



# **Towards a Zero Debris Future: Insights from the 21st IAA Symposium on Space Debris**

Dr Dmitry Sizov, Instructor @ DMAE, SEDS

SEDZ.KZ Space Talks - February 23, 2024

# International Aerospace Congress (IAC)

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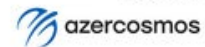
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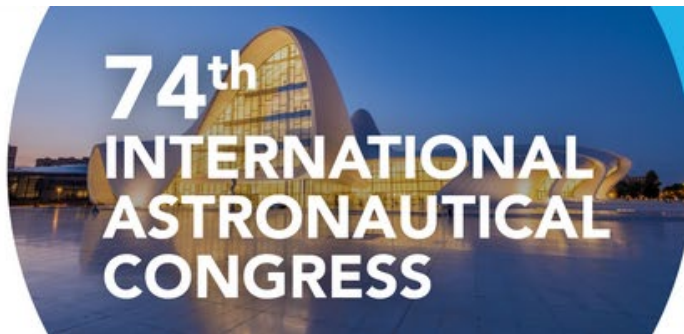
34 Symposiums:

Technical Sessions,

Interactive Poster Presentations



[https://postersessions.com/events\\_iac2023/iac-2023-poster-presentation-3/](https://postersessions.com/events_iac2023/iac-2023-poster-presentation-3/)



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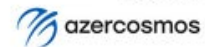
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**Exhibition**  
(Participants:  
Airbus,  
ESA, NASA, ...)



# My Talk: not about Space Debris!

## C1. IAF ASTRODYNAMICS SYMPOSIUM

**Coordinator(s):** Daniel Scheeres, Colorado Center for  
Astrodynamics Research, University of Colorado, United States;  
Vincent Martinot, Thales Alenia Space France, France;

### C1.1. Attitude Dynamics (1)

*Prof. Vladimir S. Aslanov*  
**Samara National Research  
University (Samara University)**

Attitude Dynamics of Small Satellites in Circular Near-Equatorial  
LEO/LEO

**Co-Authors:** Dr. Dmitry A. Sizov, *Nazarbayev University*  
**Paper-Nr:** IAC-23,C1,1,9,x76546



1968



2023

# The 21st IAA Symposium on Space Debris

## A6. 21st IAA SYMPOSIUM ON SPACE DEBRIS

**Coordinator(s):** Christophe Bonnal, Centre National d'Etudes Spatiales (CNES), France; Mark A. Skinner, The Aerospace Corporation, United States; Pierre Omaly, CNES, France;

- 77 Talks in Technical Sessions
- 52 Interactive Presentations

# Symposium on Space Debris: Main Topics

1. Space Debris Capturing
2. Space Debris Orbits Prediction Tools
3. Computer Vision for Proximity Operations



# (1/3) Space Debris Capturing







## COSMIC (UK ADR) – Towards the Removal of 2 UK-Owned Defunct Satellites

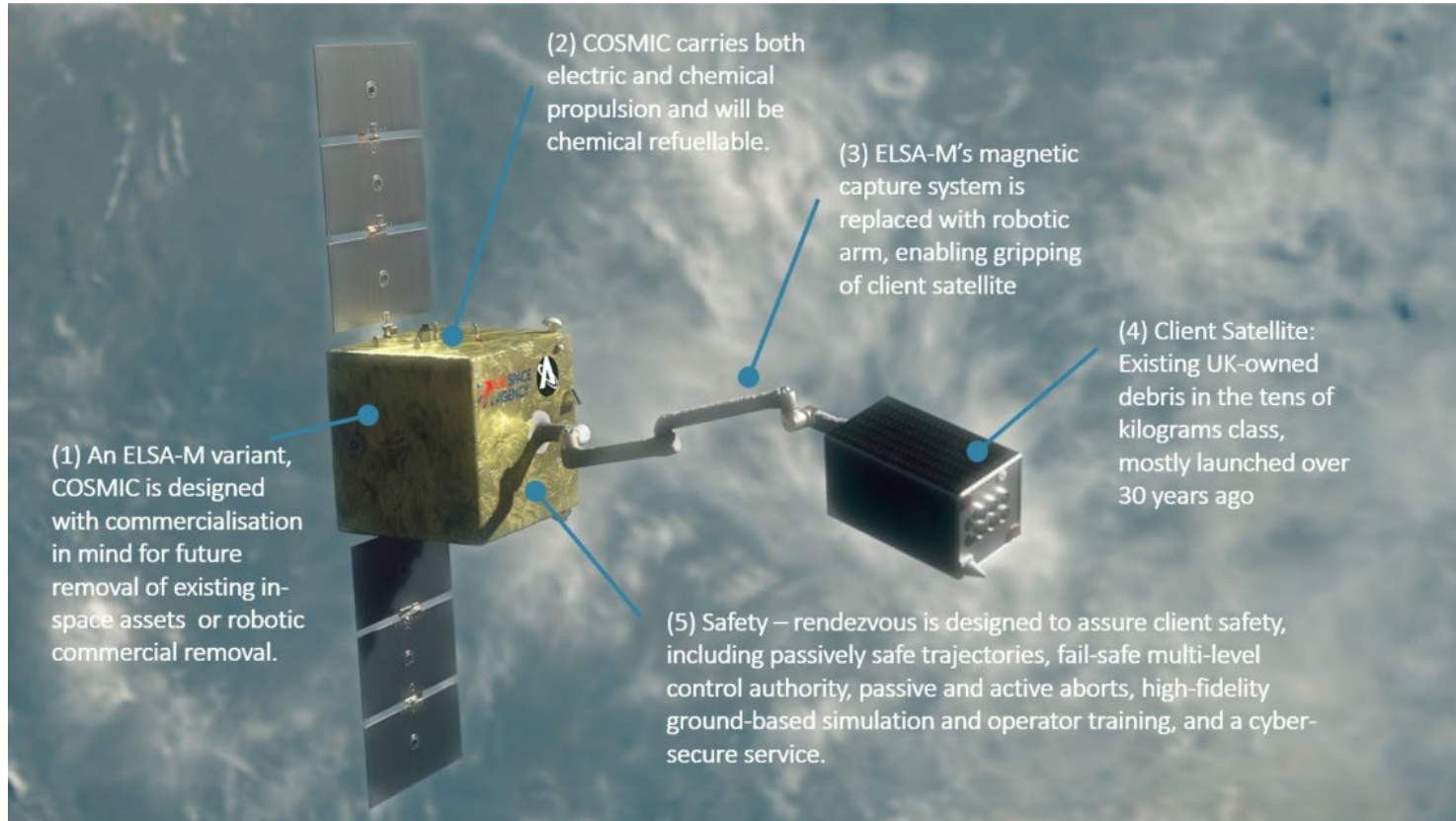
**Dr Jason Forshaw**  
**Head of Business Development &  
Product Strategy**

Co-authors: E. McKenna, J. Stuck, S. Cawley, S. Wokes,  
N. Shave, M. Lindsay, N. Okada

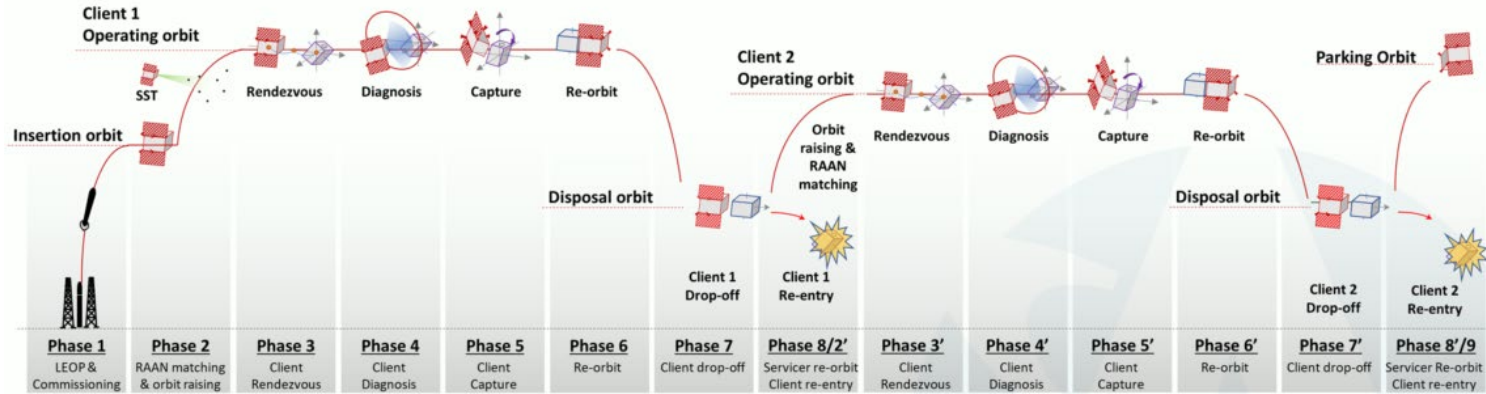
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IAC, Baku, Oct 2023





## Concept of Operations (ConOps)



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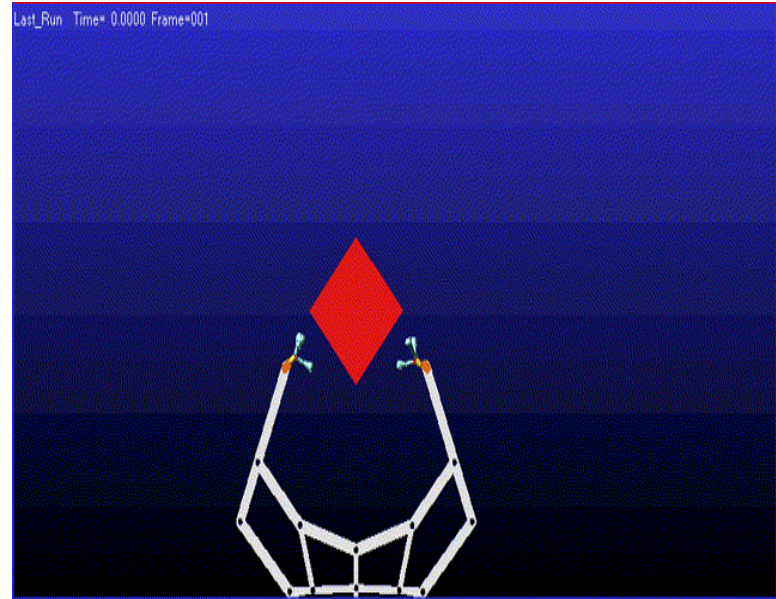
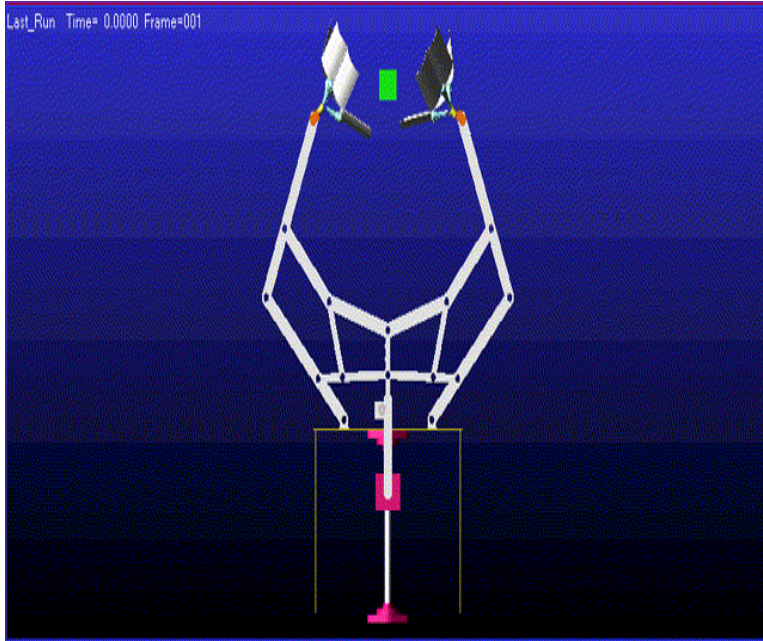


## A NOVEL ADAPTIVE CAPTURE DEVICE AND CONTROL METHOD FOR SPACE DEBRIS

Speaker: Jiale Chen

Time: 2023-10-5

National Key Laboratory of Aerospace Flight Dynamics  
Northwestern Polytechnical University, NPU, China



Copyright: Jiale Chen

## (2/3) Space Debris Orbits Prediction Tools





Università degli Studi di Napoli "Federico II"

Scuola Politecnica e delle Scienze di Base  
Dipartimento di Ingegneria Industriale



**Improving Ballistic Coefficient Estimation of Resident Space Objects in Low Earth Orbit**

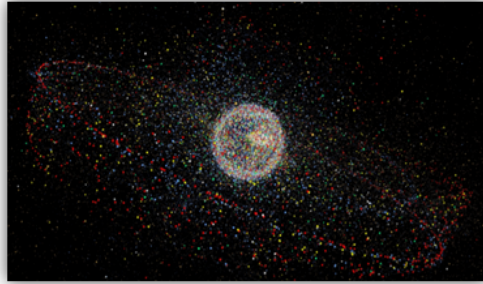
**Nicola Cimmino, Giorgio Isoletta, Roberto Opromolla, Giancarmine Fasano, Davide Amato**

**Baku, 10/2023**





## Introduction



**Need to predict  
Resident Space Objects  
(RSO) trajectories**

Copyright: Cilino et al.

### Perturbations

Gravity Force Asimmetry    Third Body

Atmospheric Drag    Solar Radiation Pressure



$f(\text{surface material, area exposed to the Sun,}$   
 $\text{drag coefficient, mass, cross-section area})$



$$BC = Cd A/M$$

- Kalman filters
- Adaptive likelihood mixtures
- Mueller's model
- Data driven methods
- Machine Learning techniques



**SMART**

SCIENCE, MATHEMATICS,  
AND RESEARCH FOR  
TRANSFORMATION  
PART OF THE NATIONAL  
DEFENSE EDUCATION PROGRAM



**IAC  
2023  
BAKU**



74<sup>th</sup> International Astronautical Congress (IAC), Baku, Azerbaijan, 2-6 October 2023

# USING MACHINE LEARNING TO PREDICT HYPERVELOCITY FRAGMENT PROPAGATION OF SPACE DEBRIS COLLISIONS

**Katharine Larsen, PhD Student**  
**Riccardo Bevilacqua, PhD**

**EMBRY-RIDDLE**  
Aeronautical University

# (3/3) Computer Vision for Proximity Operations





UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA



The University of  
Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

## 3D reconstruction of a space debris from in situ inspection exploiting CubeSats

Luca Lion, Chantal Cappelletti, Samanta Piano, Francesco  
Branz, Alessandro Francesconi

[Luca.lion.1@phd.unipd.it](mailto:Luca.lion.1@phd.unipd.it)

*Centre of Studies and Activities for Space "Giuseppe Colombo" (CISAS)*

74th International Astronautical Congress (IAC)  
2-6 October 2023, Baku, Azerbaijan

## Case Study (1/2)

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### Target:

**Space Rider (ESA)**

~8m long

~11m wide with the solar panels deployed

### Challenges:

Black painted parts

Thin features e.g. doors of the bay

Roundness of the body



Copyright: Luca Lion et al.

## Case Study (2/2)

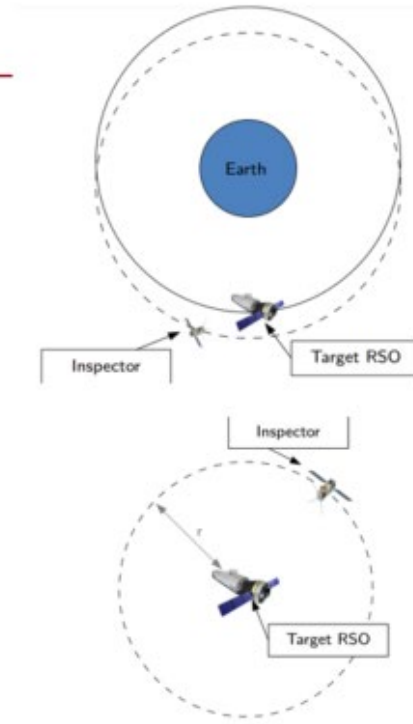
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### Inspection orbit:

#### Fly around «football» orbit

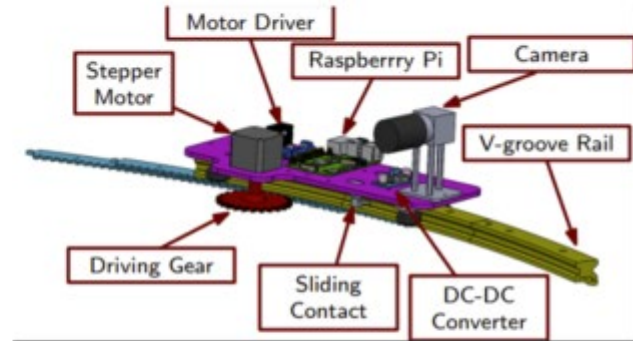
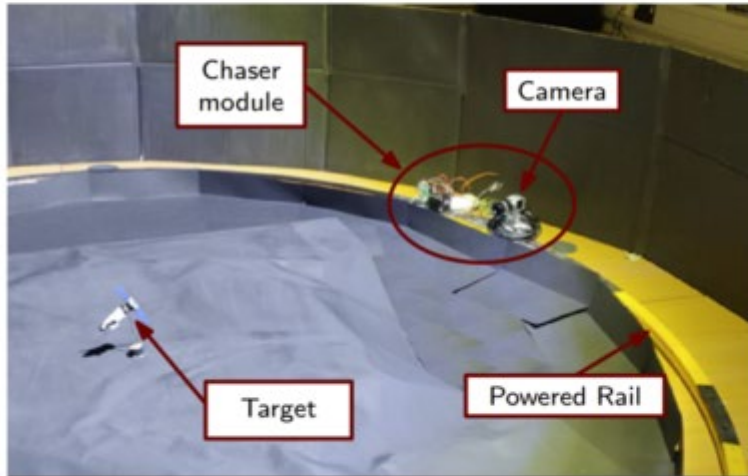
The inspector keeps a constant distance from the target, resulting in a circular relative motion

For this study it has been simulated a **relative distance of 100m**



Copyright: Luca Lion et al.

## Experimental setup



Copyright: Luca Lion et al.

- SLS 3D printed target
- Basler acA4024-29uc equipped with a 16 mm fixed focus lens

## Data processing and results (4/4)

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### Reconstruction confidence level:

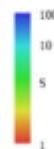
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b)



a)



b)



*74<sup>th</sup> International Astronautical Congress 2023 - Baku, Azerbaijan – 2/6 October 2023*

# Visual-based Pose Determination of Uncontrolled Space Targets Using Retroreflective Markers for Debris Removal Operations

Giuseppe Napolano, Claudio Vela, Alessia Nocerino, Roberto Opromolla, Michele Grassi  
*Department of Industrial Engineering, University of Naples "Federico II", Naples, Italy*







**POLITECNICO**  
MILANO 1863

74th International Astronautical Congress  
Baku, Azerbaijan, 5 October 2023



**IAC**  
**2023**  
BAKU

# MULTISPECTRAL VISION-BASED RELATIVE NAVIGATION TO ENHANCE SPACE PROXIMITY OPERATIONS

21st IAA SYMPOSIUM ON SPACE DEBRIS  
Post Mission Disposal and Space Debris Removal

Authors: Mr. Massimiliano Bussolino\*, Ms. Margherita Piccinin, Ms. Gaia Letizia Civardi, Prof. Michèle Lavagna



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MILANO 1863

## e. INSPECTOR

multi-spectral imaging the VESPA debris in preparation to active removal

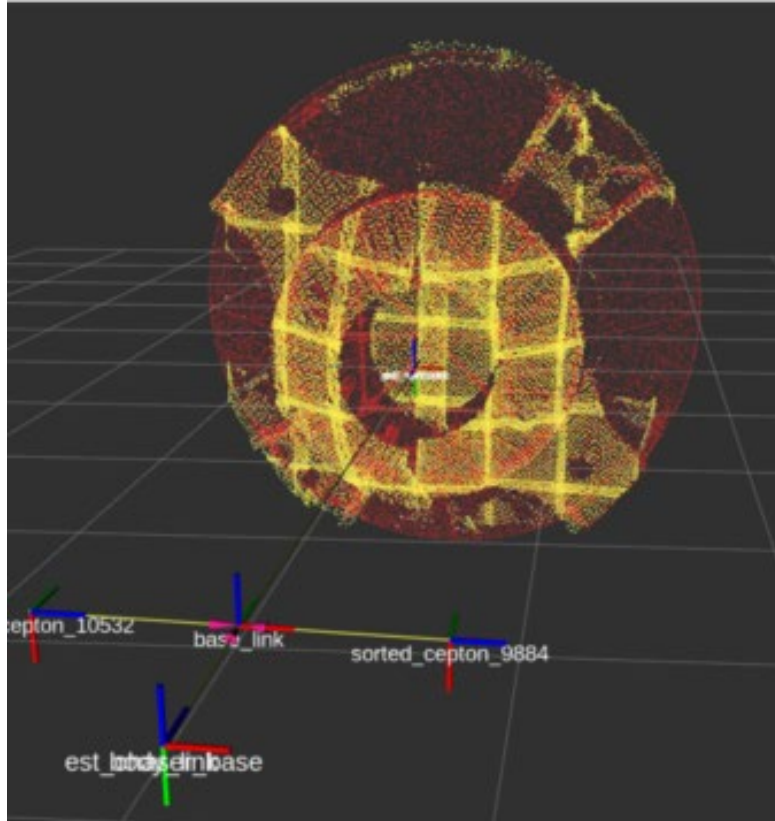
M.Lavagna,  
J.Prinetto, G.zanotti, S. Silvestrini, M. Ceresoli, M.Bechini,  
G.Civardi, A.Brandonisio, A.Foglietta, M.Duzzi, D.Labate,  
R.Briesboek



74 International Astronautical Congress, October 2-6, 2023-Baku, Azerbaijan



SEDS.KZ Space Talks - Feb 23, 2024



IAC-23-A6.5.8



## LiDAR-Based Navigation Strategies for a Non-Cooperative Target Considering Rendezvous Trajectory

Taisei Nishishita, Yu Nakajima, Takahiro Sasaki,  
Hiroyuki Okamoto and Ryo Nakamura

Japan Aerospace Exploration Agency (JAXA)



# Personal Impression

“Active LEO Space Debris Removal is less and less about science,  
now it is more and more about engineering.”



Thank you!