the ORBITAL DEBRIS MITIGATION COMPETITION

1. White Paper Instructions

- The White Paper is limited to 6 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 and description of tasks) and a preliminary project schedule. Submitters should also include in the White Paper a schematic or sketch of the proposed experiment.

- White Papers must be submitted in pdf format, by email, to GAC at this email address: ECE@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 March 20, 2017. Submission of a White Paper is not a requirement to participate in the initial stage, 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 GAC at ECE@gaerospace.com.

The evaluation criteria for the White Papers are the following, in order of priority: Relevance to the objective of the competition; Scientific and technical merit; Potential feasibility. These criteria will be scored and weighted based on a judging rubric similar to this:

White Paper Evaluation Criteria	**Weighting Factor**
Relevance to objective of 1) assessing GOLD performance or 2) orbital debris detection and tracking	30 Points
Scientific/technical merit	40 Points
Potential feasibility	30 Points

3. GOLD, Technical Requirements and Design Selection

3.1 Gossamer Orbit Lowering Device (GOLD)

The Gossamer Orbit Lowering Device (GOLD), 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 use of an inflation-maintained ultra-thin envelope, which accelerates the natural atmospheric drag decay of the object from centuries to months or weeks, based on orbit and mission parameters. The inflated envelope is protected from ultraviolet radiation and atomic oxygen erosion. In addition, the GOLD deorbit system consists of 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. The figure below shows an example 94 m diameter GOLD envelope deployed to lower the orbit of the Hubble Space Telescope from 568 km to 200 km in just 120 days. It has been estimated that this system will lower the probability of destroying operating satellites and creating new debris compared to a bare spacecraft or other deorbit methods.

GOLD helps mitigate the issue of orbital debris because it enables spacecraft or upper stages to deorbit much more quickly, thereby lowering the risk of satellite or stage 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 systems. 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 the degree to which it is integrated with its host, 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; allows satellites to use their entire propellant load to satisfy mission objectives, rather than for deorbit; reduces the probability of future debris-generating collisions; and offers lower risk to other operating satellites than competing deorbit methods. GOLD can also be used to augment a propulsion system for targeted reentry, and can provide propulsionless satellites a low-cost and mass 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.

3.2 Technical Requirements

The Debris Mitigation CubeSat consists of a 3U CubeSat (30 x 10 x 10 cm) that is expected to demonstrate up to 4 student experiments. There are two types of experiments that will be considered: 1) experiments that assess the performance of the GOLD system and 2) experiments that do orbital debris detection and tracking. For example, experiments could measure GOLD's performance during deployment and operation.

3.2.1 Assess GOLD Performance Experiments

Experiments to assess GOLD performance 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.

3.2.1 Orbital Debris Detection and Tracking Experiments

Orbital debris detection and tracking experiments are expected to detect orbital debris in the vicinity of the CubeSat. The debris that is detected can be either close to the CubeSat 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).

3.2.1 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.

Experiments that consist of mechanisms deployed after CubeSat deployment and 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 submitters must 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 expected 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 6 weeks. The bus is expected to have a voltage of 4.2V $\pm$ 1V and supports SPI, I2C, and RS 232 interface formats. The maximum interface data rate is expected to be about 115,200 bps for RS 232. All interfaces have typically orders of magnitude higher data rates than can be downlinked from the radio. White Paper submitters do not need to propose any new data downlink capability, however they should mention how the experiment is expected to interface with the CubeSat bus. The bus is expected to use a Command and Data Handling (C&DH) subsystem for command, control and data return. The satellite's C&DH subsystem is expected to provide data to insure successful CubeSat deployment and successful operation of the experiments.

3.3 Design Selection

The odds of being selected depend on the number of entries received. The contest will take the form of one preliminary round of judging to narrow the field to no more than 5 semi-finalist teams; these teams will be notified and asked to submit additional information about their experiments; judges will narrow the field to 3 finalist teams who will be invited to the National Space Society's International Space Development Conference® to present their experiment/project papers to the public and a final panel of judges selected by Enterprise In Space for their expertise relating to the state of the art of orbital debris detection and remediation and useful experiments for living and working in space.

Judges will select the top three (3) highest voted designs to move on to the final round. The third and final round of presentations by each team and voting by EIS judges, called the "Finalist Round", will be held at the ISDC in St. Louis, MO, on or about May 25-29, 2017, where up to 3 team leaders will be expected to present their designs/experiments. Finalists unable to travel to the ISDC may record and submit their presentation(s) to EIS for the judges and conference attendees to view at the ISDC. During this period, the panel of judges selected by Enterprise In Space will select one (1) Grand Prize winner, from the remaining three (3) top entries. Selection of winning entries will be determined by input from Enterprise In Space judges and winners will be notified during the Conference at a plenary or meal event, where all 3 entries will have 2 minutes each for a brief presentation. All decisions are final.