Theory and Practice of Systems Engineering in Kongsberg Projects

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Abstract

The Systems Engineering Body of Knowledge provides many means to create products and to run project creating systems. We discuss the theory and reflect on experiences from practice, focusing on Kongsberg industry.

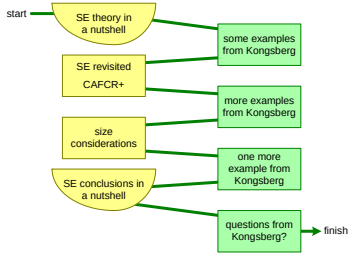

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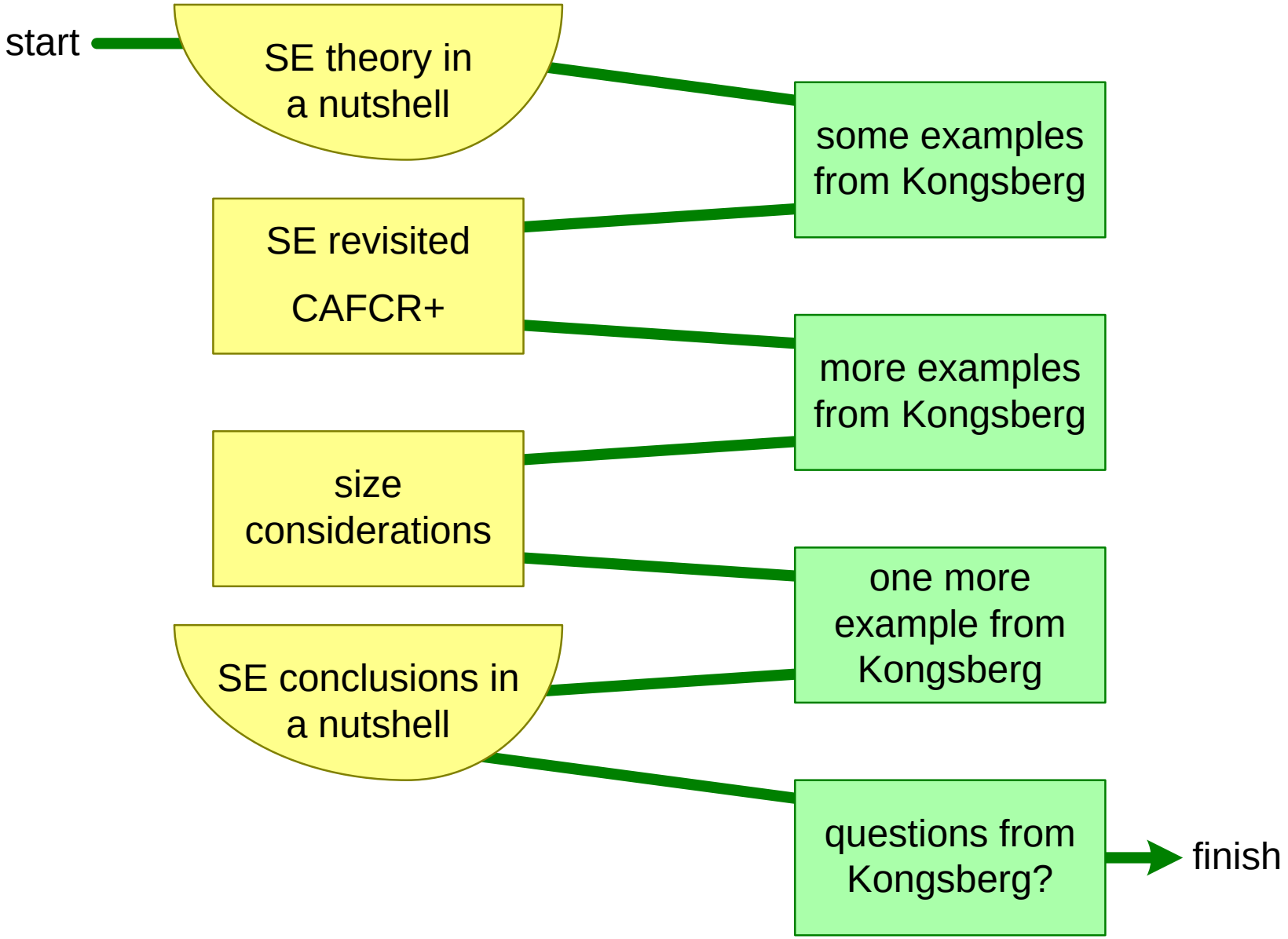
Figure Of Contents™



Summary SE theory

Systems Engineering theory

Follow phase model

needs > requirements > concepts > detailed design

SMART Requirements

Evaluate multiple concepts

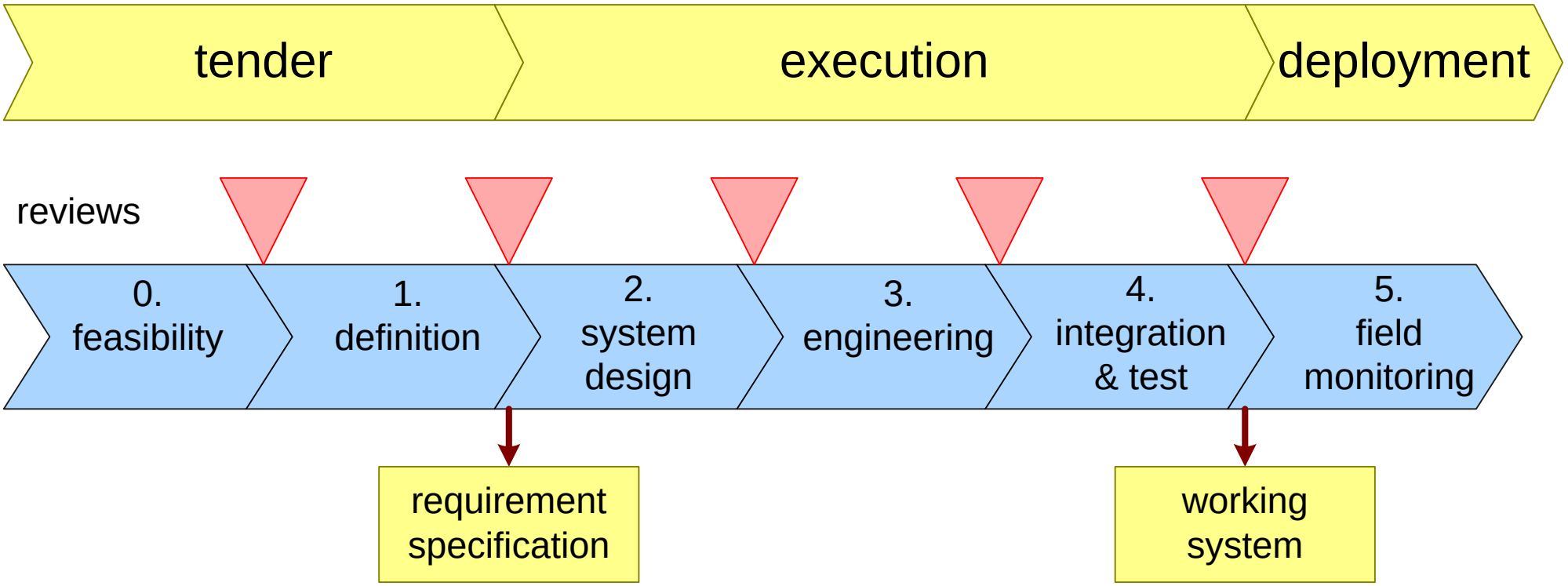
Think "Functional", What versus How

typical buzzwords

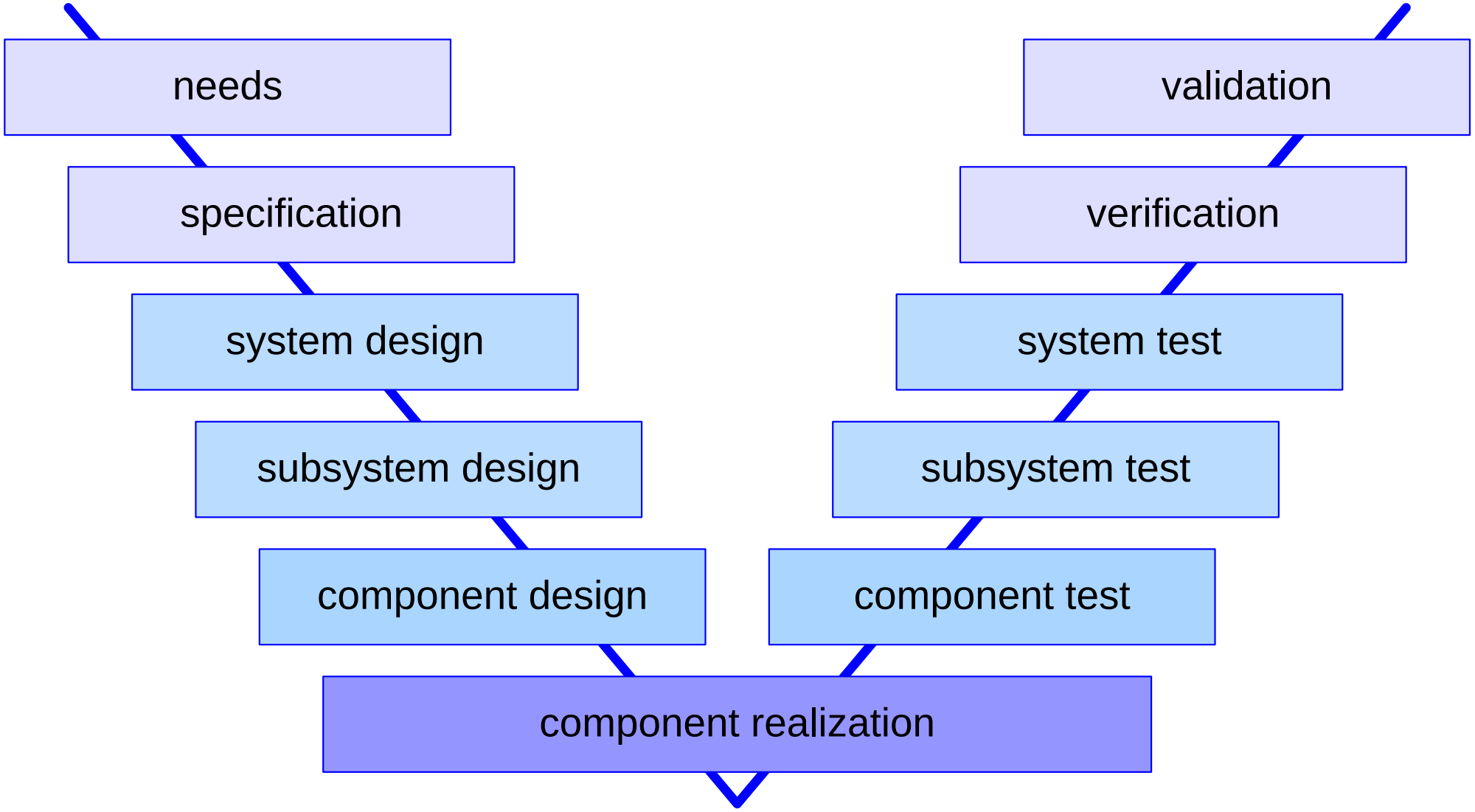
stakeholders, concerns, life cycle,

risks, reviews, V-model

Phase Model for Development



V-Model


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

The SMART acronym

- Specific — quantified
- Measurable — verifiable

acronym consensus

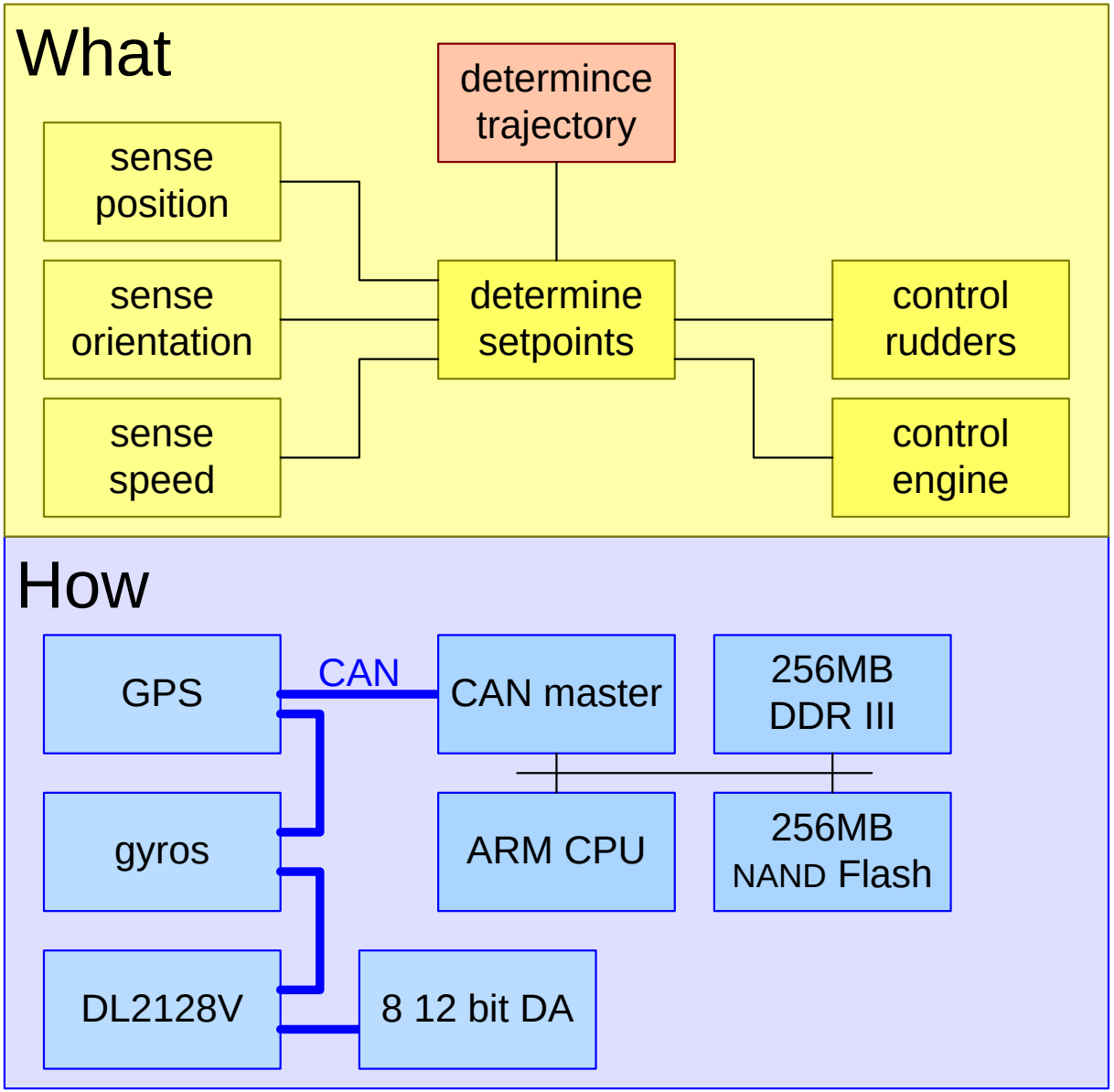
- Assignable (Achievable, Attainable, Action oriented, Acceptable, Agreed-upon, Accountable)
- Realistic (Relevant, Result-Oriented)
- Time-related (Timely, Time-bound, Tangible, Traceable)

variation of meaning

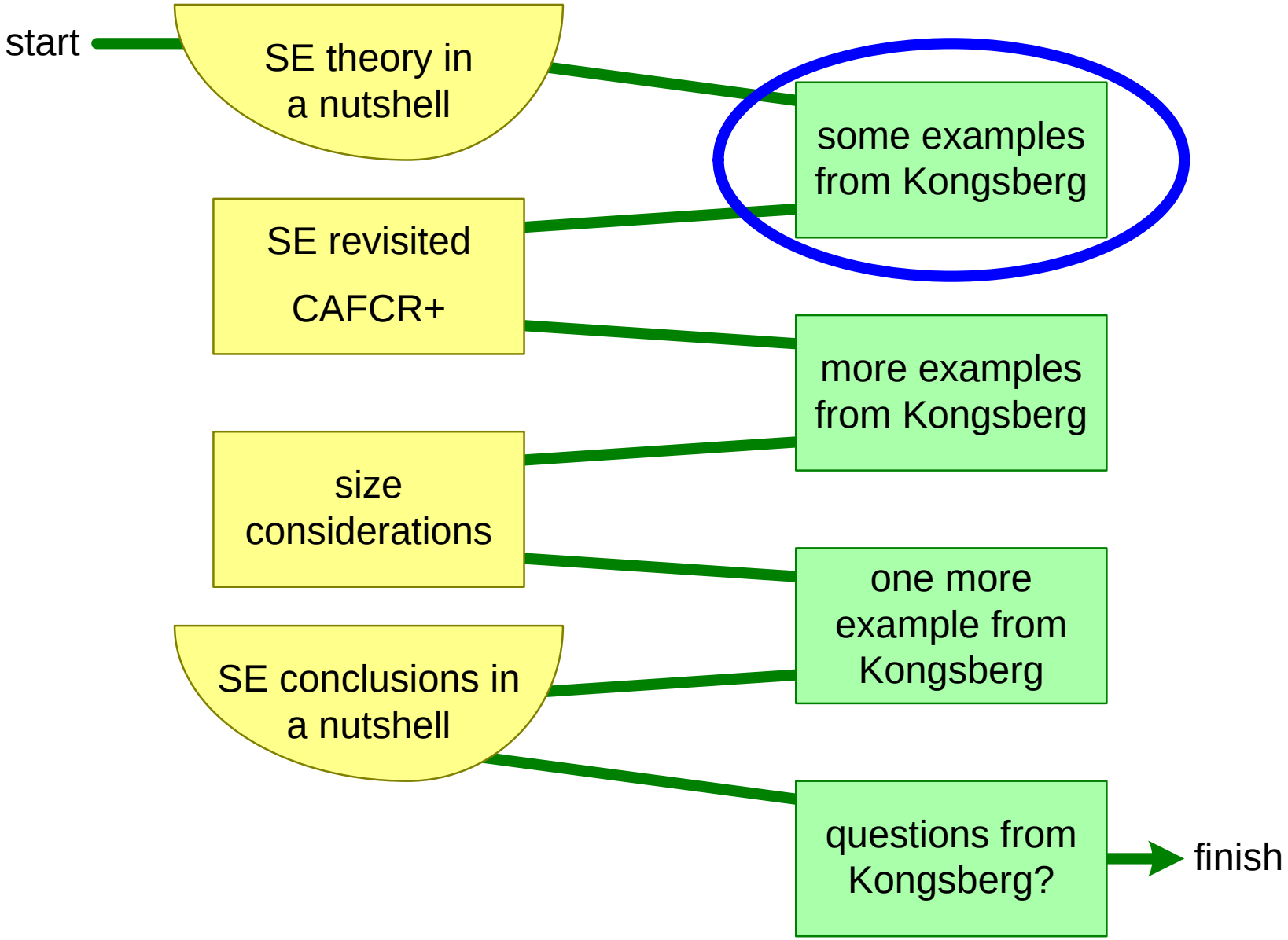
Concept Selection “Pugh” Matrix

	fuel cell	battery	generator
peak power	3	3	3
efficiency	2	4	4
weight	1	4	4
pollution	5	4	2
infra structure needs	1	3	4
	12	18	17

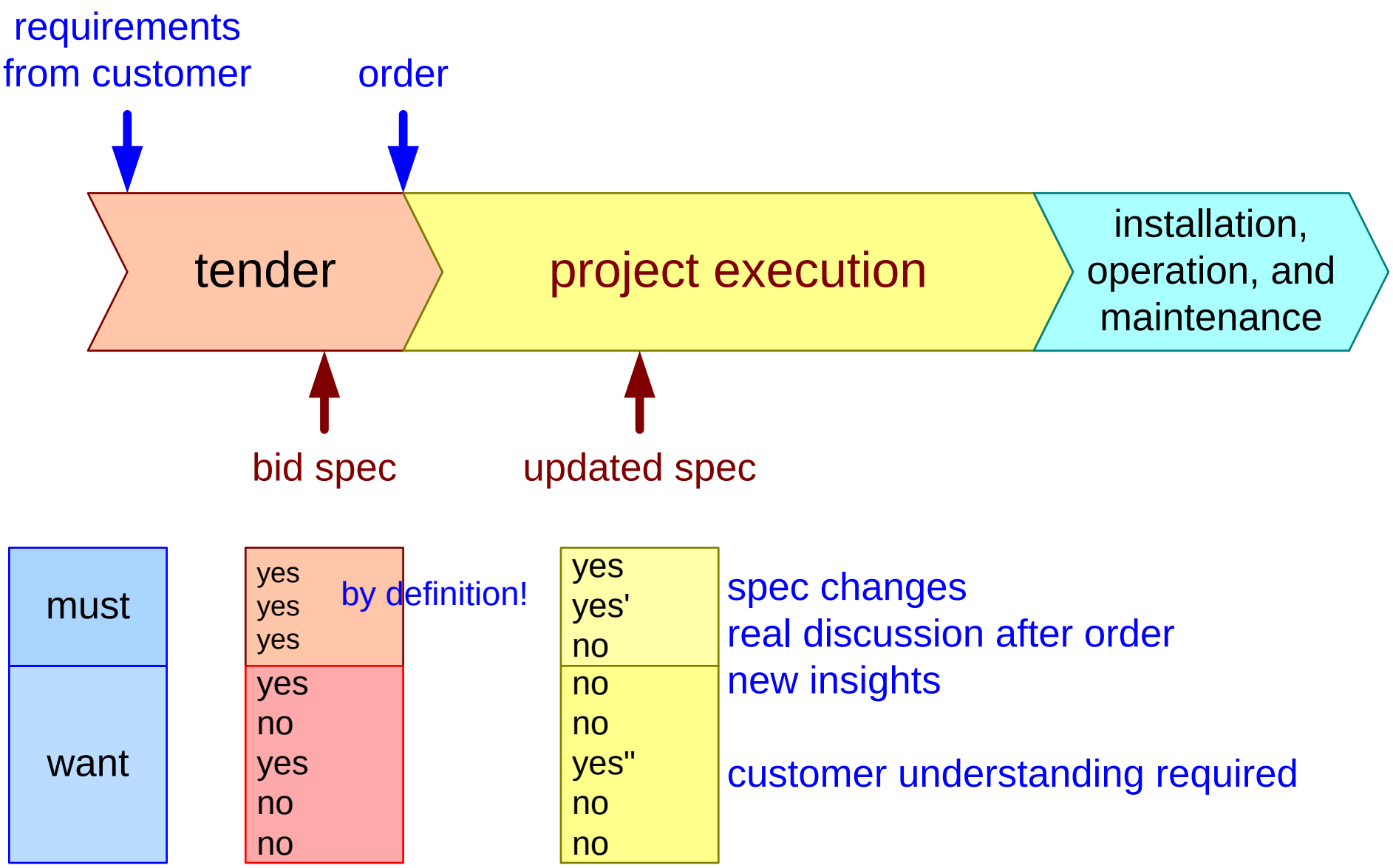
“Functional” Thinking; What and How



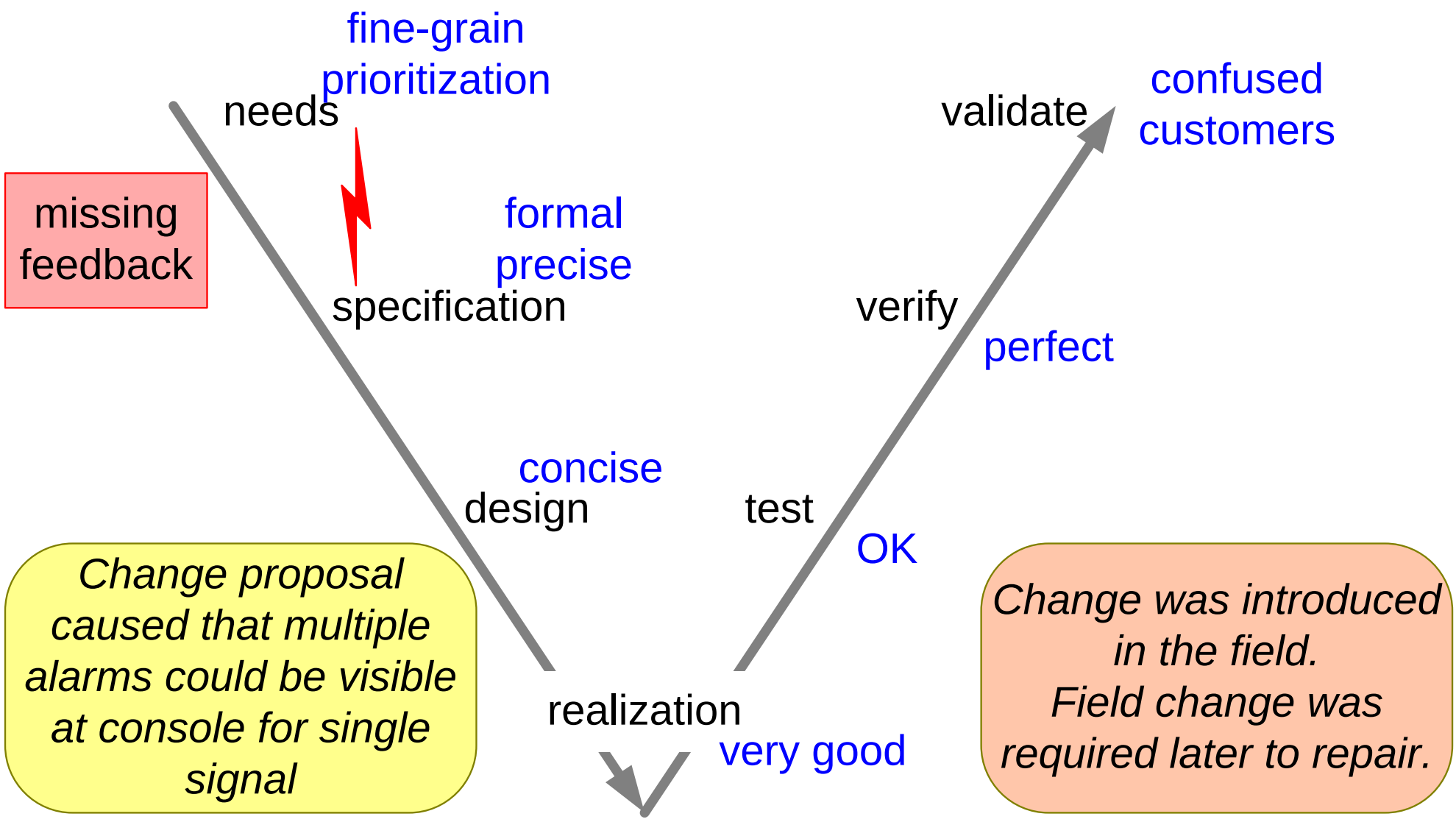
Examples from Kongsberg



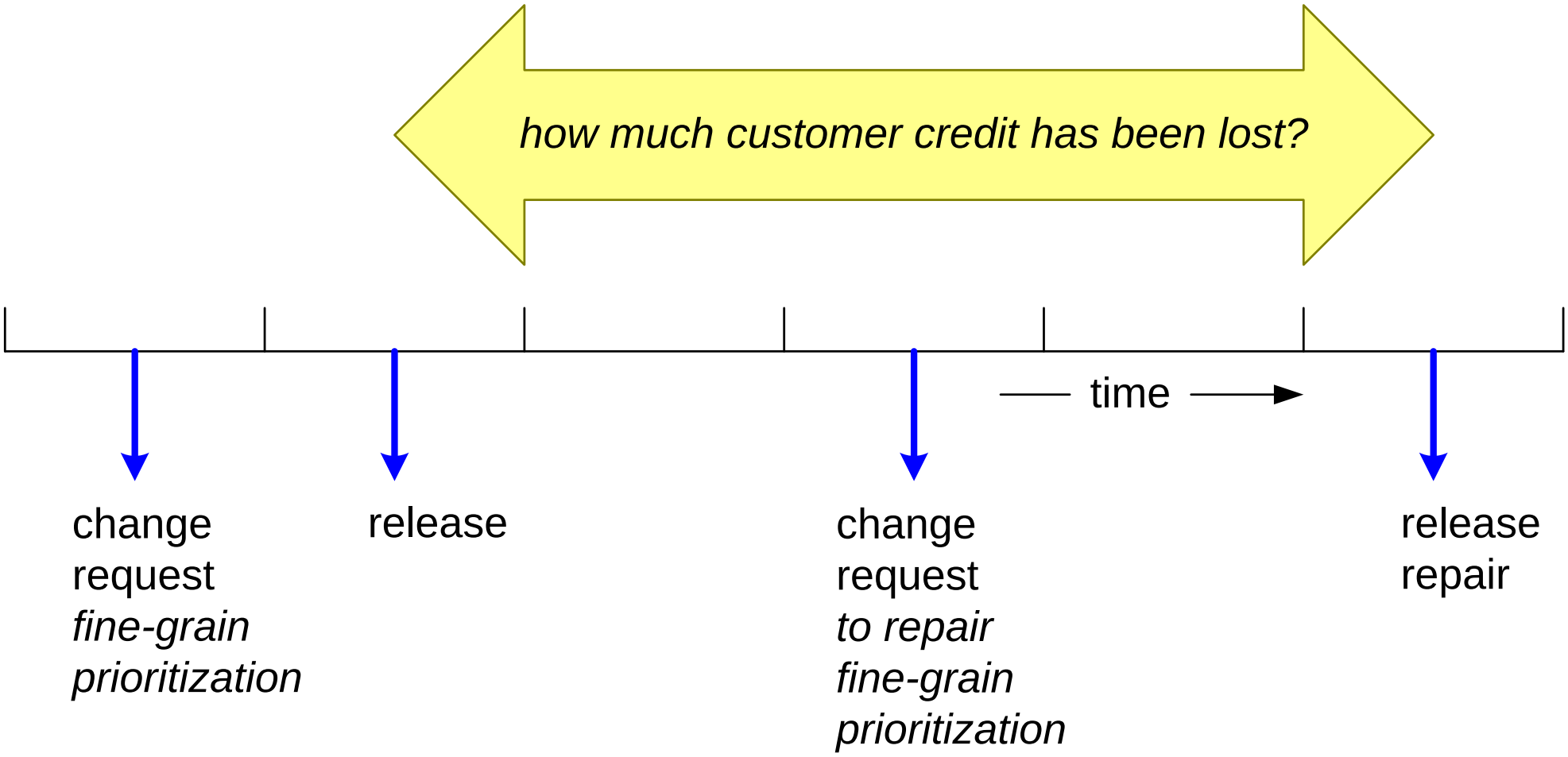
Typical Tendering with Navy



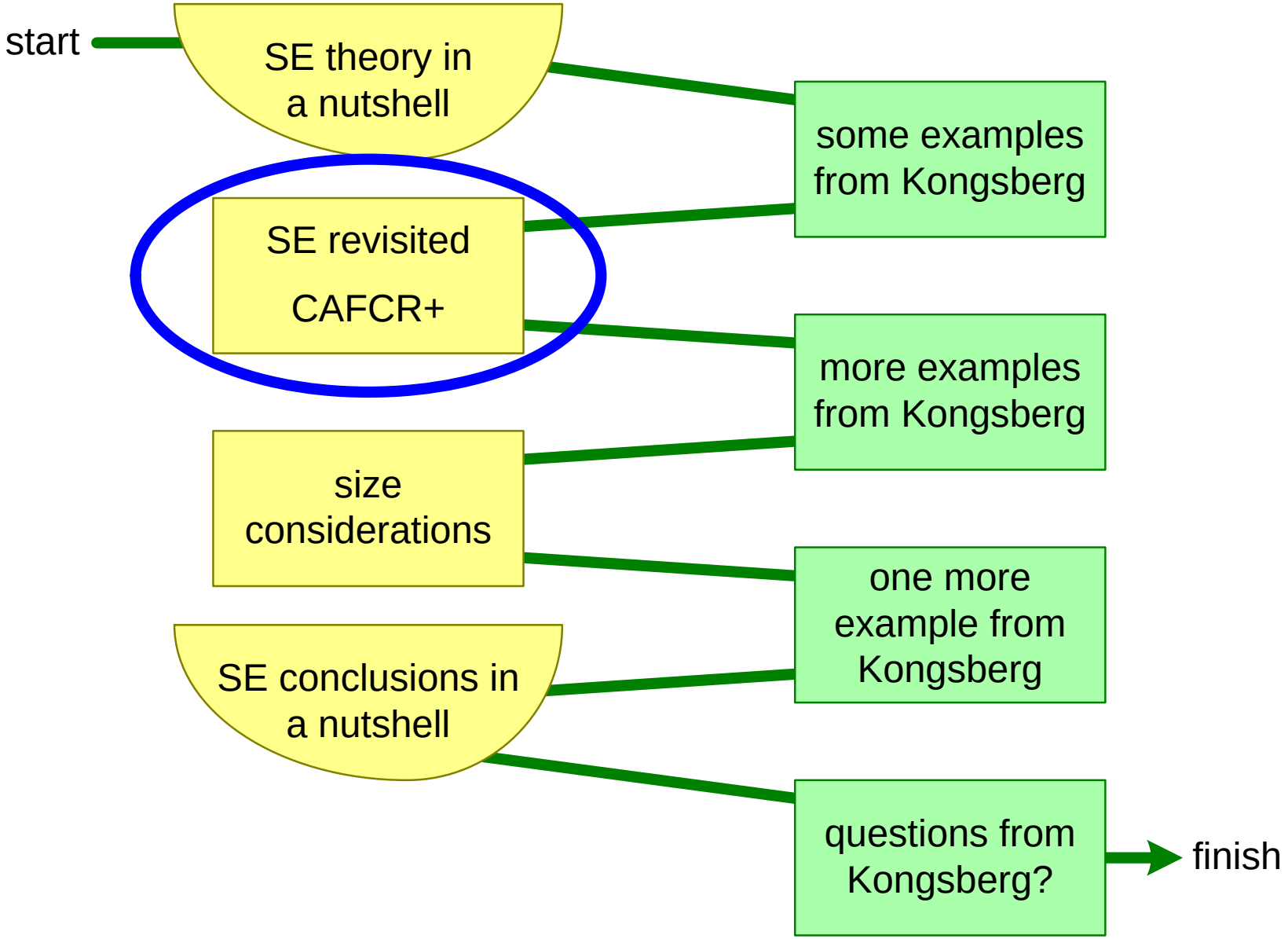
Rigor may Back Fire



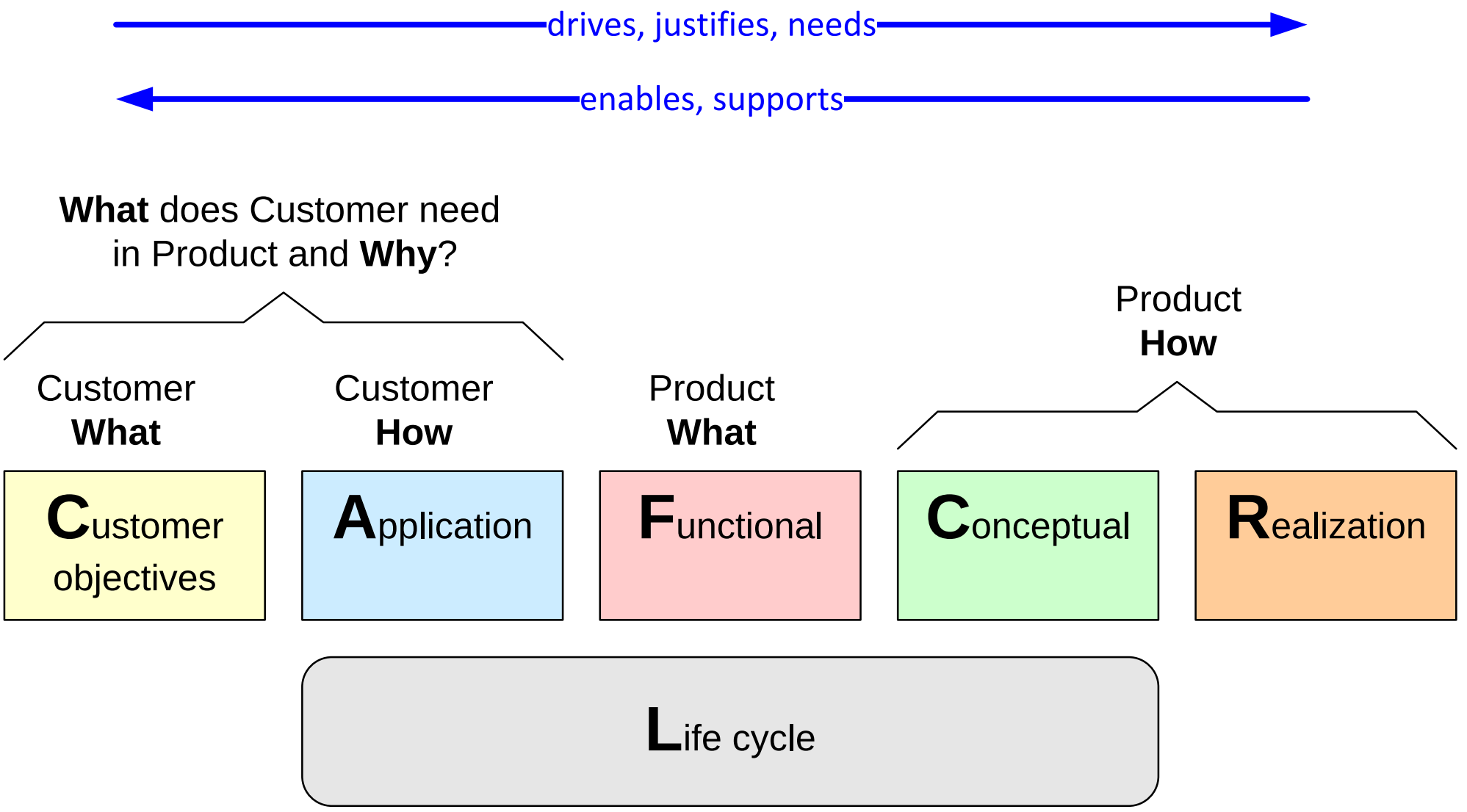
Latency of Introduction, Detection and Repair



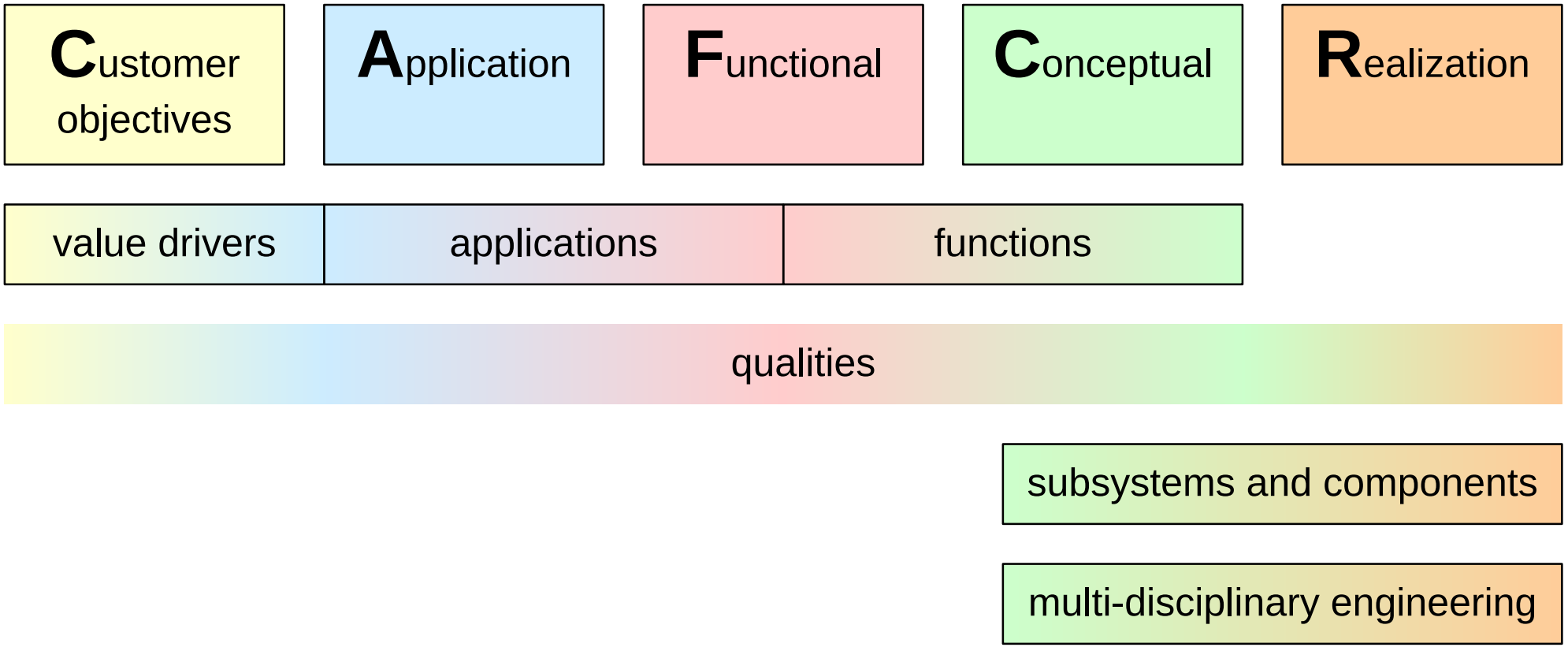
SE revisited; CAFCR+ model



CAFCR+ model


drives, justifies, needs
enables, supports
What does Customer need in Product and Why?
Customer What
Customer How
Product What
Product How
Customer objectives
Application
Functional
Conceptual
Realization
Life cycle

SE activities in CAFCR



SE revisited

understand customer and business (value)

help to transform into specification

multi-displinary design ensuring functionality and qualities

Customer objectives

Application

Functional

Conceptual

Realization

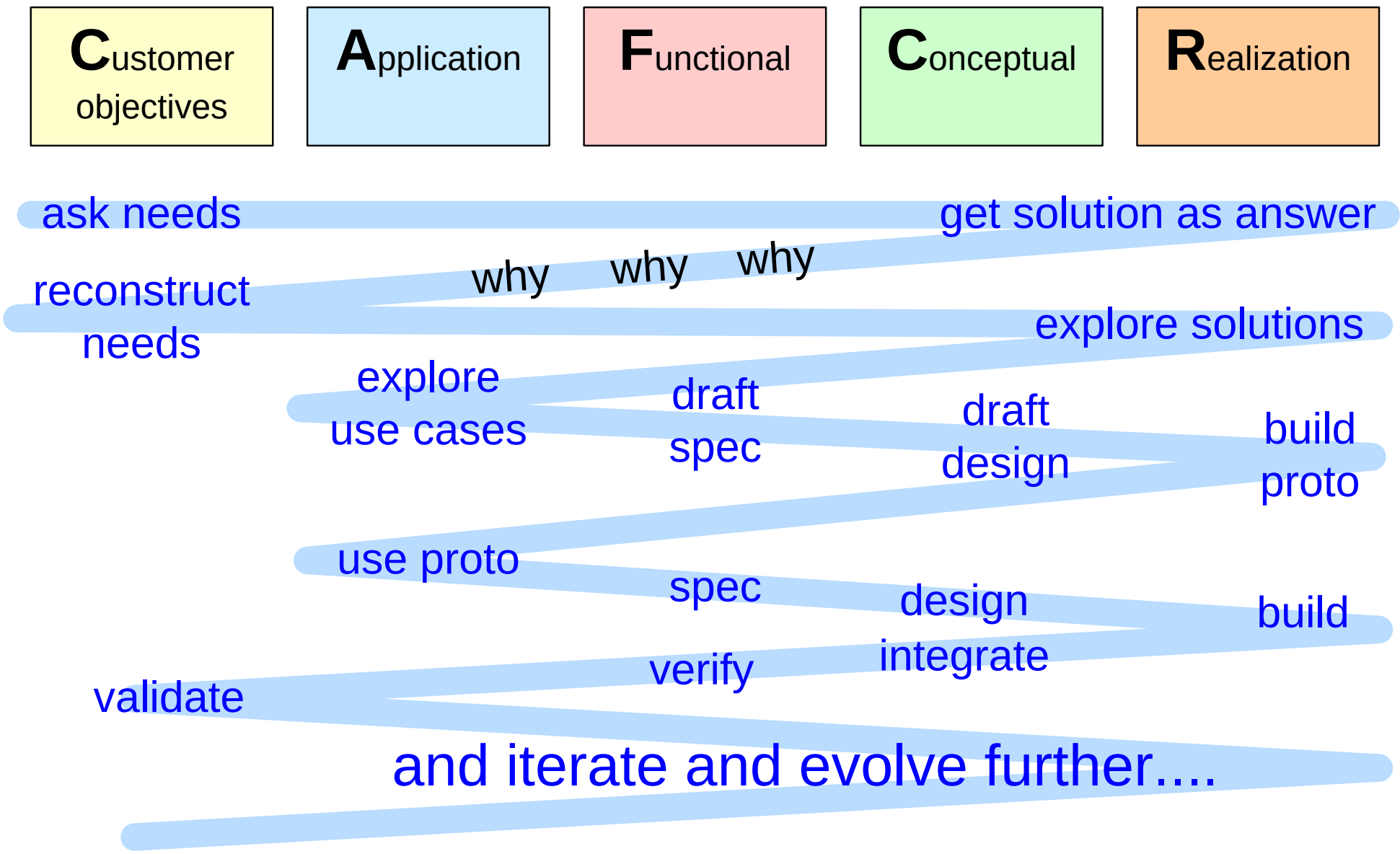
value drivers | applications | functions

qualities

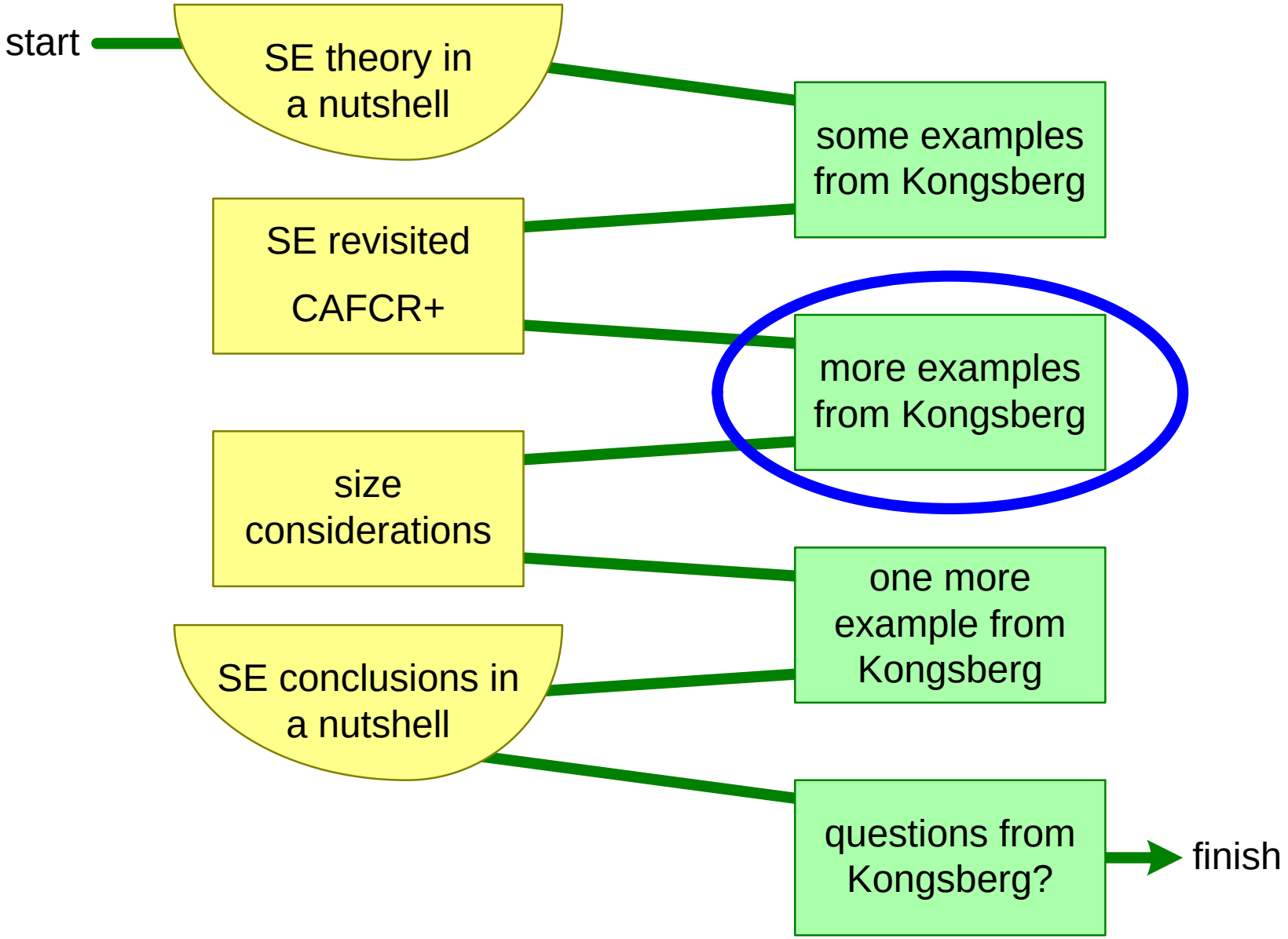
subsystems and components

multi-disciplinary engineering

Continuous Iteration



More Examples from Kongsberg



Example: K-Master

Dynamic Positioning

Independent DP joystick

Thruster control

Machinery automation and cargo control

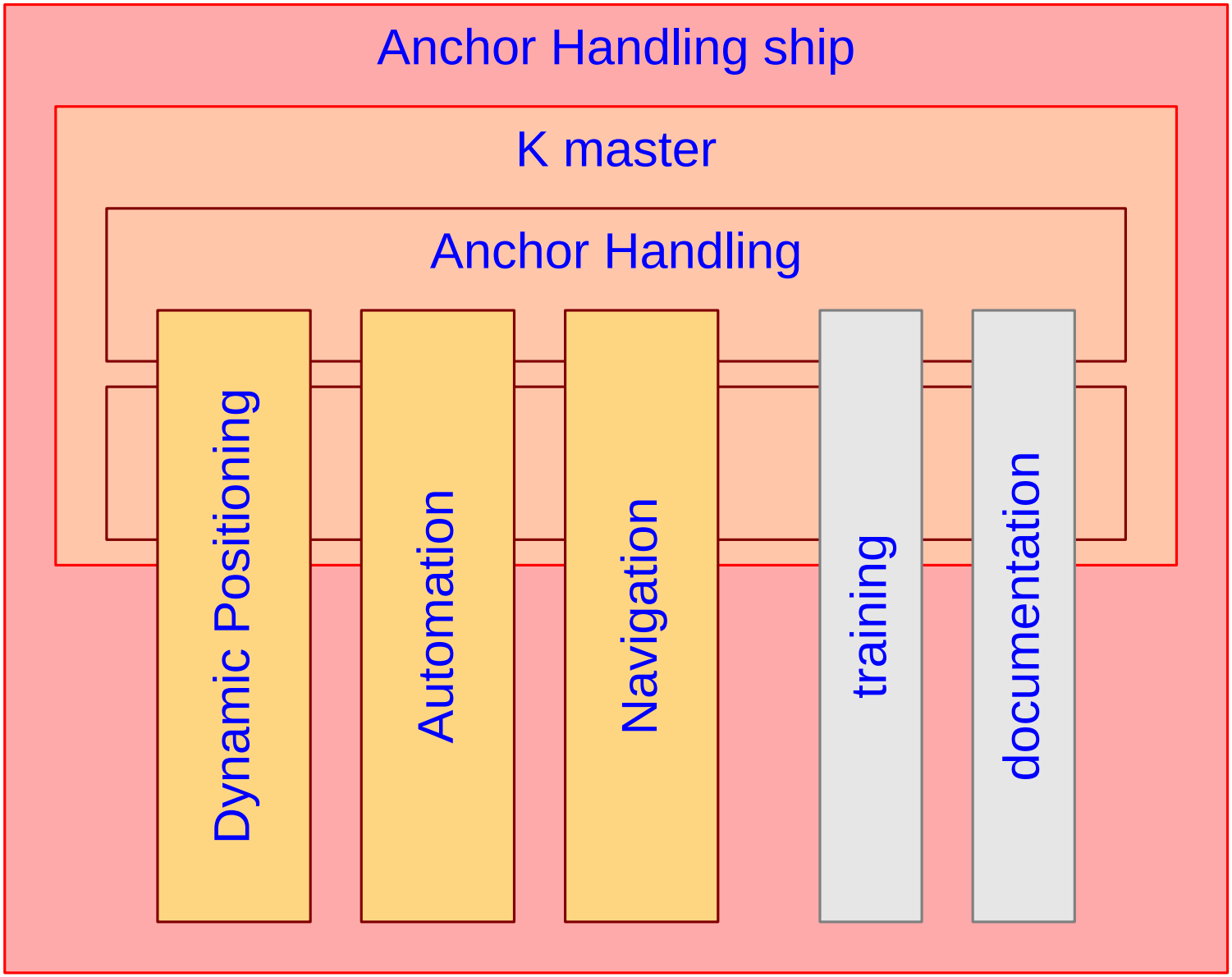
Chart radar and conning display

Bridge auxiliaries

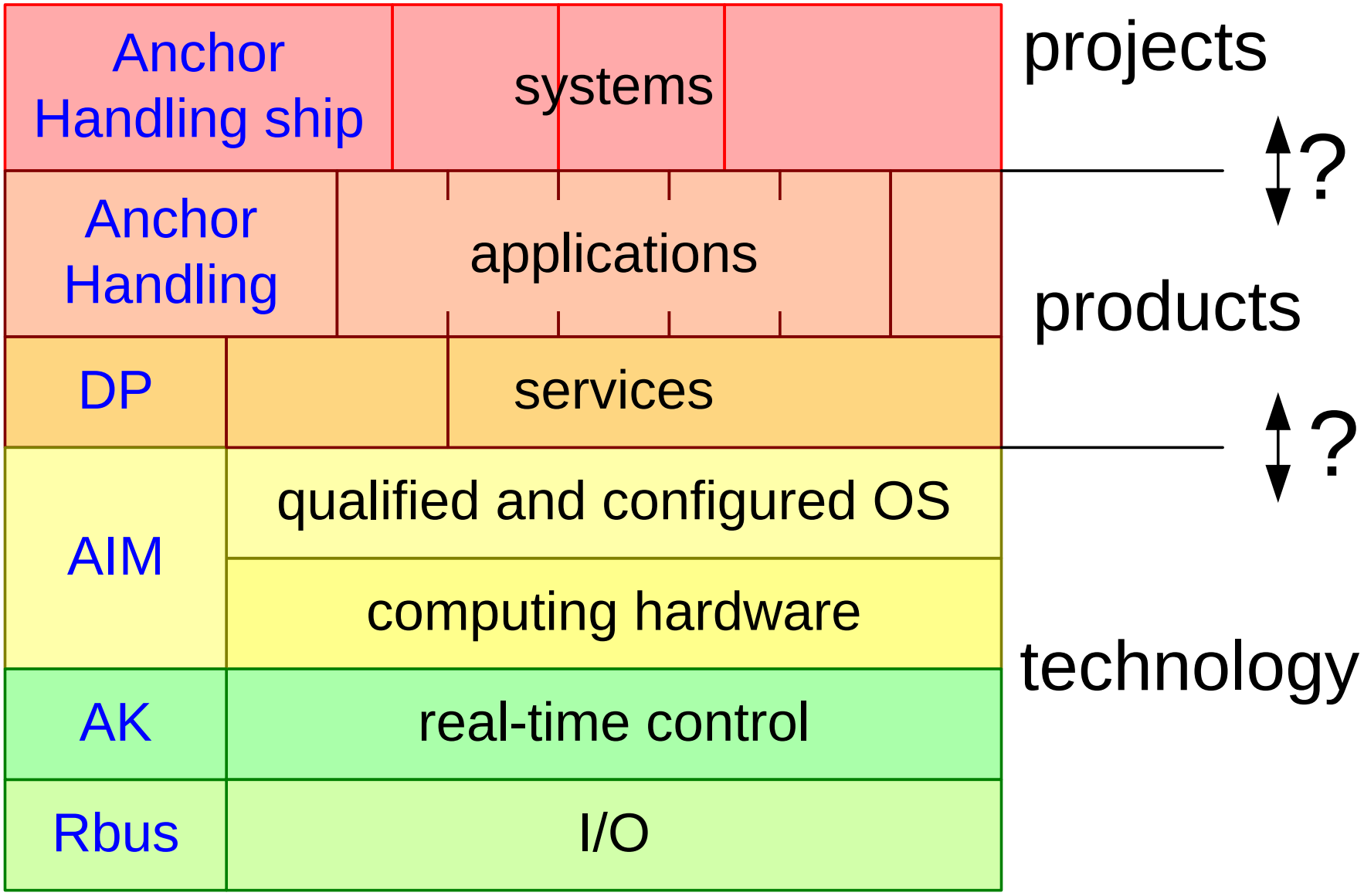
Designed for efficiency and safety

source:
http://www.km.kongsberg.com/ks/web/nokbg0240.nsf/AllWeb/F6D8ACE8F32AE306C12575C500323661?OpenDocument

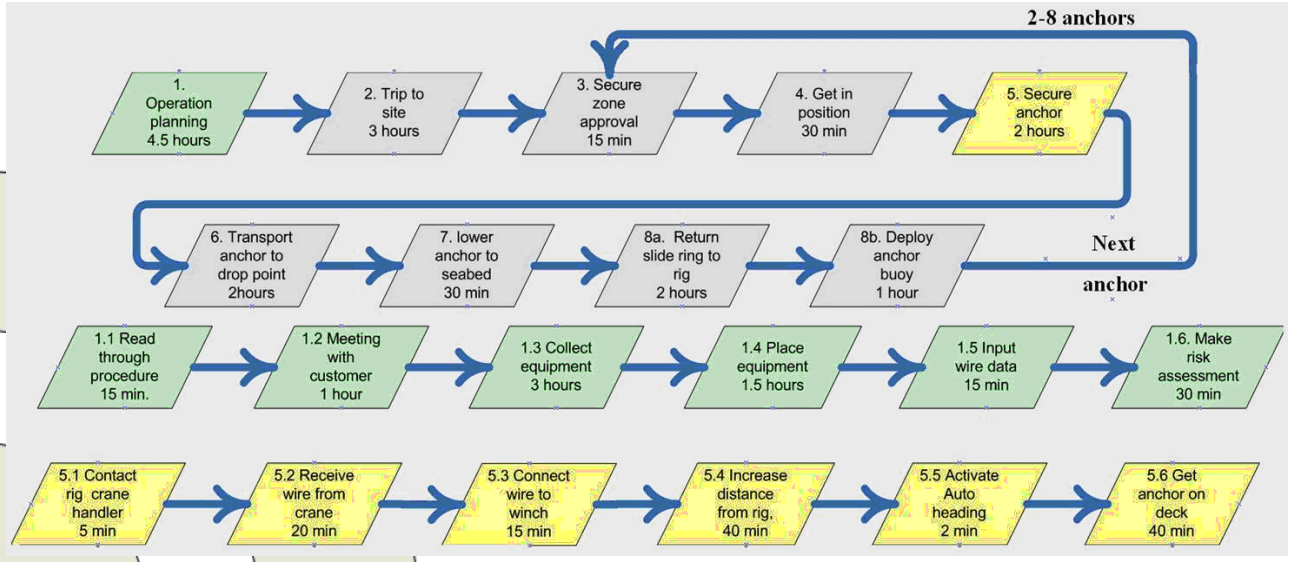
Integration of Existing Products



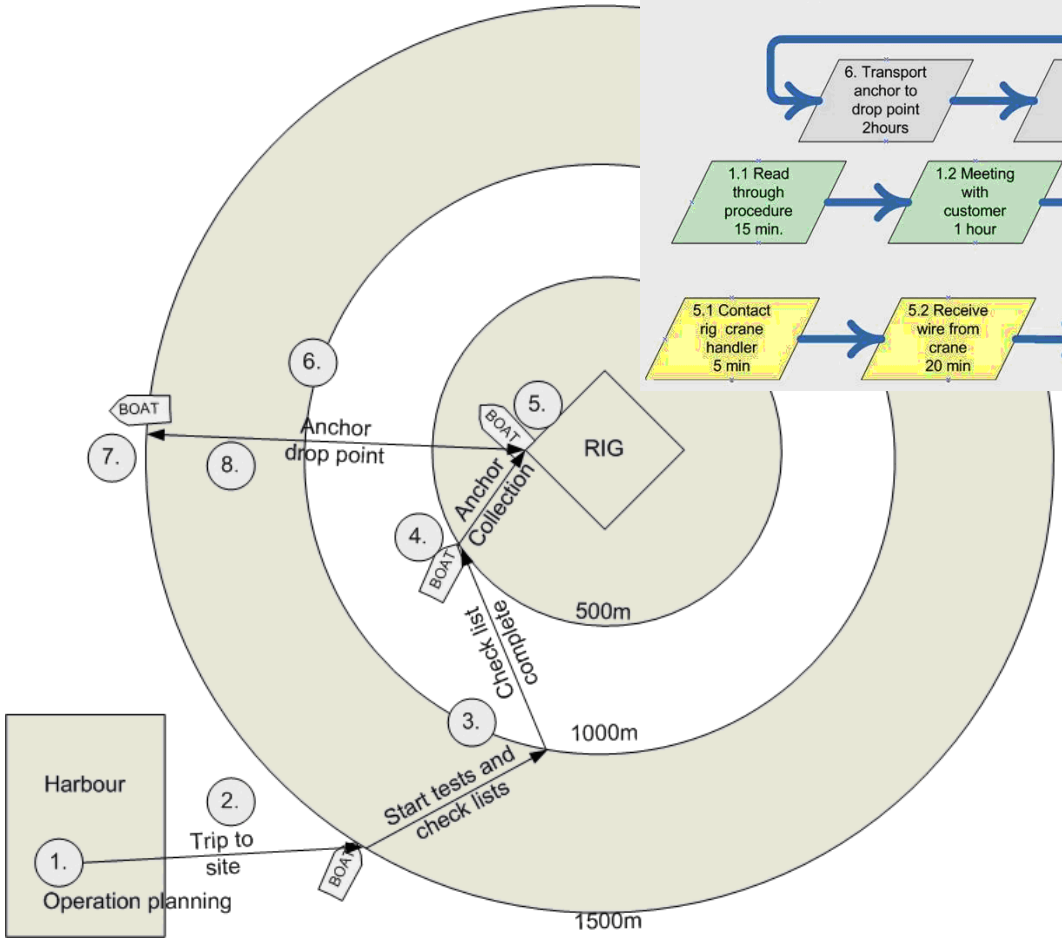
Software Stack



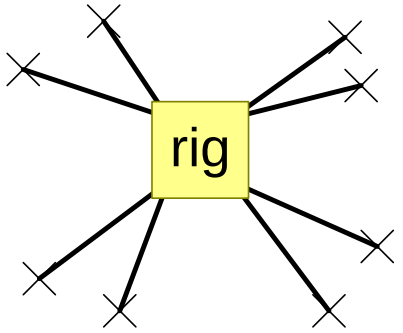
Understanding Stakeholder Needs



work flow



geographical

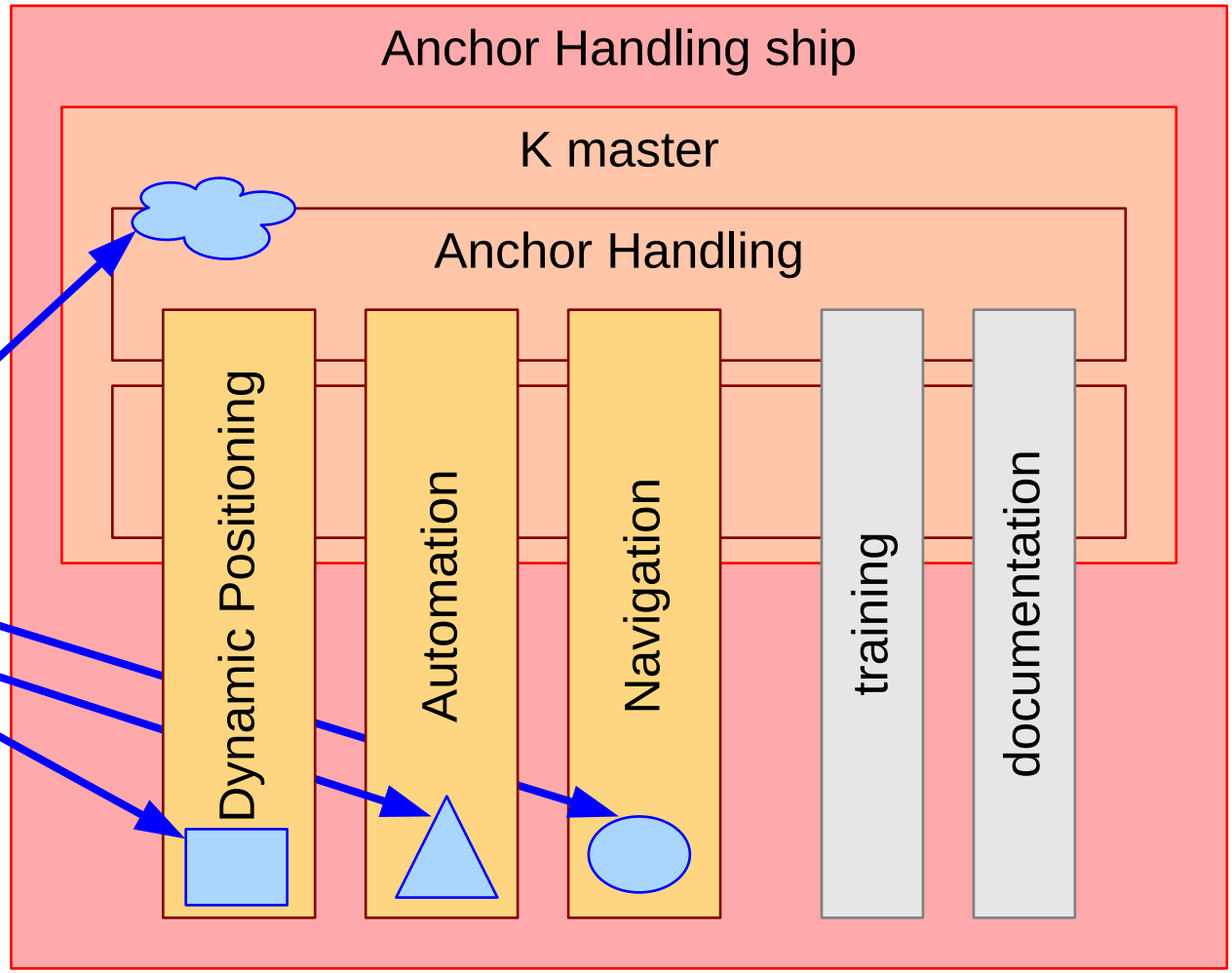


example of anchor placement

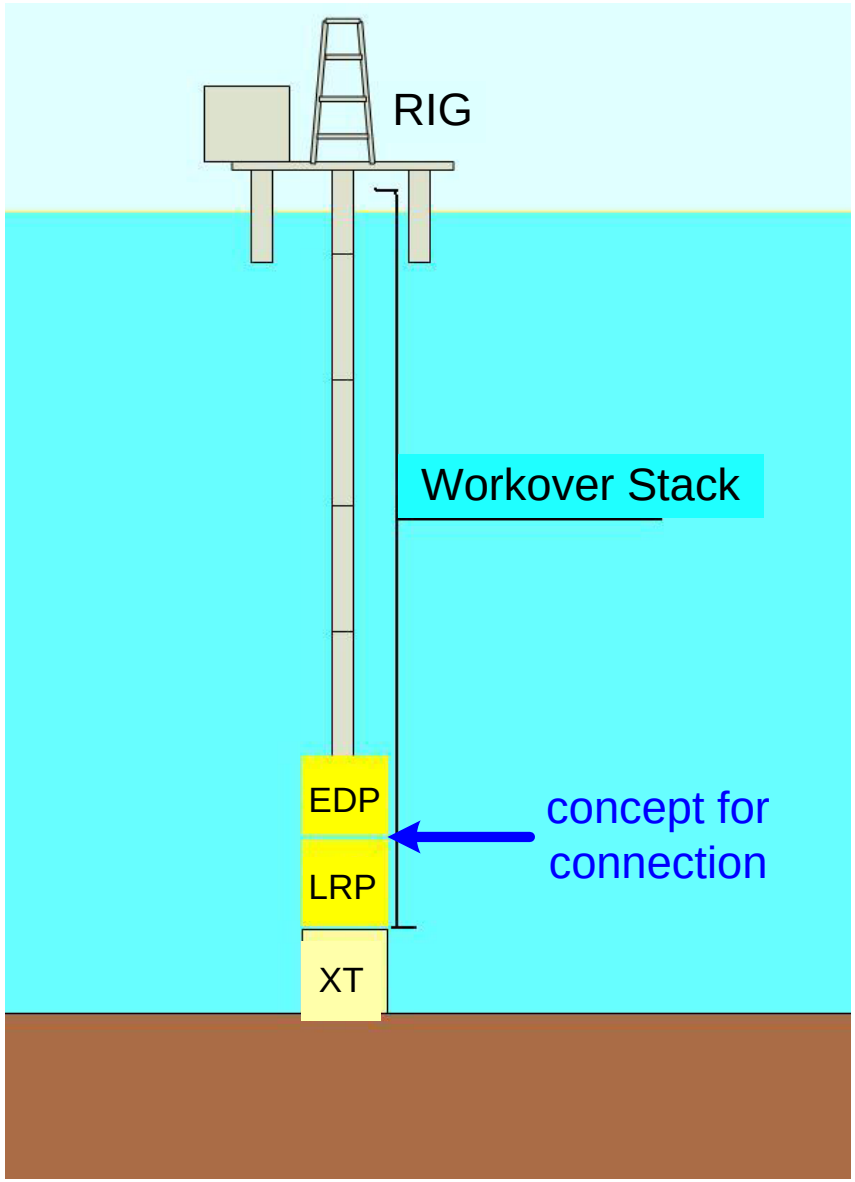
Example of System Quality: Configurability

emerging configurability:

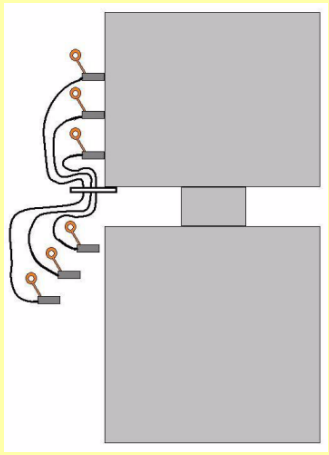
multiple configuration utilities configuring similar data in different ways



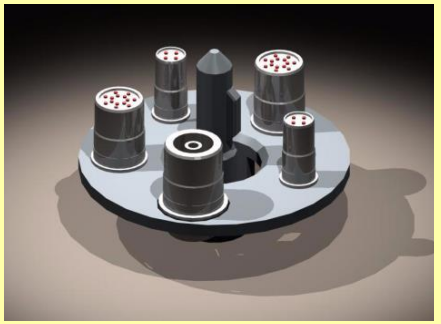
Concept Selection Examples from Subsea



two sided connectors

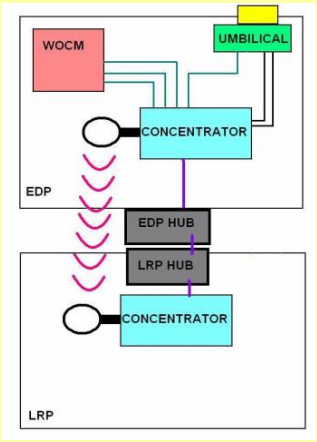


connectors in hub

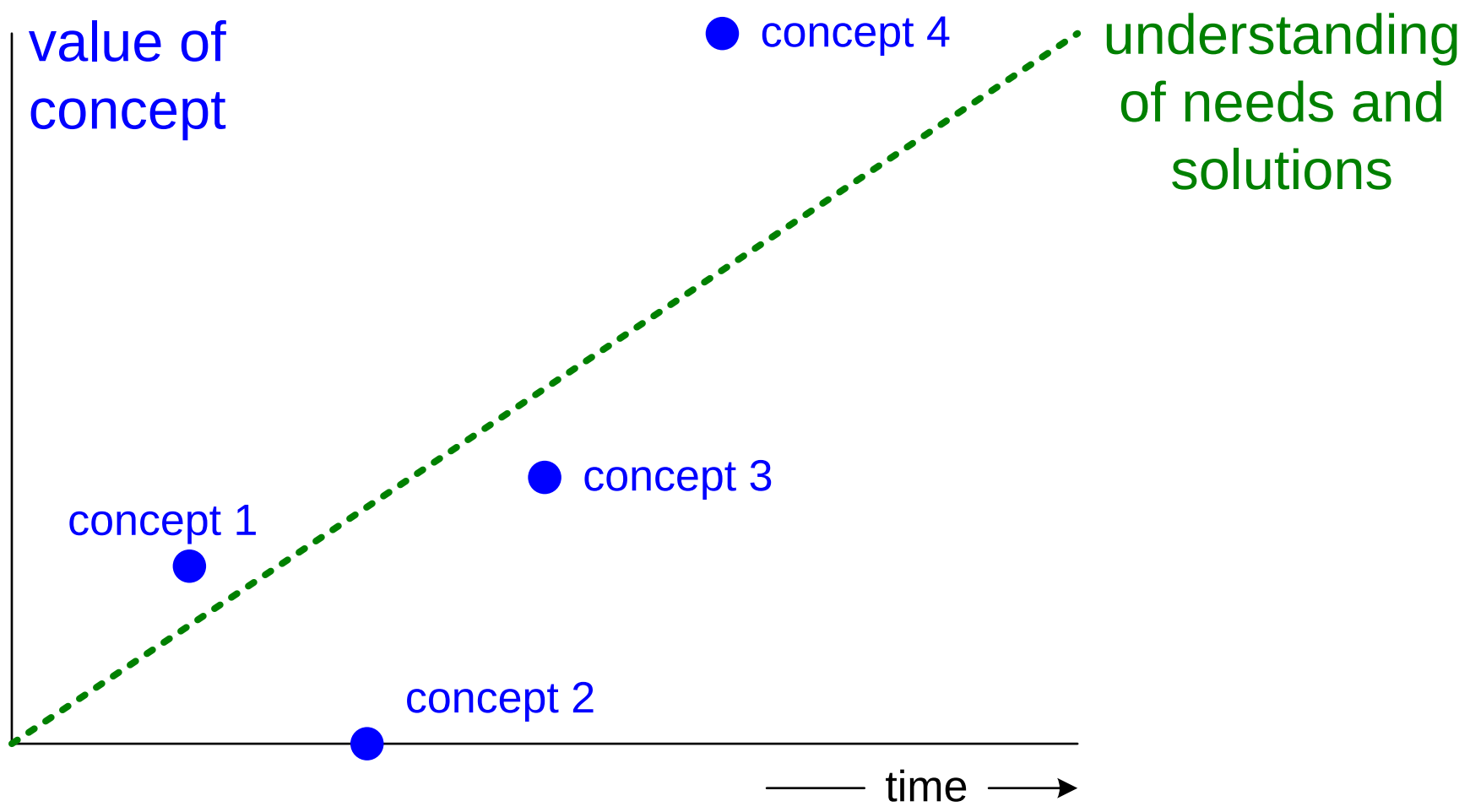


connectors in hub with roll-off

wireless connection

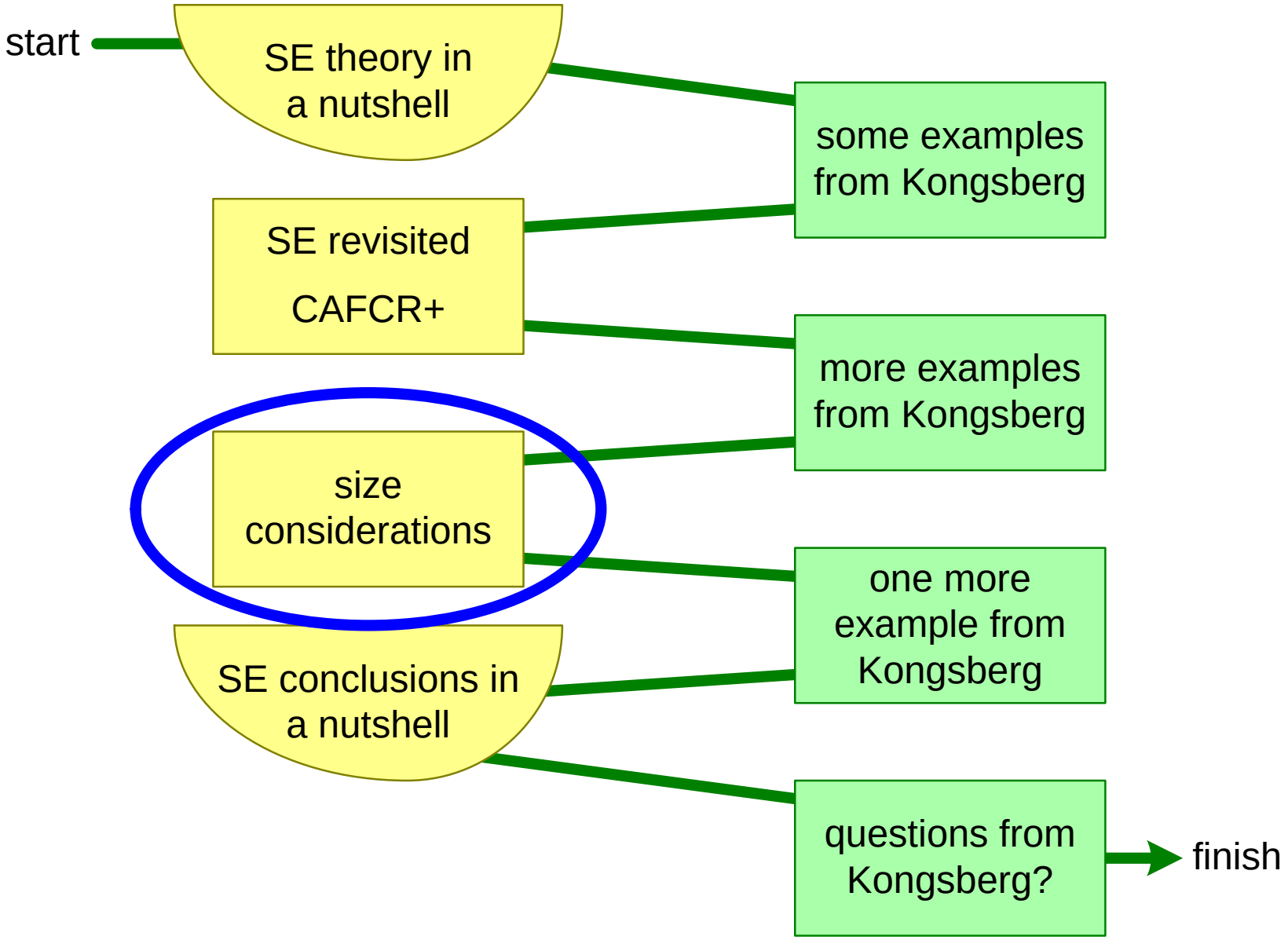


Quality and Understanding Improves by Iteration

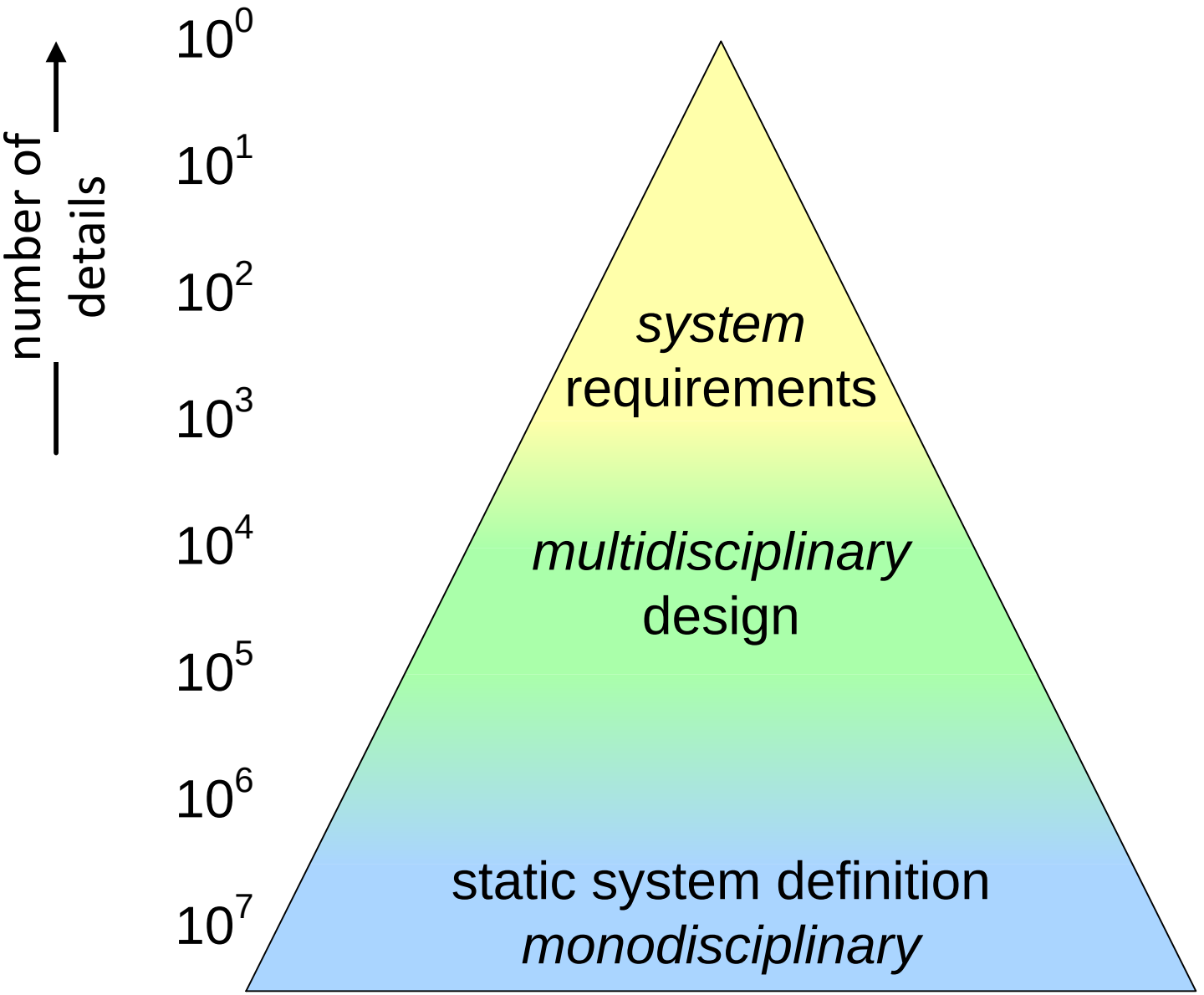


we learn by evaluating concepts; multiple iterations are needed

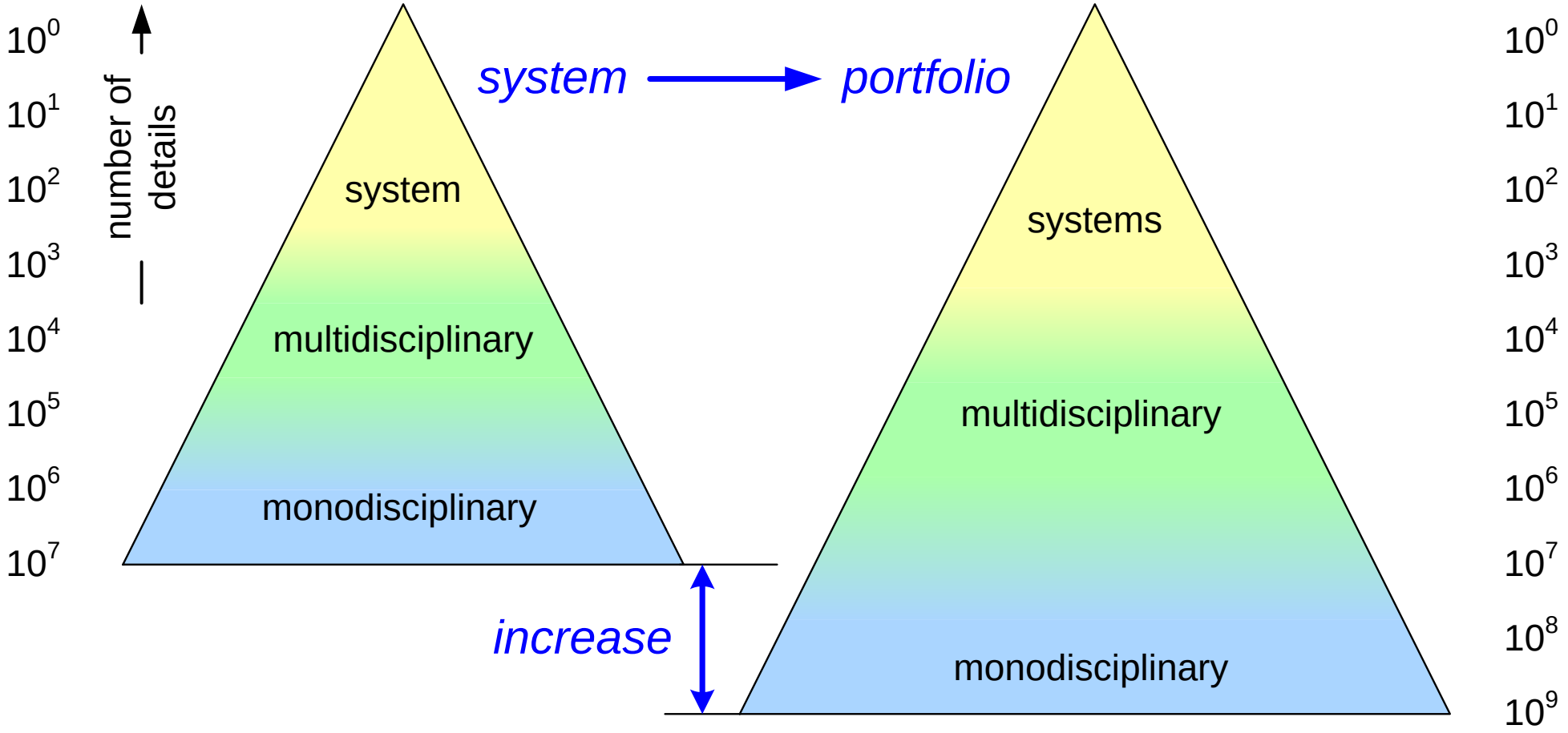
Size considerations



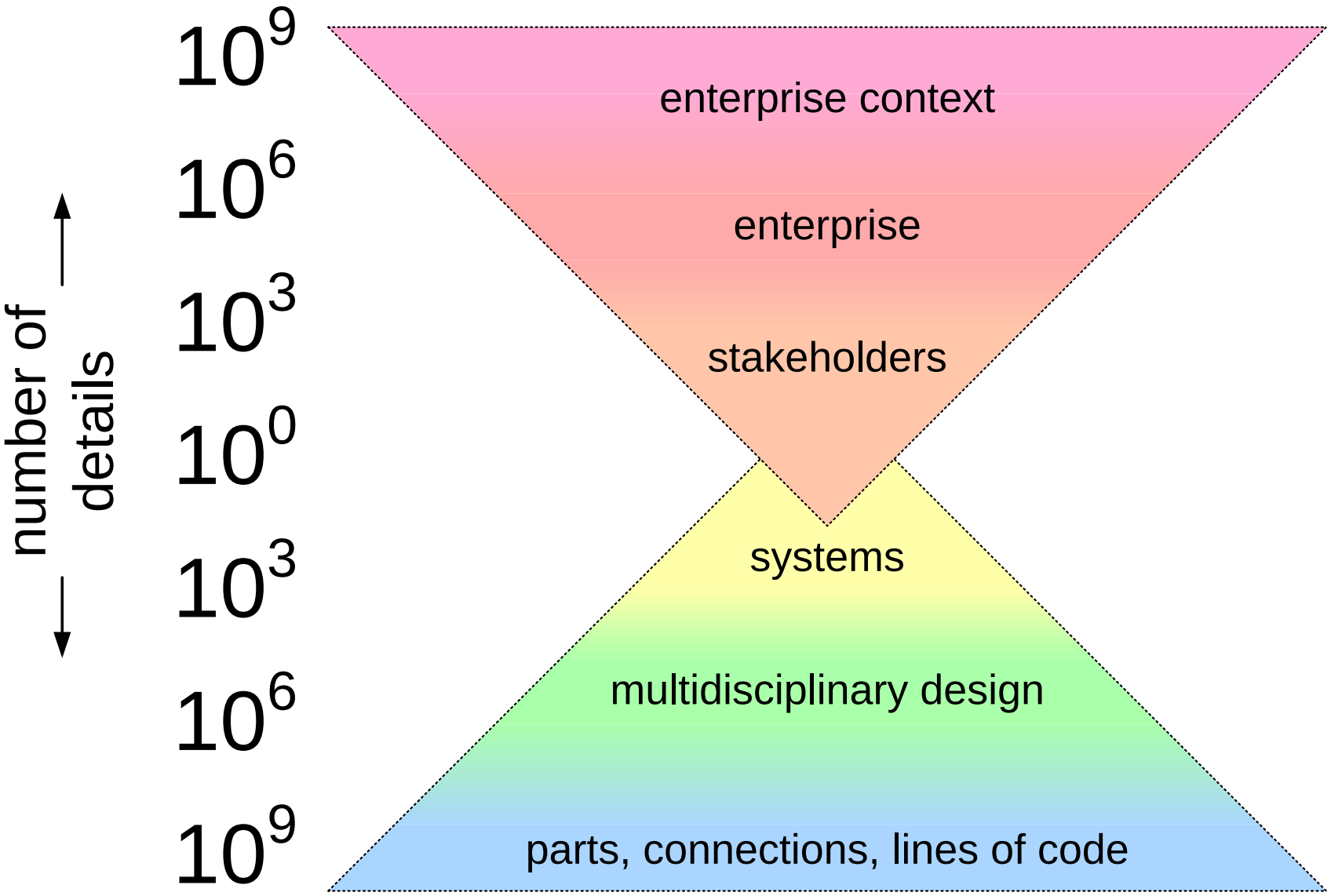
Level of Abstraction Single System



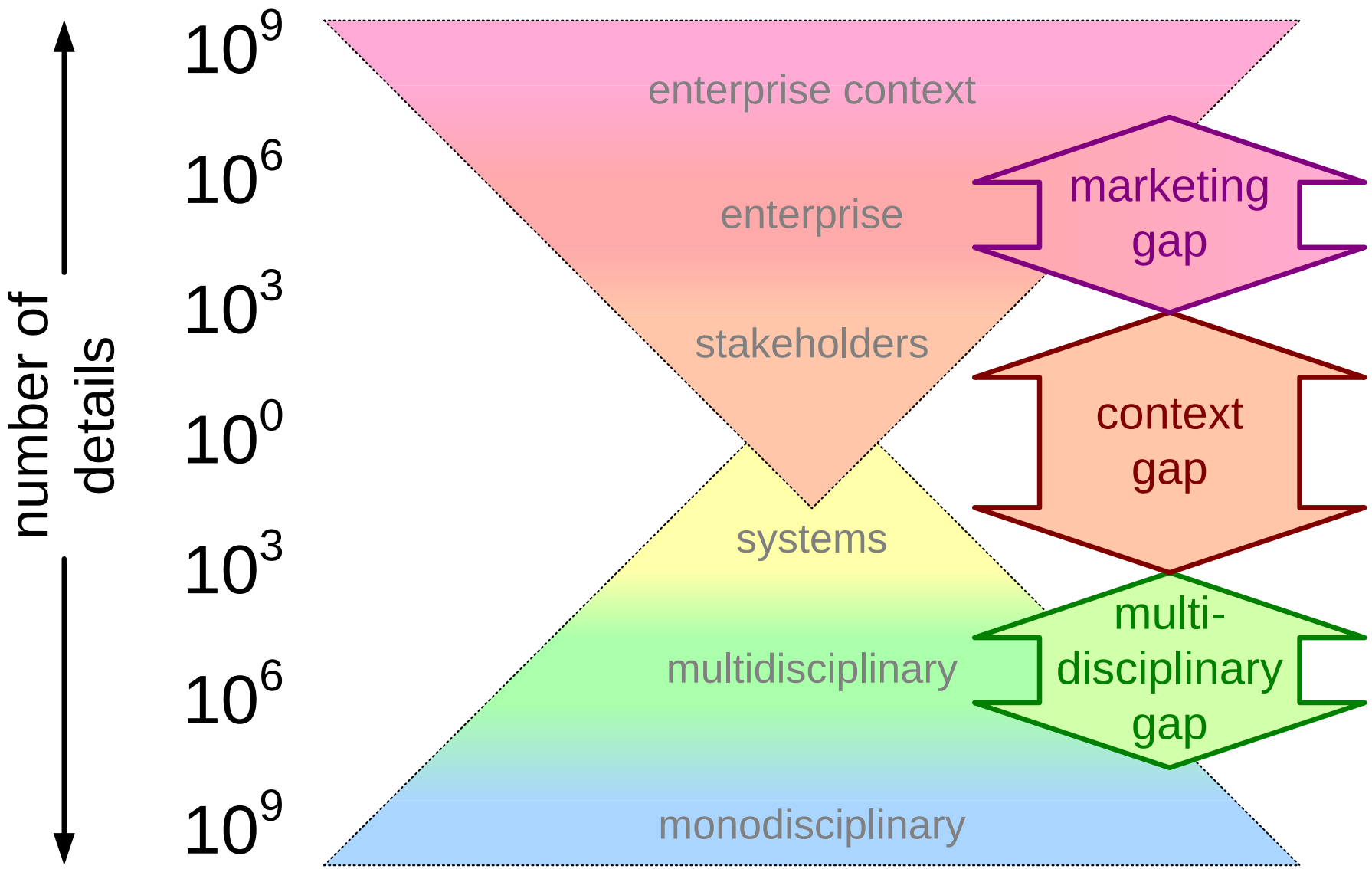
From system to Product Family or Portfolio



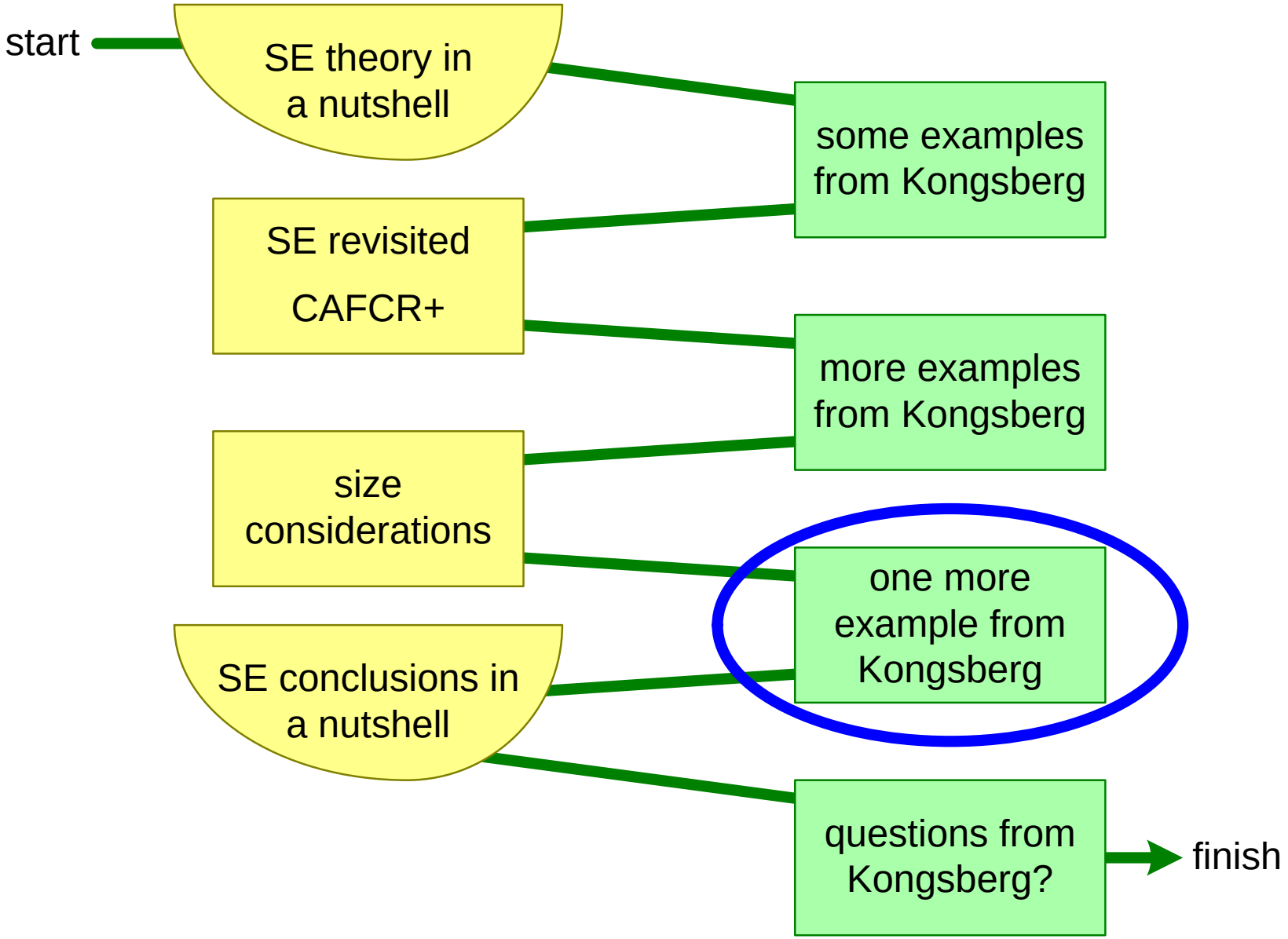
Product Family in Context



Frequently observed gaps



One More Example from Kongsberg



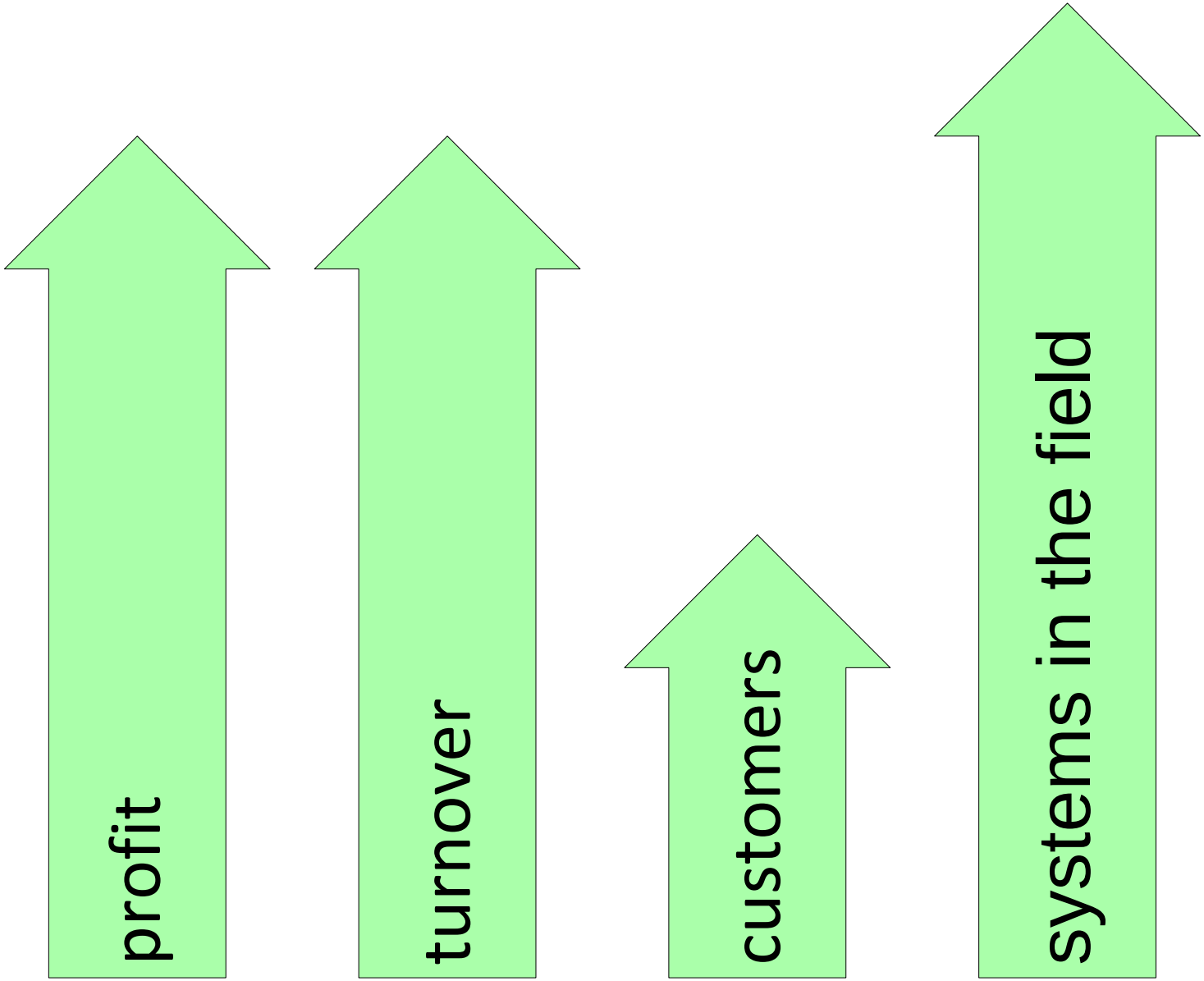
Highly Successful Remote Weapon Station

Extreme fast growing business: Remote Weapon Station

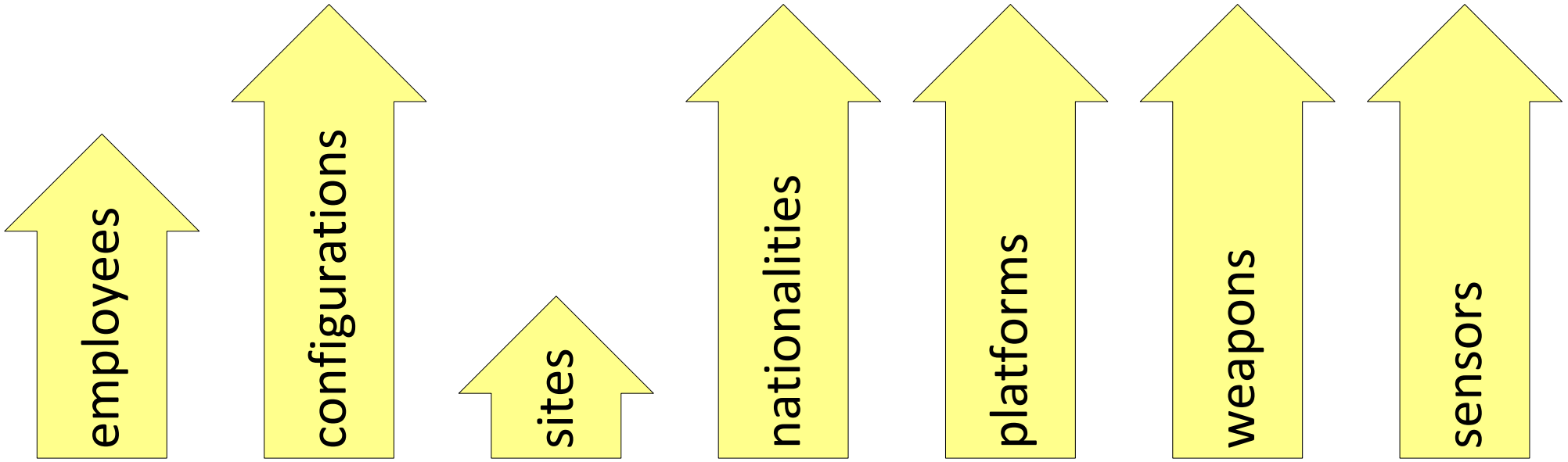
* PROTECTOR Hellfire
* PROTECTOR Javelin
* PROTECTOR Lite
* PROTECTOR NM221
* Sea PROTECTOR
* PROTECTOR M151
* PROTECTOR CROWS
* PROTECTOR Training Systems

source:
http://www.kongsberg.com/en/KPS/Products/RemoteWeaponStation.aspx

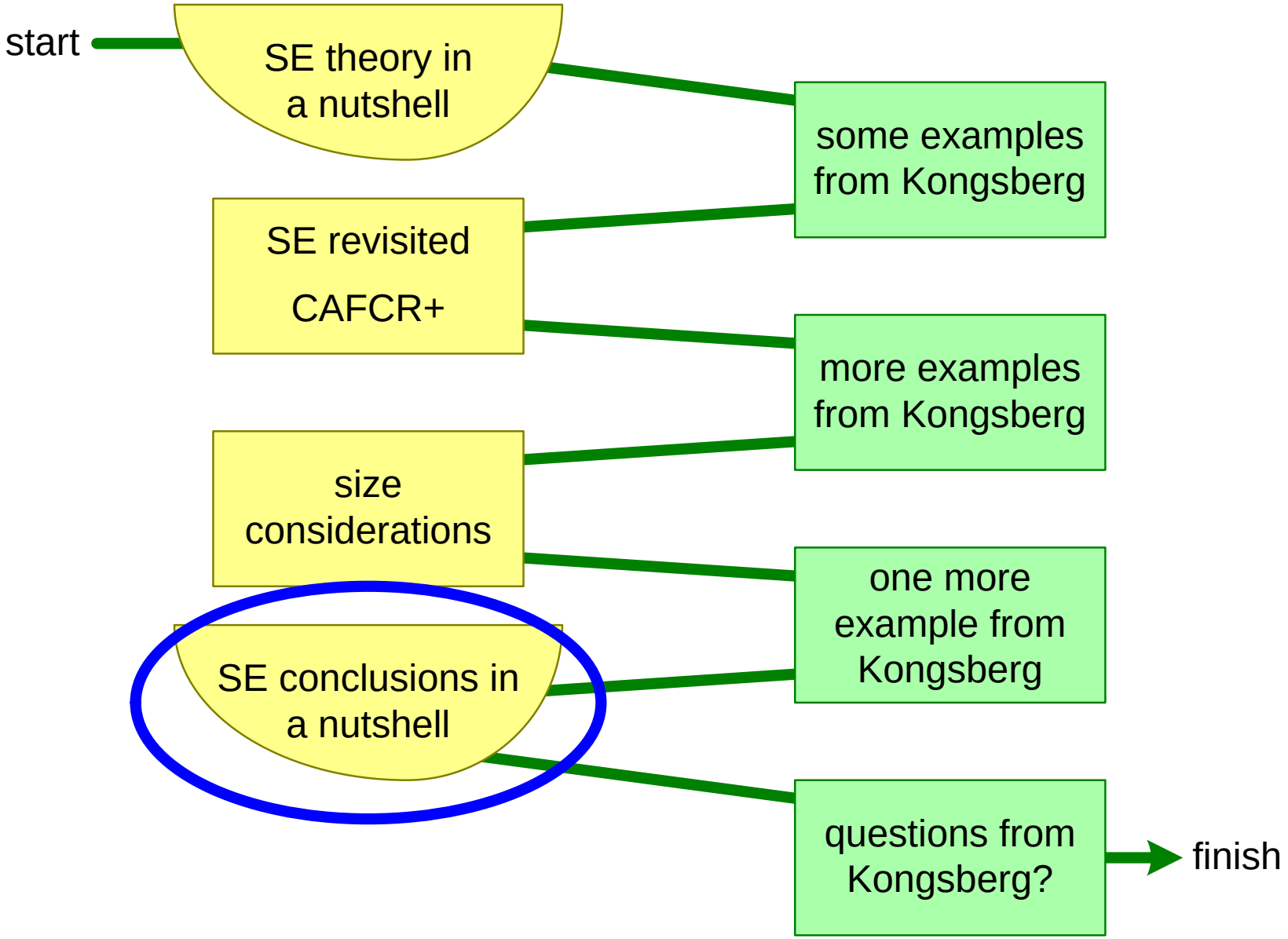
Growth in many directions



Consequences of Growth



Conclusions Systems Engineering



What I Hope that you will Remember

Know your stakeholders and their needs and concerns.

The specification must fit the needs.

Concepts and technology must be appropriate.

The system must fulfill all qualities.

And all of this has to happen in time. no analysis paralysis

Colophon

This presentation is partially based on the master project work of:

Ola Gustav Kalager

Håvard Ruden

under supervision of Thor Hukkelås

and on research work within the Kongsberg Group

where many employees contributed thorugh interviews or work shops.

One example is based on the master project of Dag Jostein Klever (FMC)

Questions from Kongsberg