UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Course guide
300085 - TM - Aircraft Trajectory Management

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

Degree: MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Optional subject).
MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2021). (Optional subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Prats Menendez, Xavier

Others: Prats Menendez, Xavier

PRIOR SKILLS

Previous concepts include knowledge of flight mechanics, control and guidance, and air traffic management, given in any bachelor's degree in aerospace engineering and reviewed in previous subjects of this Master's degree, as well as familiarity with the use of computing tools for engineering. Familiarity with Python and/or Matlab is required.

REQUIREMENTS

Concepts seen in 220309 - Transport Aeri i Sistemes de Navegació
(https://www.upc.edu/estudispdf/guia_docent.php?codi=220309&idioma=en)

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.

Generical:
CG1 MAST. Identify and learn about the main R+D+i activities in the aerospace field that are currently carried out internationally in academia, industry and the largest space agencies..
CG2 MAST. Identify and apply the fundamental theoretical, experimental and numerical analyzes currently used in aerospace engineering.

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.
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.

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.
CB8. Students will be able to integrate knowledge and face the complexity of formulating judgments based on information that, while being incomplete or limited, includes reflections on social and ethical responsibilities linked to the application of their knowledge and opinions.
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

Specific competences:

CEEaeronav1: Optimizar, predecir o simular las trayectorias de las aeronaves en cualquier fase del vuelo, a partir del análisis de sus prestaciones y el medio operacional y físico en el que se desenvuelven.

The course combines the following teaching methodologies:
- Theoretical lectures.
- Autonomous learning: students will study using self-learning material
- Cooperative learning: students will form small group (2-4 people) to fulfil some of the activities of the course
- Project based learning: students will build a small team project (3-4 people)

Directed learning hours will consist in exercises and practical examples, after the theory classes in which the lecturer exposes the content of the subject. With the directed learning hours, the students will be motivated to participate actively in their education and to complete the knowledge acquired during theory classes, usually with the help of computers.

LEARNING OBJECTIVES OF THE SUBJECT

This course focuses on the mathematical computation and modelling of aircraft trajectories. Different types of aircraft will be considered, such as airliners, gliders or aerobatic airplanes, helicopters or rocket launchers. The course covers the whole lifecycle of an aircraft trajectory computation, from its design (and optimisation) to the selection of the guidance commands for the (auto)pilot.
At the end of the course, the student will be able to:
. model the dynamics of an aircraft with a three-degree-of-freedom model;
. identify the different sources of uncertainty affecting the modelling and execution of aircraft trajectories;
. understand the concepts of flight intent, aircraft intent, and guidance modes;
. identify the principal components and functionalities in modern automatic-flight systems and trajectory computation ground-based tools.

STUDY LOAD

Type	Hours	Percentage
Hours small group	30,0	24.00
Self study	80,0	64.00
Hours large group	15,0	12.00

Total learning time: 125 h

CONTENTS

Introduction

Description:
- Introduction to trajectory modelling and review on flight mechanics and aircraft performance.
- Three-degree of freedom models for aircraft dynamics
- Trajectory uncertainty modelling and quantification
- Overview on trajectory prediction, optimisation, guidance, control and simulation.

Full-or-part-time: 12h
Theory classes: 2h
Laboratory classes: 4h
Self study : 6h

Use cases and review on trajectory management systems.

Description:
Overview, description and literature review on:
- Flight dispatching tools
- Flight management and guidance systems.
- Other on-board applications in electronic flight bags (EFB).
- Air/ground trajectory synchronization.
- Air traffic control decision support tools (AMAN, DMAN, …)
- Aircraft separation and safety nets (MTCD, STCA, ACAS, ASAS, …)
- Flight simulation.

Full-or-part-time: 12h
Theory classes: 2h
Practical classes: 4h
Self study : 6h

Project I: trajectory prediction and optimisation

Description:
Working in groups, the students will select a trajectory prediction and/or optimisation challenge among a list of topics proposed by the lecturer, which will cover different use cases and types of aircraft and trajectory missions. The students will develop an algorithm to predict and/or optimise trajectories to address the particular challenge. A report will be delivered and a presentation summarising the achievement will be given in front of the rest of students.

Full-or-part-time: 55h
Theory classes: 6h
Practical classes: 12h
Self study : 37h

Project II: Trajectory guidance and simulation

Description:
As a continuation of the first part of the project, the students will develop a small guidance and simulation software to validate the
Algorithm developed in the first part of the project. A report will be delivered and a presentation summarizing the achievement will be given in front of the rest of students.

Full-or-part-time: 46h
Theory classes: 5h
Laboratory classes: 10h
Self study : 31h

GRADING SYSTEM

Participation in class and exercises: 10%
Individual exams and tests: 35%
Projects and presentations: 55%

BIBLIOGRAPHY

Basic:
- Stevens, Brian L; Lewis, Frank L. Aircraft control and simulation. 2nd ed. New York: Wiley, cop. 2003. ISBN 0471371459.