

**Systems Modelling and Simulation**

Code: 101743  
ECTS Credits: 6

Degree	Type	Year	Semester
2501233 Aeronautical Management	OB	3	2

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

**Contact**

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**Use of Languages**

Principal working language: catalan (cat)  
Some groups entirely in English: No  
Some groups entirely in Catalan: Yes  
Some groups entirely in Spanish: No

**Teachers**

Marsel Omeri

**Prerequisites**

It has no previous requirements, although a minimum base of statistics and basic knowledge of programming is recommended.

**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, to be able to implement it with any known programming language, or 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.

## Methodology

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 pairs.
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.

## Activities

Title	Hours	ECTS	Learning Outcomes
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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	8, 7, 6, 5, 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

## Assessment

See assessment in Catalan or Spanish.

## Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final exam	40%	2.5	0.1	1, 13, 9, 17
Petri Net exercises	20%	2	0.08	13, 4, 8, 5, 9, 10, 18
Practices	40%	3	0.12	13, 2, 3, 7, 6, 9, 11, 12, 15, 14, 16

## 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

