SEDS-USA-SSPI 2020 Chapter Competition

Taking Out the Trash

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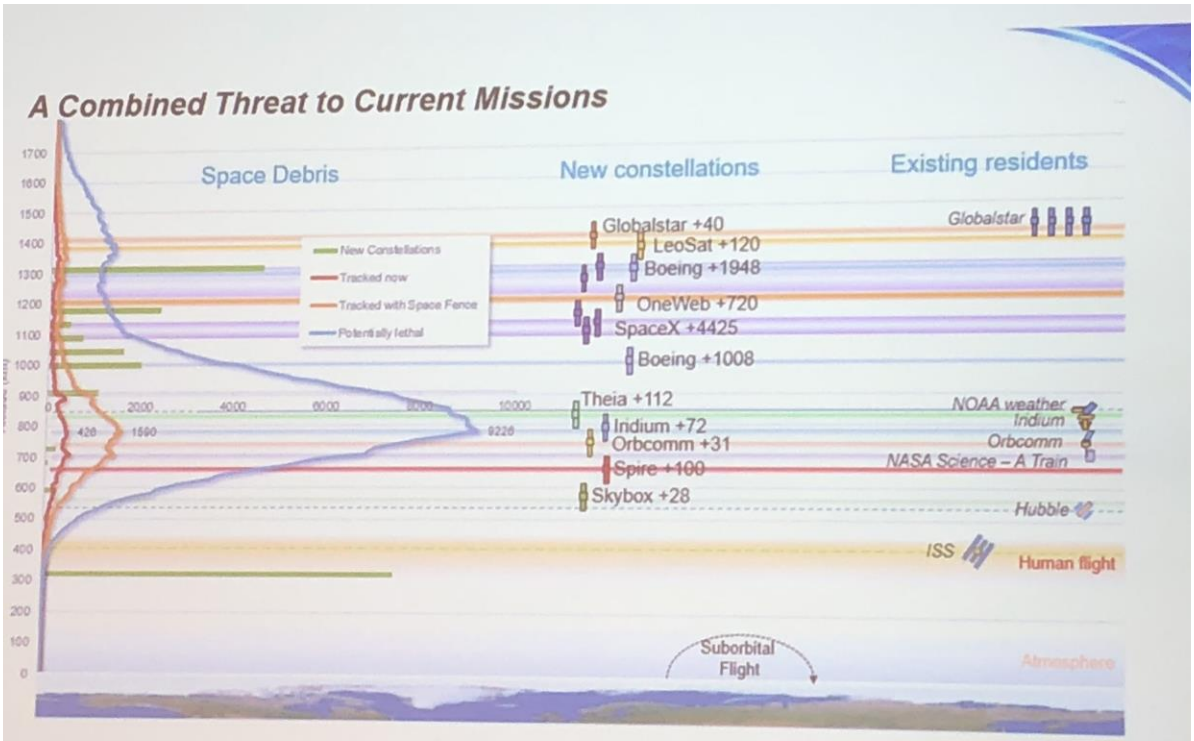
Space debris is an issue of growing concern, with the potential to block access to space, as dramatically illustrated in the film *Gravity*. The Kessler Syndrome shown in the film was proposed by NASA scientist Donald Kessler in 1978: a scenario in which the density of objects in low earth orbit is high enough that collisions between objects could cause a cascade, where each collision generates space debris that increases the likelihood of further collisions. The distribution of the resulting debris could render space activities and the use of satellites unfeasible for many generations.



The challenges to cleaning up low earth orbit are part regulatory, part technical but very much about business model. What are the sources of space debris: yesterday, today and tomorrow – including the larger number of proposed mega-constellations orbiting the earth with no onboard propulsion? Who pays to protect the “orbital commons?” How can the costs and responsibilities be equitably shared and that cost-and-responsibility sharing best enforced? What bright ideas exist for clearing it out? What combination of space law and policy, new technology and economic motivators will be required to reduce the existing cloud of space debris and to prevent additional space debris from being created?

SEDS USA

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Project Specifications

Research the problem of space debris:

- Its causes, current situation and future potential for interference in space activities, with specific focus on the different satellite orbits (LEO, MEO and GEO) most affected
- The treaties, regulations and insurance contracts that currently government responsibility for debris management, and their shortfalls that have led to the current situation
- Technologies proposed and undergoing testing for clean-up of space debris already in orbit

Following this survey of existing knowledge, propose a comprehensive solution to preventing future space debris and reducing the current density of debris in order. The solution will include:

- Recommendations for policies, regulations and treaties that will motivate launch companies, governments and spacecraft operators to prevent future space debris and reduce the volume of debris in orbit.
- Identification of economic incentives or business models that will motivate governments and businesses to adopt these policies and fund removal of debris from orbit.
- Recommendation of a technology with the greatest potential to remove space debris at the lowest total cost, based on existing proposals and solutions proposed by the team. The technology recommendation should analyze the pros and cons of the technology and explain why it is likely to deliver the best solution for the money.

Team Specifications

Teams must be comprised entirely of students at one university. Teams will be limited to one per university, and team candidacy must be submitted through that university's SEDS chapter. We recommend between 3 and 10 members per team, but we encourage team leadership to include as many interested chapter members as possible. Individual team members must maintain student status at the university naming the team and may only contribute to one project at a time.

Since this is a student project, SSPI and SEDS expect student team members to do the vast majority of the work. Mentors are assigned to assist teams with overcoming the learning curve, but should not do substantial work on the project, except when necessity dictates (driven by, e.g., proprietary software). All contributing team members should be credited on the team roster, which is submitted with the project.

Background Information

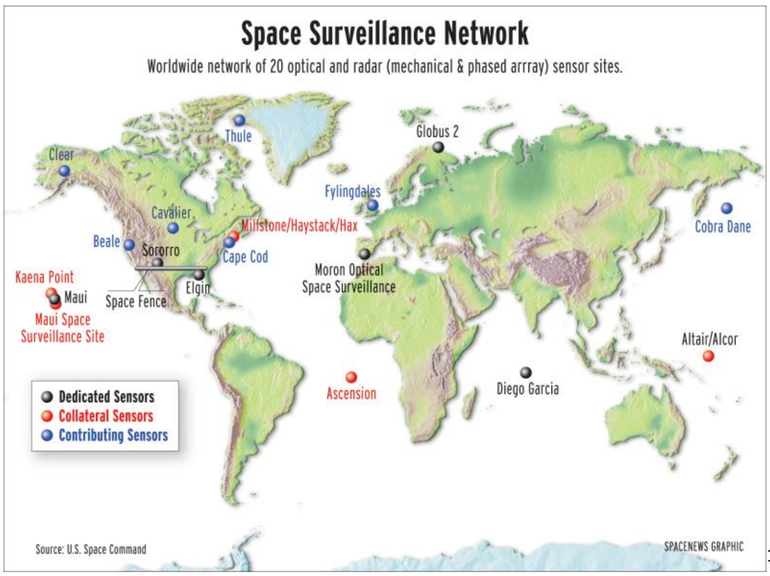
The following offer a starting point for research:

- https://orbitaldebris.jsc.nasa.gov/
- https://aerospace.org/story/space-debris-and-space-traffic-management
- https://aerospace.org/story/danger-orbital-debris

- https://spacenews.com/will-megaconstellations-cause-a-dangerous-spike-in-orbital-debris/
- http://interactive.satellitetoday.com/via/march-2019/the-gravity-of-space-debris/

Status Quo of Orbital Debris and Space Situational Awareness

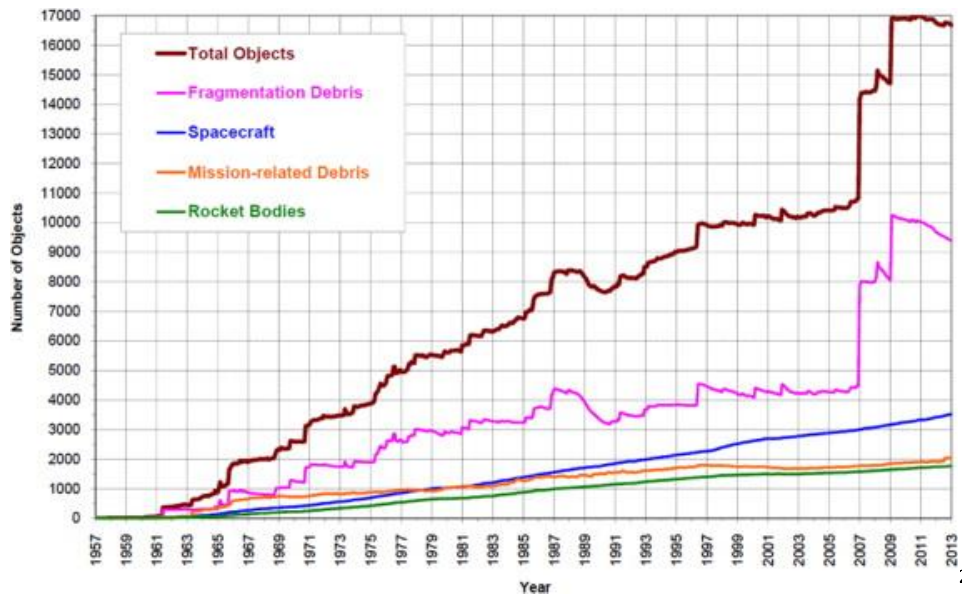
All objects in orbit are tracked by the U.S. Space Surveillance Network (SSN), and the data is published online by the Joint Space Operations Center at Vandenburg Air Force Base. This same office provides warning notices to satellite operators when a close pass between two objects occurs. The SSN is made up of many ground-based optical and radar sites as well as a small number of space-based sensors, although the published trajectory information is an aggregation of multiple measurements and cannot be tied back to any one specific sensor.



[1]

Even small pieces of debris can cause potential harm to spacecraft due to the high velocities of objects in orbit, while large rocket bodies could cause catastrophic collisions and hinder future access to commonly used orbits. For objects in Low Earth Orbit (LEO), drag is an ever-present force that continuously “cleans” the regime. However, based on the orbital altitude and physical properties of the object, this is a process that may take decades, and for higher objects, it is a common assumption that they will remain in space permanently.

[1] U.S. Air Force Envisions Sharing Space Surveillance Data with Scientists: https://spacenews.com/u-s-air-force-envisions-sharing-space-surveillance-data-with-scientists/



[2]

International Obligations Related to Space Debris

To attempt to mitigate the rising issue of debris in space, many states, including the major space operators, have independently developed guidelines for debris mitigation. Most of these guidelines are heavily based on a 2007 UN Report: [Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space](#).

This set of guidelines, while not legally binding, established many of the norms that have been adopted worldwide regarding orbital debris. Some of these guidelines include:

- Objects in GEO should be moved to a “graveyard” orbit above the GEO belt at end of life.
- If an object cannot be removed from orbit, it should have any onboard fuel depleted before operations cease.
- Objects in orbit should not release debris as a part of regular operations.

A later UN report has recommended that any spacecraft operating in LEO should have a debris mitigation plan that will result in the spacecraft deorbiting with 25 years of end of life. This 25-year rule is particularly relevant to CubeSats and small satellites, which may only deorbit due to drag, can could provide challenges to LEO mega-constellations.

Current Technologies Relevant to Space Debris

In addition to strategies for mitigations, some governments and commercial entities have considered the possibility for active debris removal. Many of these proposals have coincided with recent efforts to develop technology for satellite servicing as some of the fundamental technology and engineering challenges overlap (rendezvous, proximity operations, capture).

[2] “Optical Orbital Debris Spotter” Englert, C., Et al.

Other organizations have proposed electrodynamic tethers, nets, harpoons, and lasers as technology development opportunities for capturing and eventually de-orbiting space debris.

Timeline for Submissions

Activity	Responsible	Target Date
ANNOUNCEMENT AND DECISION		
First project announcement to chapters	SEDS-USA	Jan 13, 2020
Second project announcement to chapters	SEDS-USA	Jan 20
Teams indicate interest in participating	SEDS-USA	Feb 3
PROJECT START		
Project start	Teams	Feb 10
Mentor assignment deadline	SSPI	Feb 17
First online meeting with mentor	Teams	Feb 19
Complete outline and project plan	Teams	Mar 9
PROJECT WORK AND SUBMISSION		
Reports due to SEDS USA and SSPI for review	Teams	May 4
Completion of judging, announcement of awards	SSPI	June 30
Presentation of awards, workshop	SEDS-USA, SSPI	Nov TBA

Submission Details

Teams are expected to thoroughly document their progress through their project:

First Meeting

Team leadership should meet with their assigned mentor and submit brief documentation by the deadlines above. The documentation should include the following:

- Project overview
- Team roster
- How you will address each bullet point under "Project Specifications" (above), which you expect to be most challenging (and why), and a couple of scope reduction options.
- Brief timeline for project completion
- "Wish List" from SSPI/SEDS-USA

These items should all be discussed among team leadership before the mentor meeting.

Final Submission

The final submission should address each bullet point under "Project Specifications" (above), including brief descriptions where appropriate of why items were not treated in the project as a whole. Your submission should "tell a story," more or less.

Final submission should reference modern literature, much like a research paper. Additionally, the project must include a team roster, preferably with each team member credited with general areas of contribution. Teams are encouraged to assist and seek assistance from one another during that session.

How to Structure the Report
Use the following outline as a template for your report. You need not follow this exact order or include every item, but an effective report will use this outline as a guide.

1. The challenge
    a. Description of the current space debris problem and how it developed
    b. Identification of the policies that are supposed to govern space debris and the practices by government and business that created the problem
    c. How space-faring nations are currently dealing with space debris
    d. Risks of space debris to future access to space based on recent history and future projections
2. Review of current policy, business and technical solutions
    a. Policy and political developments, their strengths and weaknesses
    b. Business case and economic incentives for space debris reduction and removal
    c. Technologies being explored to remove space debris
3. Recommendations for progress
    a. Policy recommendations and political barriers
    b. Business and economic incentives needed to enforce effective policies
    c. Best technology options for removal
4. Conclusions

Awards

SSPI is making available up to two cash prizes payable to the top-scoring teams in the competition. The first prize is $300 and second prize is $150.