Gradient One (G1)

Artificial Gravity Testbed

Updated Design Dossier & Cost Analysis

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Prepared by: **Aegis Station Infrastructure LLC (ASI)**
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1. Executive Summary

Gradient One (G1) is a crew-rated, orbital artificial-gravity testbed designed to empirically resolve the most critical unresolved risk in long-duration human spaceflight: **how the human body adapts to sustained partial gravity**.

Despite decades of orbital operations, no spaceflight program has ever produced long-duration physiological data at **lunar- or Mars-equivalent gravity levels**. Current mission architectures rely on extrapolation from microgravity, short-radius centrifuges, or terrestrial analogs—none of which adequately replicate a full-body, continuously rotating environment.

G1 closes this gap.

Gradient One is deliberately scoped as a **minimal, high-fidelity experimental platform**, not a space station. Its purpose is to generate definitive medical, operational, and systems data required before committing to:

- Crewed Mars transit vehicles
- Permanent lunar surface habitation
- Large rotating orbital habitats (including future Aegis / G4-class systems)

G1 is a **risk-retirement instrument**, not an end destination.

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2. Program Objectives

Primary Objectives

- Demonstrate sustained, crew-rated artificial gravity in Earth orbit
- Measure long-duration human adaptation to:
    - Lunar gravity (0.16g)
    - Mars gravity (0.38g)
    - Earth-equivalent gravity (1.0g)
- Establish validated physiological thresholds for gravity exposure duration

Secondary Objectives

- Validate water-based dynamic counterbalance systems
- Demonstrate spin-up, spin-down, and long-term rotational stability
- Serve as a structural and operational precursor to large rotating habitats
- Enable hosted experiments and international participation

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3. System Overview

Gradient One consists of a **single inhabited rotating pod** mounted at the end of a long truss, counterbalanced by a water-mass system to ensure stable rotation and controlled gravity levels.

The system is intentionally simple:

- One crew habitat
- One rotation radius
- One mission at a time
- Maximum data density

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4. Core Architecture

4.1 Primary Structure

- **Main Truss Boom:** ~350 meters
- **Material:** Aluminum alloy truss elements
- **Function:** Provides centrifugal radius to reduce Coriolis effects and maintain crew comfort at low RPM

4.2 Habitat Module

- **Geometry:** ~5° torus segment
- **Tube Radius:** ~40 meters
- **Usable Floor Length:** ~30 meters
- **Configuration:** 3–4 internal decks following the arc as practicable

- **Crew Capacity:** 2–4 persons
- **Design Life:** Multi-mission capable, limited refurbishment

4.3 Counterbalance System

- **Mass Type:** Water-based modular tanks
- **Purpose:**
    - Static balance
    - Dynamic trim during crew movement
    - Spin-rate stabilization
- **Additional Benefit:** Radiation shielding and consumables storage

4.4 Gravity Regimes

Target Gravity	Approx. RPM
1.0g	~1.97 rpm
Mars (0.38g)	~0.98 rpm
Moon (0.16g)	~0.63 rpm

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5. Spin and Control Systems

- **Spin-Up / Spin-Down:** Cold gas thrusters or electric propulsion assist
- **Attitude Control:** Distributed RCS pods
- **Long-Term Stability:** Reaction control with active mass balancing
- **Bearings:** Bearingless or low-maintenance rotational interface design to minimize wear

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6. Power, Thermal, and Avionics

Power

- Solar arrays mounted along the truss
- Central battery storage in non-rotating hub
- Peak power sized for life support, avionics, and experiments

Thermal Control

- Radiators mounted on non-rotating elements
- Passive thermal isolation between rotating and non-rotating sections

Communications

- Primary: Ka-band relay via TDRSS
- Backup: S-band direct link
- Continuous telemetry during crewed operations

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7. Docking, Access, and Operations

- **Docking Port:** Located at non-rotating central hub
- **Crew Transfer:** Conducted prior to spin-up
- **EVA Capability:** Limited, hub-based only
- **Mission Duration:** 30–180 days per increment
- **Occupancy:** Not continuous; mission-based crew rotations

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8. Human Factors & Research Focus

G1 enables full-body exposure to partial gravity—something no ISS module or short-radius centrifuge can replicate.

Key Research Domains

- Vestibular adaptation and motion tolerance
- Bone density retention vs gravity level
- Muscle mass and strength maintenance
- Cardiovascular unloading thresholds
- Sleep quality and circadian stability
- Task performance in rotating frames
- Long-term habitability and crew comfort

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9. Why G1 Is Necessary

Not ISS

ISS cannot provide sustained partial gravity environments.

Not Short-Radius Centrifuges

Short-radius systems introduce Coriolis artifacts and non-uniform gravity vectors.

Not Terrestrial Analogs

Bed rest, parabolic flight, and rotating rooms do not replicate continuous orbital conditions.

G1 is the missing experimental link between microgravity and planetary surface missions.

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10. Relationship to Future Systems

Gradient One is a **direct precursor** to larger rotating systems.

- G1 validates:
  - Gravity levels
  - Rotation rates
  - Human tolerance
  - Structural scaling laws
- G4 / Aegis-class habitats should **not** be committed without G1-class data.

This sequencing reduces risk, cost, and programmatic failure modes.

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11. Ownership & Partnership Model

Gradient One is developed and owned by **Aegis Station Infrastructure LLC**.

- Government agencies may participate via:
  - Grants
  - Cooperative agreements
  - Hosted research access
- Title remains with ASI unless otherwise negotiated
- International and commercial partners may access mission slots or experiment accommodations

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12. Updated Cost Analysis (Revision 2.0)

Cost Philosophy

G1 is scoped as a **minimum viable, crew-rated artificial gravity demonstrator** with strong cost discipline and modular scope control.

Total Program Cost (TPC)

Estimated Range: $85M – $110M

12.1 Design, Program, and Engineering

Category	Estimated Cost
Program Management & Systems Engineering	$8.0M
Human Factors & Physiology	$3.5M
Safety, Crew Rating, Reviews	$4.0M
Subtotal: $15.5M	

12.2 Hardware & Fabrication

Category	Estimated Cost
Truss & Structural Fabrication	$18.0M
Habitat Pressure Vessel	$14.0M
Counterbalance Water System	$6.0M
Spin Control, RCS, Bearings	$7.5M
Power, Thermal, Avionics	$9.0M
Subtotal: $54.5M	

12.3 Integration, Test, and Launch

Category	Estimated Cost
Assembly, Integration & Test (AIT)	$8.0M
Launch Services (Falcon 9-class)	$12–15M
On-Orbit Commissioning	$4.0M
Subtotal: $24–27M	

12.4 Reserves

- **Program Reserve (≈10%)**: $8–10M

Total Program Estimate

- **Low Case:** ~$85M

- **High Confidence Case:** ~$105–110M

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13. Schedule Overview

- **Year 1:** Final design, contracts, long-lead procurement
- **Year 2:** Fabrication, subsystem testing, integration
- **Year 3:** Launch, commissioning, first crewed mission

Schedule is **funding-driven and modular**, allowing staged commitment.

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14. Path Forward

Gradient One has been previously submitted under NASA's Unsolicited Proposal process and remains active as a partner-ready program.

Next steps include:

- Updated agency engagement
- Commercial LEO partner outreach
- International research collaboration discussions
- Final design lock upon funding commitment

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15. Summary

Gradient One is a focused, credible, and urgently needed step in human spaceflight development.

It does not compete with stations, landers, or Mars vehicles.
It enables them.

By resolving artificial-gravity uncertainty now, G1 reduces risk across every future human exploration architecture.

End of Dossier