University of Padova

PhD course in *Science, Technologies and Measurements for Space*

XXXV PhD cycle - Presentation of the proposed research program

FRAGMENTATION MODELS FOR HYPERVELOCITY IMPACT

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21 Feb. 2020

Contents

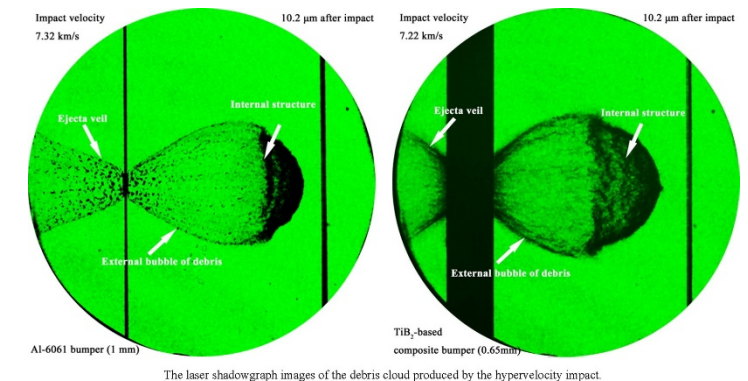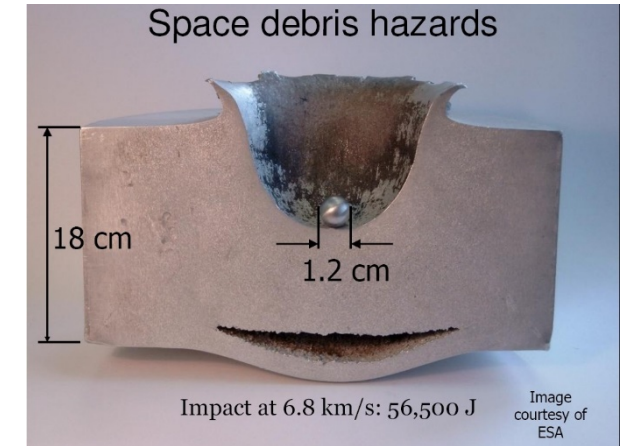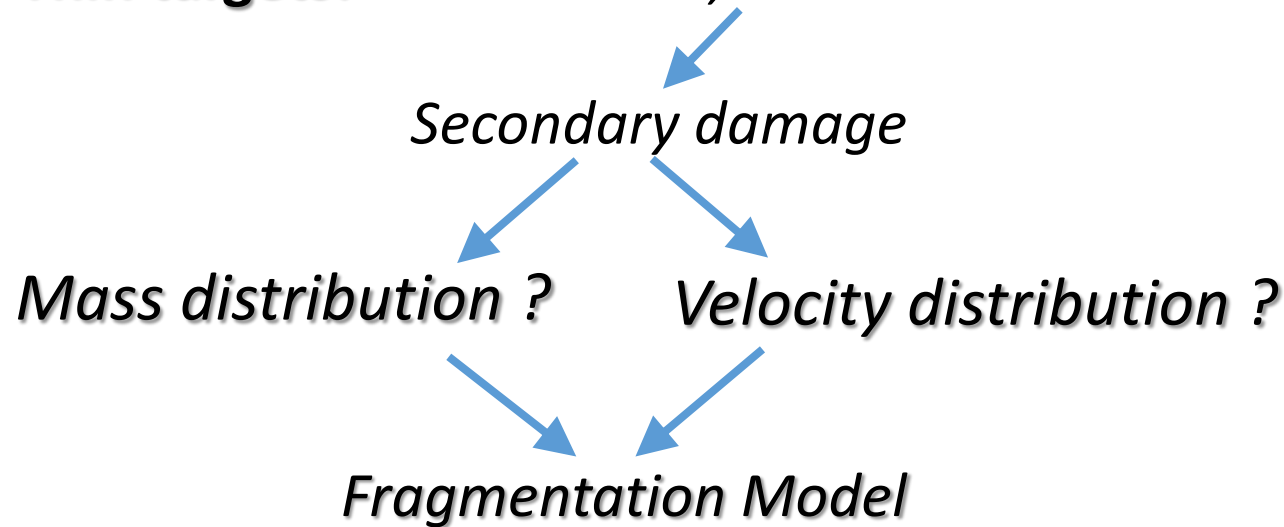Ⅰ. **Research Background**

Ⅱ. **Research Objectives**

Ⅲ. **Work Schedule**

Fragmentation Phenomena in Hypervelocity Impact

- **Hypervelocity Impact** $V_p > c_t$ (*Sound speed of target*)

  - ✓ **Thick targets:** *Cratering, Ejecta*

  - ✓ **Thin targets:** *Penetration, Debris cloud*

Secondary damage

Mass distribution ?   *Velocity distribution ?*

Fragmentation Model

Space debris hazards

18 cm   1.2 cm

Impact at 6.8 km/s: 56,500 J   Image courtesy of ESA

Impact velocity 7.32 km/s   10.2 µm after impact   Impact velocity 7.22 km/s   10.2 µm after impact

Ejecta veil   Internal structure   Ejecta veil   Internal structure

External bubble of debris   External bubble of debris

Al-6061 bumper (1 mm)   TiB₂-based composite bumper (0.65mm)

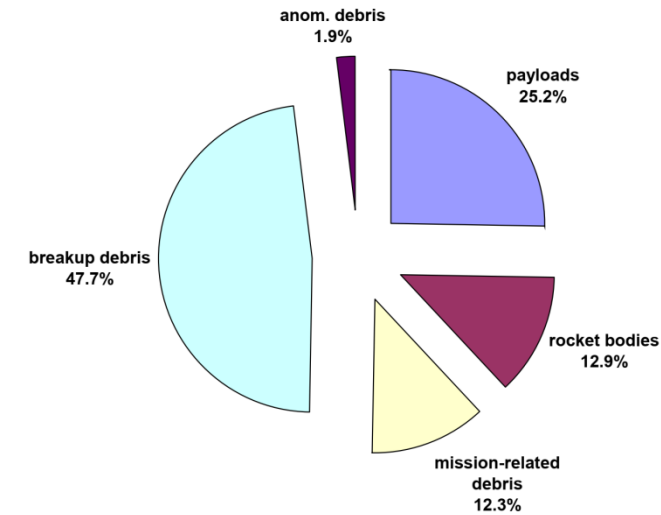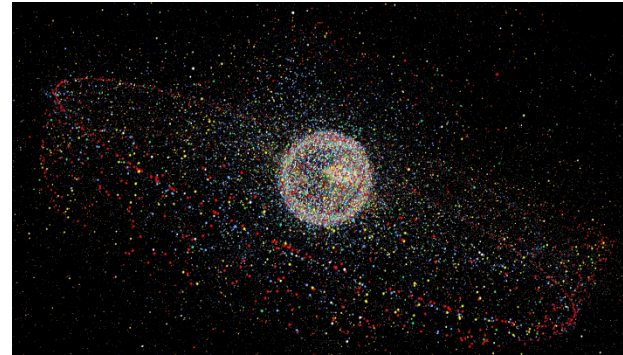The laser shadowgraph images of the debris cloud produced by the hypervelocity impact.

Fragmentation of Satellite

- Space debris population

  ✓ **Satellite breakup debris**

    nearly accounts for a half

    Collision，Explosive

anom. debris
1.9%

payloads
25.2%

breakup debris
47.7%

rocket bodies
12.9%

mission-related
debris
12.3%

- Fragmentation modes of collision

  ✓ **Full fragmentation(catastrophic collision)**
     When EMR > 40 J/g

  ✓ **Partial fragmentation:** *Components fragmentation*

Fragmentation models of satellite

Empirical models

Depends on Ground based test data & Orbital breakup data

- NASA SBM
- Battelle breakup model
- CARDC SBM
- …

Semi-empirical models

Combine with mass, momentum and energy principles

- IMPACT
- FAST
- CST *(CISAS)*
- …

- ***Size distribution***
- ***Area-to-Mass distribution***
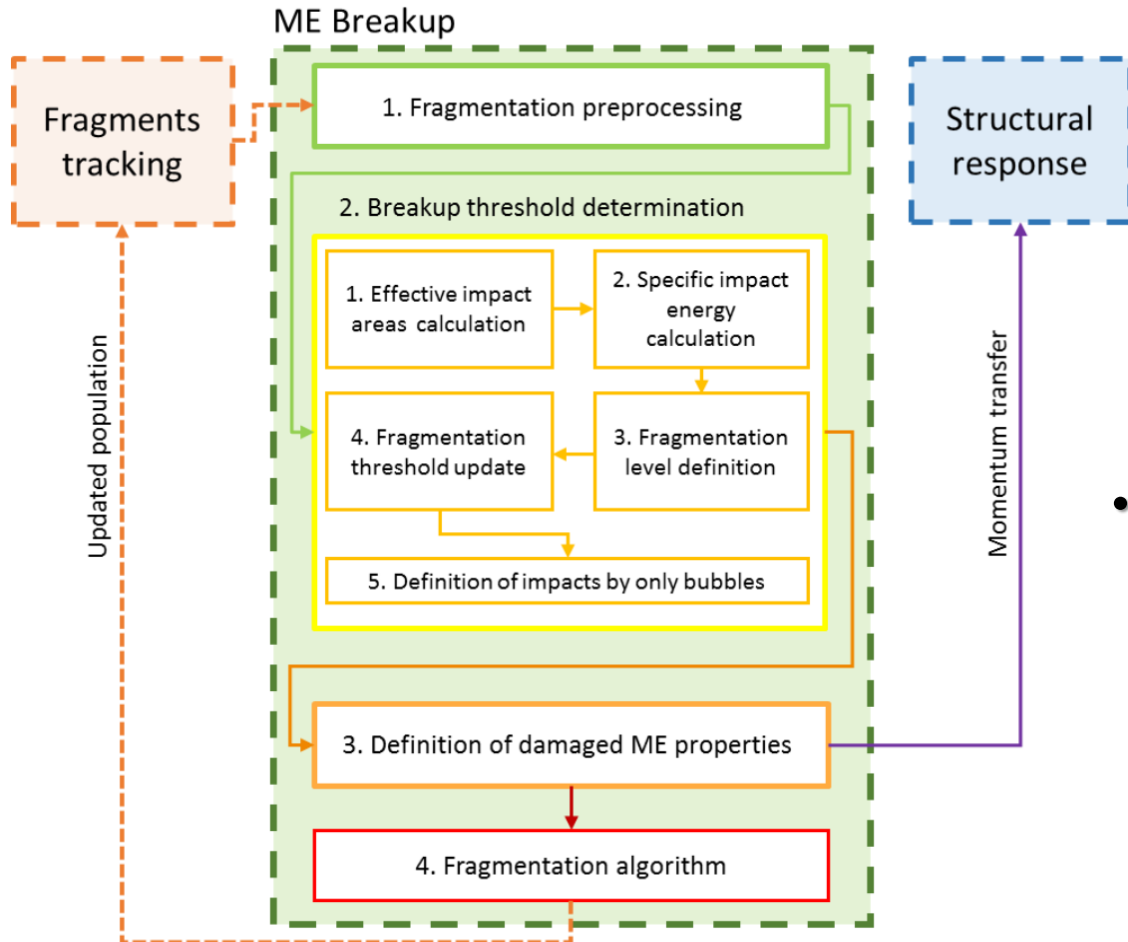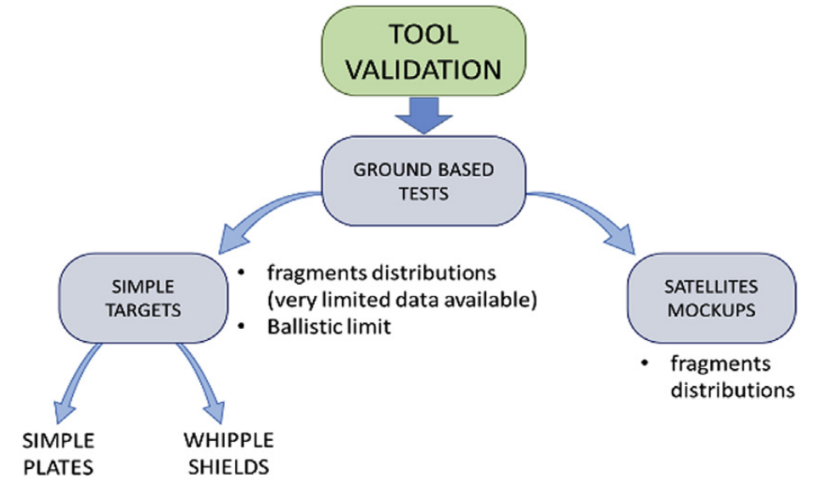- ***Fragments velocity distribution***

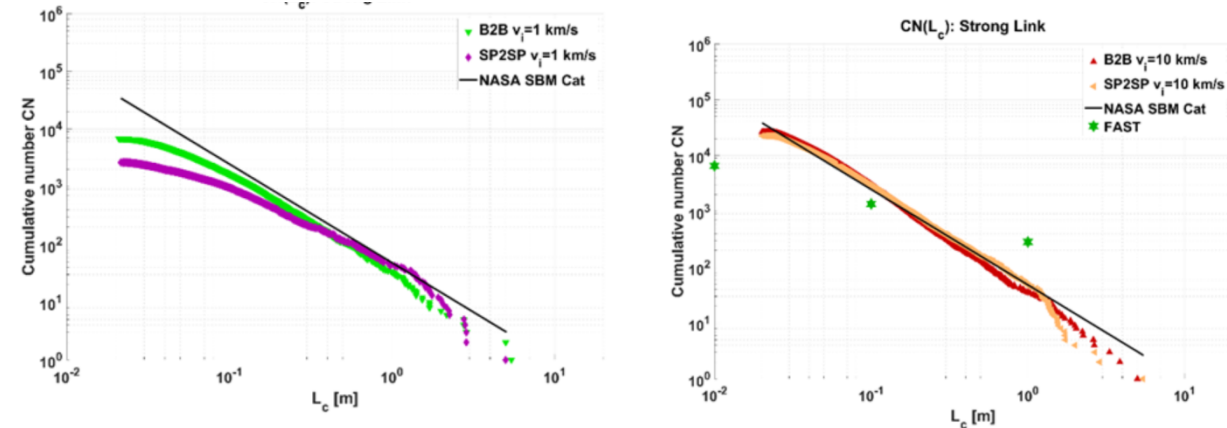*DebriSat tests for NASA SBM*

Collision Simulation Tool (CST)

- ### *CST organization*

- ### *CST validation method*

- ### *Comparison between CST and NASA SBM,FAST*

Research Objectives

- **Updating the physical algorithms of CST fragmentation model**
- **Developing an experiment for algorithms/models calibration and validation**

Research activities organization

| Research on physical algorithms of typical effects in hypervelocity impact | → | *New fragmentation model development* | → | *Experiments: Calibrating and Validation* |

- *Shape effects*
- *Impact attitude effects*
- *New material characteristics*
- *…*

- *Fragmentation threshold*
- *Size distribution*
- *A/M distribution*
- *Fragments velocity distribution*

- *Experiment instruments developing*
- *Model calibrating experiments*
- *Model validation experiments*

Work Schedule

WBS NUMBER	TASK TITLE	FIRST YEAR												SECOND YEAR												THIRD YEAR											
		T1			T2			T3			T4			T1			T2			T3			T4			T1			T2			T3			T4		
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	Literature review of hypervelocity impact fragmentation backgrouds																																				
1.1	Review of fragmentation phenomena and mechanisms																																				
1.2	Review of fragmentation models																																				
1.3	Review of the typical effects influencing fragmentation																																				
1.4	Literature review summary and research scheme adjustment																																				
2	Fragmentation model for hypervelocity impact																																				
2.1	Research on modeling the typical effects in hypervelocity impact fragmentation																																				
2.4	Research on new fragmentation modeling																																				
3	Conduct Experiments to Calibrate and Validate the Model																																				
3.1	Experiment design, instrument development and preparation																																				
3.2	Calibrating Experiments of the Model																																				
3.3	Validation Experiments of the Model																																				
4	Articles and Thesis Composing																																				
4.1	Articles Composing																																				
4.2	Thesis Composing																																				

THANKS FOR YOUR ATTENTION.