Disclaimer

Continuation of this program depends on the obtainment of funds from donors and investors to cover the costs of the CubeSat bus and the GOLD deorbit system. If these funds are not secured, this program will not proceed.

Enterprise Center for Excellence
Orbital Debris Mitigation
<u>White Papers Solicited</u>

September 19, 2016

1 Scope

The Enterprise in Space Orbital Debris Mitigation Student Competition is expected to launch to space student experiments that will support a new technology for orbital debris mitigation or develop new experiments for orbital debris detection. When this competition starts (date TBD), it will be led by Global Aerospace Corporation (GAC), the organization in charge of the Enterprise in Space Orbital Debris Mitigation Center for Excellence. The competition will be organized in different phases, at the end of which the best experiments will fly to space. GAC will manage the competition, supervise the students, and select the best experiments. The experiments will support the Gossamer Orbit Lowering Device (GOLD) inflatable deorbit system or will perform orbital debris detection and tracking.

2 Enterprise in Space

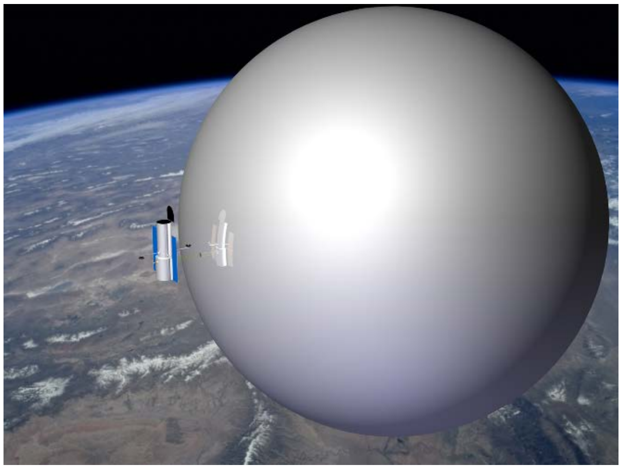
The Enterprise in Space (EIS) program will launch more than 100 student experiments to low Earth orbit. Students at the university level will compete in many subject areas including space solar power, additive manufacturing, artificial intelligence, and orbital debris mitigation. During the competition, students will design and build a variety of experiments that will fly to space. The organizations that are supporting or sponsoring the program, in addition to Global Aerospace Corporation, include SpaceWorks, Made in Space, Terminal Velocity, Horizon Space Technologies, Janet's Planet, Prairie Nanotechnologies, ValueSpring Technology, Space Canada, Canadian Space Society, Ohio University, Center for Applied Space Technology, and Deep Space Industries.

3 The Competition

Global Aerospace Corporation is part of the Enterprise in Space program as the lead organization of the Orbital Debris Mitigation Center for Excellence. When the competition launches (date TBD), students from universities will be invited to compete by submitting to GAC their ideas and proposals. The student projects will be self-funded. GAC will monitor the students and their projects as they designed and built. During the mission, students not only from universities, but also from high schools, will be involved in many ways: for example, by tracking the CubeSat and predicting its orbit.

4 Gossamer Orbit Lowering Device (GOLD)

The Gossamer Orbit Lowering Device (GOLD), shown conceptually in the images below, is a deorbit technology developed and patented by Global Aerospace Corporation (GAC). GOLD is applicable to a wide range of spacecraft from CubeSats to large scientific platforms, and can be utilized in low Earth orbit (LEO) up to about 1,000 km of altitude. GOLD increases the cross-section area of a satellite or launch vehicle upper stage by an inflation-maintained ultra-thin envelope, which accelerates the natural atmospheric drag decay of the object from centuries down to months or weeks, based on orbit and mission parameters. The inflated envelope is protected from ultraviolet radiation and atomic oxygen erosion. The whole deorbit system is characterized by an inflation control and pressure maintenance system, a controller, and various sensors. GOLD can be attached to satellites or upper stages before launch or delivered to derelict satellites and upper stages by orbital tenders. It can also be used to perform targeted and controlled reentry of large space platforms. It has been estimated that this system will lower the probability of destroying operating satellites and creating new debris compared to bare spacecraft or other deorbit methods.



GOLD Deployed System

GOLD Stowed System

GOLD helps mitigate the issue of orbital debris because it allows satellites and upper stages to deorbit much sooner, thereby lowering the risk of collision with other objects. GOLD can operate autonomously and with very little power, or it can utilize the power system of the spacecraft to which it is attached. If it uses its own power system, it can function even after a spacecraft has failed. GOLD is made of very lightweight materials and is less massive and costly than propulsive deorbit. Key system elements of GOLD are its ultra-thin and lightweight inflated envelope, the envelope storage container, and the inflation and pressure maintenance system. Optional systems, depending on mission requirements, are a gas reservoir, system operation sensors, a controller to monitor the satellite, a countdown-to-deployment system, satellite interfaces (power and heartbeat), and power for dormancy and operational phases.

GOLD offers a low-cost mission-end option for compliance with deorbit regulations, and also enables satellites to use their entire propellant load to satisfy mission objectives, rather than for deorbit, and it reduces the probability of future collisions. Therefore, its operation offers low risk to other operating satellites. GOLD can also be used to augment a propulsion system for targeted reentry, and can provide propulsionless satellites a low-cost means to change orbit to avoid predicted collisions. Finally, if used in an Active Debris Removal (ADR) program, it could further prevent future loss of satellites. More information about GOLD can be found on the GAC website.

5 White Paper Key Dates

Students are encouraged to submit an informal white paper, no longer than 5 pages, to start presenting their ideas before an actual competition starts. This will allow a preliminary assessment of various possible concepts. The best White papers will be presented during ISDC 2017. White papers are being accepted now. Submitting a White paper is not a requirement for participating in Phase I, does not imply that a submission to the actual competition will be required, and does not increase the chances to proceed beyond Phase I. The key dates related to White papers are the following:

- January 16, 2017: White paper submission deadline
- March 15, 2017: Announcement of best White papers, which will be presented at ISDC 2017
- May 2017: White paper presentations at ISDC 2017 in St. Louis, MO

6 Technical Requirements

The Debris Mitigation free flyer consists of a 3U CubeSat (30 x 10 x 10 cm) that will demonstrate up to 4 student experiments. There are two types of experiments that will be considered: those related to assessing the performance of the GOLD system and those related to orbital debris detection and tracking (i.e., sensors). For example, experiments could measure GOLD's performance during deployment and operation.

6.1 GOLD-related Experiments

GOLD-related experiments could include tracking the envelope internal pressure, micrometeoroid and small debris holing detection and characterization, envelope stress measurements or assessing the envelope's physical integrity. Experiments could also include stagnation and internal gas pressure, temperature, and atomic oxygen sensors. Students could propose where to place sensors, and how to operate them. Experiments could be attached to the envelope to monitor impacts and to measure stagnation pressure indirectly. Other experiments could assess holing in the envelope generated by micrometeoroid and small debris impact. The experiments can be characterized by sensors placed either on the balloon envelope, inside the balloon, or separate from the balloon.

6.2 Orbital Debris Detection and Tracking Experiments

Orbital debris detection and tracking experiments will detect orbital debris in the vicinity of the free-flyer. The debris that is detected can be either close to the free-flyer or far from it, as long as the measurements are meaningful and have practical utility. The experiments that can be considered include sensors or debris collection and examination systems. If needed, they can be characterized by extensible components (e.g., telescopic components).

6.3 Interface Requirements

The total volume available for all the experiments is 1U (10 x 10 x 10 cm). The volume limitation for each experiment is 1/4U (10 x 5 x 5 cm). The mass limitation is 0.5 kg. GAC will select the best experiments among those proposed. A total number of up to 4 experiments will be selected.

Experiments that consist of mechanisms that can protrude out of the CubeSat bus are allowed, as long as the total extended length is less than 1 m and the experiment does not present any risk of damaging the GOLD envelope or other CubeSat systems. Additionally, any extensible experiments must comply with the mass and volume limitations provided above when stowed. These extensible experiments might be used for example for particle detection or particle collection and examination.

Experiments can also be placed inside the envelope to conduct measurements of internal gas pressure. The volume limitation for experiments placed inside the envelope is 1/4U and such volume counts toward the total 1U available. There is room for only one experiment being placed inside the envelope. If this type of experiment is proposed, the proposers must clearly explain how it will be integrated in the CubeSat and how it will not damage the envelope before deployment, during deployment, and during post-deployment operation.

The primary sources of power for the CubeSat are solar power and batteries. The CubeSat bus can supply up to 1 W (peak) power so experiments should not require more than such peak power. The daily average power consumption should not exceed 500 mW. Experiments should have a life of at least 2 weeks. The bus has a voltage of 4.2V ± 1V and supports SPI, I2C, and RS 232 interface formats. The maximum interface data rate is about 115,200 bps for RS 232. All interfaces have typically orders of magnitude higher data rates than can be downlinked from the radio. Proposers do not need to develop any new data downlink capability, however they must create the experiment's interface with the CubeSat bus. The spacecraft bus will use a C&DH (Command and Data Handling) subsystem for command, control and data return. The satellite's C&DH subsystem will provide data to insure successful CubeSat deployment and successful operation of the experiments.

7 White Paper Submitters' Requirements

Submitters can be individuals or teams, and can be comprised of both undergraduate students and graduate students. Submitters must choose a name for their experiment and indicate it in their white paper response. Due to United States export control regulations, international submitters (i.e., from outside the United States) are not allowed to submit white papers related to GOLD's performance assessment, but only white papers related to orbital debris detection and tracking.

8 White Paper Instructions

The white paper must be limited to 5 pages, written in 12 pt font size. All pages should have 1 inch margins all around – top, bottom, left, and right. White papers must describe a preliminary concept for an experiment, according to the technical requirements in Section 6, and must also include a preliminary Statement of Work (i.e., a series of objectives and a list of tasks, explained) and a preliminary project schedule.

White papers must be submitted in pdf format, by email, to GAC at this email address: global@gaerospace.com. The white papers must indicate all the names and contact information of each author, and the university/college and year level (undergraduate, graduate, or post-doc) for each author. The white paper submission deadline is January 16, 2017. Submission of a white paper is not a requirement to participate in Phase I, but it can provide a head start to future proposing teams by encouraging them to develop a conceptual experiment design ahead of time. For questions about the white paper submission, please contact Kerry Nock (office phone: 626-960-8300 ext. 103).

The evaluation criteria for the white papers are the following, in order of priority: Coherence/compliance with the topic of orbital debris detection and mitigation; Relevance to the GOLD deorbit system (except if the experiment is for debris detection); Feasibility; Technical merit; Compliance with white paper instructions; and Clarity of language. These criteria will be scored and weighted based on a judging rubric similar to this:

White Paper Evaluation Criteria	Not Applicable	Poor (1)	Fair (2)	Good (3)	Excellent (4)	Weighting Factor
Coherence/compliance with the topic of orbital debris detection and mitigation						3
Relevance to GOLD						3
Feasibility						3
Technical merit						2
Compliance with white paper instructions						2
Clarity of language						1

9 Global Aerospace Corporation

Global Aerospace Corporation (GAC) is a research and development business founded in 1997 by former NASA/JPL engineers. Its corporate interest areas extend from the bottom of Earth's oceans to outer planets of the Solar System and beyond. Relevant expertise includes conceptual design and prototyping, systems analysis and engineering, device and mechanical systems design, underwater vehicles and expanding structures, fluid-structure interaction and aeroelasticity, balloon borne systems, automation and robotics, and thermal sciences. Past and current customers include the DoD, NASA, NSF, commercial entities, and educational institutions. GAC maintains its corporate office in Irwindale, California. GAC develops prototypes and works its projects in a 4,300 sq. ft. R&D office/industrial space. These facilities meet environmental laws and regulations. GAC also has a 1800 sq. ft. combination model shop and prototype test area.