Virtual Research Presentation Conference

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

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Program: SURP

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Introduction

Abstract

The FY20 MIT SURP extends a multi-year collaboration between JPL engineers and Massachusetts Institute of Technology space systems engineering graduate and undergraduate students. Though the SURP provided assistance to several classes, the primary objective was to support the development of the BeaverCube Earth-observation CubeSat in the two-semester undergraduate capstone courses (16.83 and 16.831). Scheduled for launch later this year, BeaverCube was designed by student-led subteams, and integration and testing is underway. JPL engineers provided mentorship for the subteams, guidance in technical areas, and review feedback for major class and program deliverables. The JPL team also facilitated the continued interaction between the MIT team and JPL Foundry in support of furthering Team Xc tools and future student-run concurrent engineering capabilities in MIT space systems engineering classes.

Problem Description

a) Context (Why this problem and why now)

The classes supported by this SURP follows the MIT capstone process of Conceive, Design, Implement, and Operate (CDIO) that was originally formulated over decade ago with support from JPL and earlier versions of this SURP. Both graduate and undergraduate classes are affiliated with this SURP, with many students taking multiple SURP-supported classes across academic and fiscal year boundaries. The SURP provides critical real-world experience for these students by maintaining an existing interface to JPL technical experts while creating new partnerships across the lab.

b) SOA (Comparison or advancement over current state-of-the-art)

- BeaverCube will be the first university CubeSat to fly both a remote sensing payload for observing Earth's climate and weather, and an electrospray propulsion (tiled ionic liquid electrospray – TILE) payload.
- The remote sensing payload measures ocean color and sea surface temperature using two infrared cameras and one visual camera, and the TILE propulsion system provides altitude maintenance.

c) Relevance to NASA and JPL (Impact on current or future programs)

- Directly supported 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.
  - This interaction gives students a unique opportunity to be introduced to a full project cycle early in their career.
- Supported ongoing collaborations between the MIT students and the JPL Foundry, while initiating a collaboration with the JPL F-Prime team.

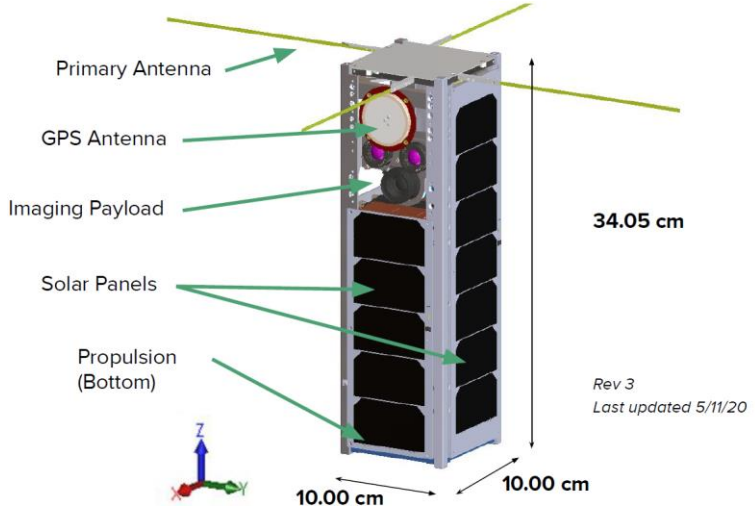
Methodology

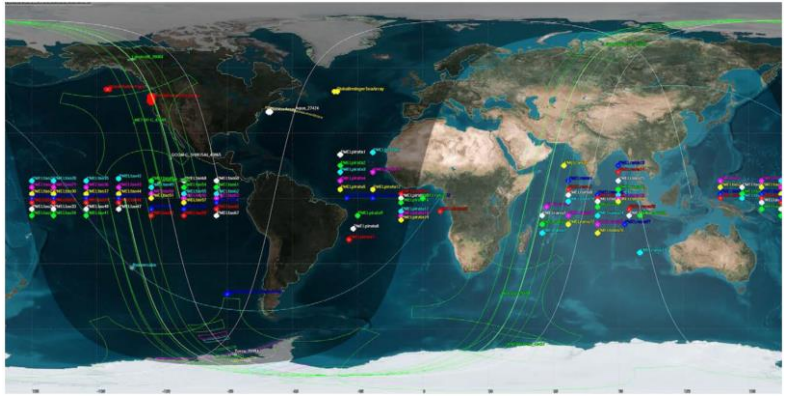
a) The project was divided into project management, systems, thermal, structures, propulsion, command and data handling, Earth observation payload, communications, attitude determination and control, and power subsystems. Student leads were chosen for each of these subteams, which each consisted of approximately three to four students. Graduate student mentors were also supported by the SURP funds for each subteam, and JPL mentors were available for each team as well.

b) The SURP was able to provide JPL support for the students as technical experts.

c) Continued discussions with the JPL Foundry team led to planning upcoming concurrent engineering studies and tool development.

d) Established relationship between the JPL F-Prime developers and key MIT Aero/Astro faculty for future projects.





Results

a) Accomplishments versus goals

The classes were a great success, with the students having the opportunity to work through the lifecycle of the early phases of mission development through hands-on testing and integration. Continuing work towards launch in October this year further advances the project with JPL support. Throughout the year, JPL staff assisted individuals and teams by providing technical help to the students as well as serving as review board members.

b) Significance

- The projects undertaken by the MIT students 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.
- Experiences gained by the students 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 technical areas of expertise.
- The Team Xc and F-Prime discussions laid the groundwork for future collaborations that will use JPL-developed tools and software on upcoming student projects.

c) Next steps

- The upcoming year's classes will include projects related to both BeaverCube's follow-on mission (BeaverCube 2) and a larger-scale spacecraft for deep space astrophysics that will use Team X as a foundation for the design.
- The lessons learned from this year's classes and Foundry collaboration will certainly play a large role in shaping the classes and student experiences over the next fiscal year.

Publications

1. Paula do Vale Pereira, Madeline Garcia, Madeleine Schroeder, Humberto Caldelas, Charles Lindsay, et al., “BeaverCube: Coastal Imaging with VIS/LWIR CubeSats”, 2020 Small Satellite Conference, 2020.
2. Madeleine Schroeder, Christopher Womack, and Amelia Gagnon, “Maneuver Planning for Demonstration of a Low-Thrust Electric Propulsion System”, 2020 Small Satellite Conference, 2020.
3. Charles Lindsay and Ethan Sit, “Open-Source Flight Computer Platform for CubeSats”, 2020 Small Satellite Conference, 2020.