# MG2045

# Decision-making for Advanced Manufacturing

**6 credits**

## Course Information

| Educ. Cycle | Start Date | End Date | Frequency | Grade Scale | Language | Campus |
|---|---|---|---|---|---|---|
| Second Cycle | 28-10-2024 | 13-01-2025 | Annually | A-F | English | KTH Valhallavägen |
| Course responsible: Robert Tomkowski, PhD | | | | | | |
| Branch of study: Mechanical Engineering | | | | | | |

## 1. Introduction

Modern engineering, the rapid pace of technology development, and customer demands for product quality have led to a situation where decisions about manufacturing are highly complex. Nowadays, these decisions cannot be made without support from IT methods and tools, often referred to as "decision support systems." Decision-making is not a trivial task; it requires a combination of hard and soft engineering skills, economic considerations, and, very often, good intuition.

The selection of machine tools, measurement equipment, production plans, production models, etc., is essential for the manufacturing industry and depends on many decisions. The decision process should therefore be conducted carefully, as its outcome can lead to not only economic impacts—both positive and negative—but also potential risks to human safety in case of negative effects. Moreover, the outcome of a manufacturing system is a product, whose features and quality are directly influenced by the right type of machinery selected.

## 2. Course context and objective

The course focuses on decision support systems in advanced manufacturing technology, specifically based on industrial metrology tools and procedures. It provides an extensive review of advanced manufacturing processes, industrial metrology tools, methods, algorithms, and their applicability, configurations, subsystems, structure, design, and operational capabilities.

Throughout the course, students receive comprehensive training in handling and evaluating production and measurement data using applicable statistical tools and machine learning algorithms to ensure traceable results. The course aims to teach students how measurement techniques support decision-making in advanced production.

Upon completing the course, students will be able to apply their newly acquired knowledge in three main activities: designing, conducting, and documenting independent research.

## 3. Course requierements

1. The student should have an exstensive knowledge about statsistics and machine learning algorithms.
2. The student should have a knowledge on using MATLAB as this will be primaly software used in the course. It is suggested that student will finish online courses from Matlab Academy website:
    a. **MATLAB Onramp - Basic free 2 hours tutorial**
    b. **Build MATLAB Proficiency**

## 4. Intended Learning Outcomes (ILO)

Upon completion of the course the student will be able to:

**ILO 1:** Describe advanced manufacturing processes.
**ILO 2:** Explain the importance of metrology (measurement technology) in advanced manufacturing processes.
**ILO 3:** Describe methods and instruments that are used industry for metrology purposes.
**ILO 4:** Evaluate measurement and manufacturing data by use of suitable statistical tools and algorithms for machine learning.
**ILO 5:** Apply decision support systems for advanced manufacturing.

## 5. Teaching and learning activities (TLA)

The course is divided into following TLAs:

**TLA 1:** 14 lectures (including guest lectures)
**TLA 2:** 3 Laboratory exercises (including study visits)
**TLA 3:** 1 Project (2 home assignments, peer-review, project presentation)

## 5.1. Lectures

The lectures focus on decision-making and decision support within the context of advanced manufacturing, emphasizing the critical role of data-driven decision processes in optimizing production systems. Throughout the course, students will explore both theoretical and practical aspects of decision support systems (DSS) tailored to modern manufacturing environments.

The lectures will delve into the foundational principles of decision support systems, examining their structure, development, and operational use in real-world applications. Key topics include methods and techniques for manufacturing data generation and how these systems integrate with advanced metrology tools. The importance of accurate data collection and analysis in improving manufacturing processes will be underscored.

Students will be introduced to various DSS methods such as the Analytic Hierarchy Process (AHP), machine learning (ML) algorithms, and fuzzy logic, learning how to select and apply these methods to different manufacturing scenarios. Data acquisition techniques will also be covered, focusing on the best practices for capturing high-quality, actionable data from manufacturing systems.

In addition, the lectures will cover advanced techniques for manufacturing data analysis, utilizing both statistical approaches and machine learning methodologies. These analytical techniques will enable students to make informed decisions by predicting outcomes, identifying patterns, and optimizing manufacturing workflows.

Real-world case studies will be presented and thoroughly discussed, allowing students to apply the theoretical knowledge they've gained to actual industry problems. These case studies will highlight the challenges and solutions encountered in decision-making for manufacturing, showcasing the practical relevance of decision support systems.

All lectures are carefully designed to prepare students for the hands-on exercises, project work, and the final examination. The exercises will provide opportunities to apply concepts such as data acquisition, analysis, and decision-making strategies to simulated manufacturing environments. The project work will involve designing a decision support system for a specific manufacturing challenge, giving students the chance to demonstrate their ability to integrate various tools, techniques, and methods covered in the course.

By the end of the course, students will have a deep understanding of how decision support systems can be used to improve manufacturing processes, ensuring that production is both efficient and capable of meeting high-quality standards.

| | **SUBJECT** | **DESCRITPION** |
|---|---|---|
| **1** | 1. Course team introduction. Course info / Course Modules division /Lab plans<br>2. Decision making and decision support systems (DSS). Introduction. | Course presentation.<br>Introduction to the topic. The purpose of DSS. What constitute a good DSS? What is a structure of DSS? How to design DSS? What are available commercial DSS? Examples. |
| **2** | Decision making in advanced manufacturing. An overview. | An overview of advanced manufacturing systems, their complexity, dependability, and impact on decision making and decision makers. |
| **3** | 1. Industrial Metrology. An overview.<br>2. The decision-making methods. An overview.<br>3. Project presentation. | Metrology tools and methods used in advance manufacturing, supporting decision making.<br>Decision making methods, tools, and their classification. |
| **4** | The future and importance of integrated metrology systems. Enablers for decision-making. | What is integrated metrology and its impact on the production systems? How integrated metrology supports decision makers? |
| **5** | Decision support systems: Analytical Hierarchy Process (AHP). | Analytical Hierarchy Process decision-making method introduction and its practical use. Examples. |
| **6** | Decision support systems: Statistical analysis of manufacturing data. | Descriptive statsistics, Statistical Process Control as tools for decision making at production shopfloor. |

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| **7** | 1. Decision support systems: Introduction to FMEA (Failure Mode and Effect Analysis).<br>2. FMEA hands-on workshop. | Failure Mode and Effect Analysis as a tool for potential errors/faults prediction in manufacturing. |
| **8** | Decision support systems: Fuzzy logic systems. | Fuzzy logic systems for decision-making and its practical use. Examples. |
| **9** | 1. Study visit.<br>2. Project consultation. | |
| **10** | 1. Data-driven decision making in manufacturing environment.<br>2. Decision support systems: Machine learning methods. | Importance of manufacruing data and its impact on decision making. Data exploration and pre-processing.<br>Introduction to Machine Learning algorithms and methods used in manufacturing. |
| **11** | Guest lecture. Machine learning methods as DSS in manufacturing. | Machine Learning algorithms and methods used in manufacturing.<br>Industrial guest lecture on using ML for decision-making in manufacturing environment. |
| **12** | Data sources and acquisition techniques. | How and from what production data are captured? What infrastructure is needed? What acquisition techniques are available? |
| **13** | Guest lecture. Decision making and support systems: industrial example. | Indsutrial guest lecture on decision making in advanced manufacturing. |
| **14** | Decision support systems: Summary lecture. Review of methods. | Summary lecture and panel discussion with students on complexity of decision-making. |

## 6. Course Literature


[1] Parsaei, Hamid R., Sai Kolli, and Thomas R. Hanley, eds. 1997. *Manufacturing Decision Support Systems*. Boston, MA: Springer US. https://doi.org/10.1007/978-1-4613-1189-8.

[2] Thakkar, Jitesh J. 2021. *Multi-Criteria Decision Making*. Vol. 336. Studies in Systems, Decision and Control. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-33-4745-8.

[3] Jain, Lakhmi C., and Chee Peng Lim, eds. 2010. *Handbook on Decision Making: Vol 1: Techniques and Applications*. Vol. 4. Intelligent Systems Reference Library. Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-13639-9.