Implementation of a Large Solar Collector for Solar Light Energy

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Introduction
The challenge of providing large amounts of electrical energy for spacecraft over the course of long duration missions has long been an area of aerospace research. This need is particularly pronounced for a solar-powered in-space 3D printer [1]. Solar flux is commonly collected with solar panels for powering spacecraft. This is a reliable and safe method for electricity generation. Other generation methods, such as onboard nuclear power, present safety concerns.

Large solar collectors also have other benefits over alternate electricity generation methods. Theses benefits include using the solar collector as a solar shade, and using the back side of the collector as a surface for heat dissipation.

This poster presents the design and implementation of a solar collector that can be used to focus solar light energy for on solar cells or for other purposes.

Goal of Design
The goal of this project is to create a system capable of collecting large amounts of solar flux and directing it to a location for direct use or conversion into electrical energy that is lightweight and low cost. The design seeks to provide a compact, robust launch configuration that is deployed and has longevity, once deployed. Additionally, modularity is also considered allowing for (comparatively) easy of replacement of the system should it become damaged beyond repair.

Traditional solar collection methods tend to be fragile, bulky, and prone to breaking. The proposed large umbrella-shaped reflector provides an area that is less prone to structural failure and significantly lighter than solar blankets.

There are several constraints that must to be taken into consideration, including volume, mass, cost, and the overall efficiency of energy production. Managing the trade-off between these constraints is crucial to the development of the deployable solar collector and ultimately the success of the spacecraft using it.

Construction Materials
The materials selected for this design include 2024 aluminum (for the structural components due to its superplasticity) to meet needs such as low structural weight, high damage tolerance, durability and fracture toughness [2]. This allows for a lightweight and sturdy design while maintaining the capability for compact launch configurations.

The reflective surface that collects the solar flux will be comprised of a aluminum backed Mylar material. This provides a highly reflective surface that is robust and lightweight. The Mylar material takes up a negligible volume within the system as it is capable of compact folded storage configurations.

The solar cells that convert the solar flux to electricity will be a gallium based solar cell system. These cells have a high efficiency (experimental efficiency of 43.5%) [3]. Gallium cells are commonly used in the spacecraft industry where efficiency is favored over cost in large solar cell systems.

Design Process & Considerations
The design process for this system was goal-driven. Due to this, special care was placed on supporting the required system launch configuration. An umbrella shaped design (shown in Figures 1 and 2, deployed and stowed, respectively) that is capable of localized distortion was chosen. The shape of the reflector was designed to maximize the amount of solar energy that is focused on to a secondary reflector.

The gallium solar cells are positioned in a multi-junction arrangement to increase the spectrum of light able to be processed [3]. This arrangement decreases cost as less gallium is needed for the photosensitive cells. This design also presents advantages in addition to decreased material usage. The blanket arrays that are used on most spacecraft are heavy and bulky (due to the number of individual cells) and their deployment mechanisms tend to be large and sensitive to impulses and vibrations. The parabolic shape of the proposed reflector solves some of these problems due to the inherent rigidity of the structure.

Current Work & Future Testing
Static, non-deployable models have been developed and are in the iterative design refinement process. These prototypes will provide data regarding the level of flux return based on terrestrial testing. The designs will then be further extended and refined to allow orbital use. These prototypes also provide the capability to test a variety of reflector materials, parabolic configurations, launch configurations and deployment configurations.

A controlled testing model will be used where some variables will be held constant using a variety of input methods. Solar flux, for example, will be simulated using flood lights or lasers. This is advantageous as precise input of energy can be determined allowing determination of the efficiency of the parabolic mirror system in various configurations. Other controllable variables include the temperature of the mirror system and the atmospheric conditions in which testing is performed.

Conclusion
There are many important features to a parabolic solar collector system. The proposed system utilizes a simple and effective design methodology which provides a low profile pre-deployment configuration. The design for the solar collector is both lightweight and has comparatively minimal production costs. This design provides a starting point for further solar collection development (either for direct use or conversion), as it is capable of concentrating large amounts of solar flux while having a compact and lightweight design.

References