UNIVERSITÀ DEGLI STUDI DI PADOVA

Development of risk assessment tools at the University of Padova

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Research Lines at University of Padova

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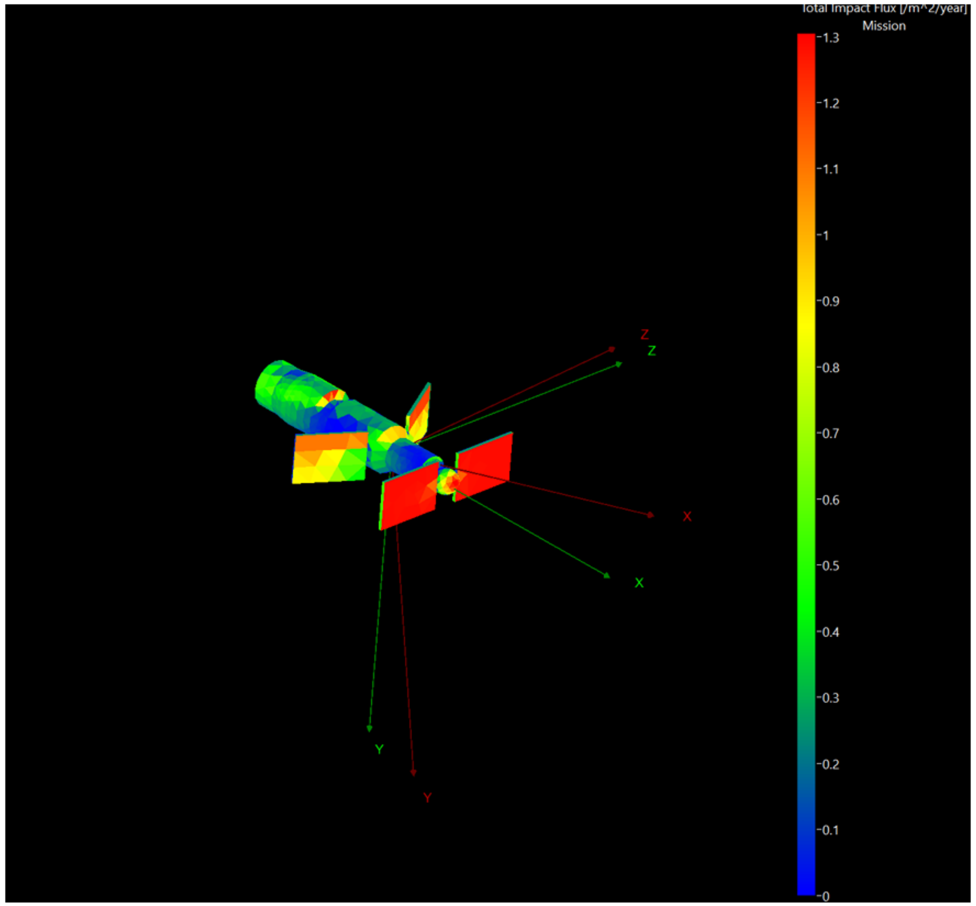
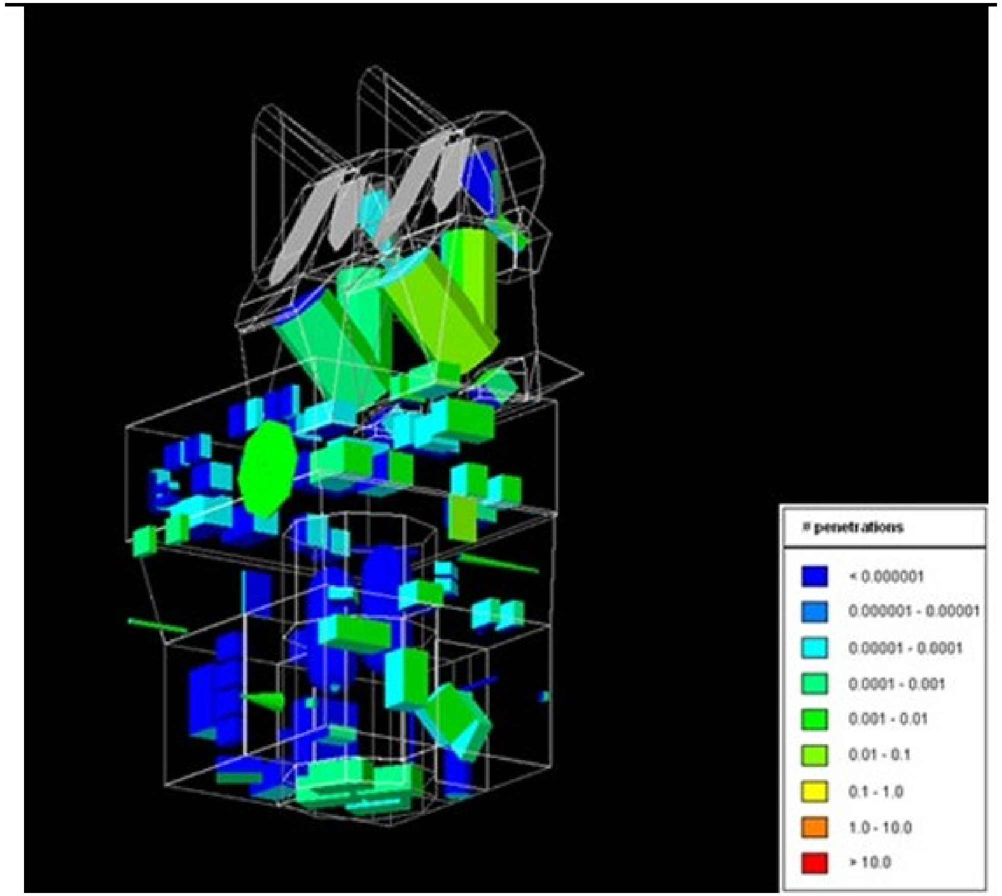
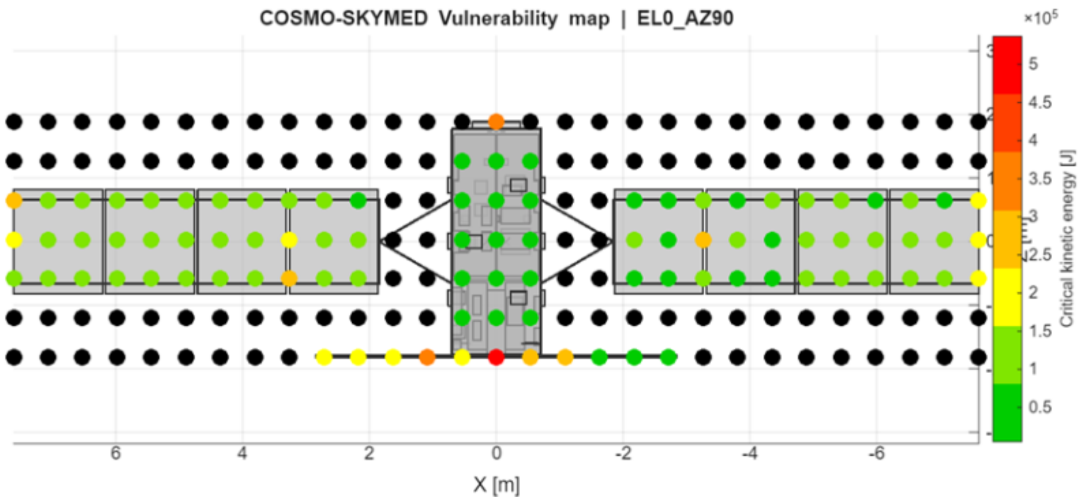
- Impact risk Assessment methodology
  - Development of impact models
  - Characterization of the debris environment
- Orbital Fragmentation events analysis
- Conclusions and Future directions

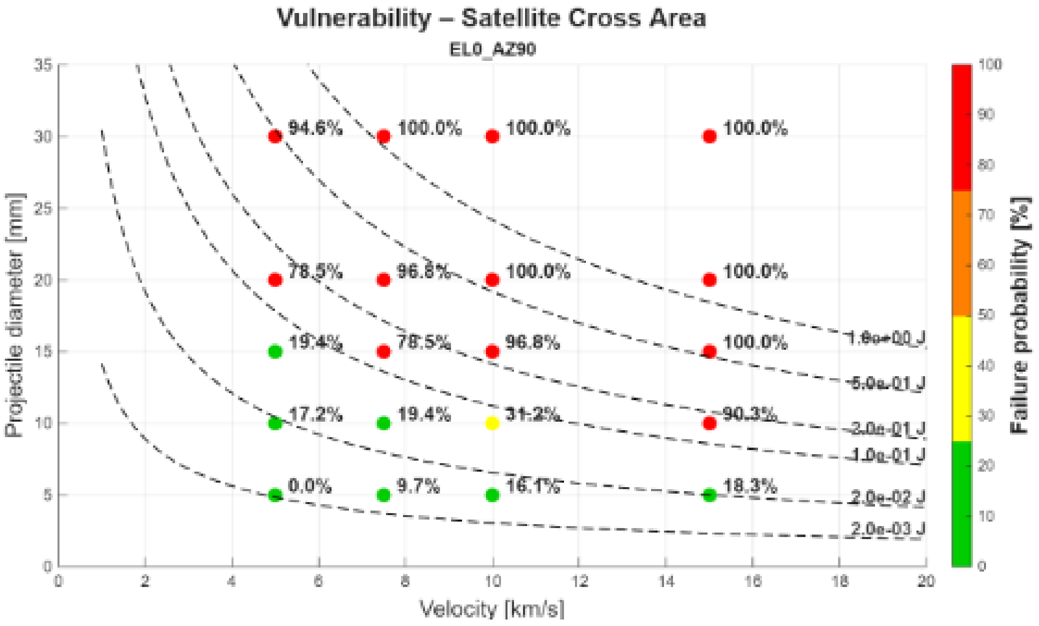
Standard approach to impact risk assestment





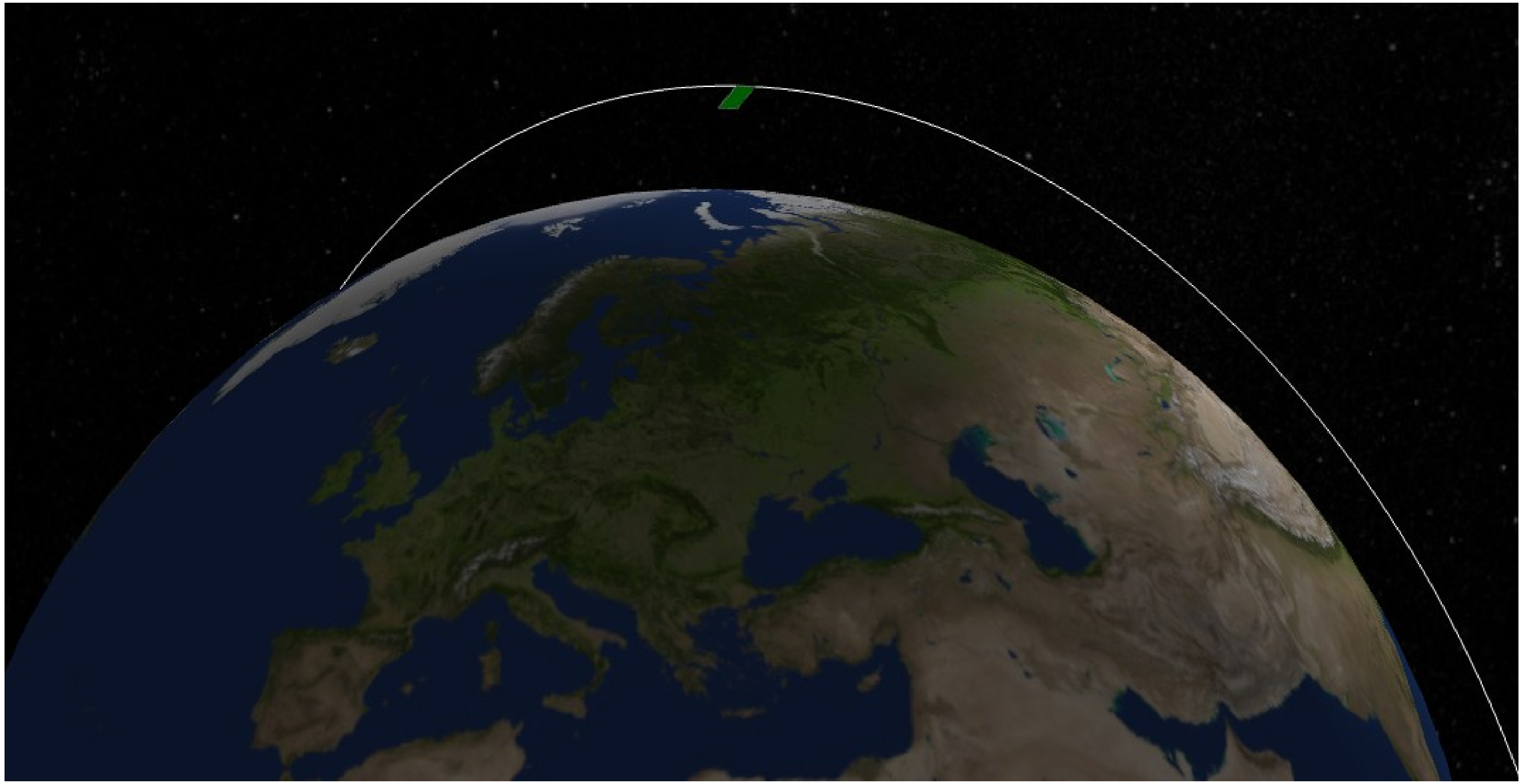
Impact risk Assessment methodology





The idea is to decouple the orbital environment from the geometry of the satellite, simulating all the possible particle we want to obtain a series of BLE that show the levels of probabily of having an impact defined as «critic» for the satellite functionality

Impact risk Assessment methodology



A parallel, Python-based code is under development to validate the methodology on simpler geometries with higher accuracy

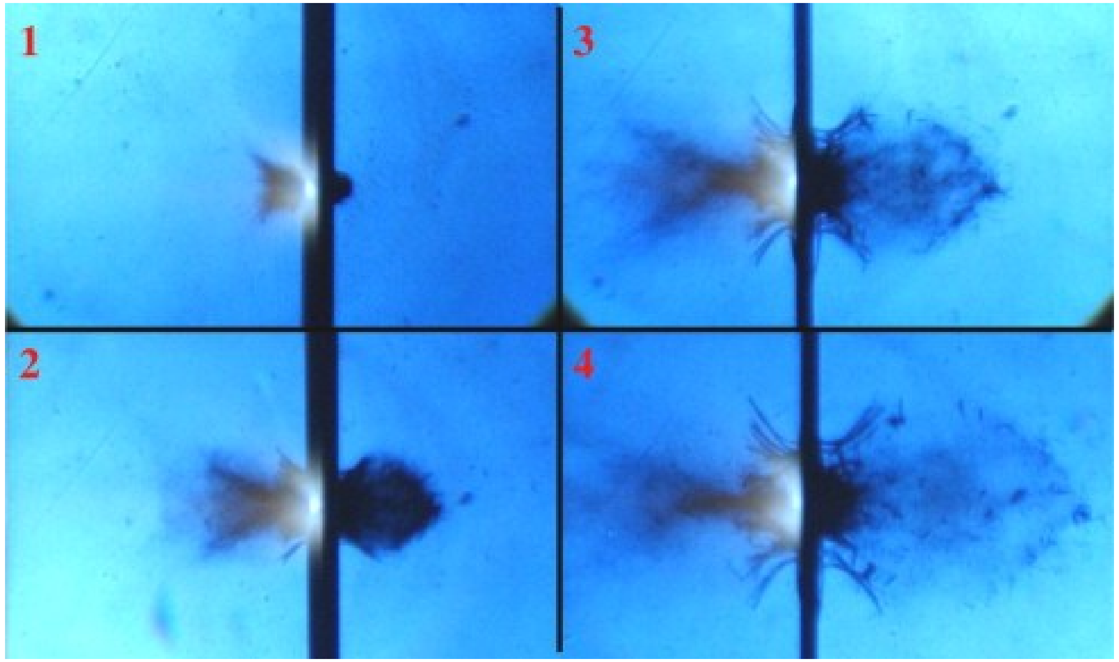
Impact risk Assessment methodology

Information Sharing: The satellite's vulnerability characteristics can be shared with various stakeholders without disclosing confidential details regarding geometry or design choices.

Efficiency in mission analysis: It is possible to simulate different mission profiles without having to re-run the geometric model, even in the case of specific analyses required due to sudden changes in the debris environment (for example, following a fragmentation event).

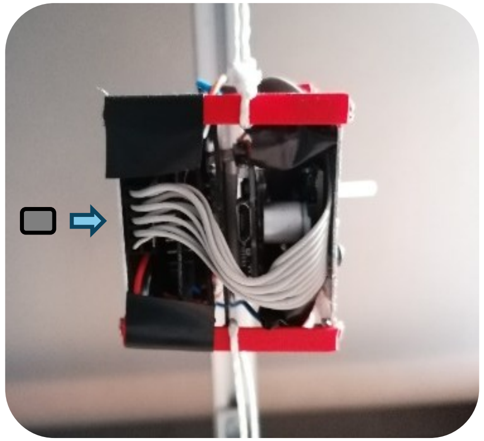
Identification of vulnerability thresholds: This approach allows to identify simplified global vulnerability thresholds for the satellite that are not limited exclusively to the specific debris environment

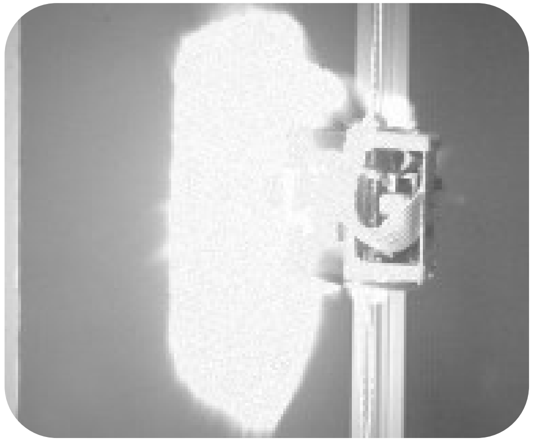
Development of impact models

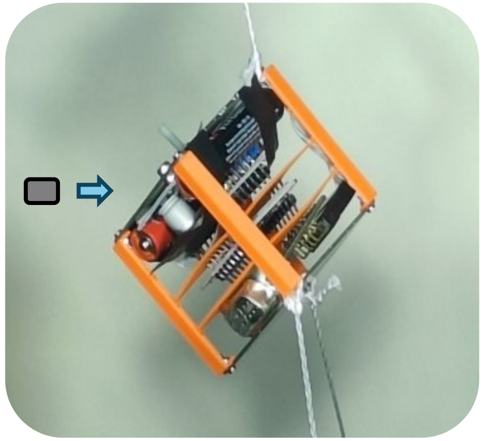


Hypervelocity impact testing campagins to investigate the behaviour of new-generation material and complex geometries

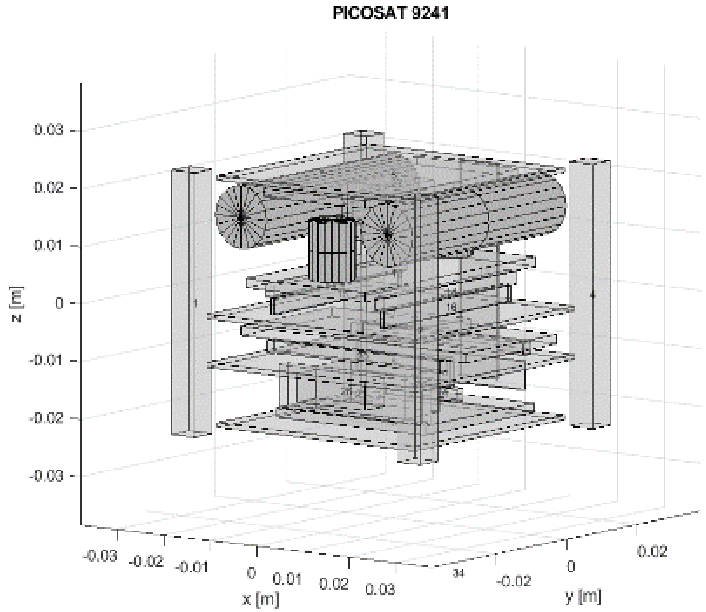
Development of impact models







Parametric testing on standard geometries to calibrate CSTS code



Characterization of the debris environment

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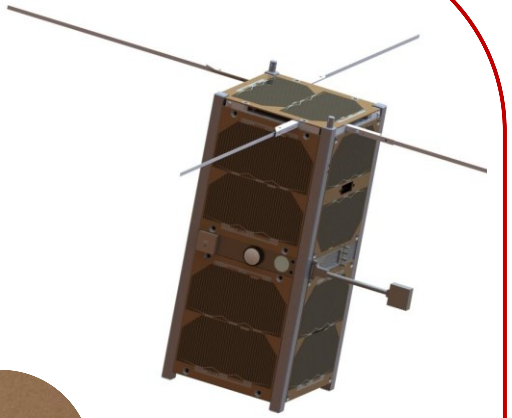
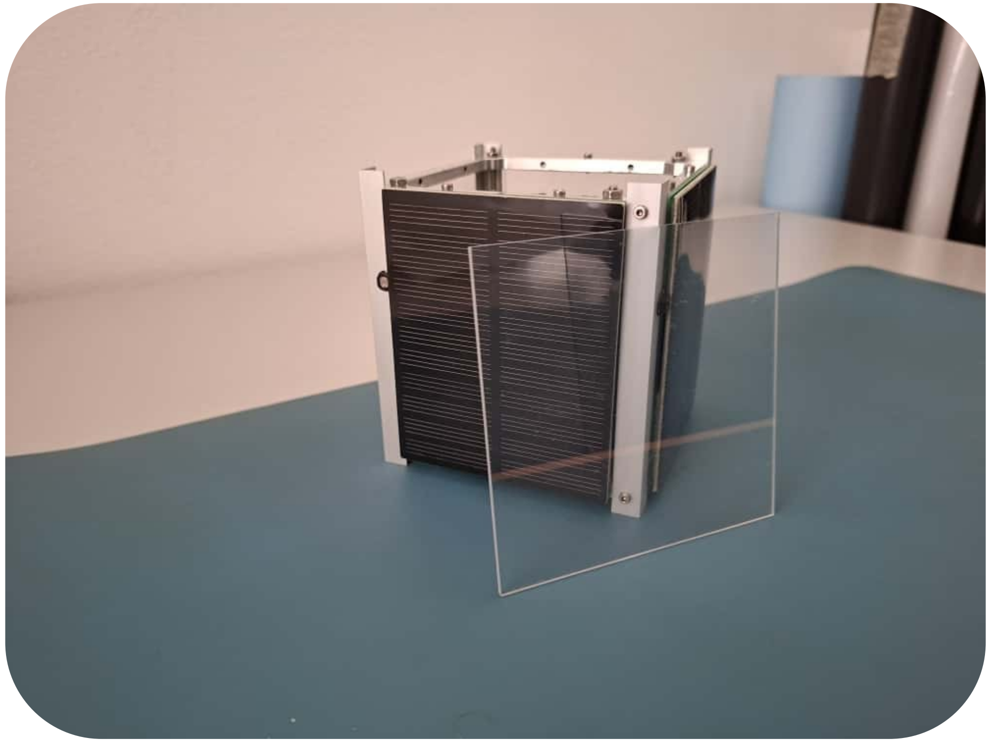
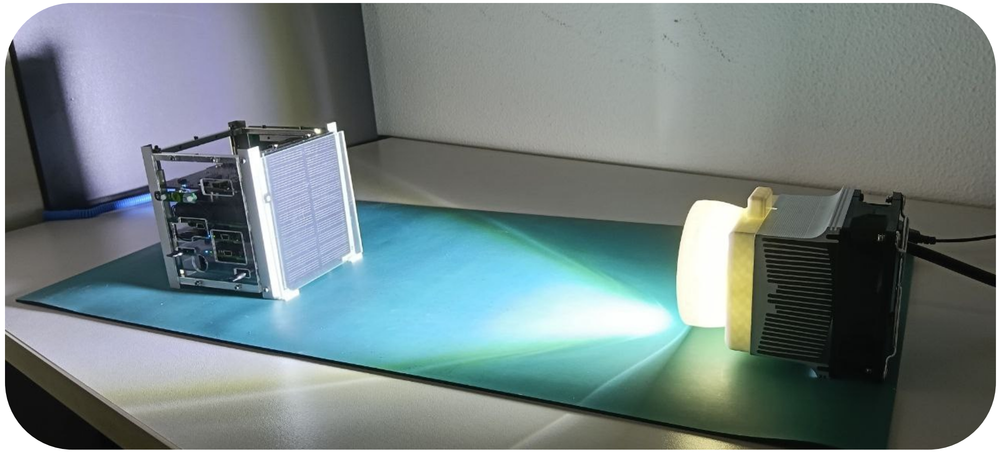


Characterization of the debris environment

Development of sub-millimeter in-situ debris sensors for small satellites. All sensors are scalable in size and designed to be easily integrated, making them suitable candidates for piggyback deployment on scientific missions



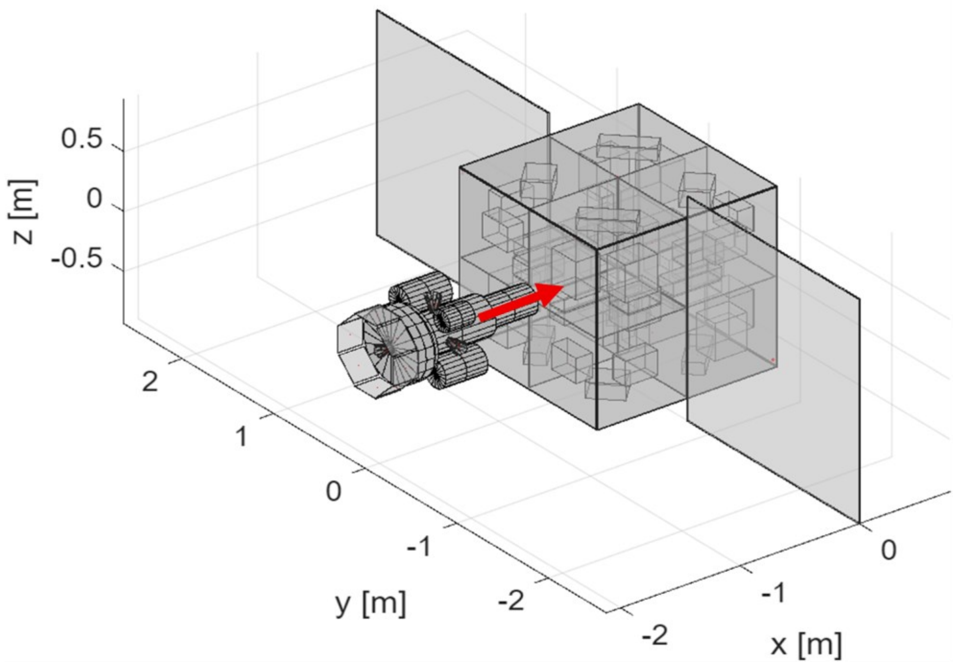


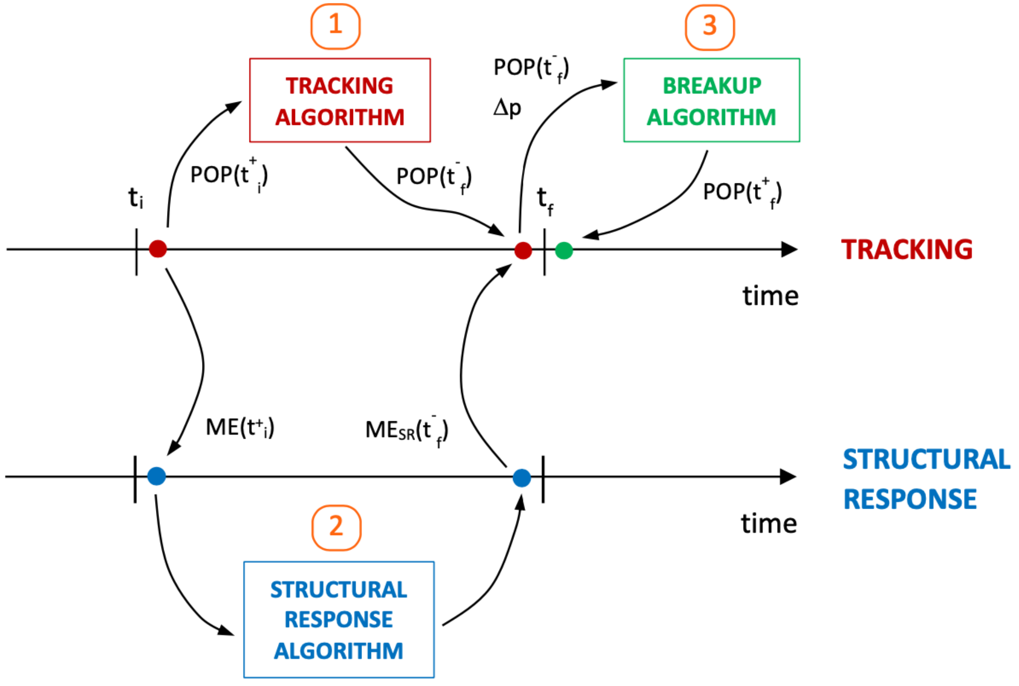
Orbital Fragmentation Events Analysis

Scenario Definition

CSTS Workflow

Mission Shakti collision scenario





Orbital Fragmentation Events Analysis

Main Outputs

- Mass
- Dimension
- Position
- Velocity

Post Processing

- Area to Mass ratio
- Characteristic Length
- Delta-V
- Orbital Parameters

Orbital Fragmentation Events Analysis

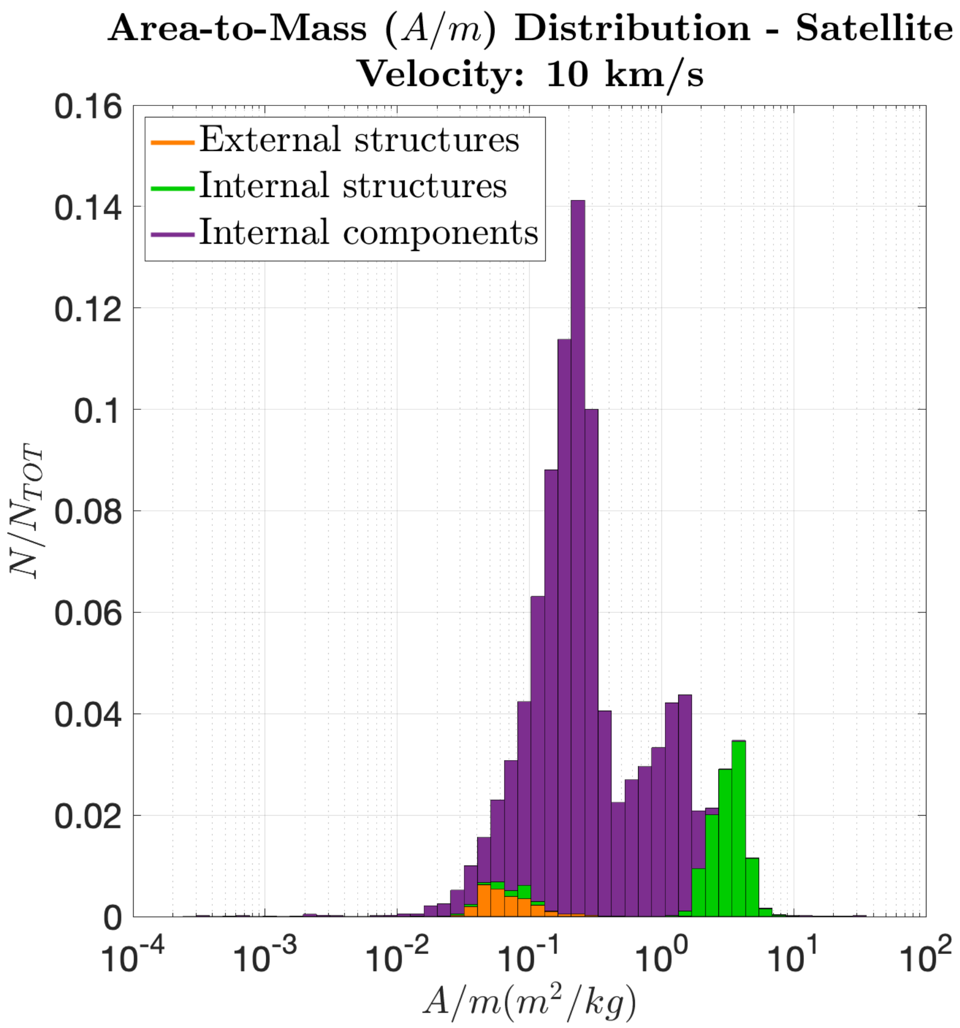


Figure: Area-to-mass ratio distribution.

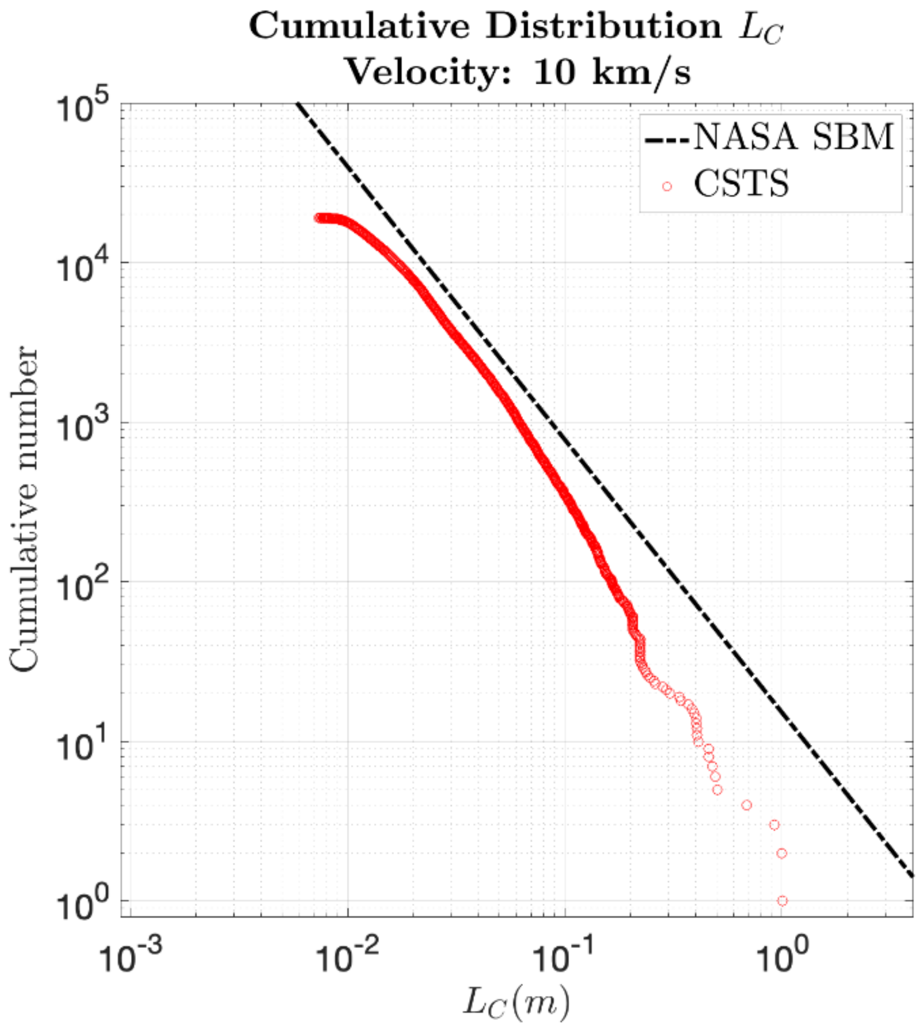


Figure: Characteristic Length distribution.

Orbital Fragmentation Events Analysis

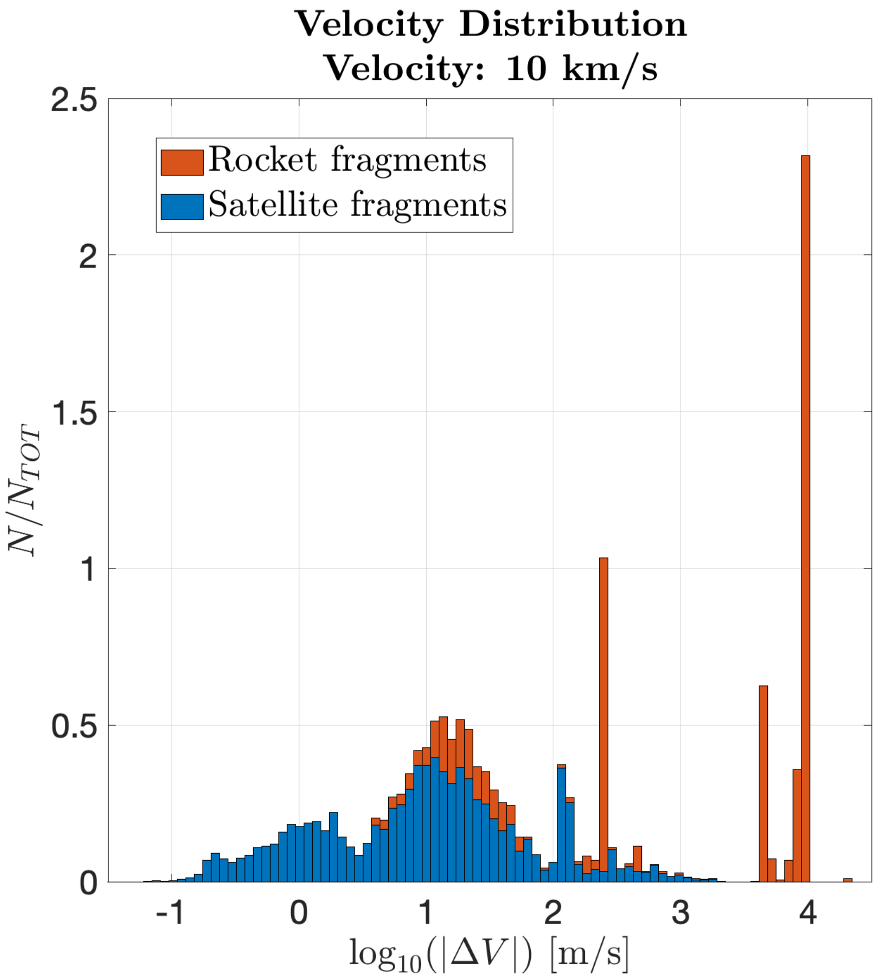


Figure: Absolute value of delta velocity distribution.

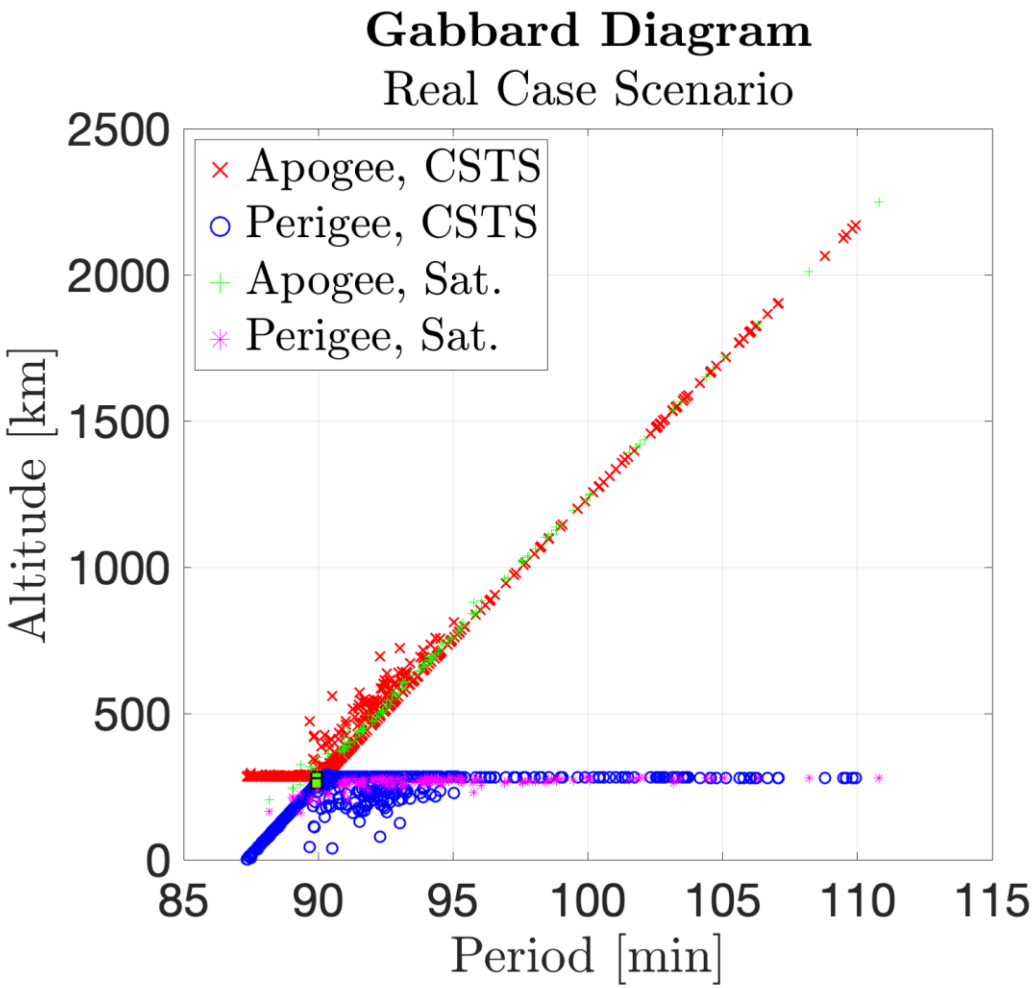


Figure: Gabbard diagram of the Microsat-R satellite considering the real geometry of impact.

Conclusions and Future directions

The **Space Debris Group** is working in several directions to create a **comprehensive ecosystem** for addressing the challenge of space debris.

- The new impact risk assessment code will be finalized in the next months and **validated against commercial software**;
- More than **100 tests** are planned for next year to develop progressively more accurate hypervelocity impact models and updated material libraries;
- The debris sensors will be finalized and their **TRL** will be increased up to **9;**
- The fragmentation event analysis algorithm will be refined.

Thanks for your attention

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