Course guide
19611 - SSE - Space Systems Engineering

Last modified: 22/01/2024

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

Degree: MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2015). (Compulsory subject).
MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2021). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Defined in the course webpage at the EETAC website.

Others: Defined in the course webpage at the EETAC website.

PRIOR SKILLS

.- Operativity with the concepts, magnitudes and basic laws of Physics and its principles of conservation.
.- Operationality in the differential and integral calculation, and in the calculation with complex numbers.
.- Operationality with algebraic structures, ordinary differential equations, vector spaces and arrays.
.- Operability with probability distribution and statistical data functions.
.- Operability with the basic magnitudes and principles of Thermodynamics as well as the physical behavior of fluids and gases in different conditions of pressure and temperature.
.- Ability to perform application programs in Matlab / Octave or C # language or similar.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE1 MAST21. Apply the scientific method to the study of the particular phenomenology of the aerospace environment.
CE2 MAST21. Apply systems engineering in the aerospace environment for the design and management of the different technological aspects associated with a mission.
CE3 MAST21. Carry out, present and publicly defend a research work carried out in a group, on a research topic in the aerospace field.

Generical:
CG2 MAST. Identify and apply the fundamental theoretical, experimental and numerical analyzes currently used in aerospace engineering.
CG3 MAST. Identify and consistently manage the different types of aerospace vehicles and the technological, design and implementation aspects of payloads for scientific missions.

Transversal:
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Basic:
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context.
CB7. Students will be able to apply the acquired knowledge and their ability to solve problems in new or little explored environments in broader (or multidisciplinary) contexts related to their study area.
CB9. Students will be able to communicate their conclusions and the knowledge and ultimate reasons that support them to specialized and non-specialized audiences in a clear and unambiguous manner.
CB10. Students will acquire learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.

TEACHING METHODOLOGY

MD1: Master class
MD2: Participatory expositive class
MD4: Problem / project based learning
MD5: Autonomous work
MD6: Cooperative work

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course, the student will be able to:
1. Develop the initial phase of a mission based on defined objectives.
2. Design the prototype of a satellite.
3. Make estimates on the different subsystems and their characteristics.
4. In particular, evaluate the best orbit according to the requirements of the mission.
5. Take knowledge about the design of complex systems.
6. Work in a team, evaluate your own work and that of others.
7. Accept reviews and perform self-analysis.

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	36.00
Self study	80,0	64.00

Total learning time: 125 h

CONTENTS

1. Mission analysis and Conceptual Design

Description:
1. Architecture of a space mission. Phases in the design of a mission: ECSS standard.
2. Characteristics of the payload of a mission.
3. Systems Engineering

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP6: Elaboration of cooperative works
AFP7: Attendance at seminars and conferences related to the subject matter.
AFP8: Tutoring.

Full-or-part-time: 12h 42m
Theory classes: 4h 30m
Self study : 8h 12m

2. Objectives of a scientific mission. Requirements and Tradeoffs

Description:
1. Science from Space. Examples in astronomy, geology, materials science, biology, fundamental physics.
2. General scientific objectives.
3. Characteristics of scientific payloads.
4. Payload requirements. Requirements of space telescopes.

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP2: Exhposition of contents with student participation.
AFP3: Problem solving, with student participation.
AFP4: Practical laboratory sessions individually or as a team
AFP5: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher.
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AFP8: Tutoring.

AFN1: Study and preparation of contents.
AFN2: Realization of exercises and theoretical or practical works outside the classroom, individually or in a group.
AFN3: Realization of projects proposed by teachers outside the classroom, individually or in groups.
AFN4: Preparation and realization of evaluable activities.

Full-or-part-time: 16h 36m
Theory classes: 6h
Self study : 10h 36m

3. Orbits and Space Environment.

Description:
1. Orbital design process. Orbital Typology and Operations. Orbital transfer. Rendezvous. Parking orbit and maintenance orbit. De-orbit.
2. Launch environment. Land cover. Launch and tracking stations. Launch window selection
3. Effects of the spatial environment. Evaluation of orbital disturbances: gravitational, third body, atmospheric drag, solar radiation pressure, Earth's magnetic field.

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Full-or-part-time: 25h 04m
Theory classes: 9h
Self study : 16h 04m

4. Satellite platform.

Description:
1. Configuration and structure. Requirements design and process design.
2. Thermal control. The space environment. Equation of thermal balance. Passive systems: absorbency and emittance of surfaces. Active systems: heat transfer towers, shutters.
3. Power subsystem. Power sources. Batteries and photovoltaic systems. Fuel cells. Passive and active systems.
4. Computer system of the aircraft. Terrestrial radiation environment: SEUs and Latch-ups. Computer requirements. Qualified electronics for space.
5. Propulsion. Systems and classification. Chemical propellants and electric propellers. Secondary propulsion.
6. Control and determination of the attitude. Interference tensioner and Euler equation. Classification according to attitude control requirements: 3-axes stabilized satellites, spinners, hybrids. Gyroscopes and moment wheels. Sensors and actuators. Limbo, solar and stellar sensors. Actuators by magneto-torquers, propellers and stabilization by gravitational gradient.

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5. Communications

Description:
1. Communications Architecture. Ground station, terrestrial segment, user segment. Telemetry and remote control.
2. Data speed. Digital and / or analog data. A / D converter. Directional and omnidirectional antennas, gain, predictions, modulation, frequencies. Data compression.
3. Link design. Typology: uplink, downlink, crosslink, forward / return link. Design criteria: orbit, RF spectrum, data rate, duty factor, link availability, access time, etc.
4. PayLoad Data Handling System. Core items. Architecture of the PDHU.

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Theory classes: 6h
Self study : 10h 36m

6. Ground and user segment

Description:
1. Design of the ground and user segment.
2. Mission control center. Tasks and elements. Scientific operations planning committee.
3. CCSDS standard
4. Office of Control of the Authority
5. Data storage, exploitation and dissemination

Related activities:
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7. Management of space missions

Description:
1. Cost estimate.
2. Policy and legislation considerations
3. Quality control

Related activities:
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Self study : 8h 12m

ACTIVITIES

A1: Exposició de continguts teòrics mitjançant classes magistrals

Description:
Exhibition of theoretical content through master classes

Full-or-part-time: 10h
Theory classes: 10h

A2: Presentation of contents with student participation

Description:
Depending on availability, the analysis and design of the proposed Mission may be carried out jointly with groups from other universities, both at the state, European and / or international level. Such would be the case, for example, of ESA's Challenging Concurrent Design program. Through a videoconferencing system and group communication platforms, students will be able to work collaboratively in the development of the different subsystems as well as competitively in the design of the Mission.

Full-or-part-time: 20h
Theory classes: 20h

A3: Problem solving with student participation

Full-or-part-time: 10h
Theory classes: 10h

A5: Classroom discussion of problems or articles, carried out by the students and moderated by the teacher

Full-or-part-time: 12h
Theory classes: 12h

A8: Tutorships

Full-or-part-time: 4h
Guided activities: 4h

A9: Study and preparation of the contents

Full-or-part-time: 30h
Self study: 30h

A10: Carrying out exercises and theoretical or practical work outside the classroom, individually or in groups

Full-or-part-time: 10h
Self study: 10h

A11: Carrying out projects proposed by teachers outside the classroom, individually or in groups

Full-or-part-time: 20h
Self study: 20h

A12: Preparation and performance of assessable activities

Full-or-part-time: 9h
Self study: 9h

GRADING SYSTEM

Defined in the course webpage at the EETAC website.

EXAMINATION RULES.

All the evaluation activities proposed are mandatory. An exam, deliverable or project not presented will be scored with a zero note. The examinations will be carried out individually, the project will be carried out in group and the delivery of problems can be both group and individual.

BIBLIOGRAPHY

Basic:
- Messerschmid, Ernst; Bertrand, Reinhold. Space stations : systems and utilization. Berlin [etc.]: Springer, cop. 1999. ISBN 354065464X.
- Wertz, James Richard; Larson, Wiley J. Space mission analysis and design. 2nd ed. Torance (Califonia) : Dordrecht: Microcosm ; Kluwer Academic Publishers, cop. 1992. ISBN 0792319982.

Complementary:
- Thomson, William Tyrrell. Introduction to space dynamics. New York: Dover, 1986. ISBN 0486651134.
- Sutton, George P; Biblarz, Oscar. Rocket propulsion elements [on line]. 7th ed. New York: John Wiley & Sons, cop. 2001 [Consultation: 15/07/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=818989. ISBN 0471326429.