Systems Engineering Master Project all slides

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

Abstract

Students will apply and show their ability to apply systems engineering methods and techniques in practice during the systems engineering master project. During the preparation phase, students determine the project topic and shape the project. During the execution phase they apply and, at the same time, research the application of systems engineering. They capture the evalution in a paper and a presentation.

October 26, 2021
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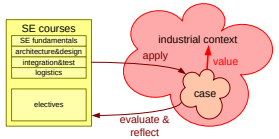
version: 1.1



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

Systems Engineering Master Project

by *Gerrit Muller* HSN-NISE
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Abstract

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

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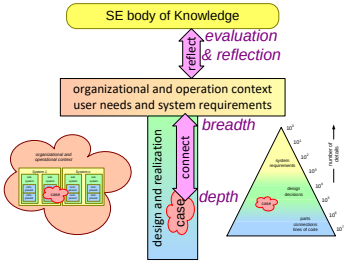
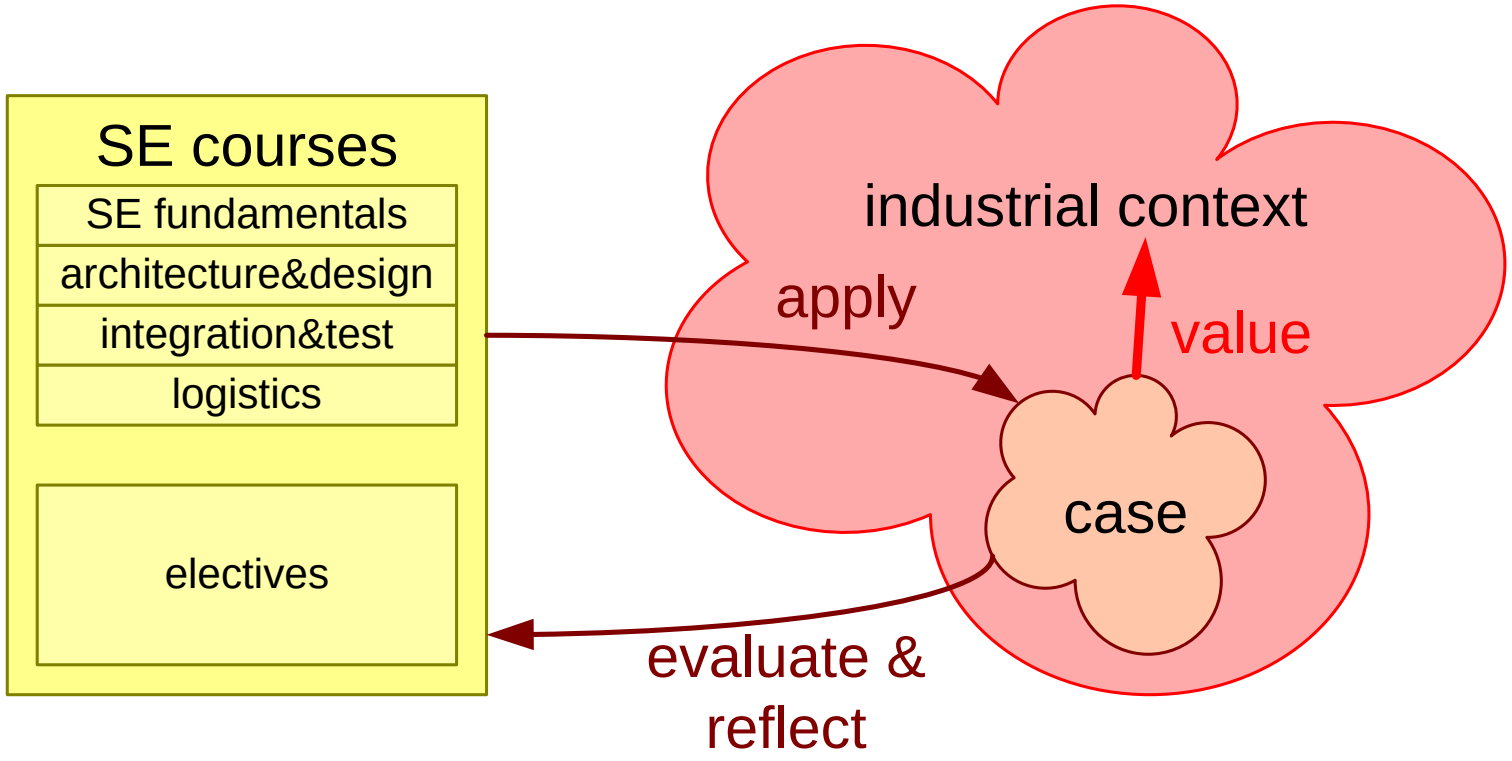


Objectives of Master Project



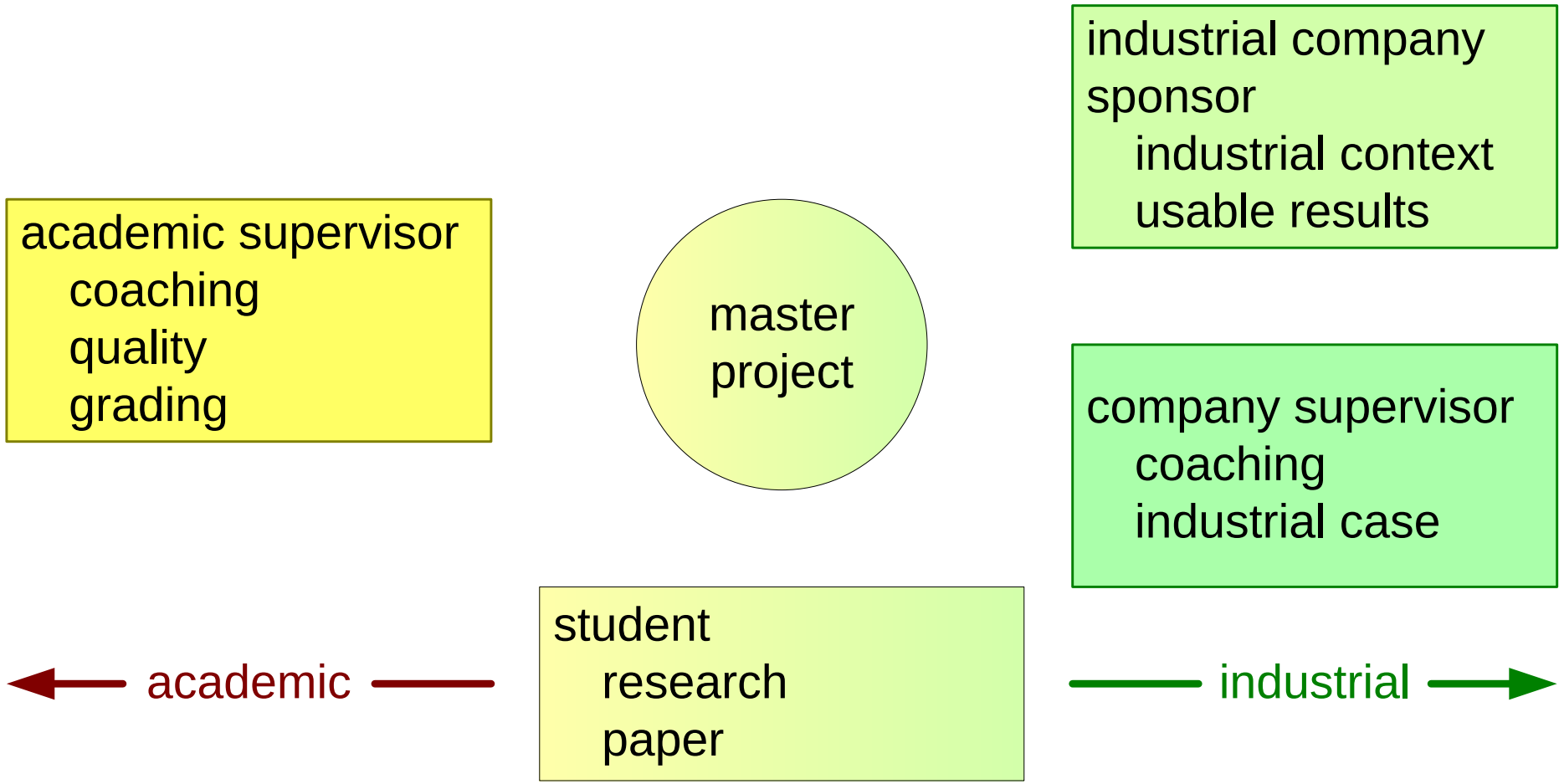
Apply SE methods, techniques, and concepts in practice
and evaluate and reflect on its application,
while providing value to the industrial sponsor

Formalized Goal Statement

The goals of the Final Project are:

- the students have to show their **professional competence** and the acquired command of the systems engineering discipline by applying it to a selected problem.
- the selected problem has to be **relevant** in the context of the **company** in which the student works
- **competence** is truly put into **practice**.
- to facilitate the students to make the step from “just applying” to “**critical evaluation** and **reflection**”.
- to verify that students are capable to operate at **academic level**.

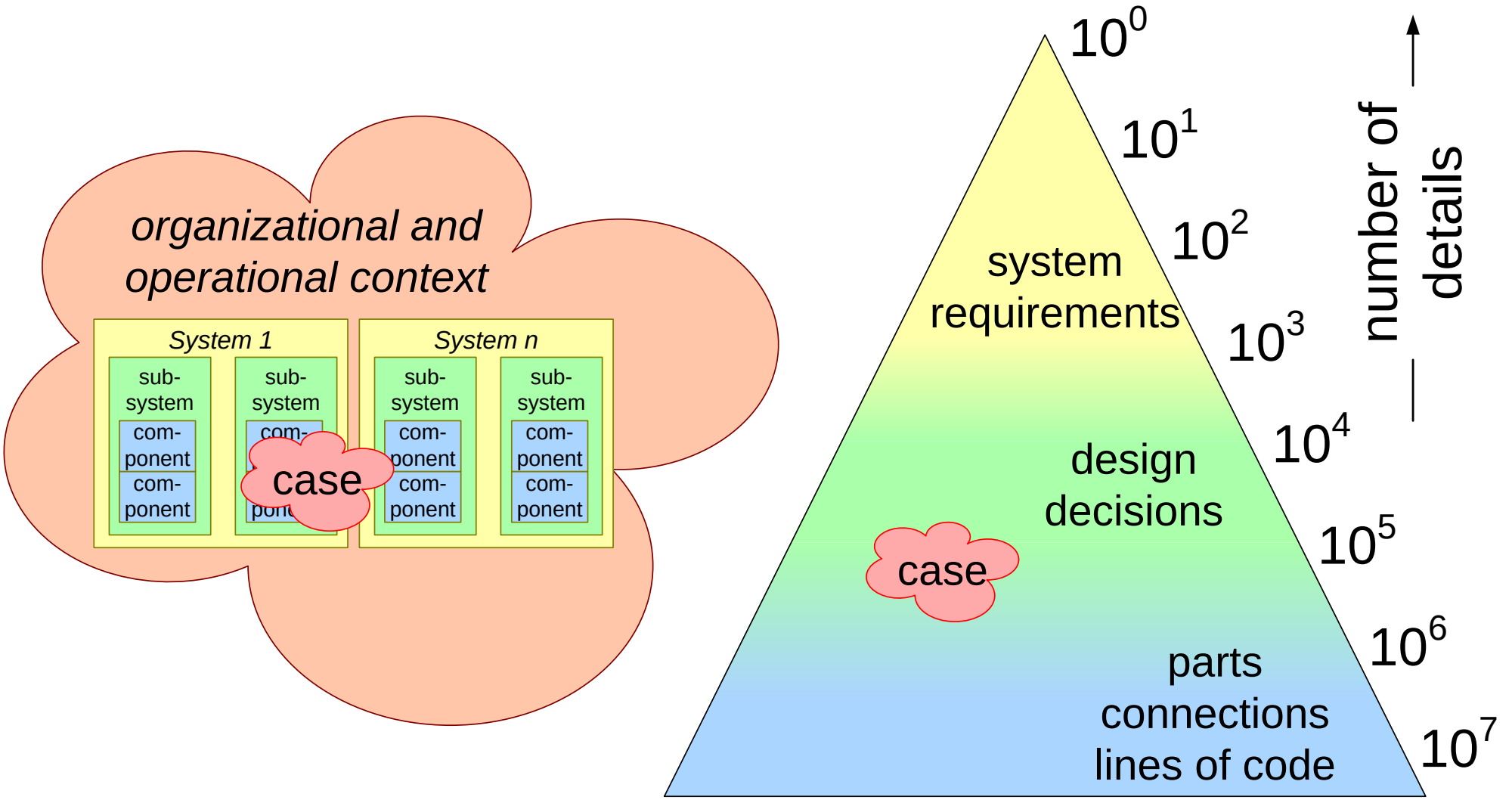
Stakeholders of the Master Project



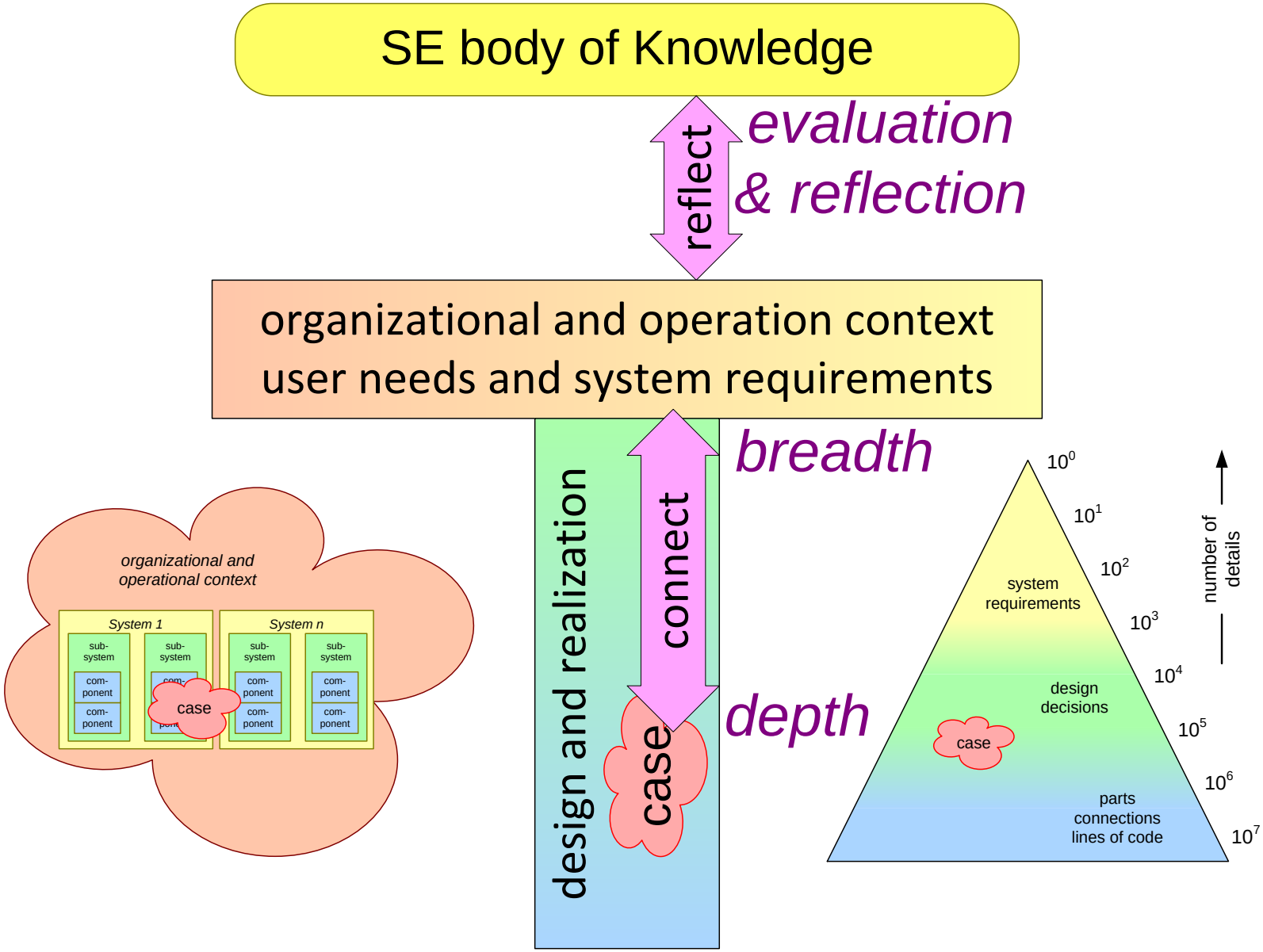
Scoping is Crucial

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

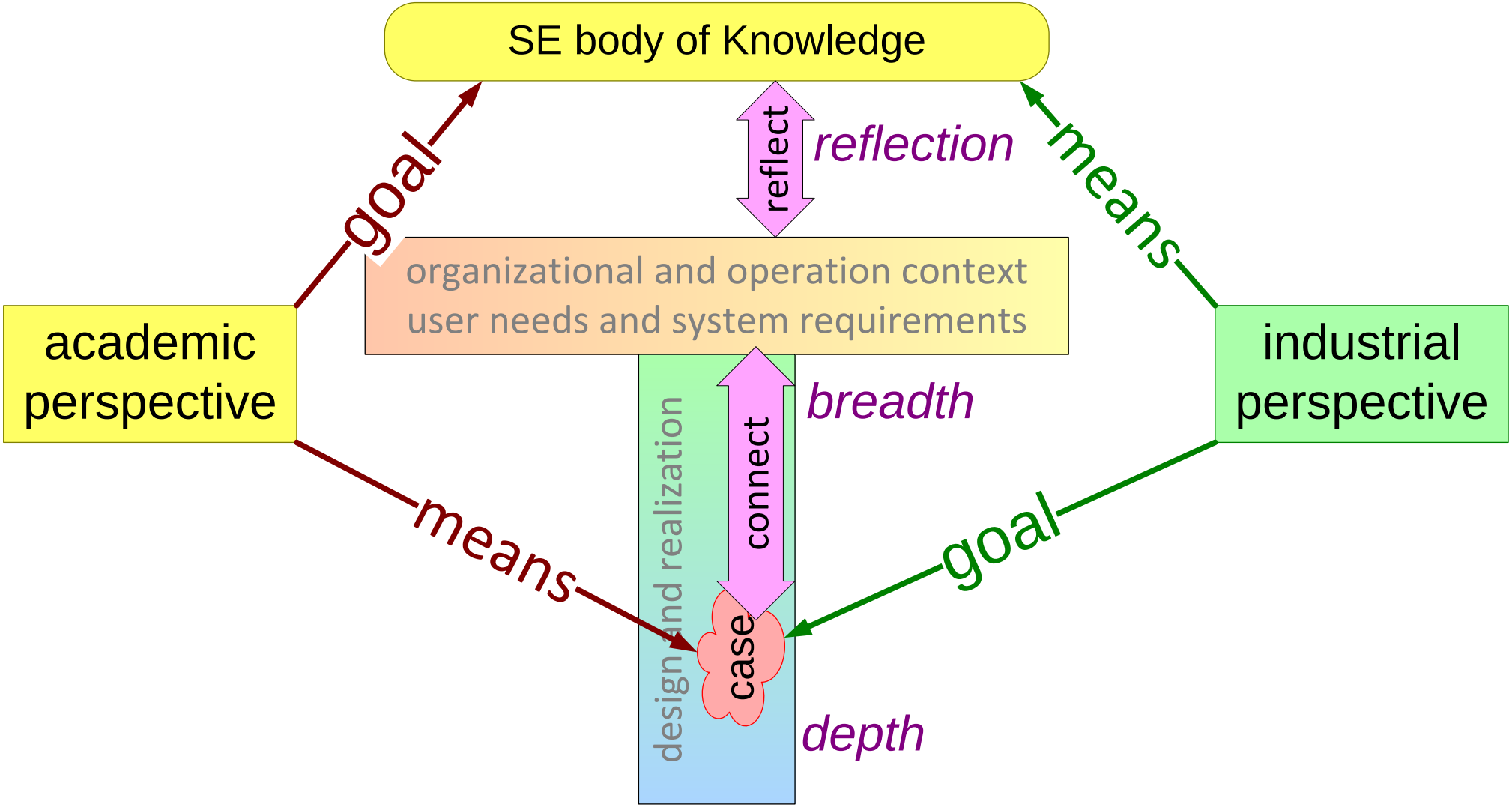
Case Positioning



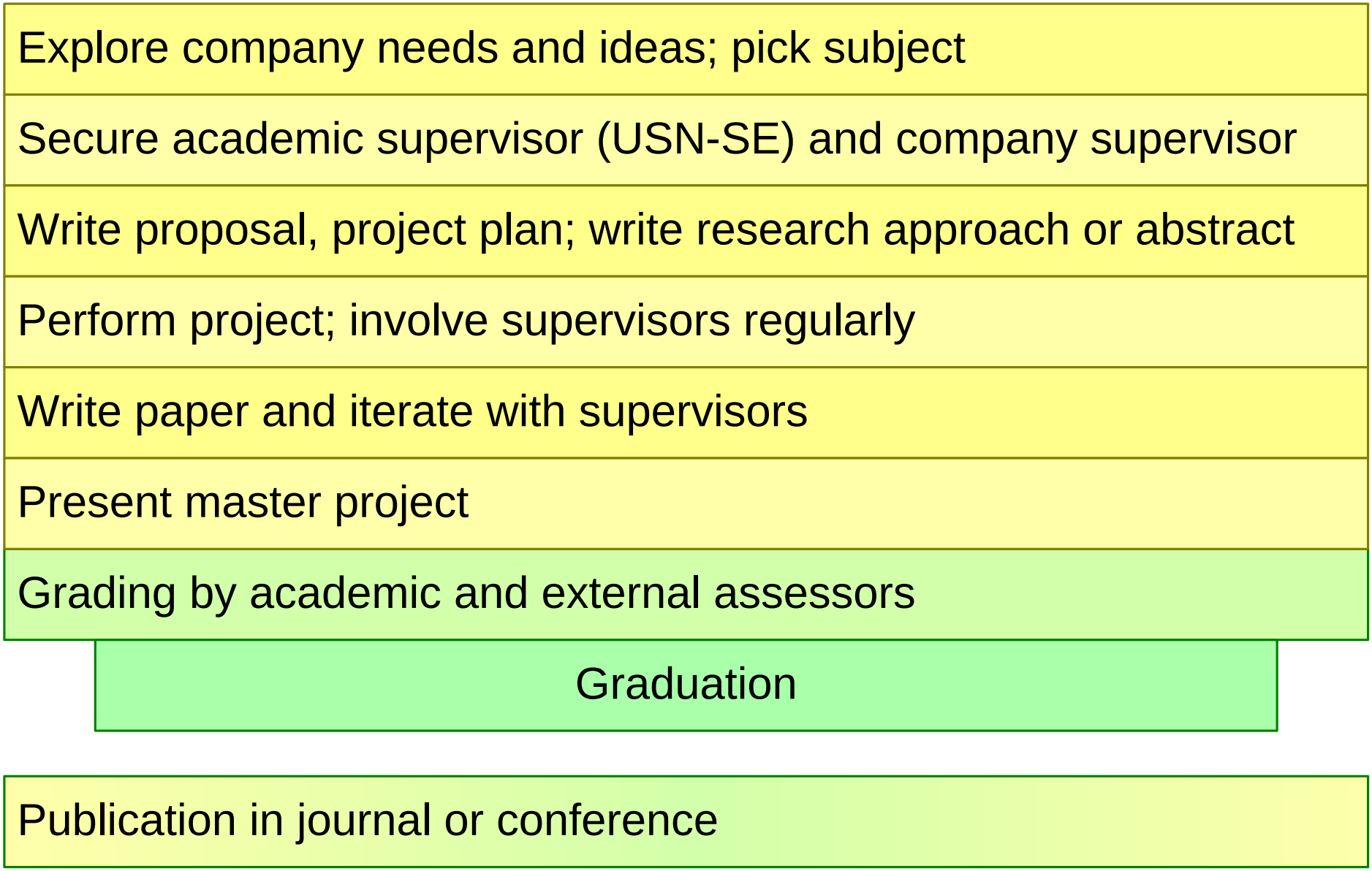
Depth, Breadth and Reflection



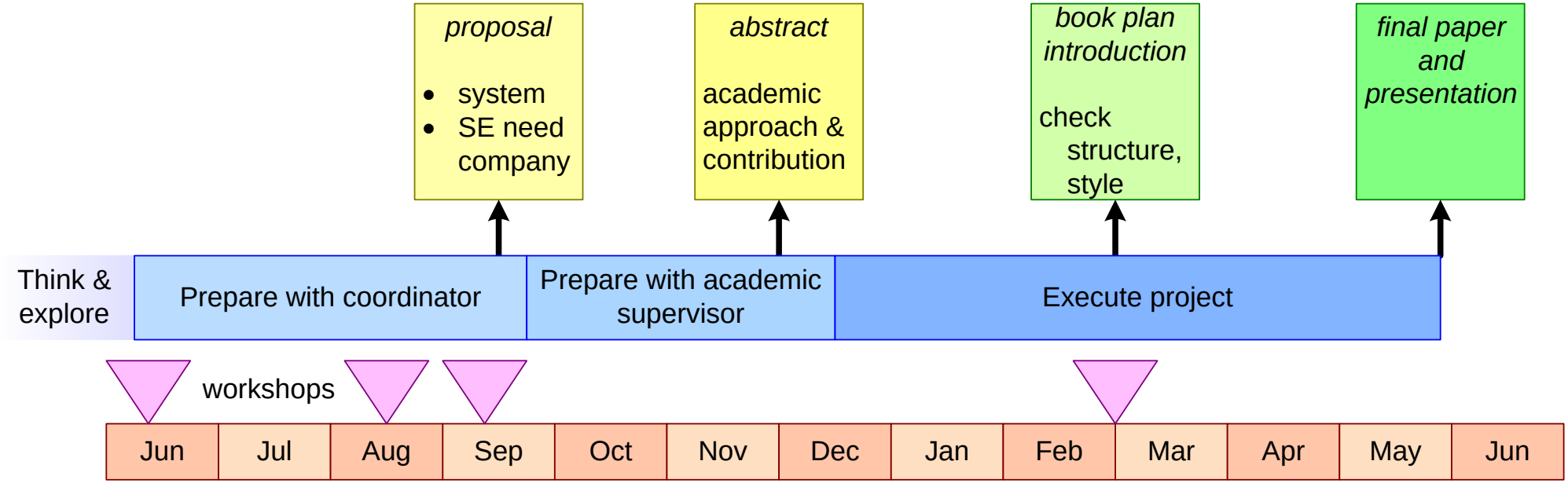
Difference Academic and Industrial Goals



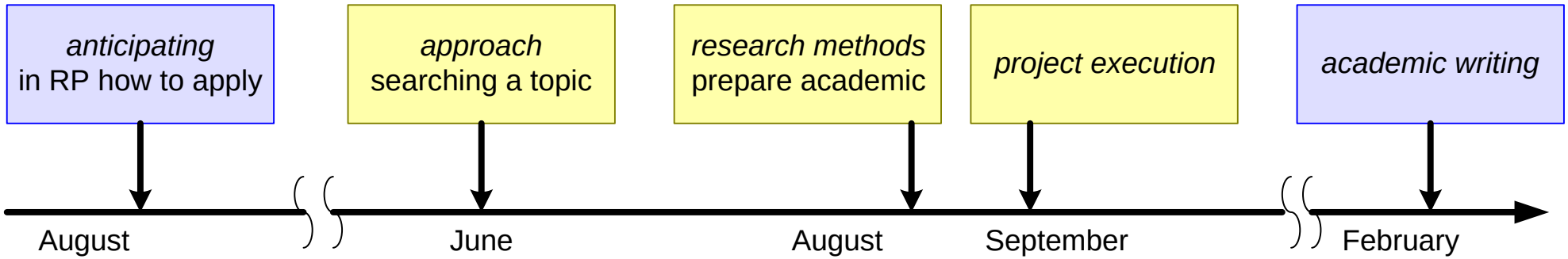
Process of Master Project



Timeline of the Master Project

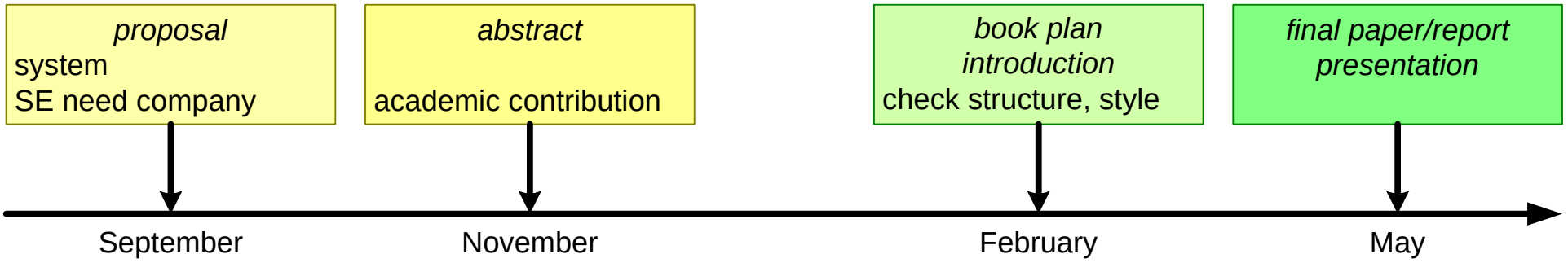


SEMP Workshops



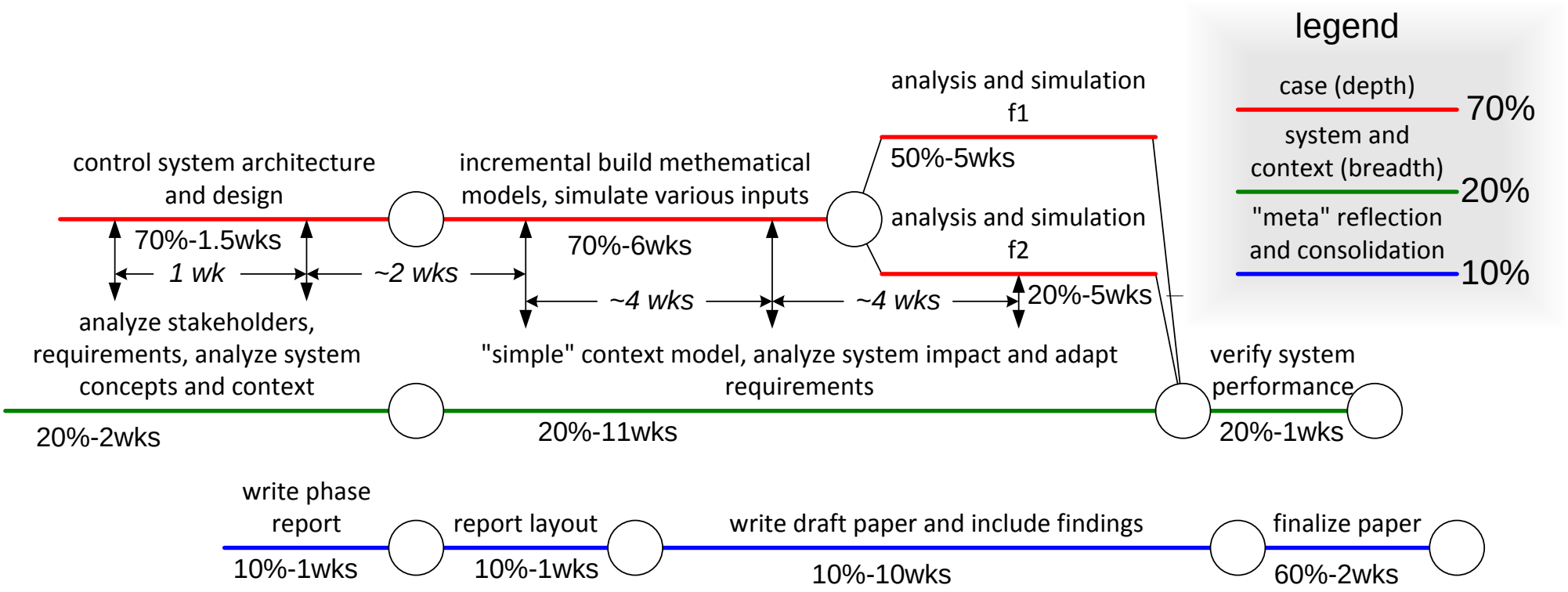
tentative dates for milestones for IM students

Master Project Milestones



tentative dates for milestones for IM students

Plan: Simple PERT Diagram



Abstract

"A good abstract should answer three questions:

What did I do,

what did I learn,

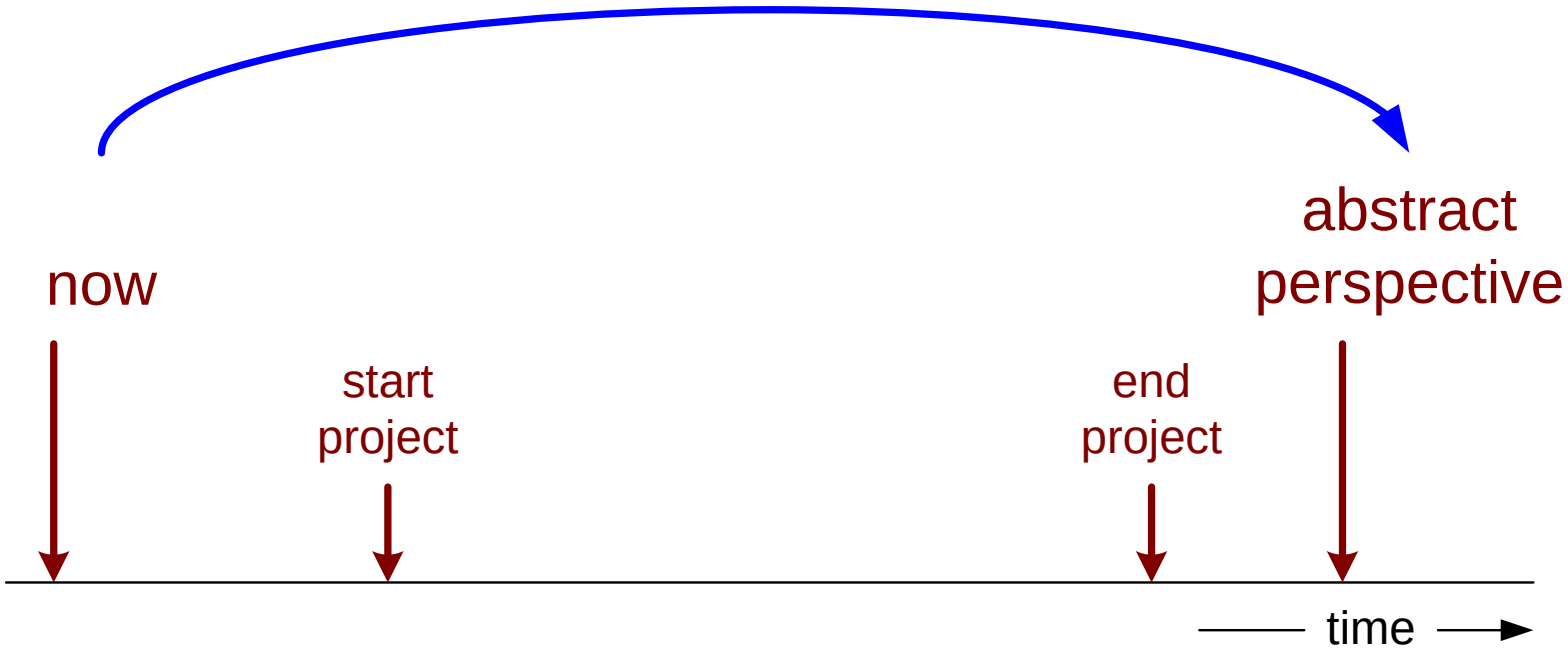
and why is that important?

The key is to identify something or things that can be reused in the future."

Prof. Michael Pennotti, Stevens Institute of Technology

Needed: Time Machine

"fast forward" yourself into the future
what do you expect to be the project outcome?



Students write an initial abstract at the start to think through what can happen. At the end of writing the paper, you write the real abstract. The academic supervisor has to accept the initial abstract before starting the project.

Project Execution

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

Publishable Paper

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; the academic supervisor may accept a report as well.

Stevens Guidelines for Paper

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).

http://www.stevens-tech.edu/ses/documents/fileadmin/documents/pdf/SE_Master_Project_Guidelines.pdf

Final Presentation at the end of the project

student presentation of master project

~30 minutes presentation

~20 minutes questioning by examinators

~10 minutes examinators conclude

committee:

- academic supervisor
- at least one other academic staff member of SE
- external assessor
- (optional) company supervisor or representative
- at least 3 people

Publication Process

Company screens paper for sensitive or confidential issues, see http://www.gaudisite.nl/BuskerudSEpublicationProcedureSlides.pdf
Select target journal or conference, typical choices are: INCOSE symposium, CSER, Journal of SE
Transform the paper into the prescribed format or template
Review of the paper by USN-SE 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

Third Party Involvement

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

Conventions for Submitting Project Deliverables

Submission instructions

use for all preparation deliverables the following conventions:

filename: SEMP <your name> <subject>.<version>.<extension>

e.g. SEMP John Student abstract.2.doc

where subject = {proposal | abstract | plan | presentation | paper | ...}

email to: <gerrit . muller@ gmail . com>

subject: SEMP <subject>

"standard" file types preferred, e.g. pdf, jpg, doc, xls, ppt

Links

workshop 1 in June

Master Project Description: http://www.gaudisite.nl/SEthesisProjectPaper.pdf

workshop 2 in August

Systems Engineering Research Methods: http://www.gaudisite.nl/SEresearchMethodsSlides.pdf

workshop 3 in September

Master Project; Writing an Abstract: http://www.gaudisite.nl/MasterProjectWritingAnAbstract.pdf

Master Project; Execution Phase: http://www.gaudisite.nl/MasterProjectProjectExecution.pdf

Publication procedure: http://www.gaudisite.nl/BuskerudSEpublicationProcedureSlides.pdf

Guidelines for visualizations: http://www.gaudisite.nl/VisualizationGuidelinesSlides.pdf

Validation of Systems Engineering Methods and Techniques in Industry

http://www.gaudisite.nl/CSER2012_Muller_validationSEinIndustry.pdf

Systems Engineering Research Methods (paper)

http://www.gaudisite.nl/CSER2013_Muller_SEresearchMethods.pdf

Systems Engineering Research Validation http://www.gaudisite.nl/SEresearchValidationPaper.pdf

Published Master Project papers: http://www.gaudisite.nl/MasterProjectPapers.html

Workshop Academic Writing http://www.gaudisite.nl/RPacademicWritingSlides.pdf

Systems Engineering Research Methods

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Abstract

Research in System Engineering research inherently addresses a mix of technological issues in relation to business, process, organization, and people aspects. We show an inventory of research methods for research done in the “field”, e.g. in industry or similar organization.

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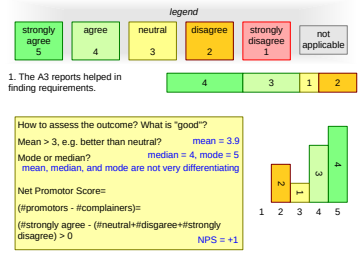
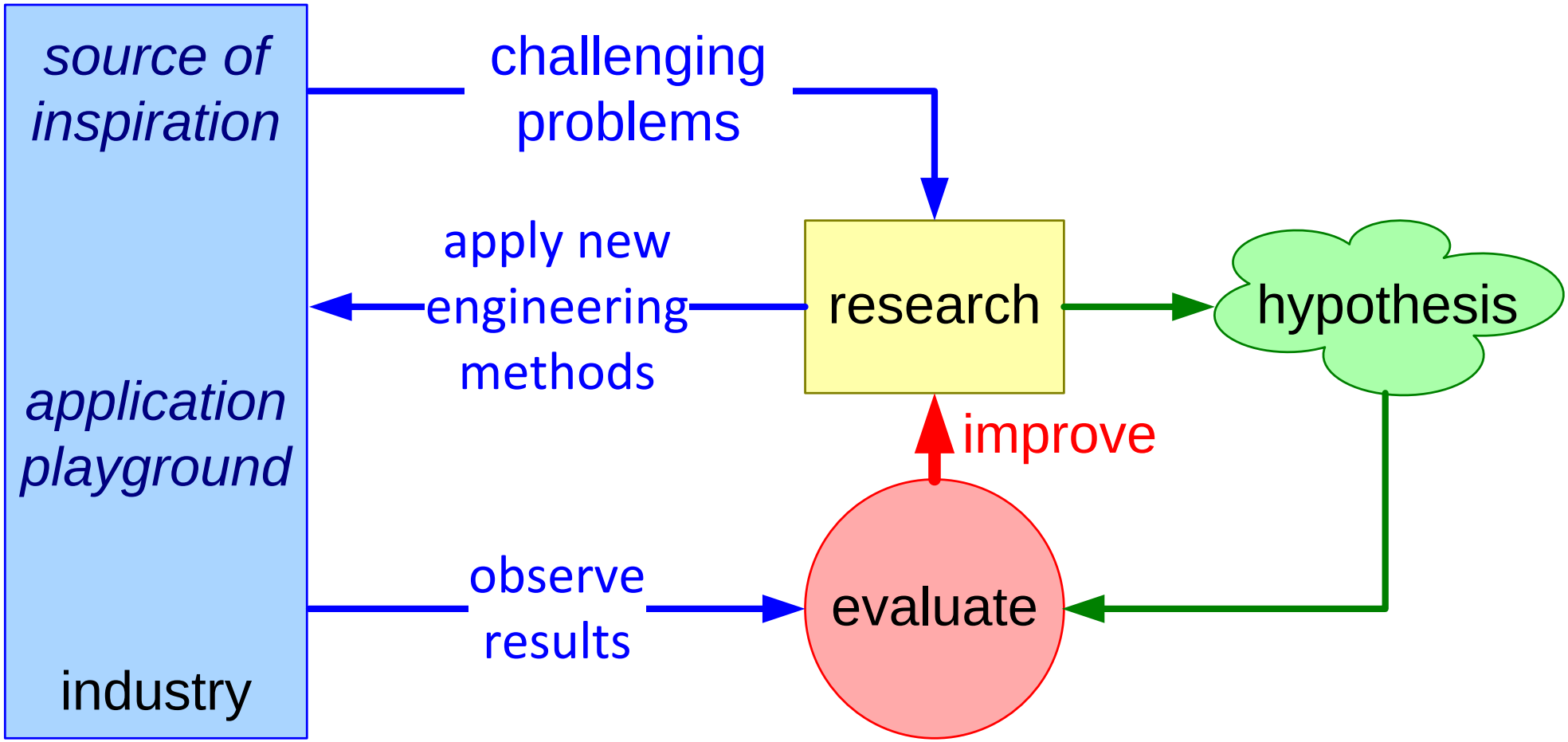


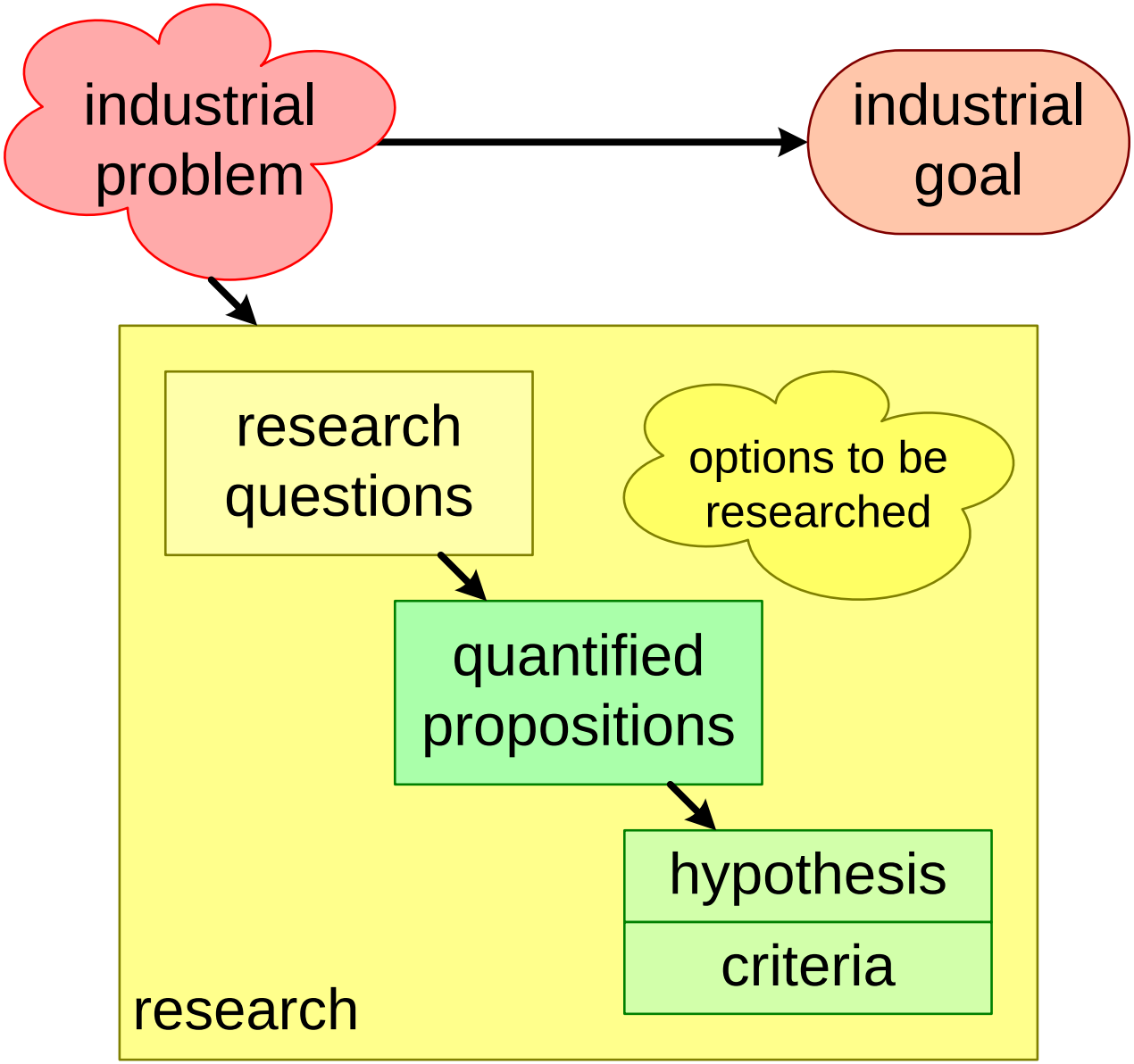
Action Research or Industry-as-Laboratory



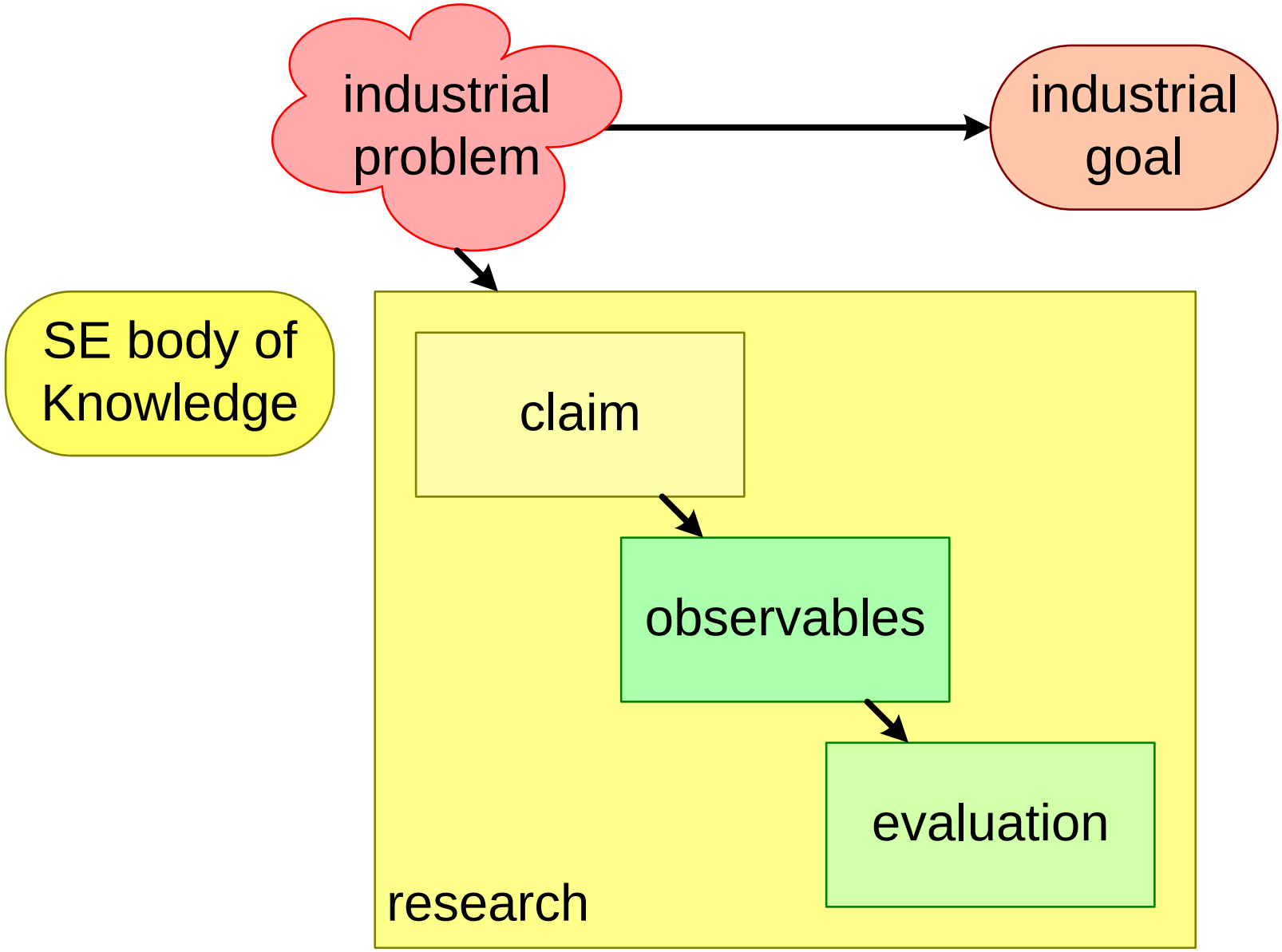
Systems Engineer vs Researchers

	systems engineer	*researcher*
normal work	elicit needs, specify, design, analyze, integrate, test	observe, experiment, argue, evaluate, write
attitude	explain, educate, sell	question everything, proof opposite

Logical Order of Research



Simplified Order for Master Project



Step 1: Formulate Claim

Claim: What benefits will your proposed improvements bring?

"Application of requirements traceability matrix
will reduce changes after the definition phase significantly"

20% or 80%
would be better

Be specific (what, who, when, how much, ...)

Does the claim address the original problem?

Is the claim realistic?

Do the benefits justify the research effort?

Do the benefits relate to the right driver?

better predictability of delivery
earlier delivery
better quality of delivery
less cost or effort

Step 2: Identify Observables

Observables: What observations or measurements will provide evidence for your claim?

number of changes after definition phase in past projects without method

number of changes after definition phase in current project with method

Be specific (what, who, when, how much, ...)

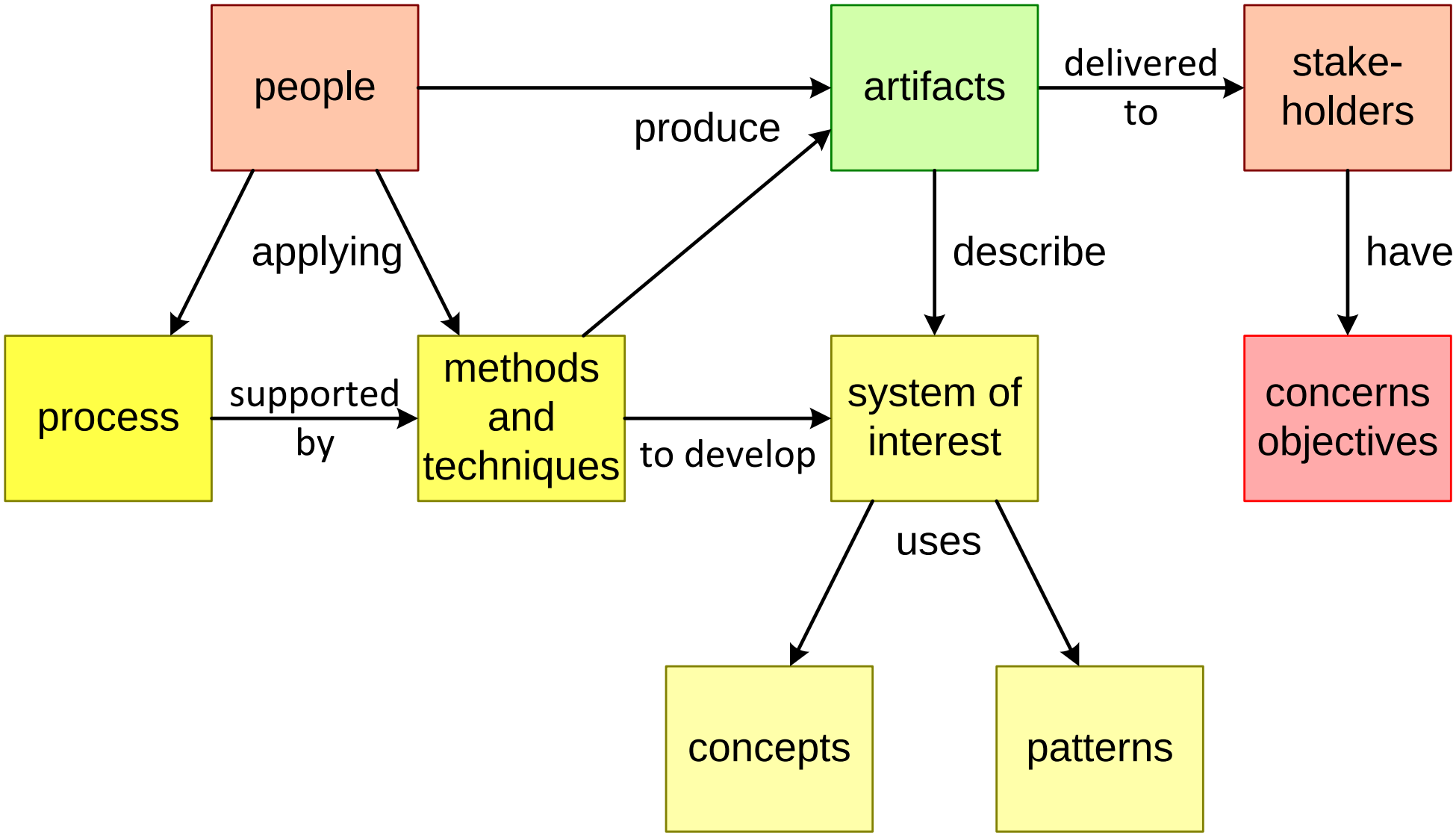
Do the observations relate to the claim?

Can the observations be made during the research period?

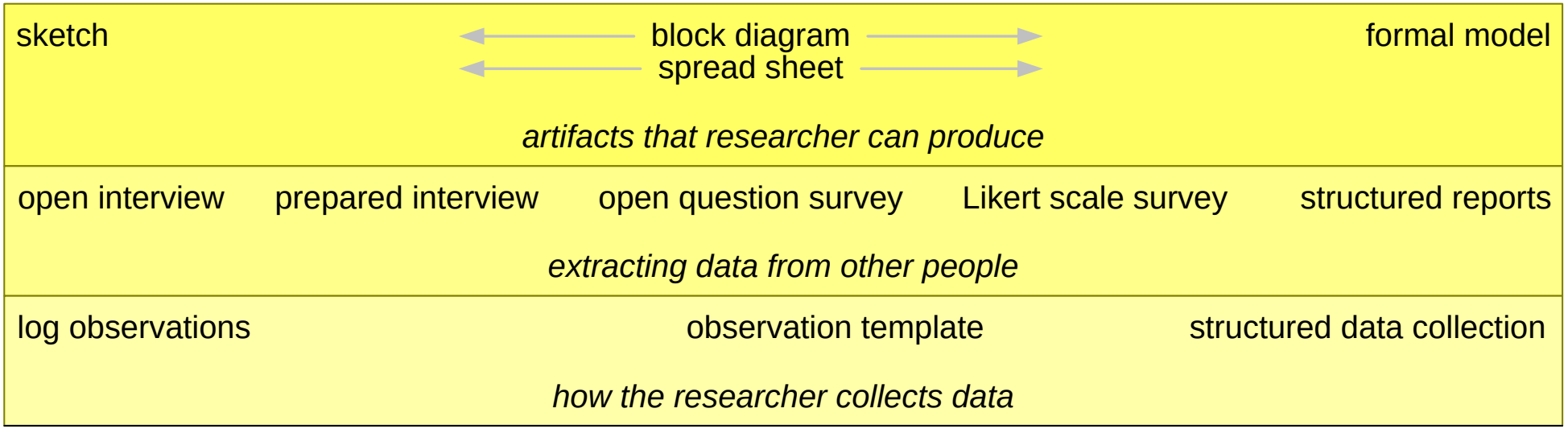
How accurate and objective are the observations?

Observe/measure the initial state before changing "zero measurement"

What to Research; Observe Context



Spectra of Research Methods



. free representation
. no formal definition
+ supports
    discovery
    exploration
- difficult for
    analysis
    comparison
    aggregation

. standardized data
. formalized definition
+ supports
    analysis
    comparison
    aggregation
- might
    restrict inputs
    affect observation

Research Logbook

Word or PowerPoint file

take notes continuously!

date/time

- what
- how
- why
- when
- where
- who

references, e.g. URLs; make electronic copy of any relevant material

all "raw" data, e.g. submitted questionnaires

all intermediate data, e.g. spread sheets with version numbers and dates

Example Observation Template

Session attributes – date (year/month/day)		
Kind of session:		Communicate information/status
		Sell a idea/concept
		Brainstorming/generate ideas
		Decision making
		Solve/discuss problem(s)/issue(s)
		Planning
		KPI/Performance/Action log
		Team building/training
		Presentation
Physical location of session:		Defined meeting room
		Colleague own office
		In the factory – "on the shop floor"
Planned session or not:		Planned
		Unplanned
A3 purpose:		
A3 name/link:		
A3 usage/iteration number:		
A3 usage time with stakeholders:		
Number of participants:		
Did everyone understand the A3:		
Did it answer some of the stakeholders questions:		
Create any new questions/concerns:		
Models changed/added:		
Stakeholder participation:		
Prefer A3 instead of A4:		
Observations/recordings:		

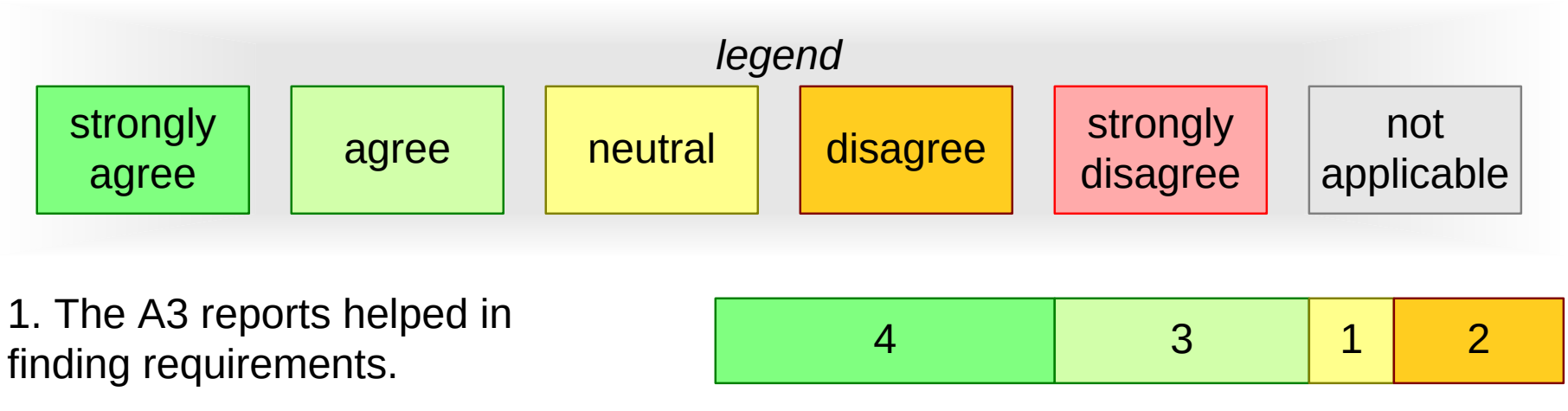
from Master Project by Espen Polanscak

Survey with Likert Scale

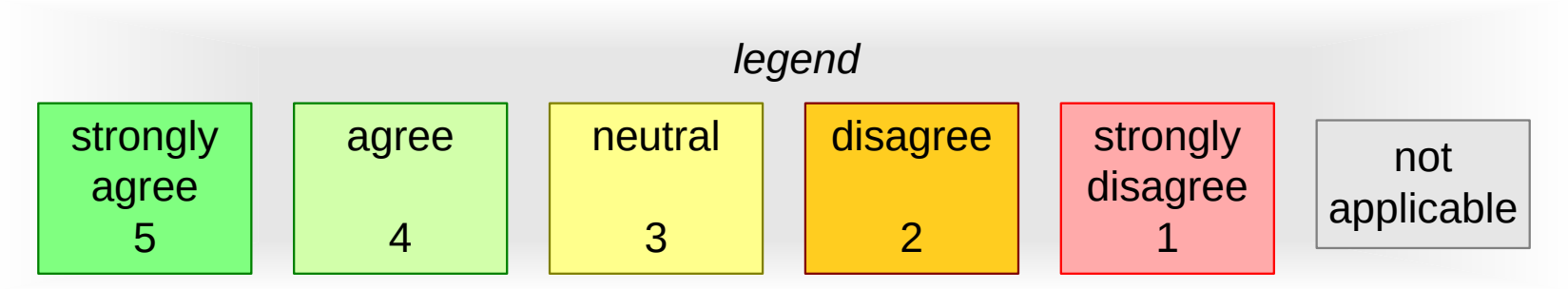
Questionnaire

	strongly agree	agree	neutral	disagree	strongly disagree	not applicable
1. The A3 reports helped in finding requirements.						

Presentation data



Evaluation of Surveys



1. The A3 reports helped in finding requirements.

How to assess the outcome? What is "good"?

Mean > 3, e.g. better than neutral? mean = 3.9

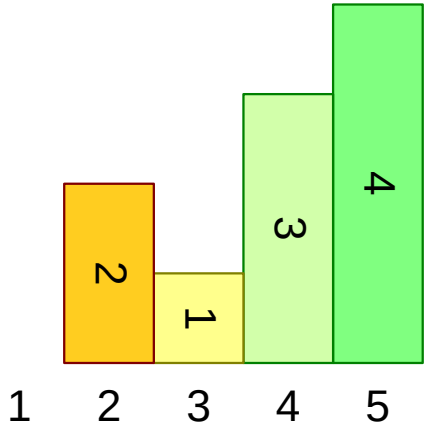
Mode or median? median = 4, mode = 5

mean, median, and mode are not very differentiating

Net Promotor Score=

(#promotors - #complainers)=

(#strongly agree - (#neutral+#disgaree+#strongly disagree) > 0 NPS = +1



References

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O'Brien, R. 1998. *An Overview of the Methodological Approach of Action Research*. University of Toronto http://www.web.ca/robrien/papers/arfinal.html#_edn2

Hilary Bradbury Huang, 2010. *What is good action research?: Why the resurgent interest?* Action Research 2010; 8; 93

Industry-as-Laboratory:

Colin Potts. *Software-engineering research revisited*. IEEE Software, Vol. 10, No. 5:19–28, September/October 1993.

Gerrit Muller and W. P. Maurice Heemels, *Five Years of Multi-Disciplinary Academic and Industrial Research: Lessons Learned*; CSER 2007 in Hoboken NJ

Case Study research:

Robert K. Yin, *Case Study Research Design and Methods*. Sage Publications Inc, 5th edition, May 2013

Likert Scale:

Jamieson, Susan. (2004). *Likert scales: how to (ab)use them*. Medical Education. http://xa.yimg.com/kq/groups/18751725/128169439/name/1LikertScales.pdf

Net Promotor Score:

Frederich Reichheld *The One Number You Need to Grow,* Harvard Business Review 2003, http://hbr.org/2003/12/the-one-number-you-need-to-grow/ar/1

Keiningham, T, L. Aksoy, L. Cooil, B. Andreassen, T, W. (2008). *Net Promoter, Recommendations, and Business Performance: A Clarification on Morgan and Rego.* Marketing Science.Vol.27, No. 3, May-June 2008, pp. 531-532. http://www2.owen.vanderbilt.edu/bruce.cooil/Documents/Publications/2008--Marketing%20Science.pdf

Tools and support see: https://min.usn.no/student/tjenester-for-studenter/it-tjenester/

Master Project; Writing an Abstract

by *Gerrit Muller* University of South-Eastern Norway-NISE
e-mail: gaudisite@gmail.com
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Abstract

An abstract is a brief desrciption of the content of a paper to facilitate readers in deciding to read the paper. This presentation explains how to write an abstract. Normally, an abstract is written at the end of writing a paper. For the master project, we challenge students to write an abstract up front, to stimulate them to think through the entire project, including the expected outcome.

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version: 0

logo
TBD

Abstract

"A good abstract should answer three questions:

What did I do,

what did I learn,

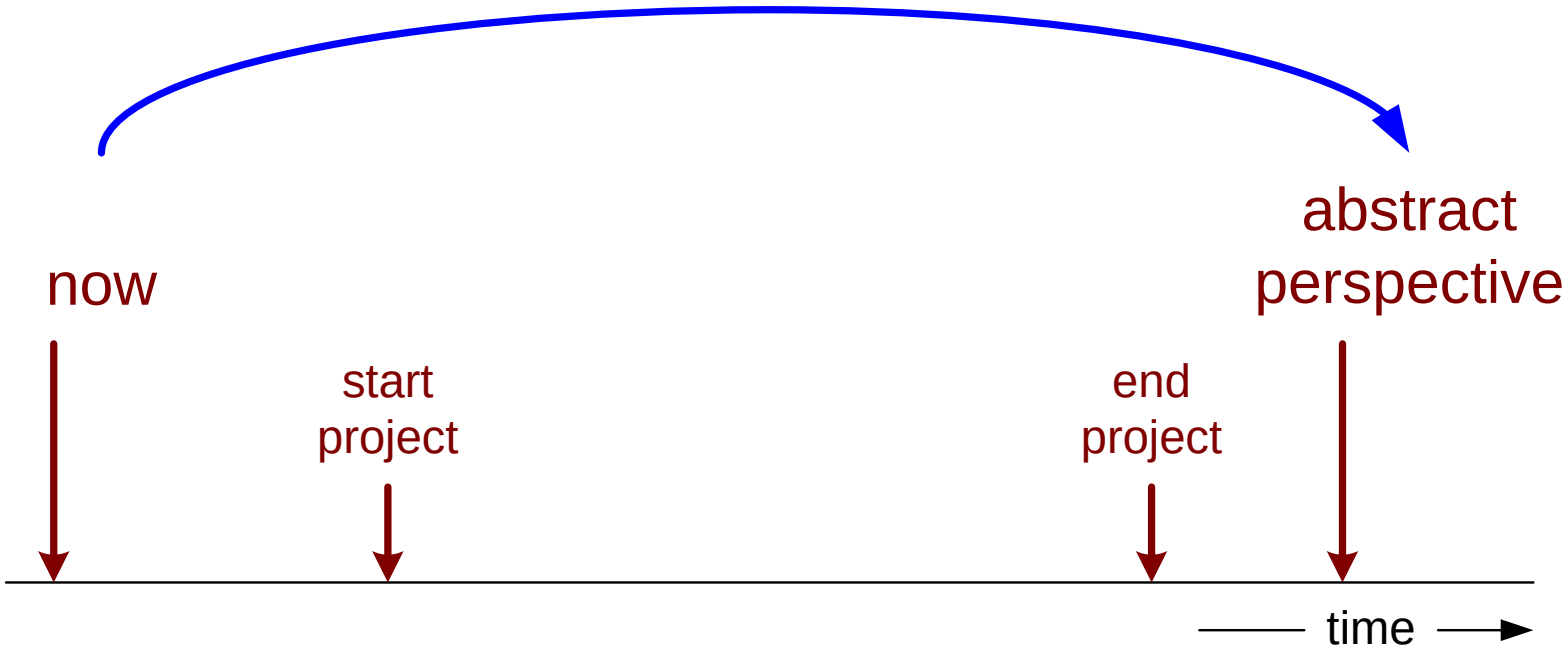
and why is that important?

The key is to identify something or things that can be reused in the future."

Prof. Michael Pennotti, Stevens Institute of Technology

Needed: Time Machine

"fast forward" yourself into the future
what do you expect to be the project outcome?



Students write an initial abstract at the start to think through what can happen. At the end of writing the paper, you write the real abstract. The academic supervisor has to accept the initial abstract before starting the project.

Multiple Levels of Academic Abstraction

SE body of Knowledge

meta^0	meta^1	meta^2
bottom line: system-of-interest	*enabling:* systems engineering methods	*academic:* research of methods
work over system missile production line turbine package control system tie-in system	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	measuring experimenting modeling surveys interviews refering to literature argumenting

Value per Meta-level

SE body of Knowledge

meta^0	meta^1	meta^2
bottom line: system-of-interest	*enabling:* systems engineering methods	*academic:* research of methods
earning money	re-use in future projects in other domains	validation of method re-use

Content of Paper

SE body of Knowledge

meta^0	meta^1	meta^2
bottom line: system-of-interest	*enabling:* systems engineering methods	*academic:* research of methods
set the context where did you apply	what did you apply and why	what can we learn based on what findings
domain system-of-interest	systems engineering challenge/need methods, expected benefit	observations argument

Exercise

Write an abstract

in 3 paragraphs

use 2 sentences per paragraph

100..150 words in total

Master Project; Execution Phase

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Abstract

A master project in systems engineering using action research or indystry as laboratory requires that the student is both researcher and engineer. In this presentation we give guidleines for the execution phase of the project to ensure that the master project student plays both roles. These roles require quite different behavior. Especially the role of researcher is new for most students.

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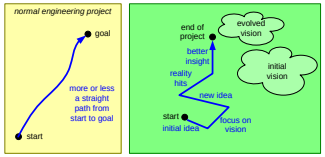
Research is an adventurous journey, be perceptive and see where it goes



Some students in the past called it a rollercoaster…

Know your Academic Supervisor

Discuss *way of working* and *expectations* with your *academic supervisor.*

The following slides are valid for supervision by Gerrit.

Other academic supervisors may have other doctrines.

Recommendations for Project Execution

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

You have Multiple Roles!

	systems engineer	*researcher*
normal work	elicit needs, specify, design, analyze, integrate, test	observe, experiment, argue, evaluate, write
attitude	explain, educate, sell	question everything, proof opposite

Maintain a Detailed Research Logbook

Word or PowerPoint file

take notes continuously!

date/time

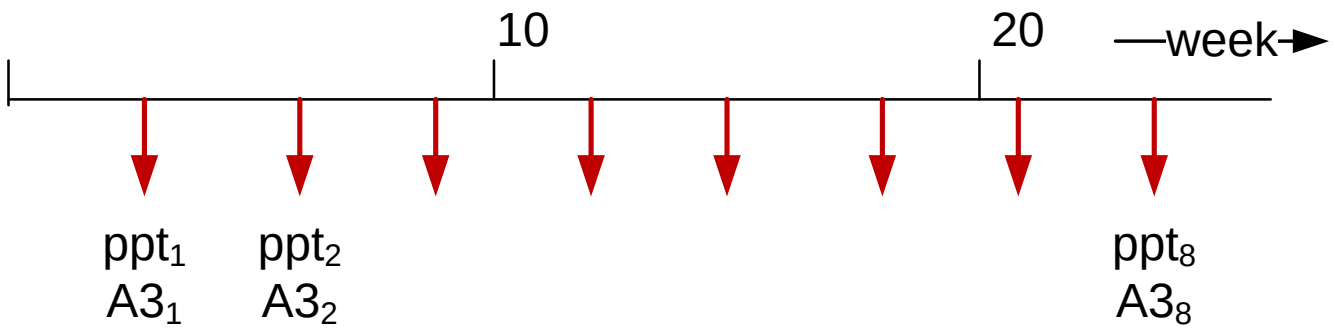
- what
- how
- why
- when
- where
- who

references, e.g. URLs; make electronic copy of any relevant material

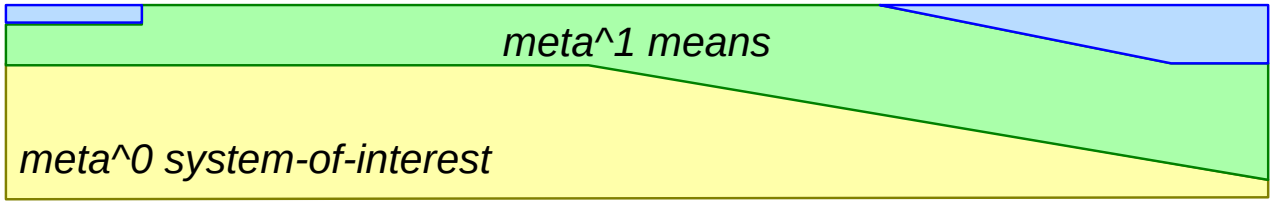
all "raw" data, e.g. submitted questionnaires

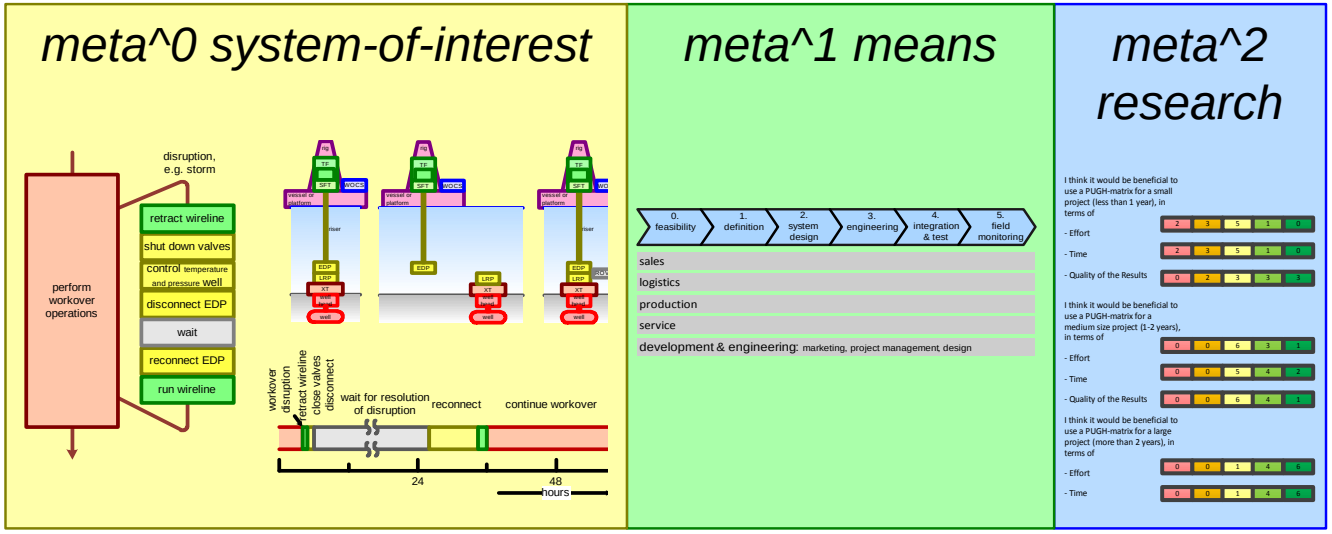
all intermediate data, e.g. spread sheets with version numbers and dates

Discuss Regularly With Company Supervisor



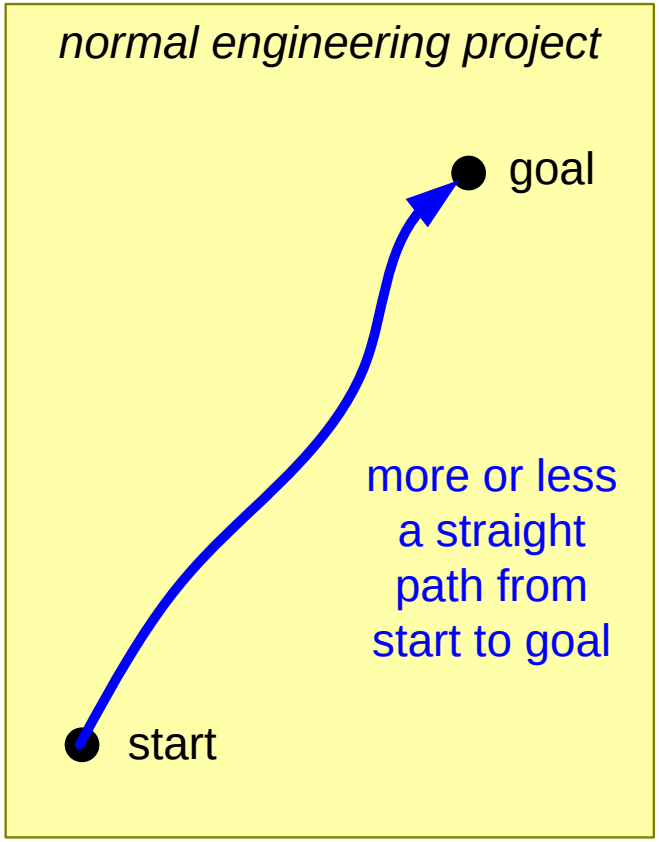
focus first on content, then means and then research approach

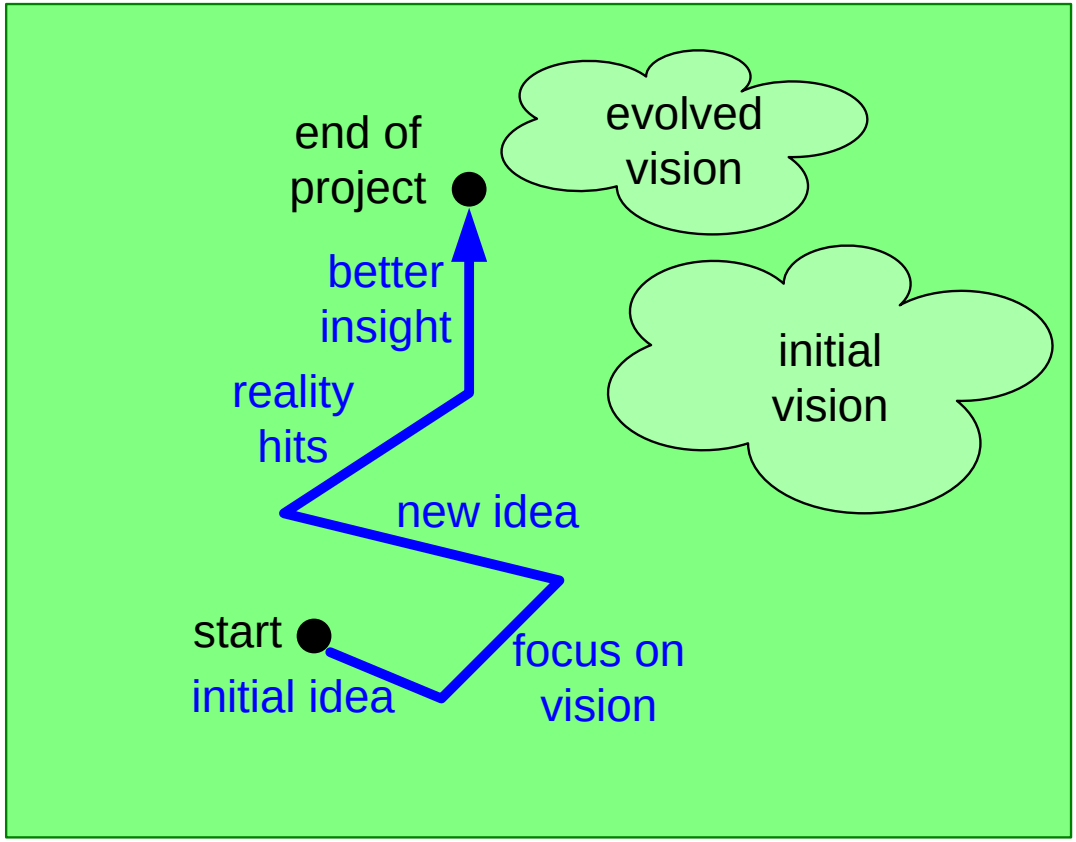




The Nature of Research Projects

Research is an adventurous journey, be perceptive and see where it goes





Some students in the past called it a rollercoaster….

Buskerud University College Systems Engineering Publication Procedure

by *Gerrit Muller* University of South-Eastern Norway-NISE
e-mail: gaudisite@gmail.com
www.gaudisite.nl

Abstract

Systems Engineering research takes place in close cooperation with industrial companies. This document describes a *Conduct of Behavior* for Confidentiality of information from the company where the research takes place. Also a *Publication Procedure* is described.

October 26, 2021
status: preliminary draft
version: 0.2

All information exchanged between researcher and company is to be treated as confidential

Academic supervisors are not allowed to make any confidential information public without permission of the company

Exception is information that was already known to the supervisor or is already public

Confidentiality of Information

All information exchanged between researcher and company is to be treated as confidential

Academic supervisors are not allowed to make any confidential information public without permission of the company

Exception is information that was already known to the supervisor or is already public

Principles of the Publication Procedure

Publications will always be reviewed by the company where the research has been done

The review identifies confidential or sensitive issues in the concept paper

All confidential and sensitive issues have to be solved before the paper can be published

Companies appoint a contact person who will ensure timely review by the company

Examples of Issues to be Identified by Review

Business, customer, organizational, or technical confidential information

market share | name or product | department size | choice of technology

Not (yet) protected intellectual property

"we use new high pressure sealing concept"

Negative image

"our company does skip reviews"

Guidelines for Review

Identify issues as specific as possible

Suggestions to resolve issues are welcome, but don't prescribe solutions

Detection of content quality problem are welcome, but not the main purpose of the company review.

Publication Procedure

author submits paper that has been reviewed by supervisors	we recommend to submit the concept at least 4 weeks before publication dead line
contact person ensures review within 2 weeks	
author solves all identified issues	these steps may be iterated a few times
author resubmits revised paper	
contact person gives permission for publication when all issues are solved satisfactory	this step normally takes a few days

Example of Company Review Process

1. the author makes an evaluation/review of the paper to identify potential changes (to remove confidential or sensitive information); this should be a short report with clear notes

2. the paper and this short report are submitted to the person responsible for the review process.

3. KM need 4-6 weeks to ensure a qualitative review.

Guidelines for Visualization

by *Gerrit Muller* University of South-Eastern Norway-NISE
e-mail: gaudisite@gmail.com
www.gaudisite.nl

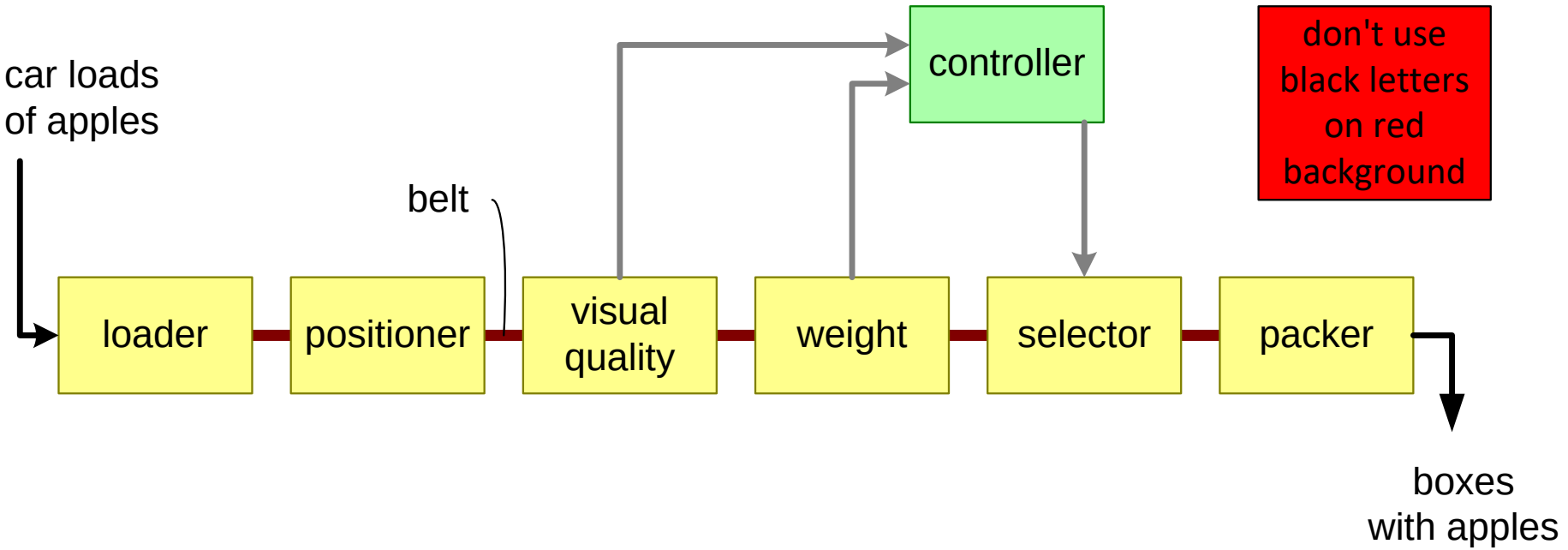
Abstract

his document gives a number of concrete guidelines for visualizations, such as block diagrams, flow diagrams, graphs, decompositions, et cetera.

October 26, 2021
status: planned
version: 0.1

logo
TBD

Readability



Texts should be readable, in PowerPoint minimum font size 14 pt

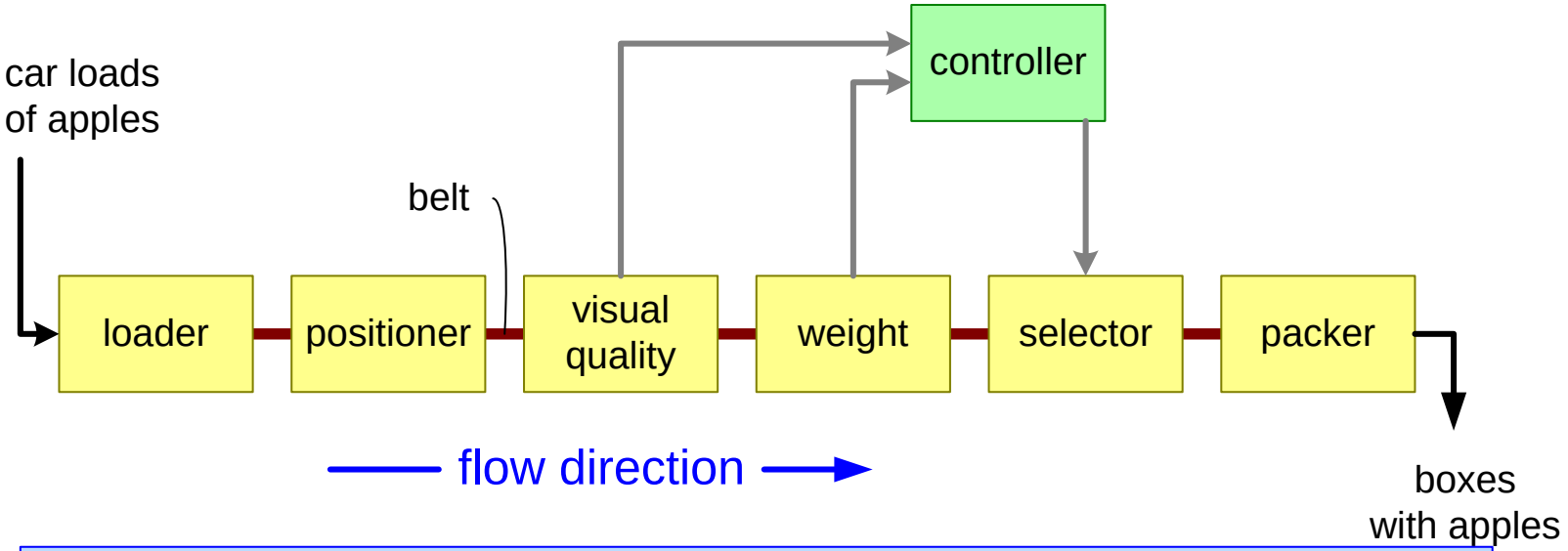
(or if you print a slide on A4, put the paper on the floor,

then you should be able to read the text)

Text and background should have sufficient contrast

(black letters on red background tend to be unreadable)

Layout



Boxes (ellipses, rectangles, triangles, et cetera) should have the same size, unless the size has a clear meaning;

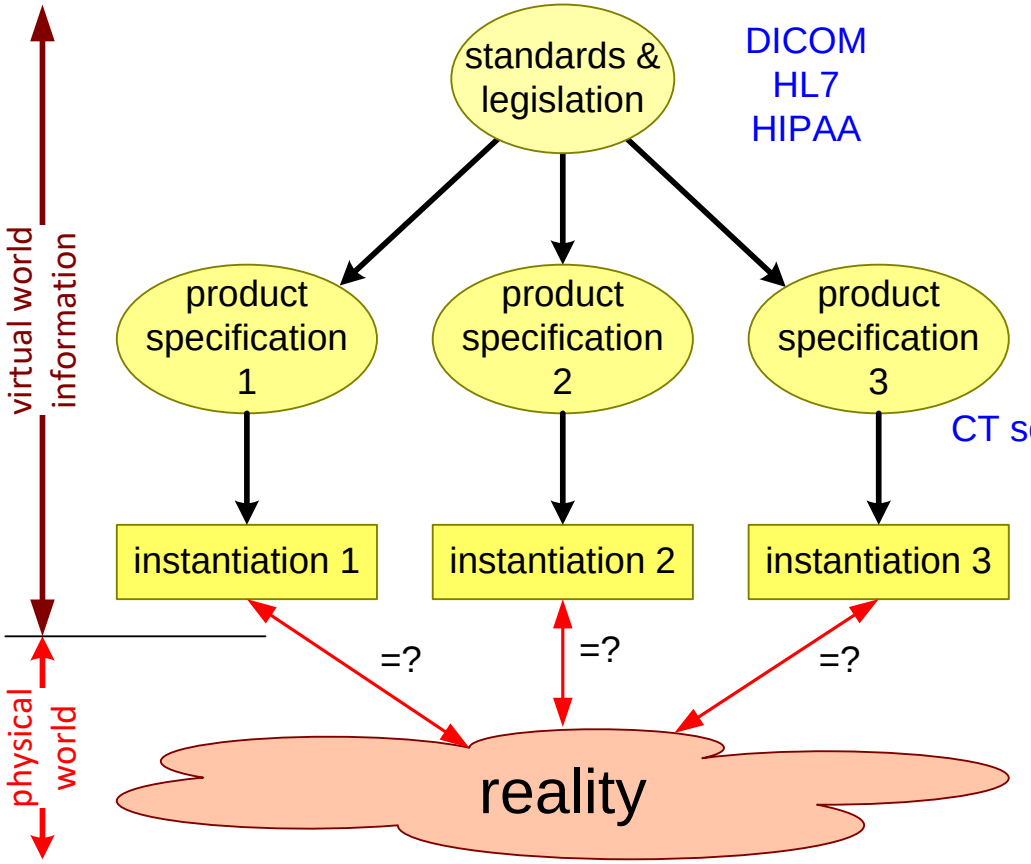
don't size the box to the text, since readers might interpret size in a way that you did not intend.

use the layout (left-right, up-down, close-remote) to support the message of the diagram; e.g. flow from left to right or from top to bottom.

design the layout such that there are few crossing lines;

this is often kind of puzzle.

Color



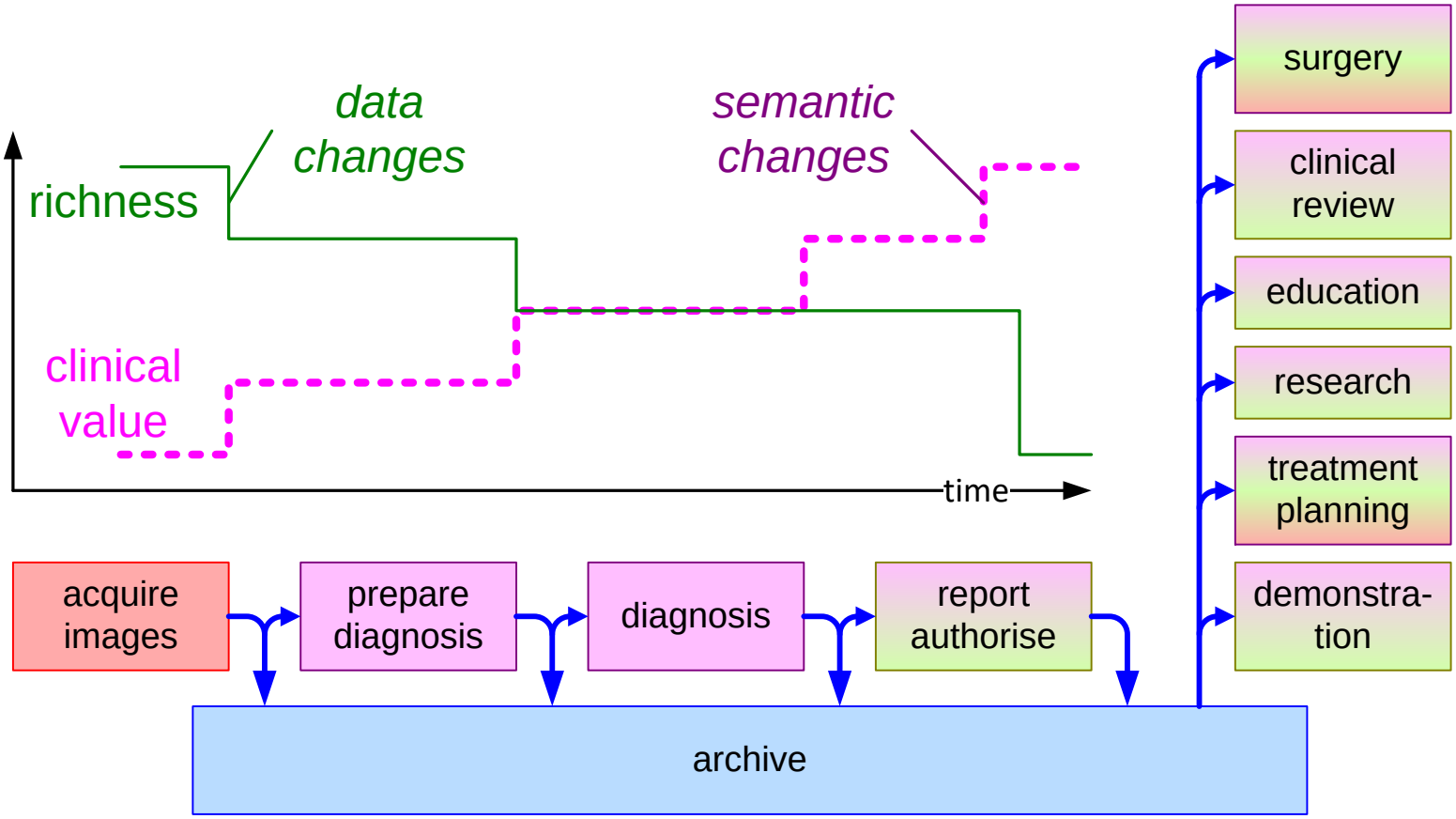
In this example the color scale is used functionally; the color indicates the "degree of virtuality"

For readability the Gaudi site uses light background colors and darker colors for text and lines

Use colors, but limited.

Try to use additional visual support to keep the diagram usable when printed black and white or for color-blind people. Alternate means to add meaning are shape (e.g. rectangles with rounded corners), line thickness, dotted lines, alternate end points or connectors.

Information



Limit the amount of information in one diagram.

Two or three types of information can be combined in one diagram. For example a block diagram that also shows effort, risk or complexity as size of the boxes. Or a flow diagram with annotations where the functions are allocated.

Generic and Specific

integrating **multiple**

applications

cilinical analysis
clinical support
administrative
financial
workflow

in **multiple**

languages

cultures

USA, UK,
China, India,
Japan, Korea
France, Germany
Italy, Mexico

delivered by **multiple**

vendors

Philips
GE
Siemens

based on **multiple**

media, networks

DVD+RW
memory stick
memory cards
bluetooth
11a/b/g
UTMS

and **multiple**

standards

Dicom
HL7
XML

and **multiple**

releases

R5
R6.2
R7.1

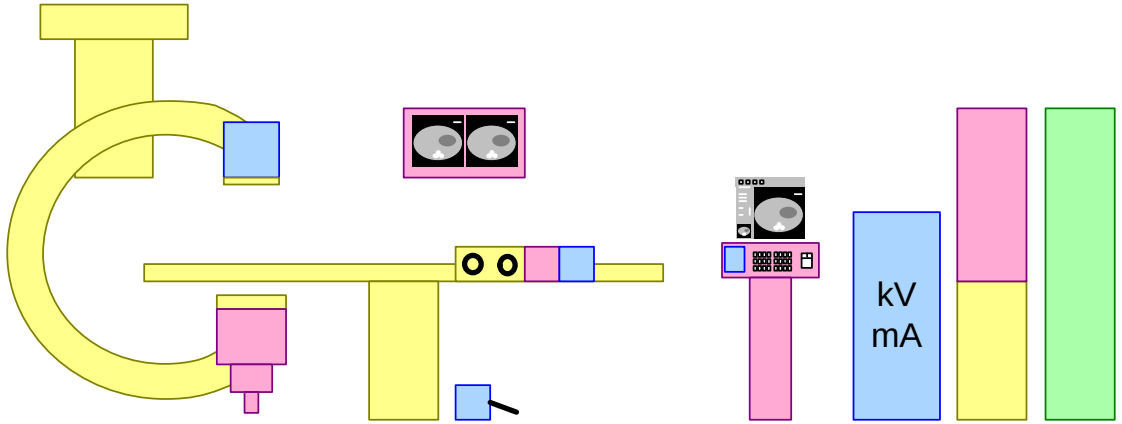
Annotate generic diagrams with specific examples; A generic diagram often captures some valuable insight, however, the examples help readers in understanding the diagram.

Use font size and type to visually differentiate main generic message and supportive specific examples

Attractiveness

..~1985
autonomous subsystems: Geo | Acquisition | Imaging | X-ray generation

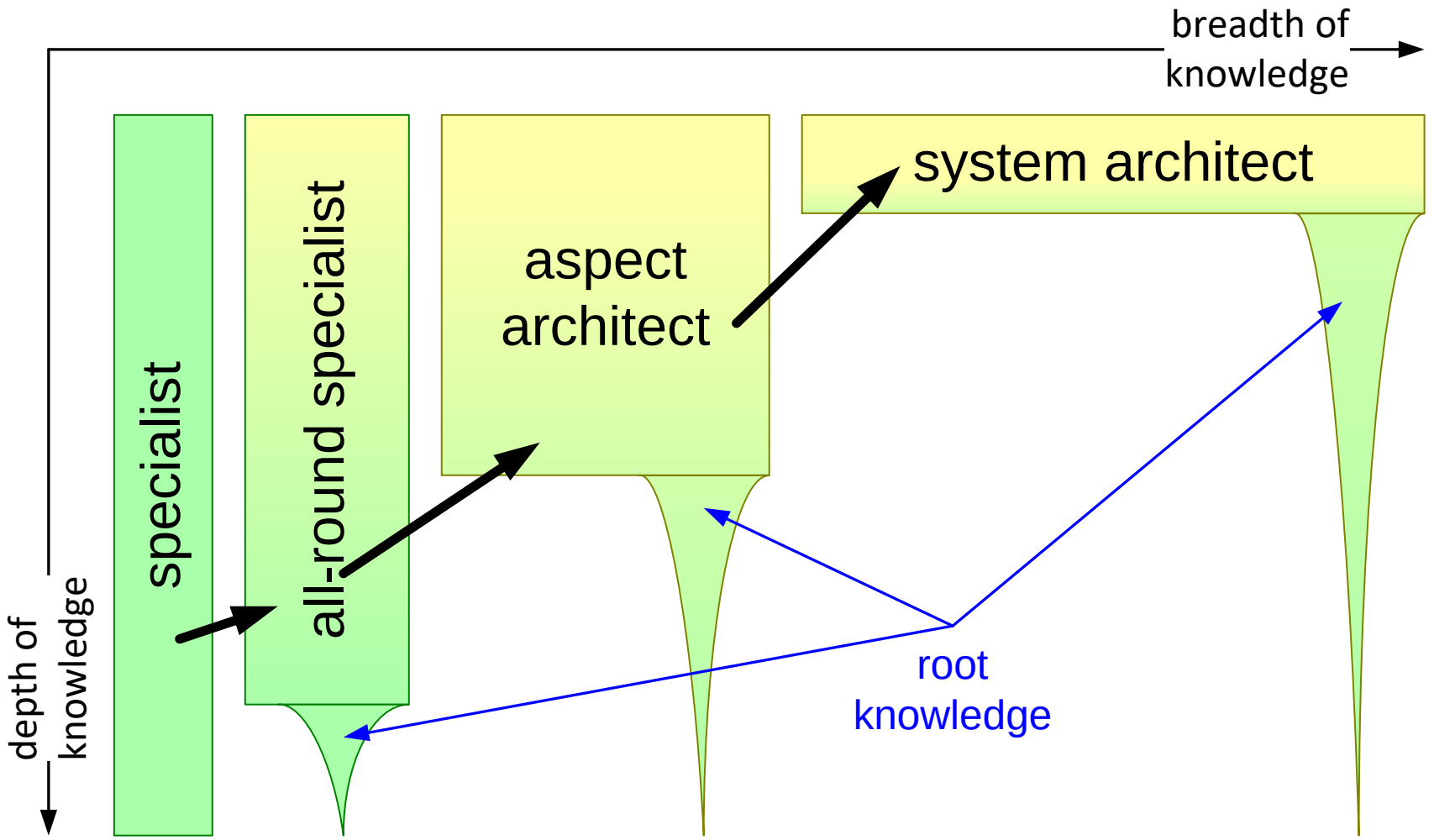
sales: preferred configurations; arbritary configurations are more expensive
system integration (SI) in R&D
SW in all subsystems
SI is is electro mechanical *and configuration parameters*
innovation elapsed time several years (f.i.,2 years for digital imaging chain)



in some cases 2D/3D drawings or photos help to make a diagram more accessible (less abstract). However, it also "clutters" the diagram. So use these "real" objects sparsely

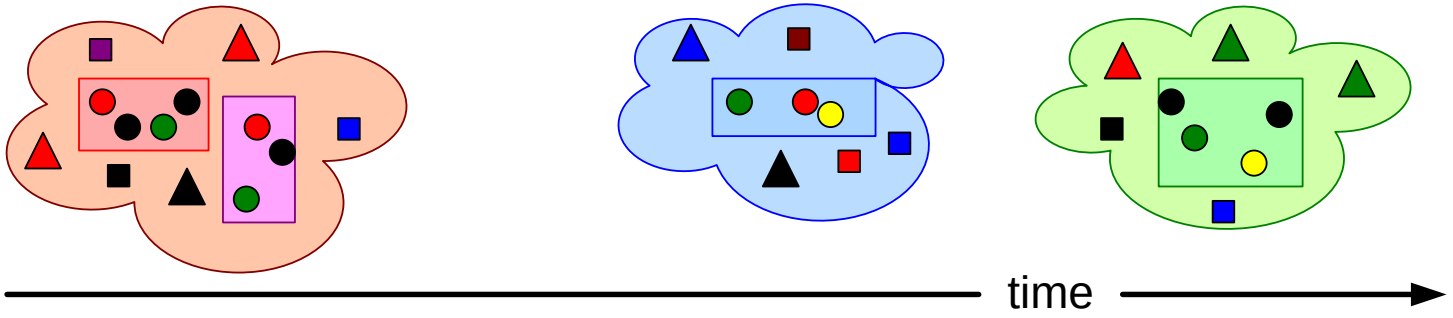
Use animations sparsely. Animations can be very powerful to visualize processes or flows. However, animations cannot be printed. Avoid animations that only make the presentation more sexy.

Message



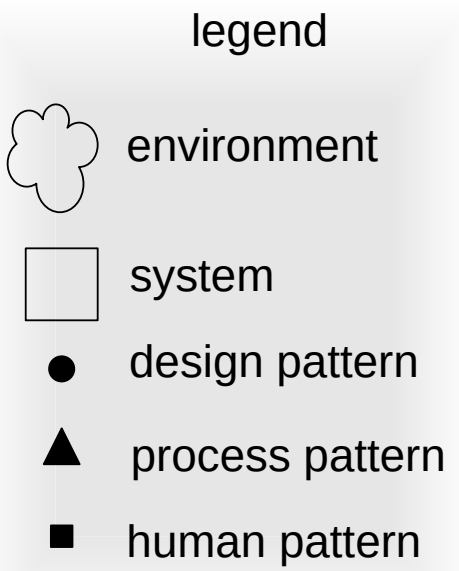
Good visualization bring and clarify a message. What is the take away of this visualization for your audience?

Legend



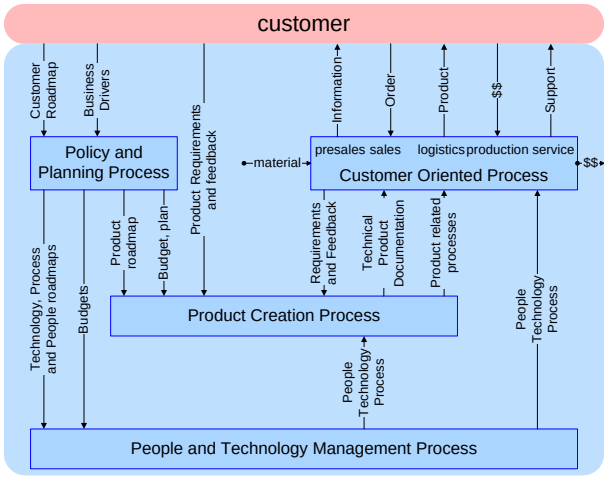
architects move from:
- product to product
- environment to environment

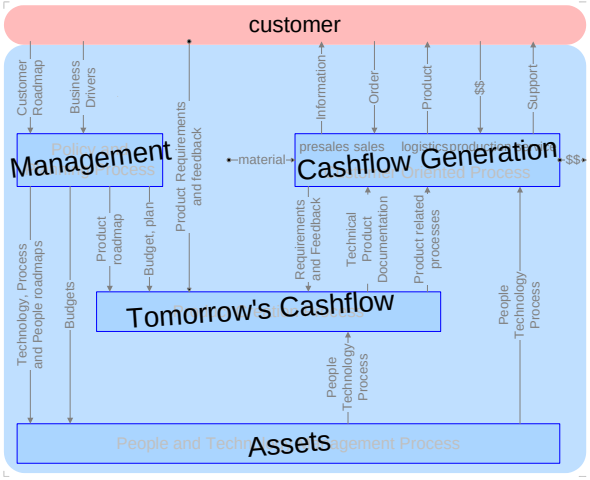
architects experience:
- thousands of patterns
- *design* patterns in systems
- *process* patterns in environments
- *human* patterns in environments

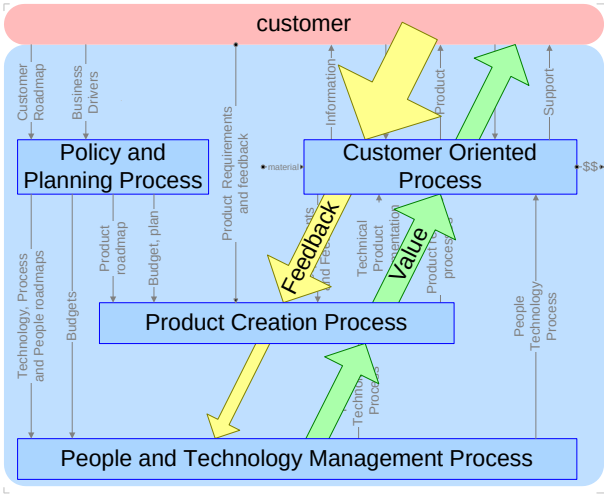


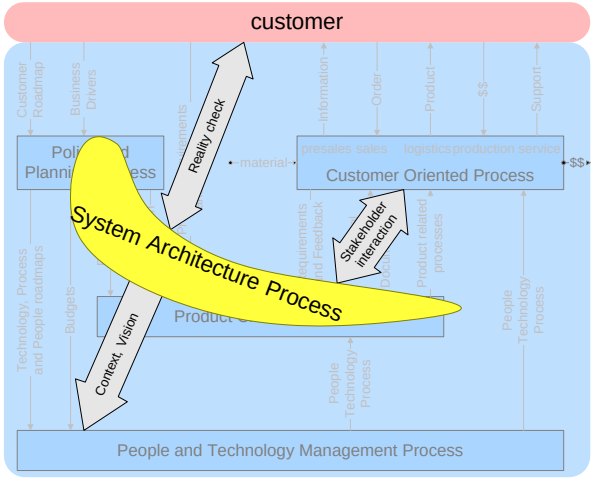
Add a legend for shapes, lines, or colors when the meaning is essential for the figure.

Separate information, prevent overload









Don't overload diagrams; if you have tens of boxes then consider simplification or divide in multiple slides plus one overview slide.

Consider to add one overview slide when dividing over multiple slides

Summary

Texts should be readable: use sufficient font size.

Text and background should have sufficient contrast.

Shapes, such as boxes, should have the same size.

Use the layout (left-right, up-down, close-remote) to support the message of the diagram.

Design the layout such that there are few crossing lines.

Use colors, but limited.

Design the diagram such that it still works when printed in black and white.

Limit the amount of information in one diagram.

Two or three types of information can be combined in one diagram.

Annotate generic diagrams with specific examples; use font size and type to visually differentiate generic from specific.

Use 2D/3D drawings or photos limited.

Ensure that the message of the visualization is clear.

Add legend to explain shapes, colors, line types, axes, etc.

Systems Engineering Research Validation

by *Gerrit Muller* Buskerud University College and Embedded Systems Institute
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www.gaudisite.nl

Abstract

System Engineering research addresses methods, techniques, models and formalisms that should advance the engineering practice of systems. This type of research inherently addresses a mix of technological issues in relation to business, process, organization, and people aspects. We discuss the challenge of validating this type of research. We look at different research and validation methods.

October 26, 2021
status: draft
version: 1.0

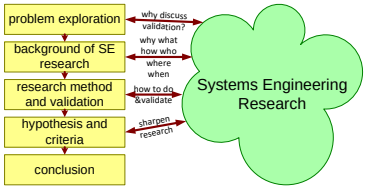
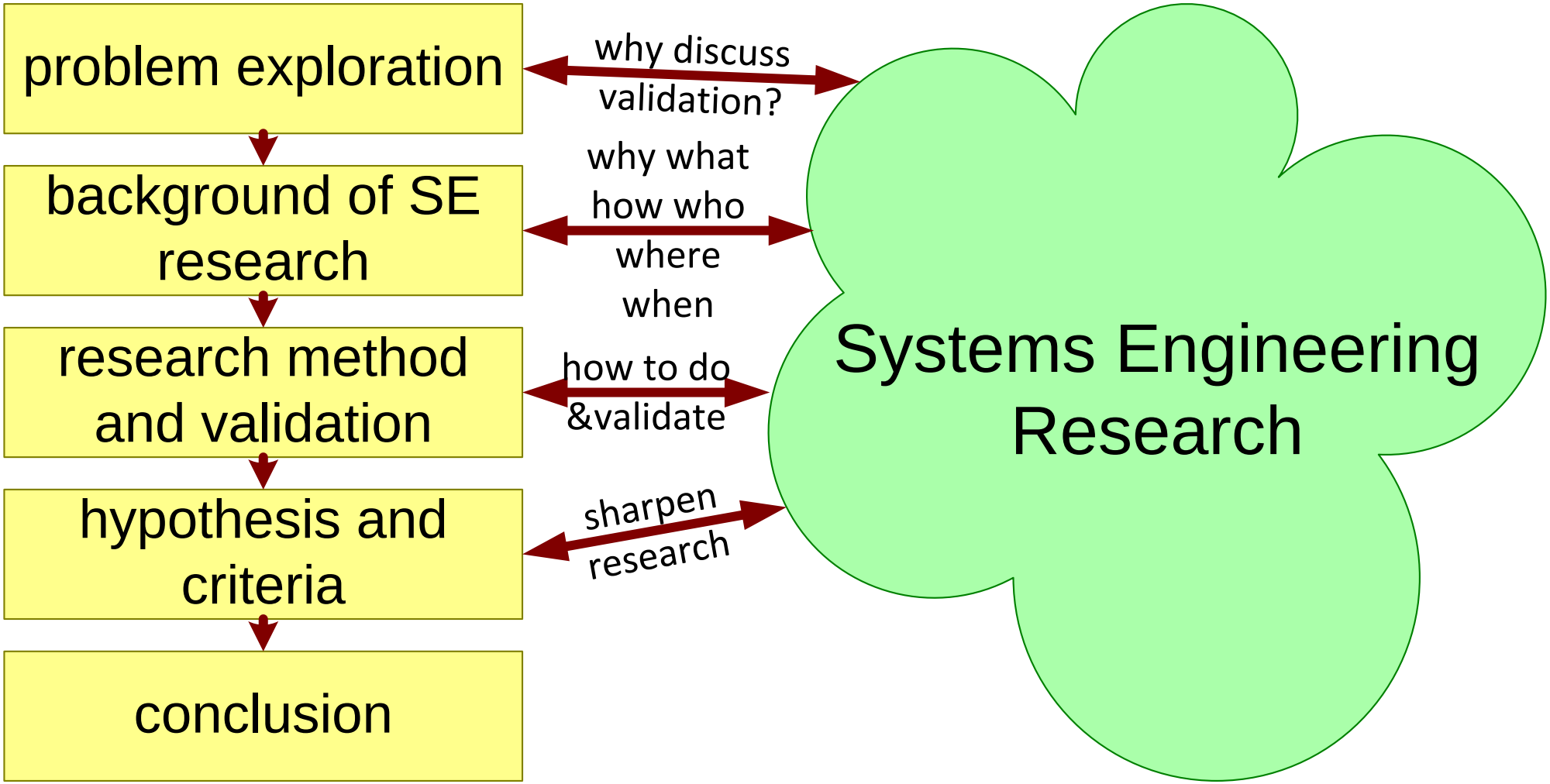
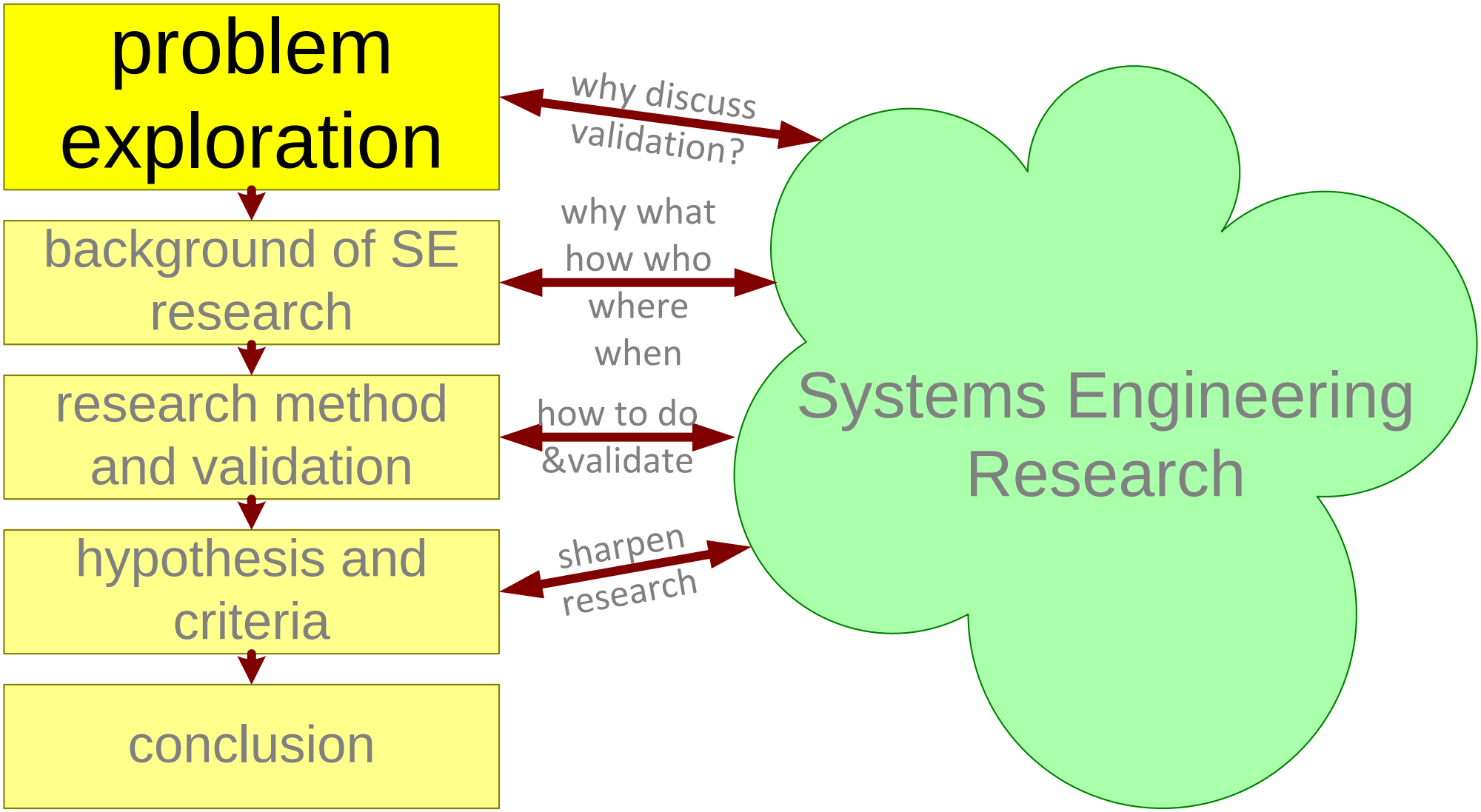
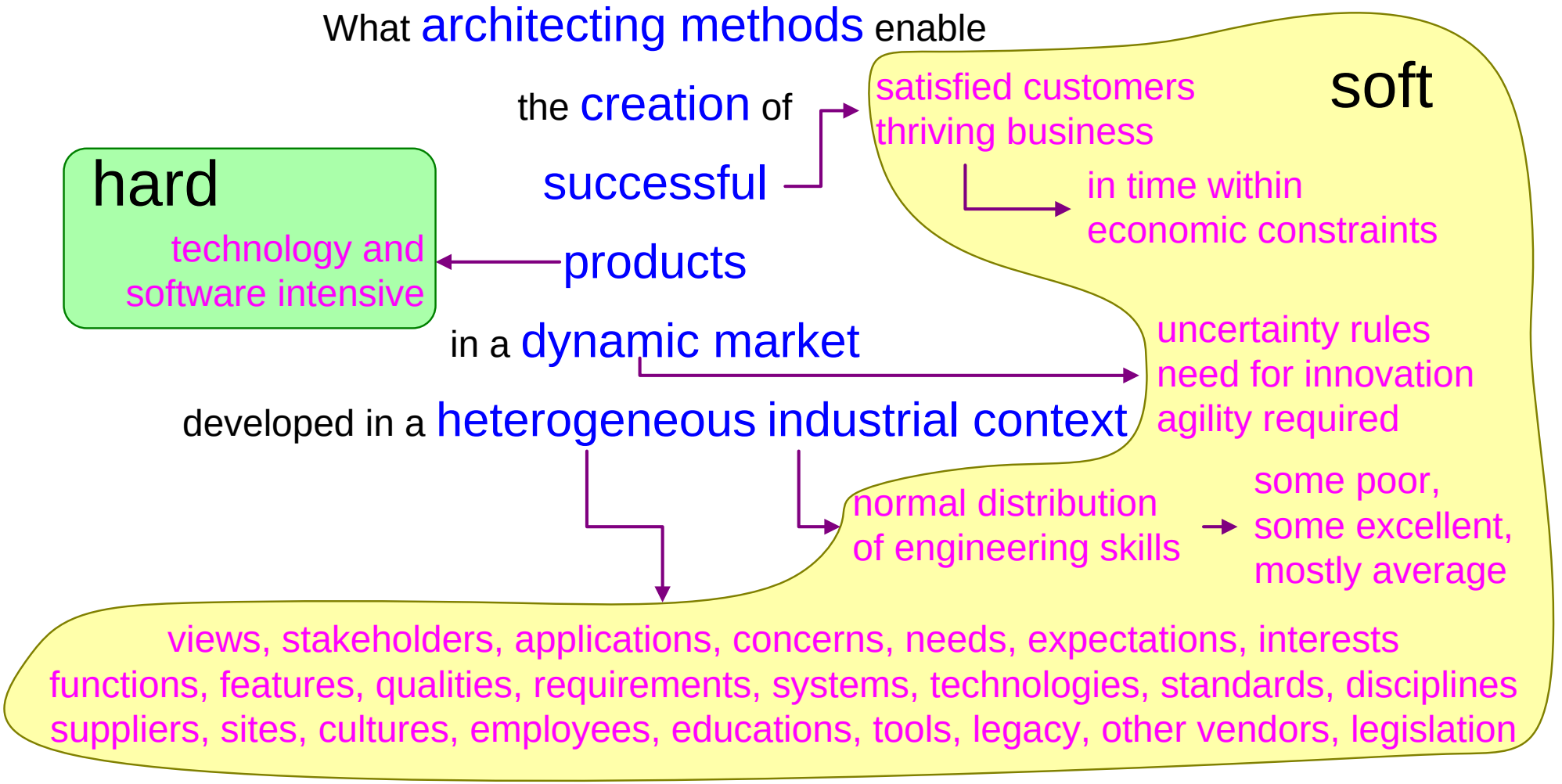


Figure Of Contents™

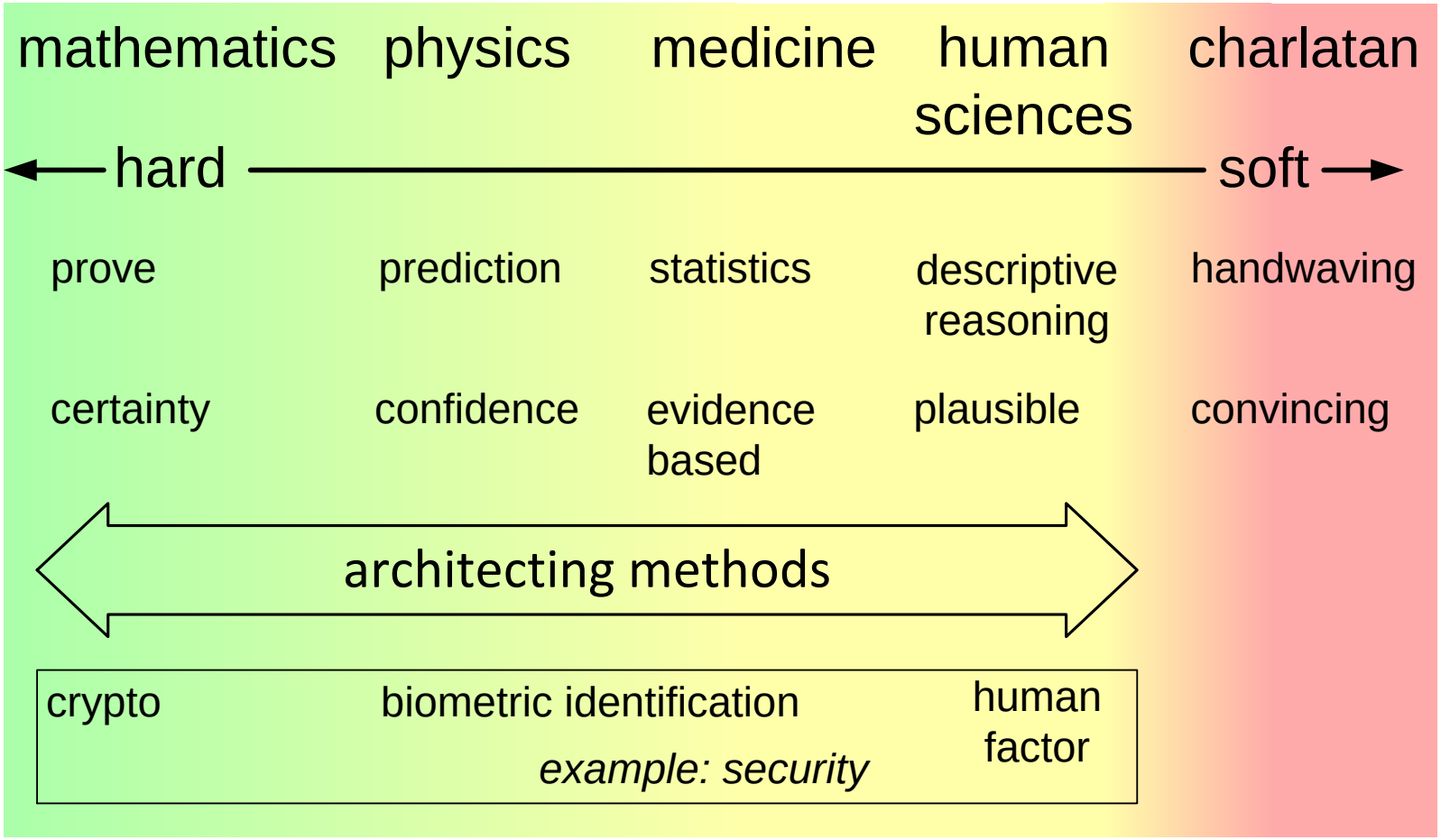


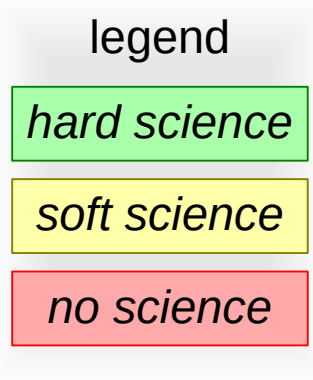

problem exploration
background of SE research
research method and validation
hypothesis and criteria
conclusion
why discuss validation?
why what how who where when
how to do &validate
sharpen research
Systems Engineering Research

Reflection from my PhD thesis



Spectrum of sciences





Problem Statement

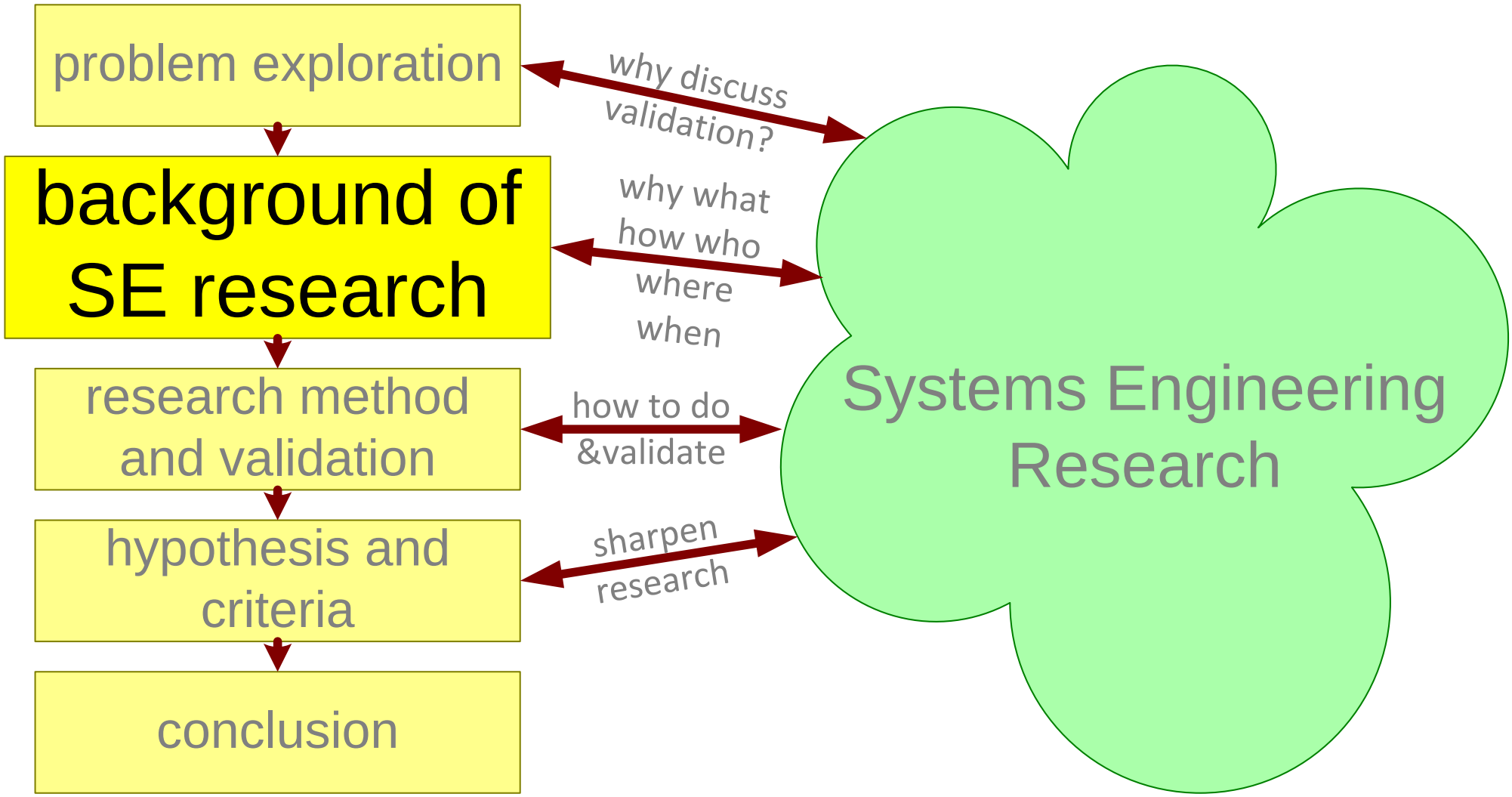
How do we validate

Systems Engineering

research

given that most context factors are

soft and uncontrolled?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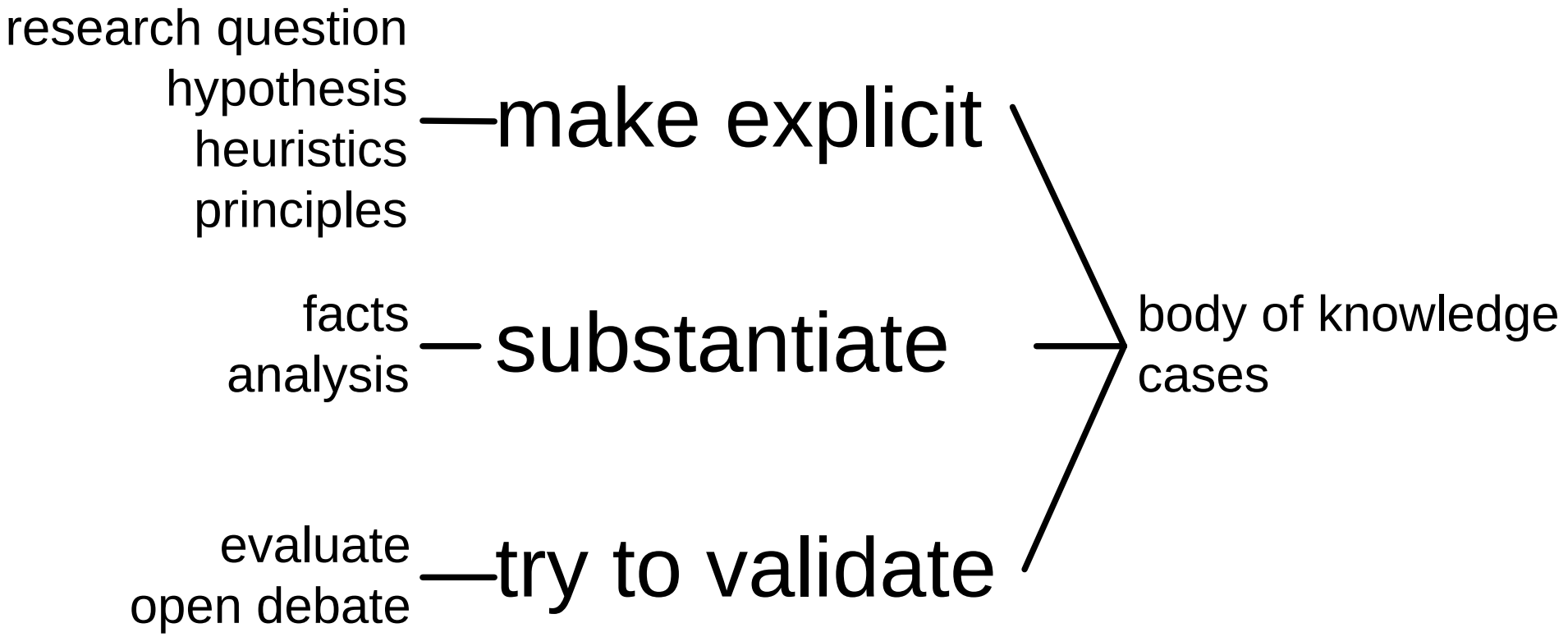
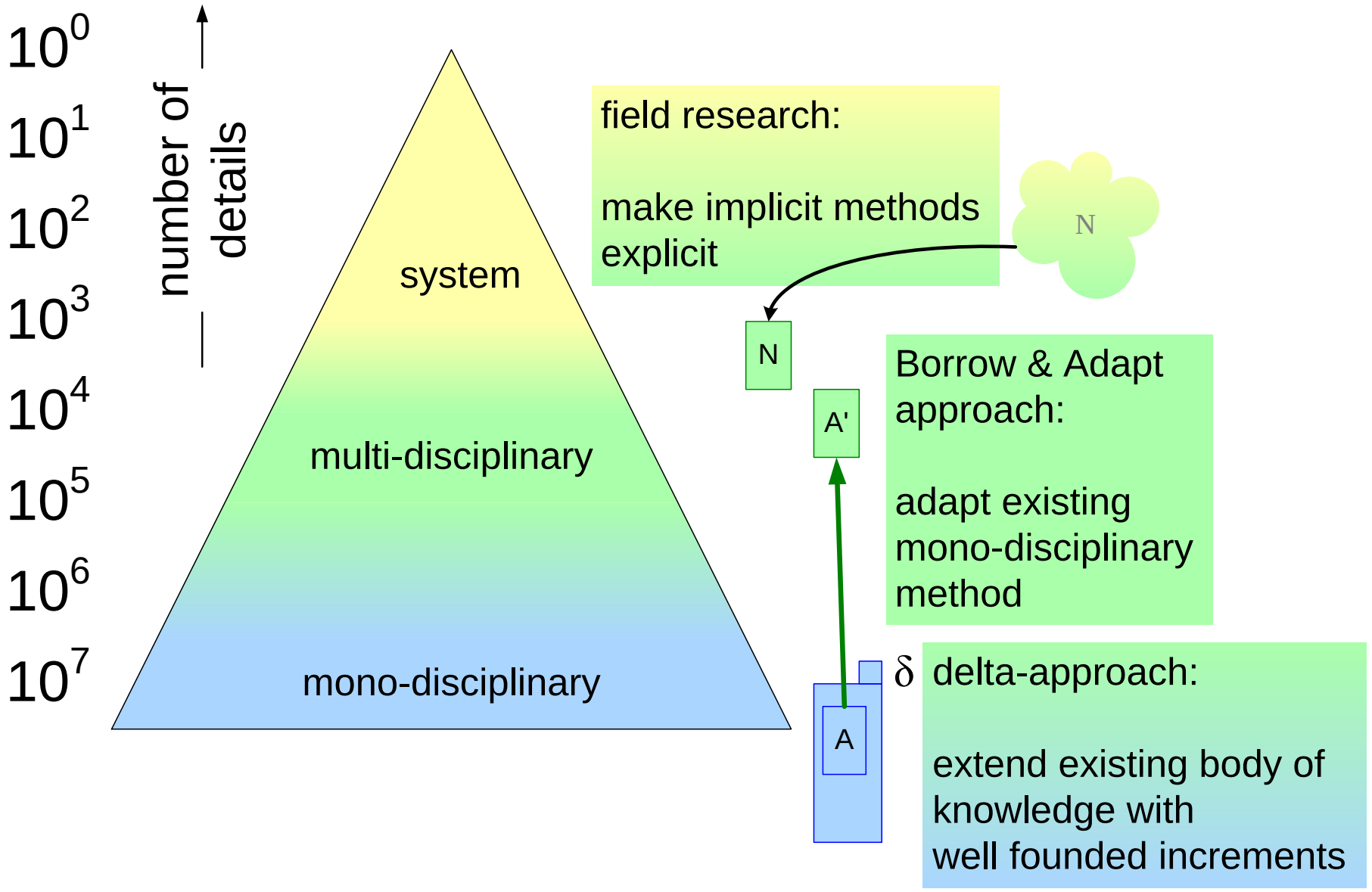
Systems Engineering Research

Soft problems can be approached with a scientific attitude

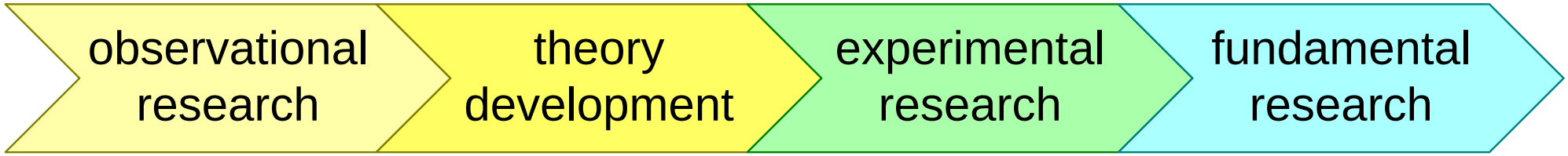
soft is not in conflict with scientific attitude



Different Types of Research

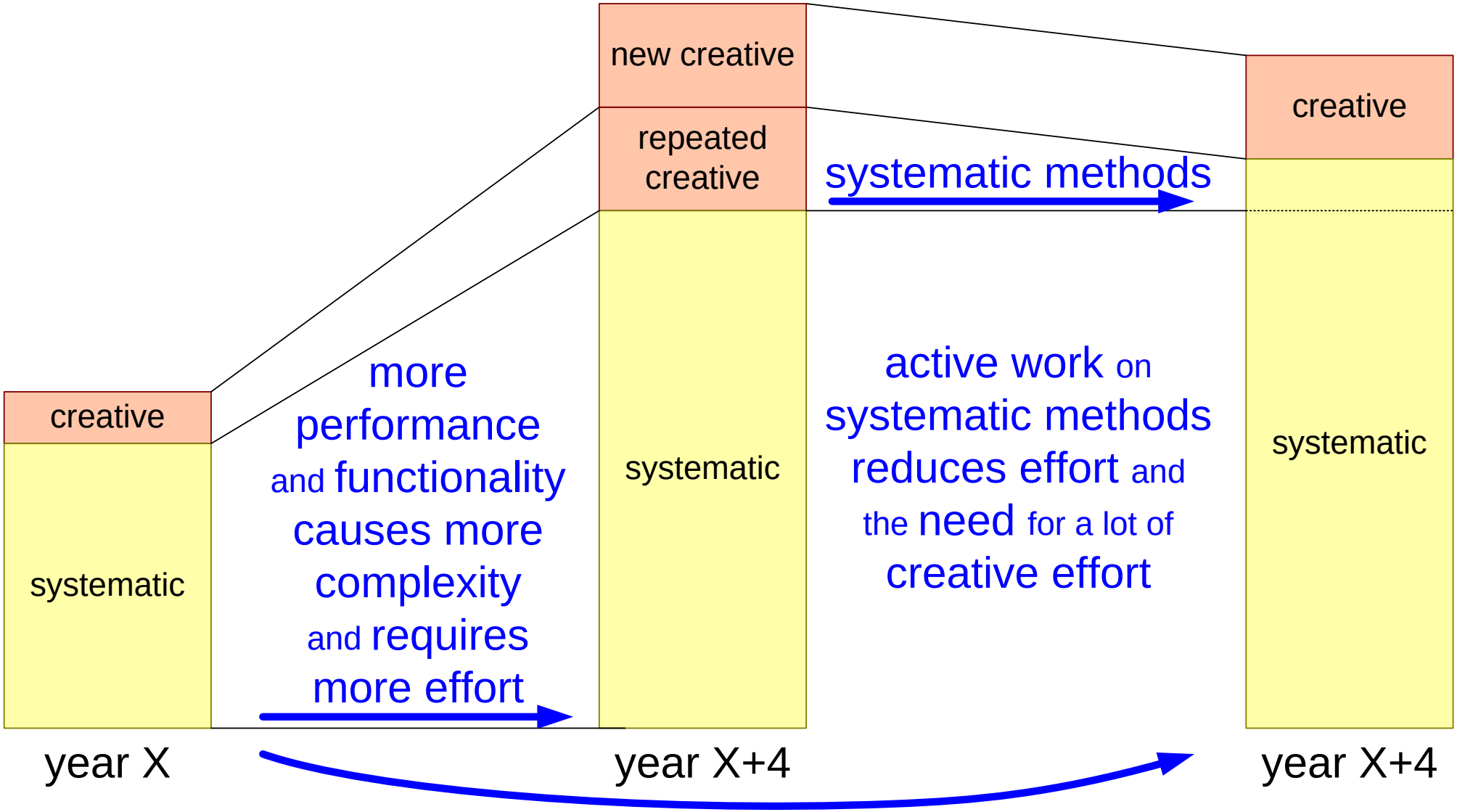


And another Dimension of Research Types

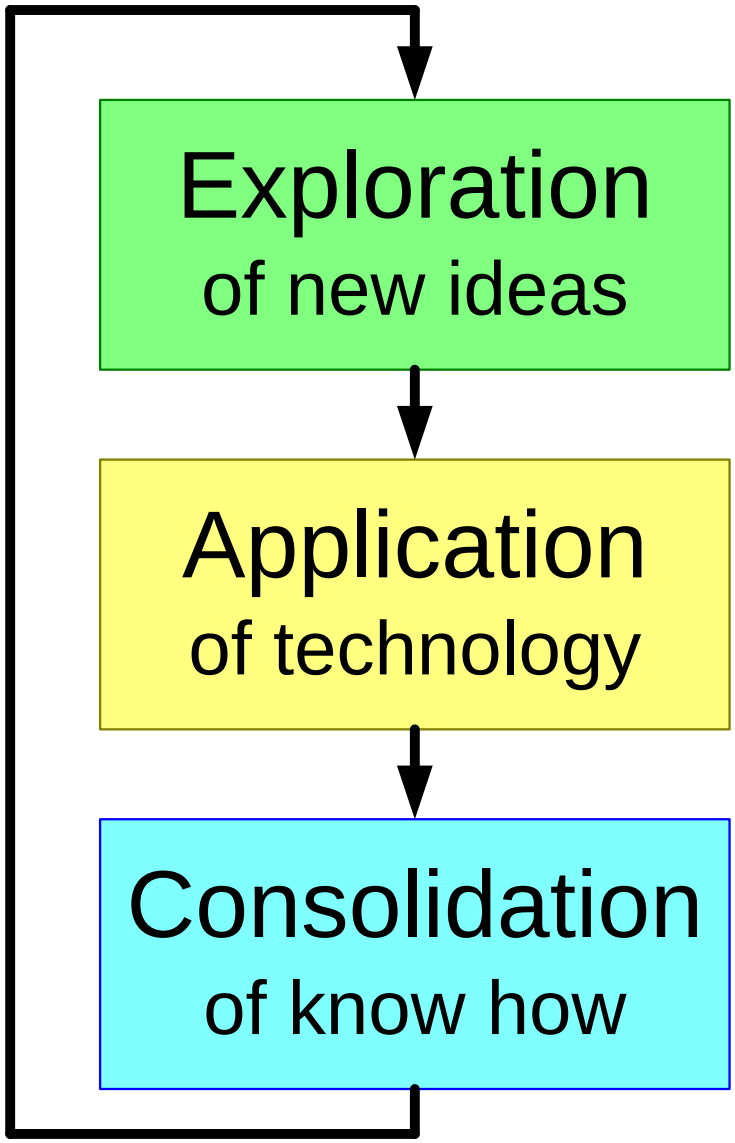


observational research	theory development	experimental research	fundamental research
best practices	metrics	theory evaluation	optimizations
heuristics	formalisms	theory evolution	rigorous proofs
classification	techniques	fundamentals	first principle based
ontology	models	principles	
	methods	methodologies	

Systematic Know-how to cope with Growing Complexity



Technology Management Cycle

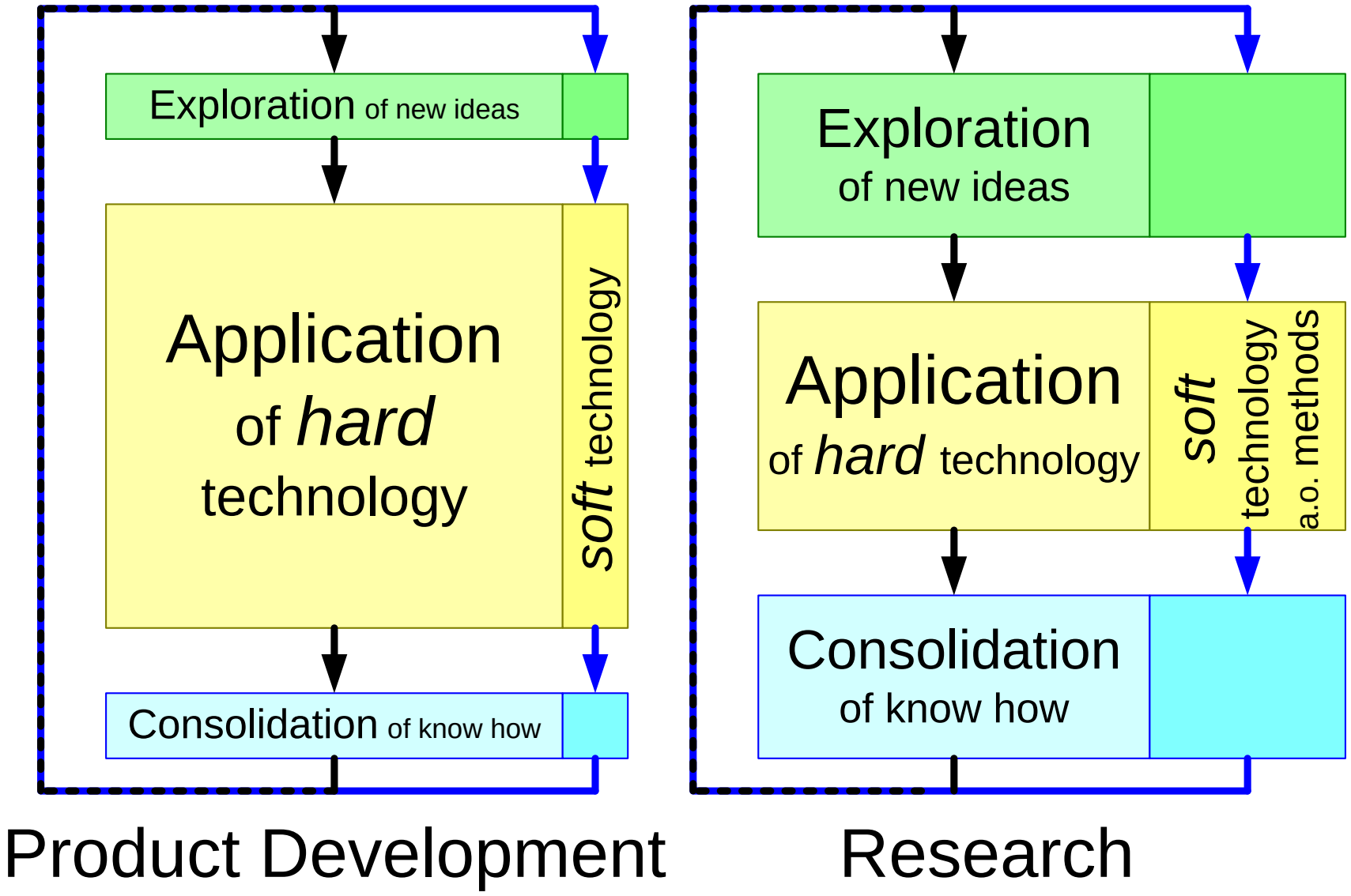


Literature search
Creative option generation
Try out

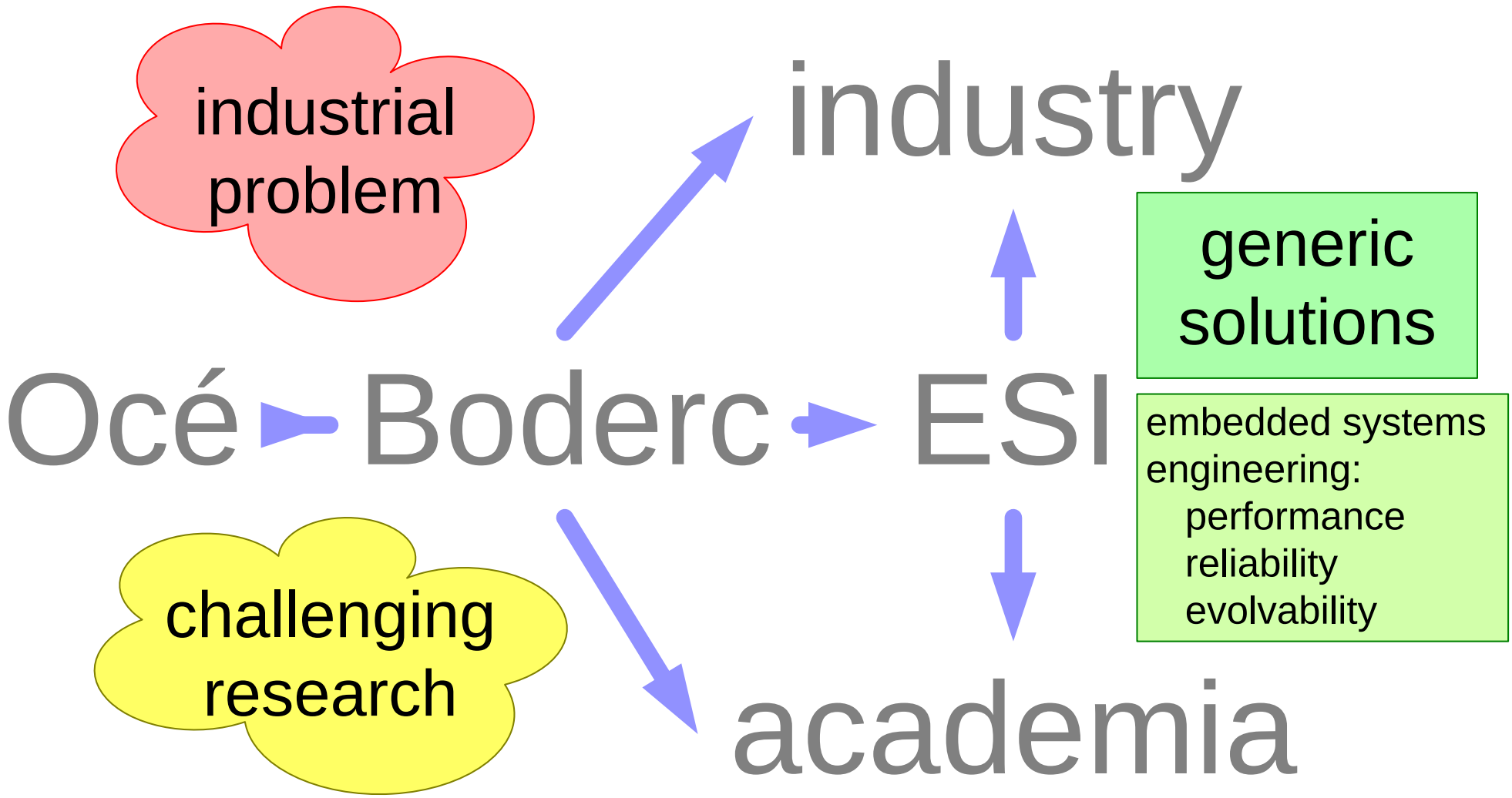
Industry as laboratory

Reflection
Write articles
Create courses

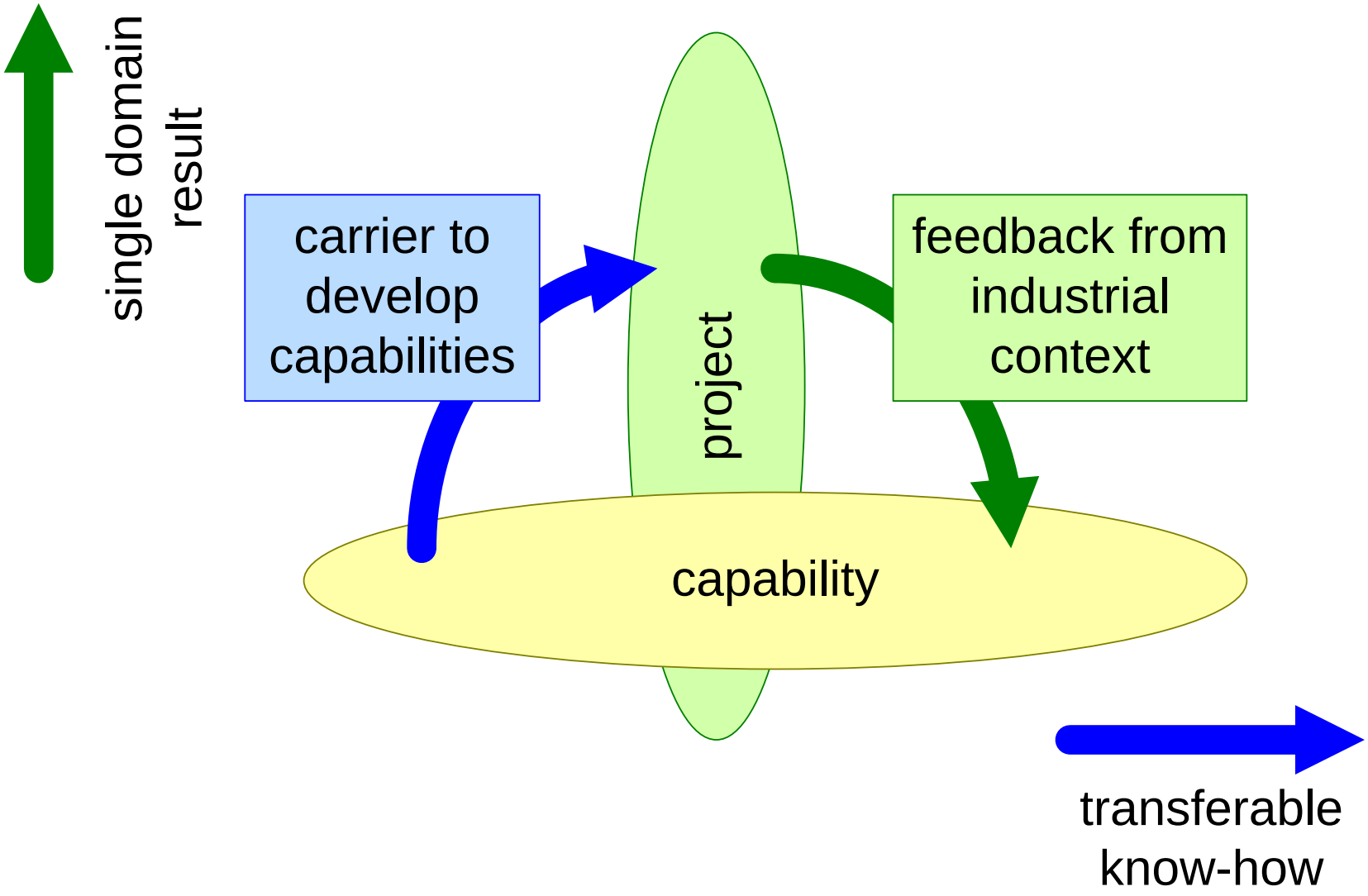
SE research requires application



Example Boderc Stakeholders



Project as Carrier for Capability Development



Methodology

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

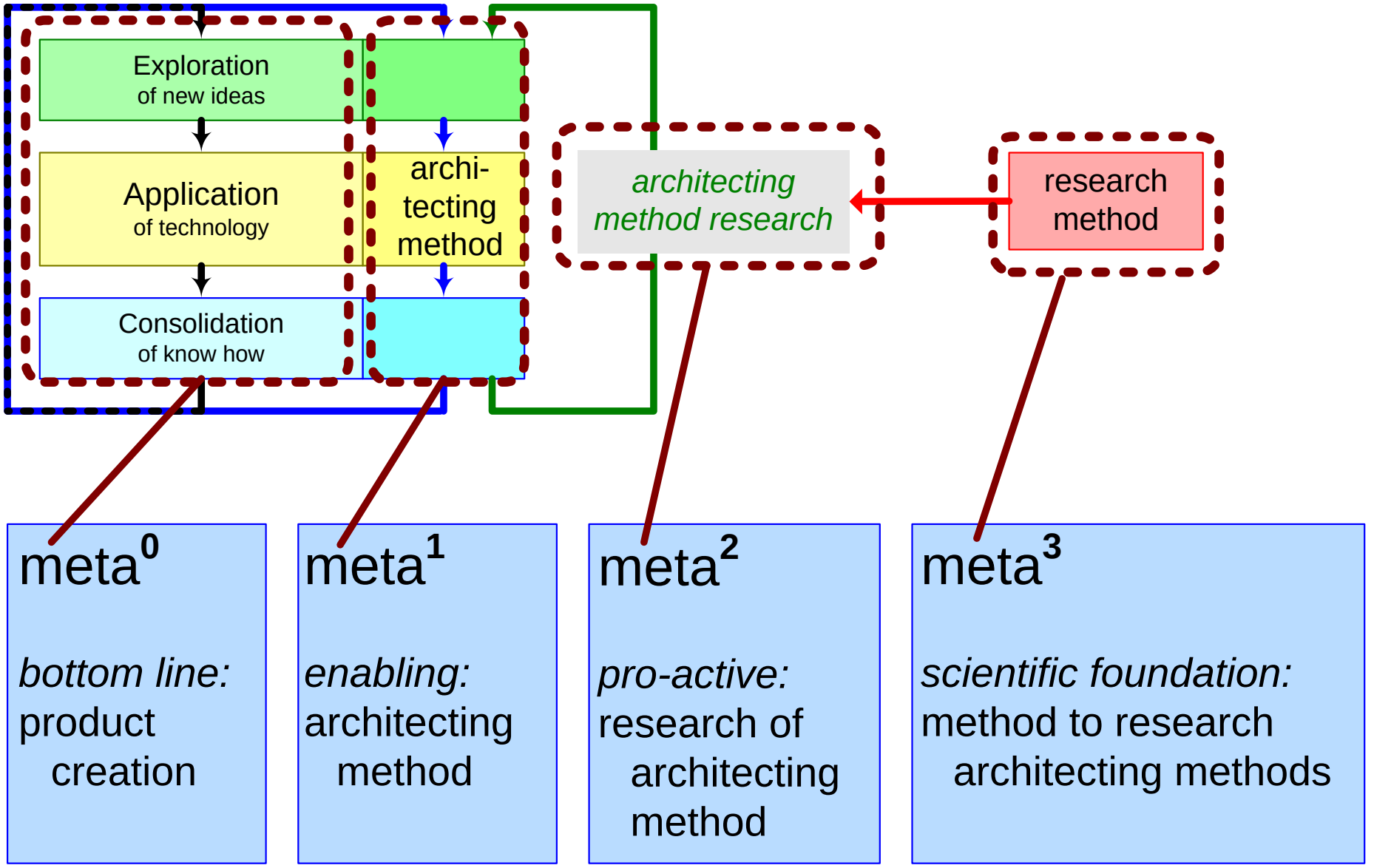
Models instantations of formalisms to understand, explore, optimize or verify specification or design

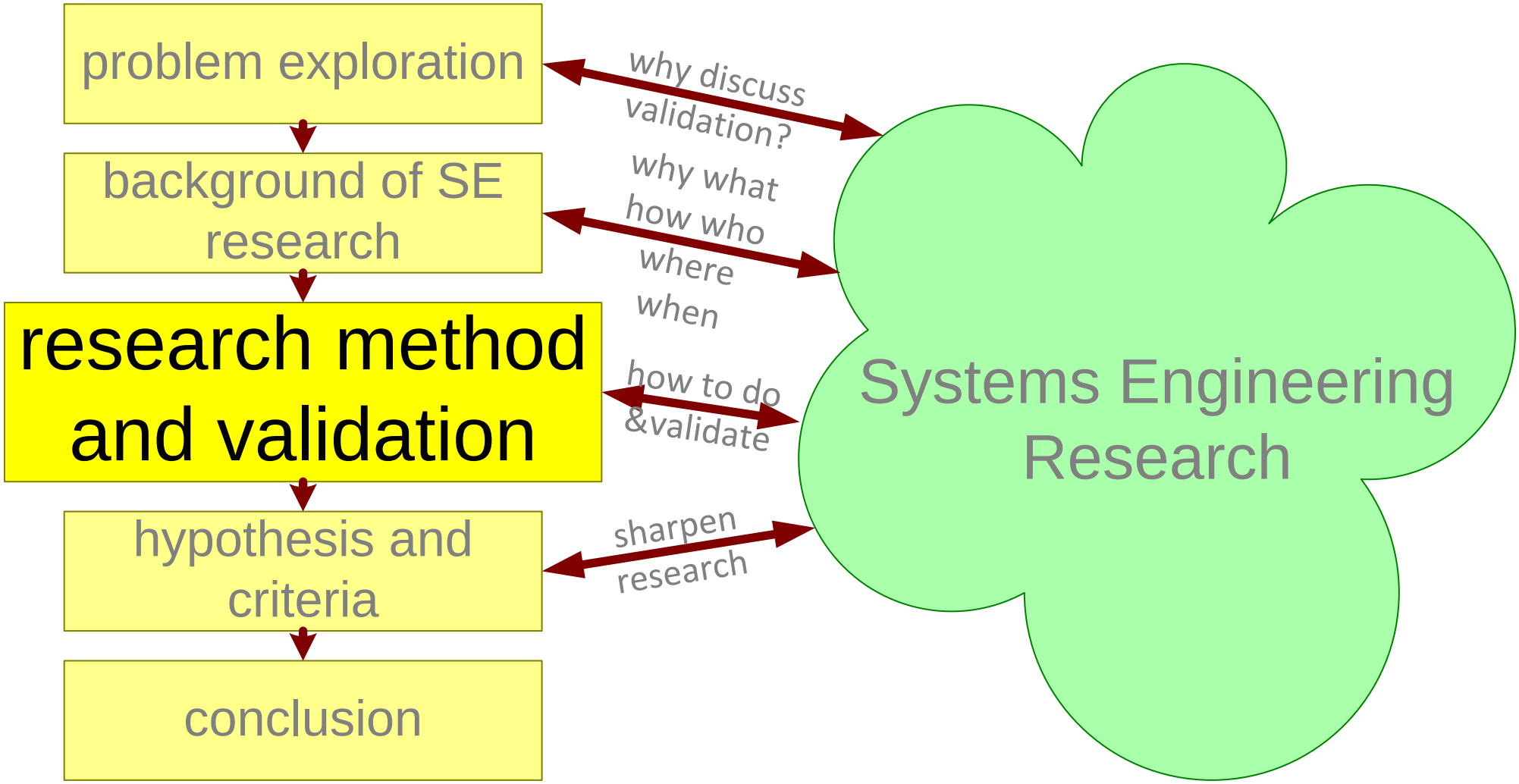
Techniques to get the required information from models: e.g. performance

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

Moving in the *meta* direction

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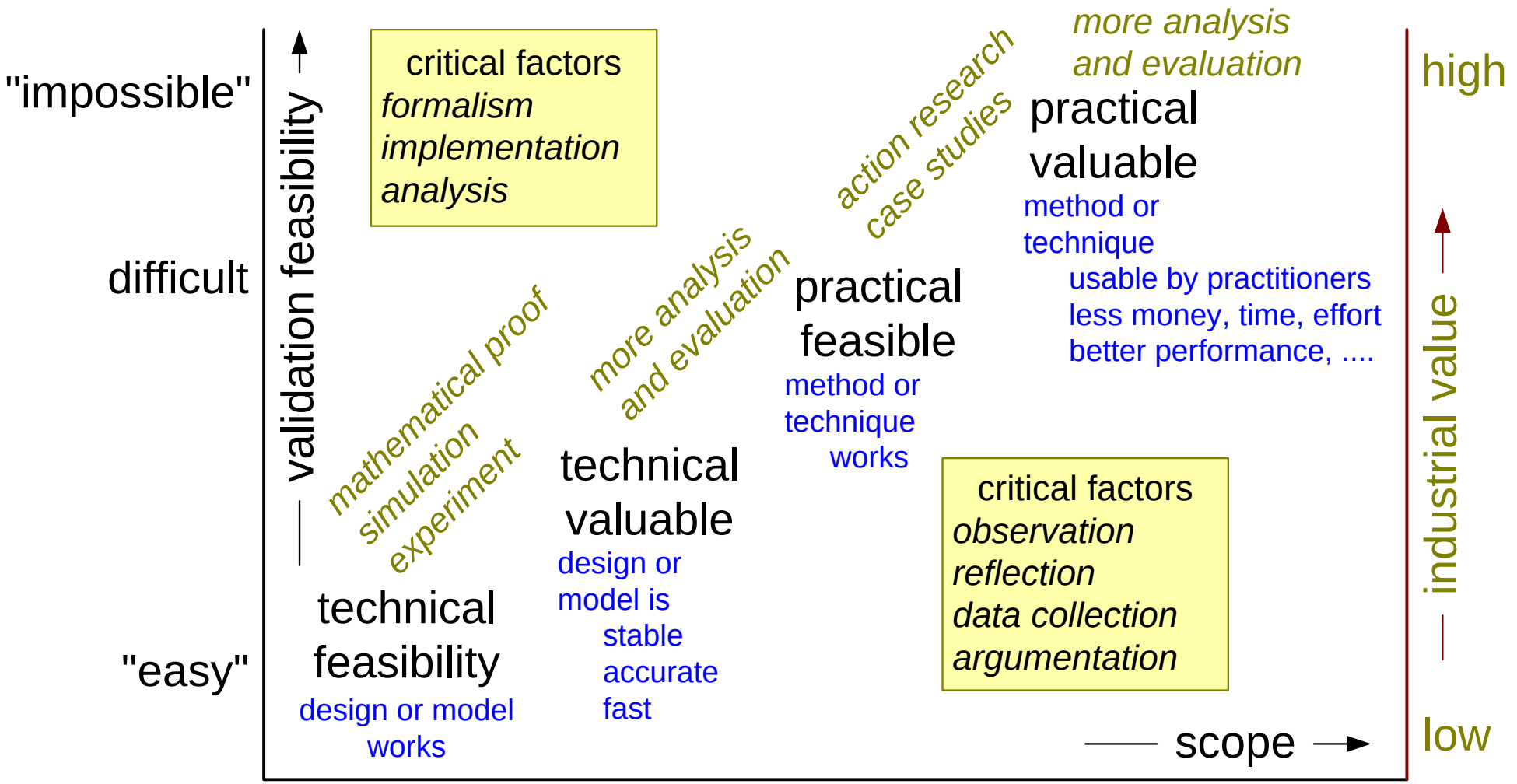
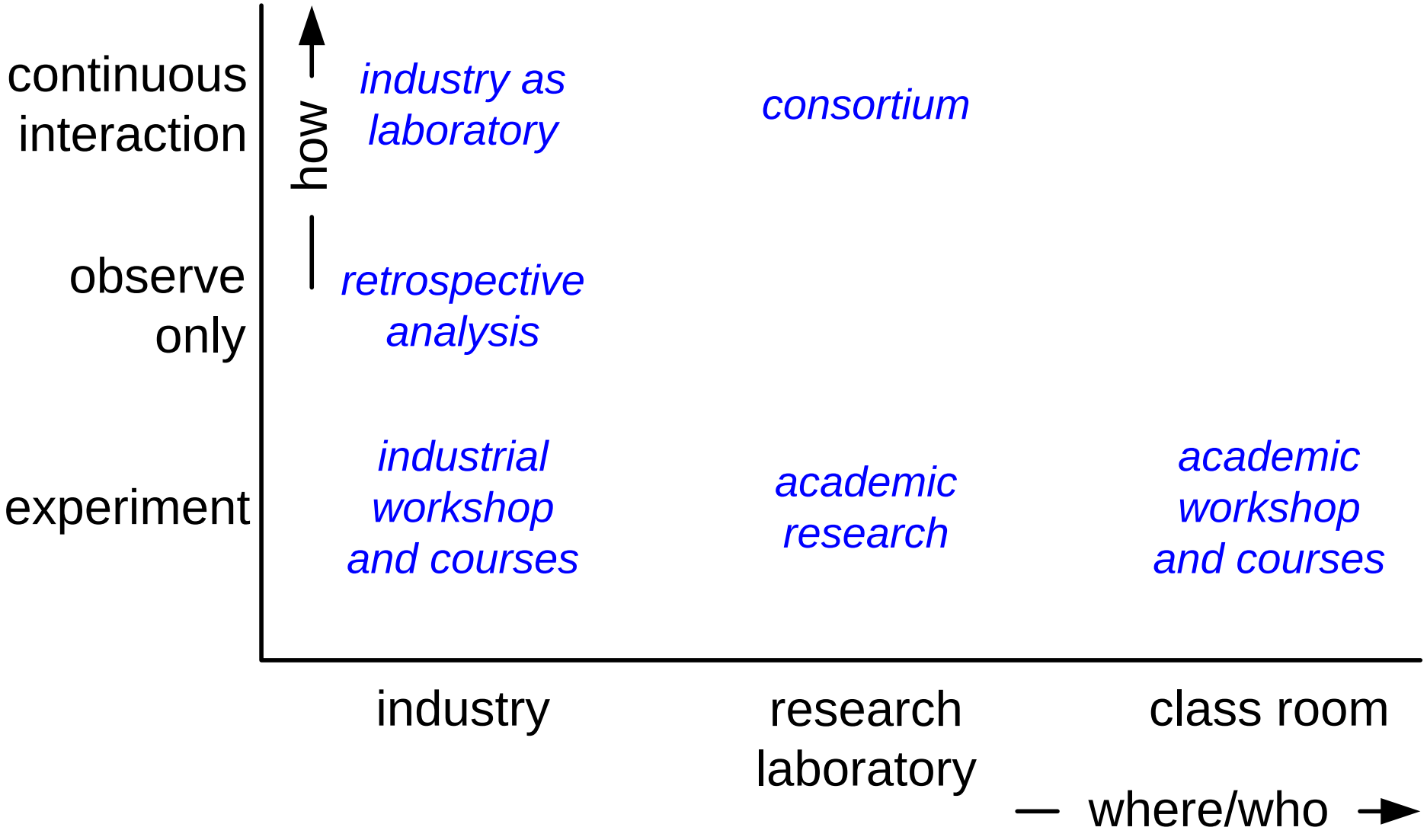
Systems Engineering Research

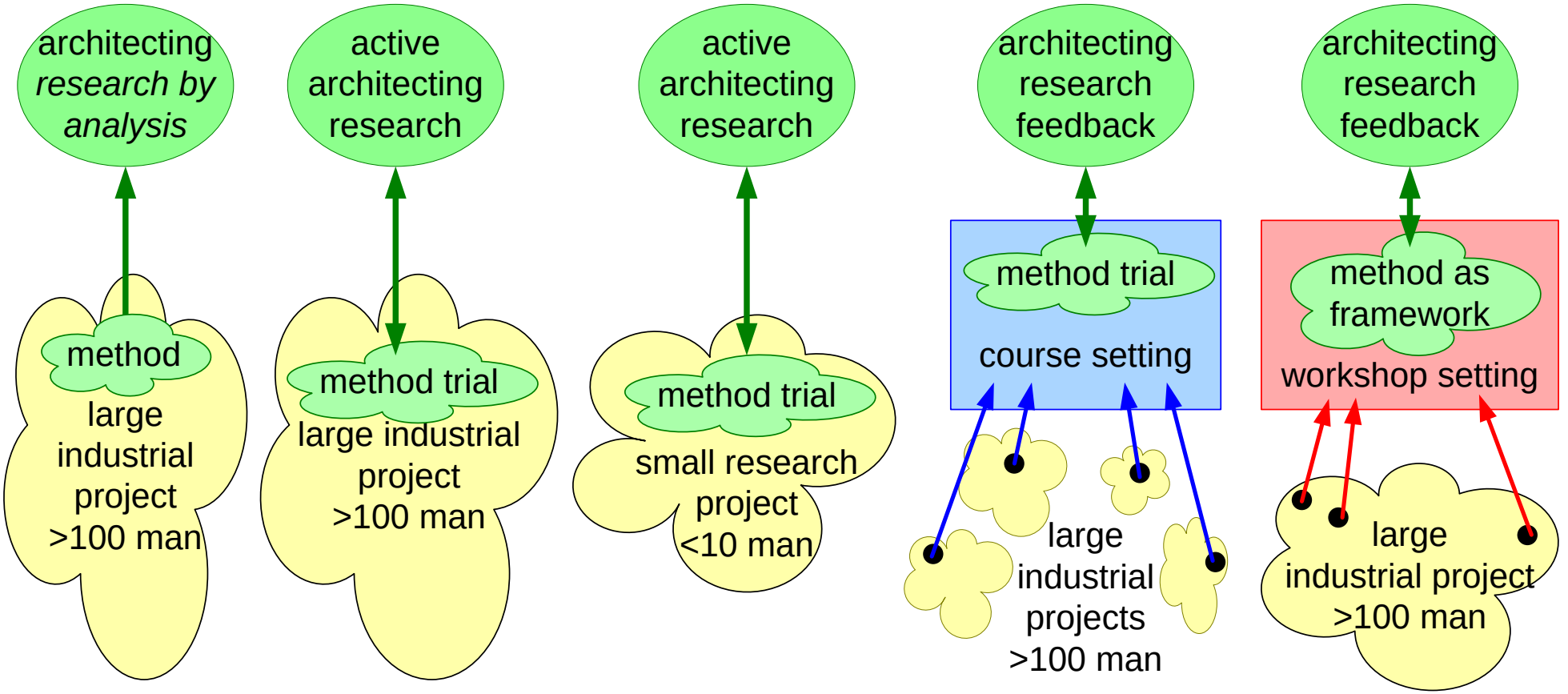
Scope versus Feasibility and Value



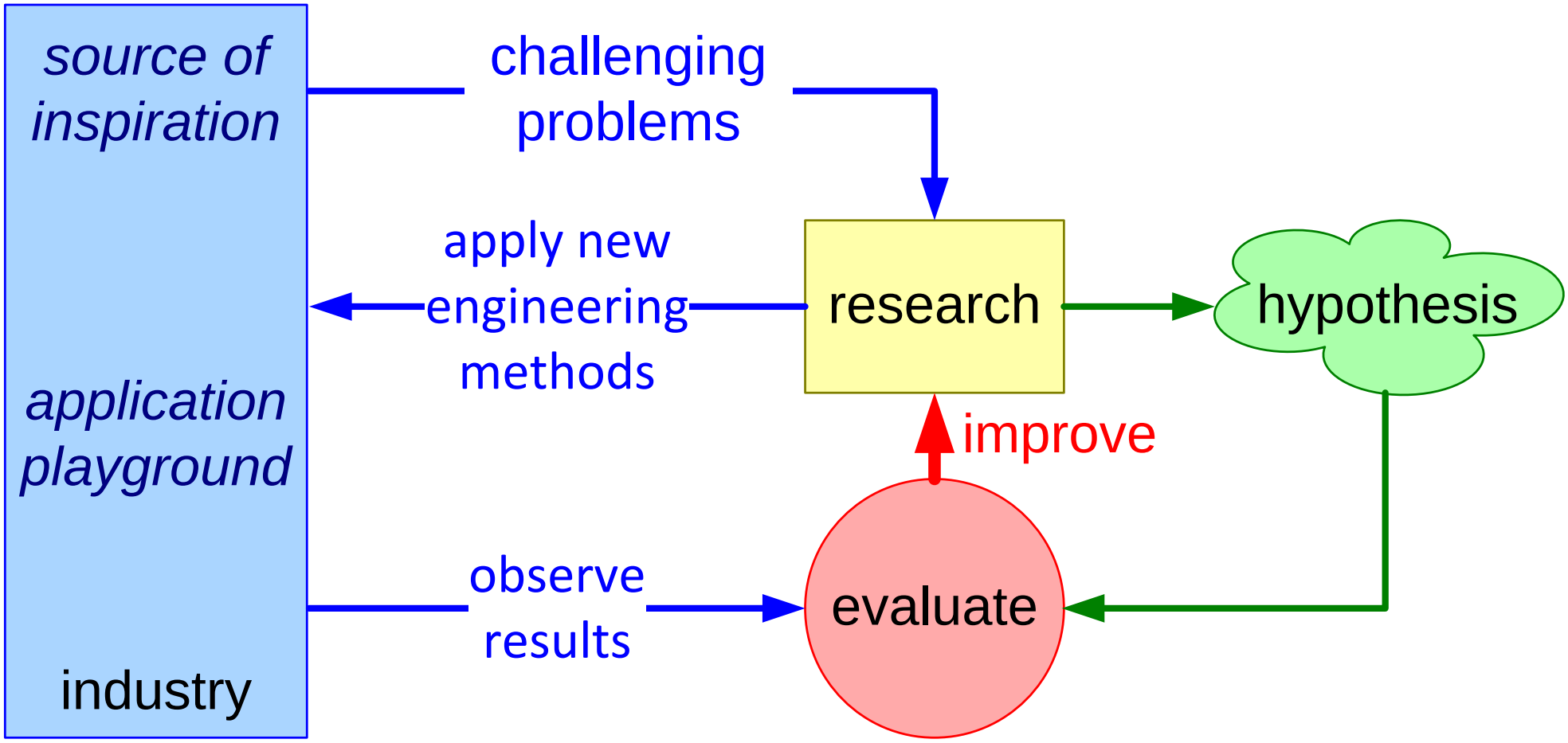
Different Research Methods

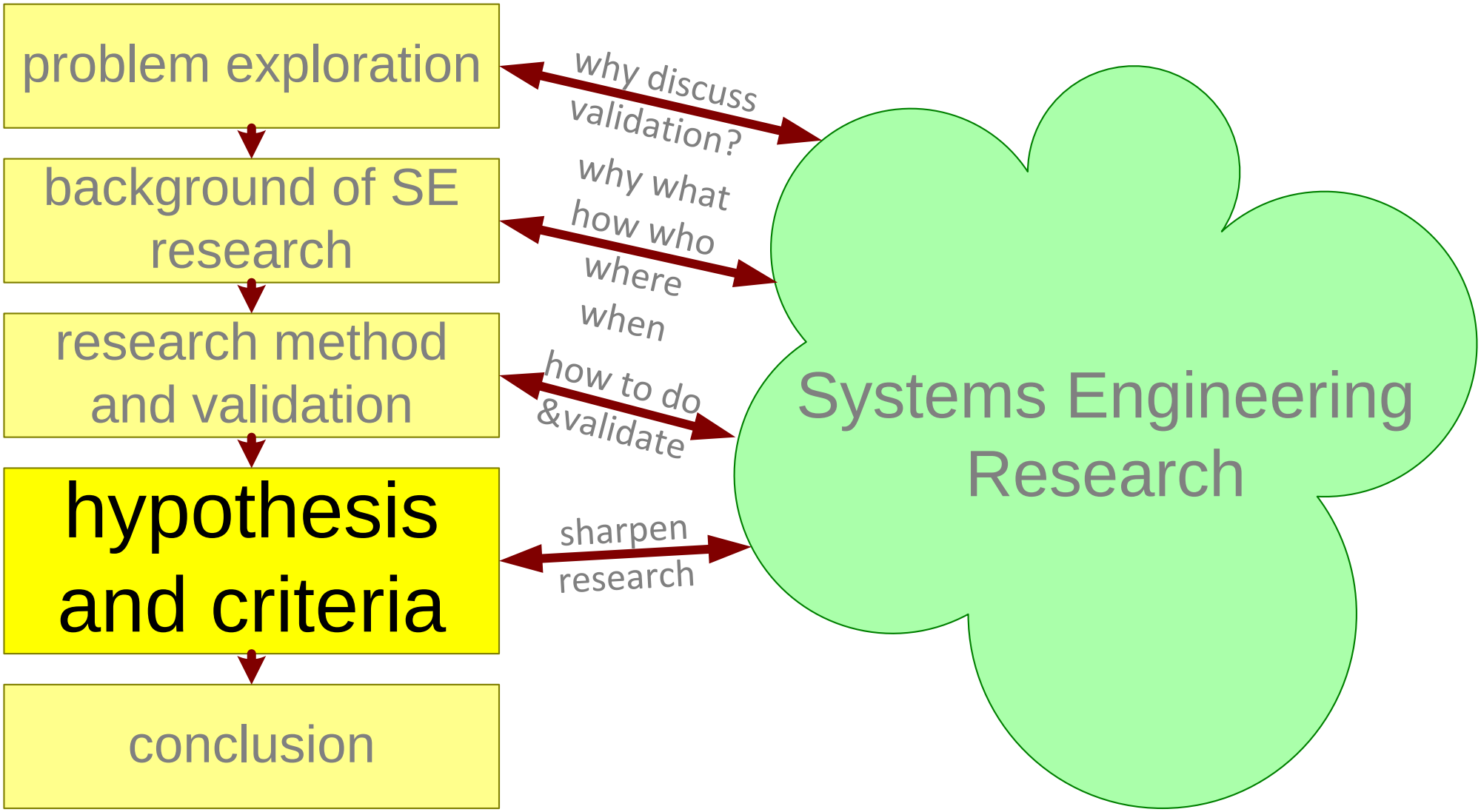


Different Research Methods (2)



Industry as Laboratory

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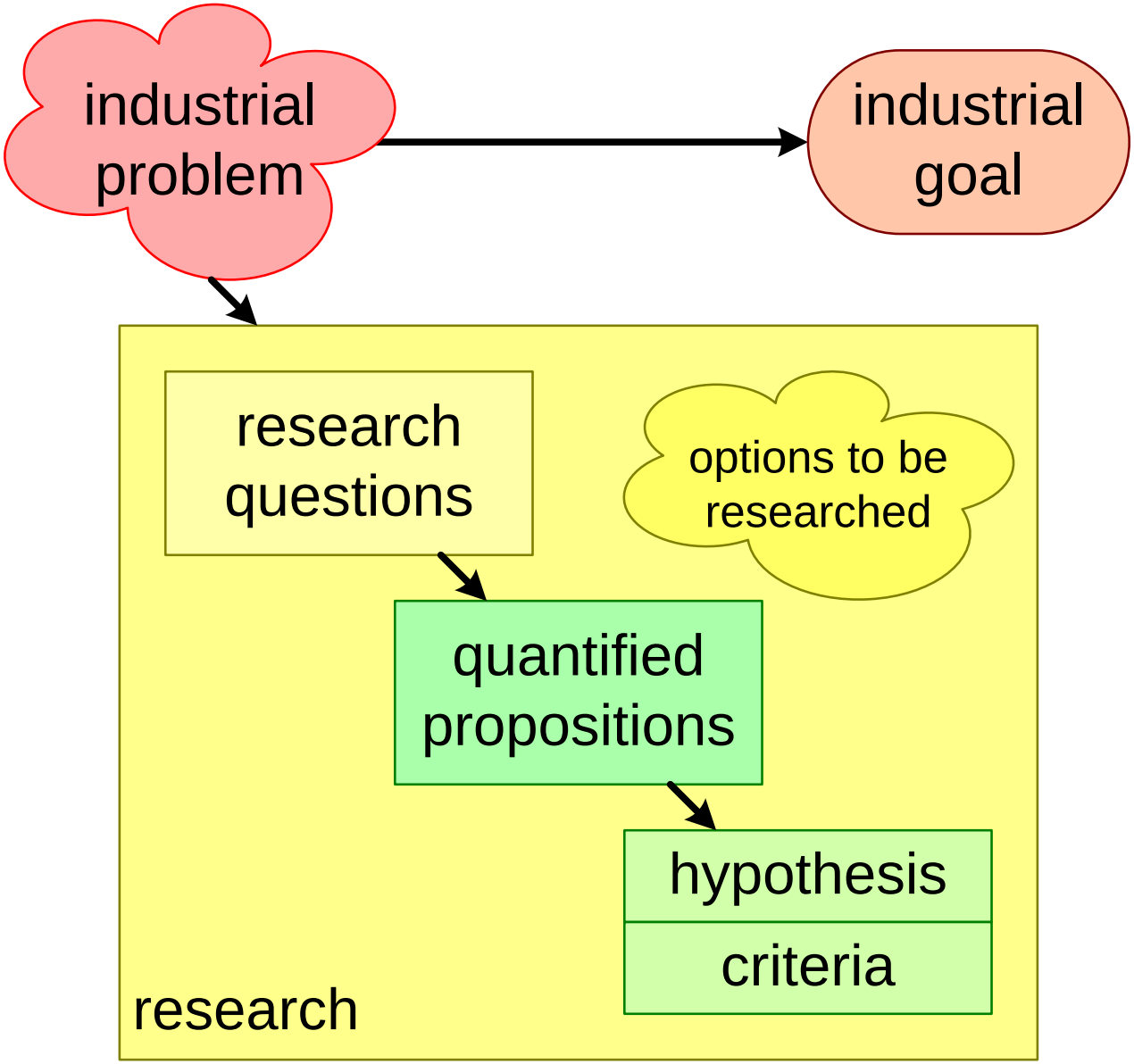
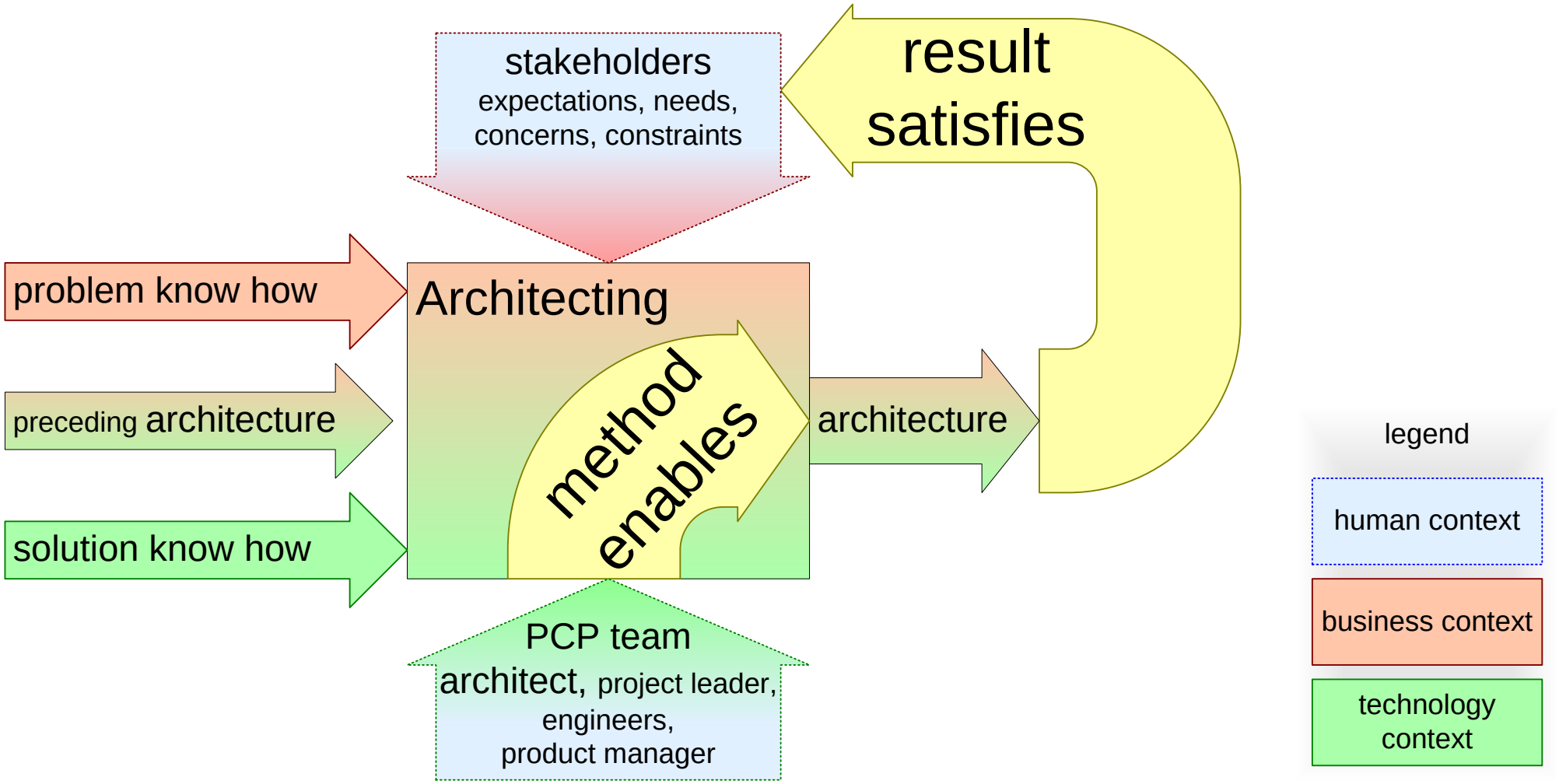
Systems Engineering Research

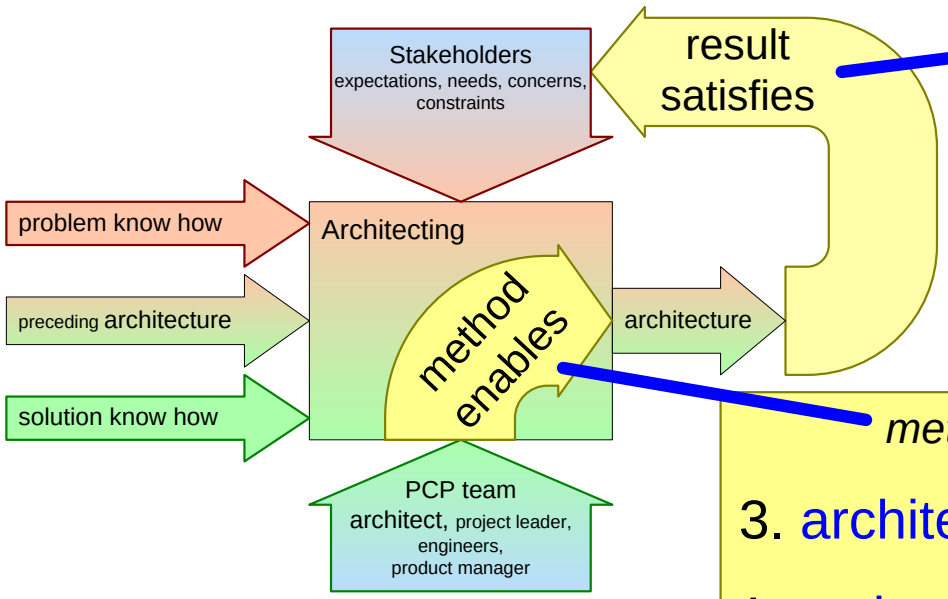
From Industrial Problem to Validated Research



Successful architecting and architecting method



From hypothesis to criteria

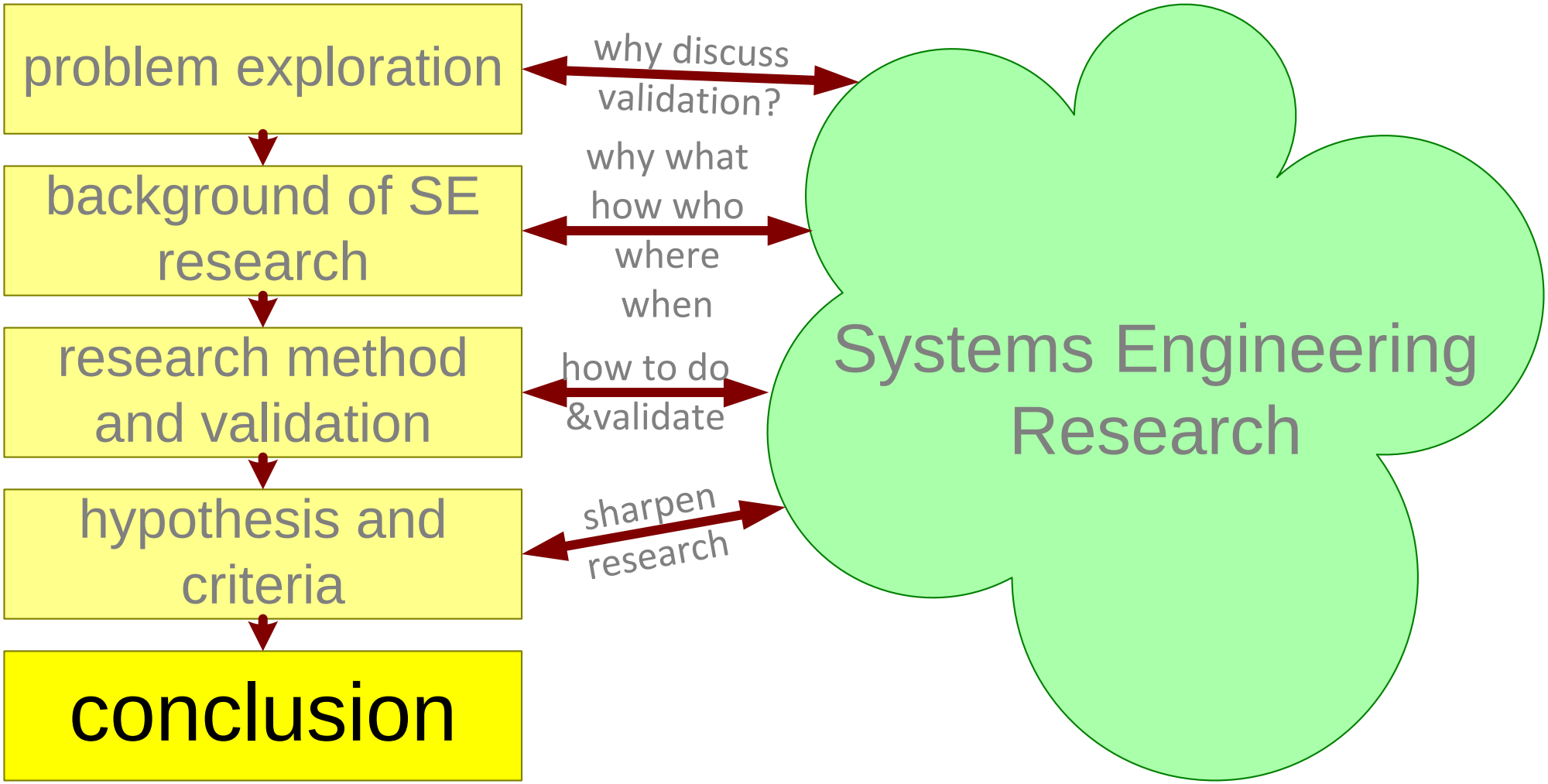


resulting architecture satisfies stakeholders

1. product is a commercial success
2. product family is sustainable commercially successful

method enables PCP team to create architecture

3. architects benefit from deploying submethods
4. project leaders, product managers and engineers are able to use the outcome of the submethods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Systems Engineering Research

The Final Result

research question, hypothesis, criteria, method

research positioning — *opening*

theory

casus (problem, goal, context)

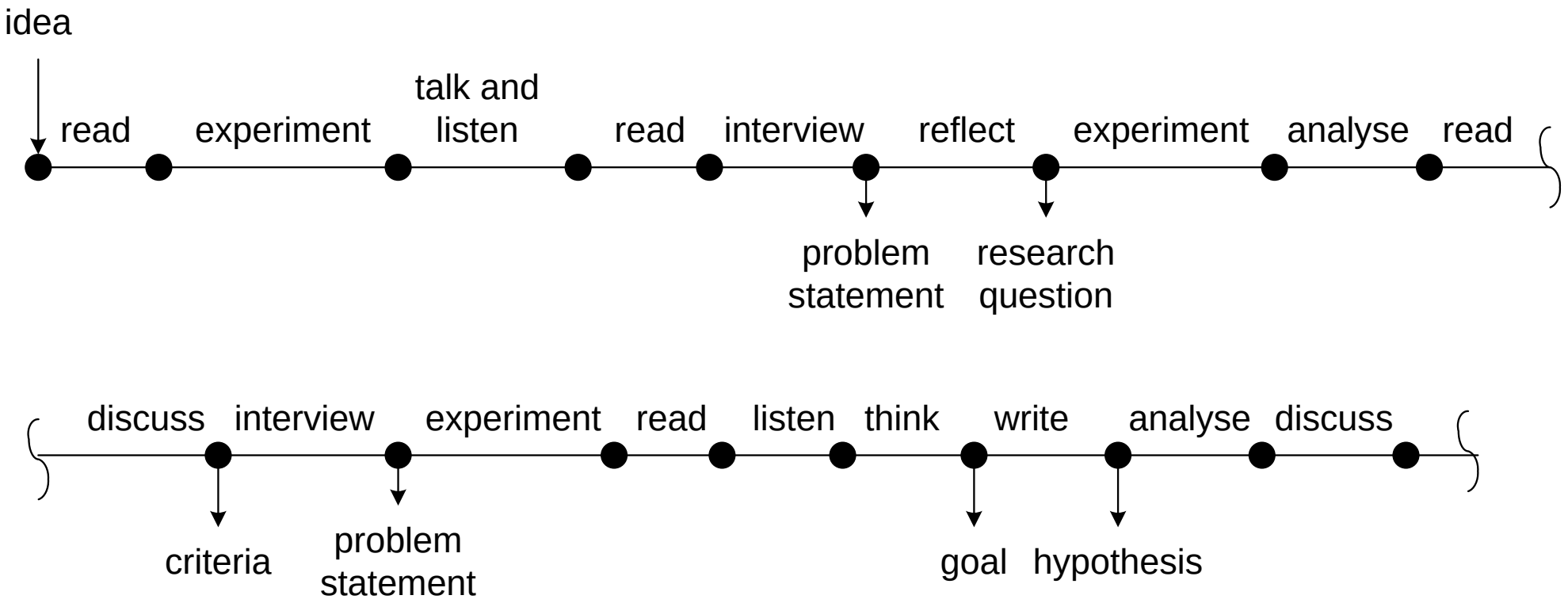
experiment

analysis — *core*

evaluation, validation

conclusion, recommendations — *closing*

and the Chaotic Route



et cetera et cetera

Recommendations

time-box research reflection, e.g. one day per half year

be sharp in industrial problem and goal,
research question, proposition and hypothesis

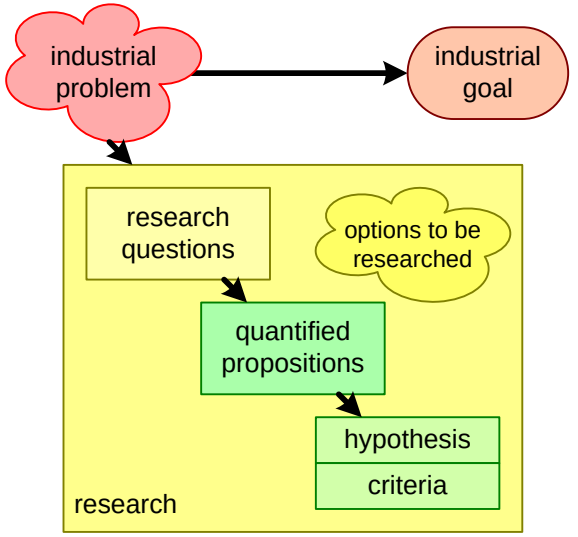
does your claim address the original needs?

does your validation address the claim?

be modest with claim

be critical in evaluation

test claim and evaluation
with others



Further Reading; chapters from PhD thesis:

- “Research in Systems Architecting”

  `http://www.gaudisite.nl/ArchitectingResearchMethodPaper.pdf`

- “Research Question and Hypothesis”

  `http://www.gaudisite.nl/CriterionsForArchitectingMethodsPaper.pdf`

- “Evaluation of the Architecting Method”

  `http://www.gaudisite.nl/ARevaluationPaper.pdf`

- “Reflection on Research Method to Study Architecting Methods”

  `http://www.gaudisite.nl/ReflectionOnResearchMethodPaper.pdf`

Further Reading; other related Gaudisite documents

- “A Multi-Disciplinary Research Approach, Illustrated by the Boderc Project”

  `http://www.gaudisite.nl/MultiDisciplinaryResearchApproachPaper.pdf`

- “Industry and Academia: Why Practioners and Researchers are Disconnected.”

  `http://www.gaudisite.nl/GapIndustryAcademicsPaper.pdf`

- “How to Characterize SW and HW to Facilitate Predictable Design?”

  `http://www.gaudisite.nl/PerformanceEngineeringPaper.pdf`

- “The Informal Nature of Systems Engineering”

  `http://www.gaudisite.nl/InformalNatureSystemsEngineeringSlides.pdf`

Systems Engineering Research; Examples of Flow and Methodology

by *Gerrit Muller* University of South-Eastern Norway-NISE
e-mail: gaudisite@gmail.com
www.gaudisite.nl

Abstract

Research in System Engineering requires a mixture of research methods. It is a challenge to capture the various aspects in a logical flow. The research methodology is also a significant challenge. This presentation shows examples of past research of visualizing the paper flow and the research methodology.

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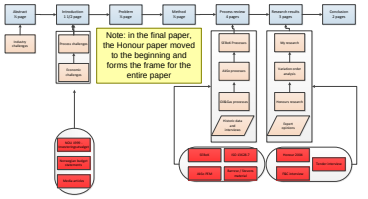
version: 0.3



Examples from Price Winning Paper

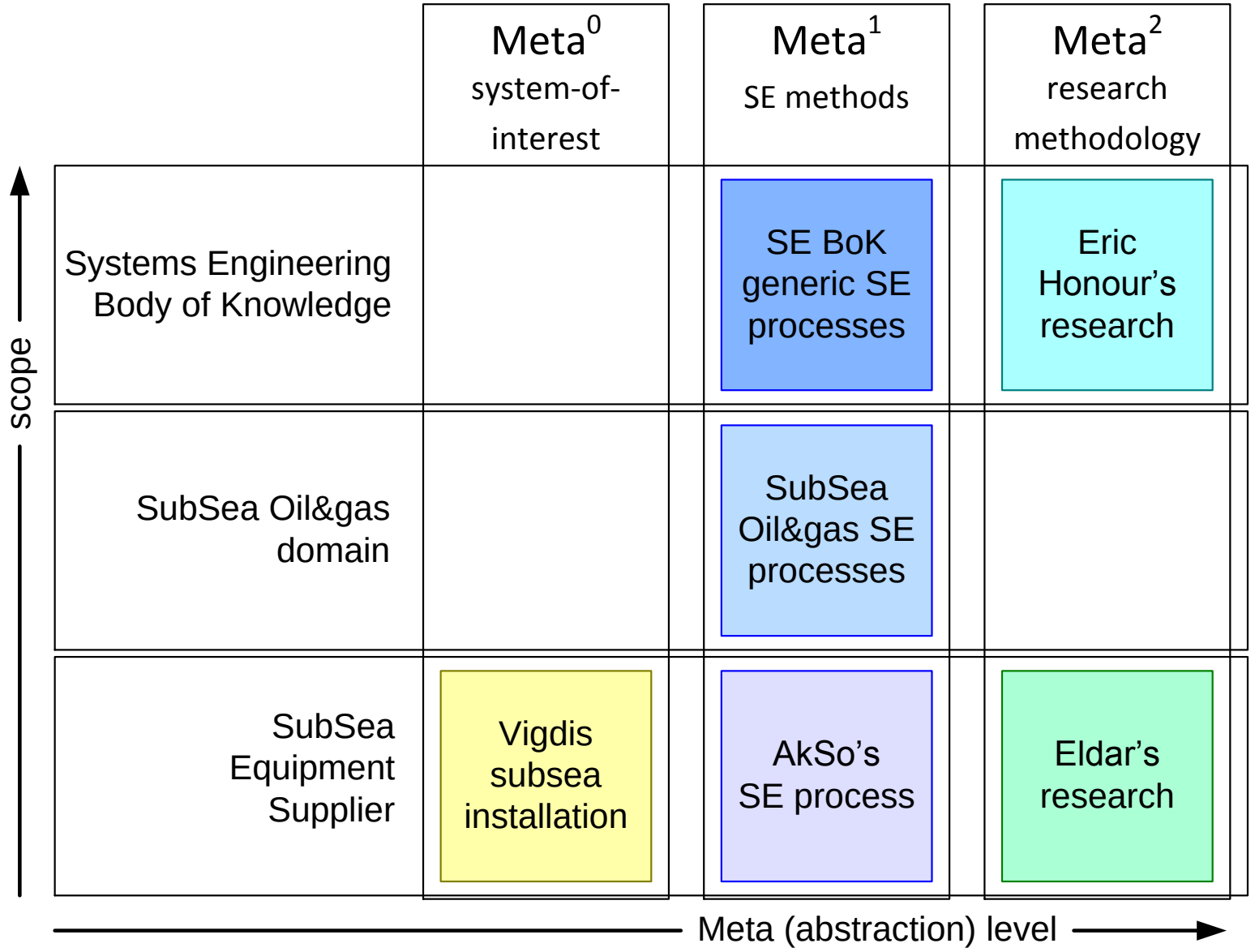
Eldar Tranøy won the **Best Student Paper Award** at INCOSE 2014 in Las Vegas with the paper

"Reduction of Late Design Changes Through Early Phase Need Analysis"

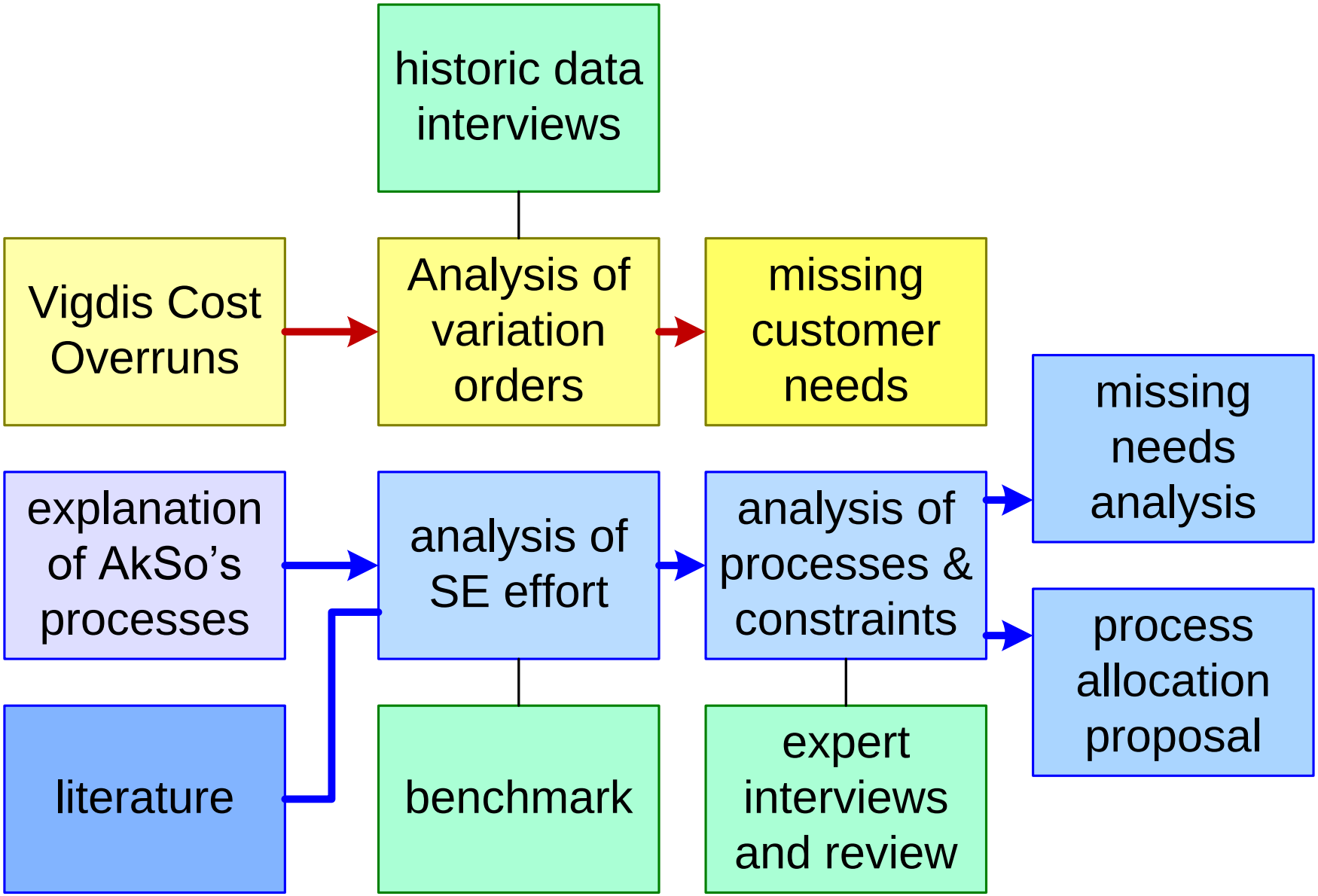
available at http://gaudisite.nl/INCOSE2014_Tran%C3%B8y_Muller_ReductionOfLateDesignChanges.pdf

The following slides show some of the attempts of finding the flow for this paper by Eldar Tranøy and the academic supervisor.

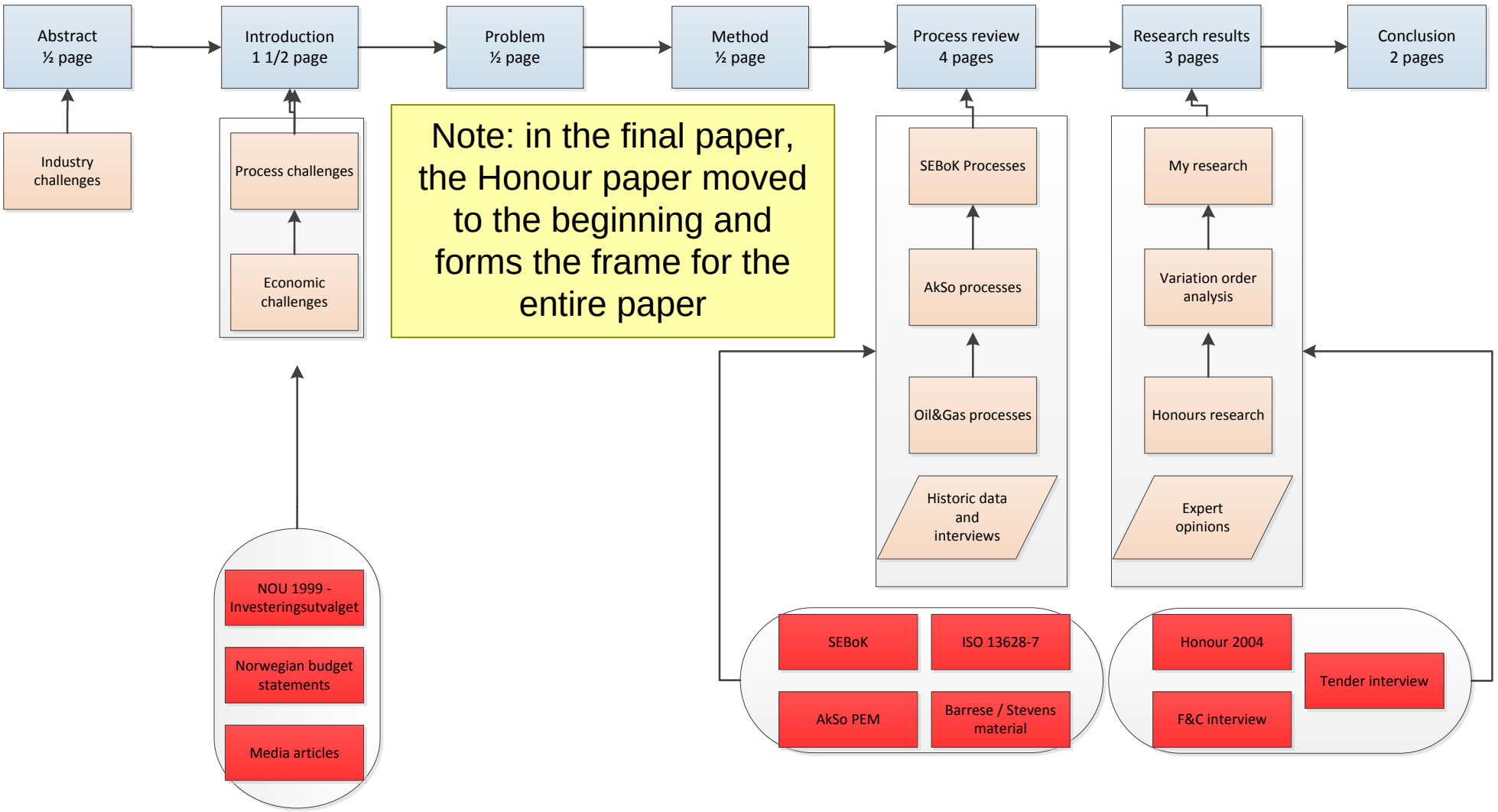
Meta Levels and Scopes by Supervisor



Paper Flow Proposed by Supervisor



The Book Plan that Eldar Made at the Start



Example Research Methodology

Linda Lønmo wrote the paper

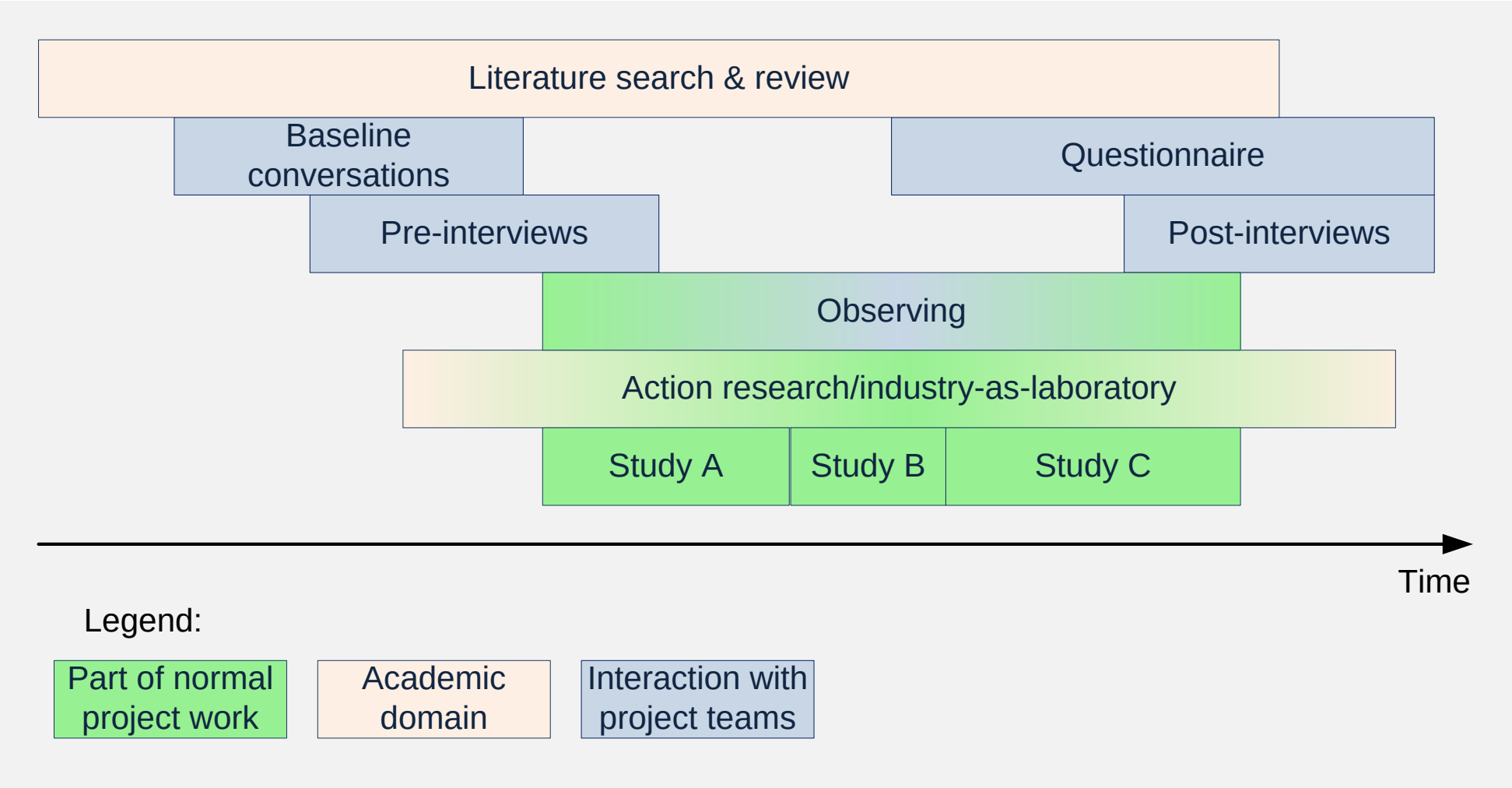
"Concept Selection - Applying Pugh Matrices in the Subsea Processing Domain"

for INCOSE 2014 in Las Vegas

available at http://gaudisite.nl/
INCOSE2014_Lonmo_Muller_ConceptSelection.pdf

The following slide shows the visualization of the research methodology by Linda Lønmo.

Example Research Methodology by Linda



from: "Concept Selection - Applying Pugh Matrices in the Subsea Processing Domain" by Linda Lønmo
INCOSE 2014 in Las Vegas http://gaudisite.nl/INCOSE2014_Lonmo_Muller_ConceptSelection.pdf

Example Research Method

Anders Viken wrote the paper

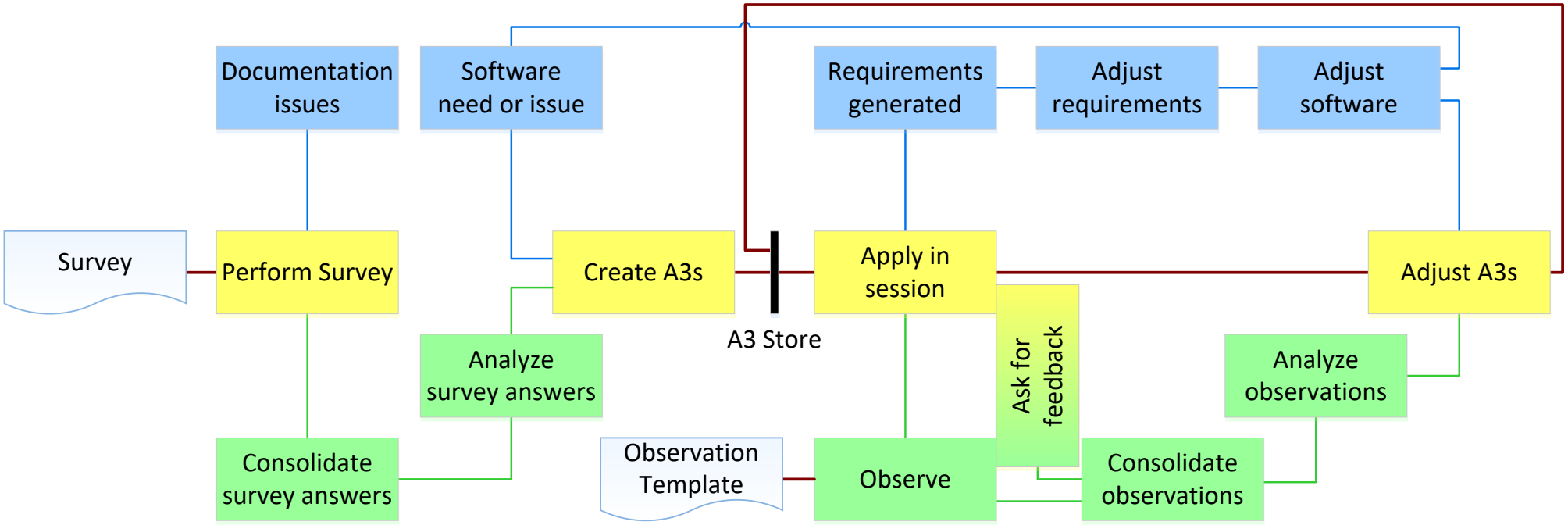
"Creating and Applying A3 Architecture Overviews: A Case Study in Software Development"

for INCOSE 2018 in Washington, DC, USA

available at http://gaudisite.nl/INCOSE2018_Viken_MullerA3.pdf

The following slide shows the visualization of the research methodology by Anders Viken.

Example Research Method by Anders



Example Book Plan that Else Dalby made

Industry Evaluation of a SW Test Framework Implemented at Unit level

- Title + authors - ¼ page
- Abstract - ¼ page
- Introduction - 1 page
  - Introduction to Company
  - Problem statement -> testing is costly and time consuming
  - Introduction to method -> framework with automated testing
  - Introduction to the case -> JUnit test framework
  - Short how the original problem will be solved
  - Short how the method serves the goal
- Current situation and problems - 2 page
  - Explain deeper the reasons why the department is interested in framework + automated testing (1 page)
  - How testing of SW is done in the department today (1 page)
- Research methodology - 1 ¼ page
  - Action research
  - Industry-as-laboratory
  - How I did my research => experiment + interviews + literature
  - How reliable and objective are the results of my research?
- Literature review - 1 page
  - Automated testing framework domain – what has been done?
- Main body - 6 pages
  - JUnit testing framework (*1 ¼ page*)
    - How and what to test with JUnit
    - How and what to test with EasyMock extension
  - Use of a test framework in the department *(3 ¾ pages)*
    - How testing of SW in the department is performed in the experiment *(3/4 page)*
    - Observations and findings *(1 ½ page)*
      - Summary of data collected in the experiment and during interviews
    - Cost and effort *(1 ½ page)*
      - Analysis of data collected – Is the case "JUnit implementation" a success? Best practices, limitations, benefits, drawbacks. (How well is the problem solved?)
  - Use of test frameworks in industry *(1 pages)*
    - Results – Evaluation of the SE method based on analysis of the data collected from the case. (How well does the method fit and serve its goal?)
- Conclusions - 1 ½ pages
  - Repeat: mention that the JUnit test framework can be recommended to the department with some restrictions
  - Repeat and summary from results how well the SE method fits and serves the goal of reducing cost and time of testing
  - Repeat and summary from results about limitations, benefits and drawbacks to the method
  - Reflection (*1/2 page*)
    - Lessons learned
    - Mention of how the research methodology worked out
- Future research - 1/2 page
  - Research to be done next is to find the error reduction rate with use of a test framework versus manual testing
  - Long term research was limited due to time constraints ,therefore it was hard to find data about how much money we can save with automated testing and how much resources the automated test frameworks will cost us to maintain
  - Experiment with implementation of JUnit in more than one unit was limited due to effort and time constraint
- References - 1 page

legend

case
system-of-interest

Body of Knowledge
systems engineering method

research method

Else Dalby's Book plan of
her master project in 2013

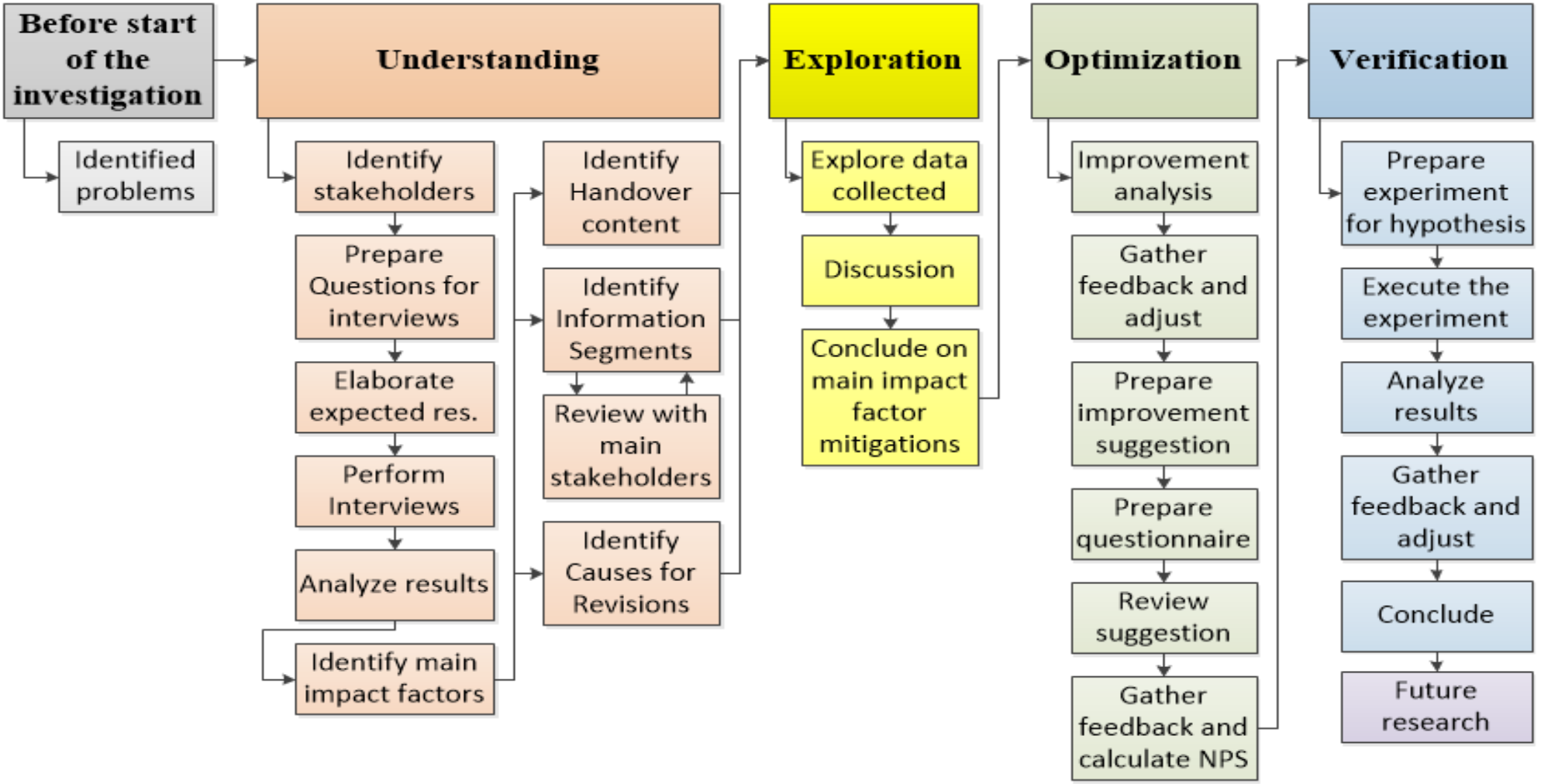
Example Research Design and Verification

Erik Thygesen won the **Best Student Paper Award** at INCOSE 2019 in Orlando with the paper

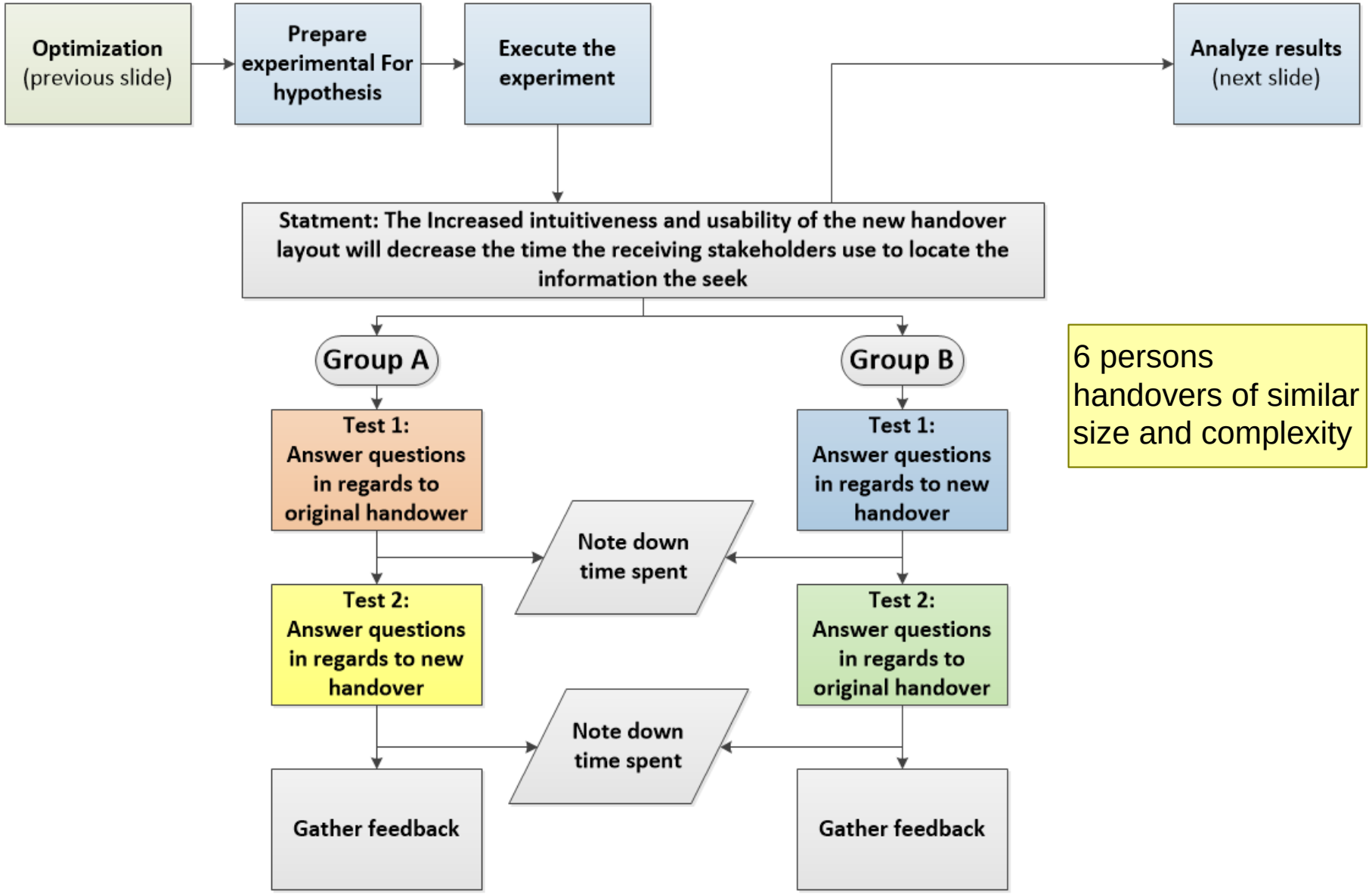
“Improving the information transfer between engineering and installation; case study at AS Nymo”

available at https://gaudisite.nl/
INCOSE2019_ThygesenEtAl_InformationTransferToInstallation.pdf

Example Research Design Erik Thygesen



Example Research Verification Erik Thygesen



6 persons handovers of similar size and complexity