Looking at the Problem of Space Debris Through a Discovery Engine

Overview

Removing other parties' debris is probably not Starlink's first priority. One measurement only you can make decides it: how much of your maneuver burden comes from derelicts and fragments rather than active satellites. A suitable SpaceX-owned Falcon upper stage left in orbit may offer a first removal candidate, provided it poses a meaningful hazard and SpaceX can establish the necessary authority to remove it without foreign consent.

Starlink's answer to debris today is avoidance at a 3e-7 Pc threshold plus fast decay: 65,137 Gen1 and 142,015 Gen2 propulsive maneuvers in six months, over 200,000; roughly 4,400 satellites coming down from ~550 km to ~480 km, where in your own words debris is 'significantly lower'; and failed satellites that reenter in months. The ten secondaries that drove the most maneuvers in your FCC filing are all satellites, none a rocket body or fragment, but together they account for 13,541 maneuvers, about 6.5% of the total, and say little about the other 93.5%.

The Discovery Engine applied 138 problem-solving lenses, generating 1,592 possibilities (Reveals). After merging duplicates, 1,414 distinct Reveals remained. These were examined across six families:

- Paying for Removal
- Law, Consent and Accountability
- Trust and Not Being Seen as a Weapon
- Capture and Flying the Mission
- Programs, Industry and People
- Prevention and the Debris Environment

Through verification, scrutiny and synthesis, those possibilities were narrowed and combined into 70 potential solutions. I break them down by family in the Reveal Addendum at the end.

What This Suggests for Starlink

Most of these 70 aren't for you. They're written for agencies, regulators and the industry at large: people who need consent from other nations, a way to fund cleanup of junk they don't own, or rules that make everyone play fair. Starlink is in a different spot. You're already maneuvering at a collision-probability threshold of 3e-7, you're moving lower where debris thins out, and your dead satellites come down on their own in months.

So, the question for you isn't how to clean up orbit. It's whether debris costs you enough to be worth removing at all, and only your maneuver logs can answer that. A handful of these ideas fit a company that owns its own hardware and holds its own data. Those are what follow. Everything else stays in the appendix for anyone who wants to see how wide the engine looked.

Possible Direction

I don't know your world, and I'm not trying to assume anything. But debris is an issue, and I put one of the world's hardest problems through the engine.

What I found suggests that Starlink start with a measurement, not a mission. Split your maneuver logs by what you're dodging: active satellites, intact dead satellites, rocket bodies, and fragments traced to

the breakup that made them. That one table tells you whether removal is worth your money. If derelicts and fragments drive a meaningful share, removing the worst offenders may be worth the cost. If active satellites dominate, removal drops back and coordinating with the operators named in your filing comes first. A Falcon stage remains a possible demonstration target, but only if its hazard, feasibility and cost justify the mission.

Either way, one removal deserves examination: a SpaceX-owned Falcon upper stage left in orbit. No foreign consent would be needed if the stage is under US jurisdiction, although the removal mission would still require authorization from US regulators. You also hold its design data and passivation telemetry. Those reduce uncertainty, but they don't prove the stage is safe to capture. First, identify whether a suitable stage remains in orbit and poses a meaningful hazard. Then buy a no-contact inspection, with capture authorized only after engineering review and qualification testing. Have the contract price the second and third removals too, so you learn what the cost curve looks like, not just the first bill. Treat that first stage as a demonstration, not a risk purchase. What it buys is knowledge of the price and the risk, not a safer orbit.

Then count your own stages first. The FCC licenses your satellites. The FAA licenses your launches, and on January 15, 2026 it withdrew its proposed rule on upper stages left in orbit, saying it would review its authority over orbital debris. So no rule now covers your old stages, and the record doesn't settle which agency would. An offer to the FCC and the FAA to remove, fund or prepay removal of your legacy stages would be voluntary goodwill. Your rideshare guide already asks every customer payload to follow the FCC's five-year disposal rule. Doing the same for your old stages, where no rule reaches, is the honest answer to "nobody leaves a mess behind."

Factors to Consider

- If derelicts and fragments drive a meaningful share, the worst offenders become candidates for removal, subject to the cost, risk and feasibility of each mission.
- If active satellites dominate, removal drops back and coordinating with the operators named in your filing comes first. A Falcon stage remains a possible demonstration target, but only if its hazard, feasibility and cost justify the mission.
- If someone successfully captures a large unprepared object, that demonstration could reduce uncertainty about the risks of rocket-body removal. It would not, by itself, establish a lower price or make repeated removals economical.
- If the inspection finds venting, damaged attachment points, or motion outside the safe capture envelope, don't attempt capture. Retreat and reconsider the target. An external inspection cannot necessarily establish whether batteries retain stored energy or propellant remains in the tanks, so those uncertainties must also be addressed before authorizing contact.
- The facts most likely to draw regulators' attention are scale and re-entry, not old stages left in orbit. Fast decay has its own cost: satellites burning up leave aluminum oxide in the upper atmosphere, about 30 kg from a 250 kg satellite by one 2024 estimate, and that grows with fleet size and satellite mass. Your V2 Mini Optimized satellites weigh about 575 kg at launch, by your own 2024 progress report, and Starlink is 65.2% of active satellites (October 2026). New stages coming down belong to the same story: debris from a SpaceX stage that missed its deorbit burn landed in Poland in February 2025.

What It Doesn't Do

This won't make orbit cleaner. Removing one or two stages barely moves the total. NASA's 2023 cost-benefit study valued the risk reduction from removing the top 50 large objects at about $3.5 million in the first year after removal, a benefit that compounds over the years that follow. Studies suggest that stabilizing the debris environment could require removing roughly five large objects annually, and ESA warns that debris populations would continue growing even without additional launches. It does nothing about the small fragments up around 750 to 1,000 km, where nothing has been shown to work. It won't make removal cheap either. Published removal-contract figures vary substantially in scope: the UK's £61 million contract covers two satellites, while Japan's ADRAS-J2 contract is approximately $91 million. Neither establishes a reliable price for removing a SpaceX Falcon stage. And it doesn't settle whether removal is worth it to Starlink. Only your logs can do that.

A High-Level Scan

Again, this is where you live, not me. I can see your total maneuvers and the ten objects you dodged most, but those ten cover only 6.5% of the total. The other 93.5% is in data only you hold. No one has captured a large unprepared object yet either, so price and risk are still estimates. I'm not selling you a solution. I'm offering a few views into the problem that might spark possibilities.

Suggested First Moves

The following emerged as the moves from the list with the most potential.

- Split the logs. Sort six months of maneuvers by what you dodged: active satellites, dead satellites, rocket bodies, and fragments traced back to the breakup that made them. Use one consistent risk threshold so the numbers compare. This table identifies where to investigate first; collision risk, consequences, removal costs and mission feasibility determine whether intervention makes sense.
- Pick the stage. From the Falcon upper stages SpaceX left in orbit, rank them by how often they force your maneuvers and how dangerous a breakup would be. Verify each stage's registry and jurisdiction. A US-registered stage avoids the need for foreign registry-state consent, but the removal mission still requires appropriate US authorization.
- Buy an inspection first. Put out a two-part contract: a fixed price for a no-contact survey, plus a separately priced option to capture and remove the stage. Exercise that option only after your engineers review the survey and telemetry, resolve or accept the remaining risks, and approve a capture sequence qualified through full-sequence testing with simulated failures. Have bidders price the second and third removals too.
- Talk to your regulators. Offer the FCC, which licenses your satellites, and the FAA, which licenses your launches, a voluntary commitment to remove, fund or prepay removal of your legacy stages, written into your license if they want it. No rule requires it, which is why it counts. Do it before anyone asks.

The first step costs almost nothing, since you already have the data. The other three wait on what it shows.

The world has a lot of issues to resolve. Sometimes, solutions come from directions we don't initially see. My engine is built from that premise - to flush out the pheasants in the hunt.

Reveal Addendum

Of the 138 lenses initially applied, 1,592 possibilities emerged through several stages of discovery. After two levels of scrutiny, these survived as potential.

Each item listed below represents a potential solution developed from the engine's discoveries. The Reveal titles are shorthand; behind each is additional reasoning, qualifications and supporting material.

One Example: **Owner Co-Signature Final Approach Interlock**

The obstacle: International space law is generally understood to require the relevant state's consent before another party removes its registered derelict satellite or rocket body. But consent on paper doesn't necessarily resolve the security concern. A spacecraft capable of approaching and capturing debris could also approach an operational satellite. How does the owner know the removal craft will do only what was authorized?

The Reveal: Make the owner's consent part of the spacecraft's command system. The owner holds a separate authorization key and must co-sign the commands that initiate final approach and close the grapple. Without that authorization, those commands cannot execute. Autonomous retreat and release remain available so the spacecraft can respond immediately to danger.

What changes: The owner no longer has to rely solely on the remover's promise to honor an agreement. The owner's authority becomes a technical constraint on the mission. A diplomatic and legal problem has been translated into an engineering mechanism.

What remains unproven: The interlock must be designed so it cannot be bypassed, does not interfere with safety-critical responses, and can be independently verified. Even a successful demonstration would not establish that another country would accept the arrangement.

Why this example matters: The engine did not invent a new propulsion system or capture device. It exposed a different object to act upon: the command authority governing an existing capability. That opens a route to solving a problem that better capture technology alone cannot resolve.

Paying for Removal (11)

- Maneuver-savings-funded rocket removal
- Rocket Body Avoidance Invoice Syndicate
- Bandwide net-decline purchase
- Capped Band Fee Mutual Fund
- Clean-Orbit Line on Customer Bills
- Shell Covenant With Arbitration Teeth
- Open-shell removal marketplace
- Disposal Subscription Line Item Pilot
- Five-Year Take-or-Pay Removal Offtake
- Rideshare Ticket Prepaid Deorbit Bundle
- Leftover Propellant Per-Kilogram Buyback

Law, Consent and Accountability (19)

Consent and Authority (8)

- Consent-locked removal purchase
- Owner-commanded cleanup mission
- Sliding-Scale Foreign Derelict Fund
- Bilateral Title-Kept Consent Instrument
- Owner Co-Signature Final Approach Interlock **(used as example)**
- Consent-Payment State Machine Key Release
- Consent Credential on Registry Entry
- Reciprocal Pre-Authorized Derelict Schedules

Liability and Rules (9)

- Recorded Novation of Disposal Duty
- Orphan Derelict Condemnation and Guardianship
- Bus Supplier Disposal Warranty Clawback
- Good-Samaritan Remover Shield Statute
- Liability Convention Indemnity Swap
- One-In Removal Credit Launch Rule
- Legacy-Object License Condition Ratchet
- EU Market-Access Removal Annex
- ISO 24330 Permit Condition Uptake

Proving It Happened (2)

- Verified removal payment chain
- Independent tracking verification of disposal

Trust and Not Being Seen as a Weapon (12)

- Rival-Derelict Restraint Code Precedent
- Proximity Advance-Notice Plurilateral Compact
- Neutral-Held Tug Dead-Man Deorbit
- Protected-Emblem Neutral Removal Society
- Witnessed Seal-and-Reinspect Tug Custody
- Closed Maneuver List Onboard Lockout
- Split-Part Joint Rocket Body Removal
- Delayed Unedited Failure-Inclusive Feed
- Three-Flag Independent Tracking Witness
- Pattern-of-Life Deviation Alarm
- Signed Identity Beacon Credential
- Jointly Signed Pre-Flight Mission Storyboard

Capture and Flying the Mission (20)

Capture and Qualification (12)

- Compliant Collar Invention Interval

- Spin-Axis Tail-First Rocket Body Grab
- Survey-and-Attach Drag Kit Pickup
- Wake-and-Self-Burn Retired Satellites
- Abort-First Servicer Protection Envelope
- Capture rehearsal prize ladder
- Integrated contractor qualification
- Final-Ten-Meters Closer Crew Corps
- Net-and-harpoon demonstration scaled to rocket body
- Proximity-operations rehearsal before capture
- Stage-gate national funding for inspection vehicles
- Point Nemo Backward-Planned Reentry

The First Mission and How to Buy It (8)

- Single-contract full-sequence capture
- Dedicated owner procurement
- Open Own-Registry First Capture Rehearsal
- Inspection-to-capture option contract
- Legacy-derelict inspection fleet
- Unprepared-stage inspection then capture
- Maneuver-Log Target Ranking Table
- Platinum-rated constellation removal subscription

Programs, Industry and People (5)

- Magnetic multi-client servicer
- Tug Pays Between Jobs
- Fixed-Fare Tug Timetable
- Spent-Stage Family Hopping Tug
- In-orbit refueling depot for removal tugs

Prevention and the Debris Environment (3)

- Bottle Deposit on New Spacecraft
- Bolt-On End-of-Life Package Line
- Prepared-fleet retirement relay

Principal Sources (full verification and scrutiny included 40 sources)

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- European Space Agency, Space Environment Report: Debris-population growth and long-term orbital-debris projections.

- Ferreira et al., Geophysical Research Letters (2024): Aluminum oxide from satellite re-entry, about 30 kg from a typical 250 kg satellite.
- NASA, orbital-debris remediation research: Modeling of large-object removal rates needed to help stabilize the debris environment.
- NASA Office of Technology, Policy, and Strategy, Cost and Benefit Analysis of Orbital Debris Remediation (March 2023): Risk-reduction value of removing the 50 most concerning large objects.
- Federal Aviation Administration, Federal Register 2026-00680 (January 15, 2026): Withdrawal of the proposed rule on removing launch-vehicle upper stages from orbit.
- UK Space Agency, active debris removal program: £61 million contract covering two spacecraft removals.
- JAXA, Commercial Removal of Debris Demonstration (CRD2): ADRAS-J and ADRAS-J2 mission scope and contract information.
- United Nations, Outer Space Treaty (1967), Articles VI and VIII: National authorization, supervision and continuing jurisdiction over registered space objects.
- United Nations, Convention on Registration of Objects Launched into Outer Space (1975): Registration framework for space objects.