CubeSat Launch Initiative Phase I: Design & Research

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***Abstract*—The purpose of this project is to go through the design stages of the CSLI. The team will choose a scientific payload, engineer the CubeSat to house and function the payload, begin writing the CSLI by excluding the funding section, and perform a full cost estimation. This stage will leave off with a firm idea of the road ahead for funding and fabrication. The next stage will start with funding based off the cost estimations this team makes.**

I. Introduction

The CubeSat Launch Initiative will be a great opportunity for RIT SPEX members to use their technical skills to make an electromechanical system. CubeSats were designed with the intent of creating a low-cost opportunity for launching satellites, geared toward allowing university students to put there skills to real use. The CSLI gives the team a free ride to space, thus eliminating a massive amount of cost to put a satellite in orbit. RIT SPEX will create a team to design, fabricate, and launch RIT's first CubeSat. There are several phases to this mission and will not be restricted to a tight-timeline. The team will be given ample time to completely design this system to their maximum potential and perform a full cost estimation. The future stage would be to secure funding. Then to finalize the CSLI proposal and submit it. If the proposal is accepted the team will begin the fabrication process. The culimination of the fabrication process will be a fully functional CubeSat ready for experimental and environmental testing.

II. Primary Objective

This part of the project, Phase I, will concern itself with the design and research of the CubeSat. This spans everything from picking/researching a payload to designing the integration of that payload to the CubeSat, with all the features required by the CSLI. The primary objective of this phase is to create a fully developed CAD model, which includes a fully researched and developed scientific payload, and the proper documentation concerned with the electronic features such that the team can write a fully detailed report on what the CubeSat does and how it does it. When these questions are answered, the next phase of the project will begin.

III. Benefit to SPEX

This project would be beneficial to SPEX for the following reasons; experience (project management, engineering, coding, etc.) given to current members, opportunities for data analytics on collected data, PR, provides base for further funding and sponserships. The PR for this would be great for getting recognition in the aerospace community. A successful CubeSat is difficult to attain. If SPEX is able to excute this project well, it would be a serious step in being national recognized as an aerospace/astronautical research group. The marketing team at RIT SPEX would be able to leverage this project to get interested companies to donate supplies, money, or their time so RIT SPEX can build and grow in their research. The experience for the team would be great because it would bring a project from pure design and research to flight. Allowing students to be part of that project lifecycle would be tremendous for growth in their respective field.

IV. Implementation

This project will start with a small design and research team. That team will be responsible for picking and appropriate payload. Once the payload is chosen, the design of the CubeSat will begin. The team will bring in members that have experience in the relevant categories, such as radio communication, structural engineering, software and firmware development, etc. The team will be responsible for creating thorough documentation on every aspect of the CubeSat to ensure future members will be able to pick it up and keep going without unnecessary time-loss and scope-creep. The team will strive to attend as many RIT poster sessions as possible, once ready, to build recognition of the project, its goals, and its status. That is imperative for when the funding phase arrives.

The project will follow *the Need-Driven Process*. This involves following a need-based mission. The steps involved in developing this mission are listed in Table I.

Step 1 of the process is to define the needs that the mission must achieve. What are the quantitative goals, and why? This information should come from a mission statement of what the mission is attempting to achieve. Step 2 identifies the prinicipal players (aka stakeholders) and the space community of which they are a part. Step 3 defines the timeline over which the project needs to be excuted to be useful. Step 4 quantifies how well the team wishes to achieve the broad objective, given the team needs, applicable technology, who the users are, and cost and schedule constraints. These requirements are

TABLE I
STEPS FOR THE NEED-DRIVEN PROCESS

Step	Description
1	Define mission needs
2	Identify principal players
3	Define timeline over which the program needs to be completed
4	Quantify mission details
5	Define alternate combinations of mission elements
6	Develop alternative mission concepts
7	Critical requirements
8	Performance Assessments and System trades
9	Quantify how well the broad objectives
10	Creating a baseline design
11	Revise system requirements and constraints
12	Design iterations
13	Begin traditional systems engineering process
14	Flow down numerical requirements

flexible and subject to change throughout the project. Step 5 defines the alternate combinations of mission elements or the *space mission architecture* to meet the mission objectives and requirements. Step 6 develops alternative mission concepts. In step 7 we identify the prinicpal cost and performance drivers for each alternative mission concept. In step 8 the team will conduct performance assessments and system trades. It will define in detail what the system is and does. Step 9 quantifies how well we are meeting both the broad objectives and the needs of the end user as a function of either cost or key system design choices. In step 10 the team will select one or more baseline system designs. In step 11 the team revises the system requirements and constraints consistent with what the team has learned, and in step 12 the team will explore other alternatives and iterate upon the design. The team will translate the now better-defined objectives, constraints, and requirements into well-defined system requirements in step 13. Finally in step 14 the team flows down these numerical requirements to the components of the overall space mission.

These steps are derived from *Space Mission Engineering: The New SMAD*, from the space mission engineering process chapter concerning the need-driven process for projects.

A. Deliverables

The team will make 2 or 3 postings on the RIT SPEX website, per semester, with progress and science updates to keep the project in outside contributors/persons of interest's field of view. The team will be required to have a poster for Imagine RIT and the undergraduate research symposium in the spring and summer terms, respectively.

The documentation for a project of this size and length is essential. Since the project is going to take a few semesters, at minimum, to complete. It is important to have enough documentation on each aspect to be able to bring new members up-to-speed as easy and quick as possible. The documentation should cover the following; fully end-to-end CubeSat assembly, necessary hardware, a full drawing packet on the CubeSat design, design requirements, engineering requirements, payload functionality, payload description, payload integration specifications, PCB design, PCB layouts, PCB components, power requirements and distribution diagram, radio signal mapping, and FEA simulation analysis. These documents should be saved in individual locations and concatenated into a master document, for easy reference.

There will be weekly meetings to discuss progress on different aspects of the project being investigated by different persons. Each member will be expected to discuss their progress and contribute to a master logbook in which documentation will be recorded for future reference. The documents can range from code to articles on specific calculations or designs, etc. Powerpoints are preferred for presenting to other members. The team will use the team communication software called WebEx by Cisco for teleconferencing and telecommuncations.

This phase of the project will be considered complete when the following is delivered; a fully developed CAD model, electrical diagrams describing the electrical functionality, a full fabrication estimation (this does not include an cost for experimentation), and the CSLI proposal drafted (excluding the funding section).

B. Milestones

The milestones for this project include surpassing each step laid out in section IV. The more general project milestones are choosing a payload, designing the payload, CubeSat structure, CubeSat avionics and software. Then also creating a risk assessment based on the first design iteration.

Once these first milestones are completed the team will go through a concept design review. This will give them early feedback based on their design decisions and allow them the opportunity to address concerns before the system design is frozen. Then the team will iterate upon their design further, figure out more details and go back for a project design review with another risk assessment. After the project design review the team will make final design iterations and prepare for the funding phase. Preparation for funding will include making many documents and graphics to show the project to potential investors and or to please already dedicated investors.

V. EXTERNALITIES

A. Prerequisite Skills

The team will have a maximum of 7 members during the design and research phase. At minimum, the team will need 3 mechanical engineers, 1 electrical engineer, and 1 computer scientist (or avionics specialist). It would be most beneficial to have mechanical, electrical, software engineers, physicst, and a computer science major. The team members will be responsible for fulfilling roles that may extend beyond the reach of their speciality. While it extends beyond their speciality, it will not extend beyond their capability. In the event that is unavoidable, outside help will be sought through professors or the appropriate student body.

In general, it is expected that mechanical engineers will be profficient in Solidworks and MATLAB. Solidworks is the chosen 3D modeling software due wide availability and experience. MATLAB will be used for calculating orbits or performing mechanical analysis. It is not required for people that have a refined coding ability. Mechanical engineers will need to have taken a strength of materials, thermodynamics, and the university physics sequence, or equivalent courses. They will also be responsible for performing finite element analysis on the system. This requires previous knowledge on the subject.

Electrical engineers may be responsible for designing circuit board layouts, coding the boards, or figuring out the electrical requirements for the payload in general.

B. Funding Requirements

The funding requirements for this design phase are minimal. There may be some cost during feasability studies if a particular technology must be demonstrated. But that will likely be low-cost. The official cost estimation for this phase of the project will be $300. All the programs the team will need, ANSYS, Solidworks, KiCAD, etc., will be provided by the university or by sponsers.

C. Faculty Support

Faculty support is difficult to gauge based on the ambiguity of the payload. Since the payload is completely unknown at this time, the extent of faculty support will be considered when the payload is selected.

D. Long-Term Vision

The long-term vision of this project is to launch a CubeSat. This project begins with the most important phase, the initial design and research. Once this is complete the team will move onto funding. Then it will complete the CSLI proposal and submit it once there is a call for papers for a CubeSat mission. If the project is selected, the team will begin fabrication. The secured funds will be used to purchase the necessary components to test the system at component-level then system-level. Once the system is complete, it will be flight-prepared and launched when possible. Once this project nears the final design of the payload, the funding phase should start. Since the payload will mostly be known at that time, it would be beneficial to start getting in contact with companies to get a foot in the door while this phase is finalized.

TABLE II
CSLI PHASES

Phase #	Title	Purpose
1	Design & Research	Chose payload, design CubeSat, write CSLI (without funding section)
2	Funding	Secure funding
3	CSLI Submission	Get CSLI proposal reviewed and submitted
4	Build	Build CubeSat with Payload
5	Testing	Perform system-level testing
6	Launch	Launch the CubeSat
7	Science	Retrieve data from CubeSat and payload

The team that works on this project does not need to be on the future stages of the project. The goal of the rigorous documentation is to allow any and all members to pick up where this team left off, with minimal reading to get caught up to speed.

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