample Return Equipment*		20						0.16	total volume of all containers.
sample return container	2		Pressurized	box	48	30	20		Dimensions are for each container, 0.06 m3 for both
sample return collection b	7		Pressurized	box	42	22	15		Dimensions are for each container, 0.1 m3 for all

*Sample Return Equipment would be empty during descent and used to carry lunar samples back to NRHO during ascent. During descent, they could be filled with other items. In the event that full return mass goal is not met and the full complement of sample return equipment is not needed, the remainder of the allocation of down mass and volume will be filled with additional science items.
**Science Equipment stowage volumes may be split if needed, however all volumes shall maintain certain minimum dimensions. Determining minimum dimensions will require NASA discussion and approval.

Items	Qty	Mass (kg)	Storage Environment	Geometry	Length (cm)	Height (cm)	Width (cm)	Volume (m3)	Notes
Up Mass Total		**100**							
Sample Return Equipment		20						0.16	total volume of all containers.
sample return container	2		Pressurized	box	48	30	20		Dimensions are for each container, 0.06 m3 for both
sample return collection bags	7		Pressurized	box	42	22	15		Dimensions are for each container, 0.1 m3 for all
Lunar Samples		80	Pressurized						would be contained in the Sampler Return volumes above
Note: Orion does not have specific storage to match the HLS sample return volume. Sample return mass to Eath via Orion might require mission-by-mission decisions on storage									

Updates to Science/Utilization Requirements for Sustained Human Landing Systems

- **Capability for cold stowage (freezer) required**
  - Worked with lunar scientists, ISS freezer experts, geology tools team, etc to create freezer/container/sample estimates to align with the desire for volatile-containing samples
  - Intent is to have flexibility for a “no freezer” mission to allow more non-conditioned samples to be returned
- **Large goal numbers**
  - Large numbers show a desire for “more” without *requiring* it
  - Both down and up mass goals are 1000kg
- **Simplification/Consolidation to allow flexibility**
  - Only mention: Freezer, Containers, Utilization Equipment (+ Samples for upmass)
- **Explicit mention of how much is carried inside the pressurized volume**
  - Important for HLS cabin design
- **Downmass increase to 182kg to be more capable, add freezer**
- **Upmass increase to 160kg per high-level direction**
  - 60kg exceedance of Orion return capability could be handled in several different ways

Utilization Mass Requirements for Sustained Human Landing Systems

Delivery from NRHO to Surface

Equipment	Storage	Threshold (kg)	Goal (kg)
Freezer	Pressurized	52.0	500.0
Containers	Unpressurized or Pressurized	65.0	320.0
Utilization Equipment	Unpressurized or Pressurized	65.0	180.0
	TOTALS	182.0	1000.0

Return from Surface to NRHO

Equipment	Storage	Threshold (kg)	Goal (kg)
Freezer	Pressurized	52.0	500.0
Containers	Pressurized	65.0	320.0
Lunar/Biological Samples	Pressurized	43.0	180.0
	TOTALS	160.0	1000.0

Government Furnished Property (GFP) Interface Requirements Document

- This document goes into more detail about the interfaces between Starship and any GFP

- While the document is being matured, it currently captures:
  - Mounting points for several internal and external utilization payloads (example below)
  - Power/data to both internal and external payloads

HLS-GFP-073 Mounting
The HLS shall provide 5 internal and 5 external mounting points capable of supporting at least 10kg of Utilization/Science GFP each.

Rationale: Utilization/Science GFP may be externally mounted prior to launch or removed from habitable volume and mounted while on the lunar surface.

Human-class Cargo Delivery Landers (HDL)

- NASA is asking companies to develop the capability for large, mission-critical cargo deliveries to the surface of the Moon during separate missions
- 12-to-15-metric ton cargo, intended for large payloads like crewed rovers and habitats

HDL-S-R-0030 Cargo Delivery
The HDL shall be capable of delivering 12 metric ton (t) (threshold) to 15 t (goal) of cargo to south lunar latitudes between 84° and 90°.

Rationale: The purpose of the HDL is to enable extended surface stays at Artemis Base Camp (ABC). The HDL will be capable of operating in the varying thermal and solar illumination/shadow environments within the required latitudes.

Follow the missions

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