Systems Engineering Project Product Introduction

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

Abstract

A course in Systems Engineering that can be taught in a few hours. It uses interaction with the participants to link SE principles and methods to the domain of the participants.

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version: 0.1

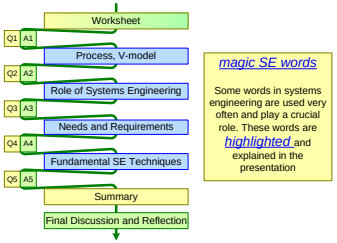
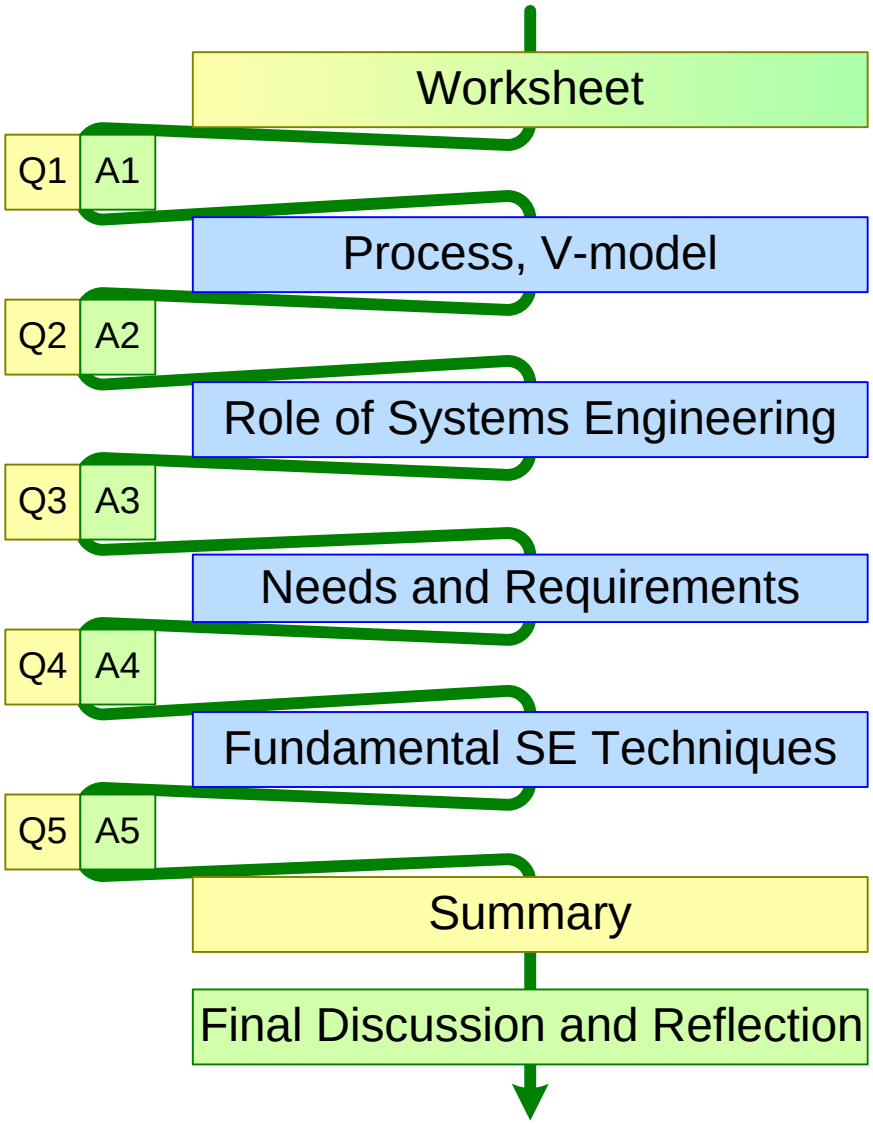


Figure Of Contents™



magic SE words

Some words in systems engineering are used very often and play a crucial role. These words are *highlighted* and explained in the presentation

Worksheet

electronic version of the worksheet: https://gaudisite.nl/SEPPIworksheet.xlsx

1	What Project/Product do you work on? Who is your external customer? If product, what project will first use it, and hence what external customer?	
2	In what phase is your project?	
3	Who are your stakeholders?	
4	What are your external customer's key drivers? What are your system's key performance parameters?	
5	What are the main functional and performance challenges for your system design?	

Question 1; Opening

1	What Project/Product do you work on? Who is the your external customer? If product, what project will first use it, and hence what external customer?	
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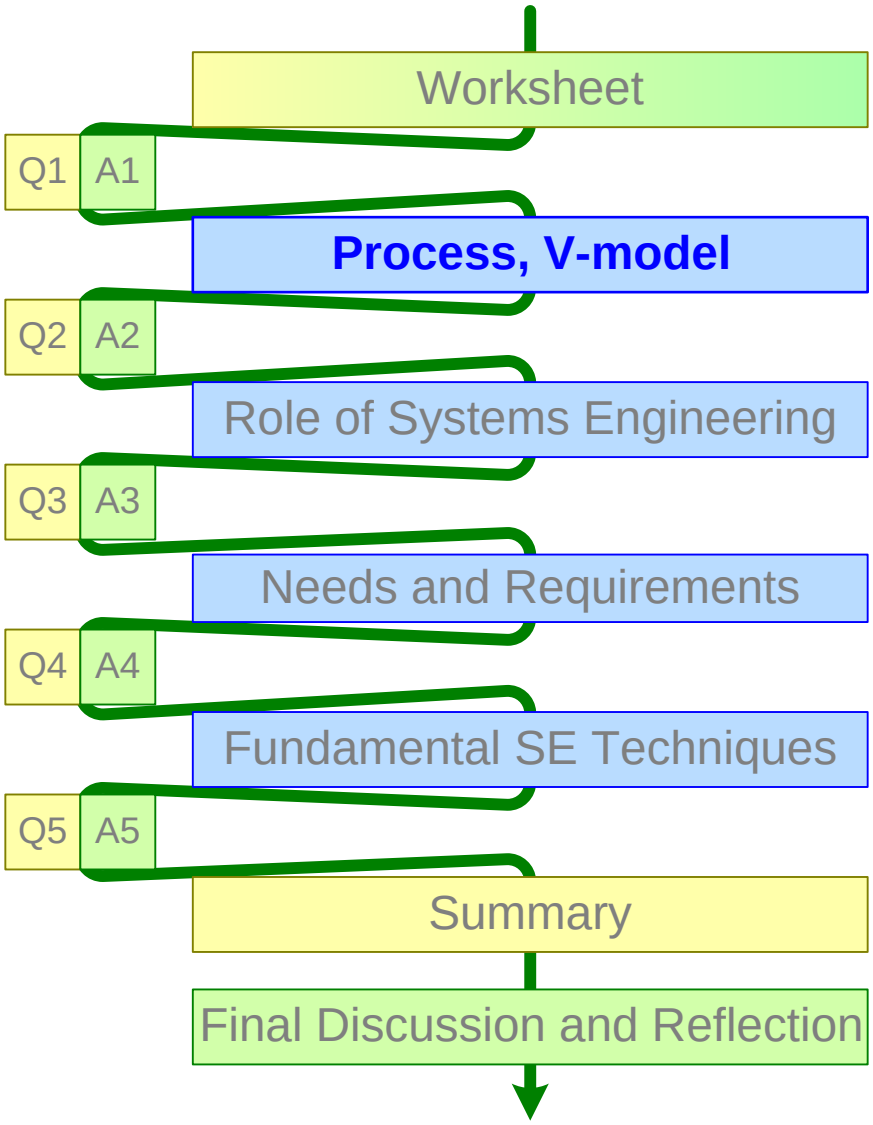
Systems Engineering Process, V-model



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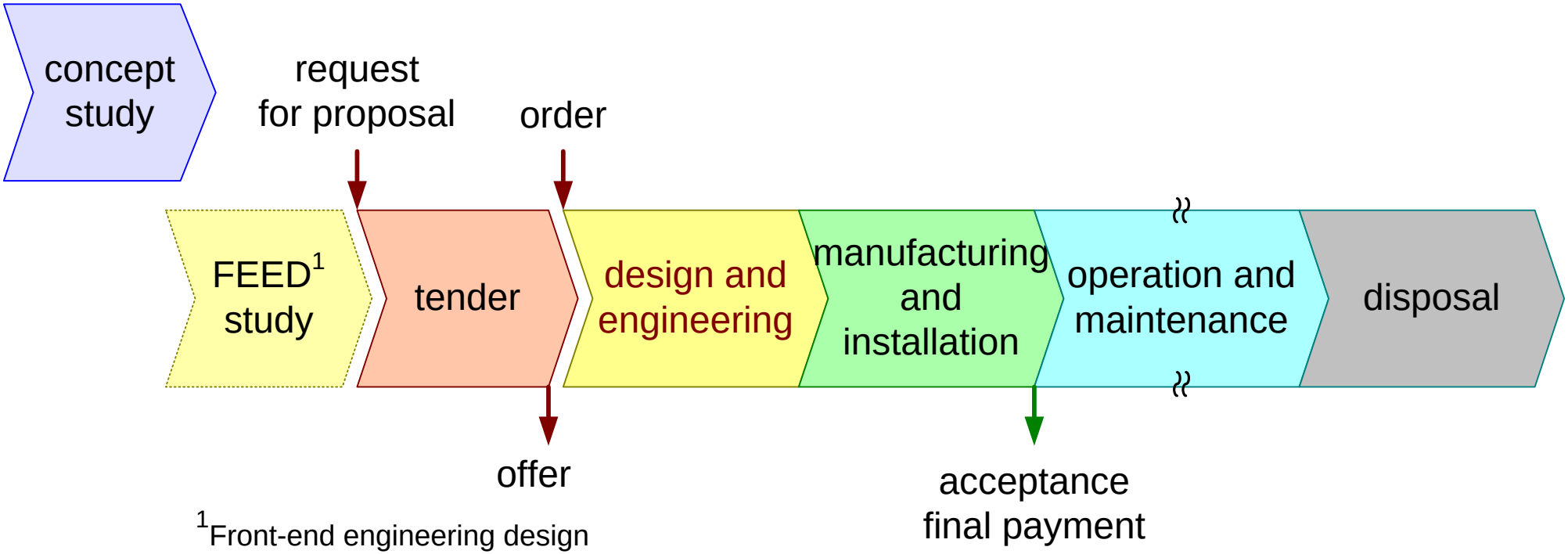
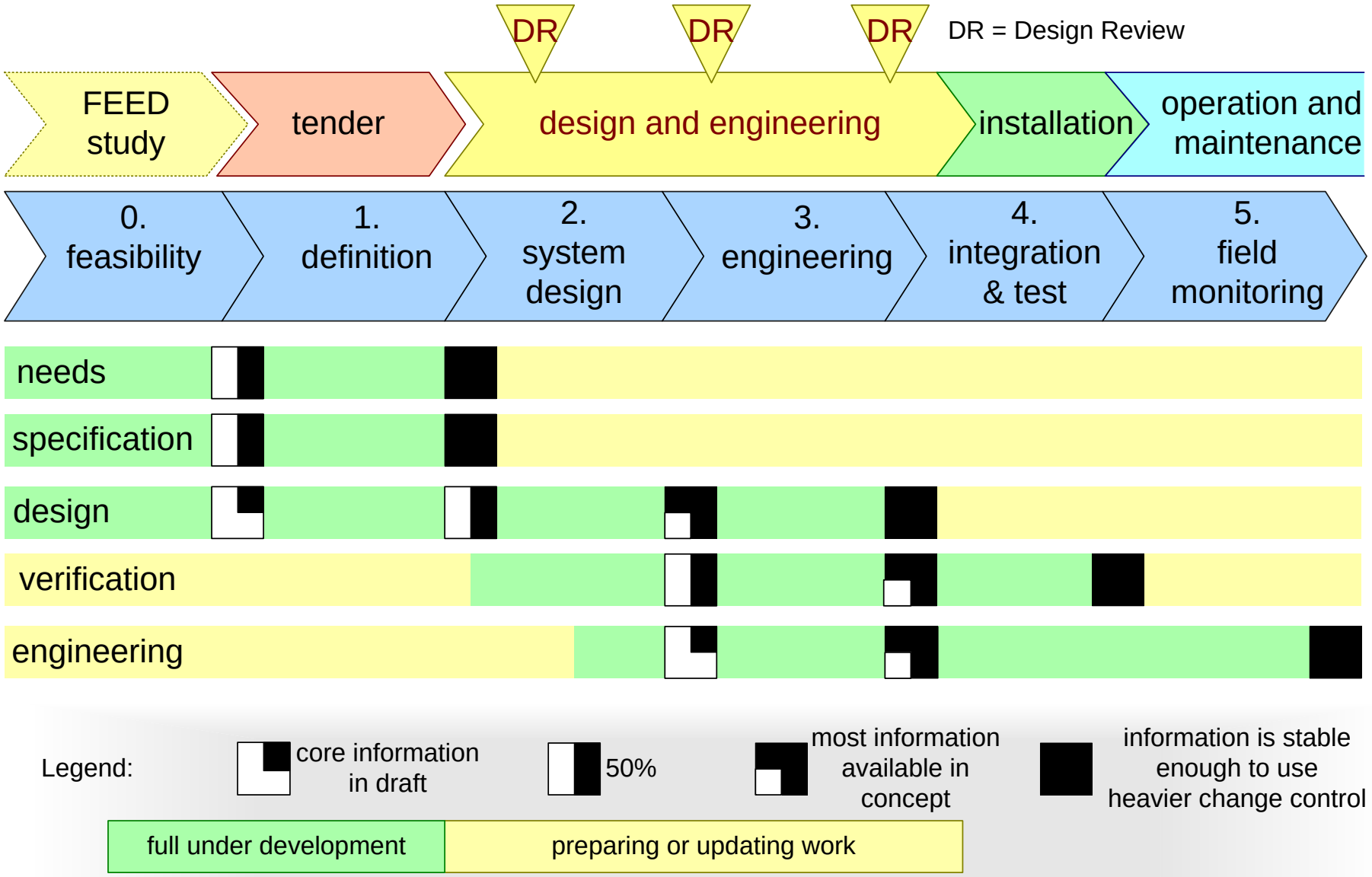
Project Life Cycle

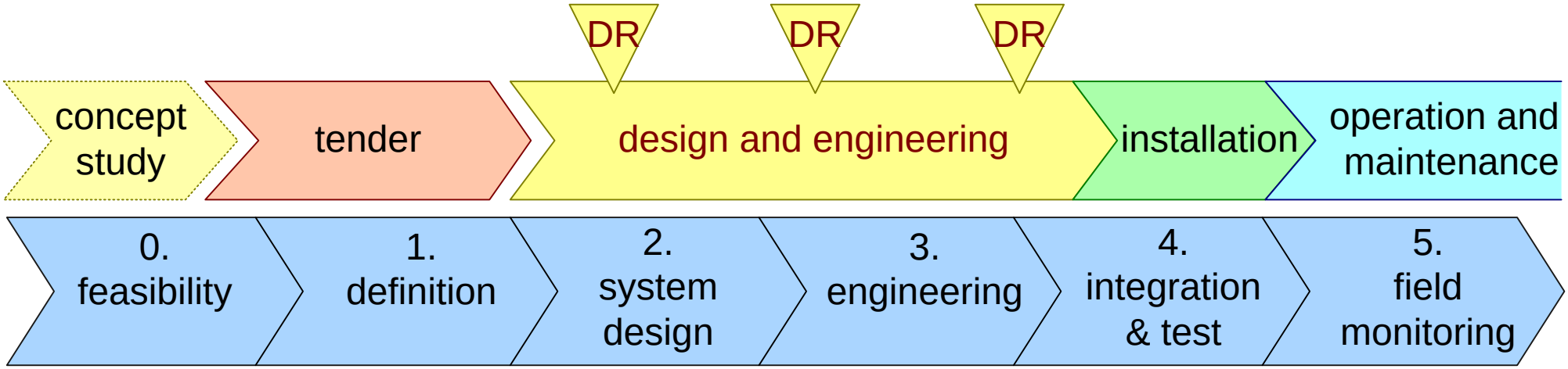


Phased Project Approach

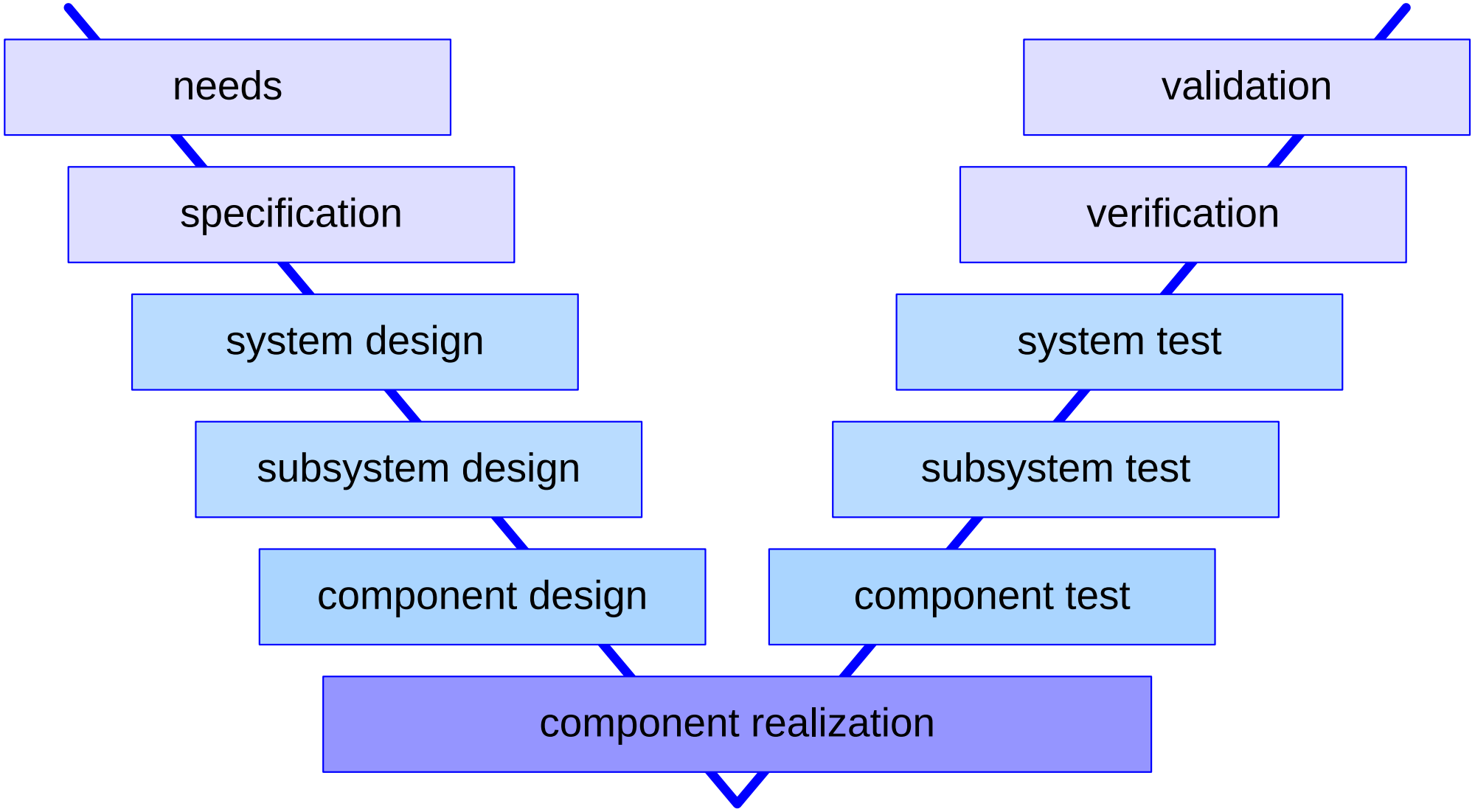


Magic Words

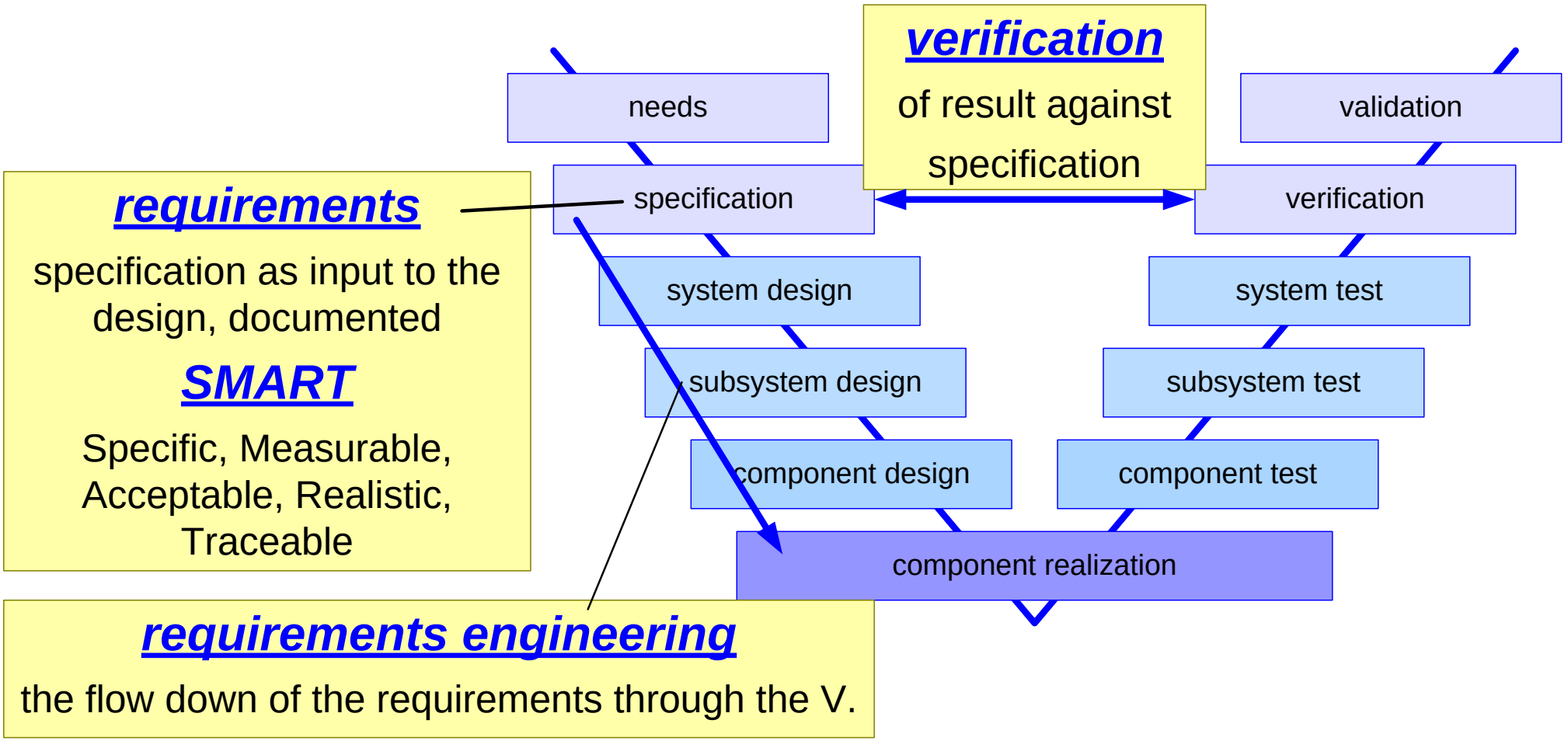
define ***objectives***, ***analyze***, and ***mitigate risks***



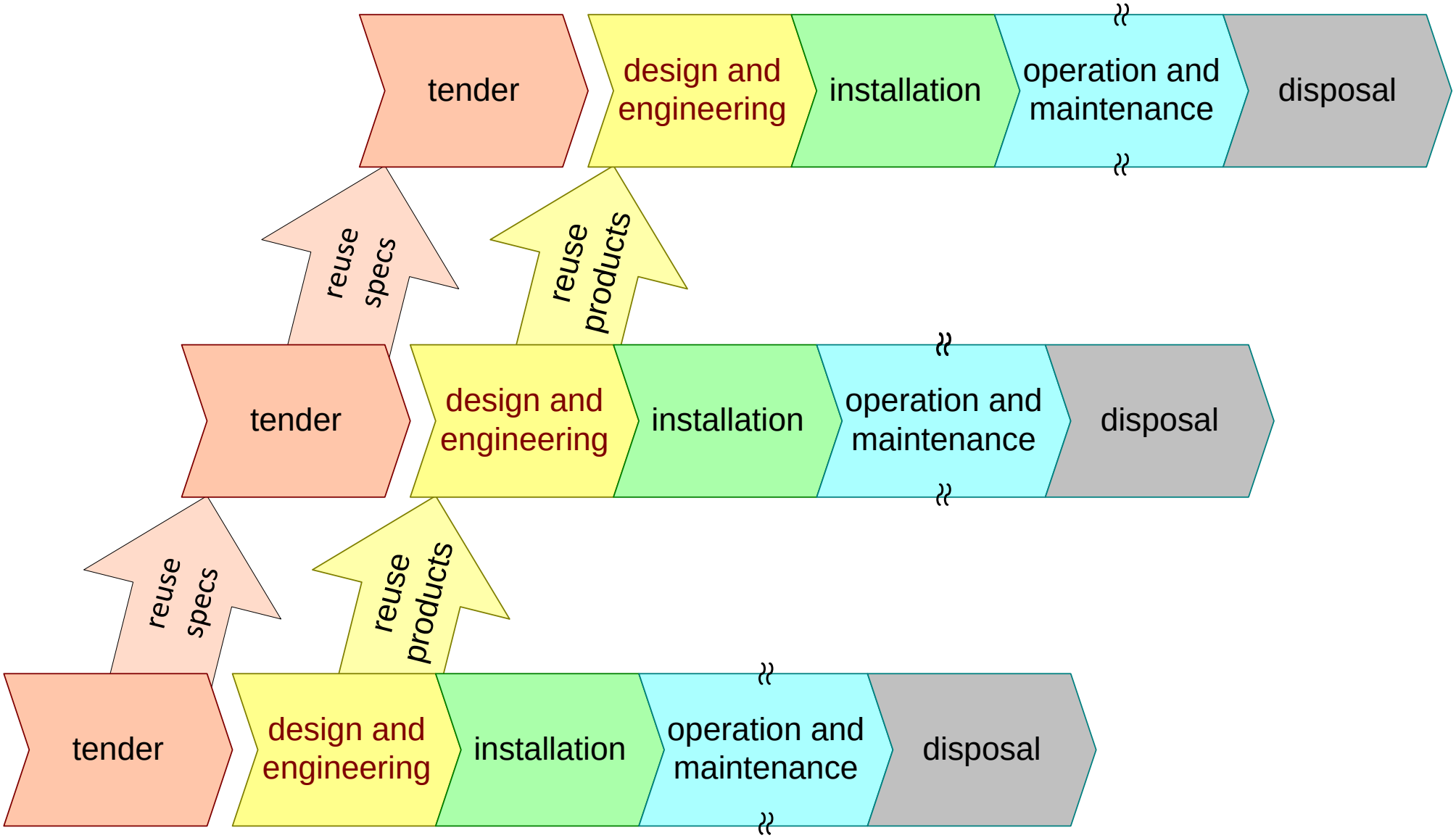
V-Model


needs
specification
system design
subsystem design
component design
component realization
component test
subsystem test
system test
verification
validation

More Magic Words



Reuse and Products



Question 2; Project Status

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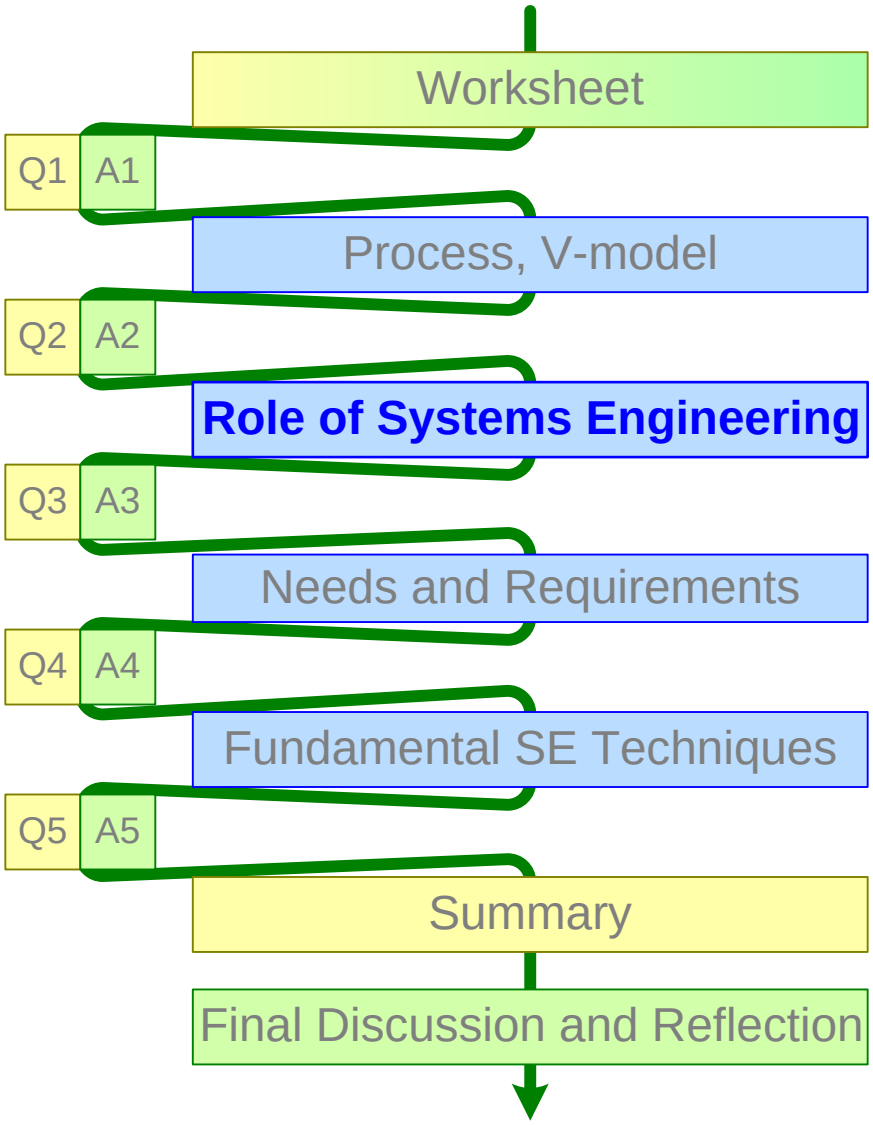
The Role of Systems Engineering



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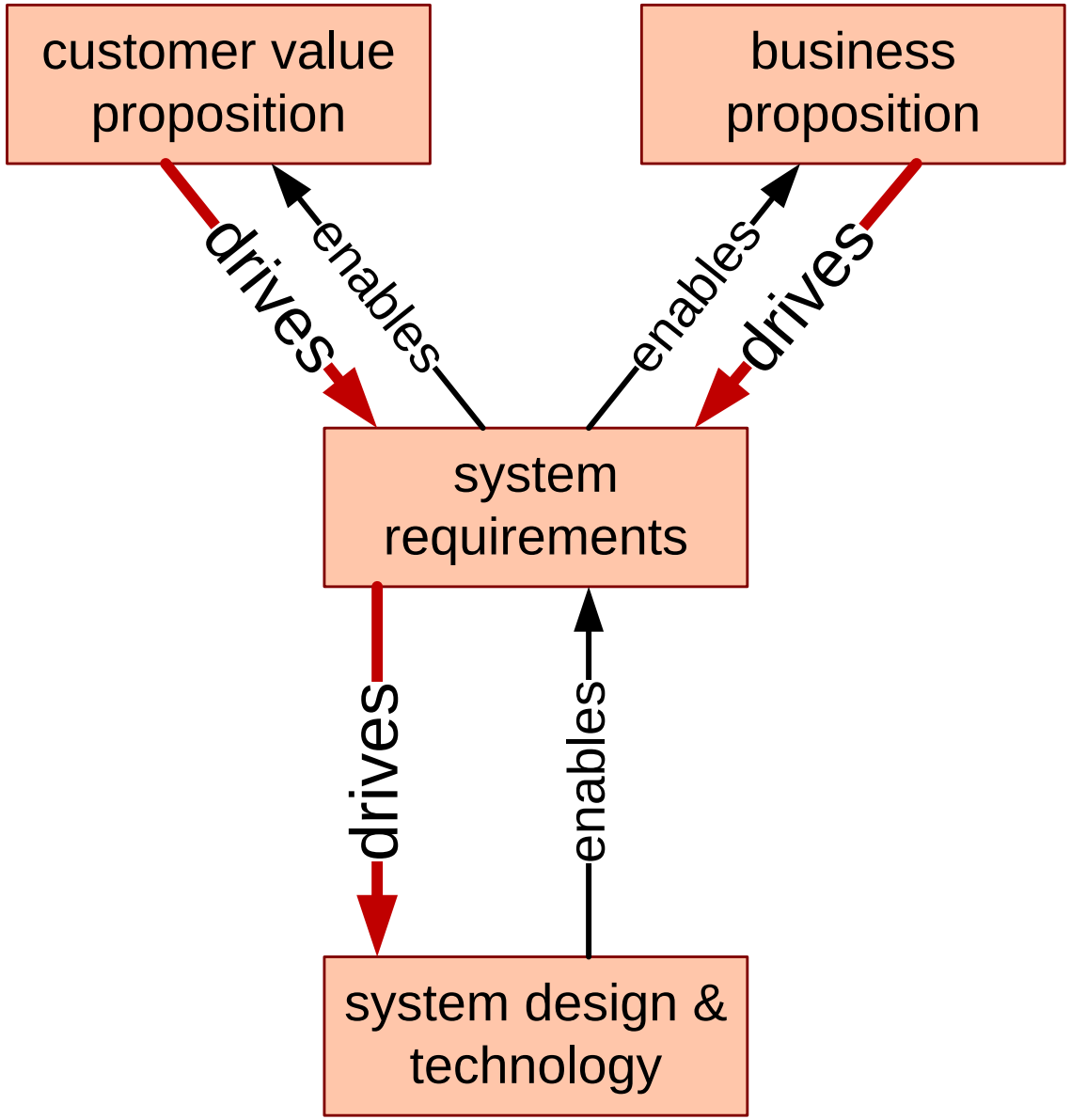
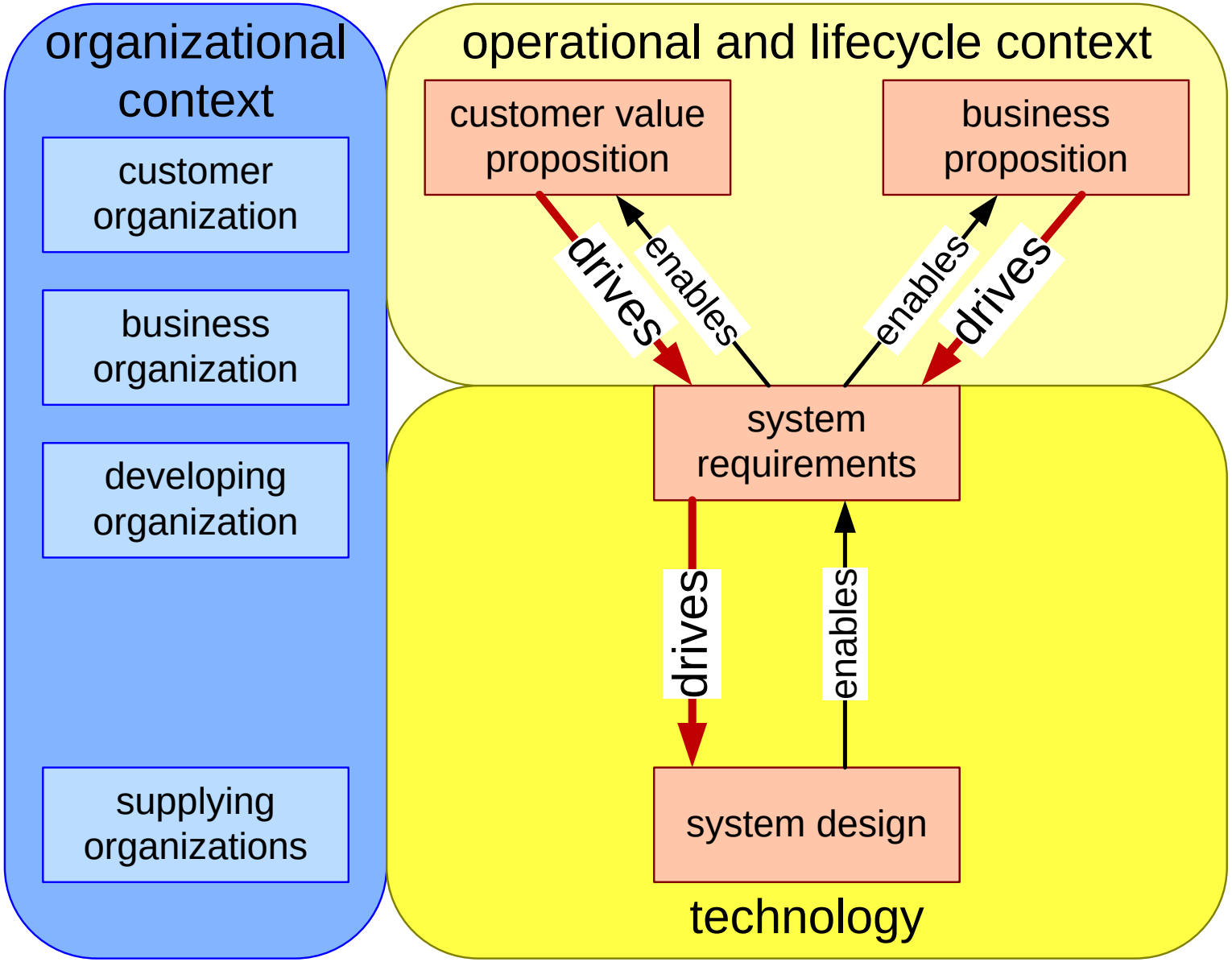
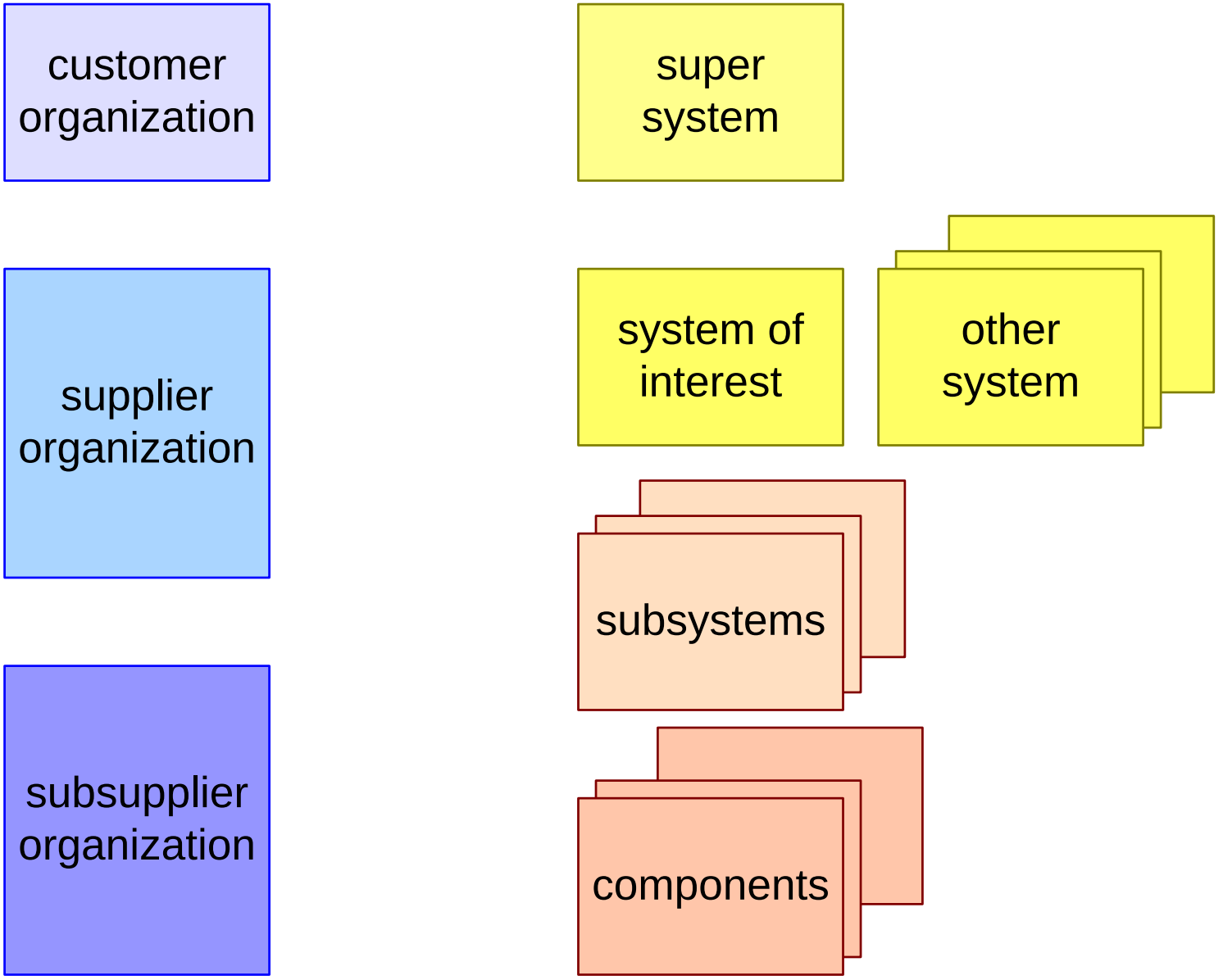
Systems Engineering Top View



Systems Engineering Field



Value Network



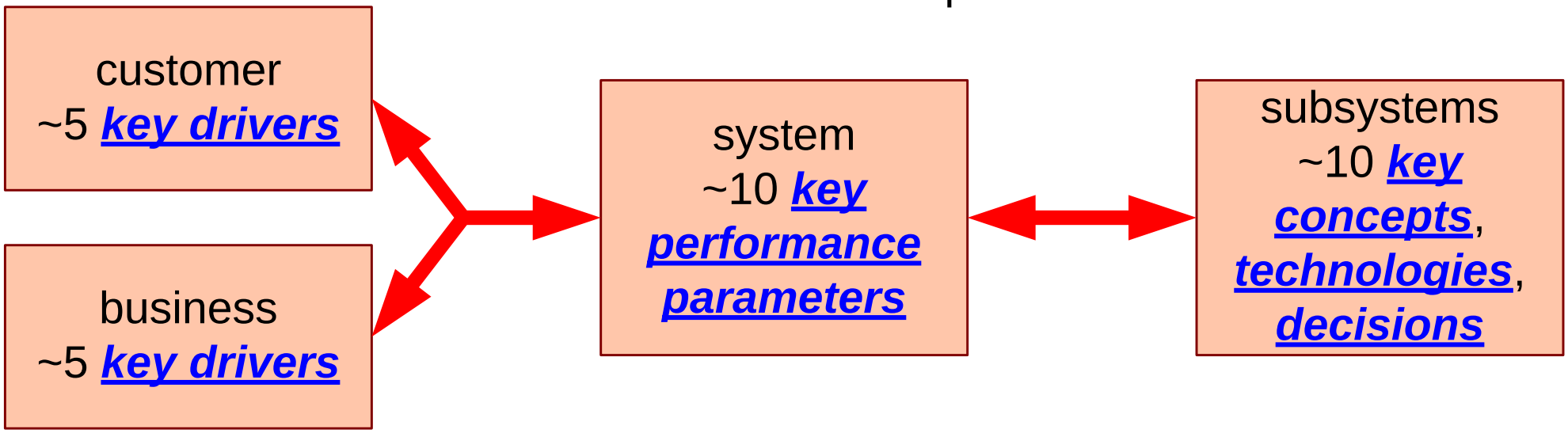
Main Responsibilities Systems Engineering

Systems Engineering: ***Fitness-For-Purpose***

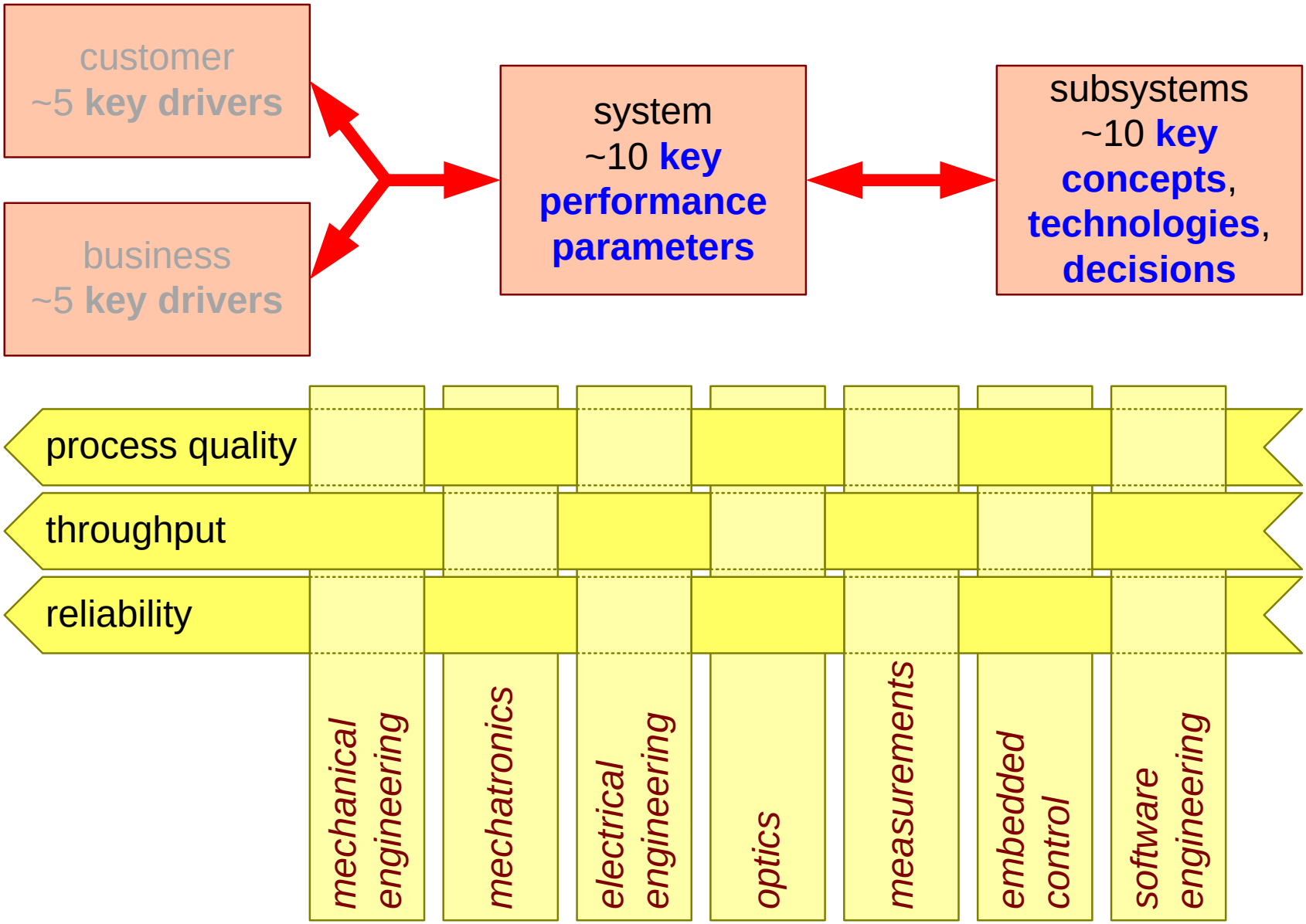
Achieving customer and business key drivers

via key performance parameters of system

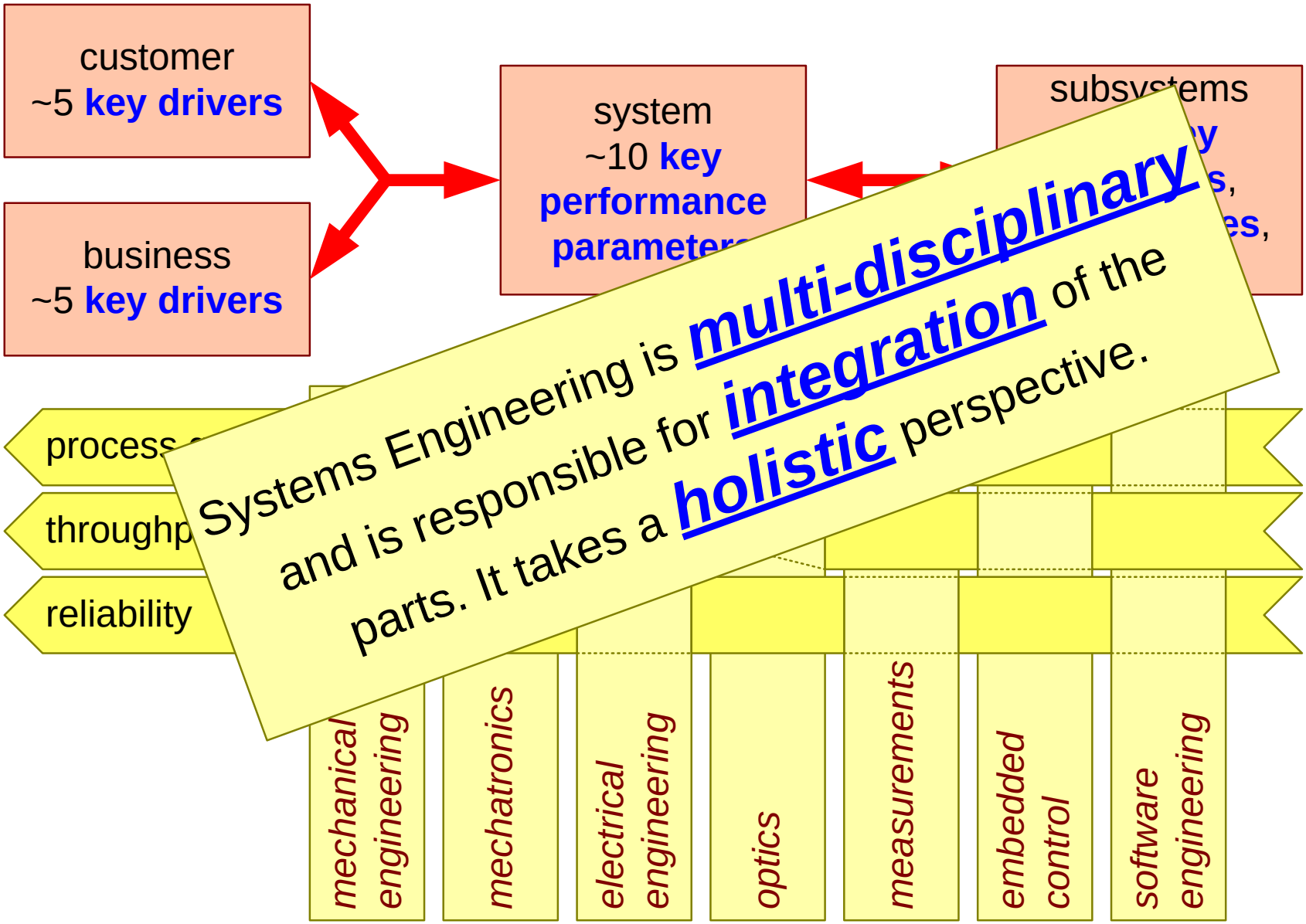
based on technical expertise



Multi-Disciplinary Design



More Magic Words



Systems Engineering and Engineering

are reponsible for development of

the ***supply chain***

stakeholders

everyone with a stake in the system, e.g.

decision makers,managers, sales, service, purchasing, engineers, operators, cleaners, regulation, standards, quality assurance, …

Stakeholders have

needs and ***concerns***

Question 3; Stakeholders

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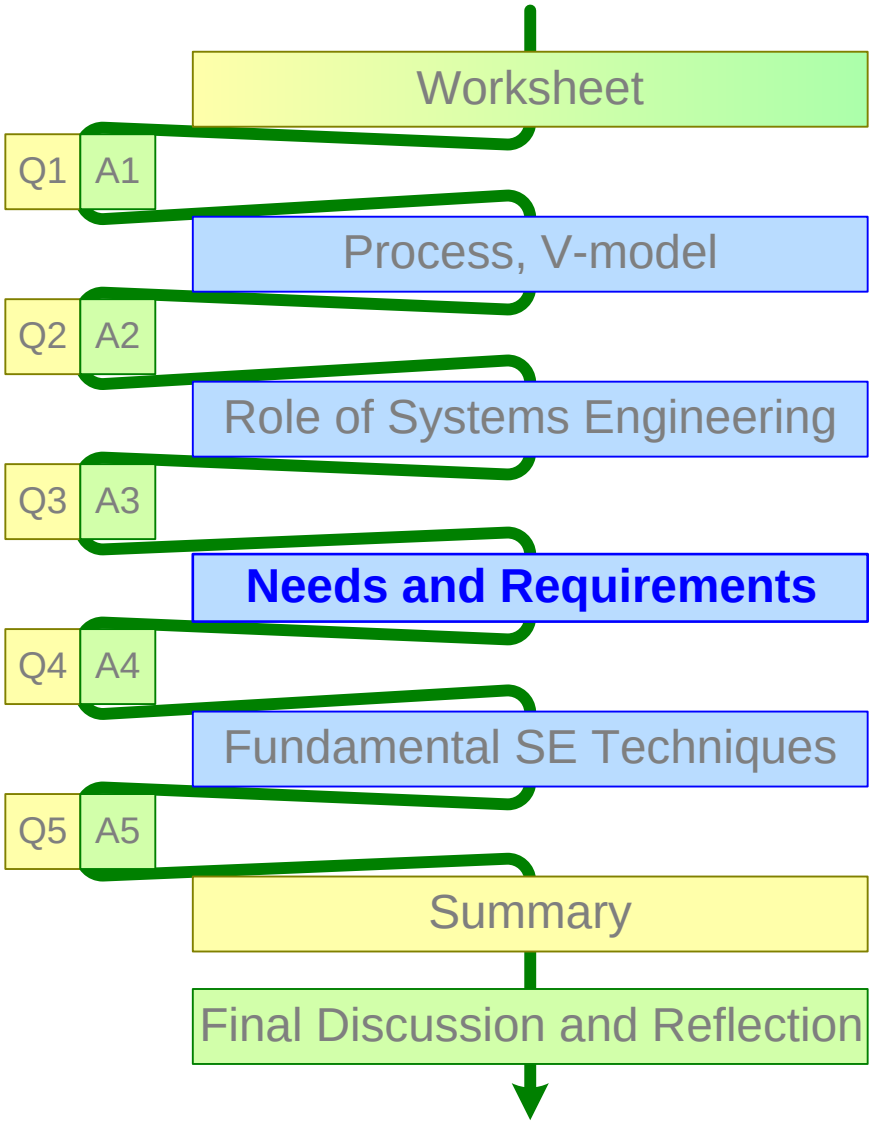
Needs and Requirements



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Early Phase Need Analysis -
Can We Ease Systems Integration?

Eldar Tranøy, Aker Solutions

- Large cost overruns on EPC projects on the Norwegian continental shelf
- 10 large EPC projects totaled a **96 GNoK cost overrun**
- Consistent trend with cost overruns from 1994 through 2008
- Main Cost Drivers: **Scope changes** and **late design changes**

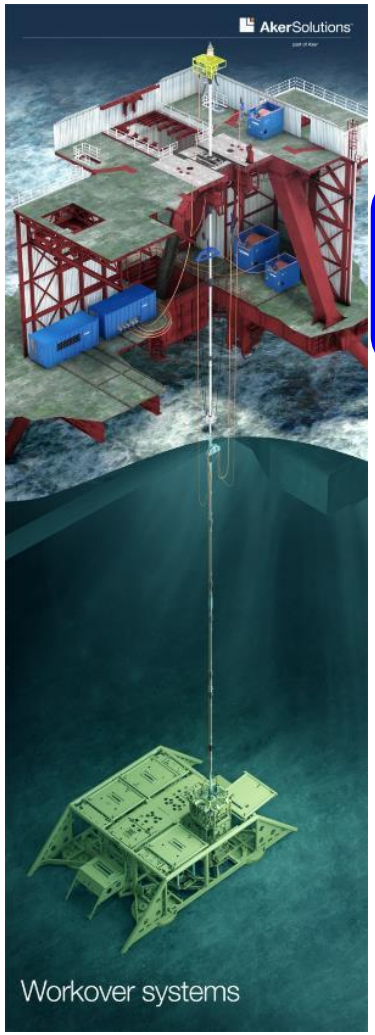
INCOSE 2014 Best Student Paper Award

Project	Estimated cost	Actual / New estimate	Change	Change in %
Balder	5	8,08	3,08	62
Gullfaks Sat 1	6,86	9	2,14	31
Jotun	6,2	7,2	1	16
Njord	6,31	7,76	1,45	23
Norne	8,62	9,27	0,65	8
Oseberg Sør	8,05	8,75	0,7	9
Oseberg Øst	3,49	4,3	0,81	23
Troll Gass	18,25	20,77	2,52	14
Varg	2,94	3,64	0,7	24
Visund	7,85	11,4	3,55	45
Åsgard	28,52	37	8,48	30
Kårstø	2,94	7,08	4,14	141
Åsgard Transport	7,36	7,96	0,6	8
Snøhvit LNG	43,8	64,5	20,7	47
Ormen Lange	72,5	107,1	34,6	48
Alvheim	8,7	17,2	8,5	98
Statfjord Seinfase	14,5	18,5	4	28
Blane	1,8	3,5	1,7	94
Valhall Re-dev	23,7	39,9	16,2	68
Gjøa (ink gaspipe)	30,2	34,7	4,5	15
Yme	4,7	8	3,3	70
Skarv	34,3	35,8	1,5	4
Vega + Vega Sør	6,4	7,5	1,1	17

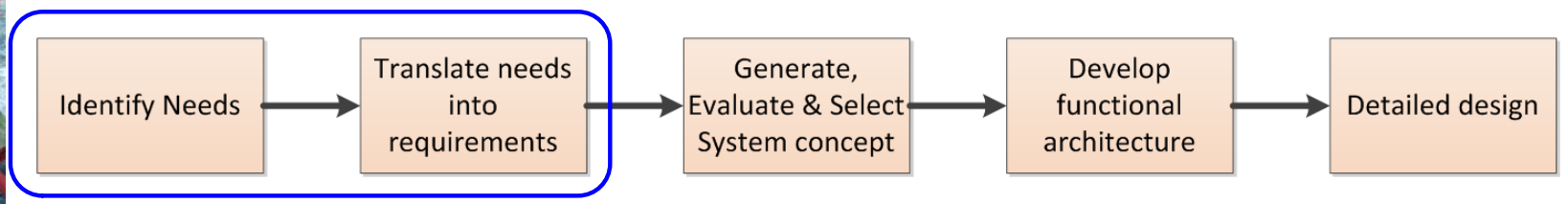
Numbers from the investment committee's report are all calculated as value pr. 1998

Eldar Tranøy Reduction of Late Design Changes Through Early Phase Need Analyis, INCOSE 2014 in Las Vegas, Brian Mar Award for best student paper
http://gaudisite.nl/INCOSE2014_Tran%C3%B8y_Muller_ReductionOfLateDesignChanges.pdf

Systems Engineering Benchmarking



- Systems Engineering Body of Knowledge (SEBoK)
- Fundamental SE process:



Example Project – Vigdis NE WOS

Amount of SE:

- **8,5% of total project cost**
- **Too low for optimum SEE**
- **High enough to expect good results**

Finding:

Mismatch between tendered design and **operational needs**

The design is **not suitable for the actual operational needs**

Examples of **typical missing data**:

- Meteorological and oceanographic data
- Field data
- Soil data
- Fluid data
- Installation vessel data

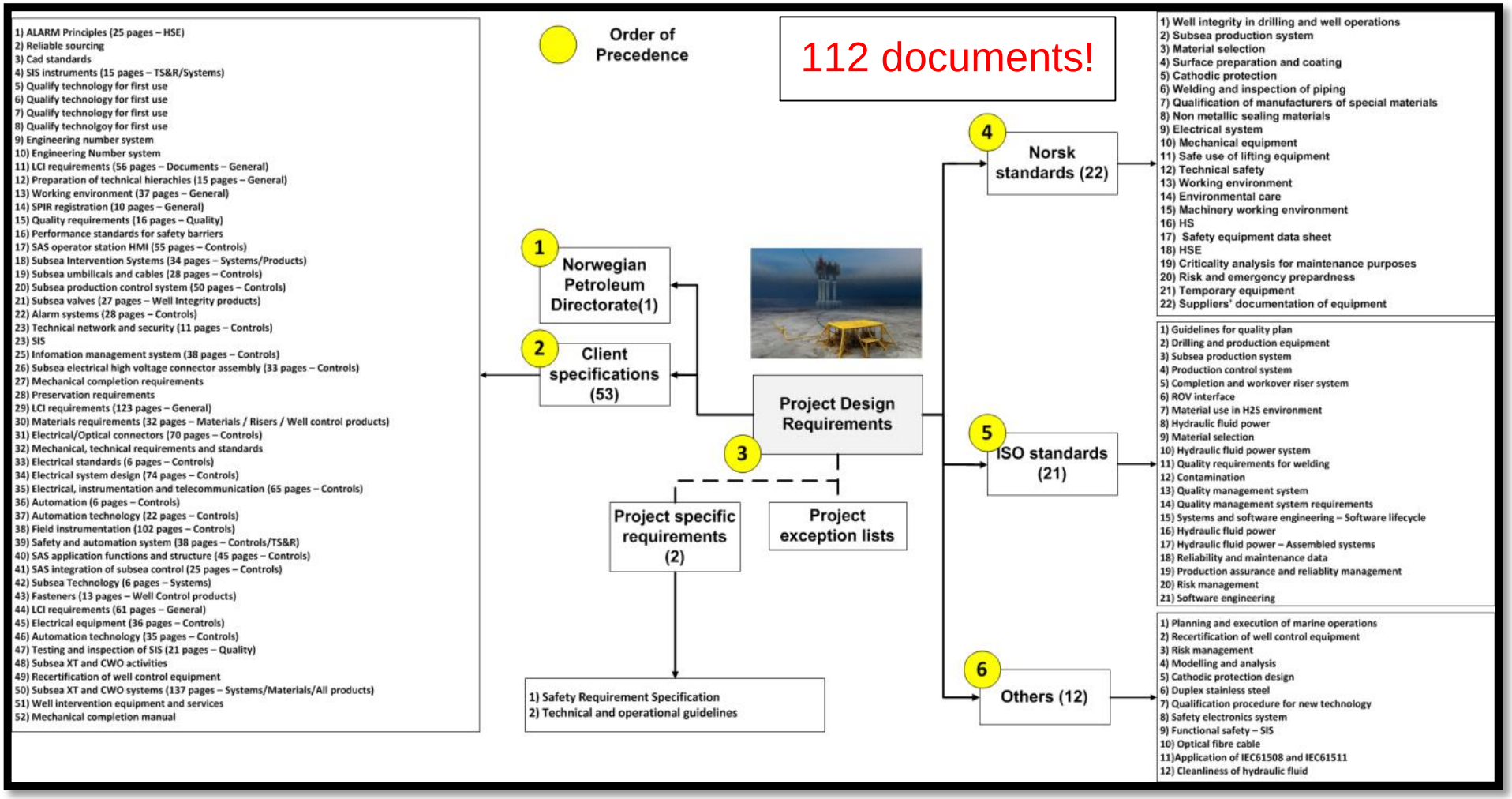
Analysis of Cost and Potential Impact

- Analysis of VO registry
  - Changes to design or scope normally results in a variation order (VO)
  - Cost of change is normally carried by customer
  - Review of 23 VO's

- **Findings**
  - **74% of the VO's were preventable by need analysis**
  - **92% of the cost incurred by late design changes, were preventable**

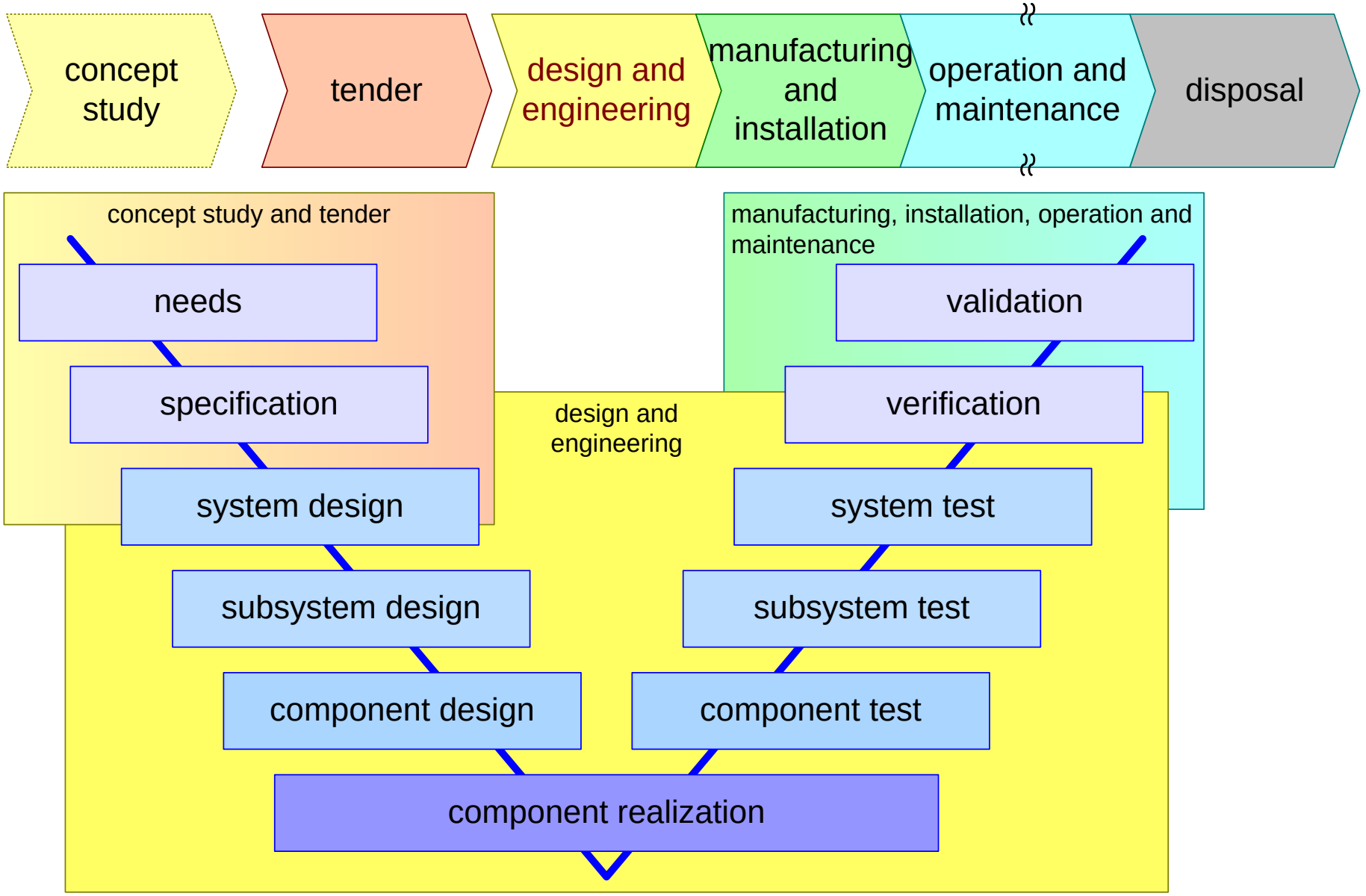
- **Root cause** analysis of the preventable VO's
  - Changes to product design
  - **Mismatches between project requirements and operational needs**

Overview of Requirements for a Workover System Project



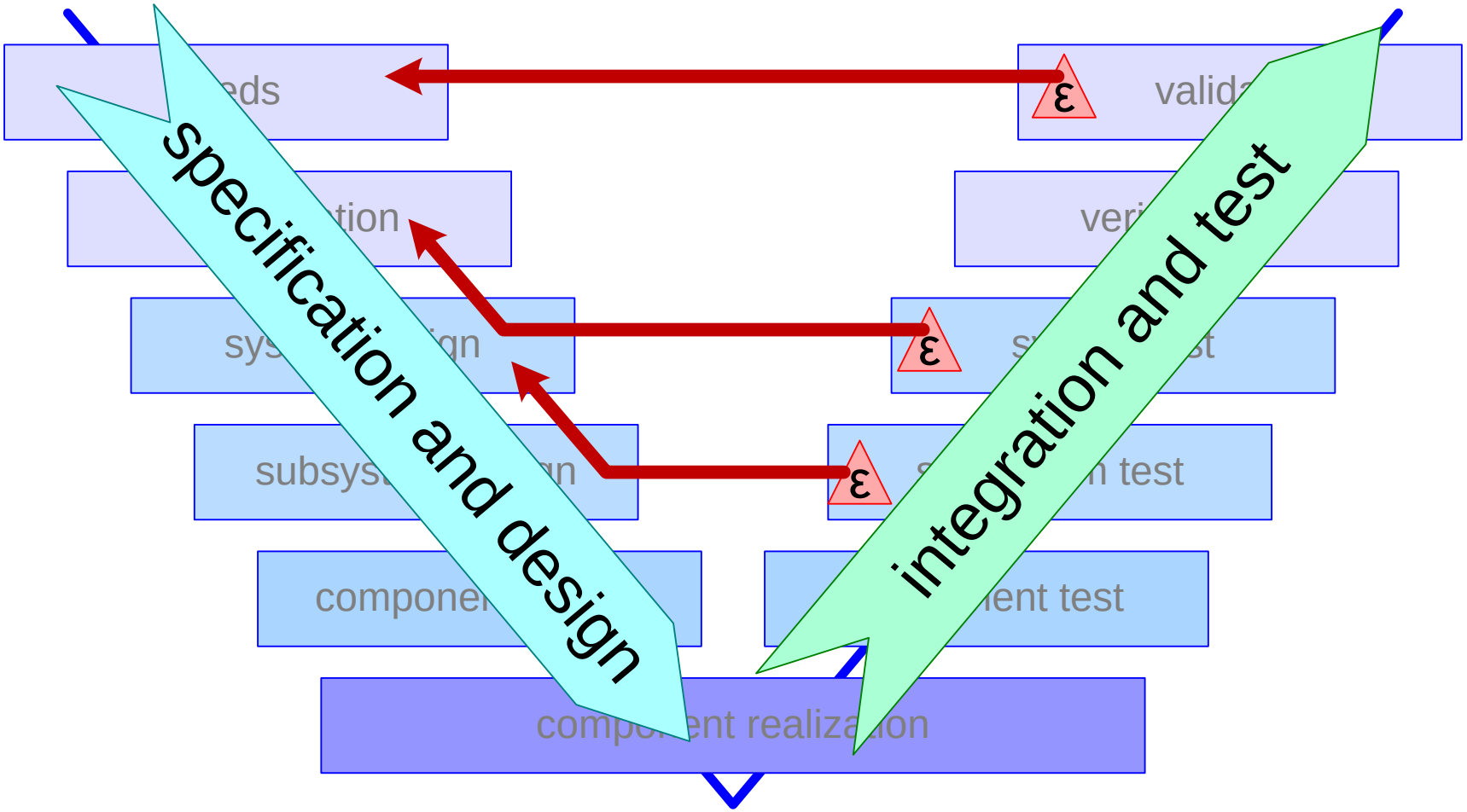
Evaluating the effectiveness and effort in applying a Requirements Management Tool on a Subsea Oil and Gas Workover System
Damien Wee, INCOSE 2016, https://gaudisite.nl/INCOSE2016_Wee_Muller_Requirements.pdf

Tender and V-model

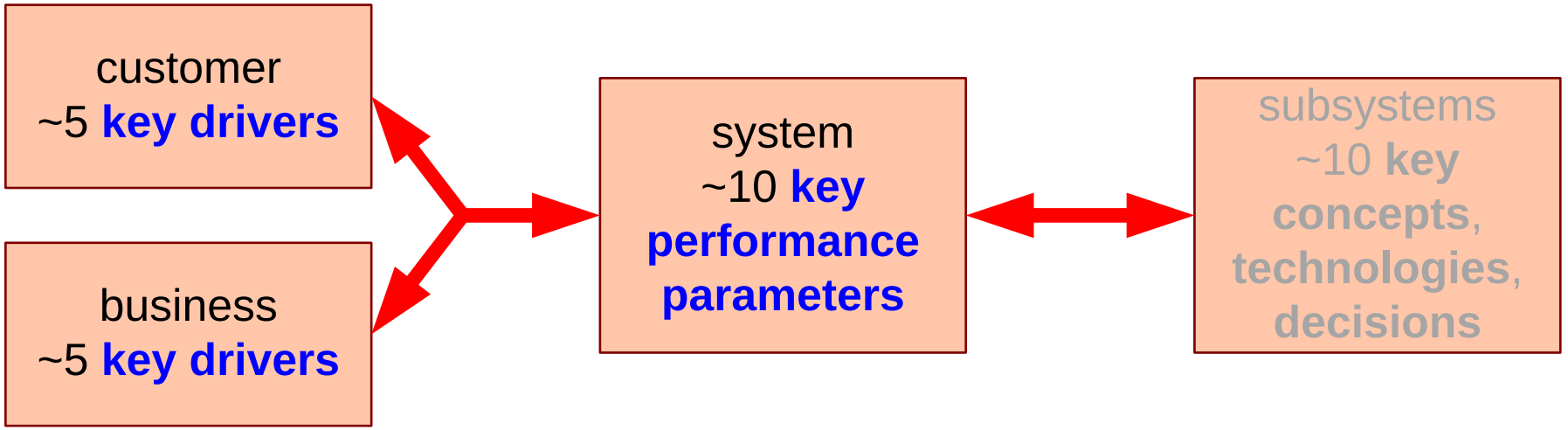


Problems Appear Late

failures found during integration and test can be traced back to ***unknowns***, ***unforeseens***, and ***wrong assumptions***



The SE Theory on Needs



- **Elicit needs** and constraints
- **Understand Customer**, field development context, and TechnipFMC (**operation**, **business**, **stakeholders**, **risks**, …)

- **Transform** into requirements
- **Understand** trade-offs, risk margins, and compromises
- **Ensure** feasibility, timely achievability, and affordability
- **Cope** with **deviations** and **changes**

Question 4; Key Drivers and Performance

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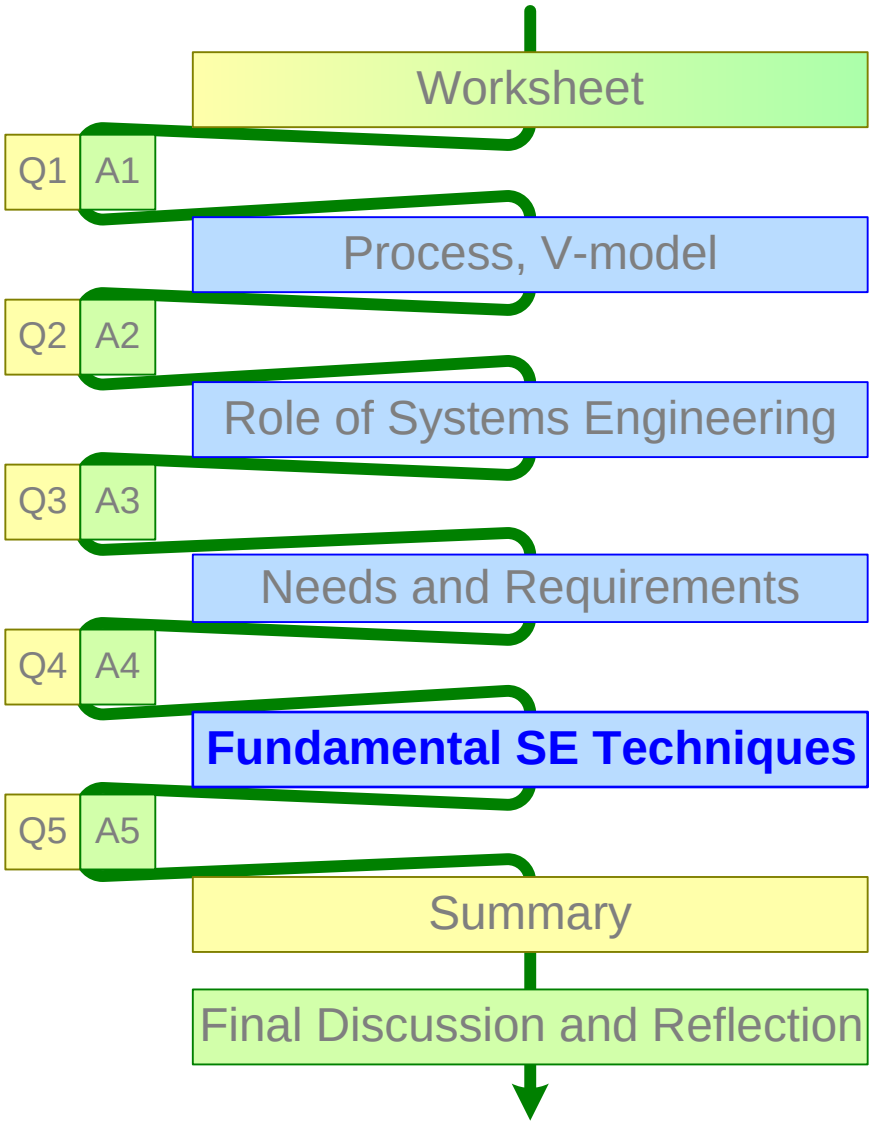
Some Fundamental Systems Engineering Techiques



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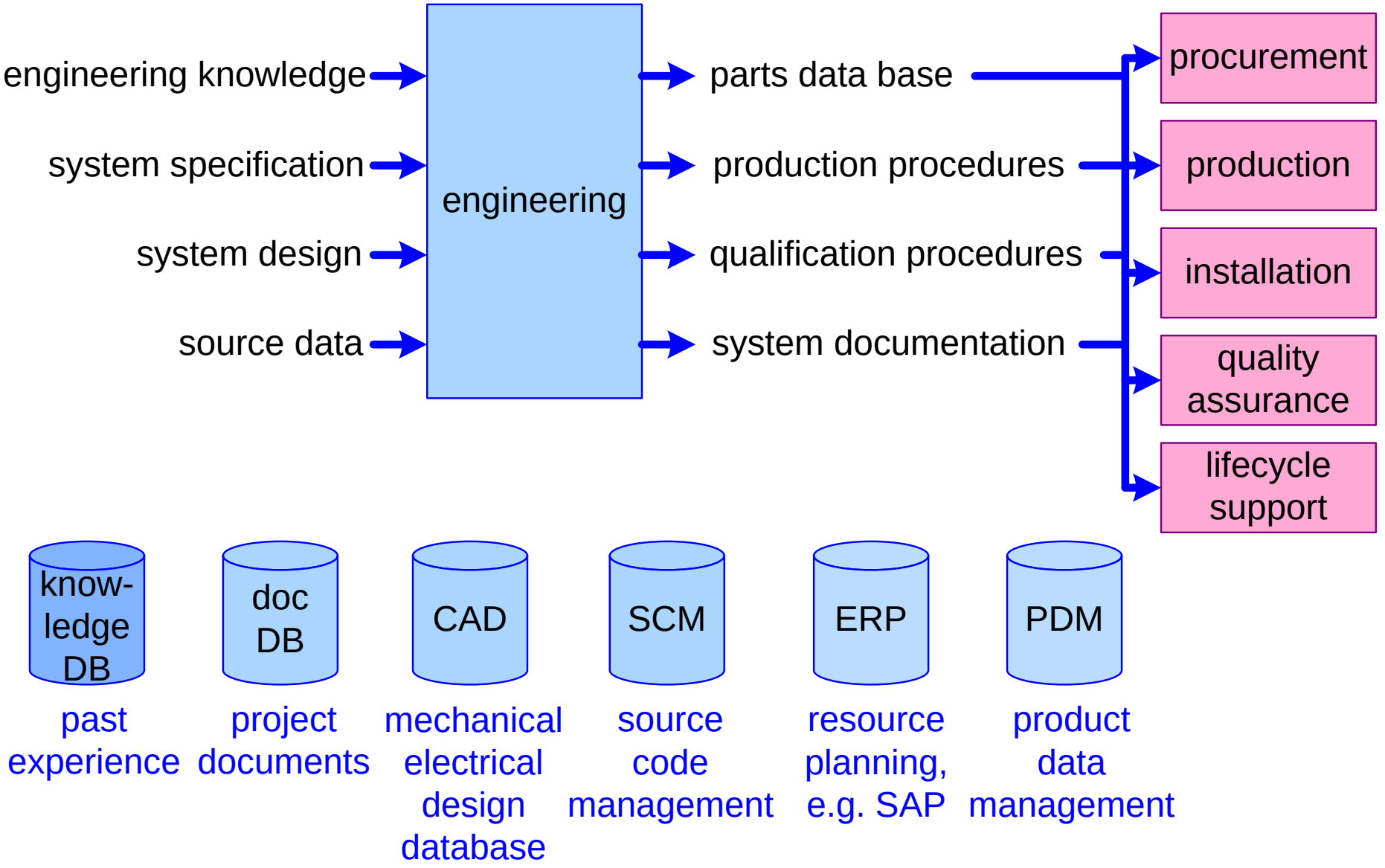
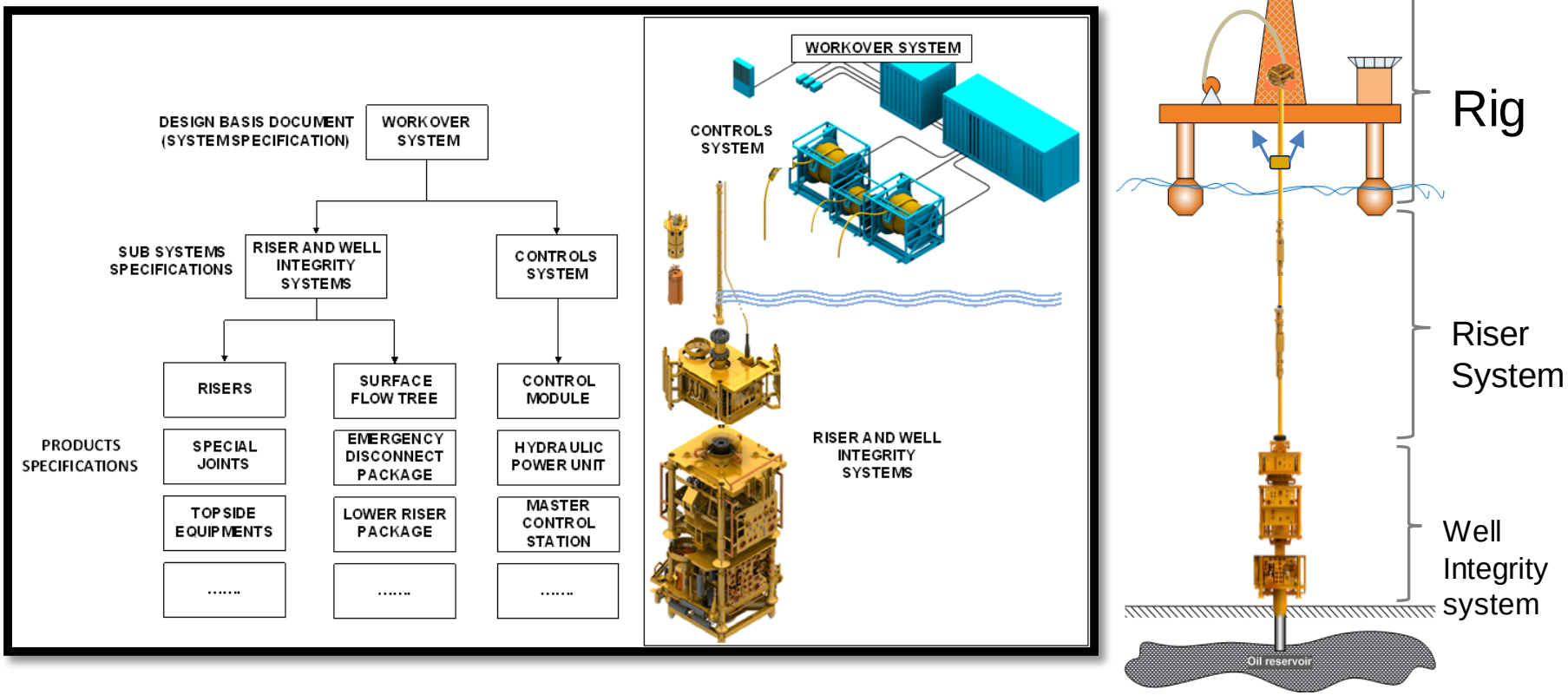
Engineering



Partitioning is Applied Recursively



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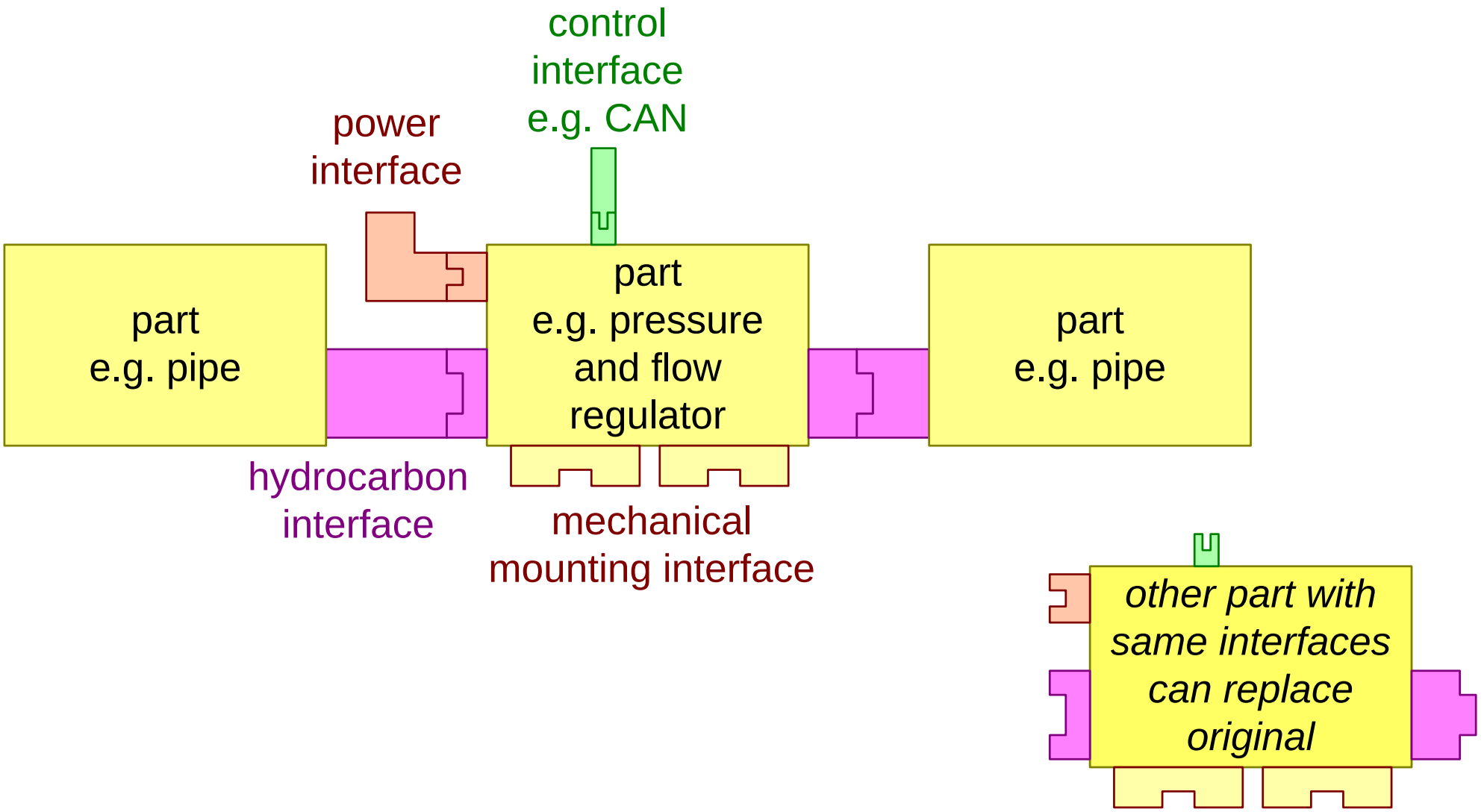
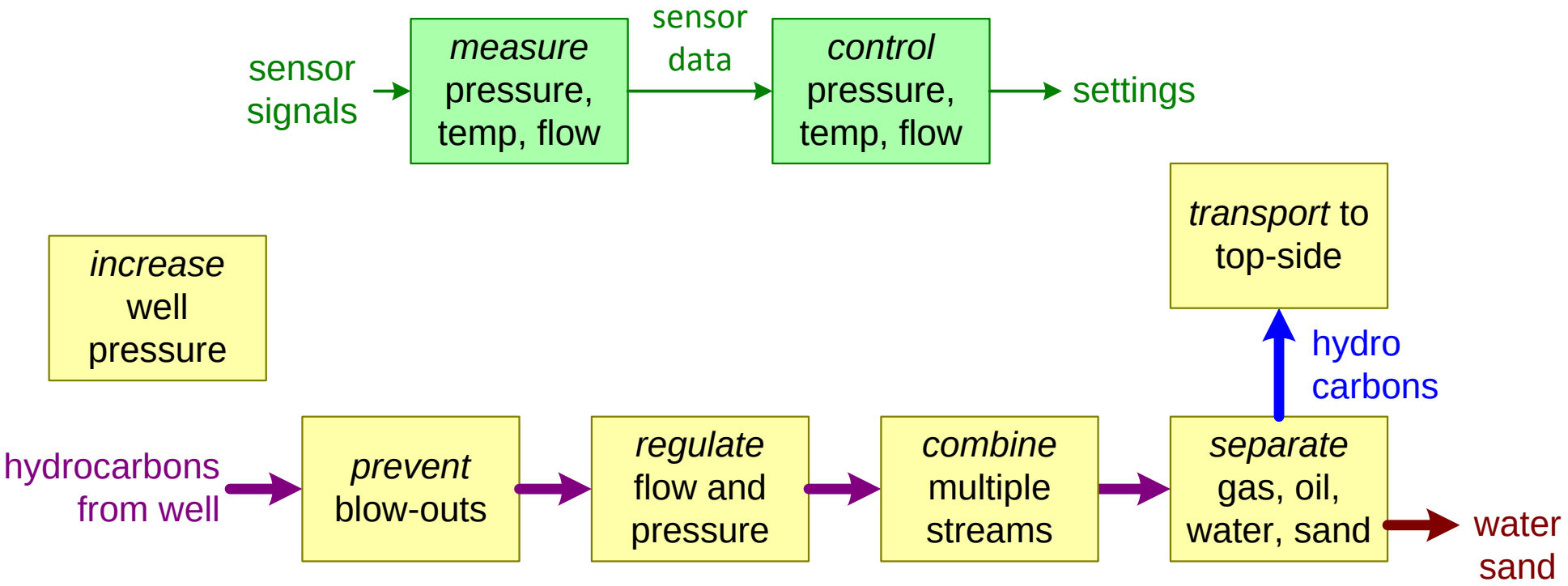
Decoupling via Interfaces



Simplistic Functional SubSea Example



Quantification

Size	2.4m * 0.7m * 1.3m
Weight	1450 Kg
Cost	30000 NoK
Reliability	MTBF 4000 hr
Throughput	3000 l/hr
Response time	0.1 s
Accuracy	+/- 0.1%

many characteristics of a system, function or part can be quantified

*Note that quantities have a **unit***

More and More Magic Words

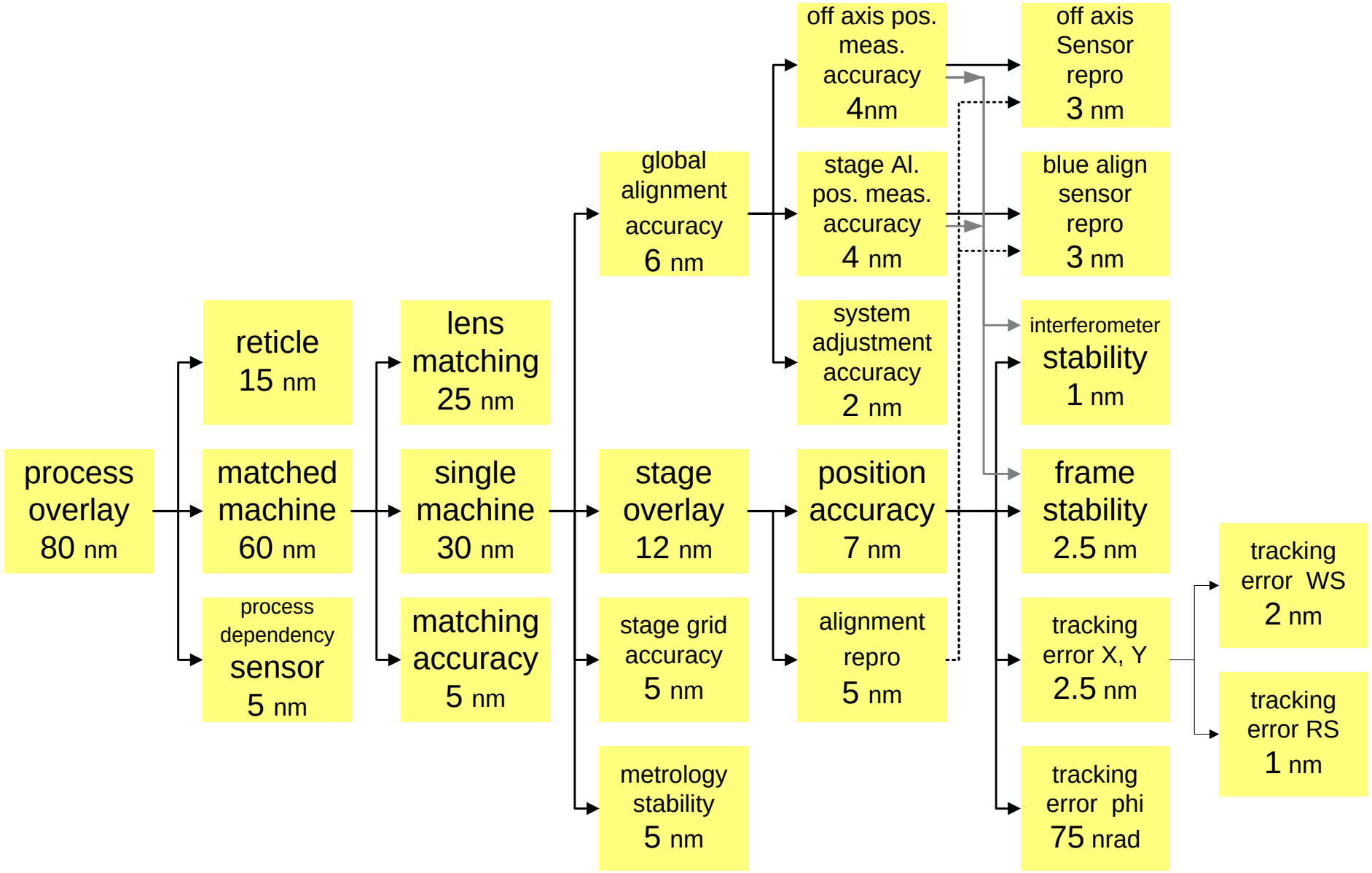
Partitioning facilitates the organization, logistics, production, and service

Interfaces are used to decouple

Functional models explain how the system and parts operate

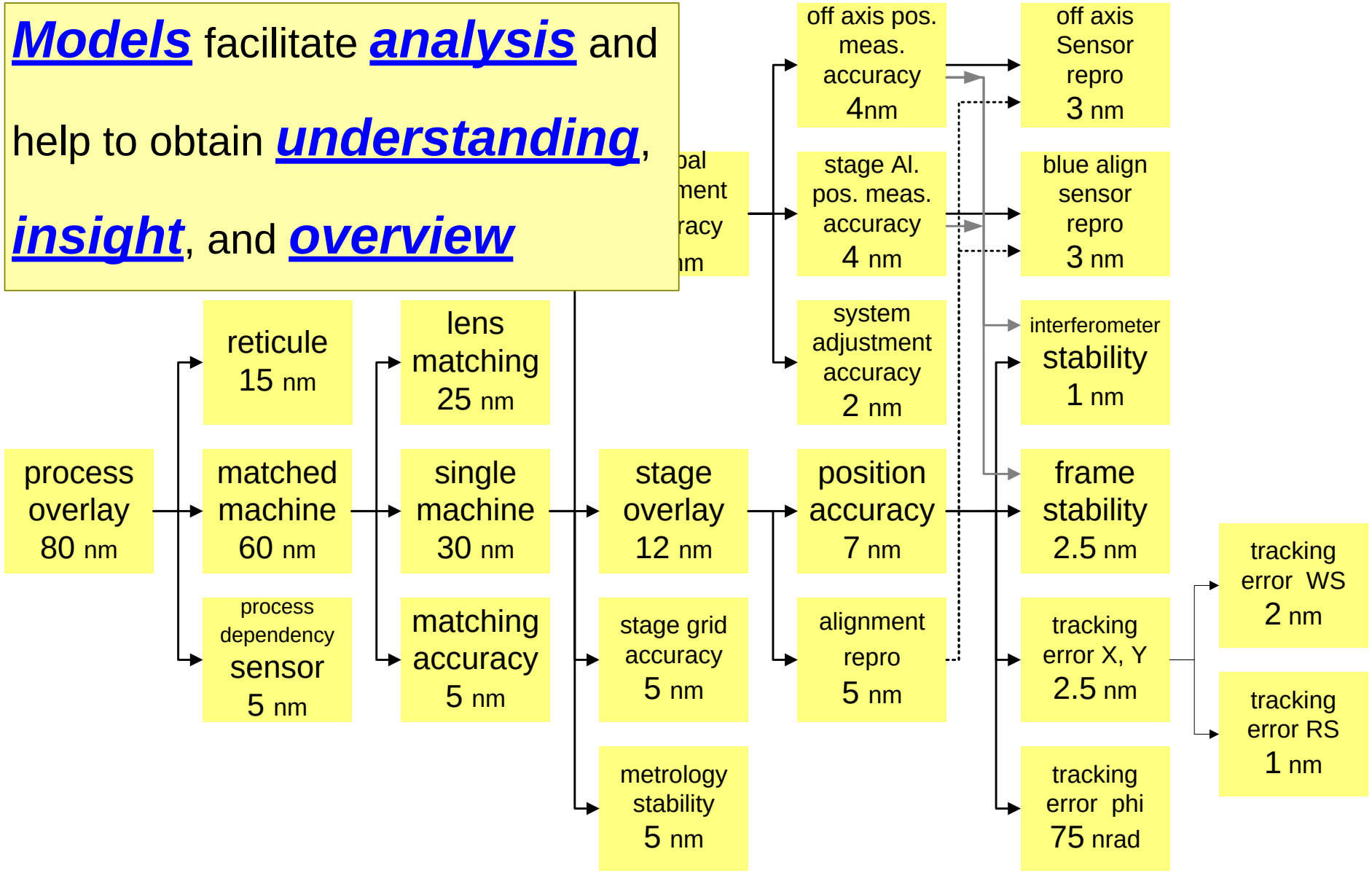
Quantification helps to achieve ***fact-based*** decision making

Example Technical Budget



Even More Magic Words

Models facilitate ***analysis*** and help to obtain ***understanding***, ***insight***, and ***overview***



Question 5; Functional and Performance Challenges

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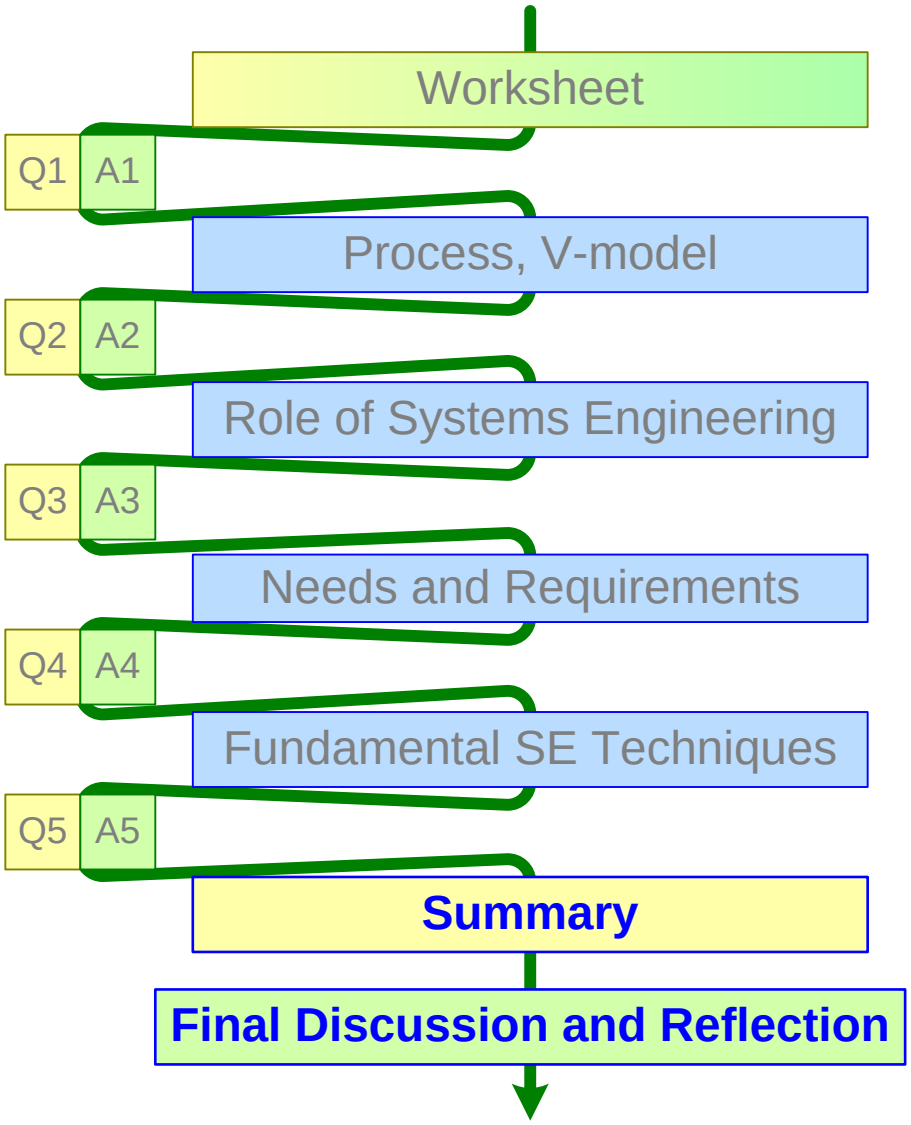
The Role of Systems Engineering



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All Magic Words

objectives	V-model	Fitness-for-Purpose
risk (analysis, mitigation)	partitioning	life cycle
requirements	interfaces	supply chain
(engineering, management)	functional	customer key drivers
SMART	fact based	business key drivers
verification	quantification	key performance parameters
validation	model	concepts
multi-disciplinary	analysis	technologies
integration	understanding	decisions
holistic	insight	unknowns
stakeholders	overview	unforeseens
needs and concerns		assumptions

Reflection

How much do you know of the Systems Engineering playing field?

What are TechnipFMC's main strengths and weaknesses in Systems Engineering?