

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.

Distribution

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July 1, 2011
status: preliminary
draft
version: 0.1

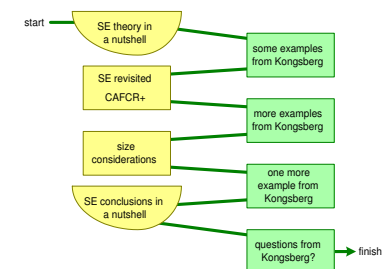
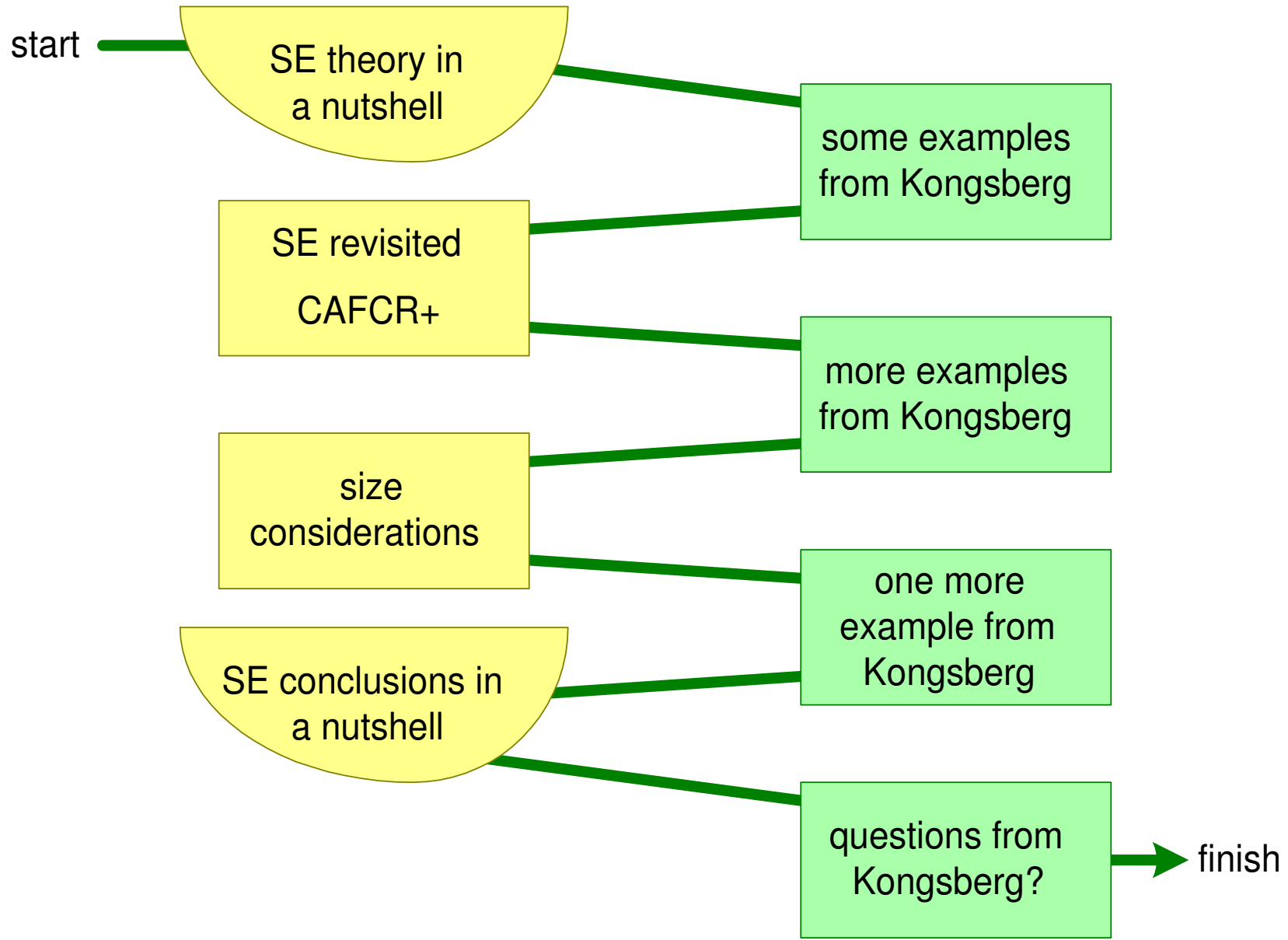


Figure Of Contents™



Systems Engineering theory

Follow phase model

needs > requirements > concepts > detailed design

SMART Requirements

Evaluate multiple concepts

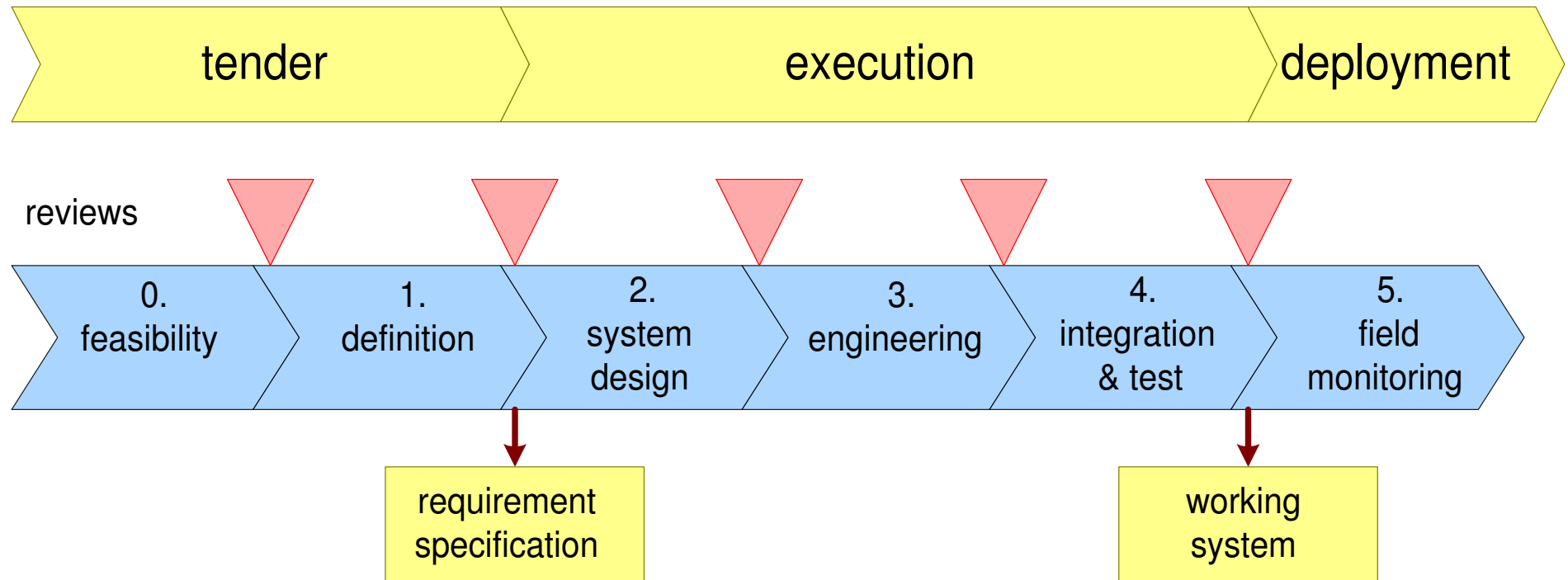
Think "Functional", What versus How

typical buzzwords

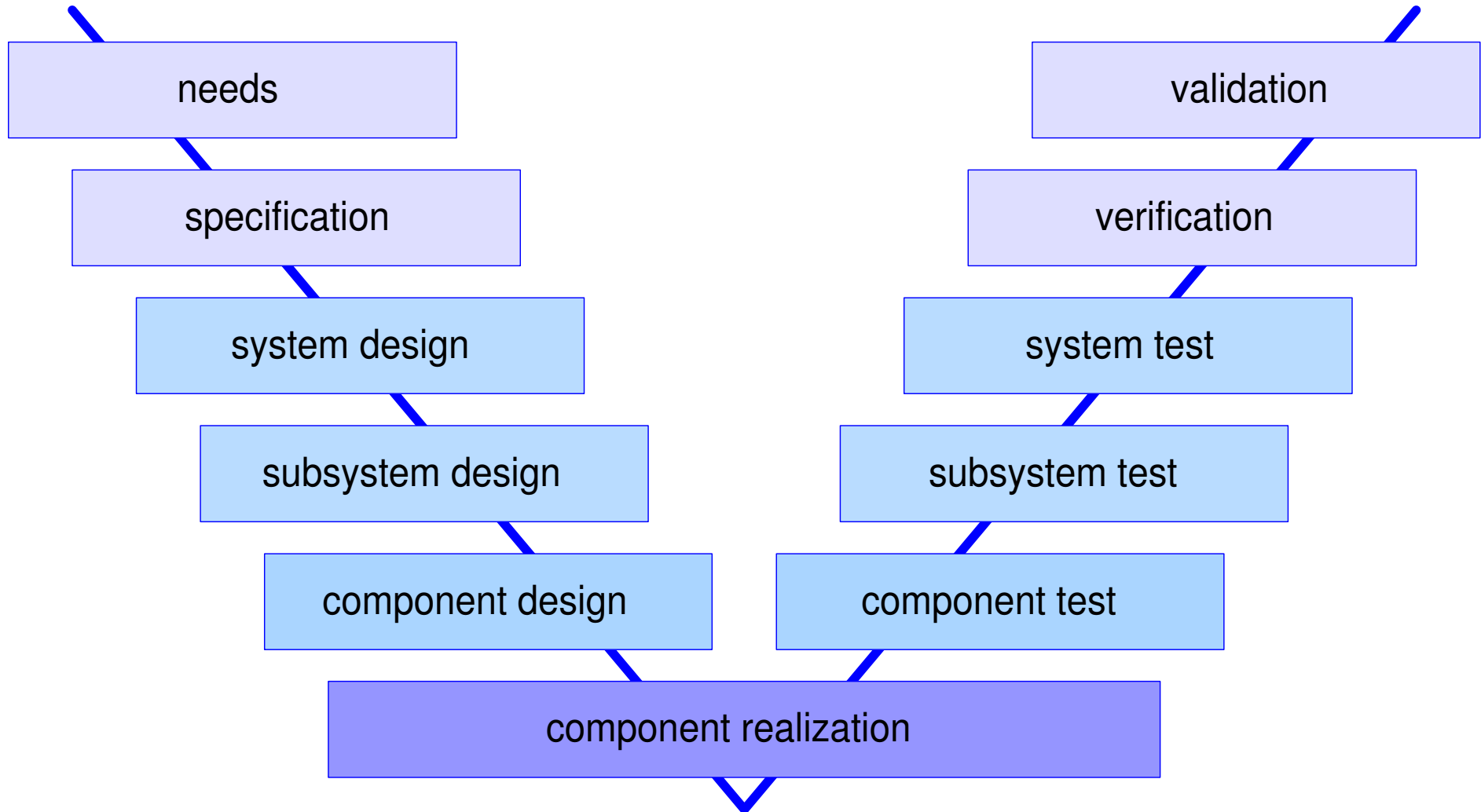
stakeholders, concerns, life cycle,

risks, reviews, V-model

Phase Model for Development



V-Model



The SMART acronym

- Specific

quantified

- Measurable

verifiable

acronym consensus

- Assignable (Achievable, Attainable, Action oriented, Acceptable, Agreed-upon, Accountable)

- Realistic (Relevant, Result-Oriented)

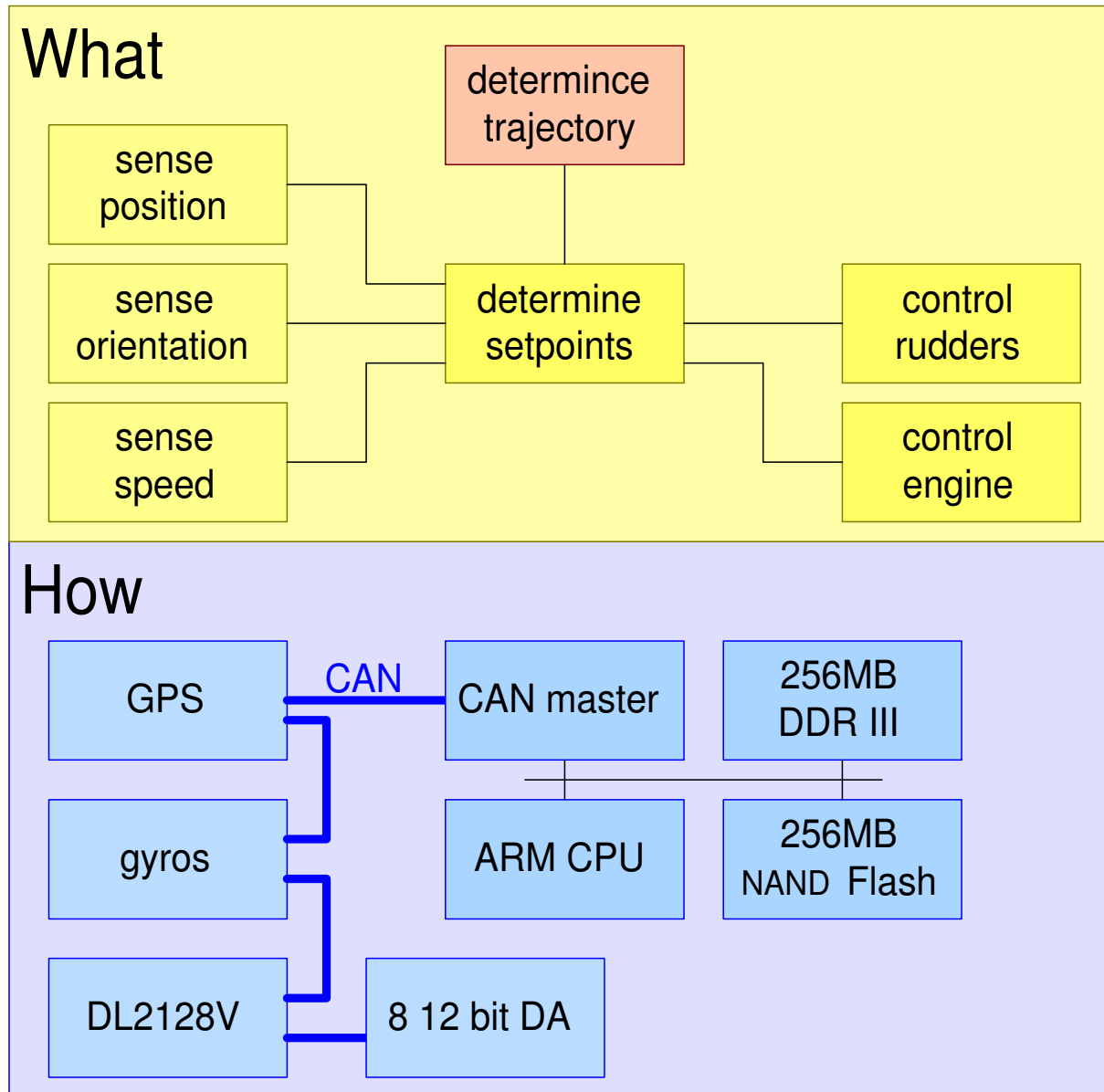
- Time-related (Timely, Time-bound, Tangible, Traceable)

variation of meaning

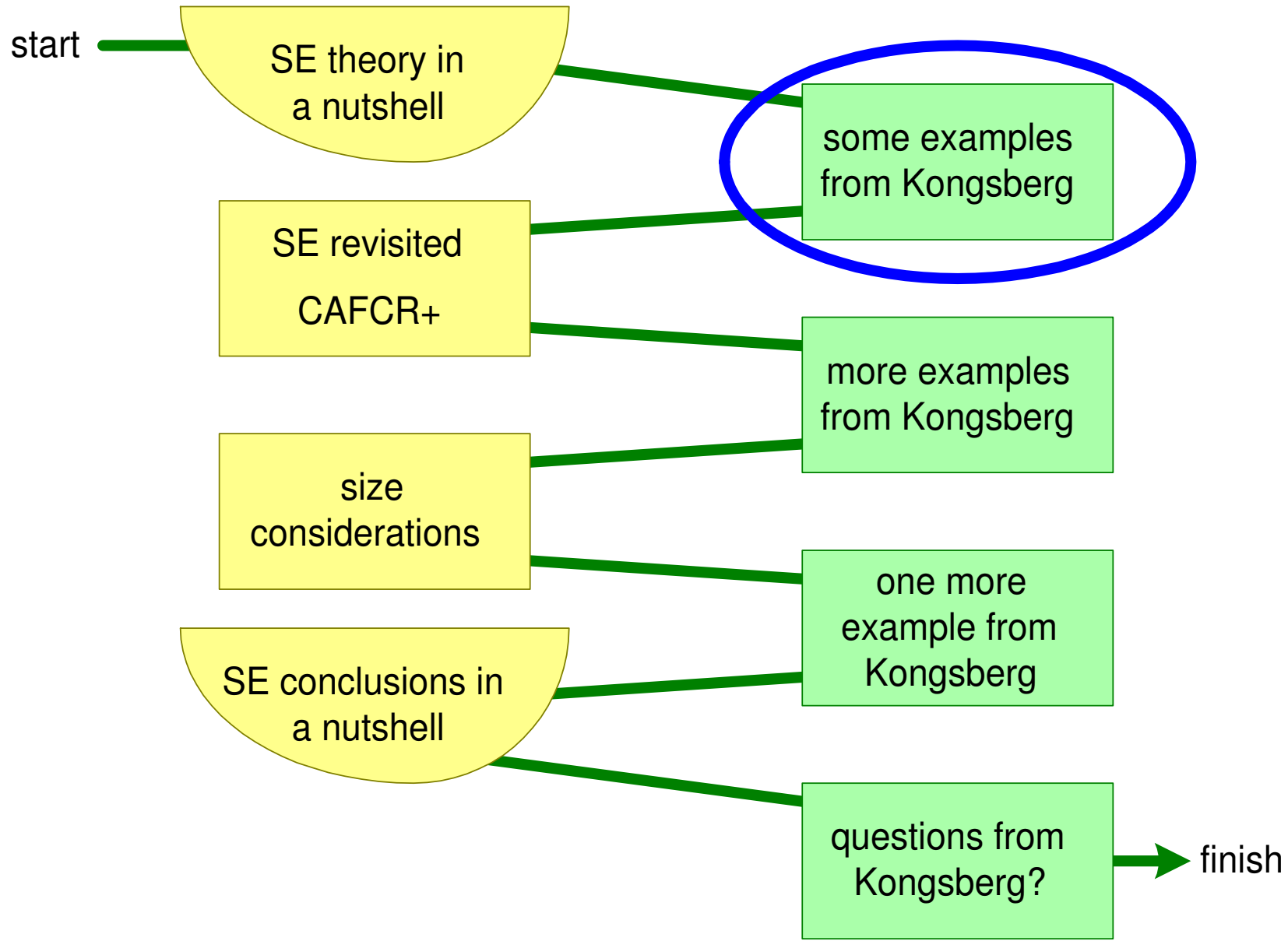
Concept Selection “Pugh” Matrix

	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

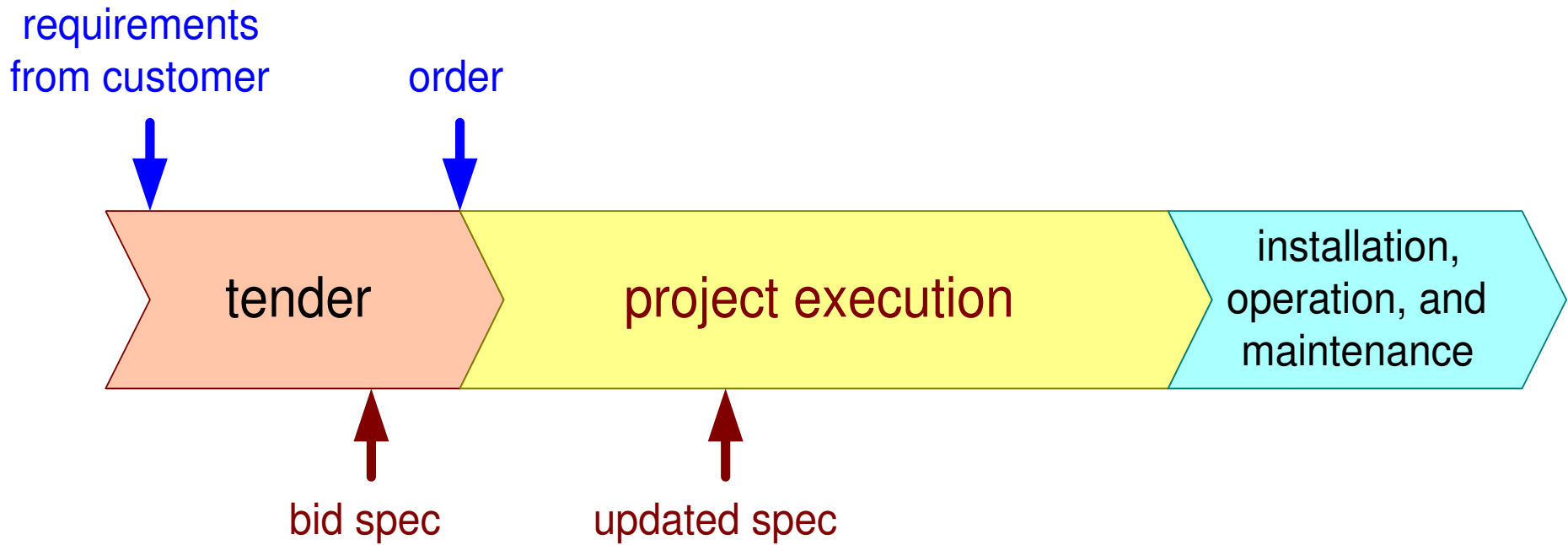
“Functional” Thinking; What and How



Examples from Kongsberg



Typical Tendering with Navy

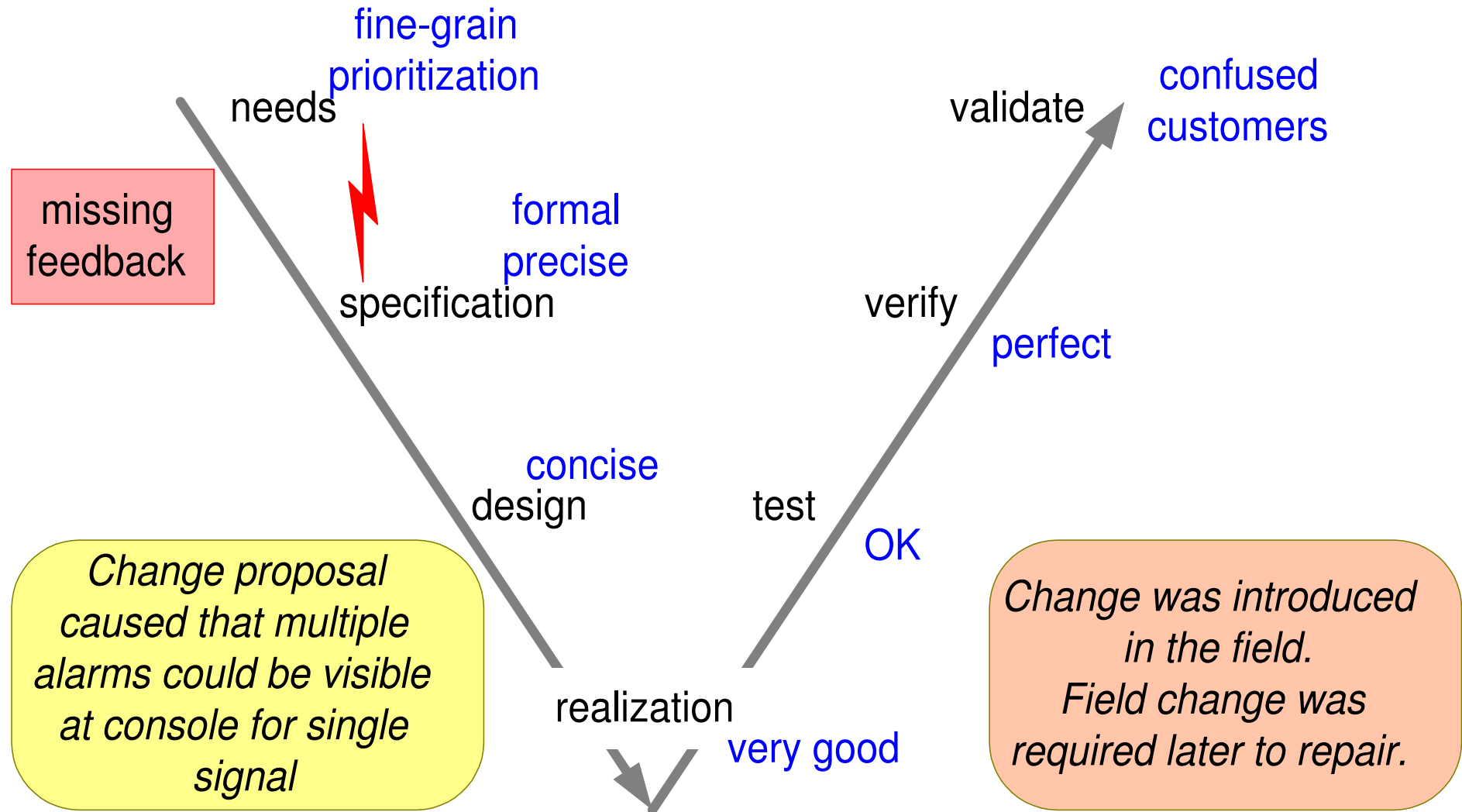


must
want

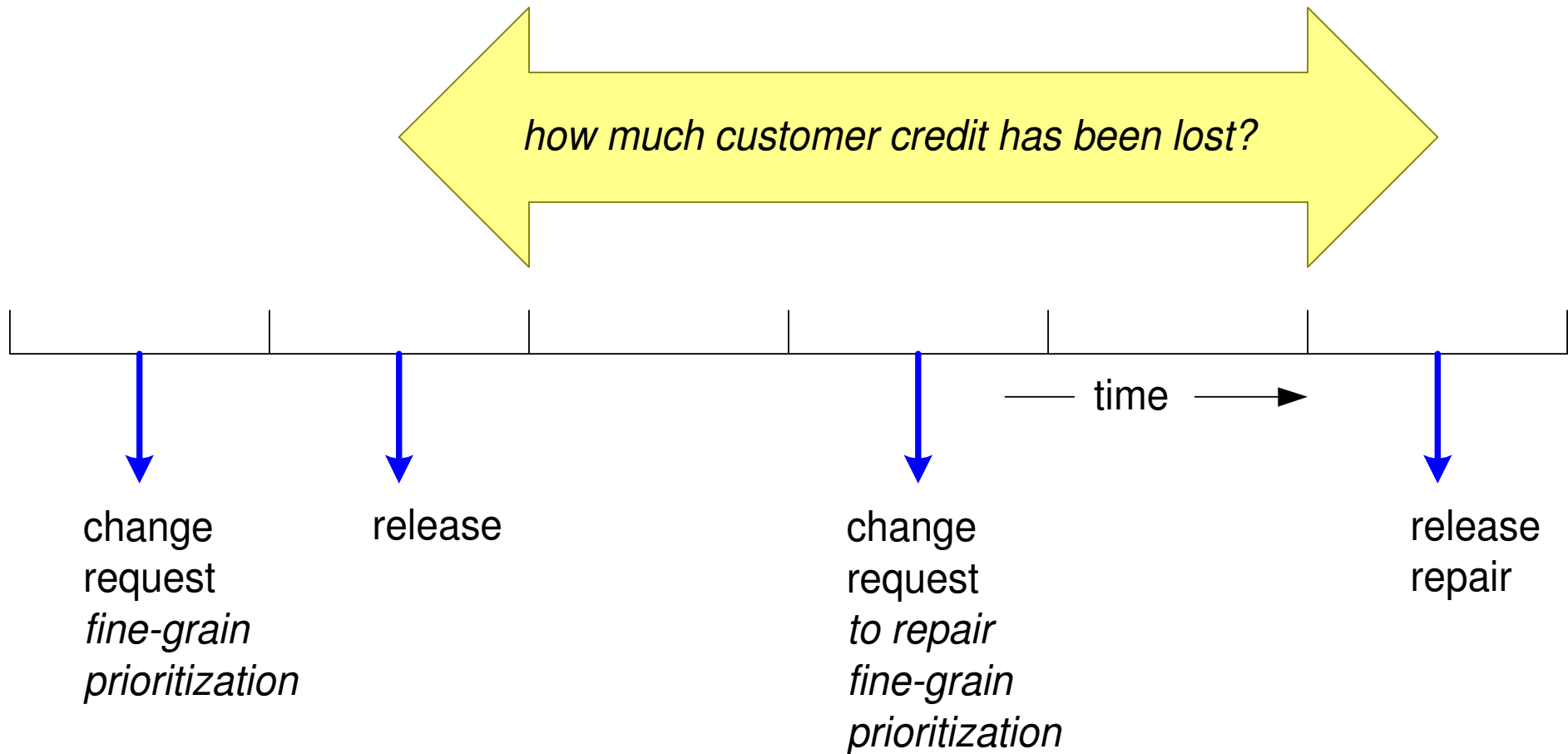
yes	by definition!
yes	
yes	
yes	
no	
yes	
no	
no	

yes	spec changes
yes'	
no	real discussion after order
no	
no	new insights
no	
yes"	
no	
no	customer understanding required
no	

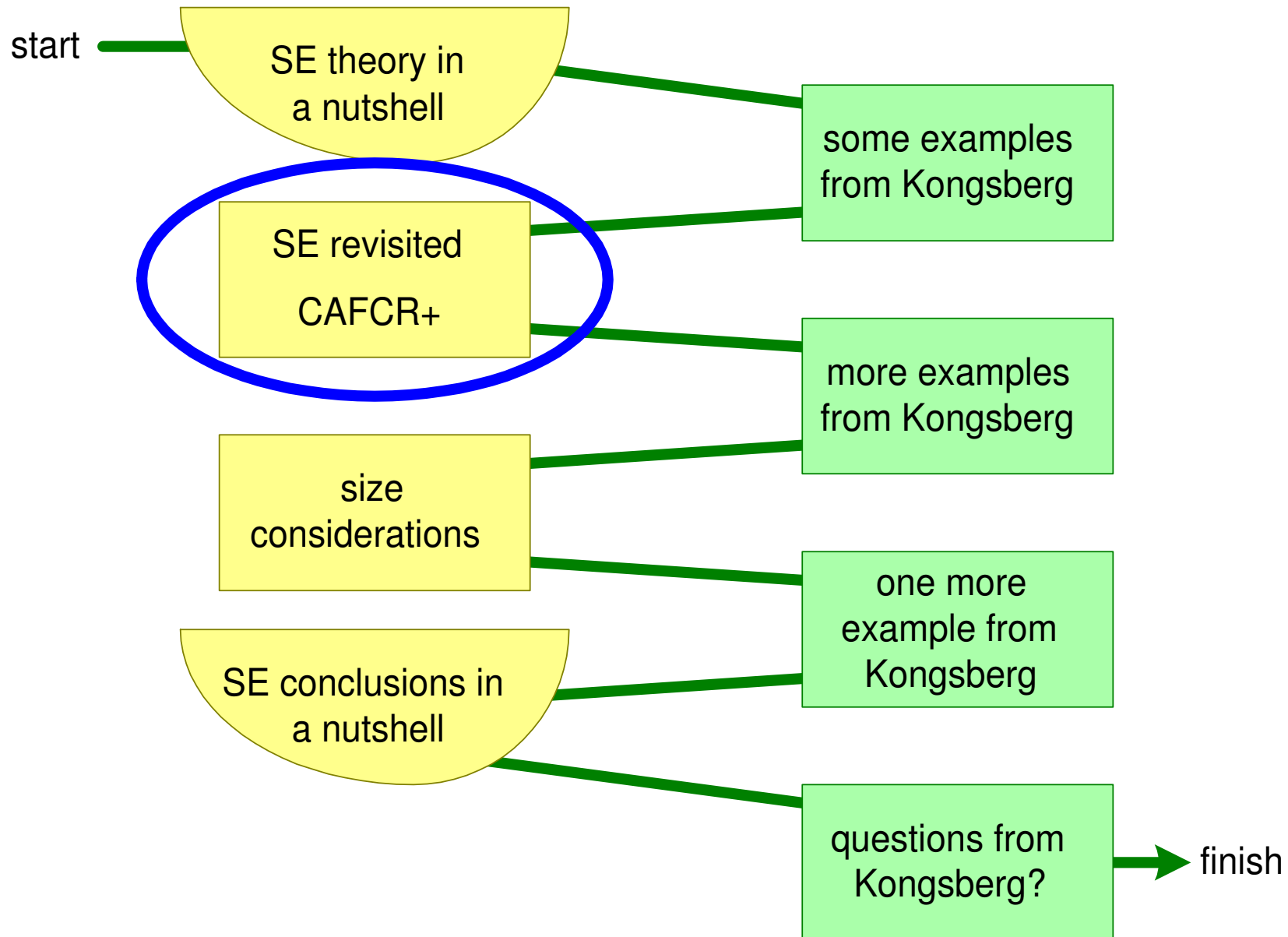
Rigor may Back Fire



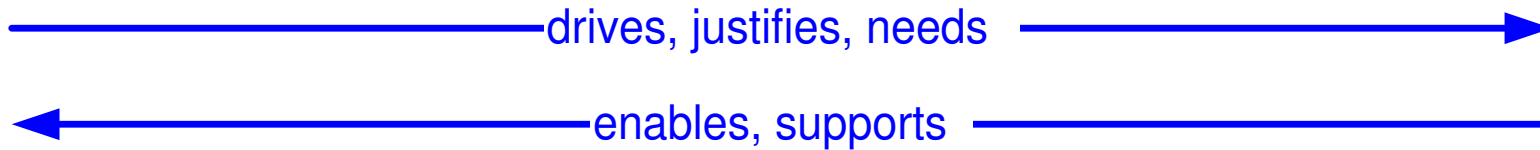
Latency of Introduction, Detection and Repair



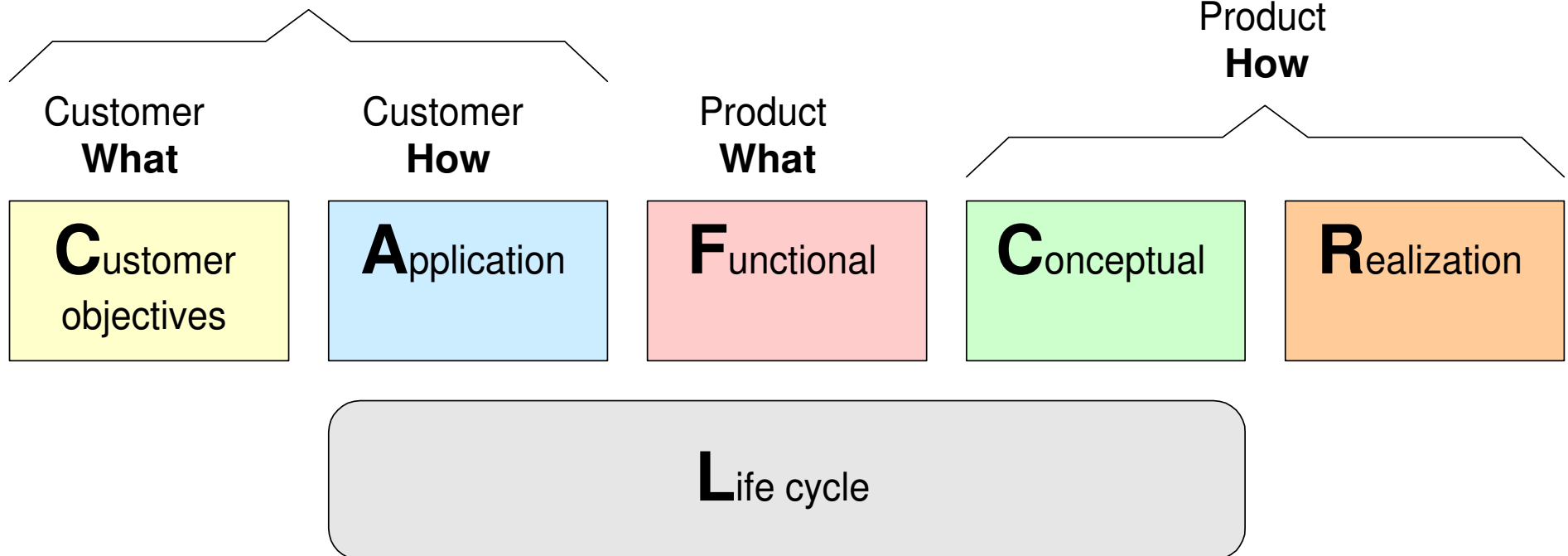
SE revisited; CAFCR+ model



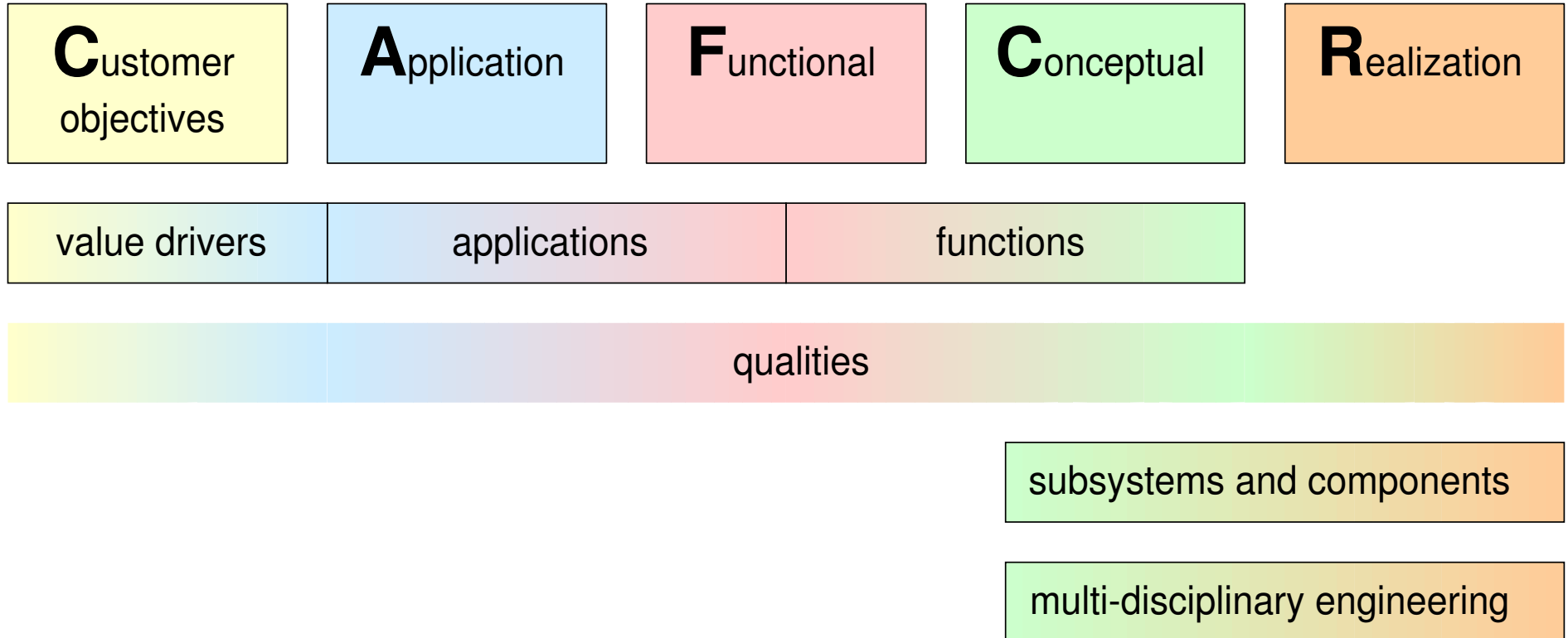
CAFCR+ model



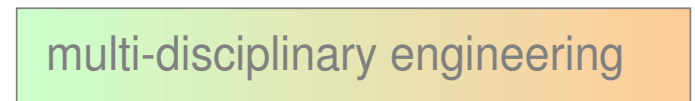
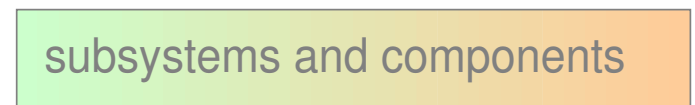
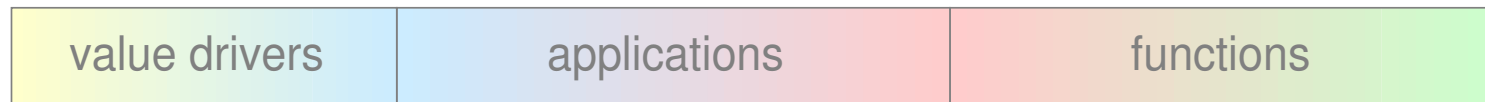
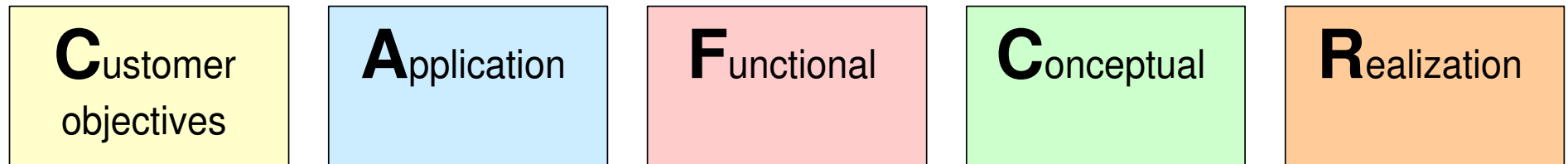
What does Customer need
in Product and **Why?**



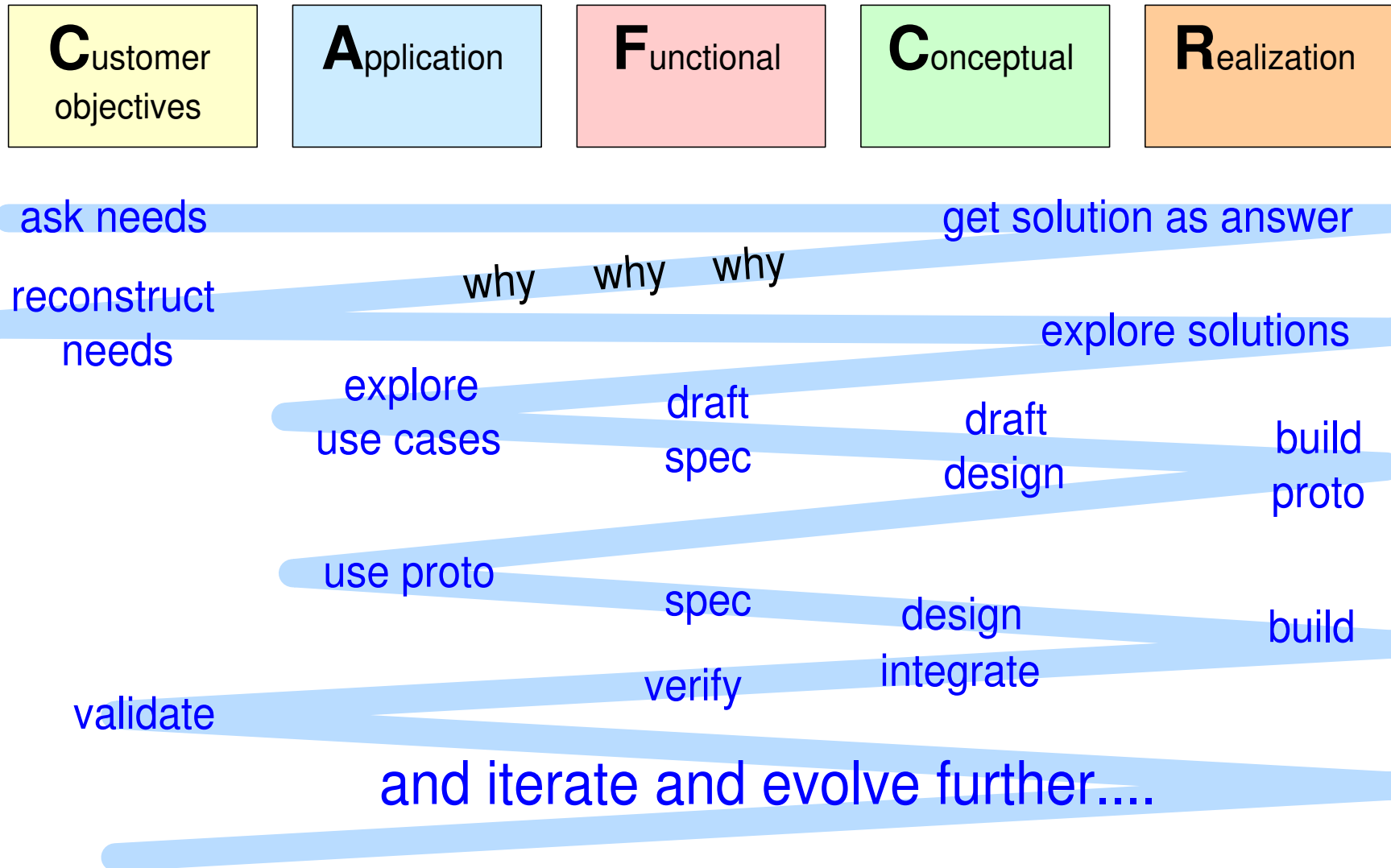
SE activities in CAFCR



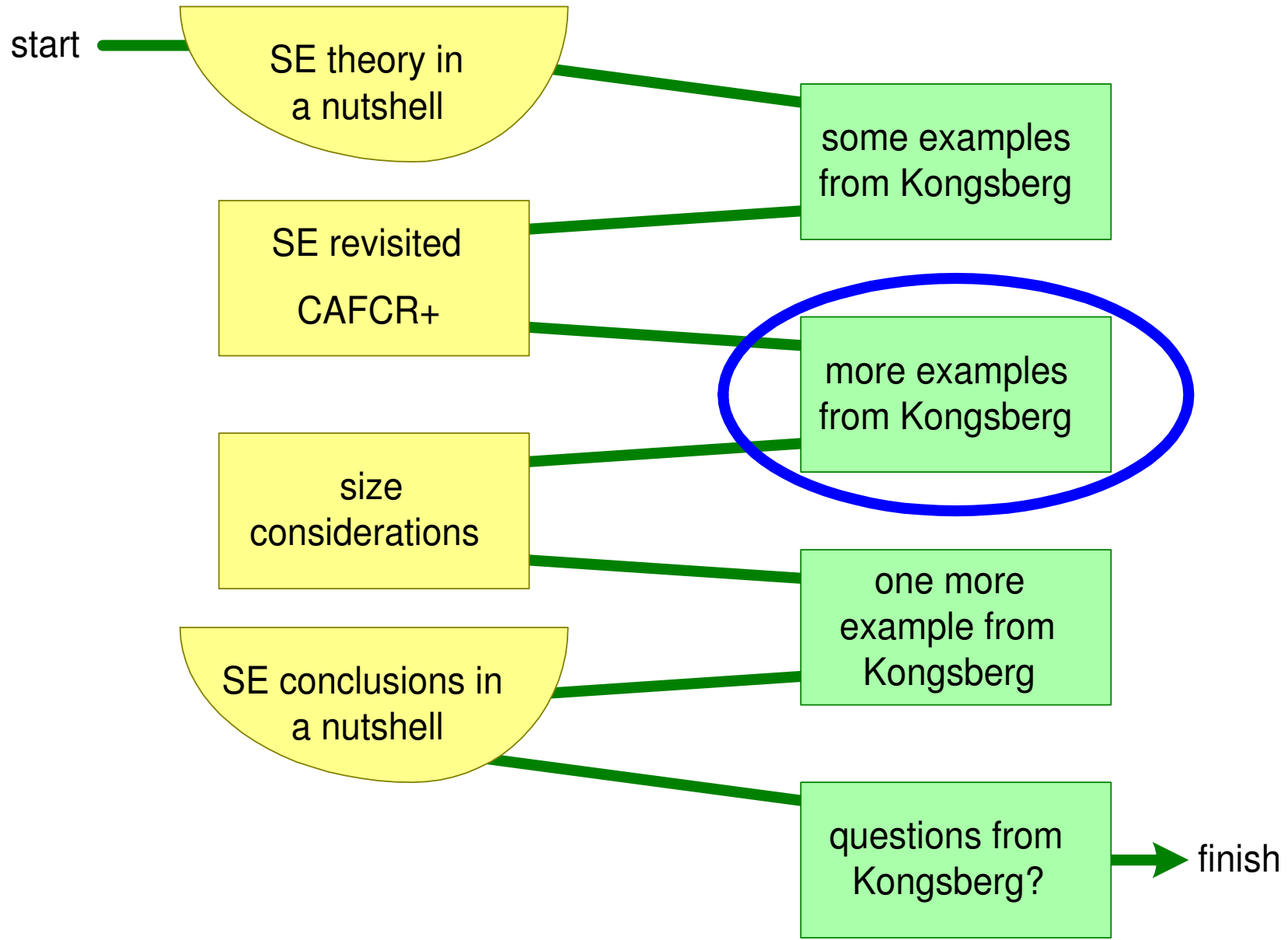
SE revisited



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

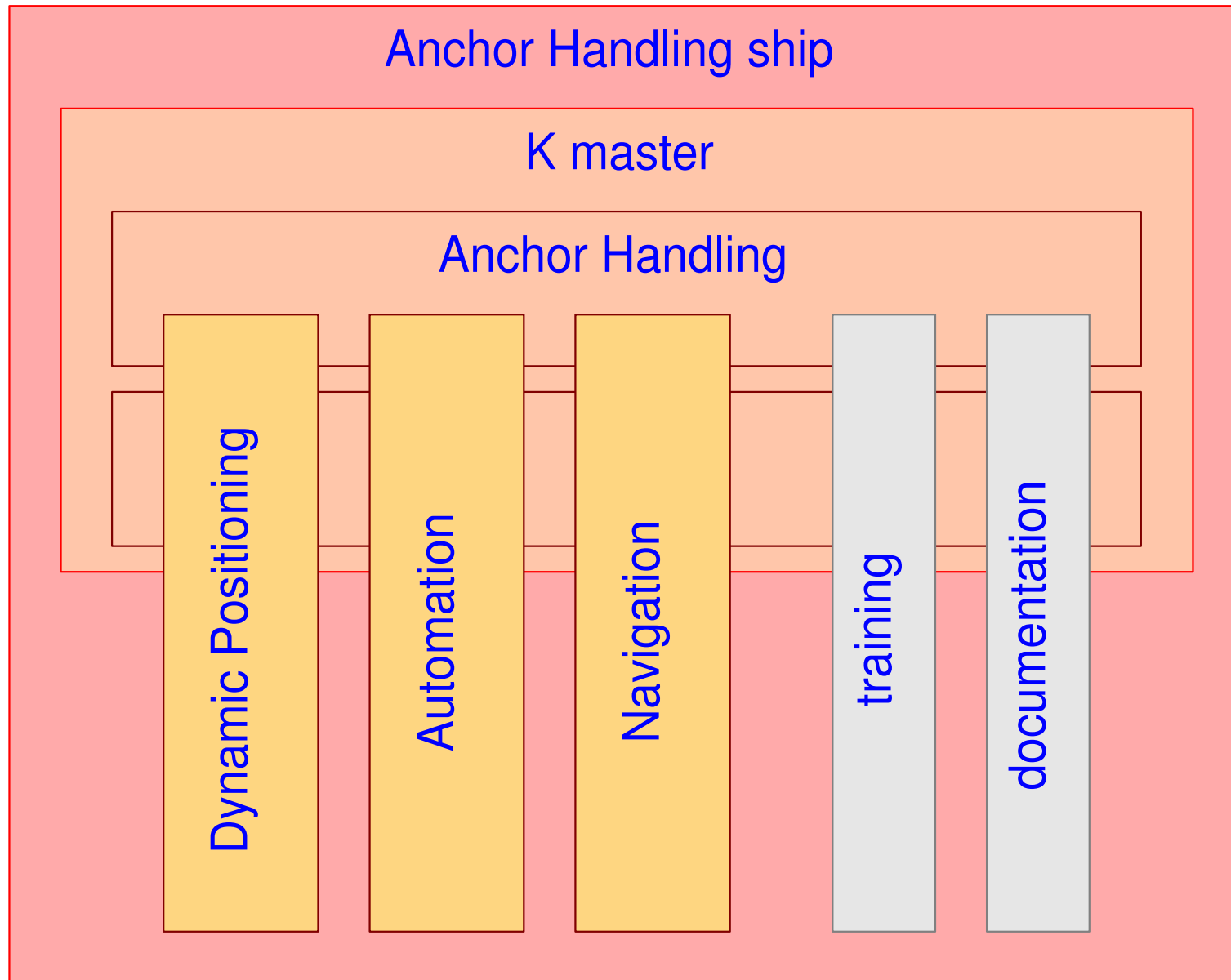
Bridge auxiliaries

Designed for efficiency and safety

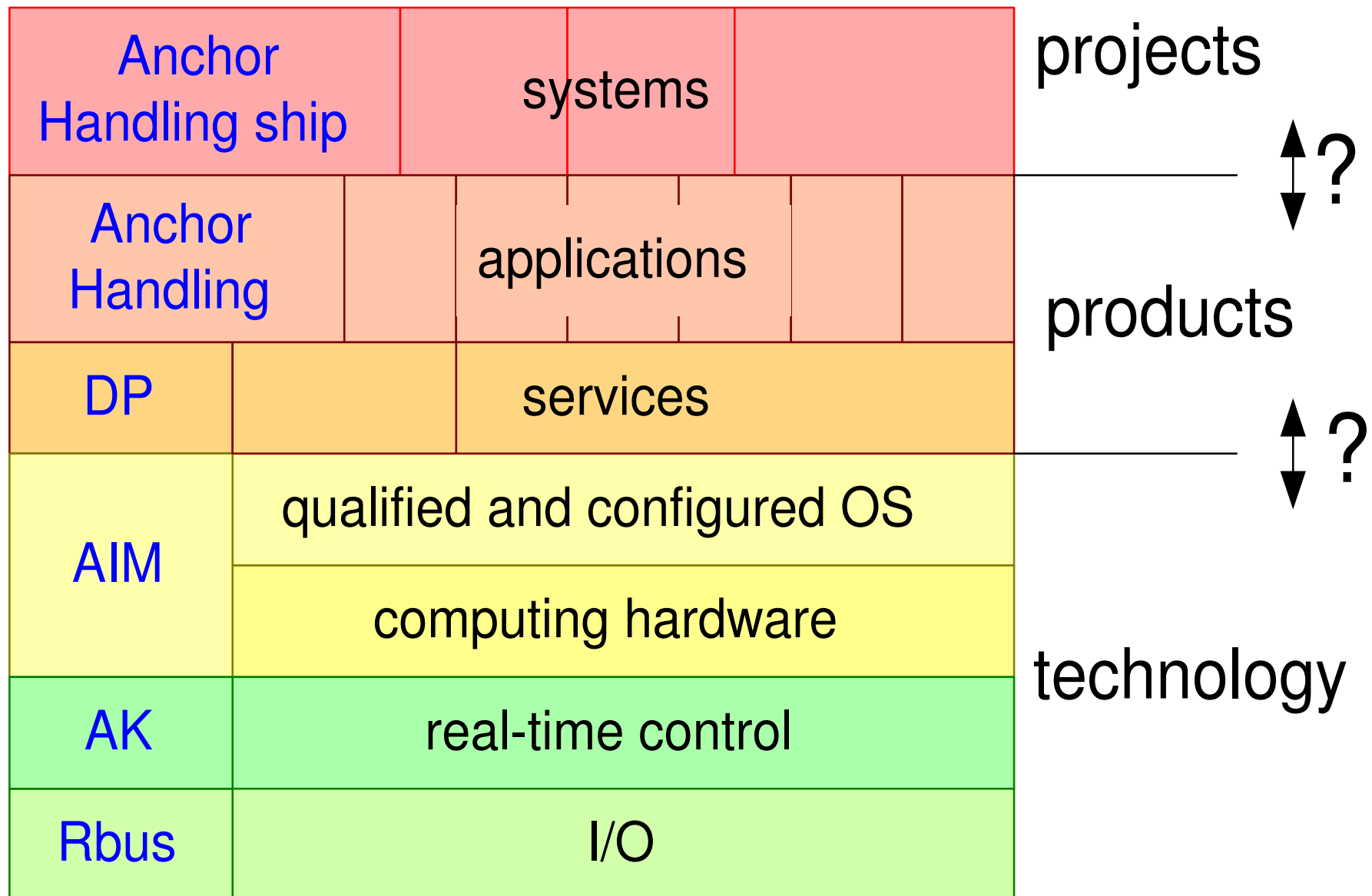


source:
<http://www.km.kongsberg.com/ks/web/nokbg0240.nsf/AllWeb/F6D8ACE8F32AE306C12575C500323661?OpenDocument>

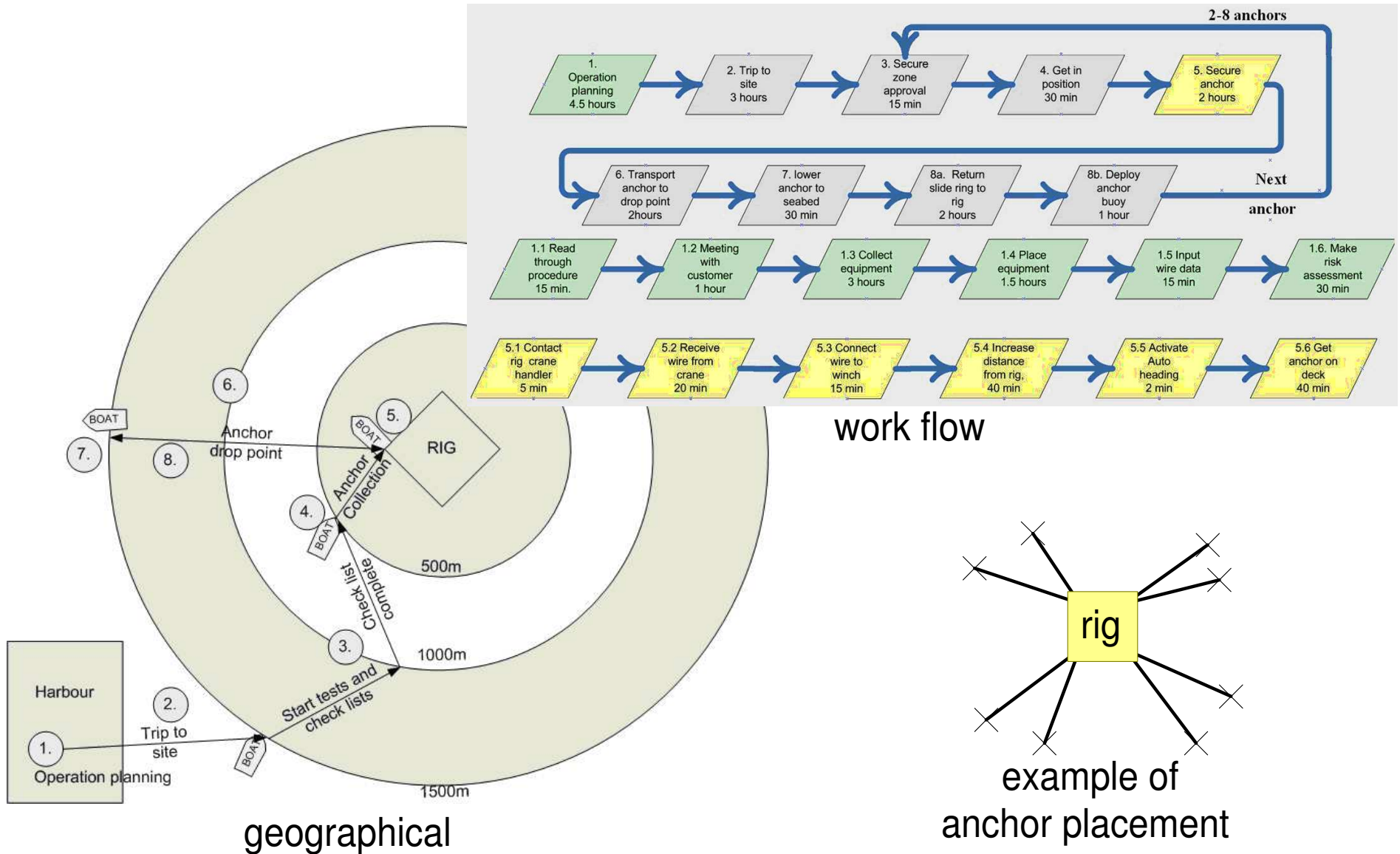
Integration of Existing Products



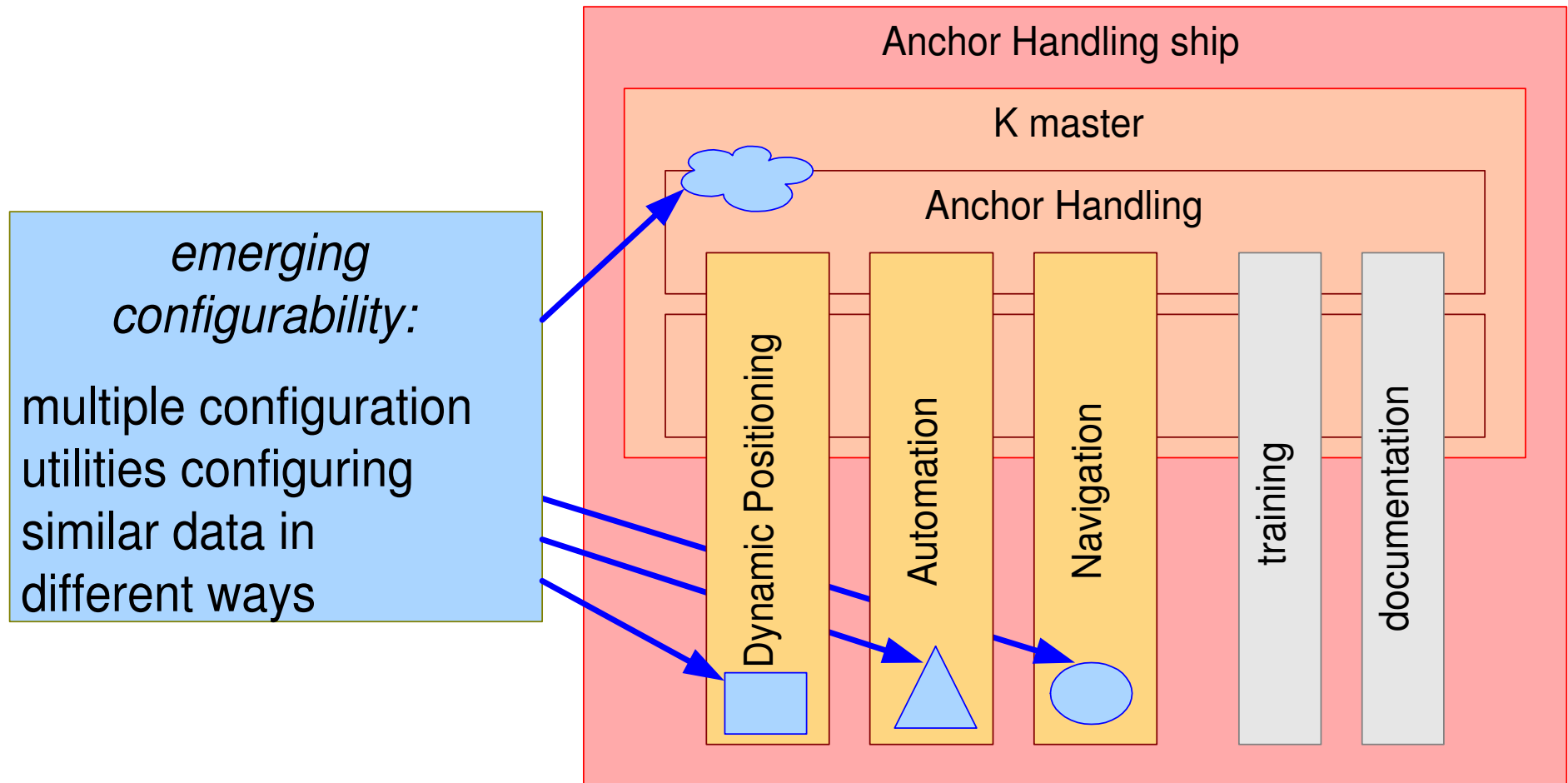
Software Stack



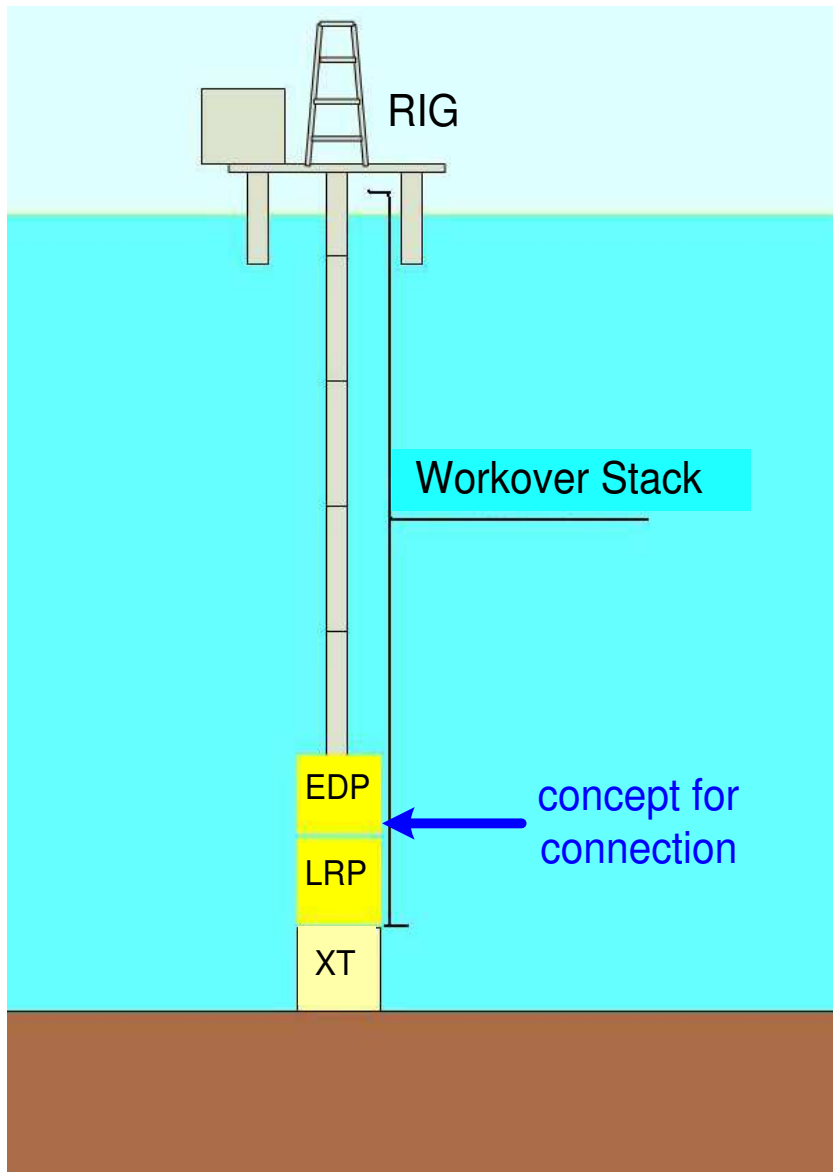
Understanding Stakeholder Needs



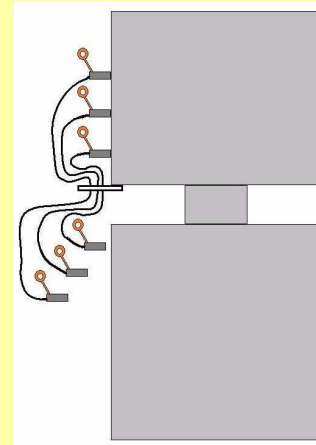
Example of System Quality: Configurability



Concept Selection Examples from Subsea



two sided connectors



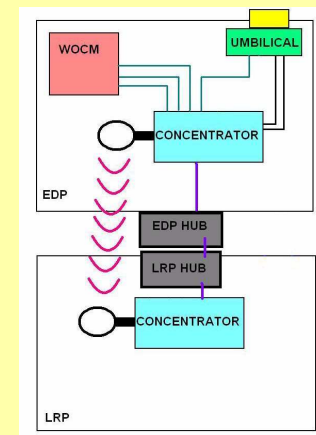
connectors in hub



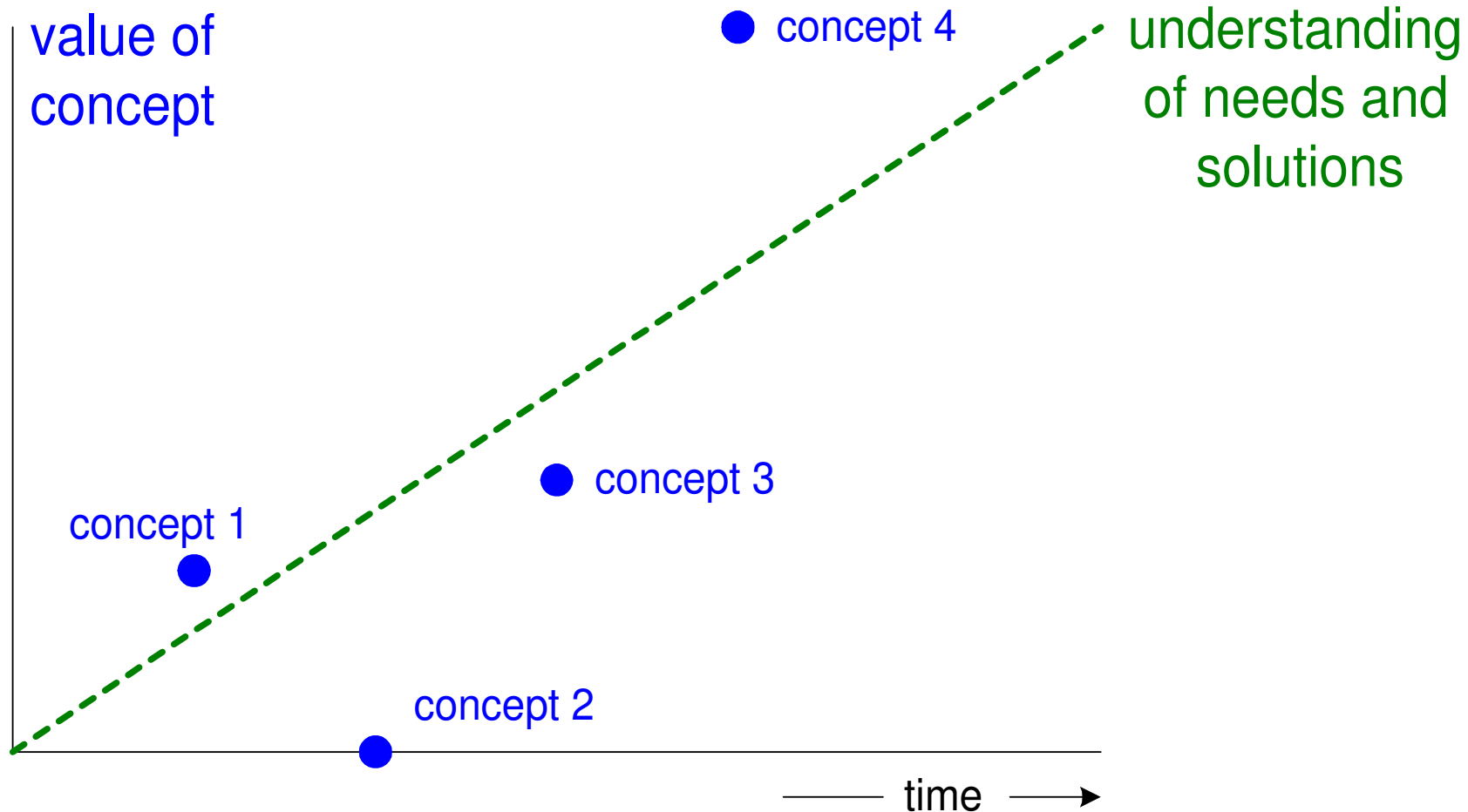
connectors in hub with roll-off



wireless connection

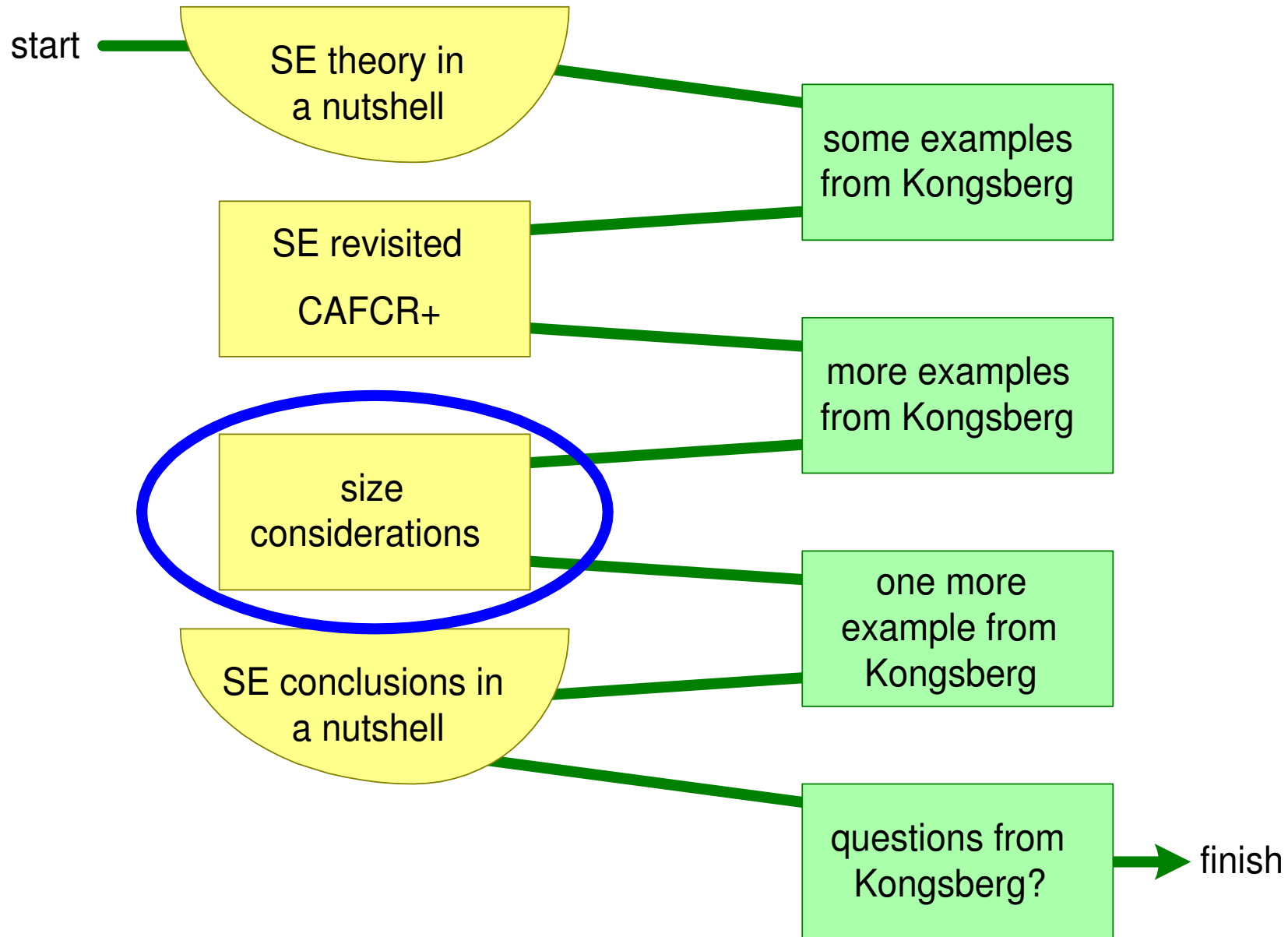


Quality and Understanding Improves by Iteration

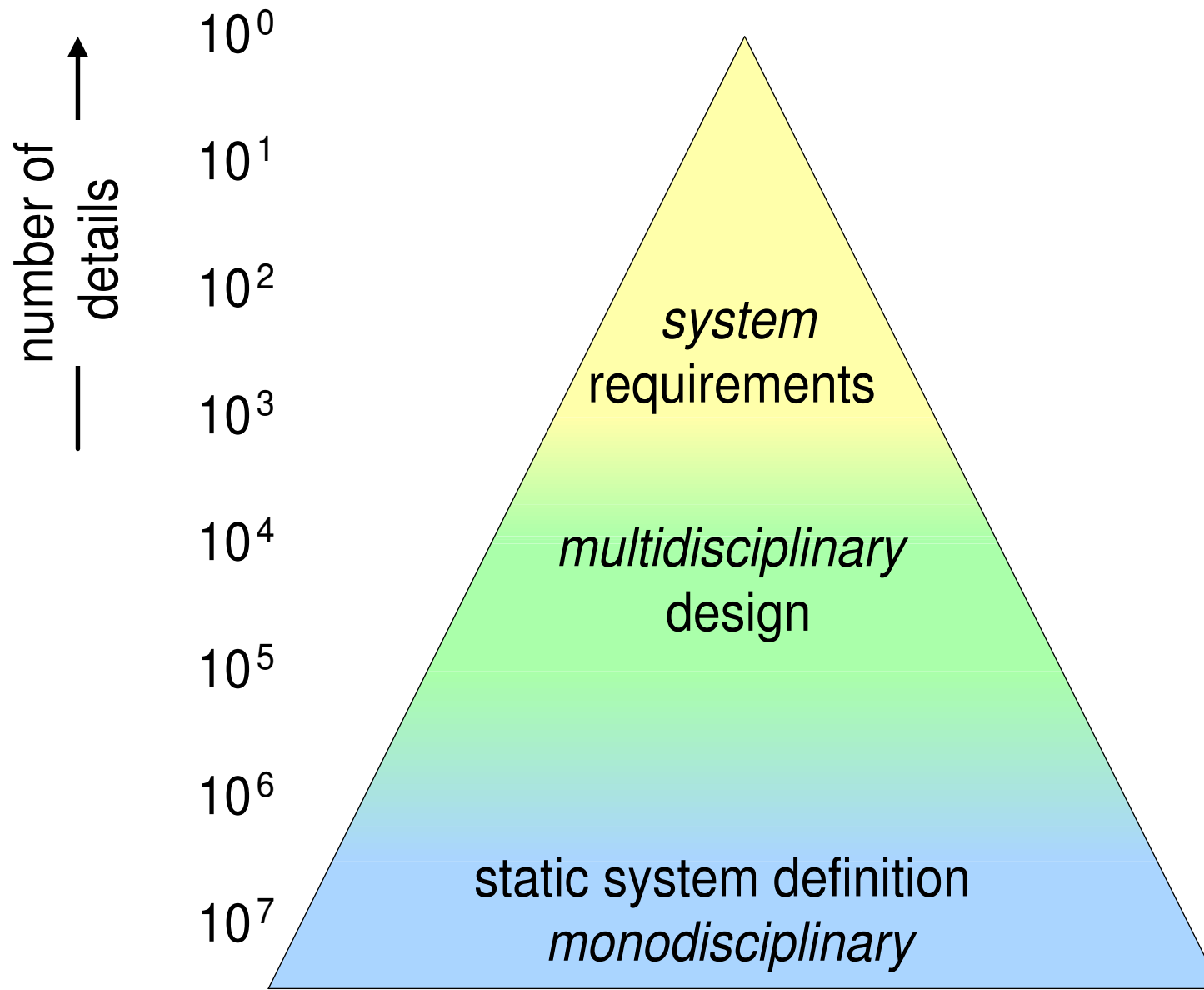


we learn by evaluating concepts; multiple iterations are needed

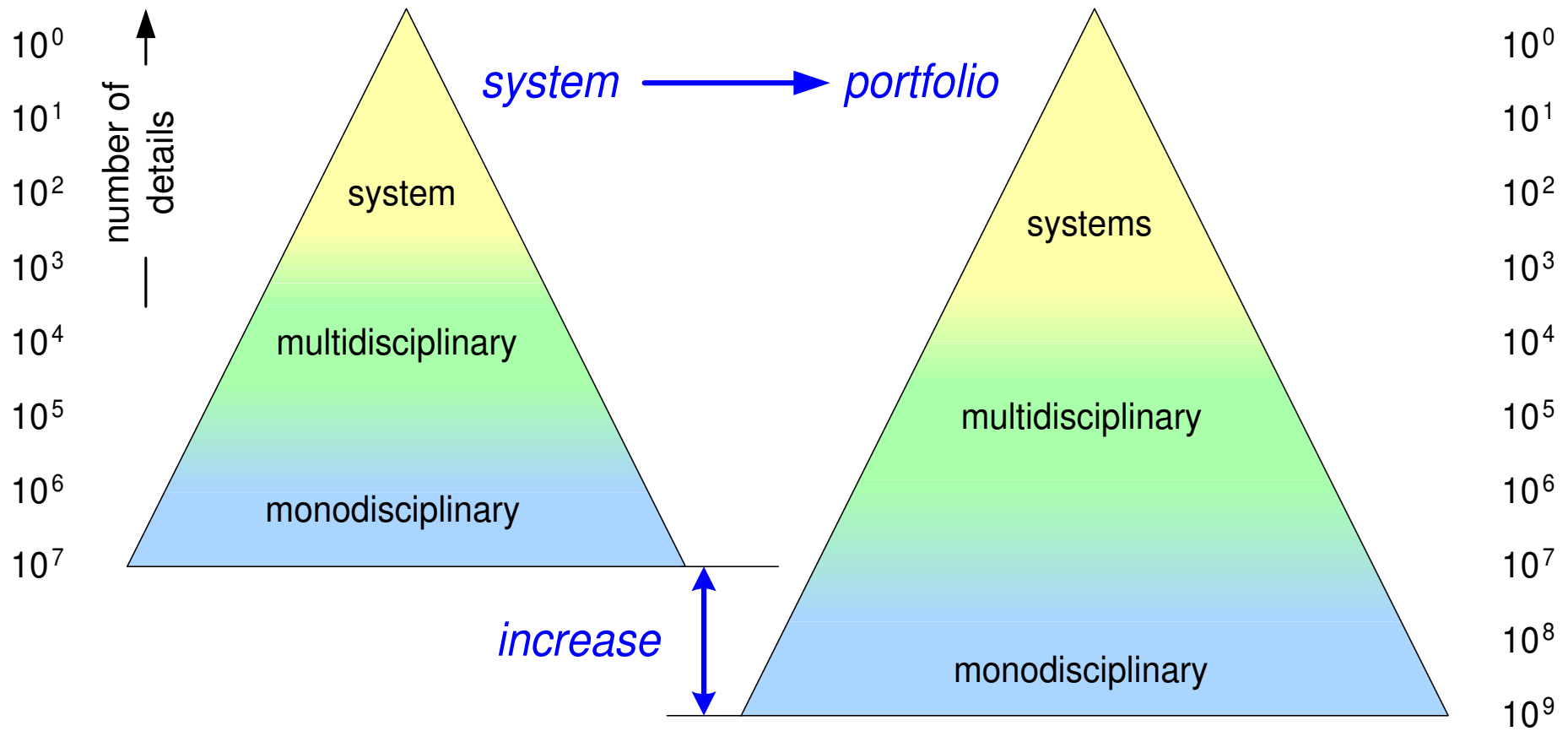
Size considerations



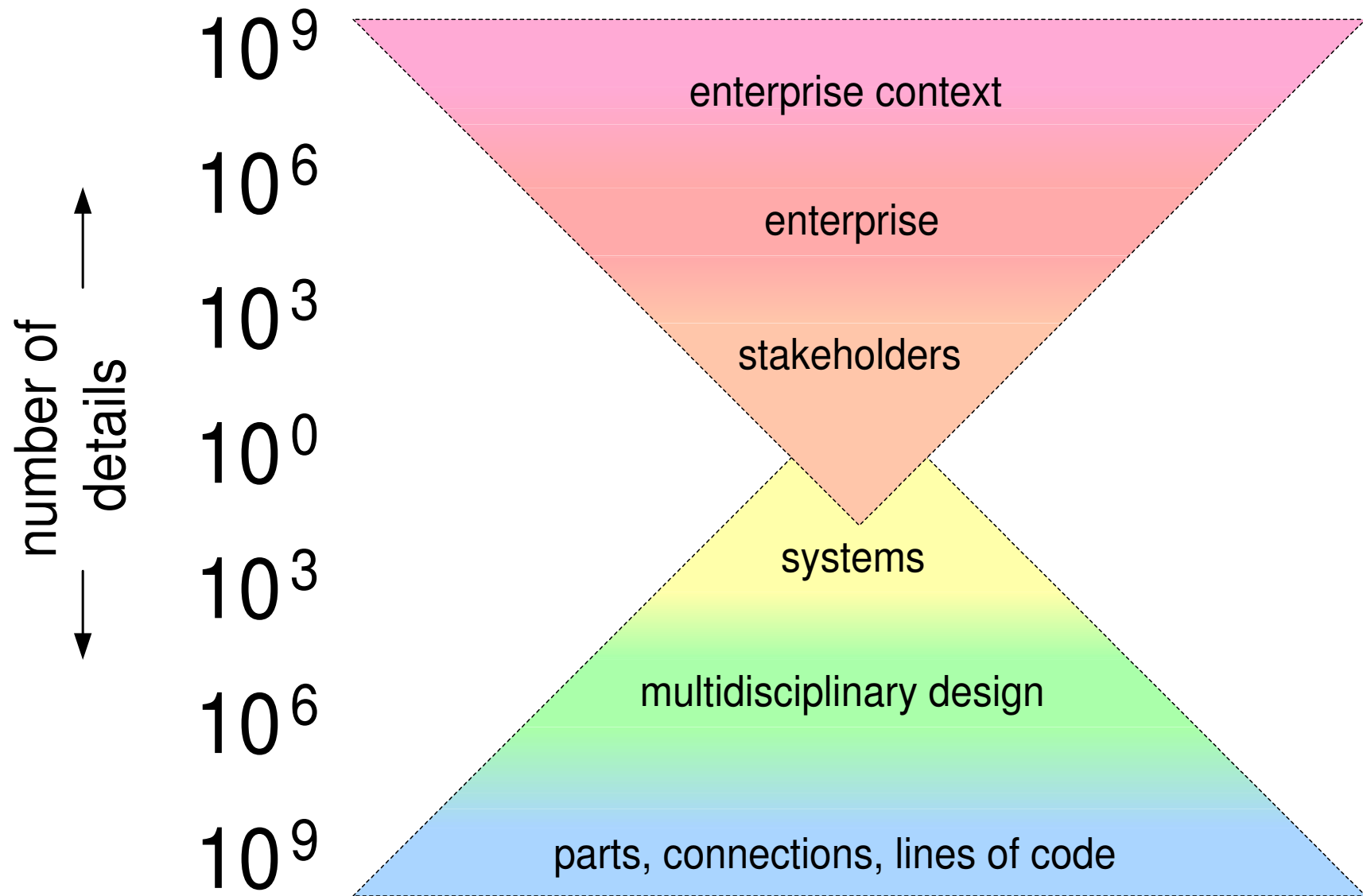
Level of Abstraction Single System



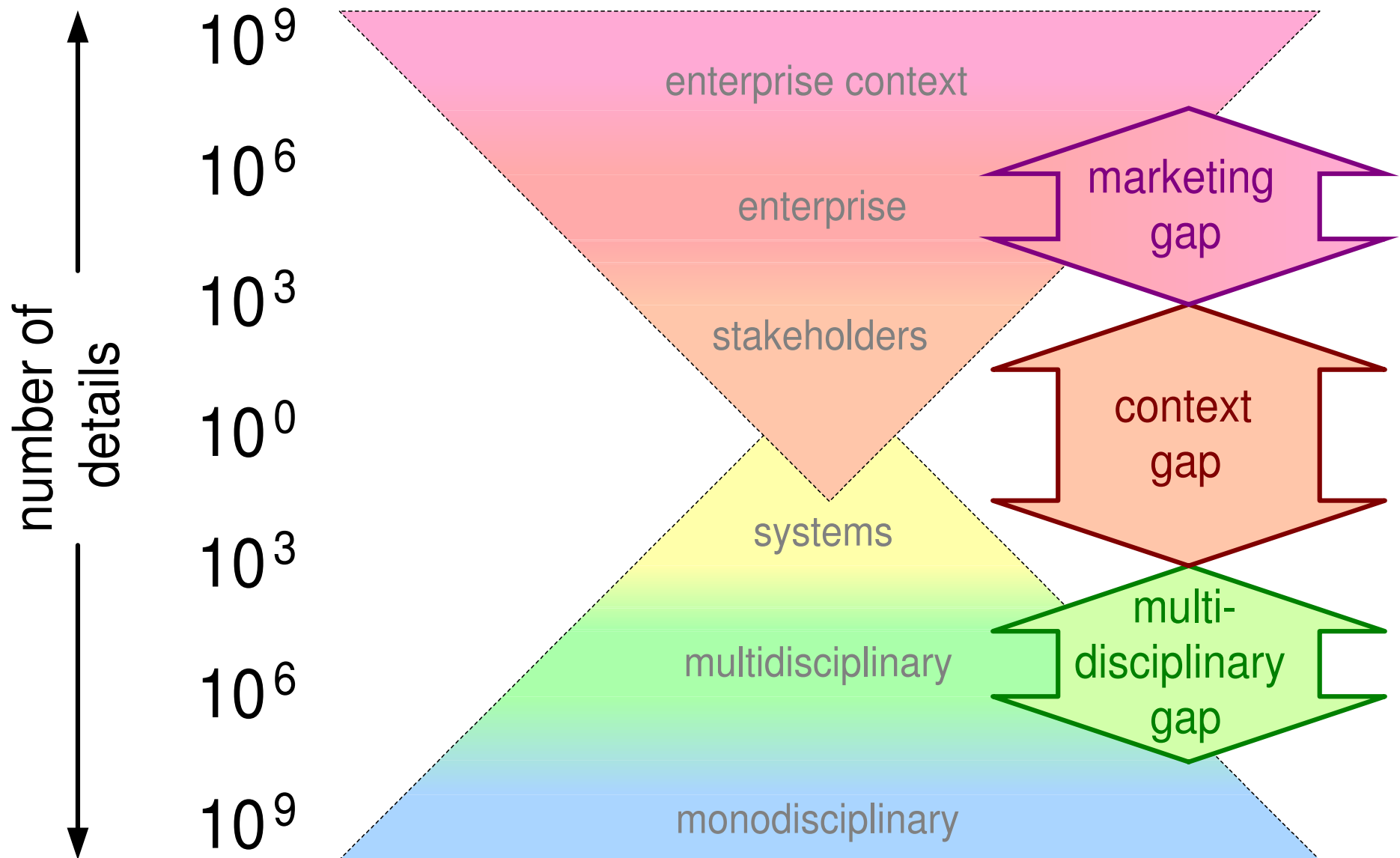
From system to Product Family or Portfolio



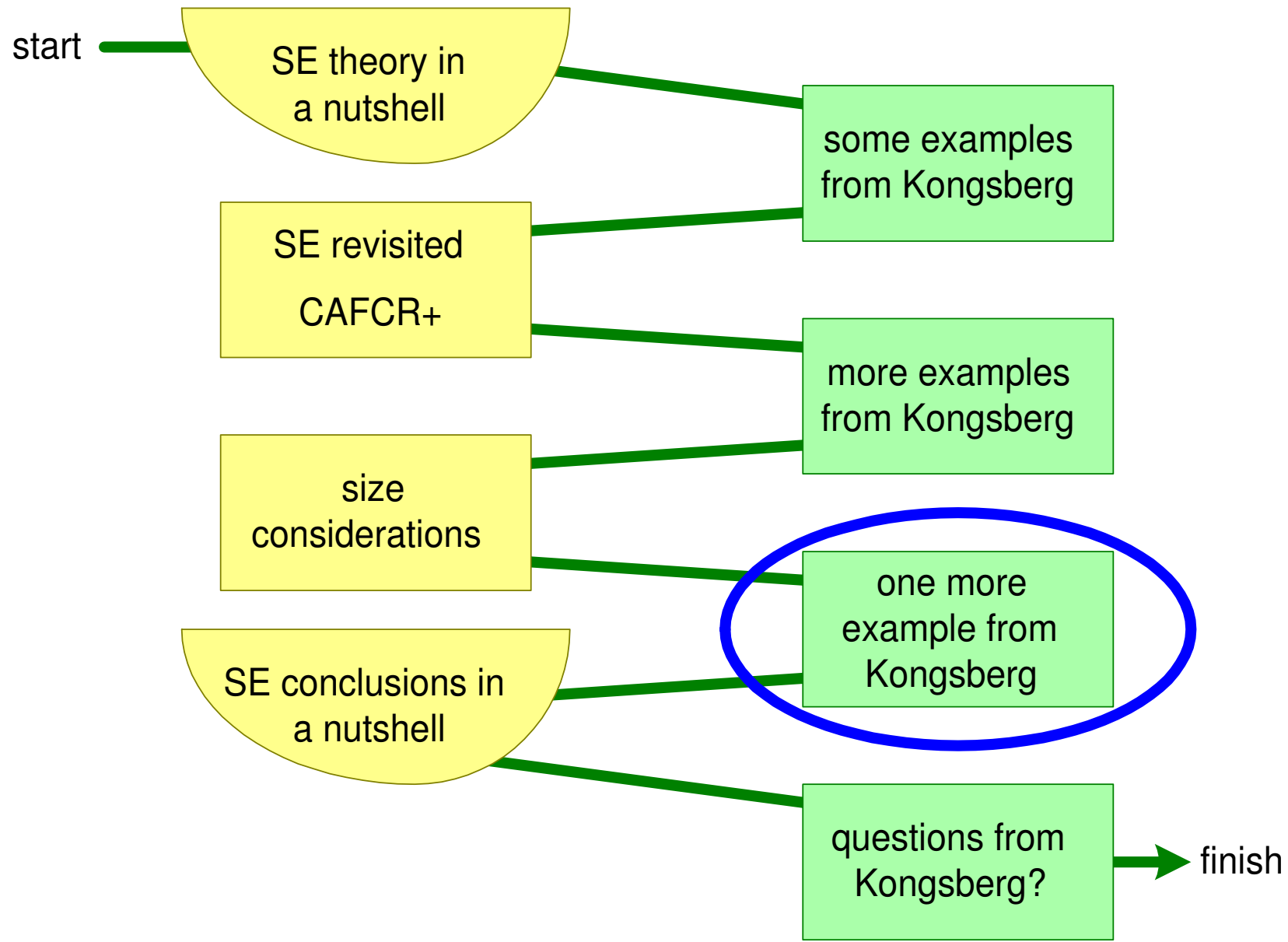
Product Family in Context



Frequently observed gaps



One More Example from Kongsberg



Highly Successful Remote Weapon Station



Extreme fast growing business: Remote Weapon Station

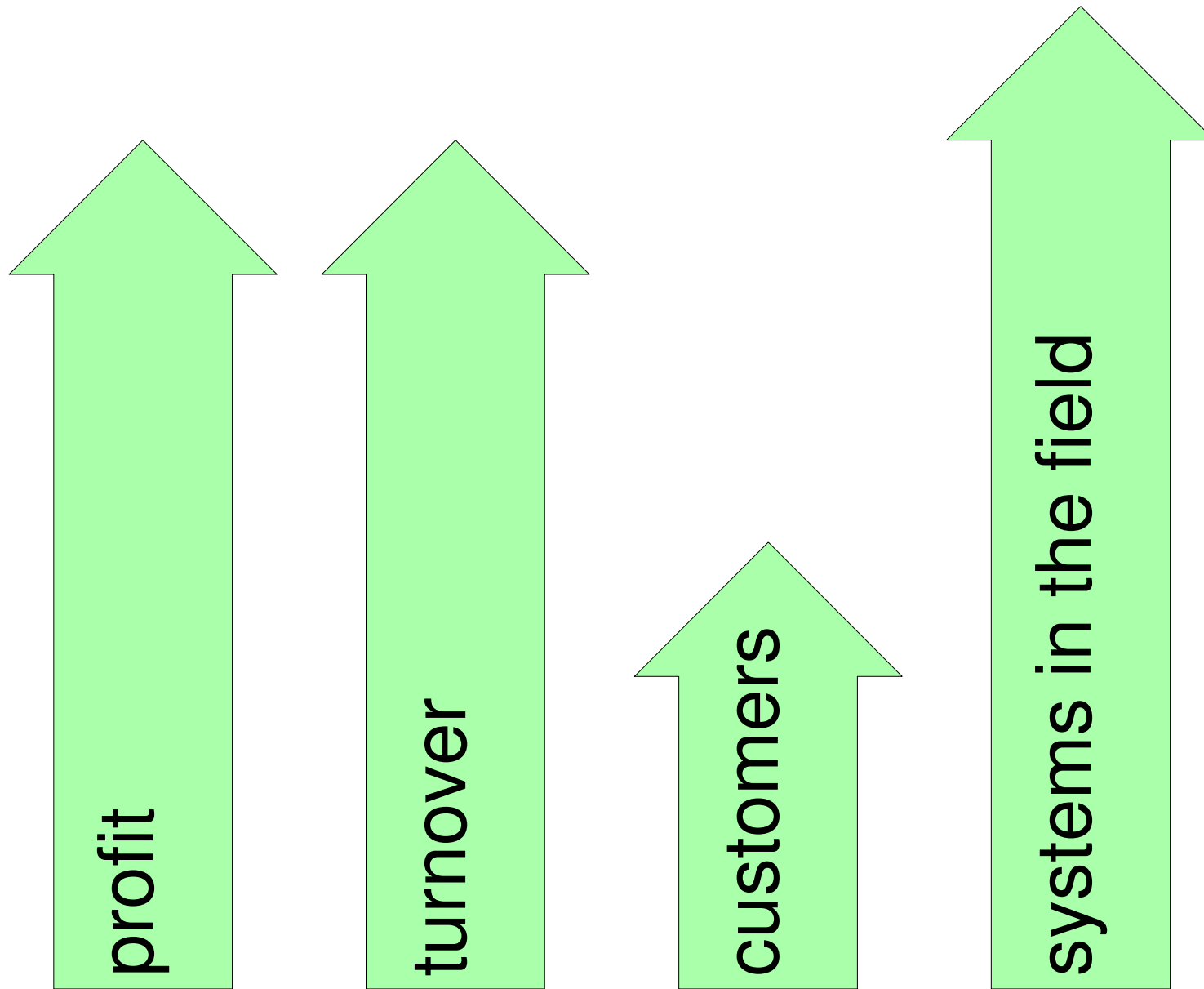
- * PROTECTOR Hellfire
- * PROTECTOR Javelin
- * PROTECTOR Lite
- * PROTECTOR NM221
- * Sea PROTECTOR
- * PROTECTOR M151
- * PROTECTOR CROWS
- * PROTECTOR Training Systems

source:

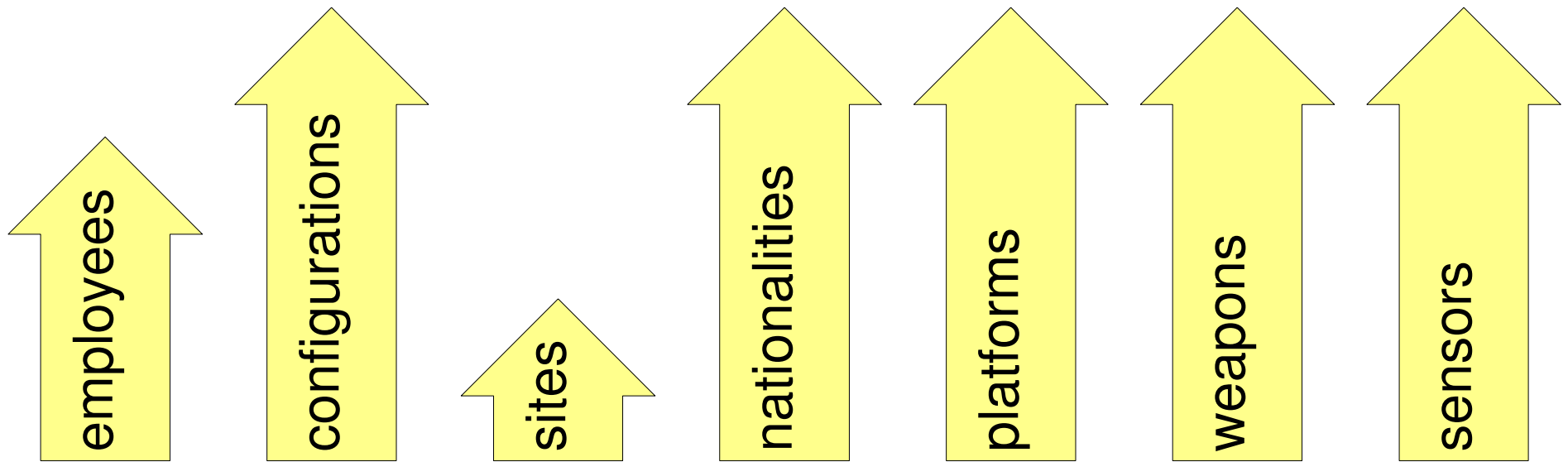
<http://www.kongsberg.com/en/KPS/Products/RemoteWeaponStation.aspx>



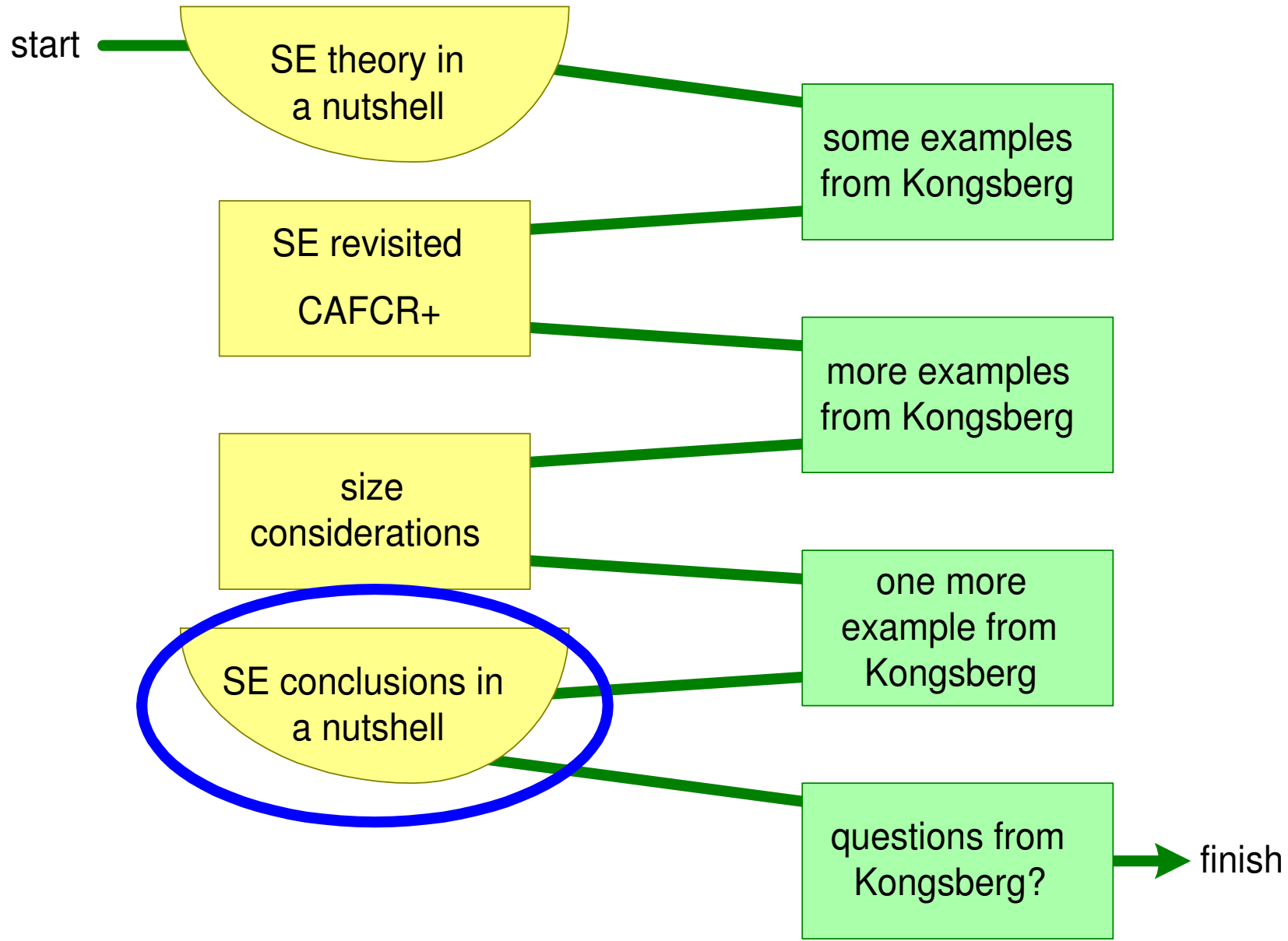
Growth in many directions



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

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 thorough interviews or work shops.

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

Questions from Kongsberg

