RIT Space Exploration Participation in the Intercollegiate Rocket Engineering Competition

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***Abstract*—The Intercollegiate Rocket Engineering Competition is a well-known competition among those interested in amateur rocket engineering as well as those who do so professionally. With over 110 participating teams, it is the world's largest university rocket competition. Every year, more and more organizations are getting involved such as the Space Dynamics Laboratory who sponsors the SDL Payload Challenge. By cooperatively partnering with RIT Launch Initiative and their rocket-manufacturing experience, SPEX has an incredible opportunity to display engineering design proficiency and an extreme passion for space by creating a custom scientific payload to integrate with Launch Initiative's custom rocket.**

Nomenclature

ESRA	Experimental Sounding Rocket Association
IREC	Intercollegiate Rocket Engineering Competition
LI	Launch Initiative
PDD	Project Design Document
RIT	Rochester Institute of Technology
SDL	Space Dynamics Laboratory
SPEX	RIT Space Exploration

I. Introduction

The Intercollegiate Rocket Engineering Compeition is an annual event hosted by ESRA for student rocketry teams from across the USA and around the world. Beginning in 2017, IREC became the flagship activity of a new annual event called the Spaceport America Cup which is held in June in the New Mexico desert. The competing rockets are typically seen with a diameter of 4 to 8 inches, a length of anywhere from 8 to 20 feet, and will travel to an altitude of either 10,000 or 30,000 feet depending on whether or not the competing team opts to enroll into the basic or advanced category. The Space Dynamics Laboratory sponsors a separate competition at the Spaceport America Cup called the SDL Payload Challenge where scientific payloads integrated into the IREC rockets are judged based on criteria such as scientific relevance and technical execution.

The RIT Space Exploration team is a student-faculty research organization dedicated to giving students the opportunity to gain hands-on expereience by working with space systems. By cooperating with Launch Initiative, SPEX would like to enter IREC in the basic category. LI will provide the rocket body and the rocket engine while SPEX will focus on the integrated scientific payload with the intent of competing in the SDL payload challenge.

II. Primary Objective

The primary objective of SPEX's involvement in this competition is to develop and deliver a functioning scientific payload that integrates with Launch Initiative's rocket structure and successfully performs in the June 2018 competition. Successfully meeting this primary objective implies that multiple supporting objectives have been achieved as well. These objectives include developing a design to meet set criteria, working with professional researchers, communicating and integrating with a separate team, and meeting deadlines through proper design and development flow. Participating in this event provides room to grow academically and professionally for every student involved.

III. Benefit to SPEX

SPEX's involvement in this globally-identified compeition will serve to provide exposure and merit to the team and any sponsors involved in contributing. Additionally, individual students engaged in this endeavor will also benefit by improving their technical knowledge and abilities while participating in a major event which can also be used to improve their resumes.

A. Benefit to RIT

By attending the event and competing against top universities, RIT will be able to use this as an opportunity to showcase how passionate and involved their students are in space exploration. This involvement can be used in media as a tool for achieving more funds and attracting new students to the University. Since RIT has not been involved with IREC before, SPEX's attendance at this compeition can also show how the University and its students are growing and taking on new challenges.

B. Partnership with Launch Initiative

Since the founding of SPEX, there has never been a strong relationship with the Launch Initiative team. By cooperatively participating in this event, a great opportunity is presented to create a good relationship between two of the largest space-related teams on campus. In the future, united efforts between the two teams could result in more advanced projects which will provide even more exposure to both RIT space teams.

IV. Implementation

A. Selection

A decision matrix was created which took into account the following factors and assigned a maximum possible score based on importance to the selection process:

- **Scientific Relevance (10 pts)**
  - How does this payload contribute to the scientific community?
- **Potential for Excellent Technical Execution (15 pts)**
  - How feasible is it for the SPEX team to have great technical success with this endeavor?
- **Time Required/ Complexity (5 pts)**
  - Will this payload result in too much time being spent on research and development?
- **Constructability (5 pts)**
  - Does this payload require large amounts of machining and assembly or materials that are difficult to work with?
- **Cost (5 pts)**
  - How expensive will this be?
- **Weight (5 pts)**
  - Will it be easy to meet the 8.8lbs minimum requirement while also not being too heavy?
- **Programmability (5 pts)**
  - Does this payload require the use or creation of advanced software?
- **"WOW" Factor (5 pts)**
  - Is this payload attractive? Will it stick out among others?

Based on the results of the individual scoring of each idea throughout the team, the "Hyperion" payload was selected to move forward with with an average score of 44 out of a maximum 55 points.

B. Payload Details

Hyperion is modeled after the black box technology found in aircraft. It represents a combination of two initially separate concepts of extreme self-diagnostics and an airbag deployment mechanism for assited landing similar to the Spirit and Opportunity Mars rovers. As per the IREC rules and requirements, the payload will follow a traditional cubesat standard. It is estimated that a 3U (10cm x 10cm x 30cm) volume will be utilized.

On the self-diagnostics side, data gathered from the rocket and the payload will be written to nonvolaltile memory as well as transmitted to a receiving ground station. The data gathered within the payload includes linear acceleration, angular rate, magnetic field detection, temperature, absolute barometric pressure, GPS information, pressure within the landing balloons, and a variety of analog measurements from the circuit itself. Other data gathered from the rocket includes vibration, mechanical strain, and a potential for engine data such as fuel consumption depending on the engine selected for use by LI.

During apogee at 10,000 feet, Hyperion will separate from the rocket and fall back to Earth. At a sufficient altitude, Hyperion will electrically open valves that control the flow of CO2 from compressed canisters to inflate the balloons before striking the ground with a designed force of 500 Joules. This relatively low impact force will allow for proof of concept without subjecting the payload to unnecessary stresses.

C. Timeline

The timeline is based largely around two important dates. The first is the hand-off of the external mechanical design to LI on November 1st which will provide time for LI to incorporate Hyperion into their own designs. The second important date is the competition itself. Although the specific day has not been announced yet, past competition dates suggest that it will be held during late June. The timeline is as follows:

- September 1st: Begin narrowing down payload ideas using a decision matrix based on the SDL Payload Challenge scoring rubric
- September 8th: Decide on the specific payload and make a plan of action for research and design
- September 30th: Present a preliminary design with estimates for size, cost, and weight
- November 1st: Mechanical design and delivery to LI. No changes to the external frame can be made after this point
- Semester's End: Final hardware design completed and materials ordered
- April 1st: Integration testing of rocket and payload
- April/May: Test launch of rocket and payload
- June 22nd-24th: Intercollegiate Rocket Engineering Competition

This timeline provides SPEX with roughly 1 month until a preliminary design is created. After this, there will be another month to refine the design before the final size and interface details must be provided to LI. After this point, there will be more internal design and development for the remainder of the semester with a goal of purchasing all materials by the semester's end. If this timeline can be adhered to, then the entire spring semester and summer months leading up to the competition can be used for manufacturing, programming, integration, testing, and characterization.

D. Deliverables

The first deliverable is the preliminary design and bill of materials with a corresponding estimate of size, weight, and cost. If it is found that additional funds need to be raised, then the preliminary design can be used in fundraising requests so that businesses and investors know that sufficient research and development has already been put into the project. After the preliminary designs, the next deliverable is the final external dimensions and interfaces so that LI can proceed with their construction of the rocket. Finally, the actual payload will need to be delivered by the competition date although it will be provided much earlier than that due to the necessity of integration and testing.

V. Externalities

A. Prerequisite Skills

To participate in this endeavor, there are no prerequisite skills. However, for the project to succeed, there will need to be individuals who are proficient in computer-aided design and mechanical analysis for the structure of the payload. These members are responsible for the selection of materials and the construction of the frame, airbag deployment, and the return parachute. There will also need to be individuals proficient in electronic design, specifically with respect to printed circuit boards. These members are responsible for sensor selection and implementation, power regulation, and maintaining electrical connections between each part of the payload. Individuals proficient in programming will be required for embedded systems design, ground-station processing, and the overarching communication network that is needed to meet the goals of the project. Finally, there will need to be some individuals who are willing to ensure that each subsystem is compatible and properly interfaced. These indiduals will be responsible for communicating with the separate LI team and acting as a resource to those designing the hardware and software.

B. Funding Requirements

Although the preliminary design has not yet been completed, component selection has already begun and estimates for total cost have been gathered. The high-level cost breakdown assessment is as follows:

- **Mechanical Construction**
  - Aluminum - 200
  - Kevlar - 60
  - Nomex - 90
  - CO2 Canisters - 40
  - Solenoids - 300
  - Fittings - 80
  - Rocket Connectors - 150
  - Miscellaneous - 30
- **Electrical**
  - Sensors - 220
  - PCBs - 40
  - Other Components - 60
- **Communications**
  - Radios - 100
  - Antennas - 40

Although these numbers are preliminary, a realistic estimate of total cost is roughly 1,500 dollars. The SPEX internal budget has allocated 500 dollars towards this project. The remaining 1,000 needs to come from external sources. One such potential source is the Students for the Exploration and Development of Space (SEDS) non-profit which has grants available for participating chapters. If additional sources are needed, the preliminary designs and this project definition document will be used in a fundraising campaign to reach out to local individuals and businesses.

C. Faculty Support

Faculty support will be consistently saught after during the design and manufacturing of the payload. Although no faculty have yet been willing to dedicate a large block of time to assist this project. There have been multiple offers to provide guidance in a limited capacity. Although this project can succeed solely with SPEX members, this is a great opportunity to cooperate with RIT professors and researchers who can provide their knowledge and experience.

D. Long-Term Vision

The long-term goal of this project is to establish a relationship between LI and SPEX in which the teams can continue to cooperate in future IRECs and other multi-team projects. By working off of past successes, SPEX and LI can grow together and eventually compete in the advanced category against the leading schools. Another long-term goal is to show that SPEX is a strong team with a lot of hard-working individuals who are extremely passionate about space.

Acknowledgements

The author would like to thank all of SPEX's sponsors as well as Phil Linden for providing a great template for writing documents such as these.