CAL POLY
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Letter of Support:

Design and Development of a Versatile CubeSat Structure for the Cal Poly Nanosatellite Program

The proposed project is a critical investment to improve the capability of future Cal Poly Nano-Satellites. As CubeSat class spacecraft are becoming a mainstream component in the space industry, advanced payloads are being developed to perform more complex missions. A key requirement for these missions is high power availability. The proposed project would develop a new multipurpose CubeSat structure including accommodations for deployable solar panels. The resulting system would allow future Cal Poly satellites to accommodate more advanced payloads and compete for future funding opportunities including grants from NASA and the NSF.

The PolySat team has significant experience developing CubeSat structures with 10 spacecraft completed or in development. All these spacecraft have included structures and electronics developed internally by our students. These efforts required a multidisciplinary approach to guarantee that the resulting structures are compatible with the CubeSat standard and can accommodate all other subsystems in the spacecraft including electronics, payload, and mechanisms. In addition, the proposed project will also take advantage of the PolySat's team experience developing electronic systems in order to develop deployable solar panels. The team assembled to complete the effort proposed here is already experienced in the design and development of CubeSat class spacecraft. All students involved have been part of the PolySat team for at least a year. It is expected that a number of the students will utilize this project as a senior project topic or as the beginning of a Master's thesis.

The work proposed will be primarily performed in the CubeSat lab (192-101). The lab has all of the facilities required for the design and functional testing of the proposed systems. In addition, the team will utilize testing facilities operated by the CubeSat team including vibrations testing and thermal vacuum facilities. Finally, the students will utilize the Mustang '60 lab to manufacture structural components.

Sincerely,

Jordi Puig-Suari, Professor
Aerospace Engineering Dept.
CubeSat Faculty Advisor
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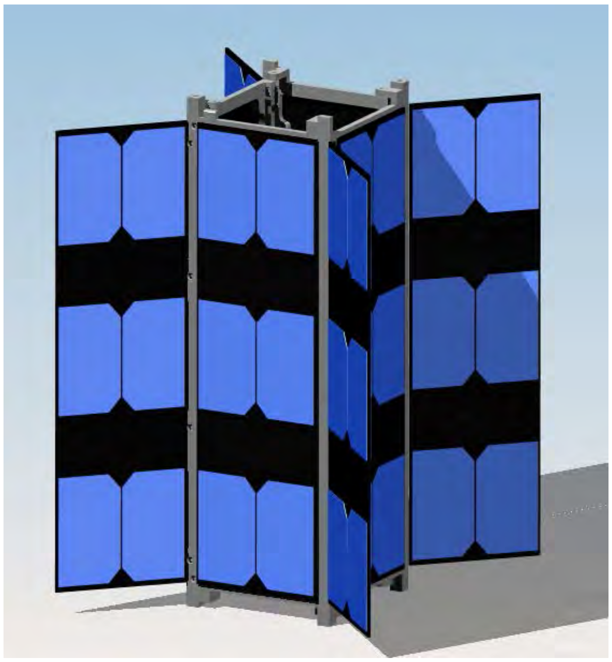
Warren J. Baker Endowment

Excellence in Project-Based Learning

PROPOSAL NARRATIVE

I. Abstract



This project will aim to create a new CubeSat satellite structure that incorporates new subsystems to increase the manufacturability and versatility of PolySat's standard satellite architecture. This new structure will incorporate deployable solar panels into the system, increasing power generation for the satellite. The structure of the CubeSat is vital to the overall system's performance, and developing a standard high-performance system will allow for the integration of various payloads while minimizing the need for mission-specific customizations. This project will also allow for a majority of the structure to be manufactured in-house in the Cal Poly machine shops, allowing for the direct application of learn-by-doing.

The integration of deployable solar panels will also involve design and fabrication of circuit boards. To complete these goals, we will leverage experience that we have had with the design and construction of previous CubeSats. Moreover, students have a chance to incorporate design processes that they have learned in various Cal Poly courses. This new structure will allow us to push the limits on what we can do with our already powerful CubeSat design. The design will allow us to provide higher performance to possible project sponsors, thus increasing the chance of winning future project proposals. Winning project proposals not only brings in funding for PolySat research projects, but also facilitates campus-wide development by bringing in additional funds for the university.

II. Introduction

PolySat is a multi-disciplinary program composed of mechanical, software, computer, electrical, aerospace, and industrial engineering majors working to build cube-shaped satellites (CubeSats). Since the start of the program, the team has developed eight 10cm x 10cm x 10cm satellites. Recently, the team has developed two satellites of double and triple that size for NASA Kennedy Space Center and the National Science Foundation. The volumetric expansion has been driven by a high demand for further satellite functionality, which necessitates large

power generation capabilities. A larger satellite allows the team to add more solar cells, thus meeting the increasing power requirements.

The growing CubeSat industry continues to push the limits of these small satellites. In order to remain competitive, it is crucial to develop a platform that can provide enough power to the increasingly complex systems residing inside the spacecraft. In order to accomplish this task, the PolySat team wishes to develop a mechanical structure that will facilitate this increased power requirement. With funding from this proposal, the team will investigate multiple structure configurations that allow for deployable solar panels.

While the CubeSat industry is booming, there exist a large number of COTS (commercial off the shelf) structures that can be purchased. However, the students in the PolySat program pride themselves in designing, as well as manufacturing, as much of the structure as possible. Redesigning the baseline structure will allow more of the structure to be manufactured in-house at Cal Poly. We are able to manufacture approximately 50% of our current structure in-house. A redesign of the structure should push this figure closer to 75%. This will allow us more flexibility in our schedule and reduces project cost. Manufacturing in-house gives students vital exposure to an important part of the engineering design process. In an evolving field, the skills gained by this experience are invaluable to future employers.

The deployable side panels will incorporate lessons learned from previous PolySat missions by the electrical and computer engineers on the team. The electrical connectors and sensor arrays will be traded as part of the redesign, with the goal of increasing relevant telemetry data from the external panels and simplifying integration procedures. Current PolySat designs require extensive integration procedures for each build.

An amount of $5,000 is being requested for this project. The majority of this funding will go towards the cost of raw materials for structure and circuit board fabrication. The remaining funds will be used to purchase supplies and materials to aid in testing and fabrication.

III. Objective(s)

(1) Development of a new and advanced baseline structure which will allow for higher power, complex missions to be taken on by the students in the PolySat program.

(2) Development of new and advanced deployment techniques including springs, hinges, release mechanisms, dynamic stability of stowed/deployed configurations, and support for simultaneous or staggered deployment.

(3) Development of circuit boards to enable the mounting of the maximum amount of solar panels and placement of sensors for external telemetry including power and temperature.

(4) Development of new connectors for the circuit boards to provide a reliable link to the system.

IV. Methodology

To begin the project, a list of objectives for the project will be generated in the form of design requirements. Students involved on previous missions and current missions will use their experience to create this list of requirements. Once the project requirements have been determined, the individual teams (e.g. electrical or mechanical teams) will perform design trade-off analysis to determine the best possible solution to meet each design requirement of the project.

A project wide review will happen between all teams to critique each design choice and ensure that all solutions will work together appropriately. Prototyping will commence once each design has been approved by the team. This includes the electrical boards mounted on the sides of the structure and the individual structural elements. The prototypes will be tested. The mechanical structure will undergo fit checks and complete assembly along with a vibrations test from vibe tables in the aerospace department's space environments lab. The electrical boards will be checked for mechanical mounting and for electrical functionality using software written by the CPE and CSC teams.

Concluding the testing on the prototype model, a final redesign will correct any unforeseen issues found. This will include team wide scrutiny with another review. A revised design will be manufactured to remedy the previously encountered issues. The final design will be subjected to more testing. The testing results throughout the process will be documented so that future projects may reference the results. A final report that contains the design and testing results will be written to conclude the project.

V. Timeline

Complete By	Task	Teams Responsible
Start Date	Project commencement	Aero, ME, EE, IME, CPE, CSC
Week 2	Define Specific Requirements	Aero, ME, EE, IME, CPE, CSC
Week 6	Trade Studies/Concept Development	Aero, ME, EE, IME, CPE, CSC
Week 8	Design Review	Aero, ME, EE, IME, CPE, CSC
Week 14	Initial Prototyping	ME, IME, EE,
Week 18	Preliminary Prototype Testing	Aero, ME, IME, EE, CPE, CSC

Week 24	Manufacture Revised Design	ME, IME, EE
Week 28	Final System Testing	Aero, ME, IME, CPE, CSC
Week 32	Final Report	Aero, ME, EE, IME
Early 2015	Delivery	Aero, ME, EE, IME, CPE, CSC

VI. Final Products and Dissemination

The final product of this project will consist of a satellite structure with deployable side panels including the electrical boards. A CAD model of the structure and the printed circuit boards will be generated along with any electrical schematics. Finally, a report documenting design philosophy, choices and testing results will be created for PolySat internal documentation and for external release in the Warren J. Baker Endowment final report.

Due to the nature of the project, some of the engineering students involved may use this as an opportunity to complete a senior project. This may include a mechanical engineering student to do the physical structure and an electrical engineering student doing the printed circuit board designs.

Several configuration options are shown below.

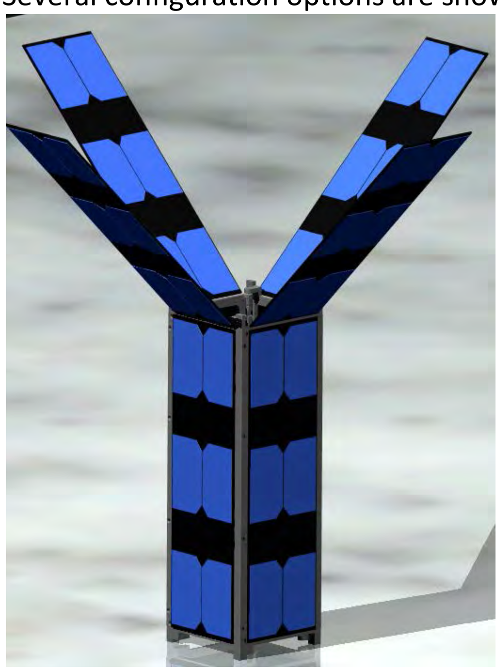


Figure 1: "Aerodart" Configuration

Figure 2: "D-wing" Configuration

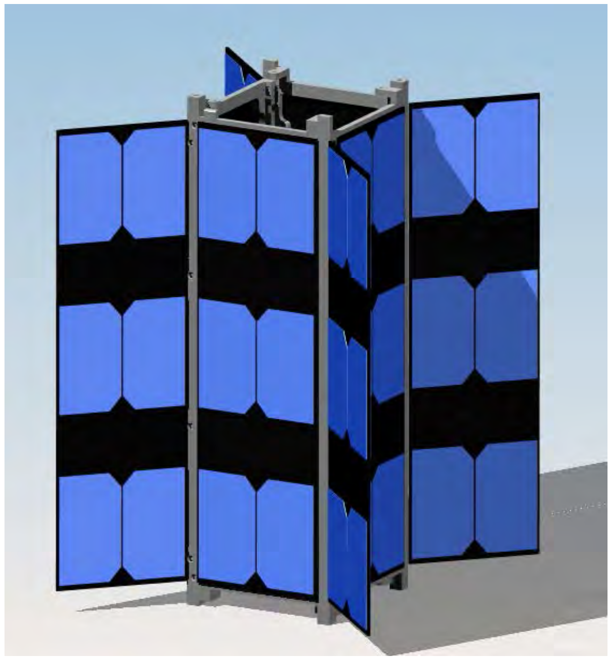


Figure 3: "X-wing" Configuration

VII. Budget Justification

Rapid Prototyping Material	$700
Prototype Units Material & Hardware	$1200
Final Unit Material & Hardware	$1200
Prototype Solar Panel Boards	$600
Final Solar Panel Boards	$600
Solar Cells and Mounting Material	$700
Total:	**$5,000**

PROPOSAL BUDGET

Student Applicant(s): Vanessa Faune, Eric Baumgarten, Oliver Woolsoncroft, Jeff Weaver, Alex Saunders, Jimmy Tang, Chad Taylor, Noah Wietz	
Faculty Advisor: Jordi Puig-Suari	
Project Title: Design and Development of a Versatile CubeSat Structure for the Cal Poly Nanosatellite Program	**Requested Baker Endowment Funding**
Travel *subtotal*	**$ 0**
Travel: In-state	**$ 0**
Travel: Out-of-state	**$ 0**
Travel: International	**$ 0**
Operating Expenses *subtotal*	**$ 5,000**
Non-computer Supplies & Materials	**$ 4,600**
Computer Supplies & Materials	**$ 0**
Software/Software Licenses	**$ 0**
Printing/Duplication	**$ 0**
Postage/Shipping	**$ 400**
Registration	**$ 0**
Membership Dues & Subscriptions	**$ 0**
Multimedia Services	**$ 0**
Advertising	**$ 0**
Journal Publication Costs	**$ 0**
Contractual Services *subtotal*	**$ 0**
Contracted Services	**$ 0**
Equipment Rental/Lease Agreements	**$ 0**
Service/Maintenance Agreements	**$ 0**
TOTAL	**$ 5,000**