Debris Mitigation Competition

Post-Mission Disposal for Micro and Smaller Satellites: Concepts and Trade Studies

(IAA Study Group 4.23)

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Outline

- Overview
- Background
  - UNISEC-Global
  - Debris Mitigation Competitions
- IAA Study Group “Post-Mission Disposal for Micro and Smaller Satellites: Concepts and Trade Studies”
- Conclusion

Overview of IAA-Study Group 4.23

- **Title of Study**: Post-Mission Disposal for Micro and Smaller Satellites: Concepts and Trade Studies
- **Commission** 4 – Space Systems Operations & Utilization
- **Members:**
  - **Chairs:** Darren McKnight (USA), Toshiya Hanada (Japan), Alex da Silva Curie (UK), and Peter Martinez (South Africa)
  - **Secretary:** Rei Kawashima (Japan)
  - **Experts** : IAA members and non IAA members
- **Overall Goal:** Provide framework for a practical implementation to assure compliance with Space Debris Mitigation guidelines for micro and smaller satellites.
- **Target Communities**: Universities, micro/nano/pico-satellite manufacturers, and new spacefaring entities

Background: UNISEC-Global

UNISEC-Global is an international nonprofit body, consisting of local-chapters across the world. Since its establishment in November 2013 in Japan, it has provided an annual forum to promote practical space development activities. Its primary objective is to help create a world where space science and technology is used by individuals and institutions in every country, rich or poor for peaceful purposes and for the benefit of humankind.

Vision 2020-100

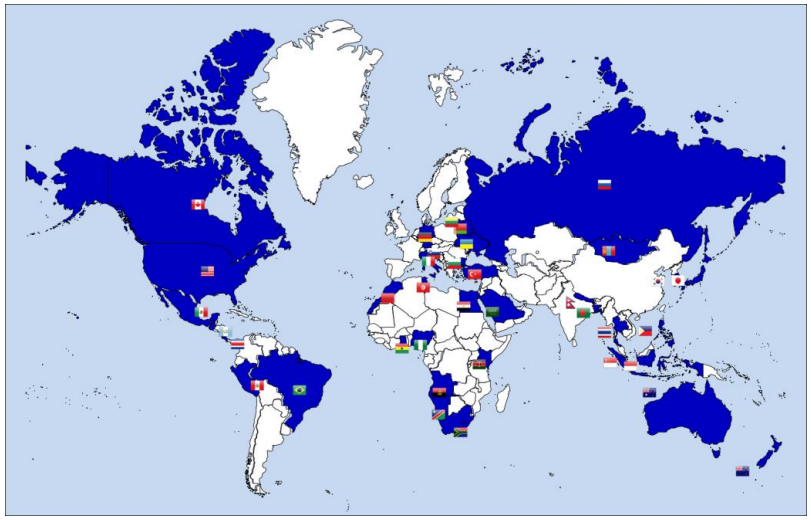
- *"By the end of 2020, let's create a world where university students can participate in practical space projects in more than 100 countries."*

15 Local Chapters were established and **44 Points of Contact** are working for the 5th UNISEC-Global Meeting

UNISEC Local Chapters

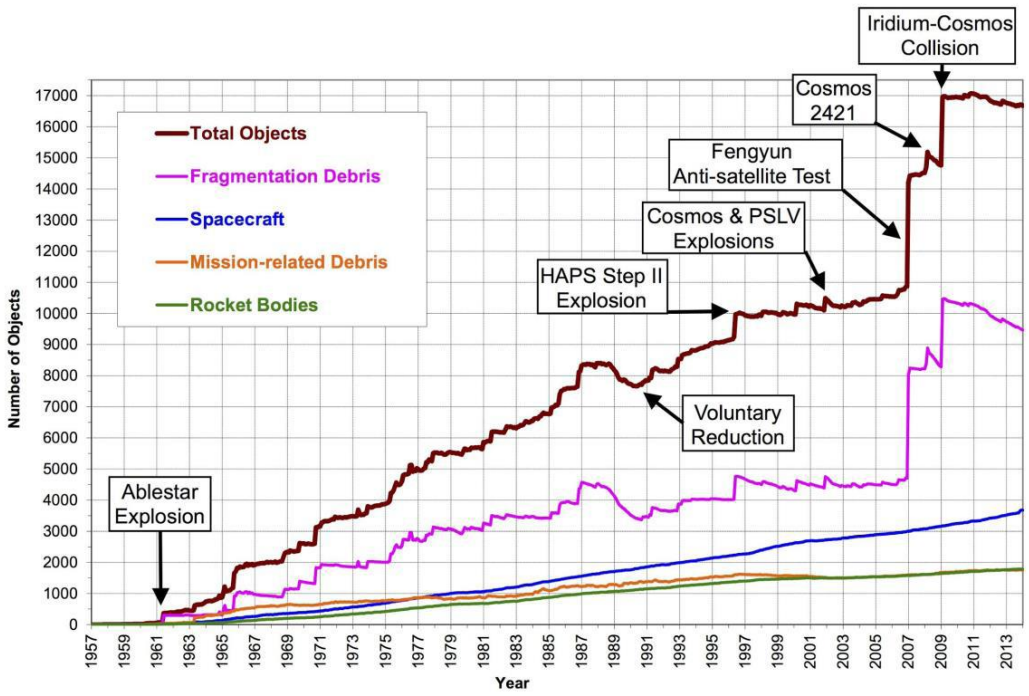
POC in 44 regions: Australia, Bangladesh, Belarus, Bolivia, Brazil, Bulgaria, Canada, Chile, Costa Rica, Egypt, El Salvador, Germany, Ghana, Guatemala, Indonesia, Italy, Japan, Kenya, Korea, Lithuania, Malaysia, Mexico, Mongolia, Morocco, Nepal, New Zealand, Nigeria, Peru, the Philippines, Saudi Arabia, Singapore, Samara (Russia), Slovenia, Spain, South Africa/Angola/Namibia, Taiwan, Thailand, Tunisia, Turkey, Ukraine, USA and Vietnam

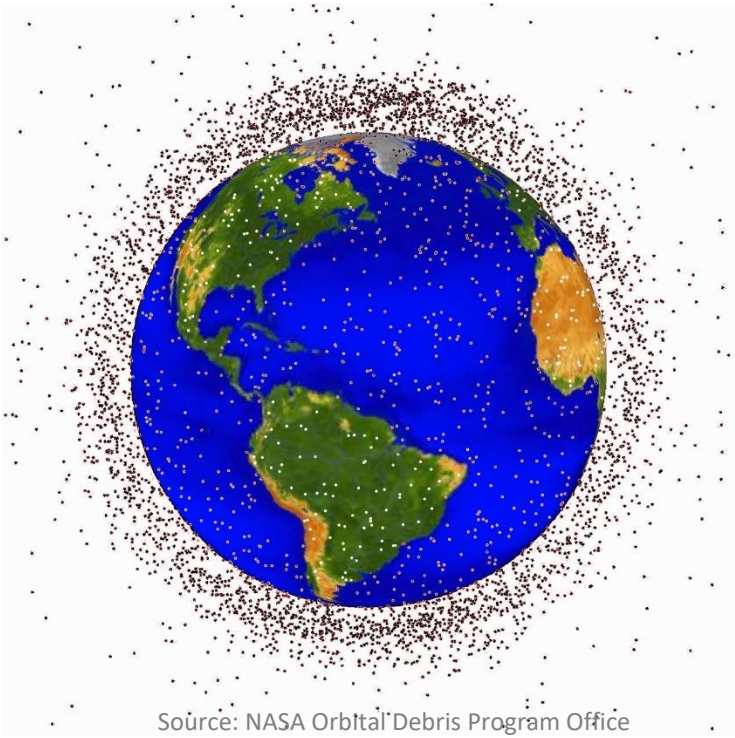
(Local Chapter in Red)



15 Local Chapters and 1 Association of Local Chapters have been acknowledged.

Background: Space Debris



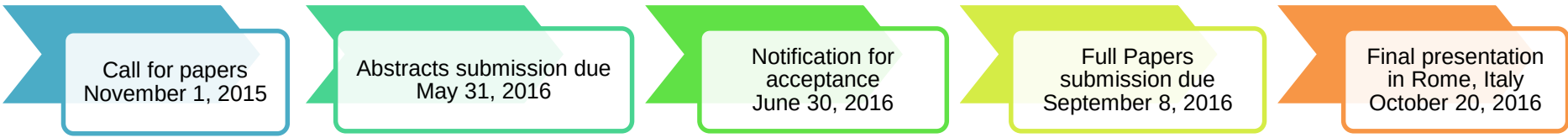


- Objects in the chart are limited to larger than 10 cm due to limited tracking capabilities

Reference: NASA Orbital Debris Quarterly News, Vol. 16, Issue 1, January 2012.

Deorbit Device Competition（DDC）(1st Debris Mitigation Competition)

- Objectives:
  - Increase awareness of debris problems among nano/micro Satellite developers and university students
  - Facilitate sharing of innovative solutions for debris mitigation and developing effective deorbit devices that can be demonstrated and validated with CubeSats.
- Timeline



DDC: Results

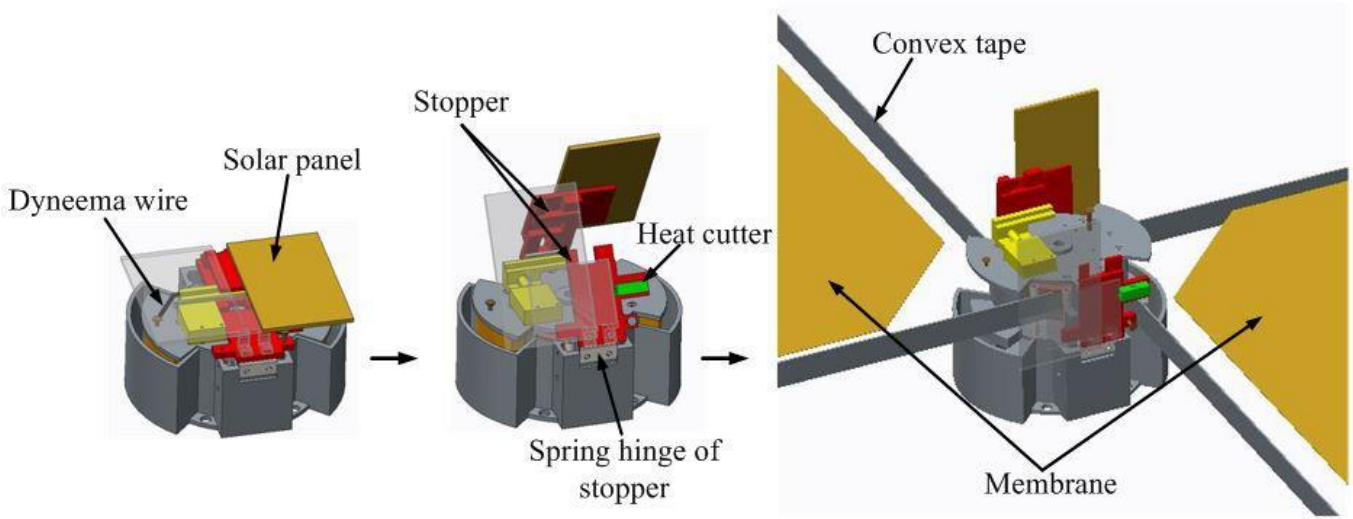
- **22 Abstracts from 15 countries**:
  - Drag sail derivatives - 13
  - Nano-propulsion systems - 6
  - Electrodynamic tethers - 2
  - Unworkable solutions – 1

Presenters of the Deorbit Device Competition

- **10 Finalists from 8 countries**:
  - France, Italy, Japan (2), Poland, Russia, South Africa (2), Turkey, USA
- **8 applicants** provided the chance to make poster presentations.
- **8 Withdrawals** due to lack of information to evaluate, unworkable solution or couldn't come for presentation.

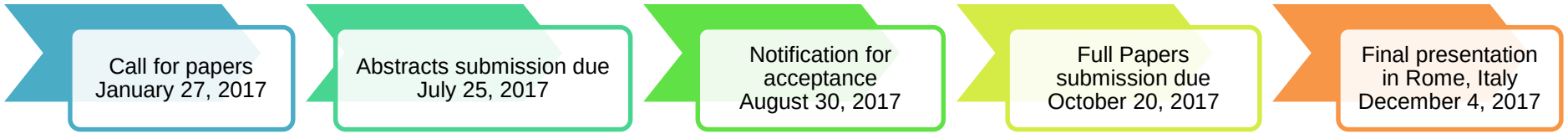
DDC: Results

- 1st Place: Mr. **Noboru Tada**, Nihon University, **Japan**.
- Proposal: "*Membrane Deployment de-orbit System by convex tapes*"



2nd Debris Mitigation Competition

- 2nd Competition was held as “Debris Mitigation Competition (MDC)” on Dec 4 during the 5th UNISEC-Global Meeting (Dec 2-4) Rome, Italy.
- The objective is to facilitate the sharing of innovative solutions for debris mitigation and developing effective **post-mission disposal (PMD) and/or active debris removal (ADR)** device that can be demonstrated and validated with a micro satellite.
- Timeline



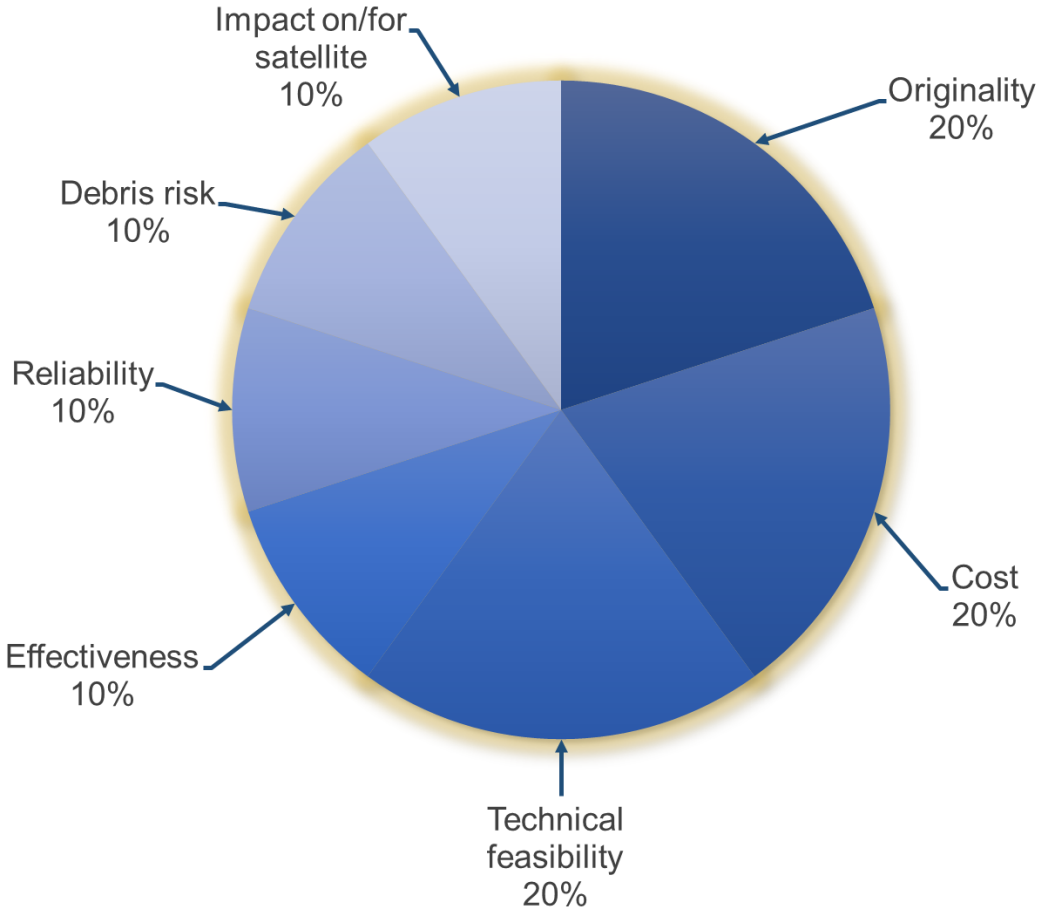
DMC: Requirements

- Propose a post-mission disposal (PMD) or active debris removal (ADR) device that satisfies the following requirements:
- The device must be designed for the removal of a potentially non-cooperative lean satellite of 50 kg mass and maximum dimension of 1 meter. Total mass of a satellite and device can exceed 50 kg.
- The device will enable the satellite to re-entry within 11 years (i.e. one solar cycle) after activating. You can use any systems such as thruster, tether, membrane or electric propulsion.
- The device will be activated at 00:00:00 UTC, January 1, 2020 with the following orbit element:

Semi-major axis	7128 km
Orbital inclination	98.4 degree
Eccentricity	0.001
R.A.A.N	30 degree
Argument of Perigee	210 degree
Mean Anomaly	190 degree

DMC: Evaluation Criteria

The proposed Deorbit Mitigation concept is evaluated according to the following criteria:



2nd DMC: Results

- **11 Abstracts from 7 countries**:
  - Drag sail derivatives - 4
  - Propulsion systems - 2
  - Electrodynamic tethers – 1
  - Laser beam – 1
  - Unworkable solutions – 3

- **5 Finalists from 5 countries**:
  - Argentina, Japan, Russia, South Africa, Turkey

Comparison between DDC and DMC

Parameter	DDC	DMC
Target Satellite	CubeSat (1-3U)	Micro-Satellite (50kg)
PMD/ADR	PMD	PMD and ADR
Semi-major axis	6930 km	7128 km
Orbital inclination	97.6 deg.	98.4 deg.
Eccentricity	0.002	0.001

Be a part of solutions,
not a part of problems

Study Scope and Objectives

- Create framework (from trade study organization and results of trade study) for debris mitigation compliance for university space users leveraging post-mission disposal (PMD) devices.
  - Define all relevant terms.
  - Do not recommend specific products.
- This report should also useful for emerging space powers and possibly regulators.
- Make it clear that a PMD simply exerts a force on the microsat (or smaller) to help it adhere to debris mitigation guidelines. Current minimum guidelines call for 25 years explicitly (even though report should show how to comply to any timeline) but also to do so without inadvertently posing more risk while executing the reorbit/deorbit process.

Methodology

- **Methodology**
  - Reviewing the effectiveness and the risks of debris mitigation devices, processes, and operational concepts in the light of existing debris mitigation guidelines.
- **Intermediate Goals**
  - Determine how to evaluate the positive/negative impact of various debris mitigation devices, processes, and operational concepts.

Parameters to vary in trade study for micro and smaller satellites

- Altitude and inclination
- Satellite mass, power, pointing accuracy, communications, propulsion, computing power, etc.
- Budget (financial)
- Collision hazard posed to the environment (number of objects and size of objects)
- Reliability of satellite
- Number of satellites

Parameters to vary for potential PMD solutions:

- Technology Readiness Level (TRL) (i.e., availability, previous use, etc.)
- Reliability
- Complexity (in installation and operations)
- Size, weight, and power requirements
- Type of force to leverage
  - Drag, propulsive, solar radiation, electromagnetic, etc.
- Typical summary figures shall include, but not be limited to, the following:
  - Mass-applicability (i.e., how massive of an object can this work for)
  - Orbit-applicability (i.e., altitude and inclination)
  - Capabilities-applicability (i.e., power, pointing accuracy, etc.)

Timeline

- **2017**
  - **September (during IAC)** Kick-off
  - **December 4** Informal Meeting associated with Debris Mitigation Competition during UNISEC-Global Meeting held in Rome, Italy
- **2018**
  - **March 26-29** Planning meeting at IAA spring meeting
  - **October 1-5 (during IAC)** Complete the first draft
- **2019**
  - **March 25-30** Planning meeting at IAA spring meeting
  - **October ? (during IAC)**: Complete the second draft.
- **2020**
  - **March** Complete final report

Conclusion

- UNISEC-GLOBAL proposed a Deorbit Device Competition (DDC) as a platform to increase awareness of debris problems and facilitate the sharing of innovative solutions for debris mitigation. The first DDC/MDC was conducted in 2016 with a target satellite 1-3U CubeSats.
- The second Debris Mitigation Competition (DMC) with target satellite of up to 50kg was conducted during the 5th UNISEC-GLOBAL meeting in December, 2017 in Rome, Italy.
- A new IAA Study Group has been launched. “Post-Mission Disposal for Micro and Smaller Satellites: Concepts and Trade Studies”
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