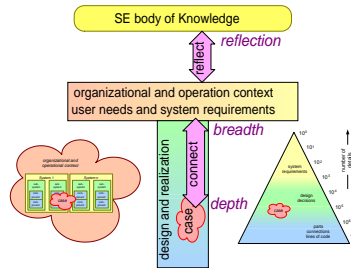


# Systems Engineering Master Project

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## Abstract

The master study Systems Engineering is completed by performing a thesis project. This document describes objectives and guidelines for the project and the thesis.

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version: 1.1

status: concept

August 20, 2010

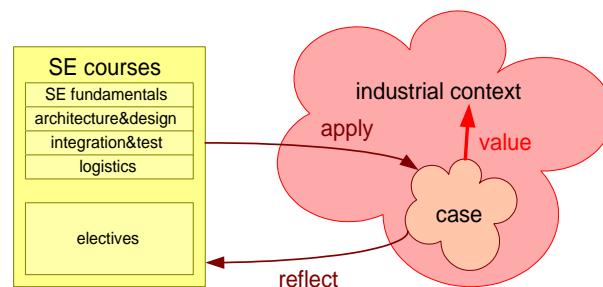
# 1 Introduction

Students must do a research project as part of the Systems Engineering master education at Buskerud University College. The project is performed in the last semester of the study. The goals of the project, further elaborated in section 2, are to apply systems engineering techniques in practice and to do actual research.

The master project is 6 months full time work, resulting in 30 ECTS.

This document is mostly applicable for many master studies, although this document described the specific situation of Systems Engineering at BUC.

# 2 Project Goals and Positioning



Apply SE methods, techniques, and concepts in practice and reflect on its application, while providing value to the industrial sponsor

Figure 1: Objectives of Masters Thesis Project

The main goals of the master project, shown in Figure 1, are:

- to apply Systems Engineering methods and techniques in practice
- to reflect on the value
- to create value for the industrial sponsor
- to do research at academic (master) level

The project has multiple stakeholders with different concerns. Figure 2 shows at the right side the industrial stakeholders: the sponsor who provides the industrial context and who expects usable results, and the supervisor who does the daily coaching and who is involved closely with the industrial case. At the left hand side the academic stakeholders are shown: the SIT professor responsible for the quality and the grading, and the BUC professor who does the daily academic coaching and

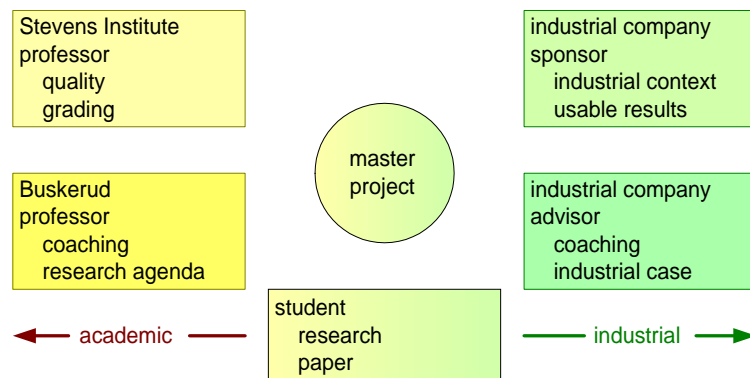


Figure 2: Stakeholders of the Thesis Project

who aligns the project with the BUC research agenda. In the middle the master student is shown as remaining stakeholder, doing the research project that must result in a paper.

What methods, techniques, tools, concepts	Systems Engineering
What (sub)systems, releases, functions, qualities, aspects, disciplines, technologies	industrial
What timing of activities and deliverables	planning
What resources (student time, means, advisors)	planning
What approach, criteria	research

Figure 3: Scoping is Crucial

The industrial environment is broad and complex, and the field of Systems Engineering is also quite broad. Scoping of the project is a crucial success factor. It is difficult to reach a specific result with some substance in a half year, if the scope of the project is broad.

Figure 3 shows that the project can be scoped in multiple dimensions. Core part of the scoping is what Systems Engineering methods and techniques will be researched and what industrial case will be used. The scope can be further fine-tuned by the project planning, resources and research method.

The student has to select what methods, techniques, tools or concepts will be applied, to scope the Systems Engineering content. Note that in general several methods and techniques will be used in the case, however, the focus of the research itself has to be more narrow. For example, in the industrial case requirements, selection matrices, functional models, use cases, and activity diagrams might be used, while the focus of the research is only on selection matrices.

The industrial supervisor and the student have to scope the case, by determining what component(s), what subsystem(s), what function(s), what qualities, aspects, disciplines and technologies belong to the case. For example, the case could be the control engineering part of the motion control component in the positioning subsystem.

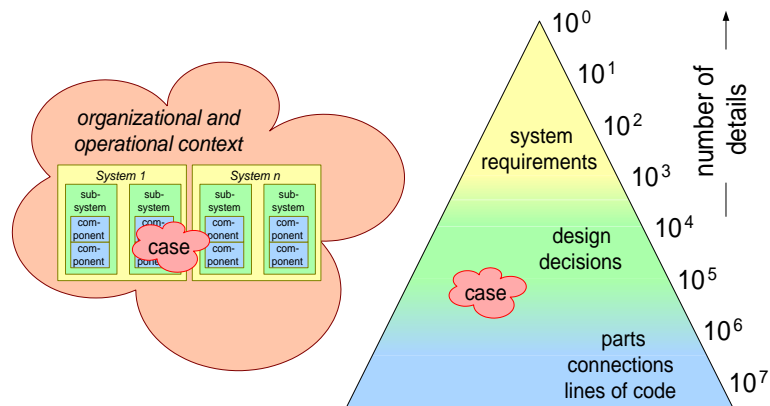


Figure 4: Case Positioning

We have described the case positioning above in several dimensions. Figure 4 adds one more perspective on the case positioning: the level of abstraction or the amount of details taken into account.

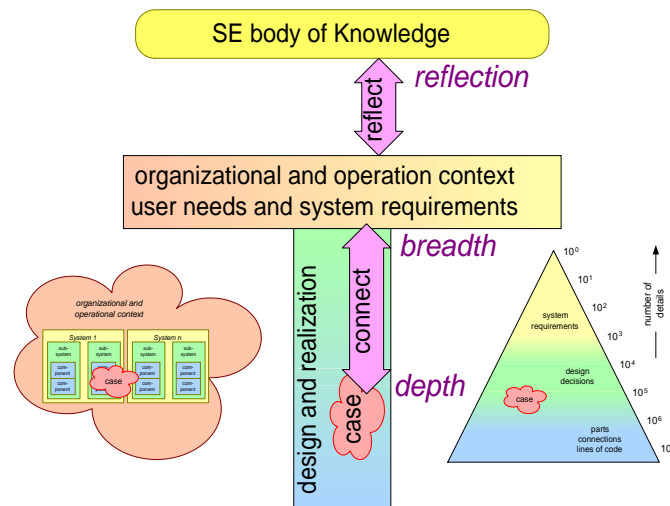


Figure 5: Depth, Breadth and Reflection

Typical cases that have been scoped to fit the project needs address only part of the system, making the case somewhat remote from the system itself and the

customer needs. Figure 5 shows that the breadth of Systems Engineering requires the student to link the case to the system requirements, the user needs and the organizational and operational contexts. The research part of the project is to reflect on this depth and breadth interaction in relation to the Systems Engineering Body of Knowledge.

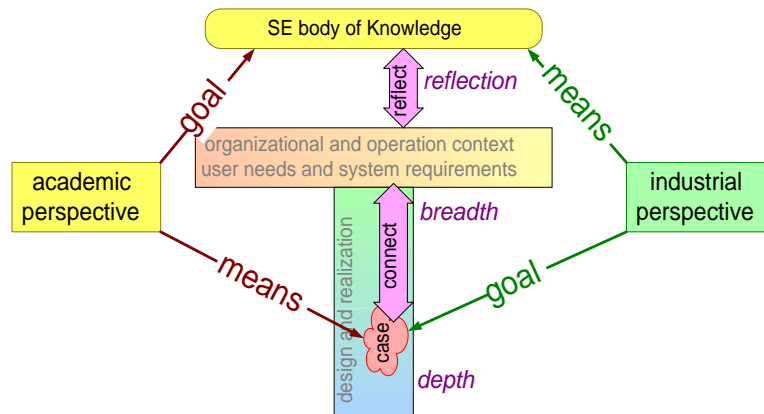


Figure 6: Difference Academic and Industrial Goals

Finally, Figure 6 shows that the industrial and academic interests are different: industrial interests are primarily to address the case, using Systems Engineering knowledge as means, while the academic interest is to extend and solidify the Systems Engineering Body of Knowledge, using the case as means.

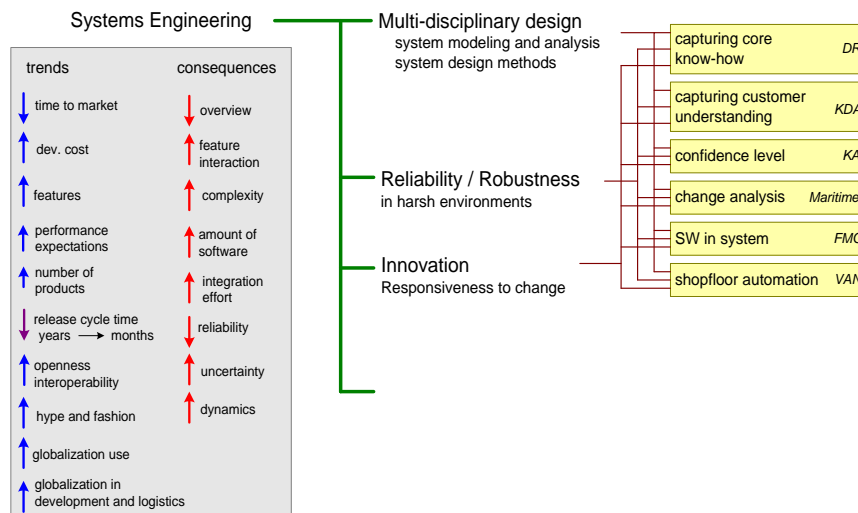


Figure 7: Buskerud Research Agenda

The research projects must also fit in the interests of the academic supervisor. The Buskerud Research Agenda, shown in Figure 7 from [2], provides some direction to select the Systems Engineering content and industrial case to fit in the BUC interests.

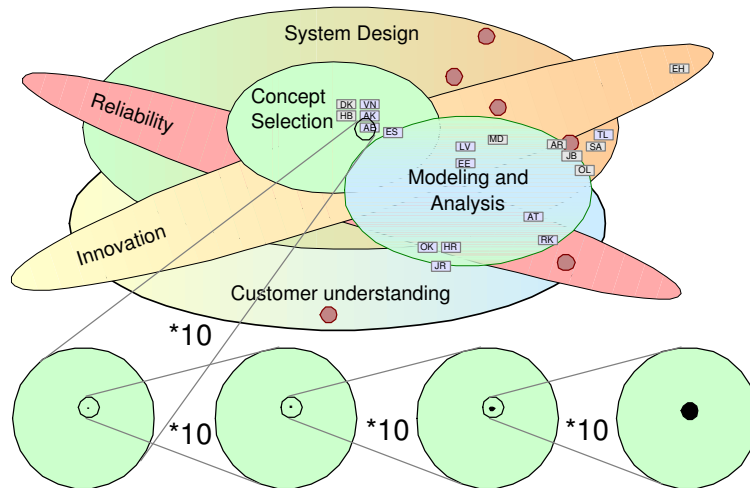


Figure 8: Mapping Master Projects on the Research Agenda

Figure 8 shows how the master projects of the first generations of master students map on the research agenda. The research agenda is shown different: as a Venn diagram. Every small rectangular box with two letter initials represents the position of that specific master project. At the bottom of the diagram it is shown that every individual project is a very small contribution to the research area. However, the combination of many small projects helps to get a better understanding of the research field, to see patterns, and to start validation across projects and domains.

### 3 Preparing and Performing the project

Figure 9 shows the entire process of preparing and executing the project. The first steps are to pick the subject for the project and to secure the advisors. Then the subject can be scoped, as described in Section 2.

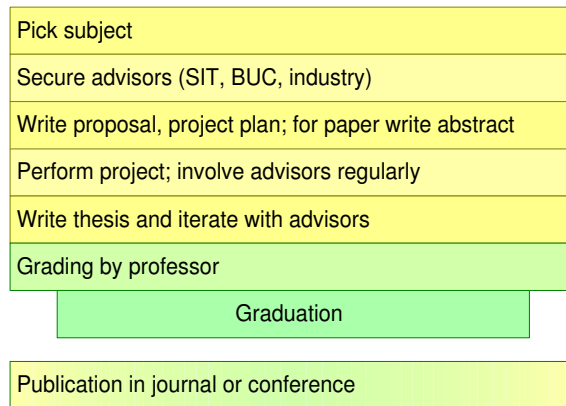


Figure 9: Process of Thesis Project

The project is described in three single page deliverables:

**proposal** describing the project, the case, and the value for the industrial sponsor

**plan** showing the project time-line, activities, milestones, and their relations

**abstract** of the paper to delivered at the end of the project

[3] provides more background information on shaping this type of multi-disciplinary projects.

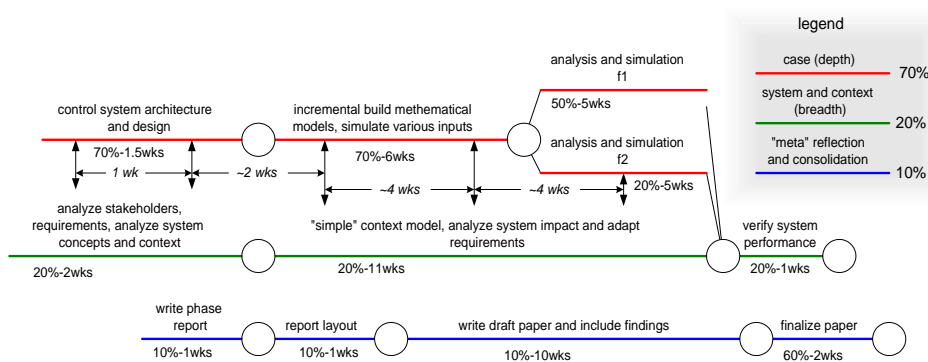


Figure 10: Plan: Simple PERT Diagram

We recommend to draw a simple and straightforward PERT plan [4]. An typical example for this type of projects is shown in Figure 10. In this plan we show the three main topics shown in Figure 5: the case specifics, the system and its context, and the reflection and research activities. Note that all these activities run concurrently. We recommend to use time-boxes of hours to days to manage this concurrency. The plan also shows that typically most time is spend in the case itself (about 70%), less time is spend on the system and its context (about 20%), and the time of actually reflecting and writing (the final delivery) is only about 10%.

*"A good abstract should answer three questions:  
 What did I do,  
 what did I learn,  
 and why is that important?  
 The key is to identify something or things that can be reused in the future."  
 Prof. Michael Pennotti, Stevens Institute of Technology*

Figure 11: Abstract

After scoping the project, and discussing it with the advisors, the next challenge is to write the abstract of the paper before the actual project start. Writing of the abstract forces the student to think and to be sharp about the research project its goal and the expected outcome. Figure 11 shows a quote from Prof Pennotti from SIT explaining what constitutes a good abstract.

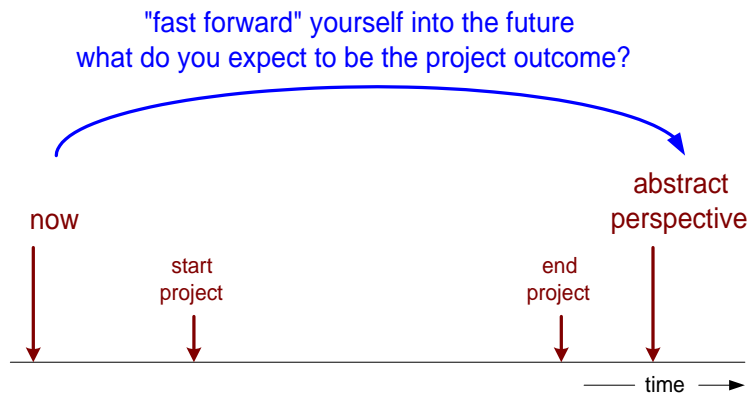


Figure 12: Needed: Time Machine

The challenge in writing such abstract is that the student has to take the future perspective: imagining that the project has been finished. Figure 12 illustrates this "time machine" that is needed to write the abstract. Note that the actual abstract

in the final paper probably will be adapted to fit the actual findings. The students don't have to fear that the abstract is fixed after writing this initial version.

maintain a project log	data, findings documents references
keep supervisors involved	regular presentations regular meetings
time box and iterate	case system and context reflection and consolidation
early feedback on paper	start writing early elicit feedback early work incremental

Figure 13: Project Execution

Once the project is approved the project execution can begin. Figure 13 gives a number of recommendations for the execution of the project:

**maintain a project log** during the entire project execution, from the early beginning onwards:

- Make bibliographic notes of papers, books, and other documentation sources.
- Store all "raw" data obtained by interviews, measurements, or any other project activities.
- Archive intermediate results, such as presentations.

**keep advisors involved** by organizing regular meetings and presenting regularly

**time box and iterate** the different levels of activities in the project:

- the case work itself (depth)
- the system, user needs, and the organizational and operational contexts (breadth)
- reflection and consolidation

**elicit early feedback on the paper**, start writing parts of the paper early and ask for feedback early and frequently from different stakeholders. Create the paper in an incremental way.

The final deliverable of the project and the main input for grading is the paper. The goal is to produce a paper that can be published at a conference or in a journal.

- 1.Explanation of the subject; what is the goal of the project?
  - 2.Positioning of the subject in the academic context and literature; what does this paper add to the Body of Knowledge?
  - 3.How is the project performed, what has been done.
  - 4.Evaluation of the project, reflection on the results and the project itself.
  5. Paper should be submittable to a refereed conference or to a journal
- Paper content is being discussed with Stevens Institute*

Figure 14: Publishable Paper

Figure 14 shows what should be the content of the paper. Note that grading is a responsibility of SIT until BUC is accredited. Papers that are perceived to be publishable by the academic supervisors get an "A" grade, else the grade will be "B" or less.

1. Clearly introduce the problem that the manuscript is discussing/ addressing,
  2. Discuss the problem background. That is, discuss the research that has been previously conducted by you or others in the field (or related fields) to solve/address the same or similar problem,
  3. Develop a succinct argument for the methods or ideas proposed in your manuscript,
  4. Present a clear and understandable justification of why the proposed methods or ideas contribute to a superior or different solution to the problem. A clear statement of your contributions is often crucial to reviewers. Clear specify this when possible. And finally,
  5. Discuss the likely future directions of the research being conducted by you (your group).
- [www.stevens.edu/sse/fileadmin/sse/pdf/SE\\_Master\\_Project\\_Guidelines.pdf](http://www.stevens.edu/sse/fileadmin/sse/pdf/SE_Master_Project_Guidelines.pdf)

Figure 15: Stevens Guidelines for Paper

At [www.stevens.edu/sse/fileadmin/sse/pdf/SE\\_Master\\_Project\\_Guidelines.pdf](http://www.stevens.edu/sse/fileadmin/sse/pdf/SE_Master_Project_Guidelines.pdf) more detailed guidelines can be found by SIT.

## 4 Publication

We intend to publish the paper in a journal or at a conference. The student is the first author of the paper, the academic supervisor(s) are second and third author.

Publication takes time and practically takes place after graduation. Figure 16 shows the publication process.

Company screens paper for sensitive or confidential issues, see <a href="http://www.gaudisite.nl/BuskerudSEpublicationProcedureSlides.pdf">http://www.gaudisite.nl/BuskerudSEpublicationProcedureSlides.pdf</a>
Select target journal or conference, typical choices are: INCOSE symposium, CSER, Journal of SE, Systems Reserach Forum
Transform the paper into the prescribed format or template
Review of the paper by BUC and Company, adapt paper
Submit paper to journal or conference
Process journal or conference feedback
Final review by company
Submit final version
Visit conference and present paper

Figure 16: Publication Process

If a third party is involved, e.g. a customer or supplier, then ask the third party to agree with publication procedure:

<http://www.gaudisite.nl/BuskerudSEpublicationProcedureSlides.pdf>, and ask who will be reviewer for the third party.

## 5 Practicalities

We do have a set of conventions to more easily manage the stream of artifacts produced during the preparation and the execution of the project, see Figure 17.

We assume that all communication of artifacts takes place electronically. All filenames should follow the conventions shown in Figure 17, the concatenation of the abbreviation *SEMP* (Systems Engineering Master Project), the *students name* (first name, family name), the *subject* (e.g. proposal, abstract, plan, presentation, paper), *dot*, *version*, *dot extension*.

The file type should be reasonably standard, e.g. pdf, jpeg, or one of the file formats that can be read both by Microsoft Office as well as OpenOffice (doc, docx, xls, xlsx, ppt, pptx). Exotic formats, such as Microsoft Projects, only after approval by the advisors.

Submissions have to be send to both Gerrit Muller and Gunnar Berge. The subject should again contain the abbreviation *SEMP* and the subject.

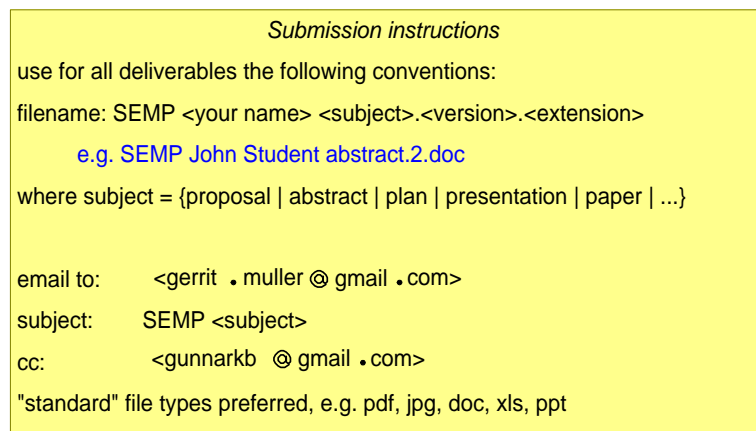


Figure 17: Conventions for Submitting Project Deliverables

## 6 Acknowledgements

This document has been written with inputs from Stevens Institute, especially Mike Pennotti, and from Gunnar Berge. The first cohorts of students doing their master project helped to shape this document.

## References

- [1] Gerrit Muller. The system architecture homepage. <http://www.gaudisite.nl/index.html>, 1999.
- [2] Gerrit Muller. Buskerud university program systems engineering. <http://www.gaudisite.nl/BuskerudAgendaPaper.pdf>, 2008.
- [3] Gerrit Muller. A multi-disciplinary research approach, illustrated by the boderc project. <http://www.gaudisite.nl/MultiDisciplinaryResearchApproachPaper.pdf>, 2008.
- [4] NetMBA.com. Topics in project management: PERT. <http://www.netmba.com/operations/project/pert/>, 2007.

## History

**Version: 1.1, date: August 20, 2010 changed by: Gerrit Muller**

- added publication to process
- added slide about publication
- added third party slide
- removed alternative project report
- added map of research projects
- removed paragraph in introduction about the relation Stevens and BUC
- changed status to concept

**Version: 1.0, date: February 3, 2009 changed by: Gerrit Muller**

- made a paper version
- changed status to draft

**Version: 0.3, date: February 2, 2009 changed by: Gerrit Muller**

- added submission instructions

**Version: 0.2, date: January 29, 2009 changed by: Gerrit Muller**

- added figures to explain multiple levels
- added PET plan
- added abstract explanation
- changed title

**Version: 0.1, date: January 26, 2009 changed by: Gerrit Muller**

- added figures to position case and project work

**Version: 0, date: May 23, 2008 changed by: Gerrit Muller**

- Created, no changelog yet