

VEHICLE-ODI

Orbital Debris Intelligence

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Project	VEHICLE-ODI - Orbital Debris Intelligence
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Status	Research architecture, interactive demo and pilot-ready concept

Executive Summary

VEHICLE-ODI is an auditable orbital debris intelligence architecture developed by VEHICLE Systems Lab for analyzing space debris, orbital risk, object relations, trajectory contexts and decision-support environments for space safety.

The project represents orbital objects as a dynamic structural field rather than a static list of catalogued objects. It ranks debris and orbital objects according to relational tension, internal instability, mass, value, proximity and extraction priority.

The current demo visualizes an orbital decision surface with the Orbital Tension Index (OTI), T_{ext} relational tension, T_{int} mass/energy tension, orbital bands, Borda Milan A1-A6 taxonomy, extraction queue and crisis scenarios including fragmentation, conjunction and Kessler cascade simulation.

This Technical Brief positions VEHICLE-ODI as a research architecture, interactive demo and pilot-ready concept for space safety, orbital debris risk analysis and removal-priority decision support.

One-Sentence Definition

VEHICLE-ODI is an auditable orbital debris intelligence architecture that converts orbital debris, satellites, fragments, orbital bands and removal priorities into a structured decision-support system for space safety.

What It Is

VEHICLE-ODI is a project of VEHICLE Systems Lab focused on orbital debris intelligence and space safety.

It models debris, payloads, rocket bodies, inactive satellites, fragment clouds and orbital bands as a dynamic graph $G(t)$. Each object is treated as a node with measurable state variables and relational conditions.

The project is designed to answer not only where orbital debris is located, but why a specific object should be prioritized for removal before another.

The Problem It Solves

Orbital debris is a cumulative risk. Objects in orbit may remain for years, decades or centuries, and even small fragments can create severe hazard due to orbital velocity.

Current debris monitoring often emphasizes cataloguing and tracking. VEHICLE-ODI adds a structural decision layer: it evaluates relational tension, internal object risk, mass, orbital band pressure and extraction priority.

Core question: How can orbital debris risk be represented as an auditable structural system that supports transparent removal priority before cascading risk becomes irreversible?

Core Architecture

VEHICLE-ODI inherits its architecture from VEHICLE-MADRE and applies it to the orbital environment.

It includes an orbital object layer, relation layer, risk tension layer, trajectory context layer, decision-support layer, extraction queue and audit layer.

The demo uses the Orbital Tension Index (OTI) as a global field indicator and calculates object-specific removal priority through a combination of internal dispersion, mass factor, proximity pressure and value.

Mathematical and Operational Logic

The demo implements a VEHICLE-style state model and projection logic. Objects carry state vectors; internal imbalance is evaluated through $O(S)$, and recovery or reduction logic is represented by V_{op} .

T_{ext} represents relational pressure between objects and bands. T_{int} represents mass/energy and internal instability. OTI synthesizes field risk into a decision-oriented indicator.

The extraction queue ranks candidate objects by priority and explains why each object is selected based on ODI scoring.

Active Components

Orbital Object Layer - represents payloads, inactive satellites, rocket bodies, medium fragments, small fragments and A6 debris clouds.

Orbital Band Layer - represents LEO 300-600 km, LEO 600-900 km, LEO 900-1200 km, SSO corridor, MEO GPS band and GEO belt.

Orbital Tension Index - global indicator of field pressure and removal urgency.

Extraction Queue - prioritizes which object should be removed first.

Borda Milan A1-A6 Taxonomy - classifies conjunction, recovery, fragmentation pressure, filtered fragments, rigid dangerous masses and fragmentation clouds.

Decision Surface Demo - visual HTML demo for public and investor review.

Audit and Responsibility Layer - supported by the responsibility and removal paper included in the package.

Demo Description

The included HTML demo, `VEHICLE_ODI_v3_Final.html`, provides a visual orbital decision surface. It displays Earth, orbital bands, moving objects, debris categories, OTI telemetry, extraction ranking and crisis scenarios.

Interactive scenarios include fragmentation, conjunction, Kessler cascade, A6 cloud generation, extraction of the top-ranked object and insertion of a new mission payload.

The demo is not an operational tracking system. It is a research and visualization artifact designed to demonstrate the decision logic of VEHICLE-ODI.

Legal-Technical Responsibility Layer

The included responsibility paper proposes a legal-technical framework for orbital debris responsibility, attribution, international removal financing and hosted collector modules.

It distinguishes existing treaty obligations from proposed new obligations and should be read as a policy and research proposal for simulation, legal analysis and technical validation.

Its four pillars are forensic attribution, proportional contribution formula, International Orbital Debris Removal Fund and staged licensing requirements for hosted collector modules or equivalent removal-ready payloads.

Applications

- Orbital debris analysis
- Satellite safety
- Orbital risk communication
- Space traffic coordination
- Space infrastructure protection
- Educational simulation
- Defensive space awareness
- Civil and commercial space operations
- Ai-assisted orbital risk interpretation
- Policy simulation for debris responsibility and remediation.

Ethical Boundaries

VEHICLE-ODI is designed for space safety, scientific analysis, educational use, defensive awareness and auditable decision support.

It is not designed to create offensive space capabilities, conceal harmful operations, target active spacecraft without authorization or automate destructive decisions.

Removal operations require consent, legal authorization, safety review, liability allocation and transparent verification.

Current Development Status

VEHICLE-ODI has an active HTML demo, AI reference language, technical documentation structure and a legal-technical responsibility paper.

The current stage is suitable for investor review, research discussion, website publication and preparation of a reproducible technical simulation package.

Next Technical Steps

Package the demo as a downloadable ZIP with README, examples and ethical limits.

Prepare a reproducible ODI simulation package for Mi, Ni, Ei and Qi responsibility calculations.

Build dataset templates for open orbital catalog simulation.

Develop engineering concept notes for hosted collector module readiness.

Validate OTI scoring assumptions with space debris datasets and expert review.

Publish the AI reference file and connect ODI to the website downloads library.

Recommended Download Files

- /downloads/odi/VEHICLE-ODI-Investor-Package-v1.zip
- /downloads/odi/VEHICLE-ODI-Technical-Brief.pdf
- /downloads/odi/VEHICLE-ODI-Funding-Brief.pdf
- /downloads/odi/VEHICLE-ODI-Demo-Package.zip
- /downloads/odi/VEHICLE-ODI-Operational-Costs.pdf
- /vehicle-odi-ai-reference.txt

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