National Aeronautics and Space Administration

Space Systems Product Development: Educating the Next Generation of Engineers

Principal Investigator: Dr. David Sternberg (3432)
Co-Is: Prof. Kerri Cahoy (MIT), Dr. Farah Alibay (394B), Dr. Sydney Do (312I), Jennifer Maxwell (313A), and James Chase (3120)
Program: Student Research Initiative

Project Objective:

The objective of the Massachusetts Institute of Technology (MIT) undergraduate Space Systems Development courses (16.83 and 16.831) is to immerse juniors and seniors in the full lifecycle of developing an aerospace project. This two-semester design-build course is designed to provide future engineers, and potential JPL interns and employees, with an understanding of the impact of requirements definition and design decisions on the performance, manufacture, integration, test, and operations of the system, as well as to enable them to perform research and technology development. Additionally, the one-semester graduate student design course, 16.851 Satellite Engineering, has a similar approach, and it is paired with a project-specific design or implementation second semester with the number 16.89.

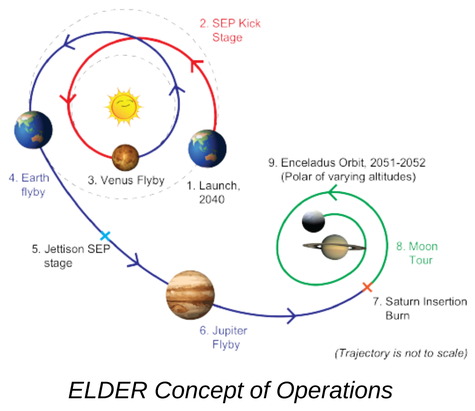
Through this SURP, students are guided through focused analysis and application of the design process to provide practical solutions for new and challenging research problems. The SURP funds were used to support the undergraduate and graduate research projects both during the course and over the summer in support of the class work. The students in 16.83, which focused on creating a solar-powered ocean worlds space mission to orbit Enceladus, delivered a journal-style paper for each of the main subsystems and a public outreach summary computer rendition of the mission. Meanwhile, the students in 16.89 delivered a single team report covering their analysis of a proposed path for sustainable US space exploration beyond Low Earth Orbit.

The SURP also had the objective of furthering the implementation readiness of the new Team Xc tool for concurrent engineering as part of JPL's Team X and Xc Foundry capabilities. The SURP coordinated and funded a Team Xc study, where 14 MIT summer interns were invited to shadow JPL subsystem chairs. This had the two-fold benefit of 1) being the most intensive beta-test to date of the new tool, and 2) exposing the students to the JPL systems engineering and concurrent engineering processes.

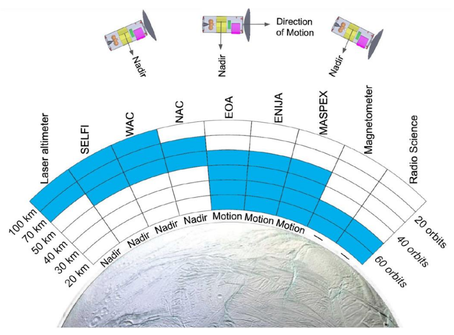
FY18/19 Results:

Enceladus Life Detection, Exploration, and Reconnaissance (ELDER)

The 16.83 class created a mission concept to the ocean world Enceladus. Throughout the semester, the students presented at a mission requirements review, preliminary design review, and critical design review for their concept. The students were divided into six teams: systems, creative communications and immersive virtual mission experience, life detection and instrumentation, system autonomy and remote operations, spacecraft design, and launch/ navigation/ entry/ descent/ landing. The students generated a science traceability matrix along with a full mission concept with JPLers guiding the process and offering feedback along the way.



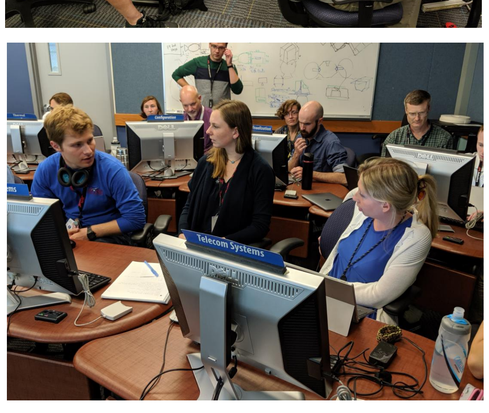
ELDER Concept of Operations



ELDER Observation Schedule

Team Xc Integrated Modeling Environment Test Study

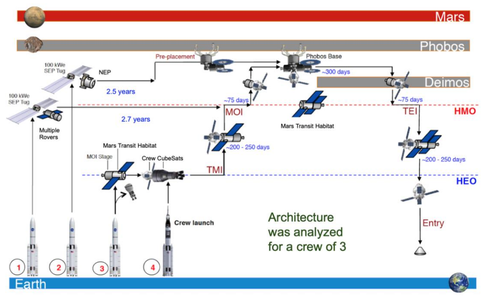
The SURP supported a Team Xc study at JPL over the 2019 summer to design an Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA)-class small spacecraft for an airglow seismicity mission to Venus. The goal of performing this mock study was both to further the systems engineering and mission concept development experience of MIT students, taking advantage that some students were already at JPL as interns over the summer and to stress-test the new integrated modeling environment tool for Team Xc concurrent engineering studies. During the study, 14 MIT interns working alongside a full complement of Team Xc chairs (staffed by JPLers). It was the most stressing study yet performed with the new tool, with the largest number of simultaneously active users. The group of students were a mix of those who will soon take and those who had taken one or more of the classes directly supported by this SURP.



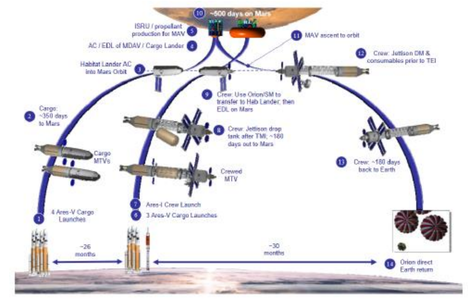
MIT Students in Team Xc Study to Develop New Concurrent Engineering Tools and Skills

Sustained Mars Exploration Architecture

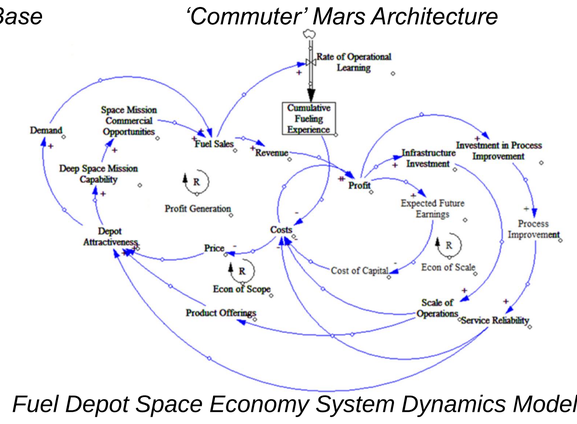
The 16.89 class focused on developing ways for using resources and experience from getting to the Moon to reduce cost and time needed to carry out future missions to Mars and other deep space locations. The Moon was utilized as a technology demonstration and testing environment on the path to Mars, relying on technology that could be scaled for deeper exploration with both crewed and unmanned vehicles. The Mars campaign implemented a three-phase approach: 10 missions to the Moon to gain operational experience with travel outside the Van Allen radiation belts and to test new technologies necessary for a successful Mars campaign, a series of five missions to Mars starting with a crewed Mars orbital mission from which the crew would operate robots on the surface, and the establishment of at least one semi-permanent habitat on Mars with multiple long-duration human missions.



'Telecommuter' Mars Architecture with Phobos Base



'Commuter' Mars Architecture



Fuel Depot Space Economy System Dynamics Model

Benefits to NASA and JPL:

The projects undertaken by the MIT students are relevant to robotic exploration of ocean worlds, Venus, and the human exploration of the solar system. These are areas of high interest for JPL, and in particular the 3x and 4x directorates. Furthermore, the Team Xc study over the summer provided significant benefits both for the MIT student participants and for the Team Xc chairs. Being the most challenging study yet conducted owing to the number of chairs actively working the models simultaneously, this test of the software led to dozens of feature requests that will make the tool even more streamlined, capable, and user-friendly. Additionally, the students learned valuable insights into the tool generation process, JPL's concurrent engineering process, and the differences between student team project development and early-stage flight system proposals. Finally, this SURP is educating the next generation of systems engineers using JPL best practices and reinforcing JPL's hiring pipeline by providing students with direct access to JPL engineers and scientists during their undergraduate and graduate education.

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

PI/Task Mgr. Contact Information:
Email: David.C.Sternberg@jpl.nasa.gov
Phone: 818-354-6685

Poster No. RPC-156