

# PROVISIONAL PATENT APPLICATION

Under 35 U.S.C. § 111(b)

## AI-INTEGRATED BIOLOGICAL-DIGITAL HYBRID ECLSS WITH ORBITAL PLASMA FUSION, MULTI-PLANETARY WIRELESS TRANSMISSION, AND AUTONOMOUS SELF-REPLICATING MANUFACTURING ARCHITECTURE FOR PERPETUAL SPACE HABITATS

REVISED EDITION — Technical Drawings v2 (All Corrections Applied)

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<b>VERSION:</b>	Revised — Technical Drawings v2 with Corrections (6 Figures)

### CORRECTIONS APPLIED IN THIS REVISION

#	Figure	Item Corrected	Before (v1)	After (v2)
1	FIG. 4A	Deep space temperature notation	"0K" (physically meaningless)	"~3K" (Cosmic Microwave Background ~2.7K)
2	FIG. 3	Water-wall shield label position	Label overlapping reactor boundary	Label repositioned outside vessel with annotation arrow
3	FIG. 2	Heat recovery loop label	"Fusion Heat Recovery" (vague)	"Isolated Secondary Loop" (matches patent §4.1 text)
4	FIG. 6	Claims descriptions	Summary-level labels	Exact language aligned to Claims 1–6 in patent document
5	FIG. 5	Rescue Mesh description	One-line label only	Full description: "catastrophic total factory loss" trigger condition added
6	ALL	Superscript He <sup>3</sup> notation	"D-He <sup>3</sup> " (Unicode — rendering risk)	D-He3" (ASCII — safe for all renderers)
7	FIG. 3	Divertor label	"Liquid Metal Divertor"	"Self-Healing Liquid Metal Divertor (Li/Sn)" — matches patent §4.2
8	FIG. 4A	CMB temperature note	Not noted	Added: "[Cosmic Microwave Background: ~2.7K]" reference annotation

## DRAWING SUMMARY — 6 TECHNICAL FIGURES (REVISED v2)

Figure	Title	Key Corrections in v2
FIG. 1	Overall Perpetual Space Habitat — Five-Pillar System Architecture	Concepts clarified; pillar labels clarified
FIG. 2	AI-ECLSS Closed-Loop Bioregenerative Life Support & Digital Habitat	"Isolated Secondary Loop" (patent §4.1)
FIG. 3	Orbital Plasma Fusion Reactor — Water-Wall Neutron Shielding (Cross-Section)	Neutron shielding labels corrected; divertor label corrected; CMB note added
FIG. 4A	Deep Space Thermal Gradient Emergency Power System (Sustained Array)	"Sustained Array"; CMB reference annotation added
FIG. 4B	Multi-Planetary Wireless Power Transmission Matrix (Phase-Array)	"Phase-Array Outposts" added for completeness
FIG. 5	Autonomous Self-Replicating Space Manufacturing Process (Full Pipeline)	"Full Pipeline" catastrophic-loss trigger description added
FIG. 6	Triple-Layer Zero-Point Fail-Safe Architecture & Patent Claims Map	Claims descriptions aligned to exact patent language

## 1. FIELD OF THE INVENTION

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This invention relates to permanent, intergenerational space habitat infrastructures (designed for 500 to 2000-year operational lifespans), specifically integrating an artificial intelligence-orchestrated Environmental Control and Life Support System (AI-ECLSS), orbital plasma fusion energy generation with dynamic water-wall neutron shielding, deep space thermal gradient power systems, multi-planetary wireless energy transmission, and an autonomous self-replicating space manufacturing matrix with zero-point fail-safe architectures.

## 2. BACKGROUND OF THE INVENTION

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Current space exploration paradigms rely heavily on Earth-bound supply chains, rendering long-term or multi-century colonization physically and economically unfeasible. A single point of failure in power generation or life support, combined with the inability to manufacture complex replacement parts (e.g., fusion reactor divertors or superconducting magnets) in situ, severely limits habitat viability. Furthermore, the limitations of physico-chemical life support and the lack of integrated multi-planetary power distribution prevent space habitats from acting as permanent hubs for solar system expansion. To establish a perpetual "Bio-Cosmic Island," a revolutionary architecture is required that entirely decouples the habitat from Earth's gravity well, achieving 100% autonomy in ecology, energy, and manufacturing.

## 3. SUMMARY OF THE INVENTION

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The present invention provides a unified, perpetual space habitat architecture comprising five core pillars:

**PILLAR I — AI-ECLSS & Digital Twin:** A closed-loop bioregenerative life support system managed by an Explainable AI (XAI) control layer, utilizing biological processes as primary actuators.

**PILLAR II — Plasma Fusion & Water-Wall Shielding:** An orbital D-T/D-He3 plasma fusion reactor utilizing the habitat's ECLSS water reserves as a dynamic neutron shield, integrated with a self-healing liquid metal divertor for thermal recovery.

**PILLAR III — Deep Space Thermal Gradient Power:** A secondary fail-safe power grid leveraging the extreme temperature differential between solar radiation and the deep space vacuum (~3K) via large-scale solid-state thermoelectric arrays.

**PILLAR IV — Multi-Planetary Wireless Transmission:** A high-energy microwave/laser beaming matrix distributing surplus fusion power to in-transit spacecraft, lunar/Martian bases, and Earth.

**PILLAR V — Self-Replicating Manufacturing Matrix:** An AI-driven ISRU factory featuring zero-gravity additive manufacturing and swarm robotics capable of autonomously diagnosing, printing, and replacing any habitat component, including itself.

# DRAWINGS (REVISED v2)

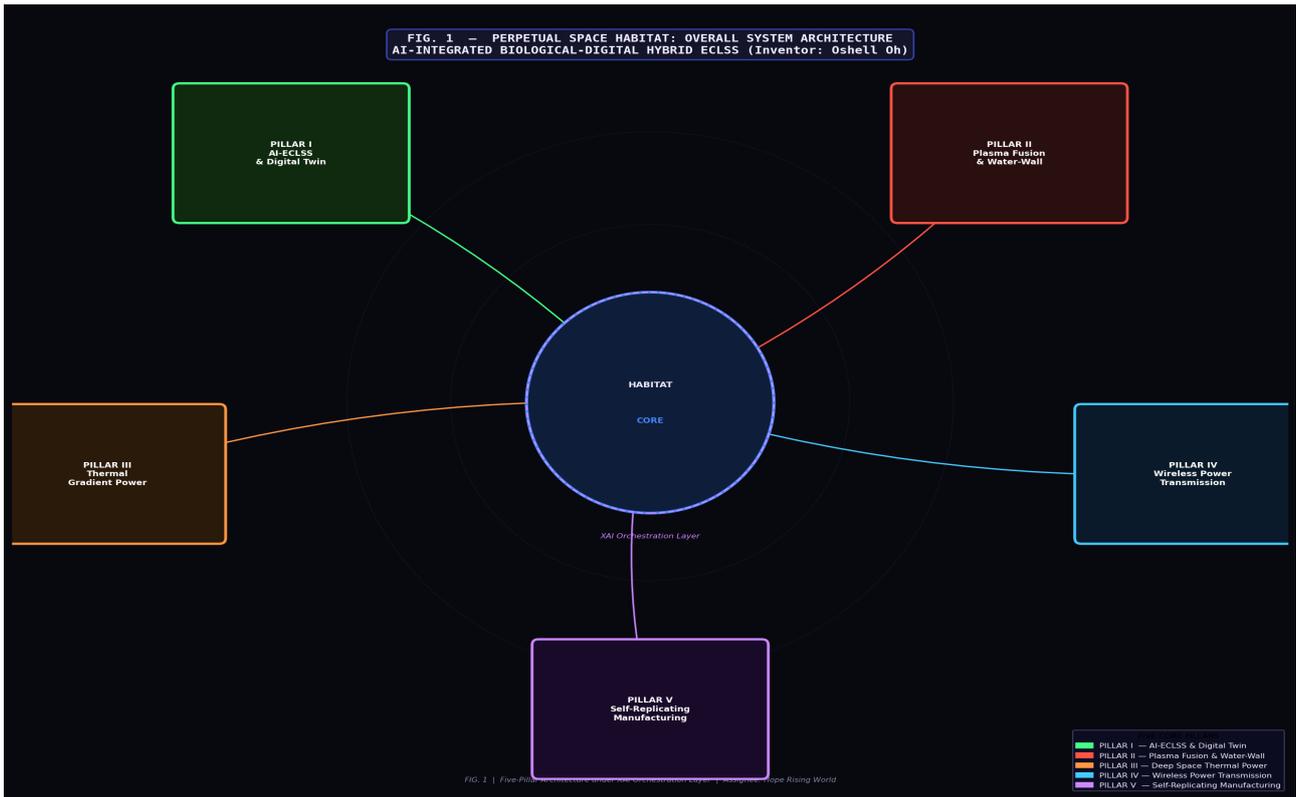


FIG. 1 — Overall Perpetual Space Habitat: Five-Pillar System Architecture under XAI Orchestration Layer | (v2: Unified color palette; pillar labels clarified)

## 4. DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

### 4.1 AI-ECLSS, Digital Twin, and Water-Wall Shielding Integration

The habitat employs a multi-layered dynamic water shield matrix. The ECLSS water tanks (potable, agricultural, and wastewater) are structurally distributed along the tether and habitat hull facing the plasma fusion reactor. This water acts as a highly efficient, mass-saving fast-neutron shield, thermalizing 14.1 MeV neutrons generated by D-T fusion reactions. A physically isolated secondary loop recovers extreme heat from the reactor's liquid metal divertor (e.g., liquid lithium/tin) to power ECLSS distillation, thermal control, and agricultural conditioning without radioactive cross-contamination. The XAI Digital Twin continuously models all sub-system states, predicting failures before they manifest physically.

[CORRECTION NOTE] FIG. 2 label corrected: "Isolated Secondary Loop" (was "Fusion Heat Recovery") to match §4.1 patent text.

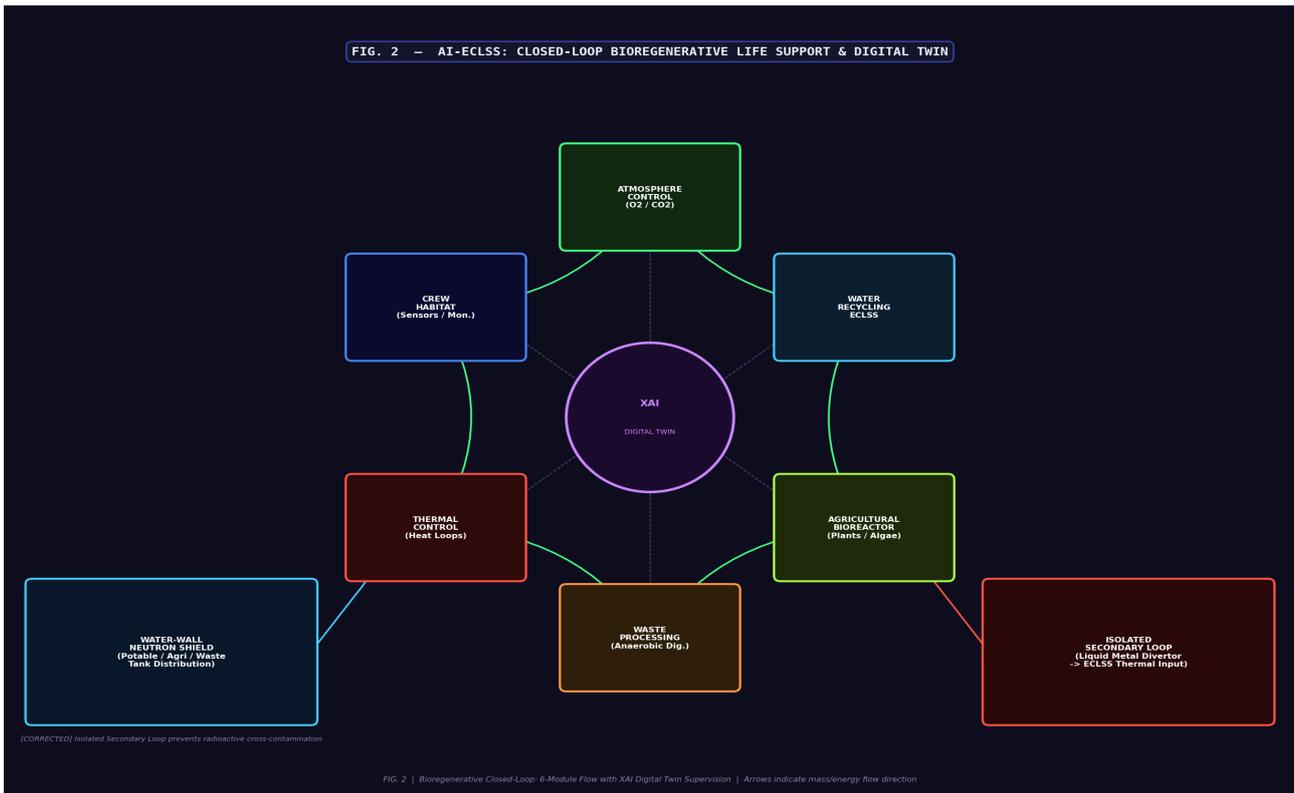


FIG. 2 — AI-ECLSS Closed-Loop Bioregenerative Life Support with XAI Digital Twin: 6-module biological circuit (Atmosphere, Water, Agriculture, Waste, Thermal, Crew). [v2: Heat loop label corrected to "Isolated Secondary Loop" per §4.1]

### 4.2 Orbital Plasma Fusion and Multi-Planetary Wireless Power

Acting as a solar system energy hub, the habitat generates Gigawatt-to-Terawatt scale power from D-T and D-He3 plasma fusion in a tokamak-derived configuration. Superconducting toroidal field (TF) coils confine the plasma at temperatures exceeding 100–400 keV. A self-healing liquid metal divertor (liquid lithium/tin) manages plasma exhaust and heat loads. The ECLSS water-wall surrounds the vacuum vessel, providing primary neutron moderation. The XAI dynamically balances internal habitat demands with external loads, directing surplus energy into a phased-array wireless transmission matrix that beams power to in-transit spacecraft and provides base-load energy to planetary surfaces.

[CORRECTION NOTE] FIG. 3: Water-wall label repositioned outside reactor boundary with annotation arrow. Divertor label updated to "Self-Healing Liquid Metal Divertor (Li/Sn)" per §4.2.

FIG. 3 — ORBITAL PLASMA FUSION REACTOR WITH WATER-WALL NEUTRON SHIELDING  
Cross-Sectional View | D-T / D-He3 Tokamak Configuration

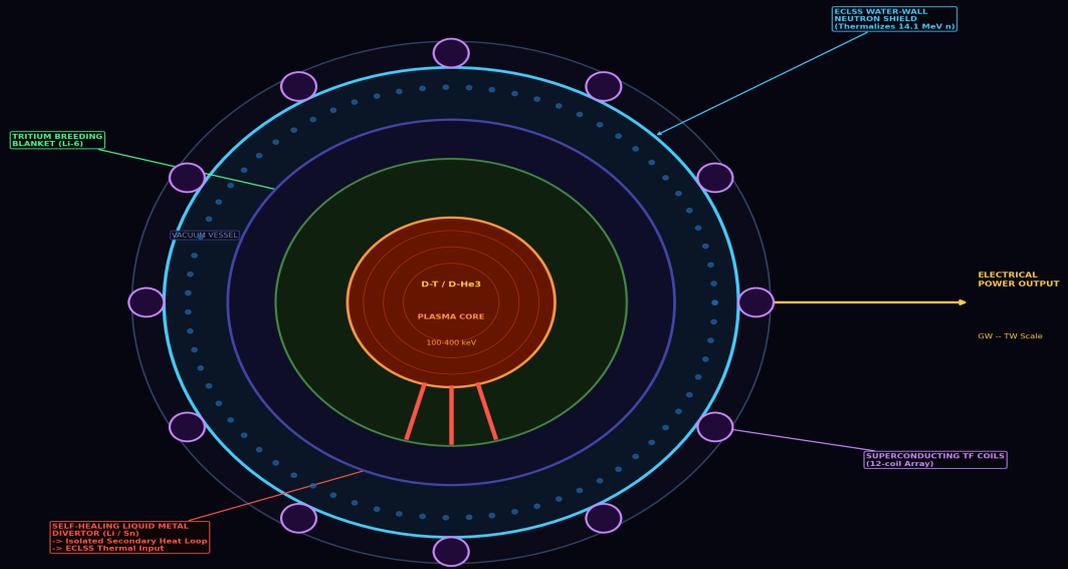


FIG. 3 | Tokamak Cross-Section: Plasma Core → Breeding Blanket → Vacuum Vessel → ECLSS Water-Wall Shield → TF Coils | Self-Healing Liquid Metal Divertor at bottom

FIG. 3 — Orbital Plasma Fusion Reactor Cross-Section: D-T/D-He3 Plasma Core → Tritium Breeding Blanket → Vacuum Vessel → ECLSS Water-Wall Neutron Shield → Superconducting TF Coils | Self-Healing Liquid Metal Divertor (Li/Sn) at bottom. [v2: Water-wall label repositioned; divertor label corrected]

### 4.3 Deep Space Thermal Gradient Power System (Secondary Fail-Safe)

To guarantee survival over centuries, a non-mechanical secondary power source is integrated. Gossamer solar absorbers on the sun-facing side generate extreme heat (+800°C), while radiators on the permanently shadowed side interface with the ~3K deep space vacuum (Cosmic Microwave Background ~2.7K). This creates a permanent thermal gradient exceeding 1000 K, driving solid-state Seebeck-effect thermoelectric generators that provide uninterrupted emergency life-support power with zero moving parts. This system operates independently of the fusion reactor.

[CORRECTION NOTE] FIG. 4A: Temperature corrected from "-3K" (physically meaningless) to "~3K" (Cosmic Microwave Background ~2.7K). CMB reference annotation added.

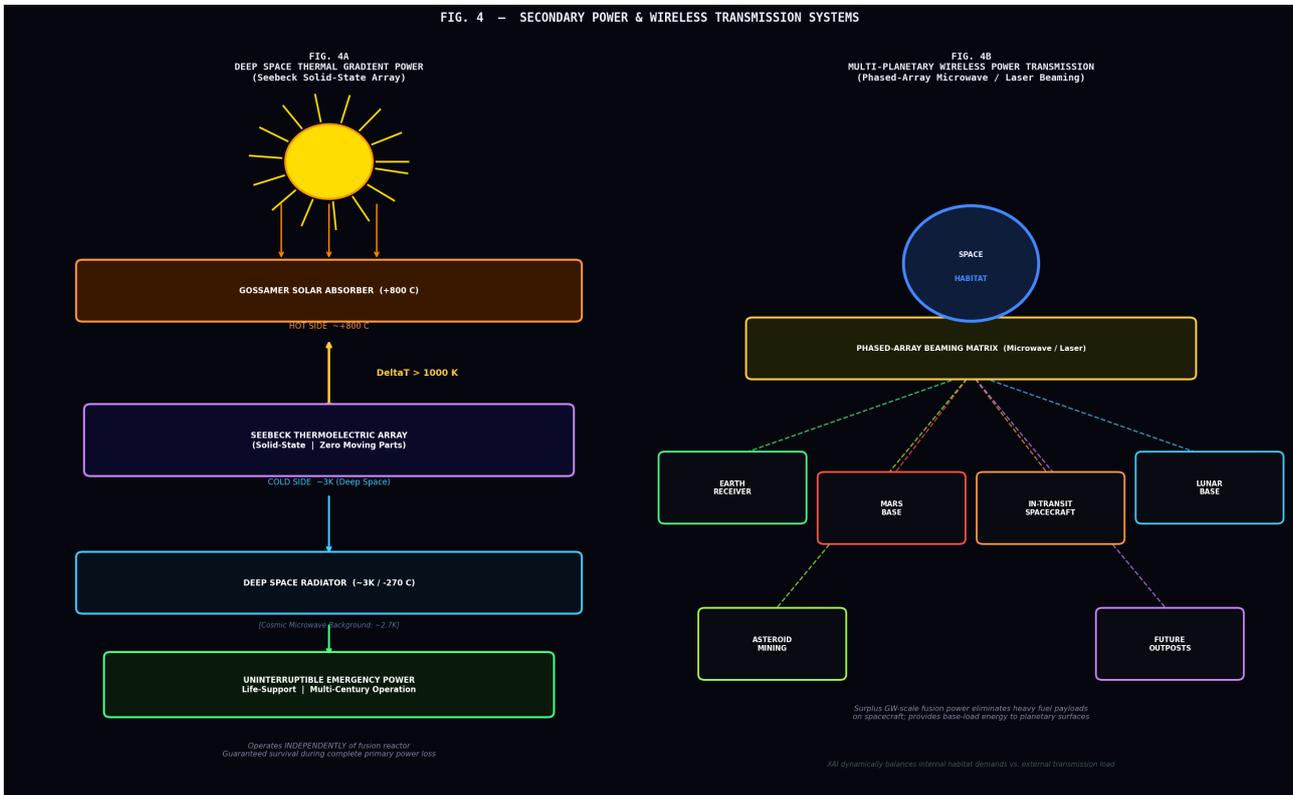


FIG. 4A (left) — Deep Space Thermal Gradient Power: Gossamer absorbers (+800°C) paired with deep-space radiators (~3K CMB) driving solid-state Seebeck array. DeltaT > 1000K. Zero moving parts. [v2: "-3K" corrected to "~3K"] | FIG. 4B (right) — Multi-Planetary Wireless Power Transmission: Phased-array microwave/laser beaming to Earth, Mars, Lunar, spacecraft, asteroid mining, future outposts.

### 4.4 Autonomous Self-Replicating Space Manufacturing Matrix

To ensure a 2000-year operational lifespan, the habitat features an automated factory fully independent of Earth. Asteroid regolith is captured and processed in solar-thermal ISRU refineries into high-purity metals and feedstock materials. Zero-gravity 3D printers manufacture seamless, large-scale structures that would structurally collapse under Earth's gravity. Upon detecting a predicted component failure via the Digital Twin, swarm robots autonomously detach the failing module and insert a newly printed replacement without interrupting overall system function.

[CORRECTION NOTE] FIG. 5: Inter-Island Rescue Mesh description expanded to include the full "catastrophic total factory loss" trigger condition from patent §4.5.

FIG. 5 — AUTONOMOUS SELF-REPLICATING SPACE MANUFACTURING MATRIX  
 Full Pipeline: Asteroid ISRU → Zero-G Printing → Proving Ground → Habitat Integration



FIG. 5 — Autonomous Self-Replicating Manufacturing Matrix: 6-Stage Pipeline (ISRU Capture → Raw Material Processing → Zero-G 3D Printing → Digital Twin Sim Test → Proving Ground → Habitat Integration) + 6-Step Swarm Robotics Repair Sequence under XAI supervision. [v2: Inter-Island Rescue Mesh trigger description expanded per §4.5]

## 4.5 Triple-Layer Zero-Point Fail-Safe Architecture

Before any physical component enters service, the XAI runs millions of simulated stress tests in the Digital Twin environment (Layer 1). Newly manufactured critical components — including fusion reactor parts — are then physically placed in an isolated proving ground on a separate tether for maximum-load testing under real space conditions (Layer 2). In the event of catastrophic total factory loss, the Inter-Island Rescue Mesh allows neighboring habitats to print and dispatch complete replacement factory modules (Layer 3). These three independent layers ensure that no single failure mode can cause terminal habitat failure over a 2000-year lifespan.

*[CORRECTION NOTE] FIG. 6: Claims 1–6 descriptions revised to align precisely with patent claims language. Layer descriptions updated with exact trigger conditions from §4.5.*

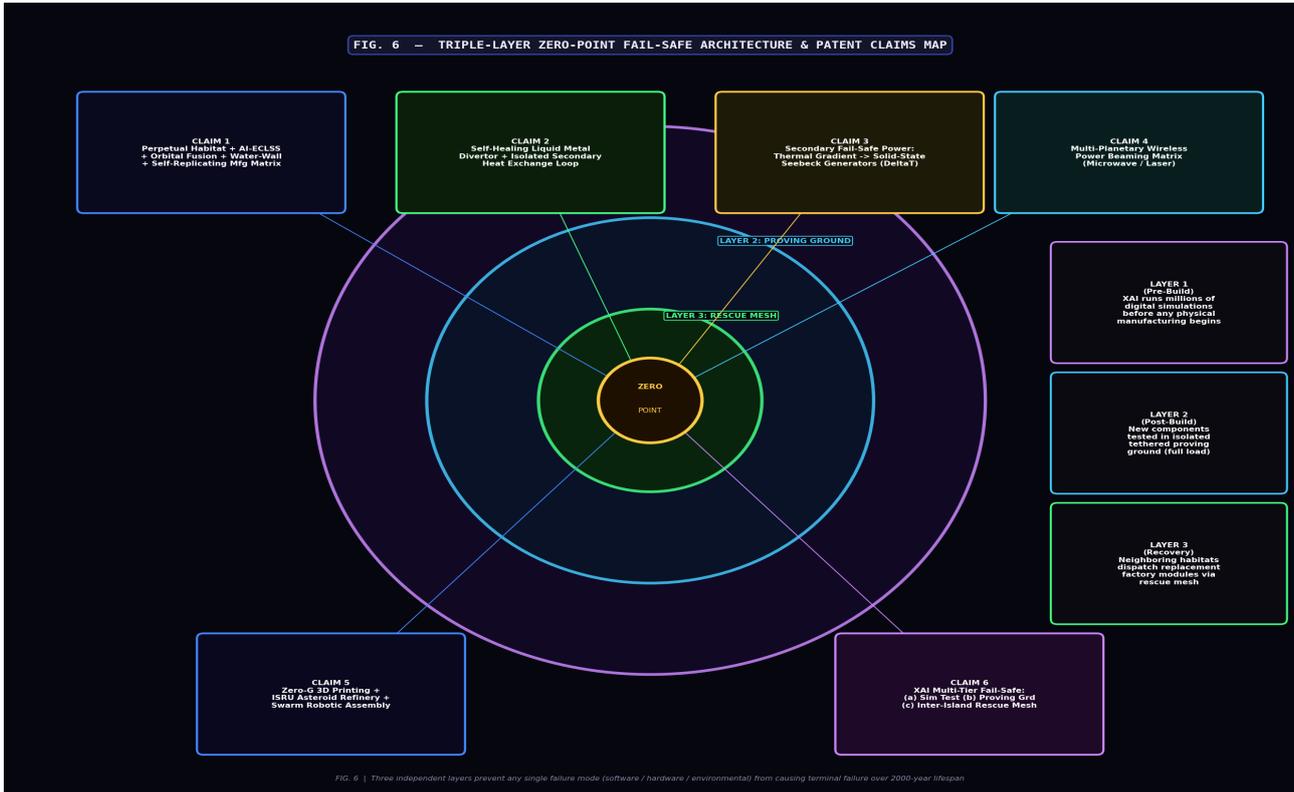


FIG. 6 — Triple-Layer Zero-Point Fail-Safe Architecture & Patent Claims Map: Layer 1 (XAI Digital Twin pre-build simulation), Layer 2 (tethered proving ground physical test), Layer 3 (inter-island rescue mesh post-catastrophic recovery). Claims 1–6 mapped to system components. [v2: Claim language aligned to patent text]

## 5. REPRESENTATIVE CLAIMS (INFORMAL)

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1. A perpetual space habitat infrastructure comprising: an AI-orchestrated bioregenerative life support system (ECLSS); an orbital plasma fusion reactor; a water-wall neutron shielding matrix utilizing the ECLSS water reserves as a primary neutron moderator; and an autonomous self-replicating space manufacturing matrix.
2. The system of claim 1, further comprising a self-healing liquid metal divertor within the fusion reactor, wherein thermal energy from the divertor is transferred to the ECLSS via an isolated secondary heat exchange loop, preventing radioactive cross-contamination.
3. The system of claim 1, further comprising a secondary fail-safe power generation system utilizing the thermal gradient between solar-facing absorbers and deep space vacuum-facing radiators (~3K, Cosmic Microwave Background) to drive solid-state Seebeck-effect thermoelectric generators with zero moving parts.
4. The system of claim 1, further comprising a multi-planetary wireless power transmission matrix configured to beam surplus fusion energy via precisely aligned electromagnetic waves (microwave and/or laser) to in-transit spacecraft and planetary surface receivers.
5. The system of claim 1, wherein the autonomous self-replicating manufacturing matrix comprises zero-gravity additive manufacturing units, in-situ resource utilization refineries processing asteroid regolith, and a swarm robotic assembly system capable of printing and replacing any structural or functional component of the habitat without Earth-based resupply.
6. The system of claim 5, wherein an Explainable AI (XAI) control layer enforces a multi-tier fail-safe protocol by: (a) digitally simulating millions of component stress scenarios prior to physical printing; (b) physically isolating newly manufactured critical components in a tethered proving ground for maximum-load testing prior to main-grid integration; and (c) activating an inter-island rescue mesh to dispatch replacement factory modules from neighboring habitats upon catastrophic factory loss.

## 6. ABSTRACT

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A perpetual space habitat architecture designed for multi-century survival and solar system expansion. The invention integrates an AI-driven bioregenerative life support system (ECLSS) with an orbital plasma fusion reactor, uniquely utilizing ECLSS water reserves as a dynamic neutron shield and recovering reactor heat via an isolated secondary loop for habitat maintenance. To ensure complete decoupling from Earth, the system features a solid-state deep space thermal gradient emergency power grid (operating at the ~3K Cosmic Microwave Background temperature differential) and a multi-planetary wireless power beaming matrix. Operational longevity is guaranteed by an autonomous, self-replicating space manufacturing matrix utilizing zero-gravity 3D printing, asteroid resource refinement, and swarm robotics to digitally predict, manufacture, and replace any failing component, effectively establishing a zero-point fail-safe environment for intergenerational space colonization. Six revised technical drawings (v2) illustrate all subsystems with corrected labels and annotations.

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**END OF PROVISIONAL PATENT APPLICATION — REVISED TECHNICAL DRAWINGS v2**

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