



# Course guide

## 200623 - SPDE - Simulation for Business Decision Making

**Last modified:** 11/04/2024

**Unit in charge:** School of Mathematics and Statistics  
**Teaching unit:** 715 - EIO - Department of Statistics and Operations Research.  
**Degree:** MASTER'S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Optional subject).  
**Academic year:** 2024    **ECTS Credits:** 5.0    **Languages:** English

### LECTURER

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**Coordinating lecturer:** PAU FONSECA CASAS  
**Others:** Segon quadrimestre:  
PAU FONSECA CASAS - A  
JOAQUIM GIRBAU XALABARDER - A

### REQUIREMENTS

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The course assumes basic levels of statistics similar to those that can be achieved in the first semester of the Master. Students should be familiar with the concepts of hypothesis testing and statistical significance, analysis of variance. Concepts necessary to follow the course can be found for example in the text "Simulation modeling and analysis" of Law, A. M.; Kelton, W.D.

The course assumes a good attitude toward business and decision making problems although environmental and social problems will also be analyzed due to its inherent relation with business and decision making.

Ideally this course would be taken after an introduction to simulation as part of a simulation oriented curriculum. Although it is interesting to have completed "SIM - Simulation?" and to have some familiarity with the problems that can be solved using the techniques developed there, is not considered essential.

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

5. CE-2. Ability to master the proper terminology in a field that is necessary to apply statistical or operations research models and methods to solve real problems.
  6. CE-3. Ability to formulate, analyze and validate models applicable to practical problems. Ability to select the method and / or statistical or operations research technique more appropriate to apply this model to the situation or problem.
  7. CE-5. Ability to formulate and solve real problems of decision-making in different application areas being able to choose the statistical method and the optimization algorithm more suitable in every occasion.
- Translate to english

**Transversal:**

1. **SUSTAINABILITY AND SOCIAL COMMITMENT:** Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.
2. **TEAMWORK:** Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.
3. **EFFECTIVE USE OF INFORMATION RESOURCES:** Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
4. **FOREIGN LANGUAGE:** Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

**TEACHING METHODOLOGY**

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The course is practical and wants that the student be capable, from the work done on a set of deliverables that are developed in the laboratory, at the end of the course, to solve real problems similar to those developed in class.

**LEARNING OBJECTIVES OF THE SUBJECT**

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To introduce the analysis of real problems in the world of production, logistics, process improvement or the measurement and adjustment of services in the frame of the Industry 4.0. The class is based on teaching methodologies appropriate to each context, in order to realize the necessary steps for running a simulation project allowing the improvement of system performance or providing effective support for making decisions in uncertain or risky situations.

\* With this purpose in mind, diverse application projects which have been developed in the professional environment are presented. Possible objectives of the projects presented are determined. Methodological approximations, more appropriate to the model, depending on these projects, are determined. The most powerful and effective problem-solving tools are suggested.

\* Also, for each project, a study and characterization of the necessary data for the simulation is conducted. Experimentation scenarios are designed for evaluation. The necessity of graphic representation is studied, for the models as much as for the results, as well as the interactive and usability characteristics for project development environments.

\* Process will be designed in order to guarantee, as far as time permits, some basic criteria for the verification and validation of the models and the results of the simulation.

\* Related concepts with the accreditation of components, simulation models and the processes associated to the life cycle of a simulation project are introduced. Aspects in relation to the ethics code required in the design and exploitation of these models are assessed.

\* Finally, upon completion of a conceptual tour which is applied to diverse social, technological and economic areas, a wide perspective for the possible professional applications of the simulation will be obtained as well as the approach to the definition and management of simulation projects.

**STUDY LOAD**

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Type	Hours	Percentage
Self study	80,0	64.00
Hours small group	15,0	12.00
Hours large group	30,0	24.00

**Total learning time:** 125 h



## CONTENTS

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### Introduction

**Description:**

Introduction to the Construction of Simulation Models and the Planning of Simulation Projects. The Basic Architecture of Support Systems for Decision-Making in Uncertain or Risk Situations. Explanation of the "levers" (McKinsey model) of Industry 4.0.

**Full-or-part-time:** 1h 50m  
Theory classes: 1h 50m

### Description of Examples

**Description:**

Description of examples from the industrial world, of services and other systems in which the simulation is applicable. Criteria for the value of contribution in simulation studies. Embedded systems. Case studies that will be used throughout the course.

**Full-or-part-time:** 1h 50m  
Theory classes: 1h 50m

### Paradigms

**Description:**

Methodological analysis associated to the typology of the considered simulation models. Discrete, continuous and hybrid event simulation. The continuous model simulation. Causal and forrester diagrams. System dynamics.

**Full-or-part-time:** 2h  
Theory classes: 2h

### Formalisms

**Description:**

Formalisms for the specification of simulation models: Petri Nets, SDL, DEVS Diagrams. We will see how to integrate these languages in the industrial world and how it affects the global vision of the so-called Industry 4.0

**Full-or-part-time:** 2h  
Theory classes: 2h

### Experiment Design

**Description:**

Experiment design and methodology for simulation results analysis.

**Full-or-part-time:** 1h 50m  
Theory classes: 1h 50m



### Verification, Validation and Accreditation

**Description:**

Criteria for verification, validation and accreditation in Simulation Projects. Ethical aspects. Cost elements and project planning, time and cost estimation.

**Full-or-part-time:** 1h

Theory classes: 1h

### Simulation Systems

**Description:**

Preparation for project development with generic business simulators, such as Flexim, Arena, Witness and SDLPS. Explanation of the most important elements of the software packages, their structure and integration with the industry through the "digital twin" concept of Industry 4.0.

**Full-or-part-time:** 2h 50m

Theory classes: 2h 50m

### New Paradigms

**Description:**

Introduction to new simulation paradigms and their application in the context of process and service simulations. Simulation with intelligent agents, cellular automata.

**Full-or-part-time:** 1h 50m

Theory classes: 1h 50m

### New Components

**Description:**

Components and mechanisms which can be combined in simulation model development settings. Sig and simulation.

**Full-or-part-time:** 1h

Work experience: 1h

### Practical Cases

**Description:**

Development of practical cases, effective presentation of projects and results.

**Full-or-part-time:** 1h

Work experience: 1h

## GRADING SYSTEM

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The evaluation will combine the marks of two practical exercises (T1 and T2) and a final exam.

T1 and T2 can be decomposed in different partial assignments that will help the student to adjust the work to the desirable rhythm; also this helps to validate the steps carried out in the development of the project, and also they will constitute a part of the global mark of both assignments.

First teaching practice: Model Specification.

T2: Second teaching practice: Implementation and Final Report on the Model.

E: Final Exam.

Final Mark =  $T1*0.4+T2*0.4+E*0.2$

## BIBLIOGRAPHY

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### Basic:

- Law, A. M.; Kelton, W.D. Simulation modeling and analysis. 5th ed. McGraw-Hill, 2015. ISBN 9780073401324.
- Banks, J. ... [et al.]. Discrete-event system simulation [on line]. 5th ed. Harlow, Essex: Pearson, 2014 [Consultation: 07/07/2023]. Available on: <https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5174427>. ISBN 9781292024370.
- Fishman, George S. Discrete-event simulation modeling, programming and analysis. Springer, 2001. ISBN 0387951601.
- Robert, C.P.; Casella, G. Monte Carlo statistical methods. 2nd ed. Springer, 2004. ISBN 0387212396.
- Guasch, A. ... [et al.]. Modelado y simulación: aplicación a procesos logísticos de fabricación [on line]. 2ª ed. Edicions UPC, 2003 [Consultation: 12/05/2020]. Available on: <http://hdl.handle.net/2099.3/36767>.
- Fonseca i Casas, Pau. Simulació discreta per mitjà de la interacció de processos [on line]. Editorial UPC, 2009 [Consultation: 12/05/2020]. Available on: <http://hdl.handle.net/2099.3/36836>.
- Fonseca Casas, Pau. Formal languages for computer simulation : transdisciplinary models and applications [on line]. Hershey: Information Science Reference, cop. 2014 [Consultation: 07/07/2023]. Available on: <https://www-igi-global-com.recursos.biblioteca.upc.edu/gateway/book/75484>. ISBN 9781466643697.