RIT Space Exploration Cube-Sat Design and Development

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***Abstract*—This proposal defines a multi-semester effort to design and construct RIT Space Exploration's (RIT SPEX) first Cube-Satellite, or Cube-Sat for short. In the past SPEX has conducted a considerable ammount of research in the design of satellite and satellite sub-systems through two CSLI proposals, an investigation into the feasibility of reproducing a low cost nanosatellite from Moorehead University, as well as SMAD mission designs. This effort is the culmination of that knowledge and the next logical step in the organizations goal of putting something into space.**

I. Introduction

This document outlines a three semester plan for the design and construction phase of RIT SPEX's first Cube-Sat. RIT SPEX has had a long history with satellites and Cube-Sats and it has been a club goal for many years to build one of its own. One of the groups earliest projects in fact was an attempt to complete a NASA Cube-Sat Launch Initiative Proposal, or CSLI. The CSLI is a proposal where students plan, design, and construct a satellite with the partnership of NASA. The students are responsible for everything involving design and construction where NASA approves and launches the device if they believe the benefit is appropriate. This effort taught the group a lot about the satellite design process and the complexity of the intercommunicating sub-systems. However, while a valuable learning experience, it was not in a state that could be submitted to NASA. SPEX then did further research into designing its own Cube-Sat with a second CSLI. Issues with the feasibility of the primary payload, as well as funding, proved to be too difficult to overcome in the semester timeframe. Some other small efforts have been made to design and develop the groups first satellite but none have followed through to completion. One such effort was the $50 Satellite project, an attempt to replicate designs from a student group at Moorehead University. That effort had signifigant work done in the planning stages but the technical knowledge required to fill documentation gaps was too great. However, despite past issues and failures, it is the best time in the groups history to take on the effort of designing and constructing its first Cube-Sat. Since the first CSLI SPEX members have worked at NASA, Lockheed Martin, Collins Aerospace, and a number of other leading aerospace companies. Members have worked on orbital mechanics, avionics programming, and some even satellite development. This industry experience, the clubs knowledge from previous efforts, as well as the connections students have made through these companies will help chart a path to success.

II. Primary Objective

The goal is to apply members' knowledge to complete the satellite engineering development process using knowledge from the past as a springboard for development. Members will engage in the design, fabrication, assembly and testing of space hardware and work through the unique challenges presented to construct the groups first Cube-Sat.

III. Secondary Objectives

A. Cube-Sat Launch Initiative

CSLI standards and considerations should be considered and abided by. While this project is more focused on design and construction of a satellite, the CSLI should be kept in mind for the future as the primary option for a launch. The majority of the documentation and work done should be transferable. This approach is different than past SPEX efforts of writing the proposal first and prolonging the start of construction.

B. Reusable Architecture

Considerations should be made for reusability in the design. Ideally this will be the base architecture for future SPEX missions and as such software should be abstracted and component based, electrical hardware should be interchangeable, and mechanical structure should be able to support additional components.

IV. Benefit to SPEX

This project will have several key benefits to SPEX in the near and long-term. This project will create a practical astronautical engineering skillset among SPEX members, and will provide opportunities when engaging with employers to showcase the application of member skills.

A. Technical Skill Development

This multidisciplinary project will require members to learn and apply technical skills to achieve success. Skills learned during the course of this project can be applied to many other SPEX activities as well as leveraged for future job opportunities. The scope of this project is ideally suited for undergraduates to undergo the whole development process and gain relevant industry experience. Some noteworthy skills or areas of knowledge that SPEX members will develop through this project include:

- Embedded system design
- Digital communication knowledge
- Fabrication
- Project management
- CAD

B. Recognition

If this effort is successful and the device were to launch it would be the first Cube-Sat at Rochester Institute of Technology to have been to space. There are very few groups on campus that are working on space hardware and this would increase our view on campus with the potential to solicite future funds for additional projects. It is also noteworthy that RIT would join many other prestegious universities to have launched their own Cube-Sat.

V. Implementation

The project will begin with payload investigations while leveraging SPEX connections for ideas. Once a payload is chosen then the group will leverage existing resoures and Senior Design Projects to determine what can be re-used. High level and low level requirements should then be developed for each sub-system. Once requirements are determined parts/components must be researched and chosen for the system to begin development in an incremental approach.

A. Deliverables

The primary deliverable will be the finished, functioning Cube-Sat. In addition, the team should have the following deliverables:

- For the requirements phase of the project the group will have documentation detailing the primary payload and justification for the choice, a set of high level requirements, and detailed low level requirements.
- Throughout the project documentation will be maintained so it is simpler for future groups to re-implement the designs. All documentation will be condensed and delivered at the conclusion of the project.
- All software written will be delivered.
- All CAD models/designs will be delivered.
- The Cube-Sat will be completed at the end of the effort and this is the primary deliverable. Many sub-components could be considered as deliverables as well, such as communications or ADCS subsystems.
- Upon completion of the project a written report will be written detailing the effort. This should be written with the intent to be become a published work.

Finally, the team will need to generate a presentation poster that could be used at ImagineRIT or other public SPEX events to highlight the project.

TABLE I
ESTIMATED TIMELINE

Phase	Task	Duration
1	Payload Investigations	2 weeks or less
2	Investigation of Prior Resources	2 weeks or less
3	Development of Requirements for each Sub-system (High/Low Level)	1 week
4	Component Investigation	2 weeks
5	Development	25 weeks or less
6	Testing and Refinement	10 weeks or less
7	Finalize Documentation	1 week
8	Write Paper	2 weeks
	Total	45 weeks

B. Milestones

Table I shows a preliminary timeline for the project. In order to be effective this timeline should be maintained with minimal schedule slip. Project management will be key to the success of the project over a three semester period, or 45 weeks. Note that some of the phases listed can, and should, be started prior to the start of the fall semester. In addition the it should be noted that this is very general and there may be overlap in some broad categories. Once the team is assembled a more concrete schedule can be created.

C. Senior Design Projects

Past senior design projects have explored various areas of Cube-Sat development. One senior design team researched solar sails and came up with a base architecture for a simple Cube-Sat. This design will likely be taken and iterated on as our base. It is also possible that additional senior design projects in the future will cover systems like ADCS. It is expected that the group constructing the satellite make use of these connections and prior work done to help improve productivity and stick to schedule.

VI. Externalities

A. Prerequisite Skills

This project will likely be the most difficult thing RIT SPEX has worked on and as a result has a high barrier to entry, where likely senior members will be able to contribute the most. The effort is multidisciplinary and will require software engineer/computer science students, mechanical engineering students, as well as electrical engineering students. In addition it may be appropriate to have math and physics students for orbital calculations. A number of students could also assist in the soliciation of funds for the project.

Computer Science/Software Engineer students should be familiar with C/C++ as well as object-oriented design/prototyping. Experience with embedded systems will be very important to the success of the project as the primary avionics board will most likely be a variant of an MSP430.

Mechanical engineers will need skills in manufacturing, thermal anaylsis, and general spacecraft design. They will be responsible for design and analysis of all physical parts outside of the electrical system.

Electrical engineers will be the most important component to the success of the project. These individuals will work hand in hand with the software engineers to assist in development of circuits for varying sub-systems. Some experience with microcontrollers will be valuable to assist the software engineers to understand circuit diagrams and general electrical conecpts. These individuals will largely be responsible for the power management system. Electrical engineers may also contribute to the production code.

B. Funding Requirements

This project will foreseeably be expensive. Components in high end university or industry Cube-Sats cost thousands of dollers. Most university estimates place their own Cube-Sats in the \$10,000 - \$100,000 range. A signifigant portion of this cost should be from corporate and university donations in addition to the clubs own fundraising. Signifigant cost can be reduced if some components are developed on site but that adds a reasonable level of risk to each affected sub-system. There is possibility for a signifigant chunk, or all, of development costs to be covered under the office of the provost.

C. Faculty Support

Faculty support is highly recomeneded for this project and involvement should be high. Students should keep the faculty up to date on developments and have weekly or bi-weekly meetings to discuss work done, roadblocks, as well as any support they can give. Ideally the faculty will take on the role of product owner while also assisting students in their respective knowledge areas. In addition their connections with other talented students and industry leaders will be very important to the success of the project.

D. Experienced SPEX Members

Considering this project is very difficult it will require more experienced SPEX members to take part in signifigant portions of development. The effort has been deemed a high priority item to SPEX from its faculty advisors and they will likely ask students for assistance throughout the semester in assistance for completion of certain aspects of the project. Due to limited number of experienced SPEX Members in certain knowledge areas, students outside of SPEX may be contacted and asked to help.

E. Long-Term Vision

This project would result in SPEX's first functional, space-rated hardware project. Ideally this would result in it being put on a launch craft and being placed in low earth orbit. In addition it will create a strong groundwork for additional satellite engineering projects.

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