COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI ICADE CIHS

Syllabus
2024 - 2025

GENERAL INFORMATION

Data of the subject	
Subject name	Aerospace Electronics
Subject code	DEA-OPT-438
Mainprogram	Bachelor's Degree in Electromechanical Engineering
Involved programs	Grado en Ingeniería en Tecnologías de Telecomunicación [Fourth year] Grado en Ingeniería en Tecnologías Industriales [Fourth year]
Quarter	Semestral
Credits	3,0 ECTS
Type	Optativa (Grado)
Department	Department of Electronics, Control and Communications

Teacher Information	
Teacher	
Name	Joaquim de Curtò i Díaz
Department	Department of Electronics, Control and Communications
EMail	jdecurto@icai.comillas.edu

DESCRIPTION OF THE SUBJECT

Contextualization of the subject

Prerequisites

Contextualization of the Course

Contribution to the Professional Profile of the Degree

The aim of this course is twofold:

1. **Understanding the Space Market**:
   - Students will gain insights into the space market, its constraints, the main actors, and the primary products: the spacecraft and the science obtained.
2. **Development Process of Space Electronics**:
   - Students will go through the complete development process of a space electronics product, typically an equipment (hardware/software).

Course Coverage

- **Technologies, Tools, and Methods**:
  - Designing electronic equipment.
  - Overview of electronic systems and equipment found in spacecraft developments such as power, data handling, and instrumentation.

- **Cost Impact Overview**:
  - Understanding the cost impacts derived from design and development activities.
- **Practical Exposure**:
  - Includes a visit to a top engineering facility (2 or 3 sessions) to provide an overview of development facilities (assembly/testing/software) and to experience a working day in a real environment with dedicated engineering support from experts in the area.

Prerequisites

- **Fundamentals of Electronics**: Analogue and digital circuits.
- **Fundamentals of Signal Processing/Data Science/Programming:** basics of statistical estimation and some knowledge of python.
- **Interest**: Curiosity about the space market and products.

Course contents

Contents

SECTION 1: Introduction to Space Market

This section aims to understand the specific constraints, needs, and context of the space market.

Chapter 1: Introduction to space market

- 1.1 Overview of S/C types
- 1.2 Main actors and normative in space product development: constraints and context of space products

Chapter 2: Constraints and context of space products

- 2.1 Main factors constraining the development of an electronic component in a space application
- 2.2 Comparison between on-ground equipment and on-board equipment: Figures and size of space electronics in comparison to on-ground equipment

SECTION 2: Introduction to main electrical S/C subsystems and equipment

This section introduces the power and data handling subsystems, providing an overview of typical units both on platform and payload (optical instruments).

Chapter 3: Power subsystem

- 3.1 Power subsystem architecture: main elements
- 3.2 Power subsystem elements sizing: solar panel, batteries, power distribution

Chapter 4: Data handling subsystem and equipment

- 4.1 Data handling subsystem architecture: main elements (antennas, processor...)
- 4.2 Typical space application equipment

SECTION 3: Designing electronic equipment for space applications

This section deals with the process, methods, and tools to design electronic equipment for space application.

Chapter 5: Specification preparation

- 5.1 How to prepare a specification – contents – requirements flow down (trace and applicability)
- 5.2 Requirement classification
- 5.3 Sizing requirements vs. non-sizing requirements

Chapter 6: Parts selection

- 6.1 EEE engineering
- 6.2 EEE parts – how are these selected?

Chapter 7: Design and dependability analysis: introduction

This section deals with the analysis to be carried out to assess a design and its performance.

- 7.1 Worst Case Analysis: concepts and purpose
- 7.2 Parts Stress Analysis: concept and purpose

SECTION 4: Introduction to electronics equipment development

This section introduces the phases, methods, and tools, and the product generated when designing electronic equipment for space applications.

Chapter 8: Development process

- 8.1 Development vs. design
- 8.2 Phases and life-cycles. Reviews
- 8.3 Main elements for the development of equipment
- 8.4 Design documentation

Chapter 9: Visit to a top engineering facility or equivalent activity (Gaming Activity): Space Electronics Design & Development

EVALUATION AND CRITERIA

Grading

Competences and Learning Outcomes

Competences

General Competences

- **CG2**: The ability to manage activities of engineering projects described in CG1 competence.
- **CG3**: The capability of adapting to new theories, methods, and changing engineering situations based on sound technical training.
- **CG4**: The capability of solving problems with personal initiative, efficient decision-making, critical reasoning, and transmitting technical information in the engineering world.
- **CG5**: The capability of understanding (and potentially providing) coarse assessment, trade-offs, and sizing.
- **CG10**: The ability to work in a multilingual and multidisciplinary environment.

Learning Outcomes

By the end of the course, students should be able to:

- **RA1**: Understand the space environment, market, and context.
- **RA2**: Understand the concept and use of electronics in the aerospace electronic field: main systems and equipment.
- **RA3**: Provide an overview of the development process of aerospace electronic equipment.
- **RA4**: Understand the main processes and tools used both for requirement engineering and designing.
- **RA5**: Select the main electronics parts for a space-qualified electronic design.
- **RA6**: Design a basic electronic circuitry (flightable design).
- **RA7**: Produce a basic functional specification (user side) and the backbone of a complete specification.
- **RA8**: Describe the main analyses to be carried out in order to guarantee the final product.

Teaching Methodology

General Methodological Aspects

The course will promote the student's own activity and involvement as the key factors to achieve the intended skills.

In-Class Activities

- **Lectures (21.5 hours)**: Theory and in-class discussion about problems previously solved at home.
  - Competences: CG5, CG3
- **Team Project (5 hours)**: Application of system analysis and research based on acquired knowledge to a specific use case or application.
  - Competences: CG4, CG2, CG10
- **Mid-term Exam (1.5 hours)**: To promote continuous work and permit continuous assessment.

Out-of-Class Activities

- **Review of the Material Presented in Lectures (12 hours)**
  - Competences: CG5, CG3
- **Personal Work on Homework Assignments (12 hours)**
  - Competences: CG5, CG3
- **Team Working on a Common Project (5 hours)**
  - Competences: CG4, CG2, CG10
- **Visit to a Top Engineering Facility**
  - Lecture from several senior experts in the field on different areas, such as space missions, costs, guidance, and navigation.
  - Understanding the Space Engineering development environment.

Assessment and Grading Criteria

Assessment Activities

Mid-term Exam: 30%

- Understanding of theoretical concepts.
- Application of these concepts to problem-solving.
- Critical analysis of numerical exercises' results.

Continuous Evaluation of Individual Learning Evolution: 10%

- Understanding theoretical aspects and their pragmatic application based on self-study.

- Preparation of classes.
- Class participation based on individual contributions.

Individual Project Report or Research Paper: 30%

- Understanding theoretical aspects and application of theory to a design case.
- Analysis and interpretation of results from problem-solving.
- Research and autonomy capabilities.
- Decision-making capabilities (line of argument, trade-offs).
- Understanding how to produce the output information.

Team Project Presentation: 30%

- Teamwork capacity.
- Understanding the development process and the expected outputs.
- Understanding how to produce the output information.
- Workload distribution to allow continuous and gradual advance.
- 15 mins in-class presentation.

Grading

Regular Assessment

- The assessment will take into account:
  - **Mid-term Exam (ME)**: 30%
  - **Individual Contribution in Class (IC)**: 10%
  - **Individual Project Report or Research Paper (IP)**: 30%
  - **Team Project Presentation (TP)**: 30%
- **Final Grade**: ME (30%) + IC (10%) + IP (30%) + TP (30%)
- The mark of the final exam must be greater or equal to 3.5 out of 10 points, and the mark of the final project must be at least 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

Retakes

- Lab practice (teamwork project) mark will be preserved, as well as that of the individual project if they show a passing grade. Otherwise, a new project will have to be developed and handed in. Additionally, the student will take a final exam.
- **Resulting Grade**:
  - Final Exam: 40%
  - Lab Practices (Teamwork Project Presentation): 30%
  - Final Project (Individual Paper): 30%
- As in the regular assessment period, in order to pass the course, the mark of the final exam must be greater or equal to 4 out of 10 points, and the mark of the final project must be at least 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

Course Rules

- **Class Attendance**: Mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Académicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences:
  - Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.

- Regarding laboratory, absence to more than 15% of the sessions can result in losing the right to take the final exam of the regular assessment period and the retake. Missed sessions must be made up for credit.

- **Academic Integrity**: Students who commit an irregularity in any graded activity will receive a mark of zero in the activity, and disciplinary procedures will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

WORK PLAN AND SCHEDULE

Activities	Date of realization	Delivery date
A detailed work plan of the subject can be found in this section. Nevertheless, this schedule is tentative and may vary to accommodate the rhythm of the class. **IN-CLASS AND OUT-OF-CLASS ACTIVITIES** **Weeks 1 & 2** • **Hours/Week**: 2.5 • **Lecture & Problem Solving**: Course presentation and Introduction to space market • **Self-Study**: Review and self-study (3 hours) • **Learning Outcomes**: RA1 **Weeks 3 & 4** • **Hours/Week**: 4.5 • **Lecture & Problem Solving**: Main electrical and electronic systems and equipment in an S/C: Power S/S • **Self-Study**: Review, self-study and problem-solving (4 hours) • **Learning Outcomes**: RA2 **Week 5** • **Hours/Week**: 3 • **Lecture & Problem Solving**: Main electrical and electronic systems and equipment in an S/C: Data handling S/S and equipment • **Self-Study**: Review, self-study and problem-solving (4 hours) • **Lab Preparation**: Project Team-preparation (1 hour) • **Learning Outcomes**: RA2 **Week 6** • **Hours/Week**: 2 • **Lecture & Problem Solving**: Power S/S sizing - In-class activity; Equipment sizing - In-class activity • **Self-Study**: Review, self-study and problem-solving (5 hours) • **Lab Preparation**: Project Team-preparation (1 hour)		

• **Learning Outcomes**: RA2 **Week 7** • **Hours/Week**: 2 • **Lecture & Problem Solving**: Requirement engineering: process and tools; Specification preparation • **Self-Study**: Review, self-study and problem-solving (6 hours) • **Lab Preparation**: Project Team-preparation (2 hours) • **Learning Outcomes**: RA3, RA4 **Week 8** • **Hours/Week**: 1.5 • **Lecture & Problem Solving**: Requirement engineering: process and tools; Specification preparation • **Assessment**: Mid-Term Exam • **Lab Preparation**: Project Team-preparation (2 hours) • **Learning Outcomes**: RA3, RA4 **Week 9** • **Hours/Week**: 2 • **Lecture & Problem Solving**: Detailed design: Components selection; Electronic parts engineering • **Assessment**: Mid-term exam (1 hour) • **Self-Study**: Review and self-study (2 hours) • **Lab Preparation**: Project Team-preparation (2 hours) • **Learning Outcomes**: RA5, RA6 **Week 10** • **Hours/Week**: 2 • **Lecture & Problem Solving**: Industrial day at Engineering facility: Design/development cases and supply chain overview • **Self-Study**: Individual Paper preparation (3 hours) • **Learning Outcomes**: RA6, RA8 **Week 11** • **Hours/Week**: 2 • **Lecture & Problem Solving**: Industrial day at Engineering facility: Design/development cases and supply chain overview • **Lab Preparation**: Project Team-preparation (1.5 hours) • **Self-Study**: Individual Paper preparation (3 hours) • **Learning Outcomes**: RA6, RA8 **Week 12** • **Hours/Week**: 2 • **Lecture & Problem Solving**: Industrial day at Engineering	TBD	TBD

facility: Design/development cases and supply chain overview • **Lab Preparation**: Project Team-preparation (1.5 hours) • **Self-Study**: Individual Paper preparation (3 hours) • **Learning Outcomes**: RA1, RA6, RA8 **Week 13** • **Hours/Week**: 2.5 • **Lecture & Problem Solving**: Equipment development cycle: phases, tools and facilities, design methodology, design documentation • **Self-Study**: Review and self-study (2 hours) • **Lab Preparation**: Project Team-preparation (3 hours) • **Self-Study**: Individual Paper preparation (3 hours) • **Learning Outcomes**: RA3 **Week 14** • **Hours/Week**: 2 • **Lecture & Problem Solving**: Final Presentations (2 hours) • **Learning Outcomes**: RA9		
In and Out-of-Class Activities **Activity**: Reviewing and self-study using textbooks • **Date/Periodicity**: After each in-class session **Activity**: Problem-solving assignments (quizzes) • **Date/Periodicity**: After specific sections of the course **Activity**: Mid-term exam preparation • **Date/Periodicity**: TBD **Activity**: Team work presentation • **Date/Periodicity**: Week 15 **Activity**: Visit to top engineering facility • **Date/Periodicity**: TBD **Student Work-Time Summary** **In-Class Hours** **Activity**: Lectures • **Hours**: 18 **Activity**: Problem solving and team project presentation • **Hours**: 5 **Activity**: Visit to plant	TBD	TBD

• **Hours**: 6 **Activity**: Assessment • **Hours**: 1 **Out-of-Class Hours** **Activity**: Student work on the lectures and self-study • **Hours**: 26 **Activity**: Student work on quizzes • **Hours**: 8 **Activity**: Team work • **Hours**: 14 **Activity**: Individual project preparation • **Hours**: 12 **Total ECTS Credits** **Credits**: 3 (90 hours)		

BIBLIOGRAPHY AND RESOURCES

Basic References

Bibliography

Basic Bibliography

- **ECSS Standards**: Open distribution
- **Specific aerospace notes and papers**

Complementary Bibliography

- **Space Mission Analysis and Design** by James R. Wertz & Wiley J. Larson – Third Edition
- **Space Mission Engineering: The New SMAD** (Space Technology Library, Vol. 28, Microcosm Inc., July 2011 Edition, ISBN: 1881883159)