

SHAKE THE FUTURE.



# MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

## INDUSTRIAL ENGINEERING

### SMART AND CONNECTED ENTERPRISE

#### YEAR 1 AUTUMN SEMESTER

PROGRAMME SUPERVISORS:  
FAROUK BELKADI, ALAIN BERNARD

# MODELLING OF COMPLEX SYSTEMS (I)

INDUSTRIAL ENGINEERING – SMART AND CONNECTED ENTERPRISE  
YEAR 1 - AUTUMN SEMESTER

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**LEAD PROFESSOR:** Alain Bernard, [alain.bernard@ec-nantes.fr](mailto:alain.bernard@ec-nantes.fr)

## Objectives

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At the end of the course the students will be able to:

- Explain the main concepts of complex systems
- Explain complexity issues and consequences on complex systems design
- Define the main methodologies of complex systems design and modelling
- Understand and read some complex systems modelling languages

## Course contents

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This first part of the course offers a general introduction on complex systems modelling. This serves other courses that will use the same concepts to introduce modelling languages, systems engineering, enterprise modelling, systems performance simulation and optimisation.

The course will alternate between lectures and flipped classroom presentations based on several main concepts, which they will have to investigate more deeply by themselves, and to present to the whole group an overview of the concept based on representative bibliographic documents.

## Course material

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- Modeling of Complex Systems, An Introduction, V. Vemuri and J. William Schmidt, ISBN: 978-0-12-716550-9
- Complexity-based modeling of reconfigurable collaborations in production industry, G. Schuh, L. Monostori, B.Cs. Csaj, S. Döring, CIRP Annals - Manufacturing Technology 57 (2008) 445–450
- Complexity in engineering design and manufacturing, Waguih ElMaraghy, Hoda ElMaraghy, Tetsuo Tomiyama, Laszlo Monostori, CIRP Annals - Manufacturing Technology 61 (2012) 793–814
- Complexity of Multi-Disciplinary Design, T. Tomiyama, V. D'Amelio, J. Urbanic, W. ElMaraghy, CIRP Annals – Manufacturing Technology 56 (2007) Issue 1, 185-188
- Integration of a working situation model for training and simulation during design and industrialisation of a system, M. Shahrokhi, PhD thesis, Ecole Centrale Nantes, 12 December 2006
- Manufacturing Systems Configuration Complexity, H. A. ElMaraghy (1), O. Kuzgunkaya, R. J. Urbanic, CIRP Annals - Manufacturing Technology, 54 (2005) Issue 1, 445-450

## Keywords

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Complex systems, Conceptual modelling, Modelling methods

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

# ENTERPRISE MODELLING

## INDUSTRIAL ENGINEERING – SMART AND CONNECTED ENTERPRISE YEAR 1 - AUTUMN SEMESTER

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**LEAD PROFESSOR:** Farouk Belkadi, [farouk.belkadi@ec-nantes.fr](mailto:farouk.belkadi@ec-nantes.fr)

### Objectives

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At the end of the course (30 hours + personal homework) the students will be able to:

- Understand the hierarchical organisation of industrial enterprise
- Conduct an operational management method
- Construct enterprise business models including various points of view and using several tools

### Course contents

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These introductory lectures aim to present the main elements that define the architecture of an enterprise. After this introduction, the following items will be presented in detail:

- Introduction to Enterprise organization
  - Functional decomposition of an enterprise
  - Levels of decision in the enterprise
- Enterprise Modelling concepts
  - Definition of the concepts of process, tasks and activities
  - Definition of actors and roles
  - Definition of informational and physical flows (distinction data/information/knowledge)
- Introduction to Enterprise Management methods
  - The concept of performance
  - Main processes of enterprise management
  - Integration of the human factor in enterprise models
- Business process modelling with IDEF0-SADT
  - Introduction to process modelling
  - Structure of IDEF diagram
- Business Process Modelling Notation (BPMN)
  - Introduction to BPMN diagram
  - BPMN symbols
  - Examples of BPMN processes
- Decision-based modelling with GRAI method
  - Main concepts: decision centers, functional view, temporal view, hierarchy, etc.)
  - Modelling concepts (decision and execution activities, objectives, constraints, etc.)
  - GRAI grid and Network
- Introduction to Archimate
  - Business process and service layer
- Introduction to UML class diagram for the description of enterprise structure

Practical exercises and homework will help students to apply the learned modelling languages in various case studies.

## Course material

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- Livre blanc - Introduction au BPM. Stéphane PLANQUART
- Business Process Model and Notation (BPMN) OMG official Standard document:  
<http://www.omg.org/spec/BPMN/2.0>
- BPMN 2.0 by Example. OMG official Standard document  
<http://www.omg.org/spec/BPMN/2.0/examples/PDF/10-06-02.pdf>
- The GRAI method  
<http://chen33.free.fr/M2/Courses/GRAI%20INTEROP%20part%201.BV.pdf>
- Integrating value modeling into ArchiMate. University of Twente
- Business Process Modeling Introduction to ARIS Methodology  
<http://www.training.com.br/download/Business%20Process%20Modelling%20-%20Introduction%20to%20ARIS%20Methodolgy.pdf>

## Keywords

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Enterprise structure, Enterprise processes, decision levels, management, BPMN, SADT, GRAI

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	8 hrs	16 hrs	0 hrs	6 hrs	2 hrs

# INTRODUCTION TO OPTIMIZATION METHODS

INDUSTRIAL ENGINEERING – SMART AND CONNECTED ENTERPRISE  
YEAR 1 - AUTUMN SEMESTER

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**LEAD PROFESSOR:** Raphaël Chenouard, [raphael.chenouard@ec-nantes.fr](mailto:raphael.chenouard@ec-nantes.fr)

## Objectives

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At the end of the course the students will be able to:

- Understand an optimization problem
- Model a problem as a mathematical problem
- Choose a classical optimization method
- Analyse the result of the optimization

## Course contents

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These lectures constitute an introduction to classical optimization methods. The main elements covered are:

- Mathematical modelling
- Linear Programming
- Optimization without constraint
- Optimization with constraint

These lectures are applied to practical examples and implemented using SciPy Python library. SciPy generic optimization functions are used, but some classical algorithms are also implemented like gradient descent or Newton algorithm.

## Course material

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- Numerical Optimization, Pegden, Jorge Nocedal, Stephen Wright. 2nd ed. Springer (2006).
- Introduction to Numerical Analysis, Arnold Neumaier. Cambridge University Press (2001).

## Keywords

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Numerical Optimization; Linear Programming; Least Squares

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	6 hrs	8 hrs	16 hrs	0 hrs	2 hrs

# PRODUCTION MANAGEMENT

INDUSTRIAL ENGINEERING – SMART AND CONNECTED ENTERPRISE  
YEAR 1 - AUTUMN SEMESTER

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**LEAD PROFESSOR:** Rosa Abbou, [rosa.abbou@univ-nantes.fr](mailto:rosa.abbou@univ-nantes.fr)

## Objectives

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At the end of the course, the students will be able to:

- Understand management techniques;
- Structure and manage information systems;
- Specify the different generating activities (purchases, logistics, production of goods and services, marketing, sales, etc);
- Structure information on ERP.

## Course contents

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This course constitutes an introduction to the management techniques with thorough knowledge of the realities of human management. The main elements covered in the course are:

- The management of information systems;
- The management of various value generating activities (purchases, logistics, production of goods and services, marketing, sales etc.);
- Human resources management.

Industrial software ERP such as SAGE will be used.

## Course material

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- Gideon HALEVI, Handbook of Production Management Methods. Edition Butterworth-Heinemann, 2001.

## Keywords

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Production Concepts; Management Methods.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	8 hrs	6 hrs	8 hrs	8 hrs	2 hrs

# DISCRETE-EVENT SIMULATION

INDUSTRIAL ENGINEERING – SMART AND CONNECTED ENTERPRISE  
YEAR 1 - AUTUMN SEMESTER

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**LEAD PROFESSOR:** Olivier Cardin, [olivier.cardin@univ-nantes.fr](mailto:olivier.cardin@univ-nantes.fr)

## Objectives

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At the end of the course (30 hours + personal work) the students will be able to:

- Understand a discrete-event simulation-based analysis
- Model simple industrial processes using a discrete-event simulation software
- Gather key performance indicators from the simulation runs
- Analyse the results of the simulation

## Course contents

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These lectures constitute an introduction to the simulation of discrete event systems applied to production systems. The main elements covered are:

- Principles of simulation
- Epistemological approach to experimental research
- Modelling for simulation
- Optimization via simulation

After an introduction lecture, practical sessions will lead to a mini-project in full autonomy. Industrial software such as Rockwell Arena will be used.

## Course material

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- Introduction to Simulation Using SIMAN, Pegden, C.D., Sadowski, R.P., Shannon, R.E., 2nd ed. McGraw-Hill, Inc., New York, NY, USA (1995)
- Simulation modeling and analysis, Law, A. M., Kelton, W. D., & Kelton, W. D. (Vol. 3). New York: McGraw-Hill (2007).

## Keywords

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Discrete-event Systems; Discrete-event simulation; Experimental research

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	8 hrs	0 hrs	14 hrs	8 hrs	2 hrs



# FINANCIAL AND ECONOMIC ASPECTS FOR INDUSTRIAL ENGINEERING

## INDUSTRIAL ENGINEERING – SMART AND CONNECTED ENTERPRISE YEAR 1 - AUTUMN SEMESTER

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**LEAD PROFESSOR:** Frederic Alexis, [frederic.alexis@ec-nantes.fr](mailto:frederic.alexis@ec-nantes.fr)

### Objectives

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Management Systems (MS) use accounting data to manage and analyze operations. This part of the course focuses on the financial and economic operations generally applied in industrial engineering.

This course introduces current measurement and analysis standards, budget management, and economic indicators to run the business and explain operational results as well as performance outcomes.

Financial and economic aspects help and influence decision making. They play an important role in coordinating operational activities regarding performance goals and resource optimization.

### Course contents

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At the end of the course (30 hours + personal work) the students will be able to:

- Outline the main factors which the board should consider in establishing a useful management accounting function within a company
- Understand how to measure and analyze costs by using financial accounting data
- Focus on Activity-Based Costing (ABC): the method of allocating overhead expenses based on actual activities and processes, not by arbitrary measure.
- Understand how to measure the performance of a company based on yardsticks and standards
- Understand performance control and monitoring tools
- Understand why and how equilibrium is necessary between different types of performance control (cultural, planning, financial and non-financial, administrative and compensations systems)
- Compute and analyze the profitability threshold
- Understand what a budget is, how it is designed and constructed and how it fits into the long-term planning of the company
- Create budgeted income statements, balance sheets and cash flow statements
- Understand dissonance between projections and actual results

Exercises will be completed during and between classes.

## Course material

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- Tukker, A., 2015. Product services for a resource-efficient and circular economy - A review. *Journal of Cleaner Production*, 97, pp.76–91.
- Berliner C. and Brimson J. (1988). *Cost management for today's advanced manufacturing, the CAM-I conceptual design*, Harvard Business School Press.
- Johnson H.T. (1992) *Relevance regained, from Top-down control to Bottom-up empowerment*, Free Press
- Johnson H.T. and Kaplan R.S. (1987) *Relevance lost: the rise and fall of management accounting*, Boston, Harvard Business School Press
- Malmi T. and Brown D. (2008). Management Control systems as a package – Opportunities, challenges and research directions, *Management Accounting Research*, vol. 19, n°4, p. 287-300.
- Vargo S. and Lusch R. (2008). Service-dominant logic: continuing the evolution, *Journal of the Academy of marketing Science*, vol. 36, n° 1, p. 1-10.

## Keywords

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Management control system, Performance, efficiency, costing

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	16 hrs	10 hrs	0 hrs	4 hrs	2 hrs

# CONFERENCES / INTRODUCTION TO RESEARCH

## INDUSTRIAL ENGINEERING – SMART AND CONNECTED ENTERPRISE

### YEAR 1 - AUTUMN SEMESTER

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**LEAD PROFESSOR:** Farouk Belkadi, [farouk.belkadi@ec-nantes.fr](mailto:farouk.belkadi@ec-nantes.fr)

#### Objectives

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Discovery of research via conferences and research papers.

#### Course contents

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Students will attend, where possible, locally held research conferences. Time will be set aside for summarising scientific publications.

#### Course material

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#### Keywords

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LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	2	hrs	hrs	hrs	hrs	0 hrs

# MODERN LANGUAGES - FRENCH

INDUSTRIAL ENGINEERING – SMART AND CONNECTED ENTERPRISE

YEAR 1 - AUTUMN SEMESTER

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**LEAD PROFESSOR:** Silvia Ertl – [silvia.ertl@ec-nantes.fr](mailto:silvia.ertl@ec-nantes.fr)

## Objectives

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The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources. Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture. At the end of the course (2 semesters), complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels.

## Course contents

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Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.

Learners will be able to use the foreign language in a simple way for the following purposes:

1. Giving and obtaining factual information:

- personal information (e.g. name, address, place of origin, date of birth, education, occupation)
- non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)

2. Establishing and maintaining social and professional contacts, particularly:

- meeting people and making acquaintances
- extending invitations and reacting to being invited
- proposing/arranging a course of action
- exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and

environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:

- making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
- making purchases
- ordering food and drink

## Course material

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Course material: Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

## Keywords

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reception (listening and reading), production (spoken and written), interaction (spoken and written), knowledge, skills, linguistic competence, sociolinguistic competence, pragmatic competence, register, cultural differences, non-verbal communication

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
French	4	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

# MODERN LANGUAGES – CULTURAL AND COMMUNICATIONAL ENGLISH

INDUSTRIAL ENGINEERING – SMART AND CONNECTED ENTERPRISE  
YEAR 1 - AUTUMN SEMESTER

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**LEAD PROFESSOR:** Spencer Hawkrige - [spencer.hawkrige@ec-nantes.fr](mailto:spencer.hawkrige@ec-nantes.fr)

## Objectives

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Introduction to Cultural and Communicational English:

- Understand the general concepts of communication English (different levels of language, etc.)
- Build a communicational project
- Develop strategies for enhanced interaction
- Organize, lead and participate in discussions, interviews and meetings
- Behavioral skills in an inter-cultural environment:
- Strengthen engagement and level of conviction
- Develop a capacity to explain and argue
- Acquire notions of corporate culture and values
- Enhance team work

## Course contents

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Cultural and Communicational English: exercises to explore in practice the areas of culture and communication

Inter-cultural project (for example, documentary project, publishing project: construct a work of fiction or of educational value and experience the complete publishing process)

## Course material

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Written and televised press, information and digital tools, general documents business environment and company strategies.

Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle).  
Our own eZoomBook template for the Intercultural project.

## Keywords

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Culture and communication, inter-cultural environment, team-building, digital tools, etc.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	0 hrs	30 hrs	0 hrs	0 hrs	2 hrs