Systems Engineering Course Research Methods; Assignments

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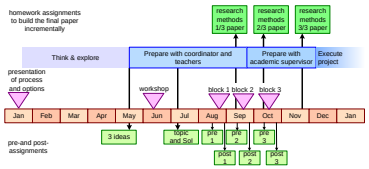

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Abstract

This course teaches research methods for systems engineering and related disciplines, such as industrial economy, engineering management, innovation, and technology management. This field of research needs research methods combining the traditional scientific methods ("hard") and methods from social sciences ("soft").
The course prepares students for their master thesis.

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1 Introduction

This paper describes the in-class and homework assignments for Systems Engineering Course Research Methods.

2 Research Methods Course Pre-assignment

During the course, we will help you to shape your master project. It is essential to have sufficeint idea about the amster project at the beginning of the course, such that you can evolve and elaborate the topic during the course and transform it into a master project proposal, and furtehr into a plan how to do the rseearch during the master project.

The goal of this pre-assignment is to have a starting point that will help you during the course. Getting form nothing to somethign is challenging. We know that this step can already eb difficult. Don' hesitate to contact one of the taechers in order to shape a good enough starting point.

- Determine a topic for the master project. Typically the topic has
  - a context
  - a case in that context,
  - a problem that manifests itself in that context
  - an idea of what specific systems engineering approach, method, tool, or concept may help to address that problem.
    * Position the topic in its context (e.g. in your company, in ongoing projects)
    * Discuss the topic with its stakeholders
    * Try to formulate an initial draft line of reasoning:
      · what is the current problem
      · for what stakeholders
      · what is the goal, e.g. the desired situation in the future
      · what solution do you envision
      · what is the rationale for this envisoned solutio
      · what are open research questions, e.g. what do you want to know at the end of the research?

3 Flow of all assignments during the course

The course consists of 3 blocks of teaching: 2 days, follwoed by 2 days, followed by 1 day. Before each block and after each block, the partici-

pants have to make pre-, post-, and homework assignments, while they also get assignments in class, during the blocks themselves.

The participants work on an in-class case and on their own master project topic. The purpsoe of the in-class case is to actively learn the research preparation approach. the idea is that by working in small groups, participants can help each other in experiencing the challenges of defining a research project. Having the same case allows them to discuss the steps.

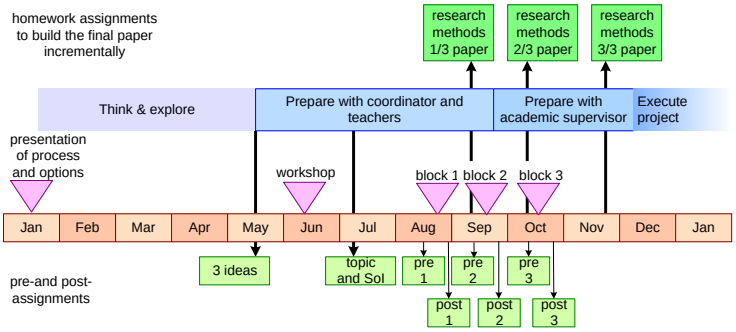

Figure 1: Timeline of assignments in relation to the course blocks

Figure 1 shows the main deliveries for the individual master project above the timeline, and the additional pre- and post-assignments below the timeline.

The homework assignments are building the final paper in 3 steps. Each step adds content and imrpoves content of the previous step. Hence the final paper of about 15 pages is the result of each individual homework assignment.

4 In-class problem exploration

4.1 What triggers this problem?

Figure 2 shows the steps to explore the problem that triggers this research. the purpose is to get an initial understanding of the rationale for doing this research. This will also help to scope the research, and doing this may change your understanding of the problem and hence may change the approach to the research.

- Describe what problem triggers your research
- Be as specific as possible, for instance asking:
  - Why, what, how, who, when, where
- If you find it difficult to describe the problem, then start with listing symptoms and challenges, or identifying dilemmas

Figure 2: What Specific Problem Triggers this Research?

4.2 Problem exploration

Figure3 proposes a set of questions to explore the problem space. Again better understanding the problem space may change your approach to the research.

- Who are the stakeholders related to this problem
- What can you ask them to explore the problem
- What can you tell them to introduce your research
- Transform the answers into a script for interviews of stakeholders

Figure 3: Problem exploration

5 Master project topic: Explore the problem

Repeat the process that you followed in the in-class problem exploration. We will continuously challenge your master project topic with the purpose of sharpenign it, making it more specific and clarifying the goal, and hence what we want to research.

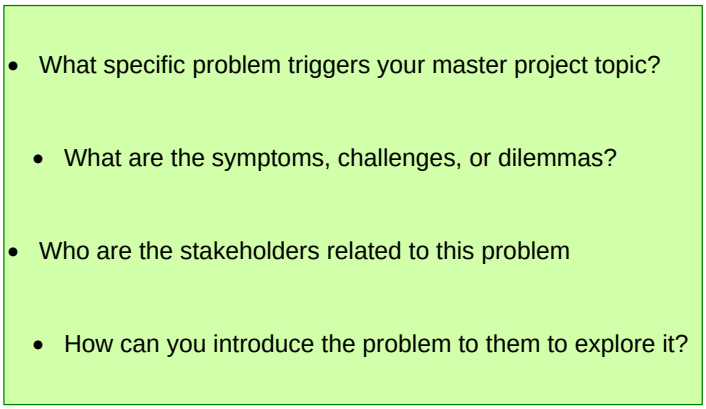

Figure 4: Explore the master project problem and its trigger

6 In-class case, formulate initial research questions

Figure5 shows the assignment of making initial research questions. Research questions form the core of the research. They help to search litarture, to define what you wnat to measure or observe, what to analyze, and bring structure to the paper especially the doisucssion and conclusion.

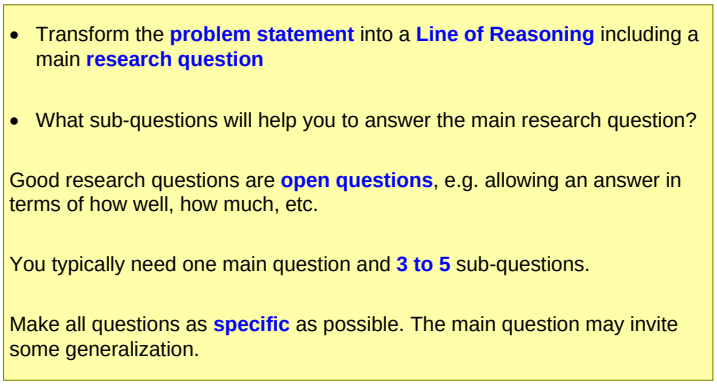

Figure 5: Formulate an initial set of research questions

It may sound easy to write research questions. However, in ptactice, the challenge is that you initially may not know ewneough, may not understand the problem itself and the possible research approach well enough yet. Hence, this is a first step, where we try to get an initial set of research questions that we will evolve (sharpen, reformulate, change) multiple times. Progressive insight will help us to get to satisfactory

research questions.

From experience we know that this step feels abstract. Don't worry, since in following steps we will revisit the problema nd posisble solutions to keep it suffciently concrete.

7 Feasibility of the master project study

Figure 6 poses a set of questions to make an overview of your master project. We make the overview on paper so thatwe can share it later with other participants and academic staff in the class. The overview will help to assess the feasibility of the envisioned study for your master project.

- Make an overview on paper with your current idea for the master topic
  - What is your current idea about the context, system of project of interest, and the Line of Reasoning
  - What scope of the research is fitting in the available time and effort
  - What do you need (e.g. information, contacts, access to people, tools, …) to perform the study?
  - What risks do you see for the research?

Figure 6: Formulate an initial set of research questions

Figure 7 describes the process of discussing the overiew with colleagues and academic staff. The purpose of this discussion is to get better insight by telling the story to othersd and by getting feedback from them. We encourage the visitors to write their comments on note stickers and adding them to the overview.

8 In-class Literature Search

We start the literature search with an initial quick search to get an impression of available literature and what it covers. This first quick search will help us to sharpen the research questions, and to update keywords. Figure 8 shows the first assignment to search literature. Search litearture for the in-class case.

- Attach your paper overview on the wall
- Half of the students stay at their overview, the other half visit their colleagues
- As a host, discuss the content of the overview with visiting staff and colleagues to gather feedback and comments to clarify your own ideas (ca 30 minutes)
- As visitor add notes to the overview with your comments
- repeat with the other half of the students (ca 30 minutes)

Figure 7: Formulate an initial set of research questions

Make sure to keep copies of all papers that you access. When papers look interesting, however, it is behind a paywall that is not accessible to us, then use the print pdf function of the browser to store the article informatio. You need to submit copies of the papers when submiting the search results. Use the same startegy for your master project, where we also need copies of all papers that your paper cites.

- Use the research questions to determine 5 to 10 key words or phrases
- Search for relevant literature
- Identify ~3 potentially interesting papers
- Make an initial assessment of these 3 papers
- Use the template SERMliteratureSearchResultsTemplate.xlsx in Canvas to keep notes on all papers you find
- Save a copy of each publication. When behind a paywall, use the browser print pdf function to capture the publication information

Figure 8: Perform a quick initial search for literaturefor the in-class case

Now refine the search using the insights gained in the initial literature search. See Figure9 shows the assignment. The purpose of this search is to identify publications that you can use in a paper to psoition the research.

Figure 10 shows the last step: uploading the search results in Canvas per team.

- Refine the 5 to 10 key words or phrases
- Look for literature reviews
- Look for founding papers
- Use these to search for relevant papers
- Order on relevancy based on abstract
- Extend the list to at least 10 publications
- Use the template SERMliteratureSearchResultsTemplate.xlsx in Canvas to keep notes on all papers you find
- Save a copy of each publication. When behind a paywall, use the browser print pdf function to capture the publication information

Figure 9: Refine Literature Search

- Upload your literature search results in Canvas
- Upload the zipfile with the publications.

Figure 10: Upload Literature search results

9 In-class case, propose a survey approach

Figure11 shows the assignment of proposing a survey approach. An essential step is defining the target groups. Target groups have different world view, and drivers, so they may need a different approach with different questions. Once you ahev defined questions, you have to define the format of the question on the spectrum from fully unstructured (free text) to fully structured, e.g. a Likert scale or predefined answers. Often you want to have a mix of these formats.

- Define the target groups
- For each target group
  - Formulate survey questions
    - Propose format per question, e.g. free text, range, Likert scale
- Submit the results in Canvas

Figure 11: Propose a survey approach

10 Initial research design for your own master project topic

Envision how you may do your research in a few months. Figure12 shows questions to think about possible ways to do your reearch

Envision how you may do your research in a few months

- What will you do, when and where with who?
- What will you look for and look at?
- How can you analyse what you did and observed?
- How will this help you to answer the research questions?

Figure 12: Make an initial research design for your own master project topic

11 Post-assignment: refine your own master project topic

The purpose of the post-assignment is to get early feedback on the direction that you are taking for the master project. In this way, the

effort you invest in the homework is likely well spend. Don't make the refinement too extensive or polished, since it only needs to be good enough to get feedback on your direction. You need your time to do the homework assignments. Normlly this step is an evolution of the course pre-assignment. When you are stuck, then contact the teachers. Figure13 shows the steps for the refinement.

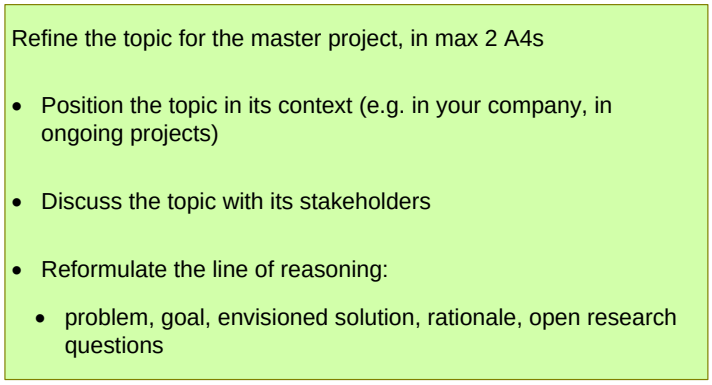

Figure 13: Post-assignment: refine your own master project topic

12 Homework Block 1: write the first part of the final paper

The homeworkis buidling the final paper in 3 steps. Each step is about 50 hours if study load. Figure14 shows how much each activity of teh course uses of the total study load. The figure elaborates how to spend the 50 hours for the first increment of the final paper:

* 30
  and using that for writing an introduction
* 60
  and writing a draft literature section
* 10
  Try to catch your ideas briefly in a few sentences

While doing all this work, maintaina logbook, e.g. capture inputs from stakeholders (with meta information,e .g. who said what when), store a copy of each paper you read, make notes on the papers

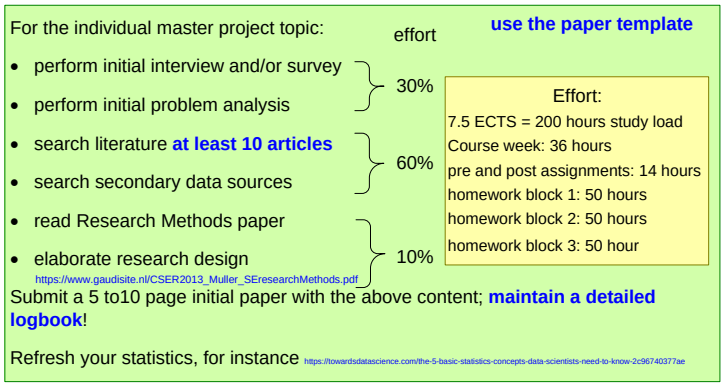

Figure 14: Homework Block 1: write the first part of the final paper

13 Colophon

This course is a joint development of Kristin Falk, Satya Kokkula, Elisabet Syverud, Omid Razbani, and Gerrit Muller.

References

[1] Gerrit Muller. The system architecture homepage. `http://www.gaudisite.nl/index.html`, 1999.

History

Version: 1.8, date: August 15, 2026 changed by: Gerrit Muller

- added SECRMAmasterProjectPostAssignmentBlock1,SECRMAmasterProjectHomeworktBl

Version: 1.7, date: August 15, 2026 changed by: Gerrit Muller

- replaced SECRMAassignmentFlow by SECRMAtimeline

Version: 1.6, date: August 6, 2026 changed by: Gerrit Muller

- started to make an article version. This version includes Block1, other blocks to be done
- updated literature search assingments with instructions for the template and saving of publications
- updated group assignments for the survey

Version: 1.5, date: August 21, 2025 changed by: Gerrit Muller

- updated SECRMAhomeworkBlock1,SECRMAhomeworkBlock2,SECRMAfinalHomework,SECRMFschedule

Version: 1.4, date: August 14, 2025 changed by: Gerrit Muller

- added SECRMAproblemReflection, SECRMAproblem, SECRMAproposal, SECRMAassessProjectStatus
- color coded in-class (yellow) and own master project topic (green)
- updated SECRMFschdule,SECRMAinitialResearchQuestions, SECRMAstudyFeasibility,

Version: 1.3, date: October 24, 2024 changed by: Gerrit Muller

- adapted abstract length to INCOSE symposium guideline

Version: 1.2, date: August 22, 2023 changed by: Gerrit Muller

- changed SECRMAliterature

Version: 1.1, date: August 23, 2022 changed by: Gerrit Muller

- changed SECRMAassignmentFlow, SECRMApostAssignmentGroup
- changed status to draft

Version: 1.0, date: September 14, 2021 changed by: Gerrit Muller

- added SECRMAmetaLevels
- changed status to draft

Version: 0.9, date: August 12, 2021 changed by: Gerrit Muller

- added SECRMAinitialSurvey
- added statistics refresh to Homework 1

Version: 0.8, date: October 29, 2020 changed by: Gerrit Muller

- added exercises day 5
- changed logo to SECRMAassignmentFlow
- changed status to preliminary draft
- added assignment MPWAexercise, SECRMAannotateBookPlan, and SECRMAresearchDesignDiagram

Version: 0.7, date: September 19, 2020 changed by: Gerrit Muller

- added exercises days 3 and 4

Version: 0.6, date: September 18, 2020 changed by: Gerrit Muller

- added assignment flow
- updated group post assignment block 2

Version: 0.5, date: September 9, 2020 changed by: Gerrit Muller

- updated homework blocks 1 and 2; added sentence on submission and case

Version: 0.4, date: August 18, 2020 changed by: Gerrit Muller

- added post-assignment group work block 1 and 2

Version: 0.3, date: September 29, 2019 changed by: Gerrit Muller

- added post-assignment block 2

Version: 0.2, date: August 13, 2019 changed by: Gerrit Muller

- added post-assignment block 1, homework block 2, final homework
- updated literature search questions

Version: 0.1, date: August 10, 2019 changed by: Gerrit Muller

- added assignments for day 2

Version: 0, date: August 7, 2019 changed by: Gerrit Muller

- Created, no changelog yet
- with input and support from Kristin Falk, Satya Kokkula, and Elisabet Syverud