

Gradient One Design Dossier with Cost Analysis

1. Overview Gradient One (G1) is a full-scale, crew-rated artificial gravity testbed in low Earth orbit. It is designed to empirically evaluate the physiological and operational impacts of long-duration partial-gravity exposure (Mars and lunar analogs) using a rotating habitat.

G1's mission is to close critical knowledge gaps in human adaptation to partial gravity, provide a structural and systems prototype for future orbital habitats, and serve as a platform for scalable industrial and commercial experimentation.

2. Core Architecture

- **Primary Structure:** 350-meter aluminum alloy truss boom
- **Habitat Pod:** 5° torus segment with a 40-meter tube radius (~30 meters of internal floor length)
- **Counterbalance Boom:** Shorter boom with water-based counterweight and active balancing system
- **Rotation Rates:**
 - 1.97 rpm (1g)
 - 0.98 rpm (Mars gravity)
 - 0.63 rpm (Moon gravity)
- **Spin System:** Controlled spin-up via cold gas thrusters or electric propulsion; long-term bearingless spin control via reaction control system (RCS)

3. Systems Design

- **Power:** Solar panels mounted along the truss structure; battery arrays in central node
- **Thermal Control:** Radiators mounted off truss or habitat shell
- **Communications:** Ka-band relay to ground via TDRSS; backup S-band
- **Propulsion:** Cold-gas RCS pods; optional secondary propulsion for reboost
- **Docking & Access:** Central hub docking port for launch vehicle interface and crew transfer
- **Human Factors:**

- Full-body rotation environment
- Isolation chamber monitoring for physiological data
- Limited EVA support from non-rotating hub

4. Key Design Features

- **Water-Based Counterbalance:** Dense, modular, actively balanced mass system for spin precision
- **Modular Habitat Construction:** Scalable torus geometry
- **Crew-Rated Design:** Launch-ready pressure vessel for full system qualification
- **Expandable Testbed:** Hardware interface points to accommodate external payloads and future add-ons

5. Cost Breakdown Summary

Cost Category	Estimated Amount (USD)
Design & Program Management	\$6,000,000
Senior/Key Personnel (PI salary)	\$750,000
Hardware Development & Fabrication	\$32,000,000
Habitat Module Fabrication	\$10,000,000
Launch Vehicle (single mission)	\$10,000,000
Assembly, Integration & Testing (AIT)	\$5,000,000
Facilities, Rentals, and Services	\$1,000,000
Contingency Reserve (5%)	\$3,191,000
Total Estimated Budget	\$67,000,000

Note: Hardware development and fabrication include outsourced manufacturing for structural elements, tanks, habitat, and mechanical systems. All major fabrication will be executed by qualified aerospace contractors.

6. Schedule by Budget Period

- **Period 1 (2026):** Conceptual design finalization, mission planning, PI labor, subcontractor studies, early procurement (\$6.13M)

- **Period 2 (2027):** Major fabrication, integration contracts, water tank and truss delivery, systems development (\$32.7M)
- **Period 3 (2028):** Flight integration, transport, launch, and on-orbit commissioning (\$21.1M)

7. Ownership Model Gradient One is developed under Aegis Station Infrastructure LLC (ASI). NASA or other partners may receive privileged mission access through grant or cooperative agreement, but full title remains with ASI unless negotiated otherwise.

8. Technology Demonstration Objectives

- First orbital demonstration of sustained human-rated artificial gravity
- Validation of water-based dynamic counterweight systems
- Modular integration with future commercial orbital stations

9. Path Forward

- Submitted under UNSOL_FY2025 for NASA consideration
- If funded: immediate start with established vendors and phased build
- If unfunded: alternative pursuit of private sector and international partners for continuation

10. Summary Gradient One is a near-term, high-value, modular, scalable pathfinder for future human spaceflight beyond low Earth orbit. Its design is rooted in engineering feasibility, cost realism, and cross-domain usability.

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