UAB
Universitat Autònoma de Barcelona

Systems Modelling and Simulation

Code: 101743
ECTS Credits: 6

2024/2025

Degree	Type	Year
2501233 Aeronautical Management	OB	3

Contact

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

There are s no previous hard subject requirements, although it is recommendable a minimum base of statistics and basic knowledge of programming in Python.

Objectives and Contextualisation

The subject Systems Modelling and Simulation could be taught in different degrees, because what is intended is that students learn to perform a simulation model of any system in order to have more knowledge about it, and make the best possible decisions to improve the performance of it. In the case of airports, there are three major subsystems: airlines, users and airport infrastructures. Getting models including part of the three subsystems would greatly help decision making within an airport.

The objectives of the subject are specified in:

1. Be able to develop a conceptual model of any system using modeling formalism called Petri Nets and Colored Petri Nets.
2. Be able to develop a simulation model in pseudocode and its implementation in any known programming language, and also in some simulation software.
3. Be able to apply the basic statistical tools necessary for the development of a complete simulation model.
4. Know how to use the simulation model to identify and solve possible problems that may occur in the system.

Competences

- Allocate and manage aircraft turnaround resources efficiently.
- Apply specific software for solving problems in the aeronautical sector.
- Communication.
- Develop software of low or medium complexity.
- Personal attitude.

- Personal work habits.
- Supervise the management of resources in an airport.
- Thinking skills.
- Use knowledge of the fundamental principles of mathematics, economics, information technologies and psychology of organisations and work to understand, develop and evaluate the management processes of the different systems in the aeronautical sector.

Learning Outcomes

1. Analyse the interdependency relationships between the subsystems interacting in a given operation.
2. Communicate knowledge and findings efficiently, both orally and in writing, both in professional situations and with a non-expert audience.
3. Create small applications to exploit the information obtained from the system (e.g., stored in databases).
4. Describe the fundamental principles of the use of optimisation and simulation environments.
5. Develop critical thought and reasoning.
6. Develop curiosity and creativity.
7. Develop independent learning strategies.
8. Develop systemic thinking.
9. Establish models for evaluating the best policies for making operational decisions.
10. Formulate and solve problems in aeronautical management.
11. Make simulation models to identify problems of performance and productivity.
12. Prevent and solve problems.
13. Understand the modelling and simulation of dynamic systems.
14. Use commercial discrete-event simulation environments to conduct experiments.
15. Use statistical analysis tools to model temporal activities and analyse the results.
16. Use virtual environments to verify critical aspects.
17. Work independently.
18. Working in complex or uncertain environments and with limited resources.

Content

Topic 1: Introduction to Digital Simulation

Introduction to the development of a simulation project:

- Definitions and basic concepts
- Stages of a simulation project
- Simulation tools
- Application fields

Topic 2: Modeling of Discrete Event Systems

Development of Discrete Event Systems models using Petri Nets:

- Definitions and basic concepts
- Dynamics of a Petri Net
- Modeling Bottom-Up
- Analysis of Petri Nets

Topic 3: Statistical Models for Simulation

Basic statistics for the simulation:

- Introduction
- Identification of the statistical properties of a sample
- Most used distribution functions
- Generation of random numbers
- Dependence between random variables
- Hypothesis test (Chi-Square-Test)

Topic 4: Simulation of Discrete Event Systems

- Elements of a simulator
- Management policies for the variable time (pseudocode)
- Simulation environments (software)
- Design of experiments

Topic 5: Advanced Modeling of Discrete Event Systems

Colored Petri Nets:

- Definitions and basic concepts
- Modeling primitives

Topic 6: Resource Management

- Introduction to resource management.
- Experimental techniques:
  - Evaluation of bottlenecks.
  - Little's law.
  - Algorithms to minimize variance.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practical classes	12	0.48	9, 14, 16
Problem classes	12	0.48	3, 9, 11, 14, 16
Theory classes	26	1.04	9
Type: Supervised			
Practices	6	0.24	9, 14, 16
Problems	15	0.6	11
Type: Autonomous			
Assessment	4.5	0.18	1, 10, 17
Personal study	23	0.92	5, 6, 7, 8, 12, 17
Practices	4	0.16	3, 9, 11, 14, 16

Preparation of Practices	20	0.8	3, 11, 14, 16
Preparation of Problems	20	0.8	7, 17

The teaching methodology used in this subject is based on the resolution of problems and the participation of students in it. The subject is focused in a very practical way and it is essential that students participate in the activities, since it is the best way to learn. The master classes of the subject are reduced to the essentials to be able to have the basic knowledge to solve the proposed problems.

The course could be divided into different activities:

1. Master classes: typical lectures, including student participation through questions and / or small exercises.
2. Problems: realization of problems in the classroom and its correction.
3. Practices: learning of a simulation environment and the realization of simulation models of diverse systems. The practices will be done in groups of 3 students.
4. Exams: There will be a partial exam during the course and a final exam. The partial exam will NOT eliminate subject matter for the final exam.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
A Simulation model implemented in Pyhton	20%	2	0.08	4, 5, 8, 9, 10, 13, 18
Final exam	40%	2.5	0.1	1, 9, 13, 17
Practices	40%	3	0.12	2, 3, 6, 7, 9, 11, 12, 13, 14, 15, 16

This subject does not consider the single assessment system.

See assessment in Catalan or Spanish.

Bibliography

Robust Modelling and Simulation: Integration of SIMIO with Coloured Petri Net / Idalia Flores De La Mota, Antoni Guasch, Miguel Mujica Mota, Miquel Angel Piera.

Modelado y simulación: aplicación a procesos logísticos de fabricación y servicios / Antoni Guasch ... [et al.]

Petri nets: a tool for design and management of manufacturing systems / Jean-Marie Proth and Xiaolan Xie Proth, Jean -Marie.

Coloured petri nets: modelling and validation of concurrent systems / Kurt Jensen, Lars M. Kristensen Jensen, Kurt.

Cómo mejorar la logística de su empresa mediante la simulación: Miquel Àngel Piera ... [et al.]

Simio & simulation: modeling, analysis, applications / W. David Kelton, Jeffrey S. Smith, David T. Sturrock

Simulation modeling with SIMIO: a workbook / Jeffrey Allen Joines ; Stephen Dean Roberts. Joines, Jeffrey A.

Software

Python

MS Excel

R-Simmer

SIMIO

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	11	Catalan	second semester	afternoon
(PAUL) Classroom practices	12	Catalan	second semester	afternoon
(PLAB) Practical laboratories	21	Spanish	second semester	afternoon
(PLAB) Practical laboratories	22	Spanish	second semester	afternoon
(PLAB) Practical laboratories	23	Spanish	second semester	afternoon
(TE) Theory	11	Catalan	second semester	afternoon