Last update: 24-07-2018

# 19611 - SSE - Space Systems Engineering

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2018
Degree: MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2009). (Teaching unit Compulsory)
MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2015). (Teaching unit Compulsory)
ECTS credits: 5 Teaching languages: English

## Teaching staff

Coordinator: 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

Basic:

CB6. (ENG) CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación.
CB7. (ENG) CB7 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.
CB9. (ENG) CB9 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades.
CB10. (ENG) CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

Specific:

CE5 MAST. (ENG) CE5: Aplicar la ingeniería de sistemas en el entorno aeroespacial para el diseño y la gestión de los distintos aspectos tecnológicos asociados a una misión.

Transversal:

CT1b. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding the mechanisms on which scientific research is based, as well as the mechanisms and instruments for transferring results among socio-economic agents involved in research, development and innovation processes.
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.

## Teaching methodology

The classes of the subject will be presential and expositive. Teaching material will be composed of PowerPoint presentations (which can be obtained from the first day) and links to pages of special relevance. Software will also be used such as SaTrak -for the calculation and representation of orbits. Group work will be one of the essential characteristics of the subject, since the students will have to do a project designing at the basic level the subsystems of a space mission and doing their exposition at the end of the course.
In particular, the teaching methodologies applied during the course will be:
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. Evaluate the best orbit according to the requirements of the mission.
2. Design the prototype of a satellite.
3. Make basic estimates about the different subsystems and their characteristics.
4. Develop the initial phase of a mission based on defined objectives.
5. Get acquittance about the design of complex systems.
6. Develop team work skills, evaluate your own work and that of others.
7. Accept revisions and perform self-analysis.

## Study load

| | | | |
|---|---|---|---|
| Total learning time: 125h | Hours large group: | 45h | 36.00% |
| | Hours medium group: | 0h | 0.00% |
| | Hours small group: | 0h | 0.00% |
| | Guided activities: | 0h | 0.00% |
| | Self study: | 80h | 64.00% |

## Content

| 1. Mission analysis and Conceptual Design | Learning time: 12h 42m<br>Theory classes: 4h 30m<br>Self study : 8h 12m |
| --- | --- |

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

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.

| 2. Objectives of a scientific mission. Requirements and Tradeoffs | Learning time: 16h 36m<br>Theory classes: 6h<br>Self study : 10h 36m |
| --- | --- |

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.
AFP6: Elaboration of cooperative works
AFP7: Attendance at seminars and conferences related to the subject matter.
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.

| 3. Orbits and Space Environment. | Learning time: 16h 36m<br>Theory classes: 6h<br>Self study : 10h 36m |
| --- | --- |

Description:
1. Classical orbital elements and alternative orbital elements.
2. Types of orbit. Orbits depending on its center, altitude, inclination, eccentricity and synchronism.
3. Orbital operations. Orbital transfer. Hohmann transfer. Orbital plane change. Rendezvous Parking orbit and maintenance orbit. De-orbit.
4. Launching environment. Land cover. Launching and tracking stations. Launching windows. Orbital design process.
5. Effects of the space environment. Orbital disturbances: gravitational, third body, atmospheric friction, solar radiation pressure, terrestrial magnetic field.

Related activities:
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| 4. Detectors | Learning time: 16h 36m<br>Theory classes: 6h<br>Self study : 10h 36m |
| --- | --- |

Description:
1. Types of Detectors: photonic, thermal and coherent. Relevant parameters: quantum efficiency, noise, linearity, dynamic range, number and pixel size, response time, spectral response, bandwidth.
2. Detectors for SAA: detectors of high energy particles, X-rays and gamma rays. Nuclear emulsion and the study of high energy particles. Plastics and meteorites. Gas detectors: proportional counters, Geiger counter and scintillation chambers. Solid state devices: semiconductors, scintillation devices, crystal detectors and Cherenkov detectors.
3. Example of development: INTEGRAL, CLAIRE, MAX ...

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| 5. Satellite platform. | Learning time: 16h 36m<br>Theory classes: 6h<br>Self study : 10h 36m |
|---|---|

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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| 6. Communications | Learning time: 16h 36m<br>Theory classes: 6h<br>Self study : 10h 36m |
|---|---|

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. Application examples: SIXE, GAIA-

Related activities:
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| 7. Ground and user segment | Learning time: 16h 36m<br>Theory classes: 6h<br>Self study : 10h 36m |
| --- | --- |

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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| 8. Management of space missions | Learning time: 12h 42m<br>Theory classes: 4h 30m<br>Self study : 8h 12m |
| --- | --- |

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

Related activities:
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AFP3: Problem solving, with student participation.
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## Qualification system

Defined in the course webpage at the EETAC website.

## Regulations for carrying out activities

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. 7th ed. New York: John Wiley & Sons, cop. 2001. ISBN 0471326429.