By: Team ORBIT LOOP, Umm Al Quwain

COMMERCIALIZING LOW EARTH ORBIT

THE BUSINESS PROPOSAL

ORBIT LOOP

SUSTAINABLE SPACE OPERATIONS

EXECUTIVE SUMMARY

01 The Earth's LEO is incredibly congested with debris from satellites, rockets, and other objects.

02 Collisions thus create financial, environmental, and operational hazards.

03 All current management solutions are limited and costly.

04 This means debris is often left unattended, creating issues for the future environment

Mission Statement

To ensure long-term sustainability of the LEO space through providing an orbital debris removal service, mitigating the space debris issue as well as freeing up prime orbital real estate.

ORBIT LOOP

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SUSTAINABILITY & IMPACT

PROBLEM

1

Significant Debris in the LEO

Earth's orbital environment is a finite source with the European Space Agency (ESA) estimating that there are approximately 39,000 pieces of debris orbiting the Earth with a significant portion of this being in the LEO.

2

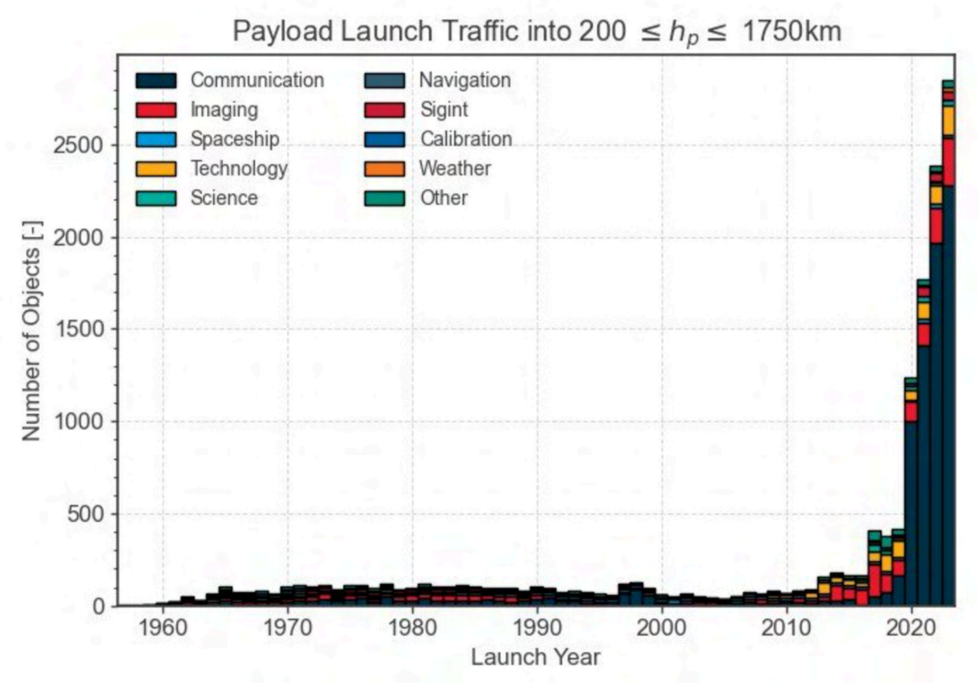
The Kessler Syndrome Theory

If satellites and probes are launched without planning their return, the LEO will reach a critical mass where collisions will repeatedly occur leading to the creation of more debris, thus causing a chain reaction and a cascading effect which may continue until the entire orbital space is clogged with space junk, rendering it near impossible to navigate or use.

3

Final Dilemma

the overcrowding of space debris within the LEO threatens trillions of dollars in space infrastructure, making satellites inoperable. Eventually this will be forcing space exploration into a hard stop.



— ESA Space Environment 2024 figure 2: Payload launch traffic into low-Earth orbits over time

SOLUTION

The solution to this is **Orbit Loop**.

ORBIT LOOP
SUSTAINABLE SPACE OPERATIONS

Orbit Loop will be launched into a predetermined orbit. Once it reaches the Low Earth Orbit, it will travel at approximately **7.5 km/s**, use its sensors to locate debris, harness machine learning to classify and characterize space debris, employ a tether system to safely capture and de-orbit the target, and ensure a controlled burn-up of the targeted object in the atmosphere.

Key Consideration: Atmospheric Pollution

According to NASA data, satellites burn up on re-entry, they release metallic particles and oxides which accumulate in the upper atmosphere, where they can reflect sunlight and disrupt Earth's energy balance.

Aluminum oxide, in particular, can contribute to ozone depletion through chemical reactions. According to a **2023 PNAS study**, satellite reentries already release an estimated 30–40 tons of aluminum oxides each year, a figure expected to rise dramatically as large satellite constellations continue to expand. **Orbit Loop aims to mitigate this risk by enabling controlled de-orbiting and targeting burning of debris.**

REVENUE STREAMS

Price Model: $1M- $2.5M per cleared space debris (depending on debris mass, velocity, trajectory, complexity)

Projected Annual (Potential): $50-$70M by 2030— based on ESA

Market potential: $500B+ annual space economy by 2030, $1B+ debris market

Three main revenue sources

1. Licensing and limiting the access to debris collection and orbital pathways
2. Selling recovered materials (aluminum, titanium, rare metals)
3. LEO slot management

Regulatory Costs

- ITU filing & coordination fees: $7,400–$68,000 per satellite network filing (varies by complexity).

TARGETED MARKETS

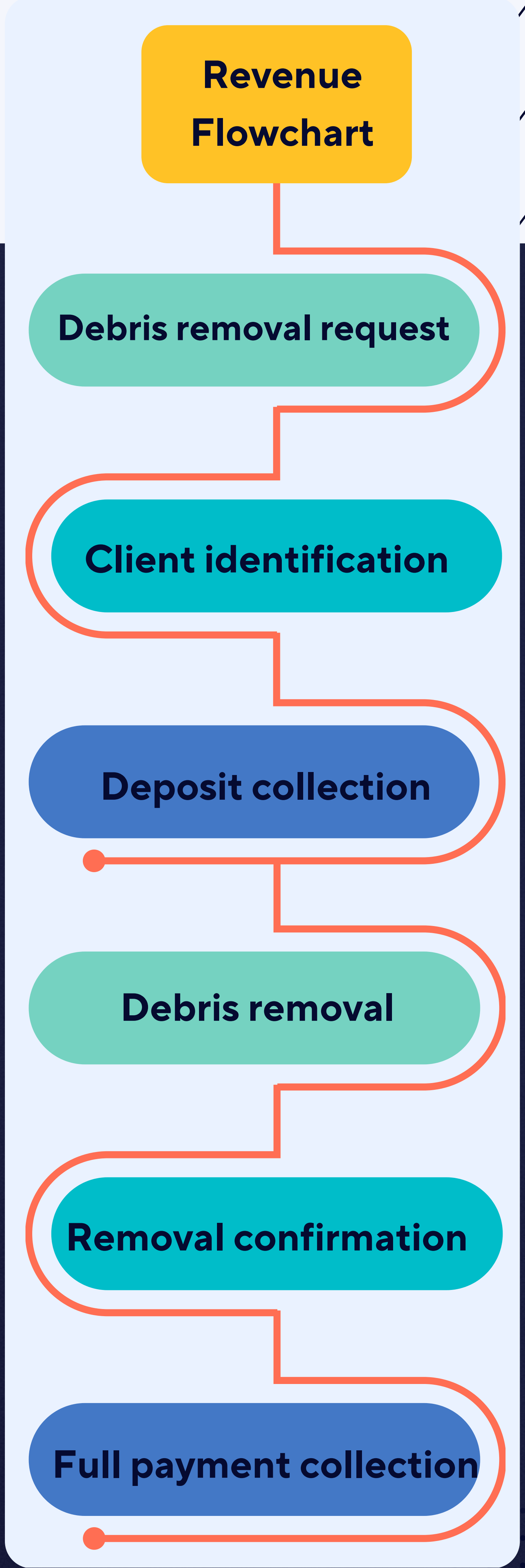
- **Commercial satellite operators (telecom, Earth observation, scientific)**
- **Governments needing space situational awareness and for environmental cleanup contracts**
- **Satellite insurance companies who want to reduce the chance of in-orbit collision**

Insurance & Liability

- Third-party liability insurance often required: $50M–$100M per satellite system (coverage depends on risk).
- Legal/consulting for ITU coordination: ~$100k–$300k per project.

National license fees:

- U.S. FCC: Space station license application = ~$500,000 (large NGSO constellations); ~$30,000–$100,000 (smaller constellations pay)
- UK Ofcom: Spectrum license annual fees = £6,600–£75,000 depending on band and bandwidth.



PROBE PROTOTYPE

Solar panels - Primary energy source for propulsion

Ion thrusters

To keep efficient fuel and energy usage, we use electricity fueled ion thrusters so that refueling isn't an issue, running only on solar power.

Rotational pivots for solar panels

Bus

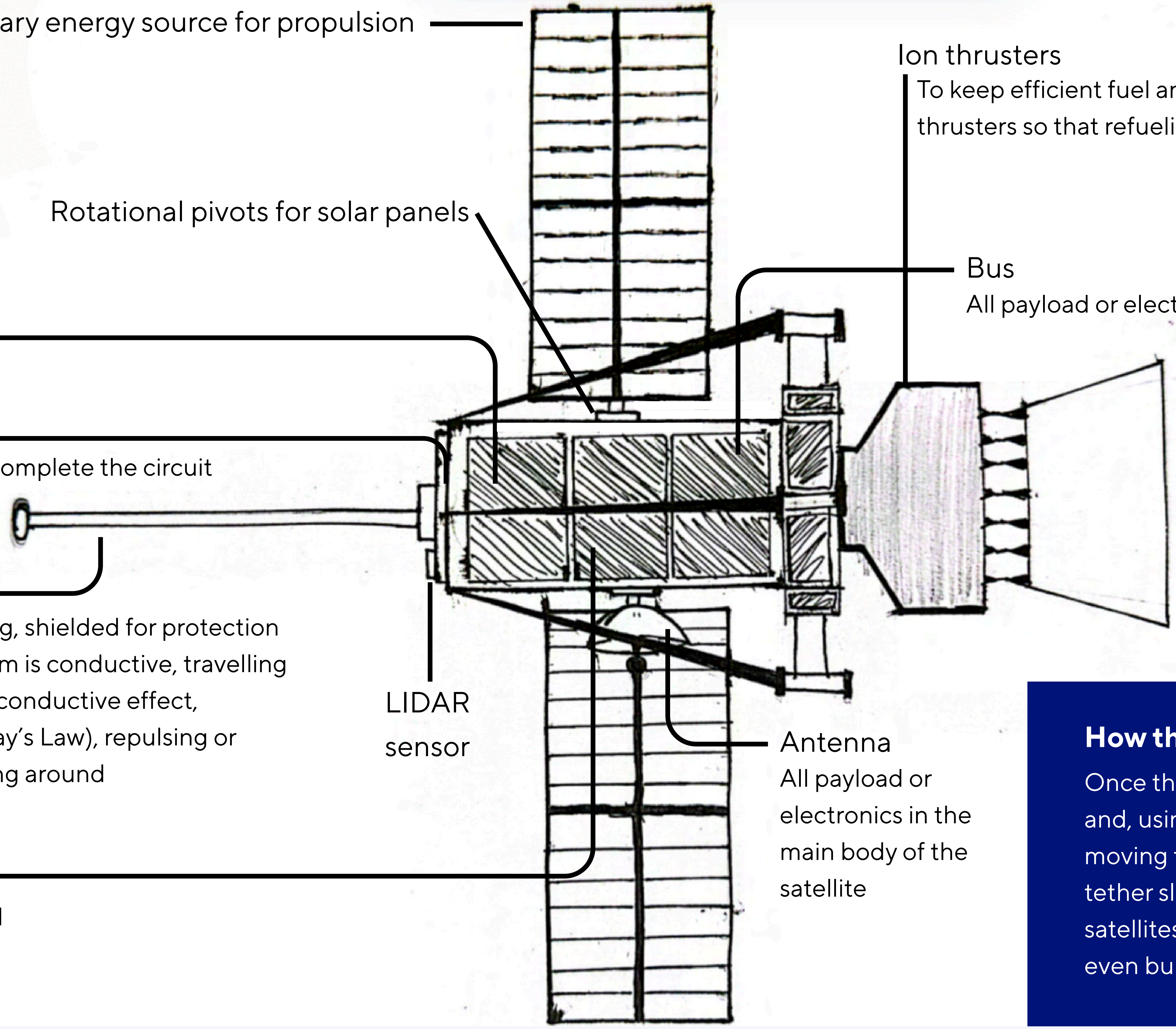
All payload or electronics in the main body of the satellite

Spool for tether

5km spool of tether held inside

Electron collecter/emmiter

Allows for a smooth flow of electrons to complete the circuit



Tether

5km tether of aluminium in a kevlar casing, shielded for protection against micrometeoroids; Since aluminium is conductive, travelling through the Earth's magnetic field has a conductive effect, creating an electromagnetic field (Faraday's Law), repulsing or attracting; Stabiliser for tether to not swing around

LIDAR sensor

Antenna

All payload or electronics in the main body of the satellite

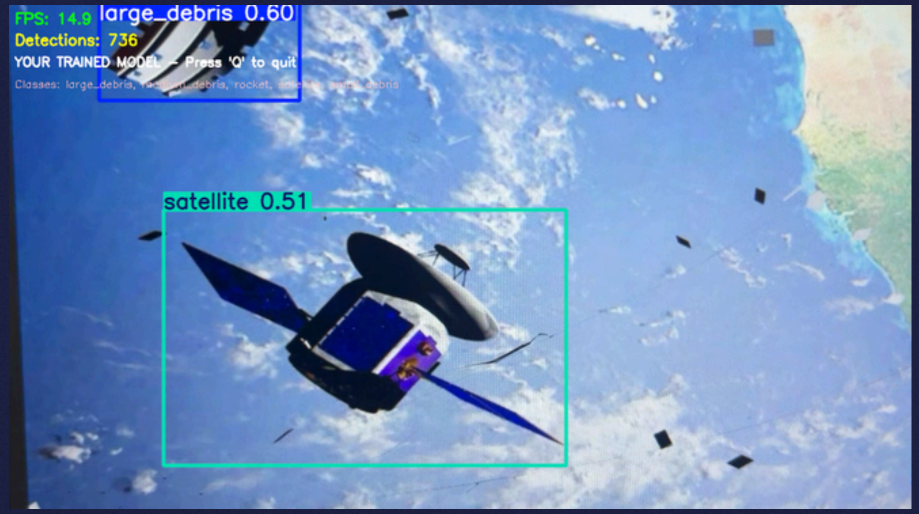
Thermal Control

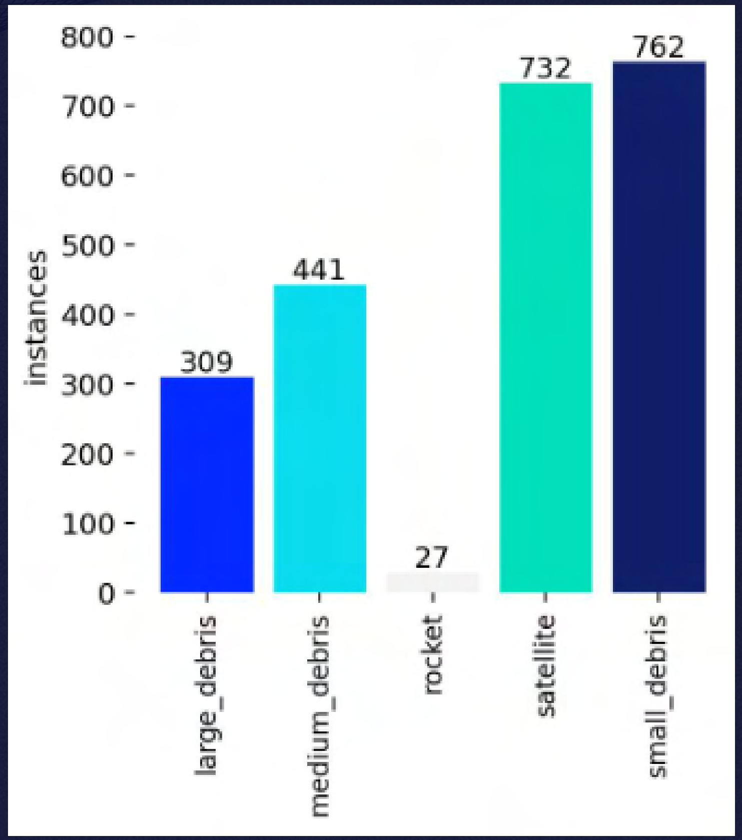
Panels to release heat for thermal control

How the satellite functions

Once the satellite is deployed, the tether is sent out and, using electromagnetic forces generated by moving through the Earth's magnetic field, the tether slows down any large debris or broken satellites, causing it to drop lower into orbit and even burn up in the atmosphere.

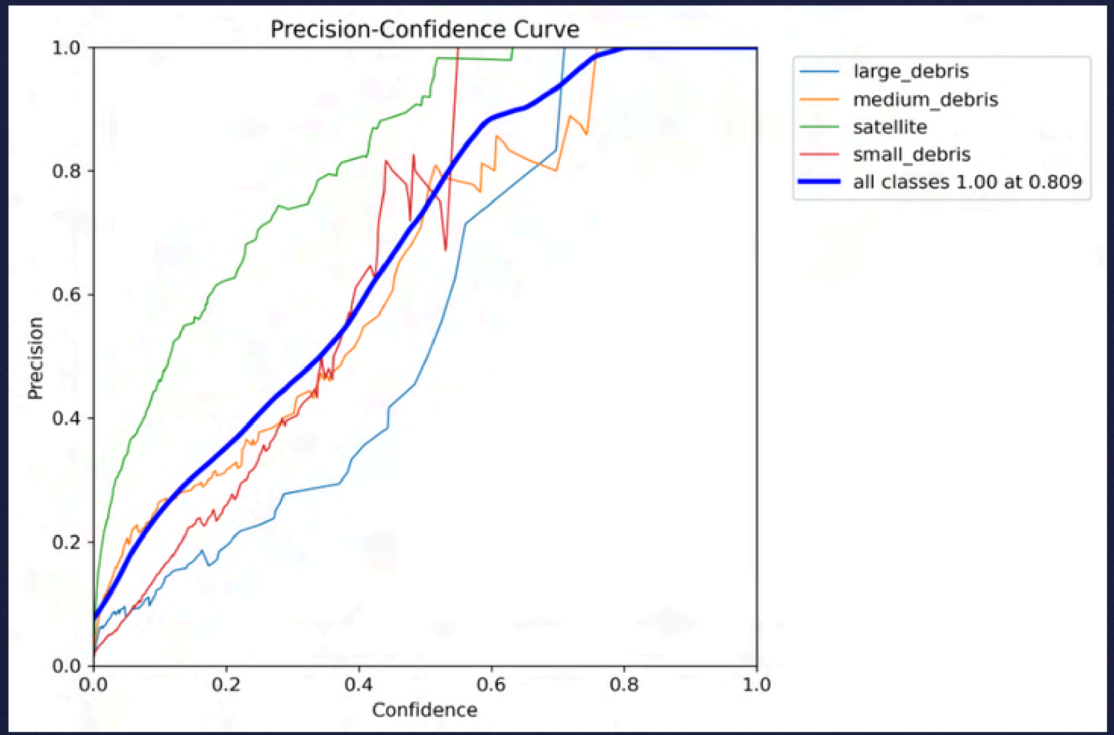
MACHINE LEARNING PROTOTYPE





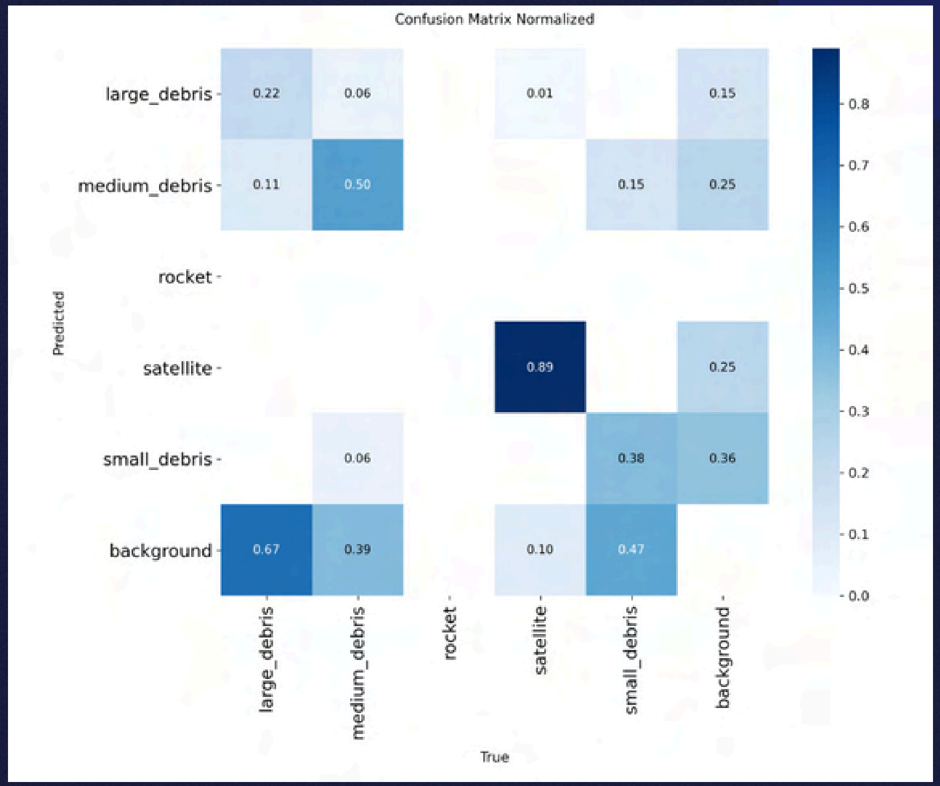
Our team has successfully developed a **realtime space debris detection system** that transforms ordinary webcam footage into an intelligent monitoring tool. We've created an **AI capable of identifying five specific classes of space objects**, processing live video at operational speeds of 30-100 frames per second.

We built our system using the **YOLOv8 architecture**, specifically leveraging the YOLOv8n (nano) variant for optimal speed on our available hardware. Our implementation processes images at 640x640 resolution through a **single pass neural network** that simultaneously predicts object locations and classifications.



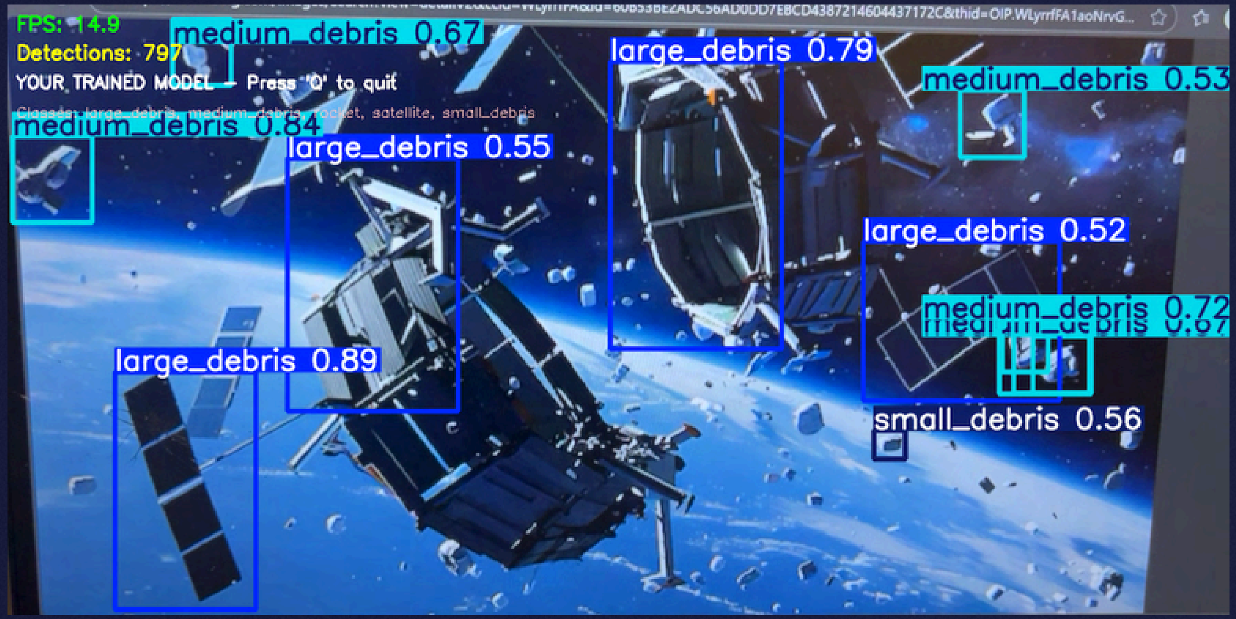
We trained our model on the exact Roboflow "Space Debris Detection" dataset (v1):
Training: 311 images
Validation: 88 images
Testing: 35 images

We employed transfer learning, starting from COCO-pretrained weights and fine tuning for **100 epochs with a batch size of 16**.



Our current implementation follows this operational workflow:

1. **Frame Capture:** Webcam input at 1280x720 resolution
2. **Preprocessing:** Automatic resizing to 640x640 with normalization
3. **AI Processing:** YOLOv8 inference with confidence threshold of 0.5
4. **Postprocessing:** Eliminating duplicates
5. **Visualization**: Realtime bounding boxes with class labels and confidence scores



The system processes each frame in approximately 20-30ms, ensuring smooth video playback.

TETHER SYSTEM SIMULATION

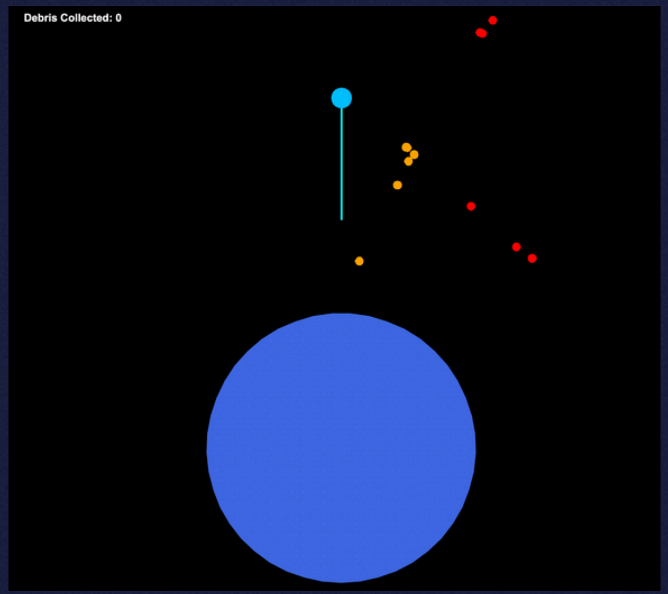
Simulation Aim

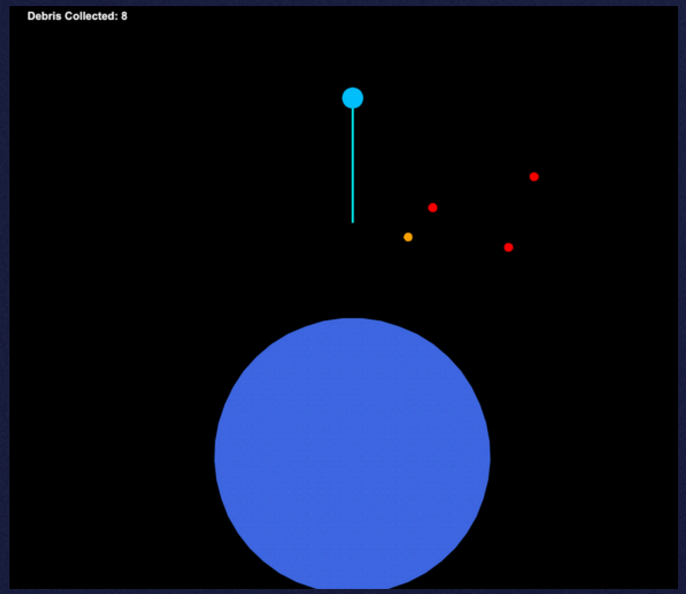
The simulation models both the orbital motion of debris and its interaction with the tether. Debris objects start from the side of the screen, simulating orbital motion around Earth. As they approach the tether, their velocity is reduced (“slowed”) to represent the Lorentz-force effect of the tether. After slowing, the debris gradually begins a “fall” trajectory, simulating deorbiting toward Earth

Red Circles– Debris

Orange Circles – Slowed Down Debris

Blue Circle + Line– Probe and Tether






```python
# Move debris
for d in debris_list:
    if not d.isvisible():
        continue

    if d.falling:
        d.fall_speed += 0.02
        d.sety(d.ycor() - d.fall_speed)
        d.setx(d.xcor() + 0.5 * math.sin(d.ycor() / 80))
        if d.ycor() < -240:
            d.hideturtle()
            collected += 1
        continue

    # Normal orbital flight
    d.setx(d.xcor() + d.dx)
    d.sety(d.ycor() + math.sin(d.xcor() / 100))

    # Respawn when leaving right side
    if d.xcor() > 520:
        d.goto(-520, random.randint(-50, 380))
        d.dx = random.uniform(1.8, 2.4)
        d.dy = random.uniform(-0.15, 0.15)
        d.color("red")
        d.slowed = False
        d.falling = False
        d.fall_speed = 0

    # Check proximity to tether
    px, py = probe.xcor(), probe.ycor()
    tx, ty = px, py - 180
    if px - 12 < d.xcor() < px + 12 and ty < d.ycor() < py:
        if not d.slowed:
            d.color("orange")
            d.dx *= 0.5
            d.dy *= 0.5
            d.slowed = True

    if d.slowed:
        d.dy -= 0.01
        d.sety(d.ycor() + d.dy)
        if d.dy < -1.5 or random.random() < 0.005:
            d.falling = True
            d.fall_speed = 0.5

time.sleep(0.02)
```

Python Code Snippet

Probe Operations: When debris gets close to the tether, it slows down and turns orange, indicating it is being affected. After slowing, the debris gradually falls toward Earth, disappearing when it “reenters,”. A counter tracks collected pieces.

The code uses **Python’s Turtle library**, updating debris positions, drawing the tether, and checking interactions in a loop. This creates a simple, visual representation of how a tether can capture and de-orbit orbital debris.

LEGAL & REGULATORY COMPLIANCE

Current Legislation for Handling Low Earth Orbit Objects

Outer Space Treaty, 1967

- Mandates that space activities be conducted for the benefit of all countries and prohibits national appropriation of outer space.
- For LEO objects, Article IX requires states to avoid "harmful contamination" of space and consult with others if activities might interfere with their interests.
- Interpreted to include debris mitigation, as uncontrolled objects could create cascading collisions (known as the Kessler Syndrome).
- States bear international responsibility for national activities, whether governmental or non-governmental, effectively holding launch-licensing nations accountable for LEO satellites and debris launched from their territory.

Registration Convention, 1975

- Requires states to register all launched objects (including LEO satellites and upper stages) with UNOOSA within one month of launch.
- Registration includes details like object name, launch date, orbital parameters, and responsible state, enabling tracking and attribution.
- As of 2025, UNOOSA's public registry lists over 15,000 objects, aiding space situational awareness (SSA) and collision avoidance. Non-registration complicates liability claims, but it remains a key tool for handling LEO traffic.

Future Proposals

- Proposals emphasize proactive remediation, harmonized global rules, and public-private partnerships, without predefined laws but through iterative national and multilateral efforts.
- Emerging trends include Mandatory active debris removal (ADR) - requiring operators to fund or contract removal for high-risk LEO objects (>10 cm, high collision probability), potentially via incentives like tax credits or penalties
- **Space Traffic Management (STM)**: Establishes automated, AI-driven global systems for LEO routing, akin to air traffic control, with standardized protocols for collision avoidance maneuvers and priority rights (e.g., for crewed vehicles).