

CANVAS: SPERS TECHNICAL DESIGN DOSSIER

SECTION 5.0: LIFECYCLE, DISPOSAL & ORBITAL RECOVERY

5.1 Cartridge Service Life & Maintenance

The **CORE-A1** unit is a consumable component designed for modular replacement rather than in-situ repair.

- **Operational Lifespan:** 18 Months or 10^9 Pulse Cycles.
- **Limiting Factors:**
 1. **Dielectric Fatigue:** Degradation of the PZT Piezo stacks due to high-voltage switching¹.
 2. **Armor Fatigue:** C/SiC shell rated for 10^9 pressure cycles before micro-fracture risk².
 3. **Coil Failure:** Redundancy allows operation until 2 of 3 parallel Litz circuits fail³.

Replacement Protocol (Level 1 Service):

- **Method:** "Cartridge Swap"⁴.
- **Procedure:** A Shielded Bell Cask is lowered over the breech. Robotic grapples rotate the unit 45° to unlock. The spent core is retracted into the cask without breaking the Red Loop containment seal⁵.

5.2 End-of-Life (EOL) Disposal Options

Strategy for the permanent disposal of the spent **CORE-A1** cartridges.

Option A: Geological Storage (Standard)

- **Concept:** Dry Cask Storage in deep geological repositories⁶.
- **Process:** The core is **vitrified** (encased in molten glass) inside a concrete silo⁷.
- **Radiotoxicity:** Decay to background levels occurs within **50 years** due to the lack of long-lived Actinides (Uranium/Plutonium) in the fusion fuel cycle⁸.

Option B: The Phoenix Protocol (Orbital Disposal)

- **Concept:** Launch sealed core to High Earth Orbit (HEO) for vaporization and material recovery⁹.
- **Mechanism:** Remote command triggers an **Inductive Overload** of the remaining superconducting coils¹⁰.
- **Result:** The core vaporizes into a plasma cloud containing valuable Rare Earth Elements (REE)¹¹.

5.3 Orbital Recovery Architecture: "Mass Spectrometer in the Wild"

Technical detail on the capture of vaporized core materials using the "Star-Skimmer" Satellite Array.

This system functions as a giant, open-space mass spectrometer, using the vacuum of space as the separation chamber.

Phase 1: The "Shield" (Magnetic Funneling)

- **Component: Magnetosphere generators** on the satellite array.
- **Function:** As the SPERS core vaporizes, it expands as a cloud of hot, ionized plasma. The satellites project overlapping **Lorentz Force Fields** (Magnetic Shields).
- **Physics:** Instead of blocking the plasma, these fields act as a "magnetic lens." Because different elements (Silicon, Carbon, Rare Earths) have different **Charge-to-Mass Ratios**, the magnetic field bends their trajectories at different angles.
- **Result:** The chaotic cloud is organized into distinct "streams" of pure elements flying through space.

Phase 2: The "Aerogel" (Kinetic Capture)

- **Component: Silica Aerogel Capture Panels** (Density $< 3 \text{ mg/cm}^3$).
 - **Function:** Large, deployable "wings" of ultra-low density aerogel are positioned in the path of the separated element streams.
 - **Physics:**
 - **Soft Catch:** The hyper-velocity ions hit the aerogel. Because the material is 99.8% air/vacuum, the particles are not smashed but are **decelerated gradually** over a few centimeters.
 - **Track Preservation:** The particle buries itself in the gel, creating a visible "carrot-shaped" track.
 - **Mining Method:** The satellites do not need to process the material. They simply "catch" the stream in the gel panels, then retract the panels into a return capsule.
 - **Yield:** High-purity harvest of Neodymium, Yttrium, and transmuted Precious Metals, free from terrestrial contamination.
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Glossary of Abbreviations

- **HEO (High Earth Orbit):** An orbit beyond the standard Low Earth Orbit (LEO), useful for disposal or specialized storage where atmospheric drag is non-existent.
- **REE (Rare Earth Elements):** A set of seventeen chemical elements (like Neodymium and Yttrium) critical for high-tech electronics and magnets.
- **PZT (Lead Zirconate Titanate):** The piezoelectric ceramic material used in the acoustic drivers¹².
- **C/SiC (Carbon-Silicon Carbide):** The ceramic matrix composite used for the reactor armor¹³.
- **Lorentz Force:** The force exerted on a charged particle (the plasma ion) moving through a magnetic field. This is the physical principle used to separate the elements in the "wild" mass spectrometer.