Course Memo Spring 2024

Version 1

MF2011 VT24 Systems engineering, 9 credits

Introduction

Systems engineering requires a holistic view, multidisciplinary cooperation, and a systems approach. Desired effects, such as long life, small energy losses and good cooling, and undesired effects, such as high cost, high weight, large deformations, vibrations and noise, are two types of technical effects intimately related to most mechanical electromechanical systems. An optimal technical design can be defined as the design that maximizes the most important desired effects or minimizes the most dominant undesired (or unnecessary) effects in the best possible way. For a design to be optimal from the customer, society, and enterprise perspectives, it must possess many other essential properties despite purely technical properties and prerequisites and good treatment of technical complexity and uncertainty.

Learning goals

After completing the course, the student should be able to:

1. Demonstrate ability to creatively, critically and systematically integrate knowledge from previous courses to analyze, judge and deal with complex systems, even based on limited information;
2. Demonstrate the ability to criticize common models for planning and executing systems engineering;
3. Demonstrate the ability to design a technical system with the support of a master CAD model and related simulation models;
4. Demonstrate the ability to make design decisions based on the outcome of the Design Structure Matrix based analysis of the architecture of a complex system and identify module candidates;
5. Demonstrate ability to visualize and discuss engineering conclusions and the knowledge and arguments behind them in dialogue with different groups, orally and in writing;
6. Demonstrate the ability to establish a qualitative risk analysis;
7. Demonstrate ability to design a complex system, including selecting technical solutions and considering relevant scientific, social, economic and environmental aspects.

Admission and course registration

Admission to the course is made via the study program's study guide to fulfill the special eligibility for the course. The course is at an advanced level, and the prerequisites are a Bachelor's in Mechanical Engineering or similar. Admitted students are responsible for

registering via KTH's student web. Re-registration on the course is done via ITM Studentexpedition Nord in connection with the course start.

Course activities

For the course (9 credits) to be approved, the following two elements must be completed and approved:

Project (6 credits) constitutes the main part of the course and is carried out in project groups of 4-6 students. The course is based on an analysis and redesign (or updated design scenario) for an existing technical system. In the end, you should have a conceptual design of the system. The whole class is one project group with one common goal divided into several subgroups. That makes it possible to solve problems with a higher degree of complexity. You need to apply theoretical knowledge in a more practical and big-picture context in the project. The project works require high demands on planning and communication within the group. A stage-gate process, Figure 1, will support this. See the detailed preliminary schedule in Appendix A.

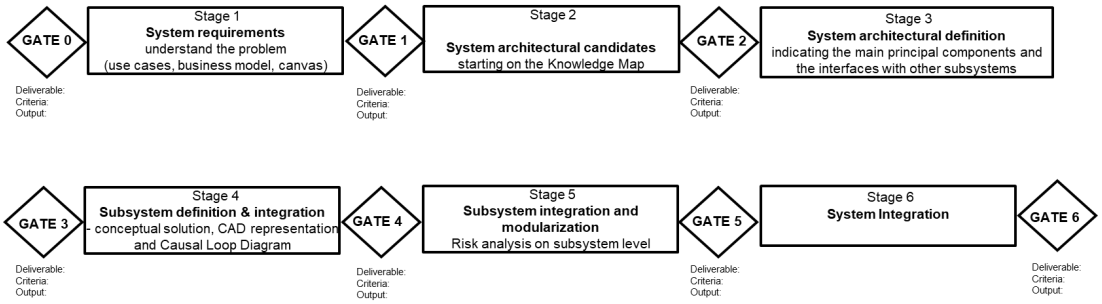

Figure 1. The project is divided into several sequential stages/phases in a stage-gate process. Each phase is preceded by a gate/decision point for go/stop and prioritizing the development project's continuation.

Home exam (3 credits) is a descriptive personal logbook on course topics and project activities, i.e., lectures, seminars, exercises, and project activities and results. The examiner takes into account whether the student has submitted on time, rating may be lowered.

Examination

Examination and final grading (A-F) are based on the following three-level scheme:

- Level 1 (Grading E or D) – Participation at the lectures, passed exercises and active participation at the seminars and in the project work+ a descriptive personal logbook on all course topics and project activities.
- Level 2 (Grading C or B) – passed level 1 + individual (good quality) contributions to project group deliverables + added reflections on each course topic and project activity to a personal logbook.
- Level 3 (Grading A or B) – passed level 2 + added final analysis, reflections, and suggestions on the project process and technical outcome on course topics and project activities to the personal logbook + an oral examination

The oral examination is named Other in the KTH schedule. Questions can be found on the Canvas page at the start of period 4. You will have 15 minutes to answer at least 2-3 of the questions, and the examiner will be able to assess if you have understood the learning goals at Level 3.

Learning activities

The course is based on an analysis and design or redesign scenario for an existing technical system combined with lectures, computer exercises, workshops, and seminars to support the project and to understand the discipline and practice of systems engineering.

Activity	Time	What	Where
Lectures (L)	10 x 2 h	Theory and examples linked to the assignments and the project.	75% attendance required
Exercises (E)	4 x 3 h	Practical assignments performed in groups. Assignments are uploaded to Canvas.	Attendance is not required
Seminars (SEM)*	4 x 4 h	The groups will be appointed literature on the seminar topic and prepare an oral presentation of the studied material. However, not all groups will be selected to present in front of the class. The presentation must be uploaded to Canvas the day before the presentation.	Attendance required
Gate meetings (P, presentations)	5 x 2 h	Project gate meetings with short subgroup presentations to track deviations and decide how to proceed to the next phase. The presentation must be uploaded to Canvas the day before the presentation.	Attendance required
Gate 6 (P, final project presentation)	1 x 6 h	The project presentation is a seminar where each project subgroup presents its subproject. All members should be ready to present. Results are documented in a technical report.	Attendance required
Workshops	6 x 2 h	Information exchange and decision-making where groups meet and track if the project is going according to plan and if there are any deviations from the plan.	Attendance required
Project work	158 h	Individual and group responsibility to plan and attend. Specific deliverables are defined at the project meetings.	Non-scheduled
Personal logbook	20 h	It can be seen as a diary and is the Home exam (3 credits), see Examination.	Non-scheduled

*The literature seminar titles:

1. SEM1 on Systems engineering
2. SEM2 on Product architecting
3. SEM3 System Dynamics
4. SEM4 on RAMS

Course room in Canvas

The course round is administered through a course room in KTH's Canvas learning platform. The students log in to Canvas with their KTH ID and gain access to the course room when they are course registered.

Course literature
Since the course applies knowledge from previous courses, it is assumed that the students can access previous course literature.

- Course material on Canvas Learning Management System (LMS)
- Systems Engineering Handbook - A Guide for System Life Cycle Processes and Activities (5th Edition) by International Council on Systems Engineering (INCOSE) Available online via KTH Library
- See also the INCOSE homepage
- Standards at KTH library, go to Primo and select SIS Abonnemang:

Software systems
We use Word, Excel, and Solid Edge 2023, LUCID Software, and presentations can be made using PowerPoint or better.

Welcome to the course!

Ellen Bergseth, bergseth@kth.se, 08-7907383
Examiner, course responsible and teacher

Teachers:
Zeinab Raoofi, zeinabr@kth.se
Claudia Andruetto, andru@kth.se
Bhavana Vaddadi, bhavana@kth.se

Coaches from the industry:
Will be introduced the first lecture.

Appendix A - Preliminary schedule

The table shows the **preliminary** schedule for MF2011 VT24.

Week	Prel. time	Activity code	Responsible for the activity	Activity	Title & short explanation of the activity
W3	2 h	1(202403) 16th Jan	Ellen Bergseth	L1	Course introduction – Why Systems Engineering?
W3	2 h	1(202403) 19th Jan	Bhavana Vaddadi	WS1	Collaborative workshop. Who are you – how can you work in groups and make the most of your different skills?
W4	3 h	2(202404) 23rd Jan	Ellen Bergseth (attended by all teachers)	Gate0	Gate 0 – Project introduction : What will you work with this semester
W4	2 h	2(202404) 24th Jan	Zeinab Raoofi	L2	Business models and stakeholder needs (Explore each project as a start up, business model canvas)
W4	3 h	2(202404) 26th Jan	Supervisory role/ students will work on their own. (Bhavana, Ellen)	E1	Collaborative design using CAD models, opening the existing master model, and trying out different CAD formats.
W5	2 h	3(202405) 31st Jan	Claudia Andruetto	L3	Systems Thinking
W5	2 h	3(202405) 2nd Feb	Zeinab Raoofi and Åsa	L4	Configuration management at Saab GUEST LECTURE
W6	2 h	4(202406) 6th Feb	Henrik Gustavsson from Alstom and Zeinab	L5	System requirements lecture (GUEST LECTURE, shows activity diagram)
W6	4 h	4(202406) 7th Feb	Claudia Andruetto and Bhavana Vaddadi	SEM1	Literature INCOSE Handbook and papers. Presenter and opponent approach.
W7	2 h	5(202407) 9th Feb	Supervisory role/ students will work on their own. (Claudia, Ellen)	E2	Function-means tree and setting up the first version of the "Knowledge Map" make sure to track your changes. SIG: CM & PDM plan
W7	3 h	5(202407) 13th Feb	Zeinab Raoofi and Ellen Bergseth	Gate1	Gate 1 – System requirements (listing the system requirements and label them), Business Requirements, scenario activity 5!? min presenations from one or two students from each group

W8	2h	6(202408) 20th Feb	Claudia Anrduetto and Fredrika Käller Fjällström	L6	SE at Saab - an introduction to SE at Saab and the everyday life of a systems engineer, including a short case to challenge your systems thinking, GUEST LECTURE
W8	2 h (Digital)	6(202408) 21st Feb	Claudia Andruetto, Zeinab Raoofi	WS2	Collaborative workshop. How do we communicate and visualize a baseline? For example, how do we put down the system requirements for the system as a whole in a way that all can follow? KPIs involved in their projects, main goals of bigger project and how to share that along with 60 students. LUCID software SIG will map this (DIGITAL)
W9	2 h	7(202409) 27th Feb	Claudia Anrduetto and David Williamsson from Scania	L7	Robust and intelligent modules, design structure matrix. David will introduce the exercise. GUEST LECTURE
W9	3 h	7(202409) 1st Mars	Ellen Bergseth	Gate2	Gate 2 - System architectural candidates (continue building on the "Knowledge Map", focus on DSM)
W12	4 h	8(202412) 19th Mar	Claudia Anrduetto and Zeinab Raoofi	SEM2	Architecting literature seminar (2 core papers and 1 unique for each subgroup). Presenter and opponent approach.
W12	3 h	8(202412) 20th Mars	Supervisory role/ students will work on their own. (Zeinab)	E3	Module clustering. David has introduced the exercise
W13	3 h	9(202413) 26th Mar	Ellen Bergseth and Zeinab Raoofi	Gate3	Gate 3 – System architecture definition
W13	2 h	9(202413) 27th Mar	Claudia Andruetto	L8	Complex Dynamics Systems
W15	4 h	10(202415) 9th April	Claudia Andruetto	SEM3	Complex Dynamic Systems (add budget papers also?) (2 core papers on SE and 1 unique for each subgroup). Presenter and opponent approach.
W15	2 h (Digital)	10(202415) 12th Apr	Zeinab Raoofi	WS3	Collaborative workshop: System Integration group will present A3 sheets of the complete train and highlight the problematic areas.
W16	3 h	11(202416) 16th Apr	Ellen Bergseth and Claudia Andruetto	Gate4	Gate 4 – System element definition & integration

W16	**2 h**	**11(202416) 17th Apr**	**Ellen Bergseth and Fredrik Asplund**	**L9**	**Reliability, Avilability and Mantainability, and Safety (RAMS)**
W17	**2 h**	**12(202417) 23rd Apr**	**Fredrik Asplund and Bhavana Vaddadi**	**WS4**	**Hazard analysis Workshop**
W17	**2 h**	**12(202417) 24th April**	**Johanna Axehill and Christoffer Joannet, SAAB**	**L10**	**System verification and validation GUEST LECTURE**
W18	**3 h**	**13(202418) 30th April**	**Zeinab Raoofi**	**E4**	**Business Model Canvas – new exercise (how can we try to budget in such an early phase of product development?) Zeinab Raoofi (Subgroups)**
W18	**4 h**	**13(202418) 3rd May**	**Ellen Bergseth and Bhavana Vaddadi**	**SEM4**	**Reliability Availability Maintainability and Safety (RAMS) seminar (2 core papers and 1 unique for each subgroup). Presenter and opponent approach.**
W19	**2 h**	**14(202419) 7th May**	**Bhavana Vaddadi**	**WS5**	**Collaborative workshop**
W19	**3 h**	**14(202419) 19th May**	**Ellen Bergseth**	**Gate 5**	**Gate 5 – System integration**
W20	**2 h**	**15(202420) 14th May**	**Claudia Anrduetto**	**WS6**	**Collaborative workshop**
W20	**6 h**	**15(202420) 17th May**	**Ellen Bergseth**	**Gate 6**	**Gate 6 – Project presentation seminar**
W21	**4 h**	**16(202420) 21st May**	**Ellen Bergseth**	**Other**	**Oral examination for those students aiming for learning goals at Level 3 (A or B)**
W22	**6 h**	**TBD**	**Ellen Bergseth**	**Other**	**Oral examination for those students aiming for learning goals at Level 3 (A or B)**