Course guide
300526 - ESA - Spacecraft System Engineering

Last modified: 29/06/2026

Unit in charge: Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: BACHELOR'S DEGREE IN SATELLITE ENGINEERING (Syllabus 2024). (Compulsory subject).

Academic year: 2026 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Definit a la infoweb de l'assignatura.

Others: Definit a la infoweb de l'assignatura.

PRIOR SKILLS

Spacecraft Systems Engineering is an integrative course that builds upon core engineering concepts from previous semesters. To successfully complete this course, it is highly recommended that students have basic prior knowledge in the following areas:
- Physics & Thermodynamics: Classical mechanics of rigid bodies and introductory concepts of heat transfer (conduction and radiation).
- Mathematical Skills: Applied linear algebra (vectors and matrices), differential and integral calculus, and methods for solving ordinary differential equations (ODEs).
- Signals & Systems: Fundamental concepts of continuous and discrete signals, linear time-invariant (LTI) systems, and basic frequency-domain analysis.
- Telecommunications & Electronics: Fundamentals of wave propagation, basic link budget calculations, and elementary DC/AC circuit analysis.
- Programming: Basic user-level programming skills to implement simple numerical simulations (e.g., using Python, MATLAB, or similar tools).

TEACHING METHODOLOGY

The course is conducted through an active learning approach comprising the following structured activities:
- Lectures: Expository sessions presenting space systems engineering principles based on the ESA/ECSS framework and the architecture of the 9 critical spacecraft subsystems.
- Practical and Laboratory Sessions: Guided hands-on workshops focused on numerical modeling and simulation of spacecraft subsystems (attitude control loop, thermal balance, and telecom link budget) using MATLAB or Python.
- Design Project (Project-Based Learning - PBL): Collaborative team project for the conceptual design of a CubeSat mission, focusing on subsystem integration, system-level budgets, and verification matrices (VCM).
- Autonomous Work: Personal study, engineering design problem-solving, and preparation of team design project deliverables.

LEARNING OBJECTIVES OF THE SUBJECT

By the end of this course, students will be able to:
- Explain the lifecycle of a space project according to ESA/ECSS standards (Phases A-F) and describe the main project review milestones (CoR, PDR, CDR).
- Formulate and balance system-level engineering budgets (mass, electrical power, RF link, and propellant ΔV) for a CubeSat mission.
- Evaluate the physical impacts of the space and launch environments on the satellite's thermal, mechanical, and electrical design.
- Design and simulate using software tools (MATLAB or Python) an attitude determination and control loop (ADCS) and a simplified thermal mathematical model.
- Critically select and justify appropriate Commercial Off-The-Shelf (COTS) components for each subsystem based on mission requirements.
- Write and present a comprehensive spacecraft conceptual design proposal for a small satellite mission, showing critical thinking in margin and risk management.

STUDY LOAD

Type	Hours	Percentage
Hours large group	55,0	44.00
Self study	70,0	56.00

Total learning time: 125 h

CONTENTS

Mission Design, Orbits and Launchers

Description:
This block introduces the foundational concepts of space systems engineering and the complete mission lifecycle. It covers documentation management and mission evaluation in the context of ESA/ECSS standard processes. Students will engage in concurrent design practices and detailed mission analysis for CubeSat projects. Furthermore, it delves into the dynamics of satellites, orbit design and maintenance, explaining orbital perturbations and ground tracks. Finally, it explores the characteristics and harsh environments of various launch vehicles used to safely place spacecraft into their target orbits.

Full-or-part-time: 25h
Theory classes: 5h 30m
Practical classes: 5h 30m
Self study : 14h

Platform and Control Subsystems

Description:
This block focuses on the physical and dynamic core of the spacecraft. It covers the design of the primary and secondary structure and mechanisms, including deployable systems and structural load paths. A major focus is on Attitude Determination and control (ADCS), including kinematics, sensors, actuators, and feedback loops to stabilize the satellite. It also introduces space propulsion systems (chemical and electric) for orbit maneuvers, as well as thermal control systems (passive and active) required to survive the extreme temperature variations of the space environment.

Full-or-part-time: 25h
Theory classes: 5h 30m
Practical classes: 5h 30m
Self study : 14h

Avionics and Power System

Description:
This block details the electrical and computational central systems of the satellite. It provides a comprehensive study of the electrical Power System (EPS), including solar energy generation, battery storage, and power management and distribution topologies. Additionally, it thoroughly examines the On board computer and data handling (OBDH/C&DH) architectures, addressing hardware redundancy, radiation mitigation strategies, standard data buses, memory configurations, and real-time flight software operations.

Full-or-part-time: 25h
Theory classes: 5h 30m
Practical classes: 5h 30m
Self study : 14h

Communications and Operations

Description:
This block connects the spacecraft to Earth by covering the complete RF communication architecture. It explores the fundamentals of space communications, antenna design, data packet standards, and link budget calculations. It specifically addresses Tracking, telemetry and command (TT&C) systems required for securely operating the satellite and monitoring its health. Finally, it analyzes the architecture, functions, and data distribution networks of the Ground and user segment, including ground stations and mission control centers.

Full-or-part-time: 25h
Theory classes: 5h 30m
Practical classes: 5h 30m
Self study : 14h

Lifecycle, Manufacturing and Reliability

Description:
The final block synthesizes the engineering process by looking at the project management and physical realization phases. It covers the intricacies of spacecraft manufacturing, reliability, and cost modeling, emphasizing how system-level design choices impact the overall mission budget and lifespan. This also includes the Assembly, Integration, and Testing (AIT/AIV) campaigns, such as environmental testing (vibration, thermal vacuum), ensuring the satellite is fully verified before launch.

Full-or-part-time: 25h
Theory classes: 5h 30m
Practical classes: 5h 30m
Self study : 14h

GRADING SYSTEM

Linked to the course's information webpage.

EXAMINATION RULES.

Continuous Assessment Exemption: Continuous assessment activities carried out during the semester (PBL Design Project, homework submissions, tutorials, and practical exercises) cannot be re-evaluated under any circumstances. Consequently, students will preserve the grades obtained in these activities throughout the academic term.

Replacement of Exam Grades: Students who do not pass the course through regular assessment are entitled to take a re-evaluation exam. The grade of this re-evaluation exam will replace the grade of the Mid-term Exam (MQ) and/or the Final Exam (FQ), provided that the re-evaluation grade is higher.

Grade Cap Limit: The maximum overall final grade that can be awarded for a re-evaluated course is strictly capped at 5.0 (Pass).

BIBLIOGRAPHY

Basic:

- Fortescue, Peter W.; Stark, John P. W.; Swinerd, Graham. Spacecraft systems engineering [on line]. 4th ed. Chichester ; New York: Wiley, cop. 2011 [Consultation: 26/06/2026]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=693314. ISBN 9780470750124.
- Wertz, James Richard; Everett, David F; Puschell, Jeffery J. Space mission engineering : the new SMAD. Torrance: Microcosm Press, 2011. ISBN 9781881883159.

RESOURCES

Other resources:

ESA ECSS, https://ecss.nl/ />National Aeronautics and Space Administration, NASA Systems Engineering Handbook, NASA/SP-2016-6105 Rev 2. Washington, D.C.: NASA Headquarters, 2016.