High Level Exploration of Potential Space Mission Concepts

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***Abstract*—This proposal defines a semester long research project to evaluate space mission concepts on a technical basis. The chosen mission objective and constraints will be evaluated for their feasibility and potential solutions and technical approximations will be described in the final report. It is intended to build technical skills as well as produce polished technical content that SPEX can showcase.**

I. Introduction

In the spring of 2016, SPEX advisors conducted a Special Topics Course on Astrodynamics and Satellite Engineering. One of the projects undertaken for this course was a high level mission feasibility study, wherein an objective was selected, and preliminary mission parameters were given to student teams. Each team assumed the responsibility of exploring the physical and technical challenges for the mission, and proposing solutions and designs for accomplishing the objective. This project would be a natural expansion upon that process, where student teams would be given new parameters and objectives and tasked with evaluating the feasibility and technical complexity of achieving those goals. The missions explored do not need to conform to the cubesat standard or be restricted to what an undergraduate research team could afford to construct.

II. Primary Objective

The goal is to engage students in the practice of astronautical engineering by presenting them with challenges encountered in the field and using applicable techniques and technology to solve problems.

Students will learn about the unique environmental conditions and practical engineering restrictions astronautical engineering presents, and become familar with the mathematical equations and physical properties that apply to that environment.

III. Benefit to SPEX

This project will have several key benefits to SPEX in the near and long-term. This project will encourage an astronautical engineering mindset among SPEX members, and will drive technical excellence for all of SPEX's projects.

A. Technical Skills

Firstly, this project requires members seek out practical engineering knowledge to solve challenges. Members will learn the mathematical process for calculating various mission and vehicle parameters. Also, systems-level knowledge will be required to ensure each sub-system can fit within the mass and volume bounds set by the project. Applying these skills is incredibly valuable, and will make members more attrative to employers, as well as build their technical competency when working on other SPEX projects.

B. Published Content

Similarly, the end goal of this project is a highly polished technical document that can be shared internally within SPEX, and self-published externally for the RIT or broader aerospace community to read. This will build SPEX's legitimacy when compared to other school's aerospace programs, and act as a first-class representation of SPEX's technical competency that can be shared with employers and potential sponsors.

C. Future Project Feasibility

As each finished study is intended to be a high level overview of potential challenges and solutions, they will provide a launch pad for other studies, reports, and projects. For example, a high level design for a probe landing system as part of a general lander mission, could be expanded upon in its own project, either as an in-depth report, or prototype engineering test article. Solutions investigated during the course of this project could be applied to other SPEX projects as well. Alternatively, problems and risk areas addressed in these studies will inform members working on future projects, and provide valuable experience.

IV. Implementation

The project will begin with selecting a primary mission objective, and establishing constraints, e.g. vehicle parameters, total cost, etc. This process could involve SPEX advisor input, finding other RIT faculty with existing mission concepts, or identifying areas of interest defined by NASA, ESA, etc.

The process will involve research, using RIT academic resources and other externally available media, to identify key challenge areas and potential solutions. Then constraints and solutions will be calculated mathetically. For example, given the requirement to transmit an image of given dimensions and total size, what are the radio requirements to trasmit that data in an expedient manner? This solutions will be checked by other members within the team, and also presented to SPEX advisors and other advising faculty. Then the teams will iterate, incorporating feedback and suggestions to eventually arrive at ideal designs.

At the end of the project (or end of semester, whichever comes first), the team writes the final report, showcasing the potential solutions to the mission objective, as well as the overall feasibility of the mission with the given constraints. Also, the mission may be a candidate for the AIAA Space conference, and an abstract could be submitted in early December.

A. *Deliverables*

The primary deliverable will be a polished report that can be published if SPEX chooses. Incorporated within the document will be clear definitions of the mission objective, external constraints, and any assumptions made by the team. Mathematical equations will be included as necessary, to showcase the mathematical foundations on which mission parameters were derived. Charts, graphs, and other data visualizations are highly encouraged, especially when they showcase a range of potential solutions and indicate why the team chose certain parameters. Sketches, CAD models, and other graphics will be included to aid the reader in visualizing the complete system and other novel solutions designed by the team.

B. *Milestones*

If this project is conducted over a semester timeline, the team will need to expediently cover the required areas defined below.

- Select mission objective and define constraints - no more than 2 weeks
- Research key technical areas - no more than 4 weeks
- Develop initial solution
- Iterate on solution and technical analysis
- Choose areas of importance to delve more deeply for technical insight
- Iterate on final deliverable
- Present finished study to SPEX adivsors and general group

The latter objectives can be handled in a variety of development techniques, e.g. waterfall, scrum, agile, etc

V. Externalities

A. *Prerequisite Skills*

While some of the mathematics involved only requires basic algebra and trigonometry, members are recommended to have calculus experience. Existing astronatical engineering experience is obviously preferred, but the goal of this project is to build that skillset, so it is not required.jk The challenges and equations this project requires are unlikely to be covered in most courses at RIT, especially in lower year levels, so members should expect to deal with a lot of never before seen material.

B. *Funding Requirements*

This project is unlikely to require direct funding. All work will consist of research, calculations, and producing a report using free or easily accessible tools.

C. *Faculty Support*

Faculty support is highly recommended for teams pursing this project. Teams should look for potential mission ideas from RIT faculty, across colleges and departments. SPEX advisors would play a key guidng role for the team, acting as de facto reviewers during the iterative phase of the process.

D. *Long-Term Vision*

As SPEX successfuly completes these feasibility studies, they will naturally provide starting points for continuation studies and other projects. AIAA Space is a potential publishing opportunity, offering a platform that accepts a variety of papers on potential mission solutions. If accepted, students from the team could apply for RIT travel grants to attend and present the paper to the wider aerospace community.

Another long-term goal would be to continue the development cycle, converting a feasibility study into an actual mission plan, and finally into an actual space mission. However, the scope of such an implementation is outside of the present and near-term ability of SPEX.

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