19613 - ANP - Architecture of Nano and Picosatellites

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 Optional)
MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2015). (Teaching unit Optional)
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
This subject requires knowledge of Physics, Mathematics, and Engineering. It would be highly desirable to have been enrolled in the topic on "Spacecraft Systems Engineering". Basic knowledge of Matlab/Octave is also required.

Degree competences to which the subject contributes

Basic:
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.
CB8. (ENG) CB8 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios.

Specific:
CE3 MAST. (ENG) CE3: Aplicar los métodos numéricos para ingeniería aeroespacial con especial énfasis en sus aplicaciones, y en especial en la dinámica de fluidos.
CE4 MAST. (ENG) CE4: Aplicar el método científico para el estudio de la fenomenología particular del ambiente aeroespacial.
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.

General:
CG1 MAST. (ENG) CG1: Identificar y conocer las principales actividades de I+D+i en el campo aeroespacial que se lleva a cabo actualmente a nivel internacional en el ámbito académico, la industria y las mayores agencias espaciales.
CG2 MAST. (ENG) CG2: Identificar y aplicar los análisis teóricos, experimentales y numéricos fundamentales de uso actual en ingeniería aeroespacial.

Transversal:
CT2. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.
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.
At the end of the topic, students will be able to identify, analyze and write the requirements of a space mission to be undertaken by means of a small satellite (less than a few tens of kilograms). They will also be able to predict the environmental conditions for the mission and to perform a Phase A design of the satellite, including its configuration, structure, power, attitude determination and control, onboard computer, thermal control, and communications subsystems, as well as the tests required to ensure that the different subsystems will perform as expected. Students will know and apply the main methods for preliminary cost determination.

We will make special emphasis on the differences between small satellite and standard satellite engineering.
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<table>
<thead>
<tr>
<th>Content</th>
<th>Learning time: 3h</th>
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</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>Theory classes: 1h</td>
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<tr>
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<td>Self study: 2h</td>
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</tbody>
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**Description:**
1. A short history of Small Satellites
2. Why small?
3. Basics of Spacecraft Systems Engineering

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

<table>
<thead>
<tr>
<th>Content</th>
<th>Learning time: 11h</th>
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</thead>
<tbody>
<tr>
<td><strong>Space Environment</strong></td>
<td>Theory classes: 3h</td>
</tr>
<tr>
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<td>Practical classes: 1h</td>
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<tr>
<td></td>
<td>Self study: 7h</td>
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</table>

**Description:**
1. Microgravity
2. The neutral medium. The high atmosphere
3. The ionized environment and the magnetosphere
4. The effects of vacuum
5. Ionizing radiation
6. Micrometeoroids and space debris

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<thead>
<tr>
<th>Content</th>
<th>Learning time: 9h</th>
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<tbody>
<tr>
<td><strong>Small satellite launchers</strong></td>
<td>Theory classes: 3h</td>
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<td>Practical classes: 1h</td>
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<td>Self study: 5h</td>
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</table>

**Description:**
1. Rocket basics
2. Piggyback launches
3. Small launchers
### Systems Engineering

**Learning time:** 7h  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h

**Description:**  
1. What is Systems Engineering?  
2. Spacecraft Design Process  
3. Concurrent Design  
4. On-orbit failure analysis

### Structure

**Learning time:** 11h  
Theory classes: 3h  
Practical classes: 1h  
Self study: 7h

**Description:**  
1. Satellite configuration  
2. Primary and Secondary Structure  
3. Shaker tests  
4. Materials  
5. 3D printed structures

### Power Subsystem

**Learning time:** 11h  
Theory classes: 3h  
Practical classes: 1h  
Self study: 7h

**Description:**  
1. Power bus types: non-regulated, quasi-regulated, regulated  
2. Photovoltaic systems  
3. Batteries  
4. Fuel cells
<table>
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<tr>
<th>Course</th>
<th>Learning time:</th>
<th>Description:</th>
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</table>
| **Communications**                        | 11h            | **Theory classes:** 3h  
Practical classes: 1h  
Self study : 7h               |
| **Tracking, Telemetry, and Commands**     | 6h 30m         | **Theory classes:** 1h 30m  
Practical classes: 0h 30m  
Self study : 4h 30m |
| **Thermal control**                       | 11h            | **Theory classes:** 3h  
Practical classes: 1h  
Self study : 7h               |

| **Description:**                          |                | **1.** Communications basics. The link equation  
**2.** Antennae  
**3.** Receivers and transceivers  
**4.** Signal modulation  
**5.** Ground stations  
**6.** Software Defined Radio |
| **Description:**                          |                | **1.** Commands  
**2.** Error correcting techniques  
**3.** Telemetry standards |
| **Description:**                          |                | **1.** Energy transport mechanisms  
**2.** Optical properties of surfaces  
**3.** Thermal balance equation  
**4.** Passive thermal control systems  
**5.** Active thermal control systems  
**6.** Tests on thermal vacuum chambers |
### Onboard computer

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<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>1. Radiation effects</td>
<td></td>
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<tr>
<td>2. Processors</td>
<td></td>
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<tr>
<td>3. Memory</td>
<td></td>
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<tr>
<td>4. Data storage</td>
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<tr>
<td>5. Communication buses: I2C, SpaceWire</td>
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**Learning time:** 7h  
- Theory classes: 2h  
- Practical classes: 0h 30m  
- Self study: 4h 30m  

### Attitude Determination and Control

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<tr>
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<tbody>
<tr>
<td>1. Basic Mechanics. Inertia tensor and Euler equations</td>
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<tr>
<td>2. Attitude representations</td>
<td></td>
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<tr>
<td>3. Classification of satellites: non-stabilised, spinners, duals spinners, momentum bias, three-axis stabilised</td>
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<tr>
<td>4. Attitude sensors</td>
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<td>5. Attitude actuators</td>
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**Learning time:** 11h  
- Theory classes: 3h  
- Practical classes: 1h  
- Self study: 7h  

### Propulsion

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<tbody>
<tr>
<td>1. Cold gas thrusters</td>
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<td>2. Chemical rockets</td>
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<td>3. Electric engines</td>
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<td>4. Electromagnetic engines</td>
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<td>5. Solars sails</td>
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**Learning time:** 11h  
- Theory classes: 3h  
- Practical classes: 1h  
- Self study: 7h
## Tests

**Description:**
1. Integration
2. Reliability statistics. The Weibull distribution
3. Testing

**Learning time:** 6h  
Theory classes: 1h 30m
Practical classes: 0h 30m
Self study: 4h

## Cost analysis

**Description:**
1. Cost options
2. Parametric and non-parametric determinations
3. Cost reduction techniques

**Learning time:** 5h 30m  
Theory classes: 1h
Practical classes: 0h 30m
Self study: 4h

## Legal issues

**Description:**
1. The UN space treaties
2. Insurance and liability
3. National regulations
4. Launch license
5. Communications and the ITU

**Learning time:** 4h  
Theory classes: 1h
Self study: 3h

## Qualification system

Defined in the course webpage at the EETAC website.
Bibliography

Basic:


Complementary:
