

EPET 401 ME 401: Capstone Project - Producing a Science Satellite

Course Description

Develops a space mission with a multidisciplinary team of engineers and scientists using concurrent science and engineering methodologies. The class will build a small spacecraft and payload. The project will seek to answer important science questions. The course is offered in Fall only.

Number of Credits

EPET 401 is a four credit lecture/laboratory course. It is cross-listed as ME 401

Relation to Curriculum

EPET 401/ME 401 is an integral part of the EPET Certificate program.

Prerequisites:

EPET 400

Class contact hours

Under COVID provisions the course is delivered as asynchronous hybrid. General class meetings are synchronous online with two TR 3-hour meetings per semester week. For laboratory and practice class will be split. Small class sections will meet F2F during the first weekly instruction day, while non-lab sections will meet online; to be reversed on the second weekly instruction day. Upon return to regular F2F instruction there will be two TR 3-hour meetings per semester week.

Course Details

The course is structured into learning modules generally aligned with semester weeks. The lecture/laboratory course structure allows about 50% of instruction time for lectures and lecture activities and about 50% for laboratory activities and course project activities. The Model Content and Topics section provides an abbreviated list/description of course modules and course module activities. Lecture and laboratory activities support the learning objectives outlined in lecture topics. Project activities focus on the conceptualization and design of spacecraft and instruments able to complete defined space mission objectives.

Course delivery

The main elements of course delivery are mini-lectures, guided Concurrent Design Sessions, and project-based learning activities. Students are engaged in designing a space mission with scientific value and produce a quality final report that can be used as baseline proposal.

The laboratory component of the course is characterized by the integration of theory and practice. In the initial weeks break-out group work and group discussions focus on practice and real problems underpinning lecture topics. Each of the break-out groups reports on the result of the exercise, leading to the advancement of the session topic. Later in the semester, break-out group work will increase in time to about half of the time assigned to the lecture component (on a weekly basis). The difficulty of problems will increase.

Learning objectives are integrated through and culminate in a group-based research project: the design and construction of spacecraft with a scientific instrument for an exploration mission. The requirement is to deliver a spacecraft and payload that can function in space.

This provides mission concepts that can be proposed as part of future NASA mission solicitations.

Textbook

Space Mission Engineering: The New SMAD, J. R. Wertz, D.F. Everett, and J.J. Puschell, Microcosm, 2011

Elements of Spacecraft Design, C. Brown 2002, AIAA Education Series

Model Content and topics

Module 1 - Introduction

Lecture, Lecture activities: Setting the stage; Motivation for TeamX exercise; Principles of Spacecraft Design; Systems Integration & Design Convergence; Conceptual space mission design; Team formations and roles assignments

Lab activities: Intro lab on concurrent design.

Project activities: Project definition; Team formations and roles assignments.

Module 2 - Science / Instrument

Lecture, Lecture activities: Principles of remote sensing and science applications; Principles of orbital remote sensing; Overview of space science payloads; NOAA licensing for optical imagers.

Lab activities: Mission requirements definition from science objectives.

Project activities: Concurrent Design Session (1).

Module 3 - Mission Design

Lecture, Lecture activities: Orbital Analysis & Visualization; Orbital Debris and Assessment Report.

Lab activities: STK and COSMOS introduction for Orbital Analysis.

Project activities: Concurrent Design Session (2).

Module 4 - Spacecraft Systems Architecture

Lecture, Lecture activities: Systems engineering overview; Spacecraft subsystems; Architecture Conceptualization; Trade Studies.

Lab activities: Design System Level Diagram.

Project activities: System Requirements Review (SRR).

Module 5 - Project Management

Lecture, Lecture activities: Documentation; Work Breakdown Structure; System and Subsystem descriptions; Mission cost and schedule; Mission assurance; Leading a science and engineering team; Task Planning.

Lab activities: Collaborative project documentation structure, document current design.

Project activities: Concurrent Design Session (3)

Module 6 - Systems Engineering

Lecture, Lecture activities: Requirements definition; Model Based Systems Engineering; Sensitivity Analysis & Trade Space Exploration; Block Diagrams & Interface Analyses; Equipment Lists; Mass and Power budgets.

Lab activities: Define requirements, prepare the various budgets.

Project activities: Preliminary Design Review (PDR).

Module 7 - Structures and Mechanisms

Lecture, Lecture activities: Launch Environment; Structure Dynamics; Finite Element Analysis; Deployable Structures; Outgassing Materials.

Lab activities: Run Finite Element Analysis on satellite bus.

Project activities: Concurrent Design Session (4).

Module 8 - Guidance, Navigation and Control

Lecture, Lecture activities: Attitude Control; Orbital Position Control; Propulsion; Spacecraft Sensors and Actuators.

Lab activities: Create dynamic motion model and run for analysis and visualization.

Project activities: Concurrent Design Session (5).

Module 9 - Propulsion

Lecture, Lecture activities: Propulsion system selection; Orbital maneuvers; Orbital maintenance.

Lab activities: Propulsion System Selection;

Project activities: Concurrent Design Session (6).

Module 10 - Flight Software

Lecture, Lecture activities: Flight software options; Command and Control; Command Scheduler; Payload operations.

Lab activities: COSMOS and CFS workshop.

Project activities: Critical Design Review (CDR).

Module 11 - Power Systems

Lecture, Lecture activities: Solar Panels; Batteries; Power Management, Distribution and Control; Power Budgets.

Lab activities: Power system design and simulation.

Project activities: Concurrent Design Session (6).

Module 12 - Thermal Control

Lecture, Lecture activities: Thermal design; Thermal analysis; Passive vs active thermal control.

Lab activities: Thermal Desktop workshop.

Project activities: Concurrent Design Session (7).

Module 13 - Telecommunications

Lecture, Lecture activities: Link budget; Flight radios and antennas; Ground radios and antennas; FCC licensing.

Lab activities: COMM hardware selection and link budget.

Project activities: Concurrent Design Session (8).

Module 14 - On Board Computing

Lecture, Lecture activities: Flight Processor; Payload Processor; Software implementation.

Lab activities: OBC workshop and software implementation.

Project activities: Concurrent Design Session (8).

Module 15 - Ground Segment

Lecture, Lecture activities: Ground Stations; Ground Data System; Data transfer.

Lab activities: HSFL/MC3 ground station workshop and operations.

Project activities: Concurrent Design Session (9).

Module 16 - Mission Operations

Lecture, Lecture activities: Mission Operations Software; Scheduling and Task commanding; Flight Readiness Review (FRR).

Lab activities: Plan mission operations and run simulation.

Project activities: Flight Readiness Review (FRR).

Module 17 - Integration and Testing

Lecture, Lecture activities: Bus integration; Payload integration; Testing and Verification; Assembly, Integration, and Verification.

Lab activities: Integration and Testing Plan.

Project activities: Concurrent Design Session (9).

Module 18 - Spacecraft Delivery and Launch, Product Assurance

Lecture, Lecture activities: Configuration & Integration; Electromagnetic Compatibility; Dependability; Reliability; Quality Assurance.

Lab activities: Complete final report and present results.

Project activities: Completion of group research project.