

# Systems Engineering Course Research Methods; all slides

by *Gerrit Muller*

University of South-Eastern Norway-NISE

## **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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# Systems Engineering Course Research Methods; Information

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## Abstract

This module provides information about the course, such as the schedule.

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# Colophon

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This course is a joint development of

Kristin Falk

Satya Kokkula

Elisabet Syverud

and Gerrit Muller

# Research Methods Course Pre-assignment

- Determine a topic for the master project
- Position the topic in its context (e.g. in your company, in ongoing projects)
- Discuss the topic with its stakeholders
- Try to formulate the line of reasoning:
  - problem, goal, envisioned solution, rationale, open research questions

# Course Schedule

	day 1	day 2	day 3	day 4	day 5
9:00	5 step framework, meta levels	literature why, what, how	research methods	re-iterate meta-levels	what is a good paper?
	line-of-reasoning			re-iterate research questions	write an initial abstract
	break	search applicable literature	re-iterate research design	how to answer them?	
10:00	specific initial problem statement	break	break	break	break
	problem exploration	practical search techniques	data collection, interpretation, analysis	data validity, bias	discussion, what is the flow in the paper?
11:00	break		what data, how to obtain?	re-iterate problem exploration	annotate the book plan with content and scope keywords
	framing the problem, prepare interviews	refine search		re-visit interview/survey	
12:00	lunch	lunch	lunch	lunch	lunch
	reflection and discussion	library resources	reflection and discussion	reflection and discussion	reflection and discussion
13:00	research questions	reflection and discussion	statistics for master students, including exercises	project execution and planning	practicalities, e.g. visualizations, citations
	break	break	break	break	break
14:00	formulate initial research questions	research design how, what to look for	what scale to use	make initial project execution plan (PERT)	make a research design diagram
	break	initial research design	how to interpret the data	academic writing, book plan	master project supervision and assessment
15:00	feasibility of study	break	ethics, plagiarism, privacy, confidentiality, regulations	break	break
	reflection and discussion	homework	reflection and discussion	homework	homework
16:00		reflection and discussion	reflection and discussion	reflection and discussion	reflection and discussion
homework	<ul style="list-style-type: none"> <li>initial interview and/or survey</li> <li>initial problem analysis</li> <li>literature survey Body of Knowledge</li> <li>search secondary data sources</li> <li>read Research Methods paper</li> <li>elaborate research design</li> </ul>	<ul style="list-style-type: none"> <li>30%</li> <li>60%</li> <li>10%</li> </ul>	<ul style="list-style-type: none"> <li>continue literature survey</li> <li>write critic of 2..3 papers</li> <li>identify challenges and risks in problem definition</li> <li>make research design more concrete</li> <li>make book plan for the course paper</li> </ul>	<ul style="list-style-type: none"> <li>50%</li> <li>15%</li> <li>30%</li> <li>5%</li> </ul>	<ul style="list-style-type: none"> <li>write a course paper, ca 15 pages</li> <li>line of reasoning</li> <li>literature survey</li> <li>research design</li> <li>execution plan</li> <li>book plan of final paper</li> </ul>

# Systems Engineering Course Research Methods; Framework

by *Gerrit Muller* University of South-Eastern Norway-NISE

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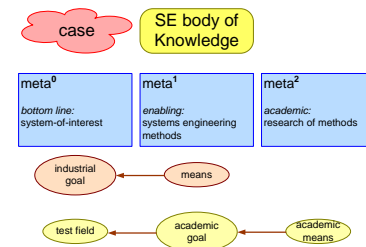
## Abstract

This module shows a framework for shaping and executing applied research, and offers guidelines for the various steps.

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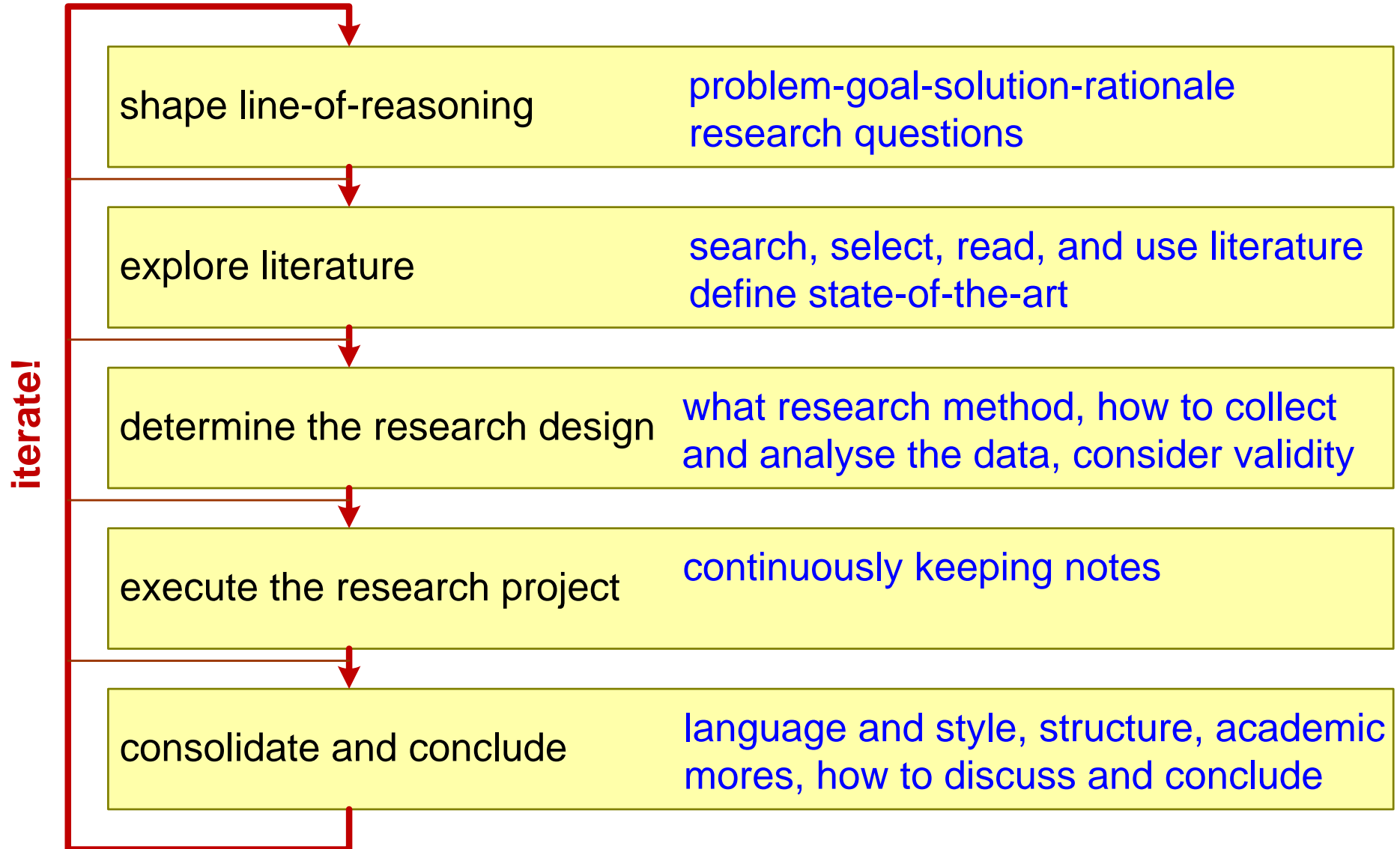
Kristin Falk

Satya Kokkula

Elisabet Syverud

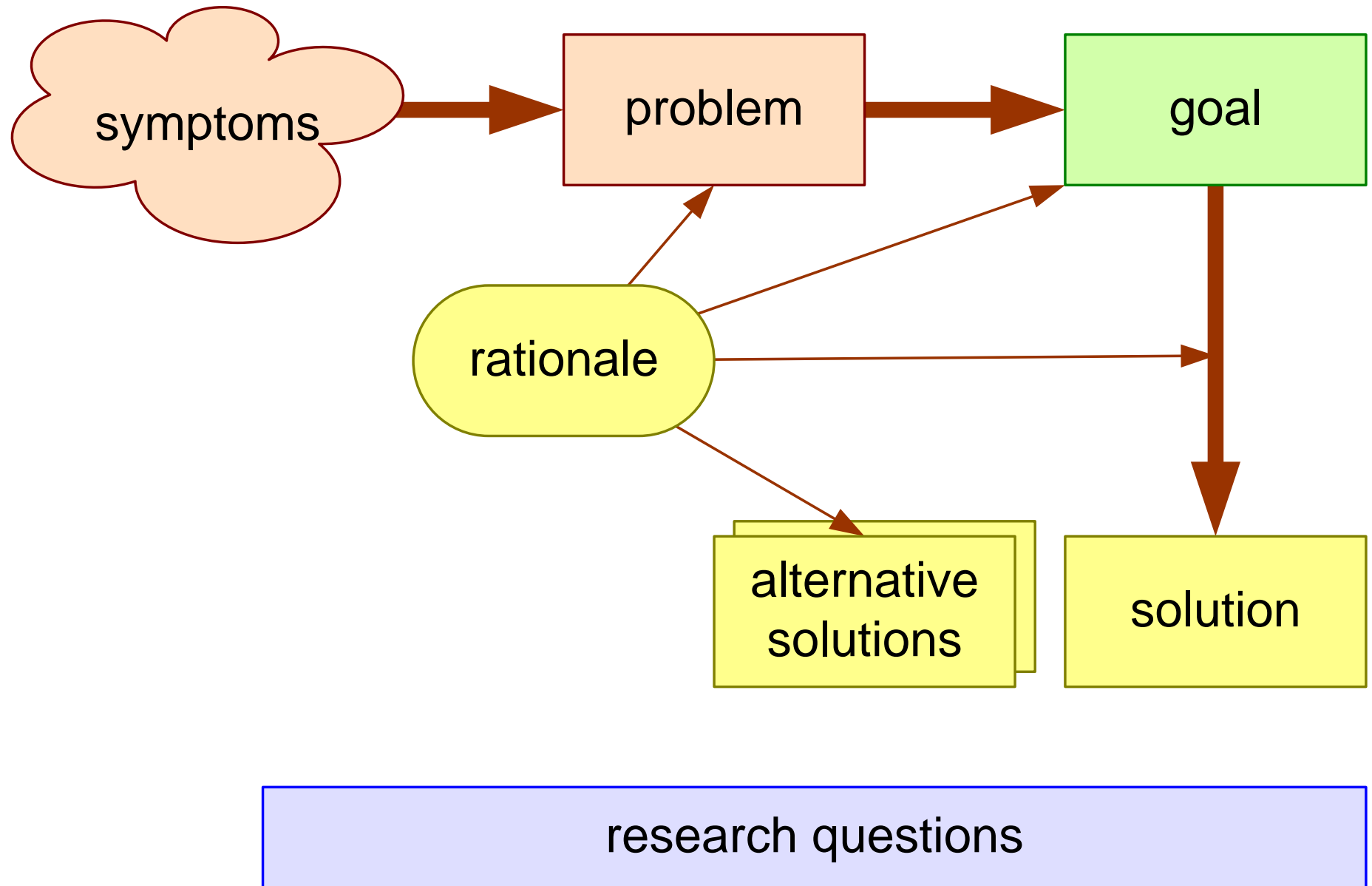
and Gerrit Muller

# Applied Research Framework





# Line of Reasoning



# Multiple Levels of Academic Abstraction

case

SE body of Knowledge

meta<sup>0</sup>

*bottom line:*  
system-of-interest

work over system  
missile  
production line  
turbine package  
control system  
tie-in system

meta<sup>1</sup>

*enabling:*  
systems engineering  
methods

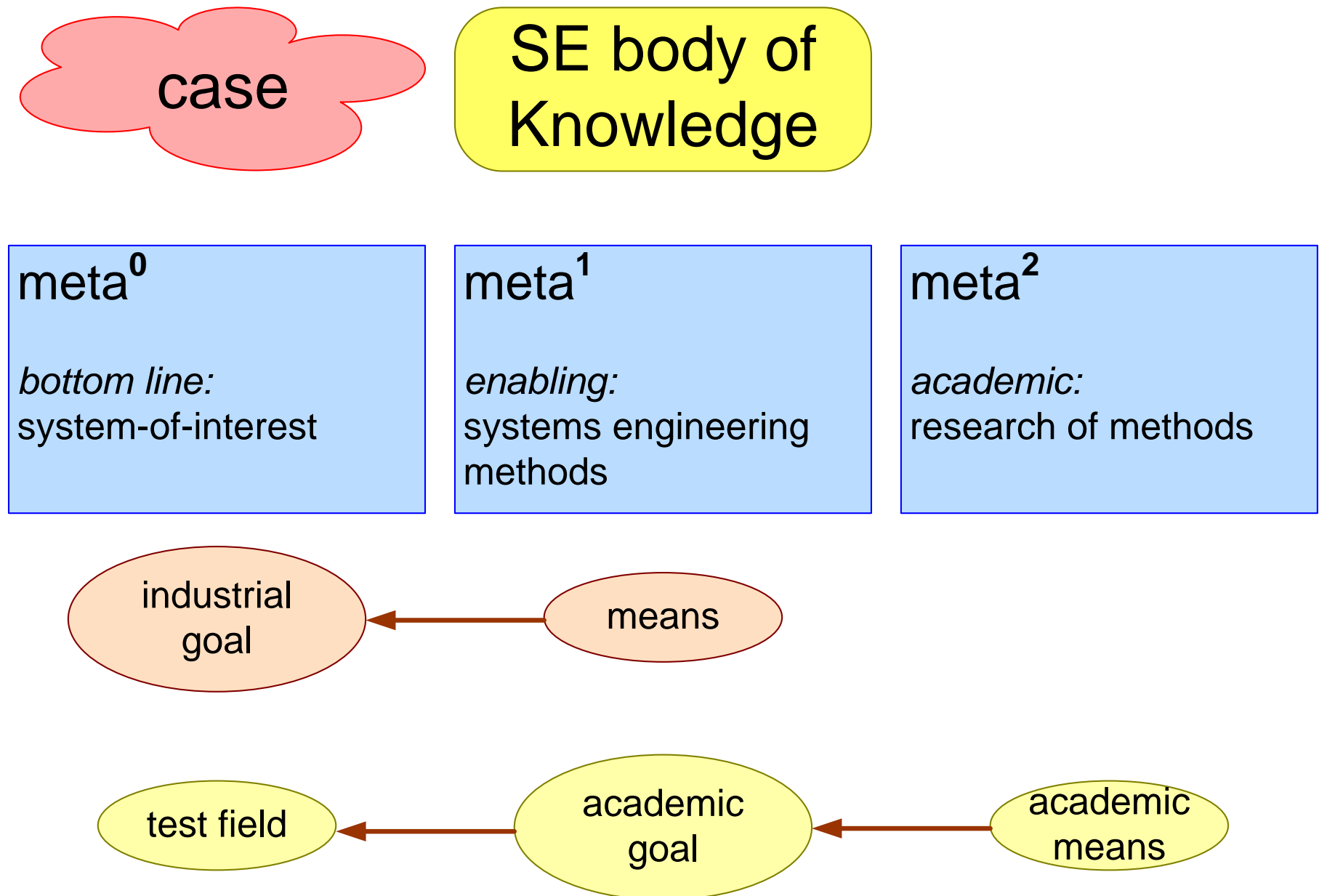
stakeholders and concerns  
ConOps  
operational needs  
need statement  
needs into requirements  
SMART requirements  
concept selection  
partitioning and interfaces  
documenting the architecture  
knowledge management  
conceptual modeling  
budget based design  
integration and verification plan  
design of qualification program

meta<sup>2</sup>

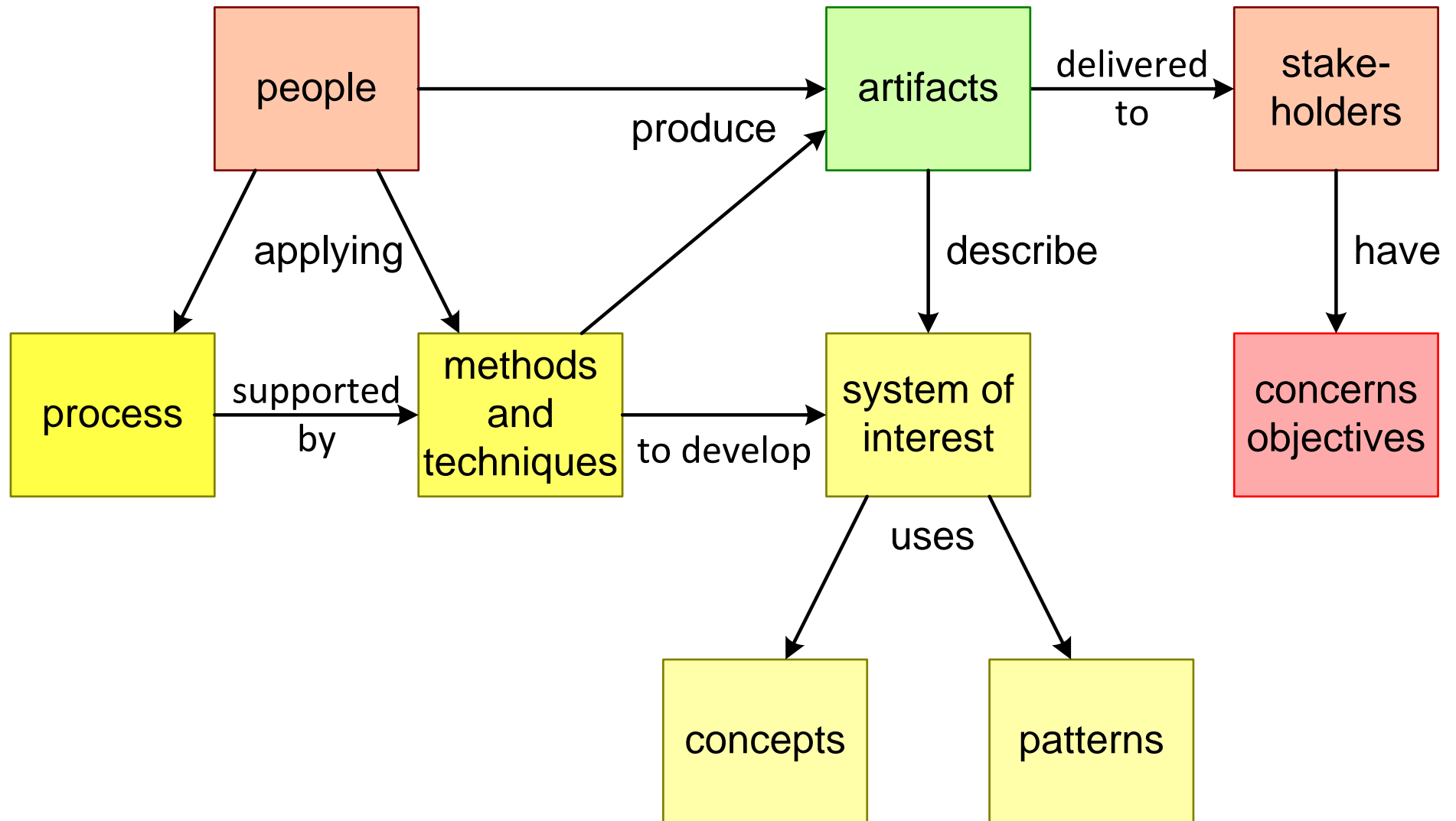
*academic:*  
research of methods

measuring  
experimenting  
modeling  
surveys  
interviews  
referring to literature  
argumenting

# Industrial versus Academic Perspective



# Research Context



# Some Terminology

**Formalisms** languages/syntax: for example, differential equations, timed or hybrid automata, finite state machines, et cetera

**Models** instantations of formalisms to understand, explore, optimize or verify specification or design

**Techniques** to get the required information from models: e.g. performance

**Methods** to provide guidelines how to use formalisms, create models, use techniques and apply tools

**Tools** to support efficient application of formalisms, techniques and methods

# Systems Engineering Course Research Methods; Problem Exploration

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## Abstract

Problem exploration requires first of all an exploration of the current situation. Next step is identifying weaknesses and issues in the current situation. Judgement of the severity of the consequences of the various weaknesses helps to get to the problem statement.

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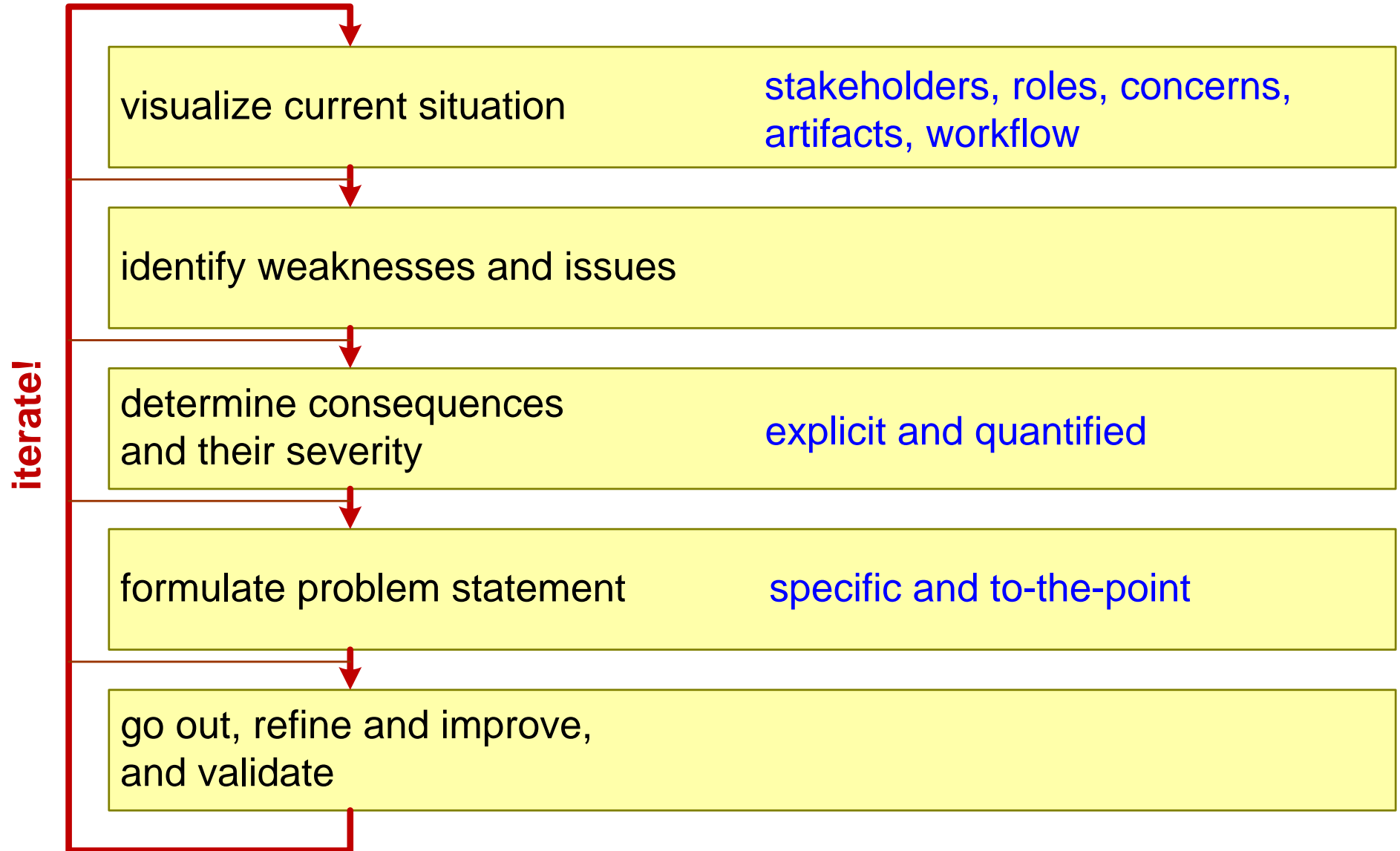
Kristin Falk

Satya Kokkula

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# Problem Exploration Approach





# Systems Engineering Course Research Methods; Assignments

by *Gerrit Muller* University of South-Eastern Norway

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## Abstract

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# Research Methods Course Pre-assignment

- Determine a topic for the master project
- Position the topic in its context (e.g. in your company, in ongoing projects)
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  - problem, goal, envisioned solution, rationale, open research questions

# What Specific Problem Triggers this 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

# Problem Exploration

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- 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

# Formulate an Initial Set of Research Questions

- Transform the problem statement into a main research question
- What sub-questions will help you to answer the main research question?

Good research questions are open questions, e.g. allowing an answer in terms of how well, how much, etc.

You typically need one main question and 3 to 5 sub-questions.

Make all questions as specific as possible. The main question may invite some generalization.

# Feasibility of this Study

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- Define the scope of the research, 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?

# Search Literature

- Use the research questions to determine 5 to 10 key words or phrases
- Search for relevant literature
- Identify ~10 potentially interesting papers
- Read the abstracts
- Sort on relevancy, based on abstract
- Read at least one paper

Keep notes on all papers you find



# Refine Literature Search

- 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

Keep notes on all papers you find

# Make an Initial Research Design

- 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?

# Block 1 Post-assignment

- Refine the topic for the master project
- Position the topic in its context (e.g. in your company, in ongoing projects)
- Discuss the topic with its stakeholders
- Reformulate the line of reasoning:
  - problem, goal, envisioned solution, rationale, open research questions

# Homework Block 1

- initial interview and/or survey
  - initial problem analysis
  - literature survey Body of Knowledge
  - search secondary data sources
  - read Research Methods paper
  - elaborate research design
- effort  
30%
- 60%
- 10%

maintain a detailed logbook!

# Homework Block 2

- continue literature survey
- write critic of 2..3 papers
- identify challenges and risks in problem definition 15%
- make research design more concrete 30%
- make book plan for the course paper 5%

} 50%

maintain a detailed logbook!

# Final Homework

write a course paper, as an academic paper of ca 15 pages, containing:

- line of reasoning
- literature survey
- research design
- expected results

and make

- an execution plan
- a book plan of the final paper

# Systems Engineering Course Research Methods; Material

by *Gerrit Muller* University of South-Eastern Norway-NISE

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## Abstract

This module provides links to the course material, both the core material and elective material.

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# Research Framework

*core*

Systems Engineering Course Research Methods; Framework

<http://www.gaudisite.nl/info/SEcourseResearchMethodsFramework.info.html>

*optional*

TBD

# Problem Exploration

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*core*

Systems Engineering Course Research Methods; Problem Exploration

<http://www.gaudisite.nl/info/SEcourseResearchMethodsProblemExploration.info.html>

*optional*

TBD