

System Thinking

Code: 44759
ECTS Credits: 6

2024/2025

| Degree | Type | Year |
|---|------|------|
| 4318306 Logistics and Supply Chain Management | OB | 1 |

Contact

Name: Miquel Angel Piera Eroles
Email: miquelangel.piera@uab.cat

Teaching groups languages

You can view this information at the [end](#) of this document.

Prerequisites

There are no requirements

Objectives and Contextualisation

Objectives and Contextualisation

It is well accepted that a supply chain (SC) is a complex system due to the difficulty to understand the underlying dynamics and its interdependencies, which can drastically affect its behaviour, and in consequence generates uncertainty to properly coordinate the different operations.

A comprehensive systems approach is a requirement for a better understanding of the different emergent dynamics which usually appears in systems characterized by a large amount of components with tight interdependencies. Quantitative models are frequently proposed for forecasting purposes, however, they lack of supporting tools for a better understanding of the system dynamics, which sometimes requires an interdisciplinary approach to consider also the human factor.

The main objective of this subject is to introduce a causal approach to develop efficient transparent models enhancing simulation tools with the capability to explore uncertainties, trend breaks, and discontinuities; and extend their potential to foster deliberation; and their relevance to decision makers. For this purpose, students will be trained with the use of Coloured Petri Net formalism to represent the cause-effect relationships that underlies in most SC systems, and the analysis of the state space for a better understanding of the so called emergent dynamics.

The set of sub-objectives of this subject are:

Introduce a holistic analysis approach, as opposed to reductionist, as a set of diverse interacting agents within an environment.

Recognize that the relationships or interactions between elements are more important than the elements themselves in determining the behaviour of the system.

Recognize a hierarchy of levels of systems and the consequent ideas of properties emerging at strategic, tactic and operational levels, and mutual causality both within and between levels.

Introduce influence variables for a better understanding of human behaviour in a supply chain system.

Learning Outcomes

1. CA02 (Competence) Interpret and develop LSCM systems as complex structures by understanding the part in relation to the whole.
2. CA03 (Competence) Develop arguments based on quantitative models and techniques.
3. KA04 (Knowledge) Select systems analysis methods and recognise the principles of systems engineering.
4. KA05 (Knowledge) Identify and model dependencies, influences and impact relationships among the components of a system.
5. KA06 (Knowledge) Identify and model emerging properties and key performance indicators.
6. SA05 (Skill) Analyse complex systems in relation to their performance and responsiveness.
7. SA06 (Skill) Use the methods and principles of LSCM systems analysis, evaluation and design.
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Content

THEORY

ST.T.1: Introduction to Complexity

ST in Logistics

Flexibility as a source of Complex Problems

Key Parameter Indicators

Key Parameter Indicators

ST.T.2: Discrete Event System Modeling

Definition and concepts.

Petri Nets: Specification of logical relationships in the logistic field.

Coloured Petri Nets: Specification of the information flow

ST.T.3: State Space

The reachability tree

Cause-effect analysis

Mitigation mechanisms of undesirable dynamics

ST.T.4: Causal Simulation Models

Try and error approach

Verification of Simulation Models

Validation of Simulation Models

ST.T.5: Experimental approaches to remove non-added-value operations:

Bottleneck evaluation.

Policies based on the Little Law.

Algorithm to minimize the standard deviation in manufacturing

PROBLEMS

ST.P.1 Examples:

Simulation of a multimodal transport system

Simulation of warehouse

Simulation of an airport terminal

Simulation of a turnaround

ST.P.2 Petri Net Exercises

ST.P.3 Coloured Petri Net Exercises

ST.P.4 CPN-Tools Exercises

ST.P.5 State Space Exercises

PRACTISE

ST.L.1 Introduction to SIMIO

ST.L.2 Serial Manufacturing Line

ST.L.3 Animation Modules in Simio

ST.L.4 Routing Material Flows

ST.L.5 Flowchart Simio Processes

ST.L.6 Simulation Project

Activities and Methodology

| Title | Hours | ECTS | Learning Outcomes |
|------------------|-------|------|-------------------|
| Type: Directed | | | |
| Personal Study | 34 | 1.36 | |
| Problem Sessions | 10 | 0.4 | |
| Theory Lectures | 20 | 0.8 | |
| Type: Supervised | | | |
| Lab exercises | 15 | 0.6 | |
| Type: Autonomous | | | |
| Modeling | 70 | 2.8 | |

Teaching will be offered on campus or in an on-campus and remote hybrid format depending on the number of students per group and the size of the rooms at 50% capacity."

The course is organized by means of lectures. The learning process will combine the following activities:

Theory lectures

Problem sessions

Practise sessions: computer lab, teamwork and oral presentation

Autonomous work

Practical case studies and simulation tools are used for promoting students hand on skills.

The proposed teaching methodology may undergo some modifications according to the restrictions imposed by the health authorities on on-campus courses.

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.

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Assessment

Continous Assessment Activities

| Title | Weighting | Hours | ECTS | Learning Outcomes |
|---------------------------------------|-----------|-------|------|------------------------|
| Petri Net Exercises | 15% | 0 | 0 | CA03, KA04, KA05 |
| Simulation Models | 35% | 0 | 0 | CA02, KA06, SA05, SA06 |
| State Space analysis and Presentation | 50% | 1 | 0.04 | KA06, SA05, SA06 |

The proposed evaluation activities may undergo some changes according to the restrictions imposed by the health authorities on on-campus courses.

The final grade will be calculated from the assessment of different evaluation activities:

Petri Net exercises

State Space analysis of a case study and oral presentation.

Simulation models and report of 2 case studies.

In order to average all the evaluation activities, the mark of each of them must be above 5 points (out of 10). All the report-based activities must be submitted within the due dates specified by the professor. If a report-based activity is failed, the student will be asked to re-submit its report according to the corrections/indications provided by the professor.

If the oral presentation is failed, the student will have the opportunity to work in a second case study for a short period of time, that will be communicated to the student well in advance.

The weights of each evaluation activity are given in the table below.

Bibliography

Flores, Guasch, Mujica, Piera, "Robust Modeling and Simulation", Springer. 2017.

N.Viswanadham,Y. Narahari. Performance Modeling of Automated Manufacturing Systems. Prentice Hall. 1992.

Merkuryev, Merkureva, Guasch, Piera: Simulation-Based Case Studies in Logistics: Education and Applied research. Springer London. 2009.

Jamshid Gharajedaghi. Systems Thinking: Managing Chaos and Complexity. Elsevier.

Further readings

Javier Campos, Carla Seatzu, Xiaolan Xi. Formal Methods in Manufacturing. CRC Press 2014.

Taylor. Agent Based Modeling and Simulation. Palgrave Macmillan. 2014

N. Gilbert . Simulation for the Social Scientist.. Open University Press.

Software

CPN-Tools (<https://cpntools.org>)

SIMIO

Language list

| Name | Group | Language | Semester | Turn |
|---|-------|----------|----------------|---------------|
| (PAULm) Classroom practices (master) | 1 | English | first semester | morning-mixed |
| (PLABm) Practical laboratories (master) | 1 | English | first semester | morning-mixed |
| (TEm) Theory (master) | 1 | English | first semester | morning-mixed |