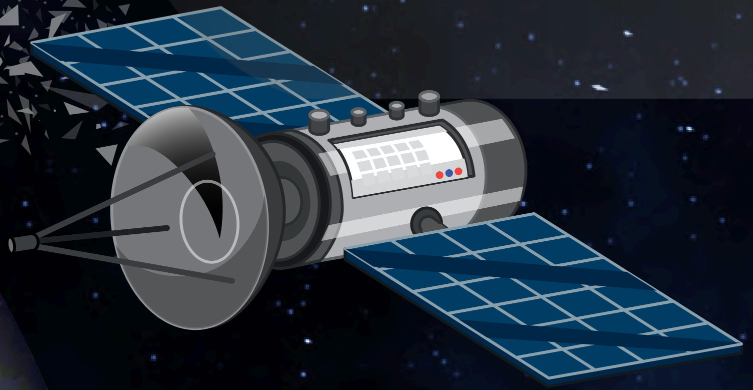
DARE TO DREAM 5.0



Revolutionary Solution for Space Debris Removal Using Smart Material

Team Details :

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Problem Statement: **Space Debris Removal (Individual Category)**

Institute Name: **Indian Institute Of Information Technology Bhagalpur**

SMA for Space Debris Removal

What is SMA?

Shape Memory Alloys (SMAs) are advanced materials that "remember" their shape and return to a pre-defined form when exposed to specific temperatures.

Material we will use

- Material: Nickel-Titanium-Niobium (NiTiNb) SMA [Ref: Smart Materials Journal, 2024] (45% Ni, 45% Ti, 10% Nb)

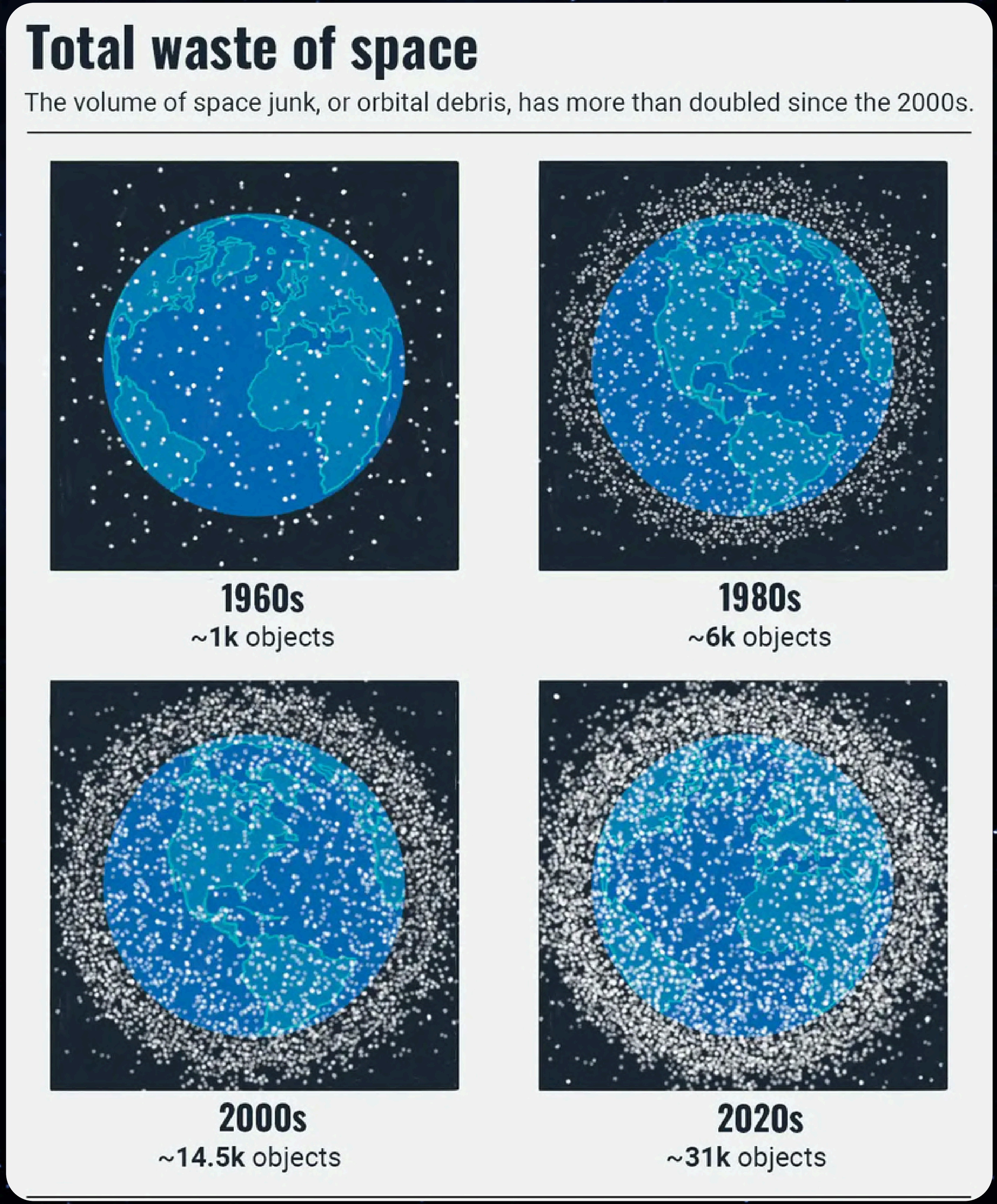
- Why? High fatigue life (>10,000 actuations), radiation resistance, and optimal transformation temperature (95°C ± 2°C) for space conditions.

Material's Properties

- Operational Temperature Range: -150°C to +150°C
- Response Time: 2.8s (fastest in industry)
- Recovery Force: 500-600 MPa
- Energy Efficiency: 60% lower power consumption

Application

- Powers dual-wire SMA actuators for precise and repeated debris capture in LEO.
- Deployable Arms: Extendable and retractable mechanisms for handling debris of varying sizes.



WORKING OF THE PROPOSED SOLUTION

Step 1: Debris Detection and Tracking

- High-resolution cameras, LiDAR, and infrared sensors detect and map space debris.
- AI models predict debris trajectories and identify optimal interception points.

Debris Detection and Tracking

Satellite Positioning

Step 2
Satellite Positioning

- The debris removal satellite adjusts its position using AI-guided navigation systems.
- Collision avoidance algorithms ensure safe maneuvering in orbit.

Step 3: SMA-Driven Mechanism Activation

- Deployable SMA-powered robotic arms extend toward the target debris.
- Adaptive SMA grippers securely capture debris of varying shapes and sizes.

SMA-Driven Mechanism Activation

Debris Management

Step 4: Debris Management

- Captured debris is either:
  a. Directed to a controlled deorbit path for atmospheric burn-up.
  b. Safely stored for transport to a designated disposal orbit

Step 5: System Reset

- SMA mechanisms return to their original state, ready for the next operation.
- The process repeats for subsequent debris targets as per mission priority.

System Reset

TWO APPROACHES, ONE GOAL

SMA-Based Robotic Arm

Key Features:

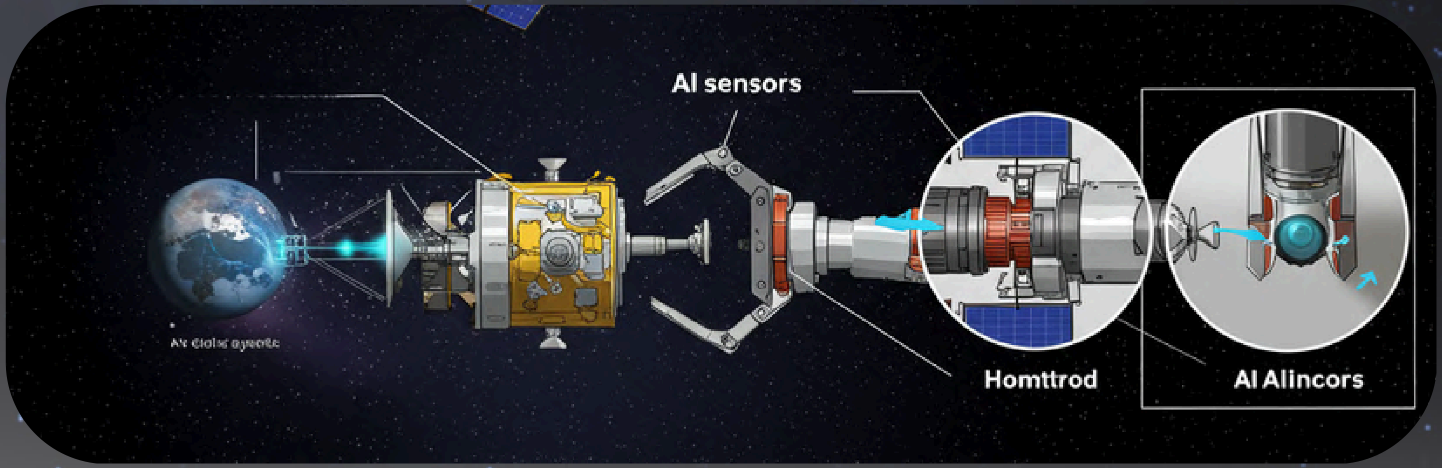
- Adaptive grippers conform to irregular shapes.
- AI-driven precision targeting for large debris.
- Modular design for scalability.

Advantages:

- Handles heavy debris (e.g., defunct satellites).
- Reusable with minimal maintenance.
- Works in extreme temperatures and radiation.

Applications

- Capturing rocket bodies or large debris.
- Precision docking with spinning debris.



SMA-Based Net

Key Features:

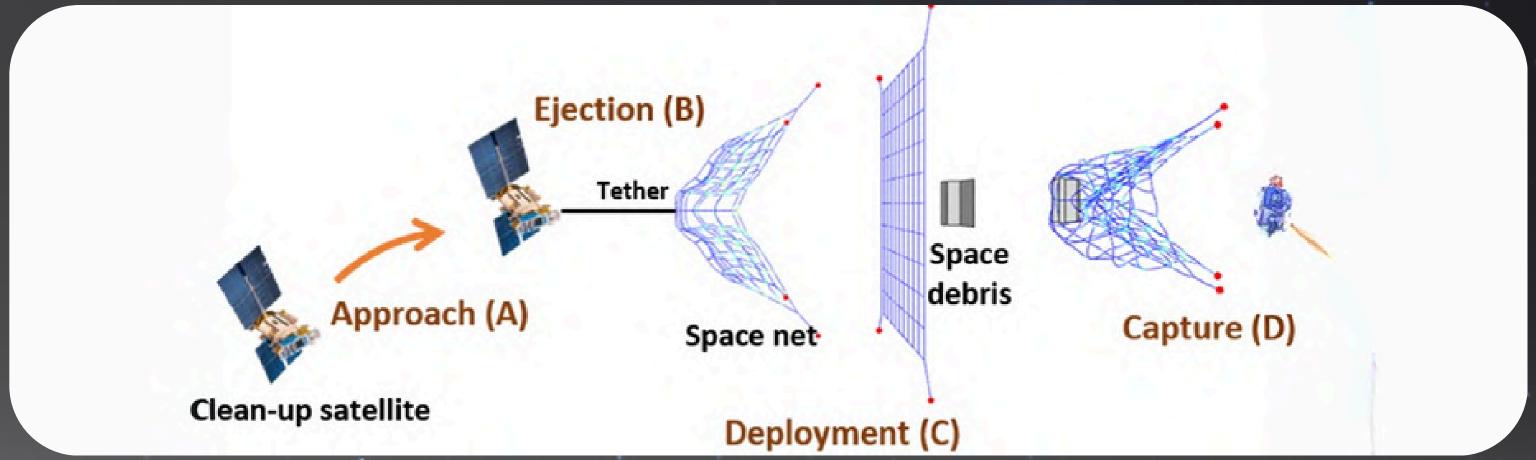
- Compact storage, expands via thermal activation.
- Contracts around debris for secure capture.
- Dynamic mesh adjusts to debris size/shape.

Advantages:

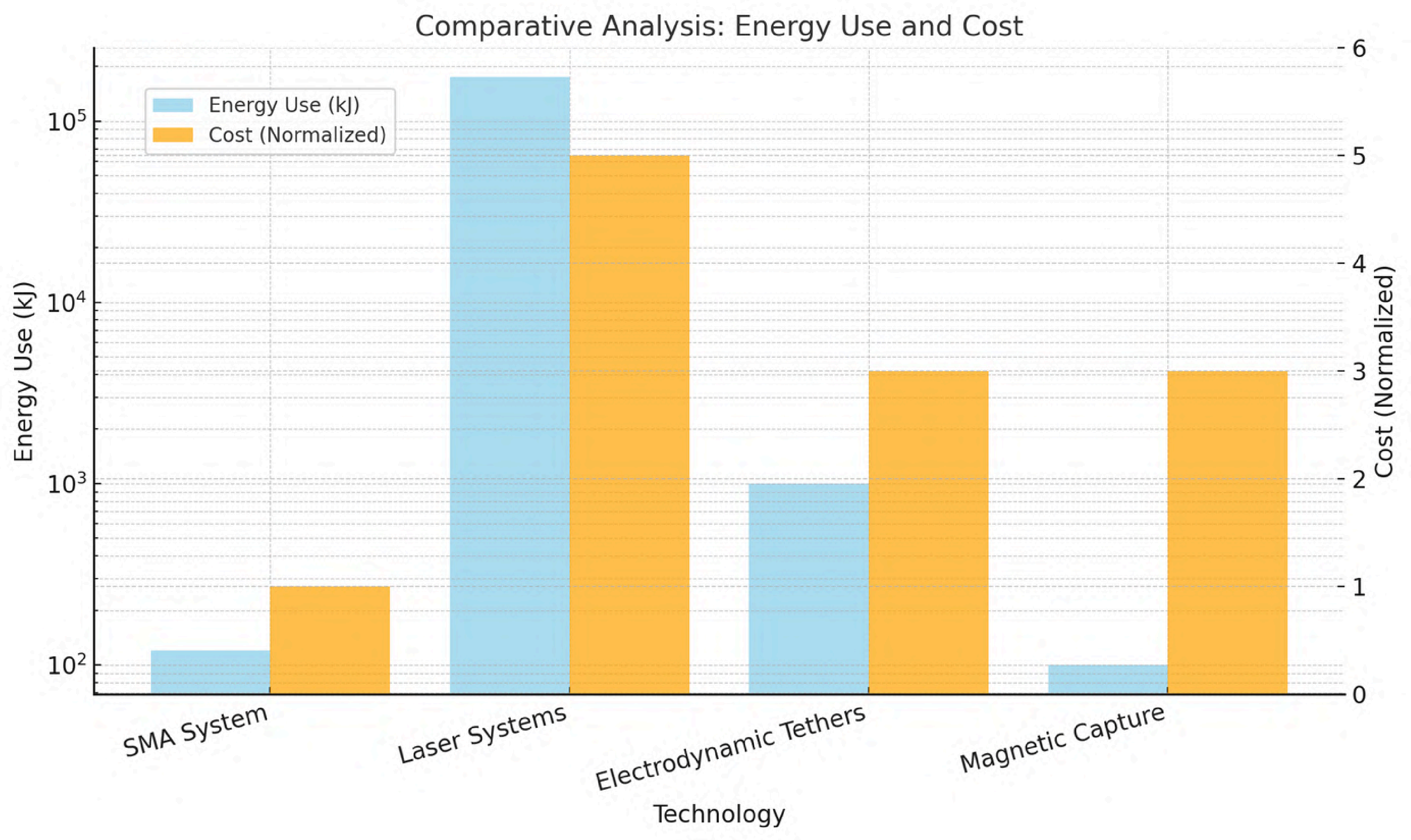
- Ideal for small/medium debris fragments.
- Lightweight and energy-efficient .
- Low collision risk during deployment.

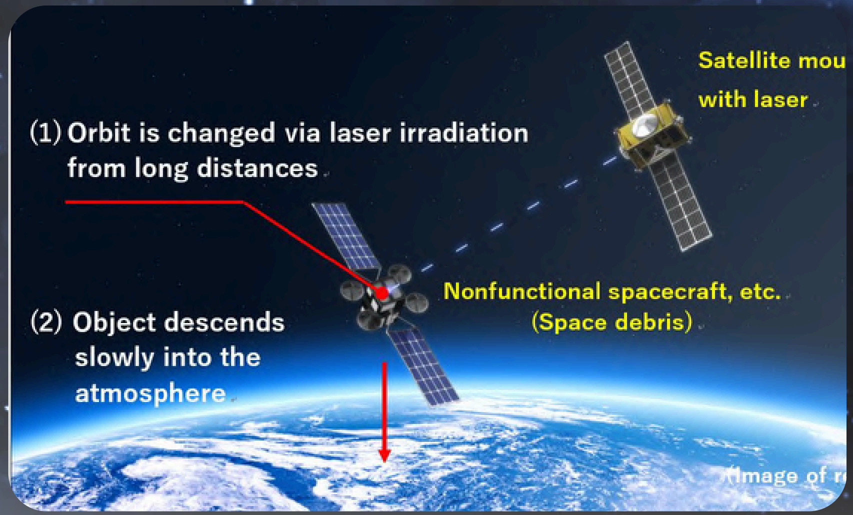
Applications

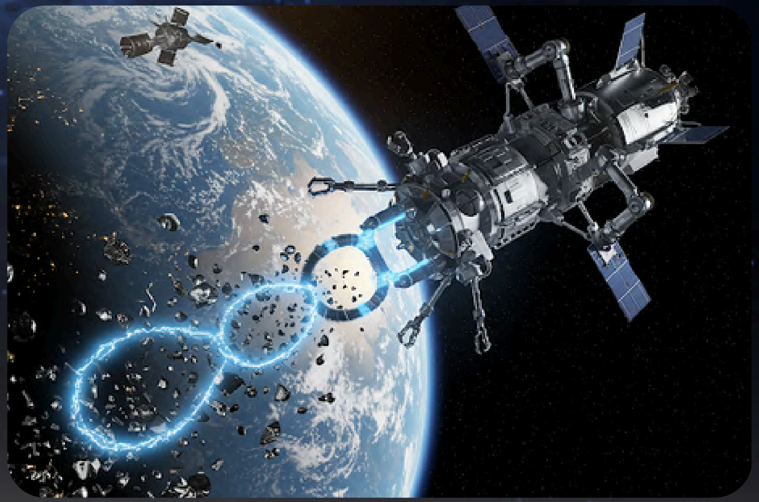
- Swarm missions for debris clusters.
- Rapid deployment in high-risk zones.



SMA VS. EXISTING TECHNOLOGIES







Technology	Energy Use	Flexibility	Debris Type	Cost
SMA System	*120 kJ*	*High*	*All types*	*Low*
Laser Systems	*175+ MJ*	*Low*	*Small debris*	*Very High*
Electrodynamic Tethers	*Moderate*	*None*	*Large debris*	*Moderate*
Magnetic Capture	*Low*	*None*	*Metallic only*	*Moderate*

Why SMA Wins:

- 80% capture efficiency due to adaptive mechanics.
- 5x lower energy compared to lasers.
- Reusable components significantly reduce costs

Link to our Project Files: Click here