COURSE DETAILS

SYSTEMS FOR AUTONOMOUS AIRCRAFT

SSDING-IND/05

DEGREE PROGRAMME: AUTONOMOUS VEHICLE ENGINEERING (MOVE)

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

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GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 6

REQUIRED PRELIMINARY COURSES

none

PREREQUISITES (IF APPLICABLE)

none

LEARNING GOALS

The course is intended to provide students with knowledge of engineering problems related to design and operations of unmanned aircraft system. The course tackles the problem of autonomy for aircraft with specific reference to unmanned aircraft systems. UAS are natively realized to perform most of the tasks in an automatic fashion. Very high level of automation, where a number of subsequent decision branches are programmed into the on-board computer, progressively enables fully autonomous aircraft operations.
The course covers basic topics of flight dynamics and control, and applies standard concepts of linear system control theory to enable the design of the onboard autopilot and its integration with autonomous tasks to be performed at higher system level, e.g. path planning and management.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should learn the basic concepts of unmanned aircraft systems for autonomous operations and missions.

Applying knowledge and understanding
Students should learn the drivers for designing unmanned aircraft systems with reference to the common engineering problems associated with autonomous flight dynamics and control, autonomous navigation, autonomous guidance and path plannig.

COURSE CONTENT/SYLLABUS

[0.5 CFU] Intro duction to Autonomous Aircraft. Autonomy in aviation. Levels of Automation. Airworthiness Certification. System Representation of Unmanned Aircraft. Categories of Systems based upon Air Vehicle Types. The System Basis of UAS: Control Station, Payload, Air Vehicle, Navigation System, Launch, Recovery and Transportation Equipment, Communications. UAS System Architecture and the Design Process.

[1 CFU] Coordinate Frames. Inertial, Body, and Wind frame. Euler's Angles. Wind triangle. State Variables for aircraft motion modelling. Translational and Rotational Kinematics. Rigid Body Dynamics. Aerodynamic Forces and Moments. Control Surfaces. Laminar and turbulent flow. Stall. Aircraft static and dynamic stability. Stability and control derivatives. Propulsion forces and moments. Atmospheric disturbances.

[1 CFU] Linear Design Models and Open-Loop Dynamics. Coordinated Turn and Trim Conditions. Transfer function models. Block Diagram for lateral dynamics controlled by the ailerons. Block Diagram for rudder to sideslip dynamics. Longitudinal Transfer function for aileron to pitch and altitude. Transfer function from pitch and throttle to the airspeed.

[0.5 CFU] Linear State-space Models. Lateral and Longitudinal State-space Equations. Reduced-order Modes. Short Period Mode, Phugoid Mode, Roll Mode, Spiral-divergence Mode, Dutch-roll Mode.

[1 CFU] Autopilot Design by Successive Loop Closure. Saturation limits and controller gain selection. Lateral-directional autopilot. Longitudinal Autopilot Design. Altitude-control State Machine.

[0.5 CFU] Sensors and State Estimation. Accelerometers, Rate gyros, Pressure sensors, Magnetometers, GNSSs. Extended Kalman Filter for attitude determination and GNSS smoothing.

[1 CFU] Design Models for Guidance. Path Planner, Path Manager and Path Follower.

[0.5 CFU] Multirotor Aerial Vehicles. Modeling and Simulation. State Estimation and Control of Multirotor Aerial Vehicle. Vision-based altitude hold and position tracking. Hierarchical approach and bandwidth separation in control architectures. Piloting modes. Behavior-based autonomy.

READINGS/BIBLIOGRAPHY

J. Gundlach, Designing Unmanned Aircraft Systems, ISBN 978-1-60086-843-6, Jan. 2012, AIAA Education Series.
R. Austin, Unmanned Aircraft Systems, UAVs Design, Development and Deployment, John Wiley & Sons, 2010.
R. Beard, T. McLain, Small Unmanned Aircraft: Theory and Practice, Princeton University Press, 2012.
Y. B. Sebbane, Smart Autonomous Aircraft, Flight Control and Planning for UAV, CRC Press, 2016.

TEACHING METHODS

Lectures an exercises

EXAMINATION/EVALUATION CRITERIA

*For **integrated courses**, this field should encompass all modules, with indication of the relative weight of each module on the final mark. For integrated courses, this field should be coordinated by the reference teacher for the course.*

a) Exam type:

Exam type	
written and oral	
only written	
only oral	X
project discussion	
other	

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the discussion during the oral exam.

The final evaluation is discussed and highlighted to each student.