

# ADVANCED PROPULSION SYSTEMS

ENAS 465

**Lecture** : 3  
**Tutorial** : 2  
**Practical** : 1

**Year : IV**  
**Part : II**

## Course Objectives:

The objective of this course is to provide students with an understanding of current and emerging technologies in aerospace propulsion. Building on the fundamental concepts covered in the third-year undergraduate propulsion course, it introduces advanced concepts, technologies, and methods for the propulsion of aircraft and spacecraft.

- 1 Aircraft Propulsion (5 hours)**
  - 1.1 Continuous and intermittent combustion engines
  - 1.2 Piston engines
  - 1.3 Turbojet and turbofan engines
  - 1.4 Combustion processes
  - 1.5 Review of Brayton cycle and performance analysis
  - 1.6 On-design versus off-design performance
- 2 Current Propulsion Technologies (8 hours)**
  - 2.1 Benefits and limitations of gas turbine engines
  - 2.2 Combined cycle engines
  - 2.3 Hybrid and regenerative engines
  - 2.4 Airbreathing versus non airbreathing engines
  - 2.5 Current space propulsion systems
  - 2.6 Current orbital launch systems
  - 2.7 Ballistic devices and sounding rockets
- 3 High-Speed Airbreathing Engines (12 hours)**
  - 3.1 Types of flight profiles
  - 3.2 Range of flight speeds and altitudes
  - 3.3 Ramjet engines
  - 3.4 Scramjet engines
  - 3.5 Oblique detonation wave engines / Shcramjet engines
  - 3.6 Pulse detonation engines
  - 3.7 Rotating detonation engines
  - 3.8 Current developments and the state-of-art

**4 Orbital Launch Systems (8 hours)**

- 4.1 Solid propellant rockets
- 4.2 Liquid propellant rockets
- 4.3 Reusability of orbital launch systems
- 4.4 Propellants and their environmental impact

**5 Spacecraft Propulsion (8 hours)**

- 5.1 Orbital mechanics
- 5.2 Orbital and space maneuver
- 5.3 Types of spacecraft thrusters
- 5.4 Planetary reentry and landing systems

**6 Future Concepts and Challenges (4 hours)**

- 6.1 Airbreathing (Hybrid) SSTO concepts
- 6.2 The nuclear option
- 6.3 Fuel problem in space
- 6.4 Fuel problem on earth and sustainability

**Tutorial (30 hours)**

- 1. Analysis of shock-shock interaction patterns in intake and isolator components.
- 2. Estimation of thrust potential and overall performance of propulsion systems.
- 3. Evaluation of single-stage-to-orbit (SSTO) concepts and feasibility.

**Practical (15 hours)**

- 1. Generation of propulsion system schematics using Inkscape and LaTeX tools.
- 2. Investigation of unstart phenomena during experimental testing.
- 3. Design of high-speed air intakes and flowfield analysis.
- 4. Calculation of non-equilibrium thermochemical flows in propulsion nozzles.

**Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapters     | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1 and 2      | 13        | 14                  |
| 3            | 12        | 20                  |
| 4            | 8         | 10                  |
| 5            | 8         | 10                  |
| 6            | 4         | 6                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

## References

1. Ward, T. A. (2010). Aerospace propulsion systems. Wiley.
2. Bertin, J. J. (1994). Hypersonic aerothermodynamics (Latest Edition). American Institute of Aeronautics and Astronautics (AIAA).
3. Anderson, J. D. (2006). Hypersonic and high-temperature gas dynamics. American Institute of Aeronautics and Astronautics (AIAA).
4. Heppenheimer, T. A. (2007). Facing the heat barrier: A history of hypersonics. National Aeronautics and Space Administration (NASA).

# AERIAL ROBOTICS SOFTWARE ENGINEERING

ENAS 466

**Lecture** : 3  
**Tutorial** : 2  
**Practical** : 1

**Year : IV**  
**Part : II**

## Course Objectives:

The objective of this course is to provide students with practical knowledge of robotics middleware, UAV simulation environments, embedded computing, vision-based navigation, Simultaneous Localization and Mapping (SLAM), autonomous mission systems and real UAV deployment. Students will integrate software and hardware components to develop end-to-end autonomous UAV applications.

### **1 Robotics Middleware (12 hours)**

- 1.1 Aerial robotics software systems
- 1.2 ROS2 (Robot Operating System 2) fundamentals
- 1.3 ROS2 nodes, topics, services and actions
- 1.4 MAVROS and MAVLink communication
- 1.5 DDS (Data Distribution Service) communication in ROS2
- 1.6 Robotics software architecture for UAVs
- 1.7 Integration of flight controller and companion computer

### **2 Simulation and Testing (8 hours)**

- 2.1 UAV simulation environments
- 2.2 Gazebo simulation for UAVs
- 2.3 Isaac Sim simulation for aerial robotics
- 2.4 Software-in-the-loop testing
- 2.5 Hardware-in-the-loop testing
- 2.6 Simulation-based mission validation
- 2.7 Testing workflow for autonomous UAV software

### **3 Embedded Computing (4 hours)**

- 3.1 Embedded computing for UAVs
- 3.2 Raspberry Pi integration
- 3.3 NVIDIA Jetson Nano/Xavier platforms
- 3.4 Companion computer architecture
- 3.5 Edge computing systems
- 3.6 Communication between autopilot and onboard computer
- 3.7 Power, weight and processing constraints

## **4 Vision-Based Navigation (7 hours)**

- 4.1 Vision-based UAV navigation
- 4.2 Camera models and camera calibration
- 4.3 Image processing for UAV navigation
- 4.4 Visual odometry
- 4.5 Vision-based localization
- 4.6 Feature detection and matching
- 4.7 Vision-based autonomous flight applications

## **5 SLAM and LiDAR-Based Navigation (8 hours)**

- 5.1 Foundations of SLAM
- 5.2 Spatial representations and mapping
- 5.3 LiDAR (Light Detection and Ranging) sensors for UAV navigation
- 5.4 LiDAR odometry
- 5.5 Scan matching frameworks
- 5.6 Loop closure detection
- 5.7 Global optimization
- 5.8 Map-based navigation

## **6 Autonomous Mission Systems (6 hours)**

- 6.1 Autonomous UAV missions
- 6.2 Search and rescue mission systems
- 6.3 Precision landing systems
- 6.4 Autonomous tracking systems
- 6.5 Mission planning and execution pipeline
- 6.6 Real-time decision-making for UAV missions
- 6.7 Fail-safe and mission recovery logic

## **Tutorial (30 hours)**

- 1. ROS2 node, topic, service and action-based problem exercises
- 2. Gazebo-based UAV simulation setup discussion
- 3. SITL (Software-in-the-Loop) and HITL (Hardware-in-the-Loop) testing comparison exercises
- 4. Raspberry Pi and Jetson-based UAV system design problems
- 5. Camera calibration numerical and practical interpretation exercises
- 6. Vision-based localization case studies
- 7. SLAM mapping and localization problem-solving
- 8. LiDAR odometry and scan matching workflow analysis
- 9. Search and rescue UAV mission design exercise
- 10. Precision landing system design discussion

## **Practical (15 hours)**

- 1. ROS2 workspace setup and UAV node communication
- 2. Gazebo or Isaac Sim UAV mission simulation

3. SITL testing of autonomous UAV mission
4. Camera calibration and vision-based localization experiment
5. Visual odometry implementation
6. SLAM or LiDAR-based mapping experiment
7. Autonomous navigation system deployment on UAV

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| Chapter      | Hours     | Marks distribution* |
|--------------|-----------|---------------------|
| 1            | 12        | 14                  |
| 2            | 8         | 10                  |
| 3            | 4         | 6                   |
| 4            | 7         | 10                  |
| 5            | 8         | 12                  |
| 6            | 6         | 8                   |
| <b>Total</b> | <b>45</b> | <b>60</b>           |

\* There may be minor deviation in marks distribution.

### References

1. Quigley, M., Gerkey, B., Smart, W. D. (2015). Programming robots with ROS: A practical introduction to the Robot Operating System. O'Reilly Media.
2. Macenski, S., Foote, T., Gerkey, B., Lalancette, C., Woodall, W. (2022). Robot Operating System 2: Design, architecture, and uses in the wild. Science Robotics, 7(66), eabm6074.
3. Corke, P. (2023). Robotics, vision and control for Python. Springer.
4. Thrun, S., Burgard, W., Fox, D. (2005). Probabilistic robotics. MIT Press.
5. Siciliano, B., Sciavicco, L., Villani, L., Oriolo, G. (2009). Robotics: Modelling, planning and control. Springer.
6. PX4 Development Team. (2026). PX4 Autopilot User Guide. PX4 Development Team.
7. ArduPilot Development Team. (2026). ArduPilot documentation. ArduPilot Development Team.
8. Open Robotics. (2026). ROS 2 documentation. Open Robotics.

# **FLEET PLANNING FOR AIRLINES**

**ENAS 467**

**Lecture : 3**  
**Tutorial : 2**  
**Practical : 1**

**Year : IV**  
**Part : II**

## **Course Objectives:**

The objective of this course is to conceptualize and visualize the process of fleet planning as applied to scheduled airlines operating aircraft. The course will prepare students to work in airlines by imparting a foundational understanding of fleet management in airlines, and how the fleet size and characteristics affect the airline operations.

### **1 Introduction (7 hours)**

- 1.1 Fleet planning
- 1.2 Role of manufacture in fleet planning
- 1.3 Resolving conflicts of time perspective in fleet planning
- 1.4 Coping with the cycle
- 1.5 The problem of stored aircraft
- 1.6 Size matters
- 1.7 Anatomy of a campaign

### **2 Fluid Statics (5 hours)**

- 2.1 Valuing the assets
- 2.2 Defining overall objectives and goals
- 2.3 Good fleet plan
- 2.4 Key decision criteria
- 2.5 Trends in tools and data

### **3 The Market Evaluation (9 hours)**

- 3.1 Setting the scene
- 3.2 Measuring production
- 3.3 Macro and micro approach to fleet planning
- 3.4 Market segmentation and spill
- 3.5 Modeling on single sector and network
- 3.6 The micro network model
- 3.7 The network matrix
- 3.8 Market share modeling

**4      Aircraft and Airline Product      (4 hours)**

- 4.1    Getting prepared to conduct the evaluation
- 4.2    Aircraft and airline product
- 4.3    Defining the aircraft configuration
- 4.4    Principles of aircraft specification and customization

**5      Aircraft Performance      (9 hours)**

- 5.1    Importance of aircraft performance
- 5.2    Background and certification process
- 5.3    Aircraft weight build up
- 5.4    Building the payload range
- 5.5    Airfield performance analysis
- 5.6    En-route performance analysis
- 5.7    Combining the probabilities
- 5.8    Aircraft selection

**6      Aircraft Economics      (6 hours)**

- 6.1    Importance of aircraft economics
- 6.2    Cost classification and components
- 6.3    Cost and revenue management- methods
- 6.4    Dynamic fleet management
- 6.5    Drivers of aircraft operating economics
- 6.6    Spares provisioning

**7      Investment Appraisal      (5 hours)**

- 7.1    Integration of Financial and Operational Evaluation Metrics
- 7.2    Impact of aircraft price
- 7.3    Scope of investment appraisal
- 7.4    Residual values
- 7.5    Choosing the right decision tool
- 7.6    Judgment and decision making
- 7.7    Analytical Rigor versus Strategic Intuition in Fleet Selection

**Tutorial      (30 hours)**

- 1.    Comparison of fleet compositions, seating configurations and range profiles across domestic airlines to evaluate route-matching strategies and market positioning.
- 2.    Utilizing operational and market datasets to forecast passenger demand, analyze fleet utilization rates and inform aircraft acquisition timing.
- 3.    Evaluation of hull insurance policies, passenger liability frameworks and third-party risk exposure to integrate financial risk mitigation into fleet planning.

4. Construction of payload-range diagrams for candidate aircraft to assess payload restrictions, fuel burn penalties and payload capacity across specific network routes.
5. Performing cost-benefit analyses by calculating Direct Operating Costs, cash flows and net present values for different aircraft size classes operating on identical route structures.

#### **Practical**

**(15 hours)**

1. Industry visit to various aircraft operation department and observe and discuss the various procedures involved in fleet planning and prepare a report.
2. Detailed case study of specific airline fleet and their planning structure.

#### **Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

| <b>Chapter</b> | <b>Hours</b> | <b>Mark distribution*</b> |
|----------------|--------------|---------------------------|
| 1              | 7            | 12                        |
| 2 and 4        | 9            | 12                        |
| 3              | 9            | 12                        |
| 5              | 9            | 12                        |
| 6 and 7        | 11           | 12                        |
| <b>Total</b>   | <b>45</b>    | <b>60</b>                 |

\* There may be minor deviation in marks distribution.

#### **References**

1. Clark, P. (2017). Buying the big jets: Fleet planning for airlines. Routledge.
2. Dolce, J. E. (2009). Analytical fleet maintenance management. SAE International.
3. Crainic, T. G., Laporte, G. (1998). Fleet management and logistics (Latest ed.). Springer.
4. Holloway, S. (2008). Straight and level : practical airline economics. United Kingdom: Ashgate Pub.
5. Wensveen, J. G., Wells, A. T. (2007). Air Transportation: A Management Perspective. United Kingdom: Ashgate.