National Aeronautics and Space Administration

Concurrent Engineering & Lifecycle Product Development: Research Opportunities for the Next Generation of Space Systems Engineers

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Program: FY21 SURP Strategic Focus Area: Systems architecture

Objectives

Through this SURP, undergraduate and graduate students in the Massachusetts Institute of Technology Space Systems Development courses are guided through focused analysis and application of the design process to provide practical solutions for new and challenging research problems. Many students are supported through both Fall and Spring semesters by the SURP because of their attendance in multiple space systems engineering classes. They are given leadership experience at personal, interpersonal, team, and organizational levels through regular interaction with fellow team members, communications, and programmatic challenges stemming from the constraints of classroom capabilities and sponsor requirements. The SURP funds were used to support the undergraduate and graduate research projects both during the course and over the summer in support of the class work. Additionally, the SURP supported a TeamX concurrent engineering study with student remote participation. The vast majority of the efforts this year were focused on the 16.83 and 16.831 classes, which developed the BeaverCube CubeSat and an Enceladus mission concept. Additional efforts supported the 16.851 and 16.343 classes by providing input for class lectures JPLer technical feedback on student projects.

Background

This task was in direct support of MIT's AeroAstro Systems Engineering classes, educating the next generation of systems engineers. The students were introduced to individual subsystems, systems engineering processes, and the importance of each step in the lifecycle design, and in particular focusing on the process of bringing a concept at a preliminary design stage to flight hardware and software implementation. Additionally, the students participate in a TeamX study to provide real-world exposure to JPL teams and to the JPL approach to concurrent engineering. This interaction gives students a unique opportunity to be introduced to a full project cycle early in their career.

Significance/Benefits to JPL and NASA

The projects undertaken by the MIT students described in this report have scientific and technological impacts that are directly aligned with JPL's interests. They are relevant to the scientific observation of our planet and to the design of small-scale spacecraft that serve both as technology demonstrators for future missions while returning scientifically valuable data as science platforms. These are areas of high interest for JPL, and in particular the 3x, 4x, and 8x directorates. Furthermore, the experience gained by the students in the development of the spacecraft will be leveraged by future satellites developed by JPL, while also providing JPL with a study concept for performing planetary operations that will enable scientific SmallSat missions that will rely on JPL's expertise in guidance, estimation, and control of autonomous and propulsive space systems. The Team X study provided significant benefits by laying the groundwork for future collaborations and new student skills that will be applied for upcoming projects in the next fiscal year.

Publications

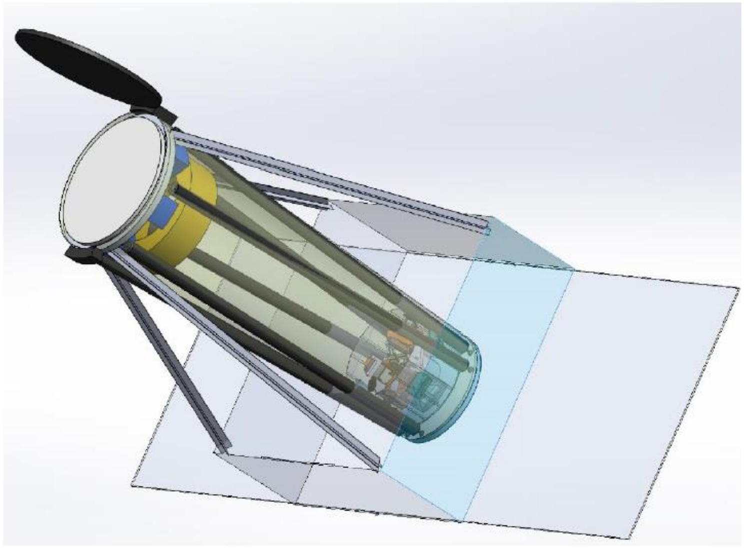
Kambhampaty, J., Colicci, V., Goode, A., et al., "Defining Enceladus: Exterior, Plumes, and Subsurface Environment Activity (DEEPSEA)", *Journal of Spacecraft and Rockets*, In Work, 2021.

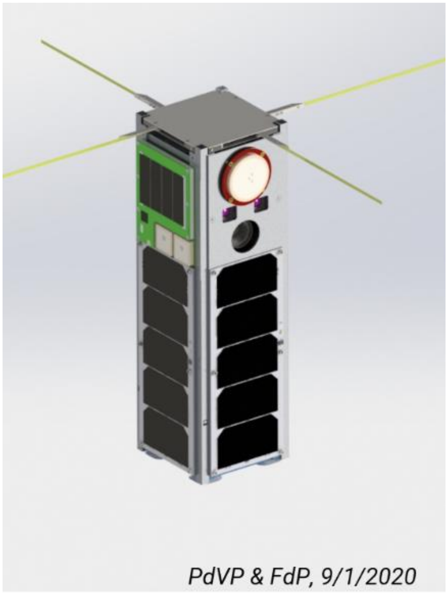
Approach and Results

The SURP provided JPL support for the space systems engineering classes at MIT in both the fall and spring semesters, while also assisting in student research projects that extended throughout the year. Throughout the classes, the SURP was able to provide JPL support for the students as technical experts. Feedback was provided regularly at weekly team meetings, during which students were free to ask questions of JPLers and technical guidance could be provided for each subsystem throughout the design phase. Additionally, the students were exposed to software packages common to JPL, including Solidworks, Thermal Desktop, Matlab, Simulink, and STK. JPL also assisted with standard practices, such as risk matrices, schedule Gantt charts, and science traceability matrices.

The primary class supported in the fall semester was 16.831 (undergraduate build space systems engineering capstone), which focused on the development of the GoSOX soft x-ray polarimeter instrument and on the BeaverCube CubeSat, which uses a remote sensing payload to measure ocean color and sea surface temperature. As a 3U design, the majority of the external surfaces are covered with solar panels, and the primary deployable elements are antennas. Additional support was provided for the 16.851 class (graduate space systems engineering class), which matured the designs of several projects from the last fiscal year's SURP. For all of the projects, student leads were chosen for the subsystem teams, which each consisted of approximately three to four students. In 16.831, graduate student mentors were also supported by the SURP funds for each team, and JPL mentors were available for each team as well.

GoSOX Instrument



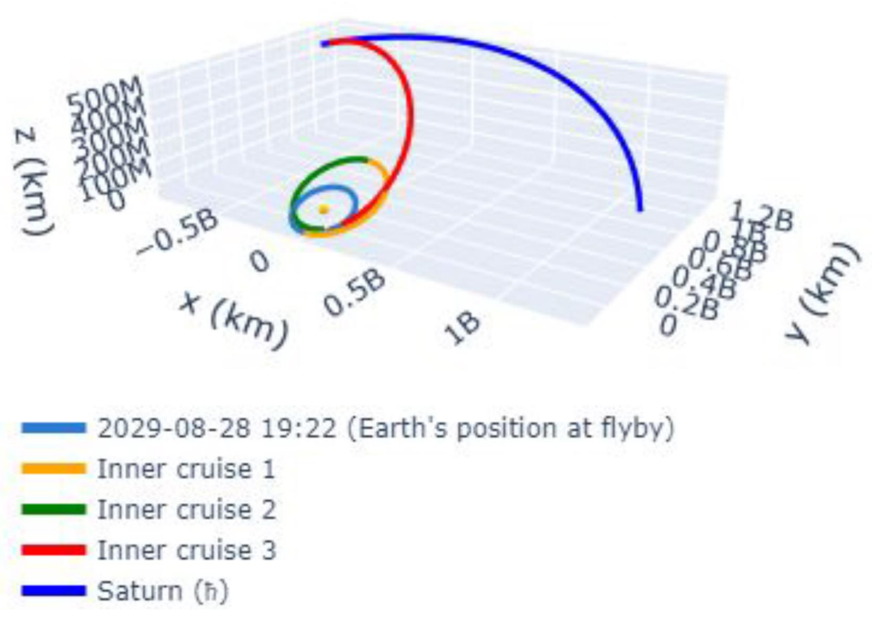


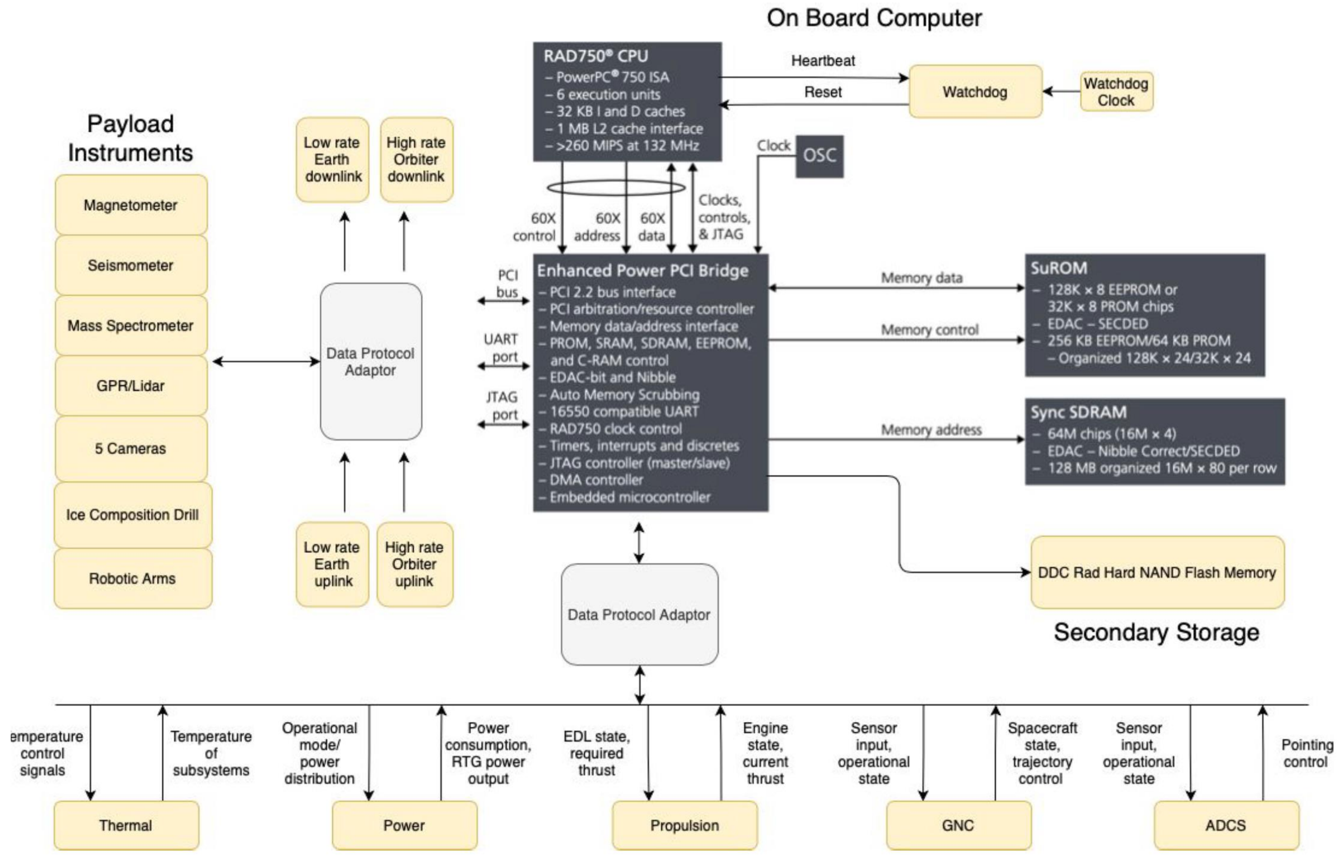
BeaverCube

Importantly, the SURP provided support for running a Team X study to mature the instrument and architecture design of the GoSOX instrument, during which a half dozen students participated as both a customer team and chair shadows. The experience built upon prior SURP engagement with the JPL Foundry, and although remote, provided valuable concurrent engineering lessons for the students.

The spring classes supported by the SURP included 16.343 (graduate space instrumentation class), for which guest lectureship was provided, and 16.83 (undergraduate design space systems engineering capstone), which was the primary focus for the semester. Students in this class designed an Enceladus mission concept with both orbital spacecraft and lander elements.

DEEPSEA Enceladus Trajectory





DEEPSEA Data Flow Block Diagram

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