SDL-IREC Competition Payload: SPEXTRO

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***Abstract*—A standard format for Project Design Documents is key to organize and document the many projects members of RIT Space Exploration wish to pursue. The goal of the SPEX Standard is to organize, refine, and archive space exploration research. Documentation is vital to sharing and maintaining the wealth of ideas and information developed by all students at RIT. Project Design Documents aim to provide a foundation for new projects to grow, or premature projects to develop months or years in the future. A standard for project design documents and reports shall provide SPEX with a robust method to maintain a healthy ecosystem of projects in all stages of development including the event where a SPEX member goes on co-op or graduates.**

I. Introduction

The project purpose is to create a 3U CubeSat payload which houses a protein spectroscopy experiment and fly on a sounding rocket in the 2020 IREC. The goal of this project is prove that this experiment can accurately detect protein-states not to prove whether or not the proteins fold in free-fall. The experiment will commence during a free-fall period of the flight. The biggest update to this payload from the 2018-2019 project is the payload will be ejected from the rocket. This will give the payload extra payload in IREC for a deployable which benefits this team and the sounding rocket team. Secondly, this will give us the ability to more finely control our free-fall period since we control the parachute deployment.

II. Primary Objective

The primary objective of this payload is a proof-of-concept mission aimed at understanding if protein spectroscopy can be performed in a CubeSat form factor. The experiment is a scientific process in which proteins are analyzed to understand if they folded under free-fall conditions. Due to the mechanics of rocket flight, free fall (similar to that of satellite orbit) is impossible to attain. Hence, the mission is focused on fitting this experiment in a 1U section of a larger 3U form factor and proving the experiment can be successfully conducted in such conditions during descent after jetison.

III. Benefit to SPEX

This project is an ordeal, as is rocketry. Launching payloads on rockets requires rigorous work to understand the intense vibrations and physical conditions as well ensuring the payload can survive the launch and function properly afterwards. The engineering is very involved, right down to the heads of the bolts (smallest details). How does everything fit together? Where do the wires go? These are but a few of the questions this team will learn to answer. The last IREC team gained a lot of experience in this area and collected and recorded it in a final document called **THE DOCUMENTE** located in the **THE DOCUMENTE LOCATIONE**. The next team will learn all these lessons intensively and painfully and will inevitably add to this list of lessons learned. While this may sound negative, it is exactly the opposite. Through the head scratching and confusion comes new ideas and engaging, novel, and rewarding experiences. This project would be massively beneficial to the students involved and thereby the rest of SPEX when these students move onto greater things.

IV. Implementation

There are a few important points that must be understood to understand the scope of this project.

This project will be a joint effort with RIT Launch Initiative. They are providing the launch vehicles and we, the payload. We are doing this together to compete in the Intercollegiate Rocket Engineering Competition in 2020. It must be understood that the project schedule will have a dependence on the LI rocketry team schedule. For instance, test fitting with their SABOT with require the mechanical footprint of the structure to be designed and fabricated. To this end, it is worth the time to obtain a working structure manufactured by the end of the Fall semester. This will serve as a initial integration structure. A important lesson learned from Hyperion was there were many integration issues that could have been sorted out far beforehand if there was a test-fit opportunity. This structure will not be the final design but an important stepping stone for the rest of the project. The manufacturing will be worthwhile training for the engineers when it comes time for the manufacturing of the flight structure.

PROPOSE TEAM STRUCTURE HERE

A. Deliverables

The final product of this project will be a flight payload with a fully functional and LI independent communications system, recovery system, protein spectroscopy experiment, and parachute ejection system. The communications system will have an APRS and GPS that operate on different frequencies than LI as to not interfer. The GPS and APRS must have sufficient battery life to support extensive time from rocket integration to launch (2 hrs) and then recovery (12 hours). The recovery system will have a buzzer and maybe LEDs,

TABLE I

RELATIVE DETAIL EXPECTED AT EACH STAGE OF PROJECT DEVELOPMENT.

Document	Purpose	Contributors	Destination
Project Definition Document	To define the goals and requirements of a SPEX project.	2–3 people	SPEX Archive
Project Plans	Specific plans for when work is to be done (Gantt charts)	2–3 people	Project Repository
Design Reviews	To review designs before work is started.	6–8 people	Project Repository
Test Procedures	Specific instructions and data logs for tests.	3–4 people	Project Repository
User Manual	Instructions for future users of project deliverabels.	3–4 people	Project Repository
Posters & Presentations	Materials for sharing projects with the public.	5–6 people	Project Repository
Technical Report	Final technical summary of work done and results.	6 or more	SPEX Archive, Conferences & Journals

this was discussed but not executed on the 2018 IREC payload. The protein spectroscopy experiment will have the full mixing system with the UV-light and sensor, the data from which will be stored locally and analyzed after recovery. The parachute system will likely include a Peregrine CO2 system, identical to the one used on Hyperion.

B. Milestones

One point that the author must be clear on:

It is my personal opinion that any attempt to achieve perfect free-fall to create the essential experiment upon the limitations of this project is time that could be better spent creating a strong design and achieving a solid scientific result that can serve as "Proof of Concept". This idea will then be green-lit for a future CubeSat proposal and this team could lay the bedrock upon which that CubeSat can be built.

The first goal of this experiment should defining the mission statement and success criterion. This will create a clear path forward for the engineering and science teams. Then the mechanical-science team should strive to create a functional experimental setup. This will be very important due the high complexity. They must first create an initial model with a mixing well, solenoids, protein, and saline. They should first work to attain a good mixing of protein and saline. Then go onto the UV-light and sensor integration and testing. Approach it one step at a time solving the problems with each one, meanwhile the structures team will work on developing an initial manufacturable model.

The initial manufacturable model must be complete by Winter break to stay on a good track. There is enough known information about the sizing of the experiment and other components to make a rough integration scheme. This assembly should favor modularity in the sense that things will change and it should be able to accomodate those changes. An idea would be to create a small structure out of 80/20 (80/20 makes very small structures that will can accomodate the size restrictions). This would allow ease of access and re-positioning. The goal of this model is to fully understand where everything will be placed including the wires. **An important lesson learned from Hyperion was understanding wire layout is essential for integration. There was much work that went into strain relief of tightly packed wires from batteries and limit switches. The limit switches presented a difficult problem in which their wires were protuding normal to the walls of the CubeSat and the extremely close proximity of the Main PCB meant those wires needed to do a 90 deg bend within an extremely tight radius. This could have avoided with properly planning and time for integration studies.**

There will also be two electrical teams, one dedicated to the scientific payload development and the other dedicated to comms, parachute ejection system, and Main PCB design. It is recommended that the Main PCB be designed and ready for fabrication (WITH SPARES!) by the end of January. It will take a month to get all the parts and then a few weeks to get it fully populated. The scientific payload team will work the mechanical engineers to create a functional experiment by the end of the Fall semester (recall: this is not scientifically functional, just mechanical and electrically).

TABLE II

NOTIONAL TIMELINE OF PROJECT MILESTONES.

Phase	Task	Duration
1	Mission Statement & Success criterion	1 week
2	Team leadership assortion	1 week
3	Design and development	6 weeks
4	Initial manufacturing	4 weeks
5	Documentation update	1 week
6	Design iterations	4 weeks
7	Critical Design Review	3 weeks
8	Final design iterations	2 weeks
9	Flight manufacturing	3 weeks
10	Flight integration and full system testing	4 weeks
11	Launch and project review	4 weeks

V. EXTERNALITIES

A. Prerequisite Skills

It is obvious that team members will learn certain skills as a project progresses, but there are always some tasks that require a minimum skill level to provide meaningful contributions to a project's development. These prerequisite skills are best identified by examining past projects and discussing the project with faculty or subject matter experts. It is strongly recommended to be conservative in skill estimation. Underestimate team member skill levels and overestimate the challenge. Many projects have failed because the team overestimated their own abilities or underestimated the difficulty of their project.

B. Funding Requirements

Like prerequisite skills, it is wise to overestimate the cost of components, materials and other resources that a project requires. For physical projects, costs may be estimated by benchmarking the costs of similar systems or determining a representative bill of materials and using the aggregate cost of its items.

C. Faculty Support

Support from university faculty is almost always essential to a project's success. Faculty provide not only guidance and subject matter expertise, but may also connect a team with resources and networking opportunities. SPEX projects do not require faculty support, but it is highly recommended to identify professors with an interest or expertise in a project as early as possible.

D. Long-Term Vision

As SPEX student members get more experience writing these papers, the group will build a library of meaningful work and be able to save it in an organized manner. Knowledge will be preserved and easily shared. Perhaps Project Design Document could eventually get published, in a journal or otherwise…

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