



# FUTURE SPACE HABITATS

A Global Comparison: Volume · Crew · Power · Recovery

# ABOUT THE AUTHOR



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Matthew is a U.S. Air Force veteran (METNAV) and a Systems and Data Analyst at Boeing, where he owns day-to-day operations for defense technical-authoring platforms: deployments, incident response, disaster recovery with engineers, and access control. He previously served as a GS-12 Telemedicine Program Manager at the Veterans Health Administration, standing up clinic programs and supervising a mostly remote team of about ten under Conditions of Participation. This independent project standardizes public data on space habitats. It is not affiliated with Boeing, the U.S. Air Force, the VA, or AIAA; the views expressed are his own.



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Available for questions.

# PROJECT BACKGROUND

Thank you for taking the time to review this comparison of space habitats. I prepared it as a personal exercise to synthesize complex data into a standardized format and allow for a cleaner comparison of how different platforms support human life.

If you have thoughts on how this project can be improved, please feel free to reach out via email or LinkedIn. I would especially welcome input from professionals with direct experience on these systems. This has been a valuable learning exercise for me, and I expect there is much more to learn.

As with all developmental programs, technical capabilities continue to evolve due to ongoing engineering trade-offs, shifting funding levels, and frequent adjustments to timelines.

# TERMINOLOGY: ABBREVIATIONS AND ACRONYMS

**1/6g:** One sixth of Earth gravity

**AI:** Artificial Intelligence

**AxEMU:** Axiom Extra Vehicular Mobility Unit

**avg.:** Average

**BAS:** Bharatiya Antriksh Station

**cont.:** Continuous

**ECLSS:** Environmental Control and Life Support

**equiv.:** Equivalent

**Hab:** Habitat

**HALO:** Habitation and Logistics Outpost

**HLS:** Human Landing System

**I-Hab:** International Habitation Module

**kWe:** Kilowatt Electric

**kWp:** Kilowatt Peak

**Incln.:** Inclination

**ISRO:** Indian Space Research Organization

**LEO:** Low Earth Orbit

**LIFE®:** Large Integrated Flexible Environment

**LVM3:** Launch Vehicle Mark-3

**nom.:** Nominal

**NRHO:** Near Rectilinear Halo Orbit

**PPE:** Power and Propulsion Element

**reqt.:** Requirement

**ROS:** Russian Orbital Station

**SE:** Systems Engineering

**TBD:** To Be Determined

# TERMINOLOGY: DEFINITIONS

**Available Power:** Net electricity left for experiments and payloads after running basic station operations.

**Average (Power):** Total energy used divided by time.

**Continuous (Power):** Delivered continuously without interruption.

**Generated Power:** Total electricity produced by the station's power systems (e.g., solar arrays).

**Habitable Volume:** The actual usable room where crew live and work, excluding structural gaps and equipment racks.

**Inclination:** The angle between an orbit's plane and Earth's equator.

**Nominal:** While operating normally and according to plan.

**Open-Loop:** A life support system that consumes stored resources without recycling them.

**Pressurized Volume:** Airtight volume kept at Earth-like pressure so crew can live without spacesuits.

**Space Habitat:** A pressurized structure providing life support and protection for humans to live and work in space or planetary surfaces.

**Water Allowance:** The strict, budgeted mass of clean water provided daily per person for metabolic survival.

**Water Recovery Rate:** Percentage of wastewater successfully recycled into usable water.



# EARTH ORBIT

# BLUE ORIGIN & SIERRA SPACE: ORBITAL REEF



*Image courtesy of Blue Origin.*

## System Design Review Completion<sup>3</sup>



PRESSURIZED: ~830<sup>1</sup> m<sup>3</sup>

HABITABLE: ~550<sup>1</sup> m<sup>3</sup>



GENERATED: ~100<sup>1</sup> kWe

AVAILABLE: ~36<sup>1</sup> kW cont.



RECOVERY RATE: TBD

ALLOWANCE: 2.5<sup>2</sup> L reqt.

Modular, commercial LEO station featuring inflatable LIFE<sup>®</sup> habitats. Target launch is no earlier than 2027 on Blue Origin New Glenn. Incln. 51.6°.

### Key Capabilities and Features

- **Focus:** Scalable, mixed-use “business park” utilizing LIFE<sup>®</sup> technology to provide pressurized volume for industrial and commercial services.
- **Crew:** Supports up to 10 crew.
- **Support Systems:** Multiple docking ports, research labs, robotics, manufacturing facilities, tourism support, and Astro Garden bioregenerative life support.

<sup>1</sup> (Mosher & Kelsey, 2024); <sup>2</sup> (NASA OCHMO, 2023); <sup>3</sup> (Exterra Journal of Space Commerce, 2026)

# VAST: HAVEN-1



Image courtesy of Vast.

## Assembly, Integration, and Testing<sup>4</sup>



PRESSURIZED: **80<sup>1</sup> m<sup>3</sup>**

HABITABLE: **45<sup>1</sup> m<sup>3</sup>**



GENERATED: **13.2<sup>2</sup> kWp**

AVAILABLE: **800<sup>3</sup> W (total util.)**



RECOVERY RATE: **Open-Loop**

ALLOWANCE: **TBD**

Compact single-module commercial LEO station. Target launch is 2027 on SpaceX Falcon 9. Incln. 51.6°.

### Key Capabilities and Features

- **Focus:** Human-centric design for research, manufacturing, and short stays, with uncrewed 1/6g experiments. It relies on Crew Dragon for transport and life support.
- **Crew:** Supports 4 crew for short missions, nominal 14 days.
- **Crew Amenities:** Personal quarters, large domed Earth-view window, communal area, and Starlink communications.

<sup>1</sup> (Vast, n.d.d); <sup>2</sup> (Vast, n.d.a); <sup>3</sup> (Vast, n.d.b); <sup>4</sup> (Vast, 2026)

# VAST: HAVEN-2



*Image courtesy of Vast.*

## Phase A: Concept and Technology Development<sup>4,5</sup>



PRESSURIZED: **1,160<sup>1</sup> m<sup>3</sup>**

HABITABLE: **510<sup>1</sup> m<sup>3</sup>**



GENERATED: **86<sup>1</sup> kW nom.**

AVAILABLE: **40<sup>1</sup> kW avg.**



RECOVERY RATE: **TBD<sup>2</sup>**

ALLOWANCE: **2.5<sup>3</sup> L reqt.**

Modular successor to Haven-1. Initial module launch is targeted for 2028 on SpaceX Falcon Heavy. Incln. 51.6°.

### Key Capabilities and Features

- **Focus:** A fully independent microgravity laboratory designed to provide continuous human presence in LEO.
- **Crew:** Supports a long-duration crew of 12 in its final configuration.
- **Growth Path:** Expands incrementally through 2032, eventually forming a "plus sign" configuration with advanced life support and robotic servicing.

<sup>1</sup> (Vast, n.d.c); <sup>2</sup> (Foust, 2024); <sup>3</sup> (NASA OCHMO, 2023); <sup>4</sup> (Foust, 2024); <sup>5</sup> (NASA, 2026)

# STARLAB SPACE: STARLAB SPACE STATION



*Image courtesy of Starlab Space.*

## Manufacturing and Systems Integration<sup>5</sup>



PRESSURIZED: **>400<sup>1</sup> m<sup>3</sup>**

HABITABLE: **~400<sup>1</sup> m<sup>3</sup>**



GENERATED: **60<sup>2</sup> kW**

AVAILABLE: **12<sup>1</sup> kW nom.**



RECOVERY RATE: **>90%<sup>3</sup>**

ALLOWANCE: **2.5<sup>4</sup> L reqt.**

Large single-launch commercial LEO station. Target launch is 2028 on SpaceX Starship. Incln. 45°.

### Key Capabilities and Features

- **Focus:** High-volume research and pharmaceuticals powered by the George Washington Carver Science Park, the first commercial science park in space.
- **Crew:** Continuous 4 crew and up to 8 short-term.
- **Advanced Systems:** Robotic arm, external payload platforms, advanced labs, and a Palantir-powered digital twin for real-time anomaly detection, predictive maintenance, and optimized resource allocation.

<sup>1</sup> (Starlab Space LLC, n.d.); <sup>2</sup> (Kehr, 2024); <sup>3</sup> (Starlab Space, n.d.); <sup>4</sup> (NASA OCHMO, 2023); <sup>5</sup> (Starlab Space, 2026)

# AXIOM SPACE: AXIOM STATION

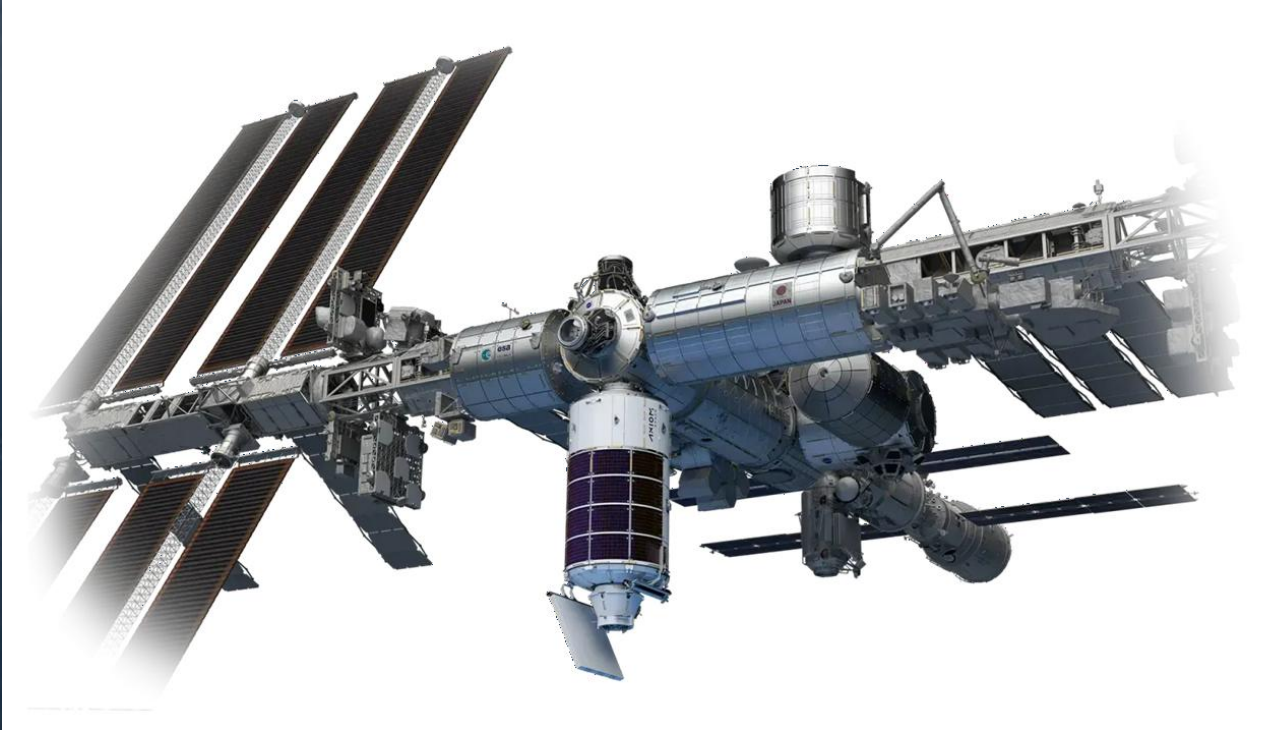


Image courtesy of Axiom Space.

## Final Assembly and Integration<sup>6</sup>



PRESSURIZED: ~280<sup>1</sup> m<sup>3</sup>

HABITABLE: ~150<sup>1</sup> m<sup>3</sup>



GENERATED: ~75-90<sup>2,3</sup> kW avg.

AVAILABLE: ~42<sup>2,3,4</sup> kW cont.



RECOVERY RATE: TBD

ALLOWANCE: 2.5<sup>5</sup> L reqt.

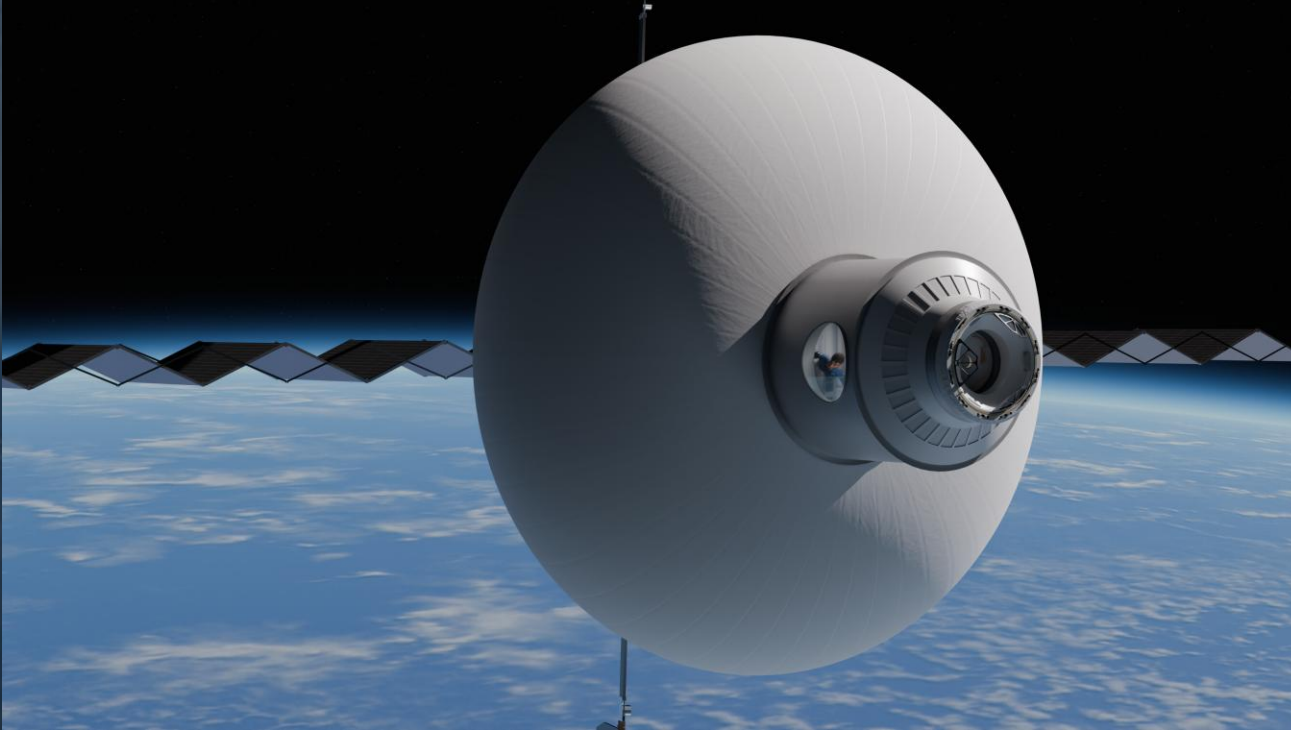
Modular commercial LEO station. Target launch is no earlier than 2027. Incln. 51.6°.

### Key Capabilities and Features

- **Focus:** Supports research, in-orbit manufacturing, and tourism. Starts docked to ISS before becoming independent.
- **Crew:** Supports up to 8 crew (4 with Hab-1, expanding to 8 when Hab-2 is added).
- **Modules:** Multiple attachable modules including Hab-1/2, airlock with AxEMU suits, power/thermal, and research/manufacturing.

<sup>1</sup> (Dittmar et al., 2021); <sup>2</sup> (NASA, 2024); <sup>3</sup> (satsearch, 2025); <sup>4</sup> (Roman, 2023) ; <sup>5</sup> (NASA OCHMO, 2023); <sup>6</sup> (Axiom Space, n.d.)

# MAX SPACE: THUNDERBIRD STATION



*Image courtesy of Max Space.*

**Pre-Phase A: Concept Studies<sup>2</sup> equiv.**



PRESSURIZED: **350<sup>1</sup> m<sup>3</sup>**

HABITABLE: **~350<sup>1</sup> m<sup>3</sup>**



GENERATED: **TBD**

AVAILABLE: **TBD**



RECOVERY RATE: **TBD**

ALLOWANCE: **TBD**

<sup>1</sup> (Max Space, 2025); <sup>2</sup> (Rabie, 2025)

Single-launch expandable commercial station. Target launch is 2029 on a SpaceX Falcon 9. Incln. unknown.

## Key Capabilities and Features

- **Focus:** Unique inflatable habitat technology that expands up to 20 times its stowed launch size. It features an adaptable "morphic interior structure" with soft, flexible layouts that can be reconfigured mid-mission.
- **Crew:** Supports a continuous crew of 4.
- **Support Systems:** Outfitted with 2 docking ports for visiting vehicles, debris protection systems, and payload capacity hosting over 60 reconfigurable slots.

# ISRO: BHARATIYA ANTARIKSH STATION



Image courtesy of ISRO.

Phase C: Final Design and Fabrication<sup>1</sup> equiv.



PRESSURIZED: **TBD**

HABITABLE: **TBD**



GENERATED: **TBD**

AVAILABLE: **TBD**



RECOVERY RATE: **TBD**

ALLOWANCE: **TBD**

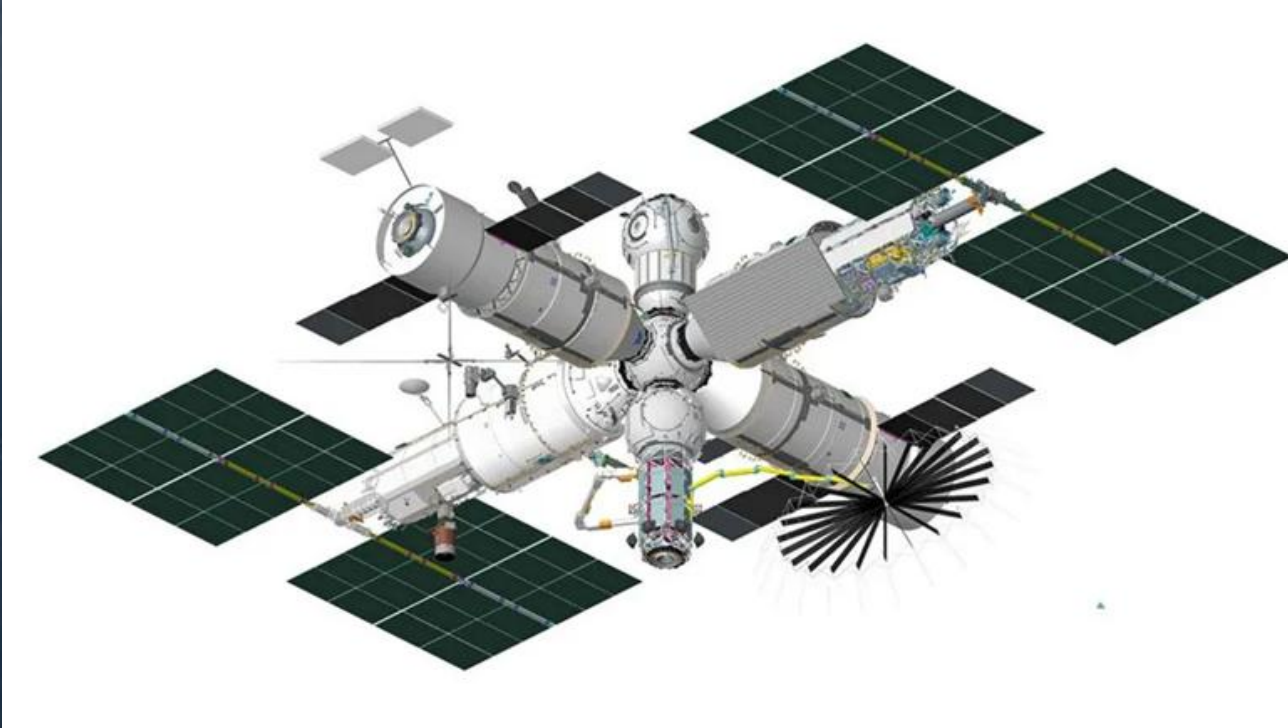
Modular ISRO-led LEO station. Targeted for launch in 2028 on LVM3, with full assembly targeted for 2035. Incln. 51.6°.

## Key Capabilities and Features

- **Focus:** Multi-module station for long-duration human spaceflight, microgravity research, and technology demonstration. Built on Gaganyaan program technologies with docking systems, and radiation protection.
- **Crew:** Continuous crew of 3-4.
- **Modules:** Features include Bharat Docking System, airlocks for EVA, and MMOD protection.

<sup>1</sup> (Press Information Bureau, 2026)

# ROSCOSMOS: RUSSIAN ORBITAL STATION



*Image courtesy of Roscosmos via Space.com.*

**Phase B: Preliminary Design and Technology Completion<sup>2</sup> equiv.**



PRESSURIZED: **387<sup>1</sup> m<sup>3</sup>**

HABITABLE: **TBD**



GENERATED: **54<sup>1</sup> kWp**

AVAILABLE: **TBD**



RECOVERY RATE: **TBD**

ALLOWANCE: **TBD**

Modular space station developed by Roscosmos as a successor to the ISS. Target launch window beginning in 2028 via Angara-A5. Incln. 51.6°.

## Key Capabilities and Features

- **Focus:** A fully autonomous, modular national outpost for material science, military-applied research, and deep-space physiological testing.
- **Crew:** Primarily uncrewed autonomous.
- **Modules:** The station expands incrementally. It features the core Science and Power Module (NEM-ROS), a Universal Node Module, and a Gateway/Airlock Module (SM) for spacewalks.

<sup>1</sup> (Luzin, 2024); <sup>2</sup> (Zak, 2026)

The image shows a view of Earth from space, with the horizon line visible. A semi-transparent blue rectangular box is centered over the image, containing the title text. The text is white with a blue outline.

# LUNAR ORBIT

# NASA: GATEWAY

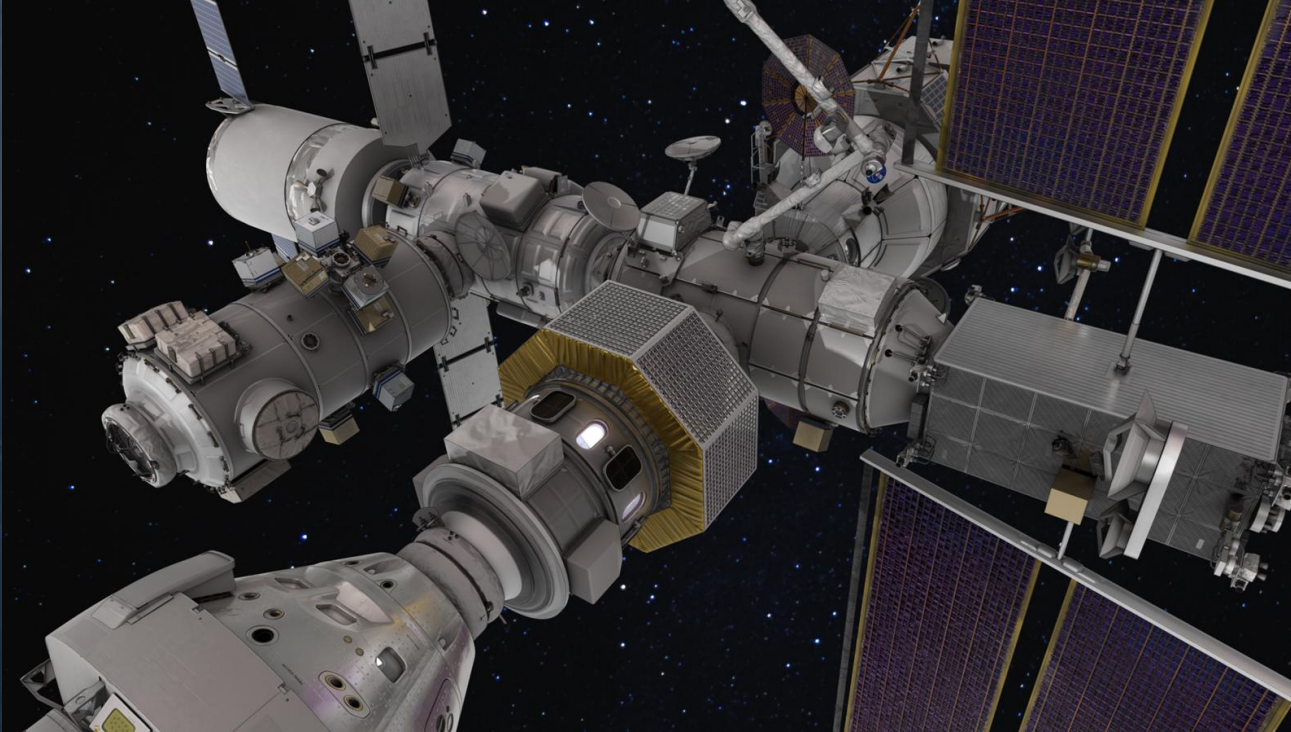


Image courtesy of NASA.

## Phase F: Closeout<sup>5</sup>



PRESSURIZED: **125<sup>1</sup> m<sup>3</sup>**

HABITABLE: **35<sup>1</sup> m<sup>3</sup>**



GENERATED: **60<sup>1</sup> kWp**

AVAILABLE: **≥4<sup>2</sup> kW cont.**



RECOVERY RATE: **Target 98%<sup>3</sup>**

ALLOWANCE: **2.5<sup>4</sup> L reqt.**

Planned international lunar orbital station and staging point for deep space missions. Development has transitioned into Phase F: Closeout to prioritize permanent lunar surface base. Near Rectilinear Halo Orbit.

### Key Capabilities and Features

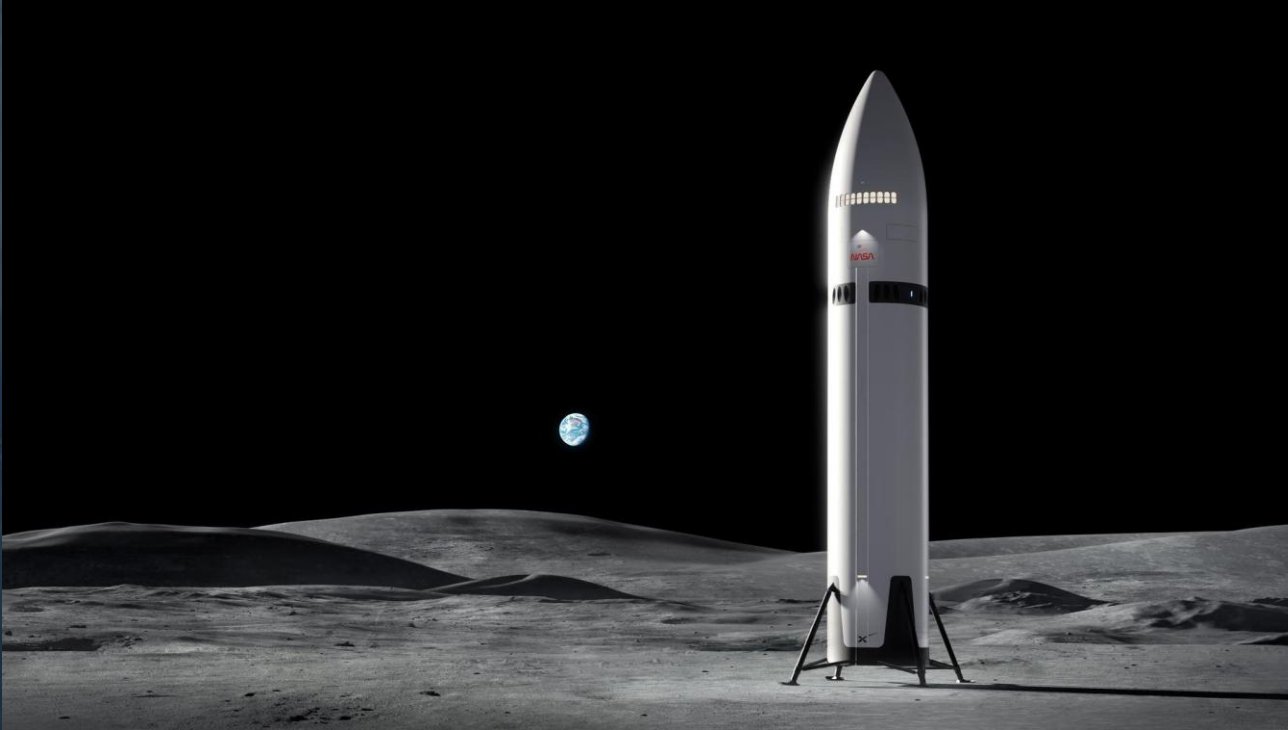
- **Focus:** Staging hub for lunar landings and a lab for deep space radiation and health research.
- **Crew:** Supports 4 crew for 30–90-day missions.
- **Modules:** Includes PPE (solar propulsion), HALO (initial hub), I-Hab (living quarters), and Canadarm3 robotics.

<sup>1</sup> (NASA, 2022); <sup>2</sup> (NASA, 2018); <sup>3</sup> (NASA, 2023a); <sup>4</sup> (NASA OCHMO, 2023); <sup>5</sup> (Dinner, 2026)



# LUNAR SURFACE

# SPACEX / NASA: HUMAN LANDING SYSTEM



*Image courtesy of NASA.*

## Phase C: Final Design and Fabrication<sup>2</sup>



PRESSURIZED: **>600<sup>1</sup> m<sup>3</sup>**

HABITABLE: **TBD**



GENERATED: **TBD**

AVAILABLE: **TBD**



RECOVERY RATE: **TBD**

ALLOWANCE: **2.5<sup>3</sup> L reqt.**

Lunar lander variant of Starship for NASA's Artemis program. Optimized for crewed surface missions with on-orbit refueling. Target launch in early 2028.

### Key Capabilities and Features

- **Focus:** Reusable, high-capacity lunar lander and temporary habitat enabling crewed surface exploration. Features massive pressurized volume, and lunar-optimized systems.
- **Crew:** Nominal 2–4 astronauts.
- **Airlocks:** Dual airlocks, ~13m<sup>3</sup> each, for parallel operations.

<sup>1</sup> (SpaceX, 2026); <sup>2</sup> (Watson-Morgan et al., 2025); <sup>3</sup> (NASA OCHMO, 2023)

# NASA: FOUNDATION SURFACE HABITAT



Image courtesy of NASA.

## Phase A: Concept Studies<sup>1</sup>



PRESSURIZED: **TBD**  
HABITABLE: **127<sup>1</sup> m<sup>3</sup>**



GENERATED: **10-15<sup>2</sup> kW**  
AVAILABLE: **grid-connected**



RECOVERY RATE: **TBD**  
ALLOWANCE: **TBD**

Fixed, pressurized surface habitat for NASA's Artemis Base Camp at the lunar South Pole. Target deployment in the early 2030s.

### Key Capabilities and Features

- **Focus:** Primary living and working module enabling longer-duration surface stays, science operations, and serving as the anchor for Artemis Base Camp.
- **Crew:** Supports 2 crew for 30-day missions initially; evolves to 4 crew for up to 60-day stays.
- **Architecture:** Hybrid metallic base with airlock + inflatable upper volume that expands on surface for three-story layout.

<sup>1</sup> (AmericaSpace, 2024); <sup>2</sup> (Schunk et al., 2022)

# JAXA / TOYOTA: "LUNAR CRUISER"



Image courtesy of Toyota.

## Phase A: Concept and Technology Development<sup>5</sup>



PRESSURIZED: ~13<sup>1</sup> m<sup>3</sup>

HABITABLE: ~9<sup>2</sup> m<sup>3</sup>



GENERATED: ~114<sup>3</sup> kW fuel cell

AVAILABLE: 10 kW<sup>4</sup> stationary reqt.



RECOVERY RATE: Open-Loop

ALLOWANCE: TBD

Mobile pressurized lunar rover/habitat for the Artemis program. Target launch is no earlier than 2029.

### Key Capabilities and Features

- **Focus:** Enables 10,000 km total cruising range (1,000km per mission) surface exploration and pressurized habitability far from fixed lunar bases.
- **Crew:** Living space for 2+ crew; up to 30-45 days of independent operations.
- **Mobility and Power Systems:** High mobility with independent wheel drive and autonomous navigation, and regenerative fuel cell power capability for surviving lunar night.

<sup>1</sup> (Gough, 2019); <sup>2</sup> (Yamazaki et al., 2024); <sup>3</sup> (Toyota Motor Corporation, 2014); <sup>4</sup> (NASA, 2023a); <sup>5</sup> (NASA, 2025a)

# GLOBAL COMPARISON

|  HABITAT |  CREW |  TYPE |  HABITABLE |  AVAILABLE |  RECOVERY |  TARGET |
|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Orbital Reef                                                                              | 10                                                                                     | LEO                                                                                    | ~550 m <sup>3</sup>                                                                         | ~36 kW cont.                                                                                  | TBD                                                                                          | 2027+                                                                                      |
| Haven-1                                                                                   | 4                                                                                      | LEO                                                                                    | 45 m <sup>3</sup>                                                                           | 0.8 kW cont.                                                                                  | Open-Loop                                                                                    | 2027                                                                                       |
| Haven-2                                                                                   | 12                                                                                     | LEO                                                                                    | 510 m <sup>3</sup>                                                                          | 40 kW avg.                                                                                    | TBD                                                                                          | 2028                                                                                       |
| Starlab Station                                                                           | 4                                                                                      | LEO                                                                                    | ~400 m <sup>3</sup>                                                                         | 12 kW nom.                                                                                    | >90%                                                                                         | 2028                                                                                       |
| Axiom Station                                                                             | 8                                                                                      | LEO                                                                                    | ~150 m <sup>3</sup>                                                                         | ~42 kW cont.                                                                                  | TBD                                                                                          | 2027+                                                                                      |
| Thunderbird                                                                               | 4                                                                                      | LEO                                                                                    | ~350 m <sup>3</sup>                                                                         | TBD                                                                                           | TBD                                                                                          | 2029                                                                                       |
| BAS                                                                                       | 3-4                                                                                    | LEO                                                                                    | TBD                                                                                         | TBD                                                                                           | TBD                                                                                          | 2028                                                                                       |
| ROS                                                                                       | Uncrewed                                                                               | LEO                                                                                    | TBD                                                                                         | TBD                                                                                           | TBD                                                                                          | 2028                                                                                       |
| Gateway                                                                                   | 4                                                                                      | NRHO                                                                                   | 35 m <sup>3</sup>                                                                           | ≥ 4 kW cont.                                                                                  | 98%                                                                                          | Closeout                                                                                   |
| HLS                                                                                       | 2-4                                                                                    | Lunar                                                                                  | TBD                                                                                         | TBD                                                                                           | TBD                                                                                          | TBD                                                                                        |
| Foundation                                                                                | 2-4                                                                                    | Lunar                                                                                  | 127 m <sup>3</sup>                                                                          | Grid-Connected                                                                                | TBD                                                                                          | Early 2030s                                                                                |
| Lunar Cruiser                                                                             | 2                                                                                      | Lunar                                                                                  | ~9 m <sup>3</sup>                                                                           | 10 kW stat.                                                                                   | Open-Loop                                                                                    | 2029+                                                                                      |
| ISS                                                                                       | 7                                                                                      | LEO                                                                                    | 388 m <sup>3</sup>                                                                          | 30 kW cont.                                                                                   | 98%                                                                                          | Active                                                                                     |
| Tiangong                                                                                  | 3                                                                                      | LEO                                                                                    | ~110 m <sup>3</sup>                                                                         | ~27 kW cont.                                                                                  | >90%                                                                                         | Active                                                                                     |

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