# Aerospace autonomous systems

**Academic Year: ( 2021 / 2022 )** **Review date: 04-06-2021**

**Department assigned to the subject: Bioengineering and Aeroespace Engineering Department**

**Coordinating teacher: SANCHEZ ARRIAGA, GONZALO**

**Type: Compulsory ECTS Credits : 3.0**

**Year : 2 Semester : 1**

## REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Air Navigation Systems
Elements of Critical Software
Advanced Flight Mechanics

## OBJECTIVES

The skills of the course are CG1-CG10, CB6, CB7, CB8, CB9, CB10, CEC1-CEC6 (see a description in Memoria Verifica)

Among these skills, one finds
1. Acquire knowledge to create the foundations for future originality in the development and application of ideas, often in a research and innovation context.
2. Acquire the capacity to integrate knowledge and face the complexity of judging given information that is incomplete and might include subjective reflexions on social responsibility and ethics.
3. Acquire the capacity to integrate the complex aerospace system and work in multidisciplinary teams.
4. Acquire the capacity to analyze and establish correction measures for the environmental impact of the developed technical solutions.
5. Acquire capacity for the analysis and resolutions of aerospace problems in new or unknown environments, within broad and complex contexts.
6. Competence in all areas related to airport, aeronautical or space technologies that, by their nature, are not exclusive to other branches of engineering.
7. Adequate knowledge of Avionics and Onboard Software, and of the Simulation and Control techniques used in air navigation.

LEARNING OUTCOMES

By successfully completing this course, the student should be able to:

Understand the technologies that apply to aerospace autonomous systems, including legislation, economical and industrial frameworks, and vehicle design. Understand specific issues related to the air navigation, the certification, and the communication (antenna) of autonomous sistems and their future trends.

Understand the mathematical foundations of some of the fundamental systems used of autonomous navigation, including the dynamics of quad-rotors, and the principles of inertial measurement units and Kalman Filters. Understand how these systems can be simulated aided by computersUnderstand how these knowledge can be incorporated into state of the art hardware. Predict the behavior of an autnomous system applying methodologies based on critical thinking, efficiency, and decision-making.

Understand the different elements that compose a quad-rotors, including hardware and software, learn how to ensemble them, calibrate the vehicles, make a flight testing, and analyze the flight data.

## DESCRIPTION OF CONTENTS: PROGRAMME

Block I: Technology that applies to autonomous vehicles

Types of vehicles and design particularities
Distingueshed aspects of the air navigation, certification, and legislation of UAVs
Socio-economical Aspects and air traffic management of UAVs.
Applications and industry
Communication, navigation and surveillance (CNS) sensors for UAVs

Block II: Autonomous guidance, navigation, and control

Arquitecture, methodologies, and decision-making in UAVs.
IMU: accelerometers and gyroscopes
State estimation. Extended Kalman filter
Nonlinear dynamics and control strategies for UAVs.

Block III: Quad-rotor ensambly lab.

Introduction to the onboard software (Arducopter). Concepts, principles, and methods of computational systems in real time
IMU Integration;
Quad-rotor ensambly;
Controllers calibration;
Flight Testing and data analysis.

## LEARNING ACTIVITIES AND METHODOLOGY

TEACHING ACTIVITES

Theoretical sessions

Practical sessions (exercises)

Labs in computer room

Hands-on labs

Individual work by the student

Group work

TEACHING METHODOLOGY

Class exposition with the aid of computers and audiovisuals, and on the blackboard. Development of concepts and analysis of the bibliographic material

Critical lecture of different material: technical reports, papers, manuals.

Resolution of exercises posed by the Professor.

Elaboration of reports and oral communications by the student

## ASSESSMENT SYSTEM

Continuous Evaluation: 40%

a) Homeworks.
b) Quadcopter ensembly/flight test lab (oral communication)

Exam: 60%

Theory Block I, Theory Block II, Problems Block II and Questions about the labs.

Minimum final exam mark is 4 (out of 10) in order to go for the continuous evaluation.

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| **% end-of-term-examination:** | 60 |
| **% of continuous assessment (assigments, laboratory, practicals…):** | 40 |

## BASIC BIBLIOGRAPHY

- Donald Norris Build Your Own Quadcopter: Power Up Your Designs with the Parallax Elev-8, McGraw-Hill/TAB Electronics, 2014
- Kenneth Robert Britting Inertial Navigation Systems Analysis, Artech House, 2010

- Robert M. Rogers Applied Mathematics in Integrated Navigation Systems, American Institute of Aeronautics and Astronautics, 2007
- Valavanis, Kimon P., Vachtsevanos, George J. (Eds.) Hanbook of Unmanned Aerial Vehicles., Springer, 2015

## ADDITIONAL BIBLIOGRAPHY

- Herbert Goldstein Classical mechanics, Addison-Wesley Pub. Co, 1980
- Kenzo Nonami Ph.D., Farid Kendoul Ph.D., Satoshi Suzuki Ph.D., Wei Wang Ph.D., Daisuke Nakazawa Ph.D. (auth.) Autonomous Flying Robots: Unmanned Aerial Vehicles and Micro Aerial Vehicles, Springer, Tokio, 2010
- Paul Zarchan, Howard Musoff, Frank K. Lu Fundamentals of Kalman Filtering:: A Practical Approach, AIAA (American Institute of Aeronautics & Astronautics), 2009
- Mohinder S. Grewal, Angus P. Andrews Kalman Filtering: Theory and Practice with MATLAB, Wiley, 2015 (4th edition)
- Donald Norris Build Your Own Quadcopter: Power Up Your Designs with the Parallax Elev-8, McGraw-Hill/TAB Electronics, 2014
- Guowei Cai, Ben M. Chen, Tong Heng Lee (auth.) Unmanned Rotorcraft Systems, Springer-Verlag London, 2011
- Michael Margolis Arduino Cookbook, O'Reilly, 2012
- Norris Build Your Own Quadcopter: Power Up Your Designs with the Parallax Elev-8, Mc Grawhill, 2014
- Reg Austin Unmanned Aircraft Systems: UAVS Design, Development and Deployment, Wiley, 2010

## BASIC ELECTRONIC RESOURCES

- Mathwoorks . Mathworks: https://ch.mathworks.com/