

# Less Heavy Systems Engineering; How Much is Appropriate?

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## Abstract

Many companies are aware of opportunities to improve systems development, system integration and complex project execution. Conventional Systems Engineering from the military and aerospace domain, although perceived as useful, also tends to be seen as “heavy” in terms of process and artifacts. In this paper we explore alternative Systems Engineering approaches that are perceived as lighter. We also explore how much Systems Engineering is appropriate.

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draft  
version: 0.1

*Effectiveness (Customer Value)*  
*Do the right things*  
What methods increase (understanding of) Customer Value?  
What can you use in your own company to increase (understanding of) Customer Value?

*Efficiency (Effort, cost, and time per result)*  
*Do things right*  
What methods improve the efficiency of the company?  
What can you use to improve the efficiency of your company?

# At the Beginning of this Century

Spring 2000, preparing key-note for conference

Let's go for Light Weight Processes

You cannot be serious  
You do not want Light Weight Architecting

Oh yes, absolutely,  
Light Weight Architecting is what  
we need



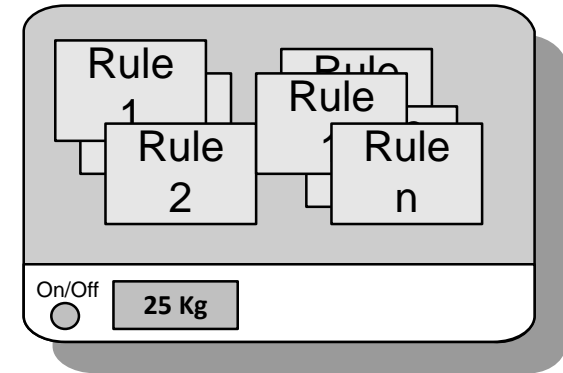
*Process  
Improvement  
Manager*



*Architect*

# Architecture Weight

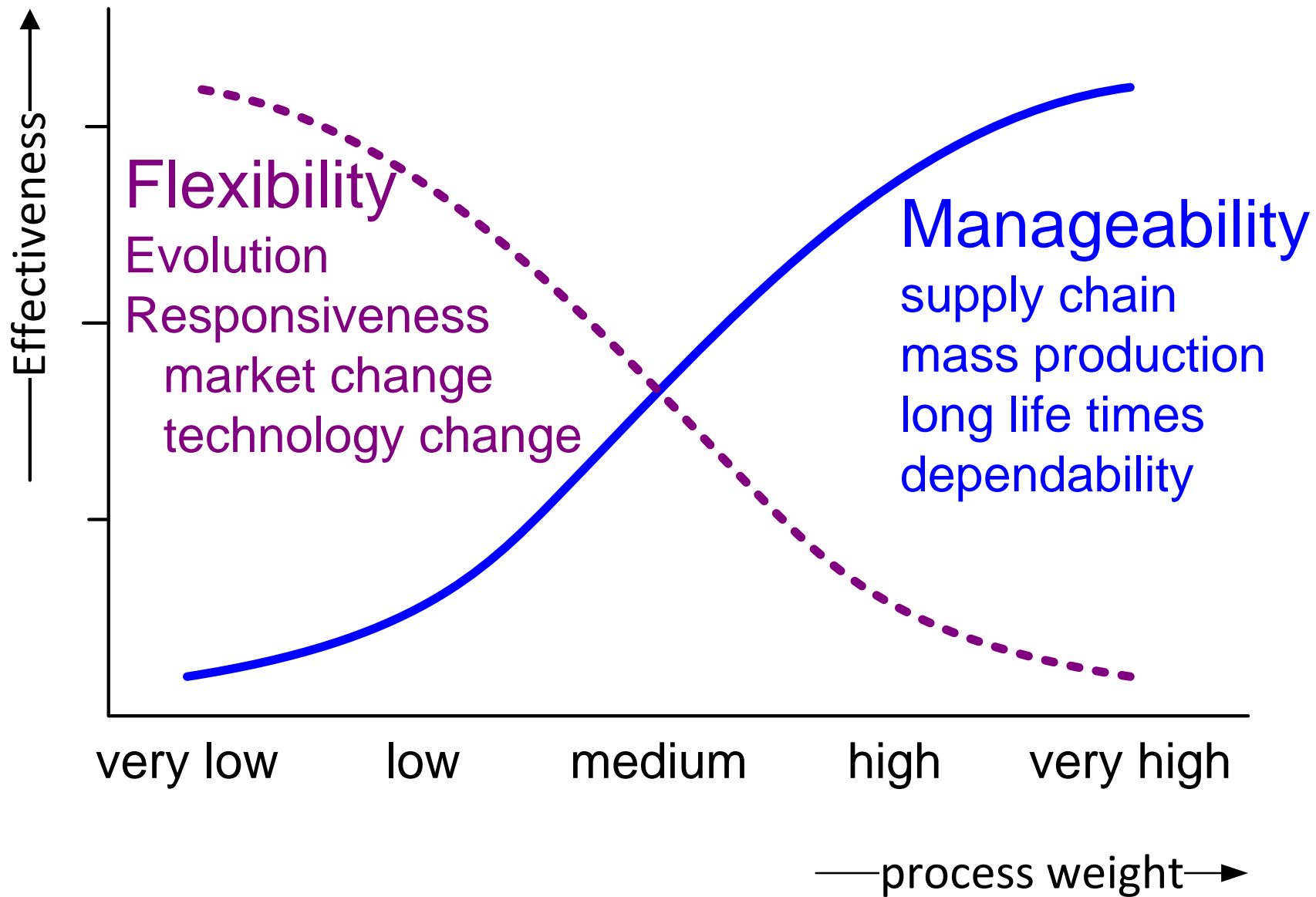
$$\text{weight}(\text{architecture}) = \sum_{\text{all rules}} \text{weight}(\text{rule})$$



$\text{weight}(\text{rule}) = f ($ 
 level of **enforcement** ,  
**scope** (impact) ,  
**size** ,  
 level of **coupling** or  
 number of dependencies )

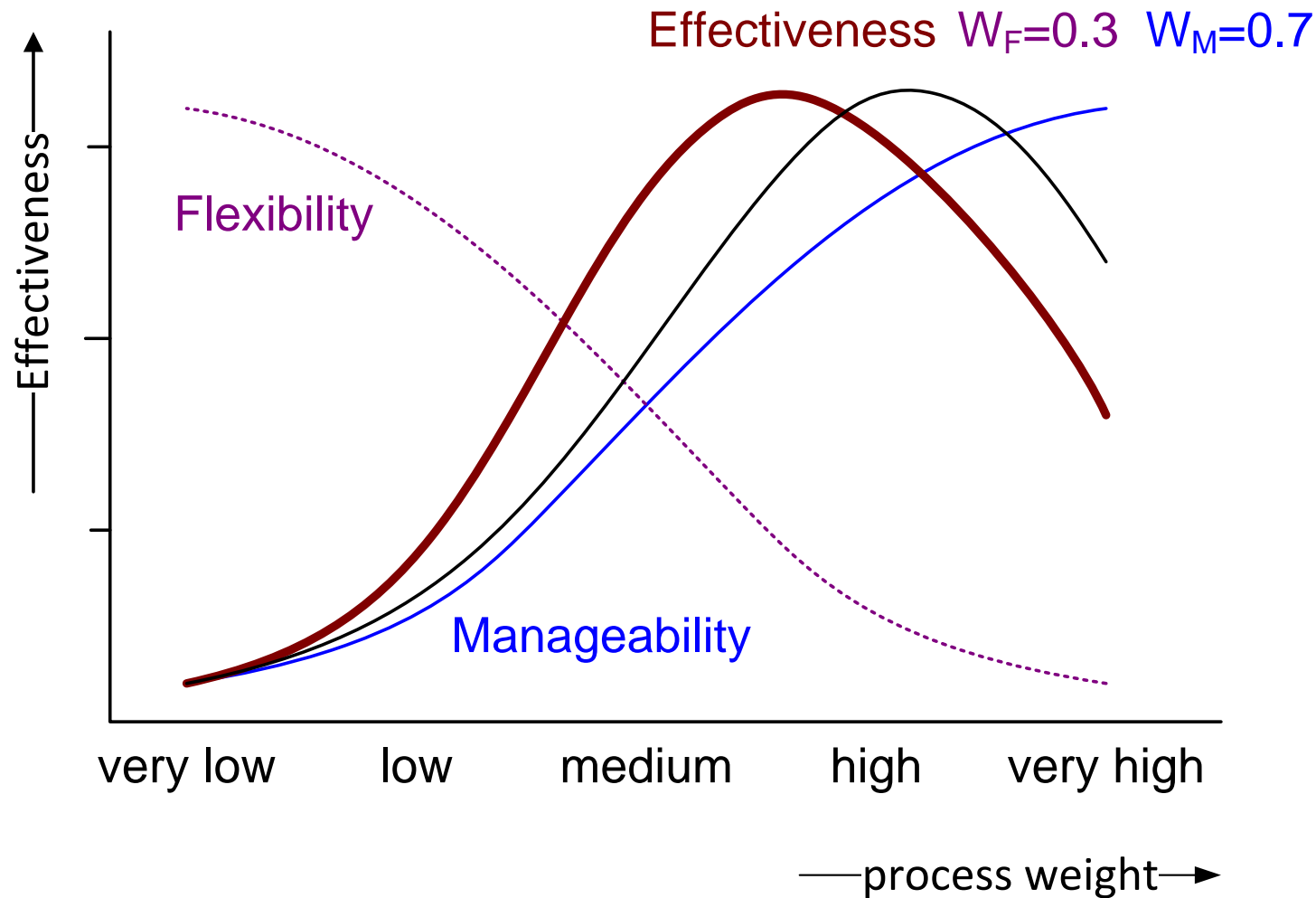
guideline	conditional rule	mandatory rule
component	product	portfolio
single-line	multi-line	multi-page
stand-alone	builds on many rules	
← low ——— weight ——— high →		

# Effectiveness(Flexibility, Manageability)



# Effectiveness

$$\text{Effectiveness} = \text{Flexibility}^{W_F} * \text{Manageability}^{W_M}$$



# Light Weight How To

$$\text{weight}(\text{architecture}) = \sum_{\text{all rules}} \text{weight}(\text{rule})$$

2. Minimize the weight per rule

1. Reduce the rule set to the (business) essential

Understand

- your customer
- your customer's customer etcetera

# Minimize Rule Weight

weight(rule)=

minimize number of mandatory rules

f ( level of **enforcement** ,

empower, delegate

**scope** (impact) ,

minimize implementation details  
focus on essential concepts

**size**,

Apply design principles on architecture

level of **coupling** or  
number of dependencies )

Multi-view architecting

## *Effectiveness (Customer Value)*

*Do the right things*

What methods increase (understanding of) Customer Value?

What can you use in your own company to increase  
(understanding of) Customer Value?

## *Efficiency (Effort, cost, and time per result)*

*Do things right*

What methods improve the efficiency of the company?

What can you use to improve the efficiency of your company?

# Work Form for KSEE 2011

	<p><i>Effectiveness (Customer Value)</i> <i>Do the right things</i></p> <p>What can you use in your own company to increase (understanding of) Customer Value?</p>	<p><i>Efficiency (Effort, cost, and time per result)</i> <i>Do things right</i></p> <p>What can you use to improve the efficiency of your company?</p>
<p><b>Håkan Gustavsson</b> Is it Lean or just common sense?</p>		
<p><b>Einar Jørgensen</b> Globalising System Engineering and Lean Principles</p>		
<p><b>Odd Guldsten</b> Complex power systems for offshore oil&amp;gas topside installation</p>		
<p><b>John Bjarne Bye</b> Lean Transformation</p>		
<p><b>Jon Wade</b> Systems Engineering: At the Crossroads of Complexity</p>		
<p><b>Andreas Thorvaldsen</b> Manufacturing Systems Modelling</p>		
<p><b>Kristian Frøvd</b> Early Validation through the A3 method</p>		
<p><b>Gerrit Muller</b> Less Heavy Systems Engineering; How Much is Appropriate?</p>		

# Explanation of Work Form

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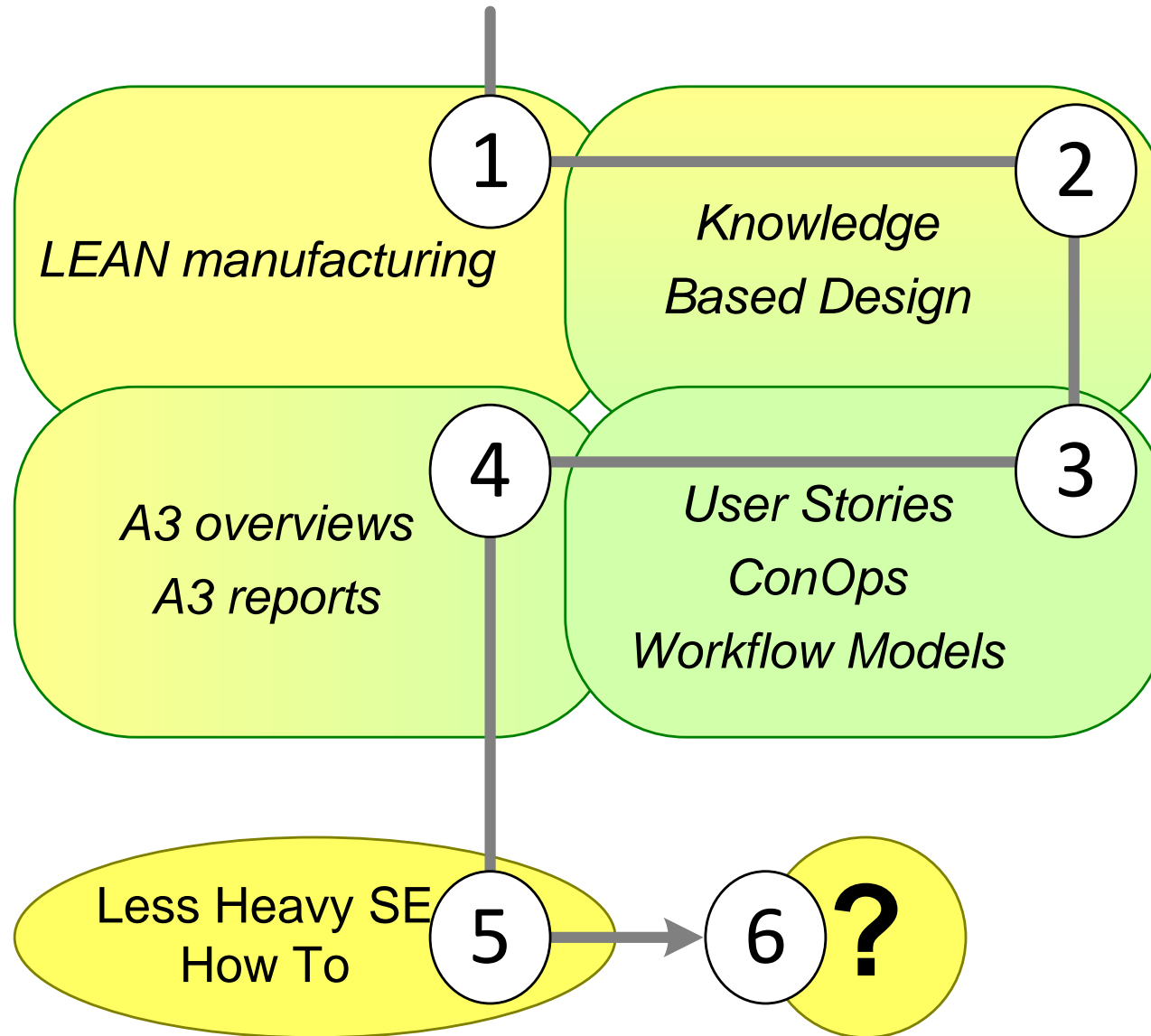
We expect that everyone fills in the form during or at the end of every presentation.

The purpose is to stimulate you to reflect on possible value for your own company.

We recommend to write down specific examples.

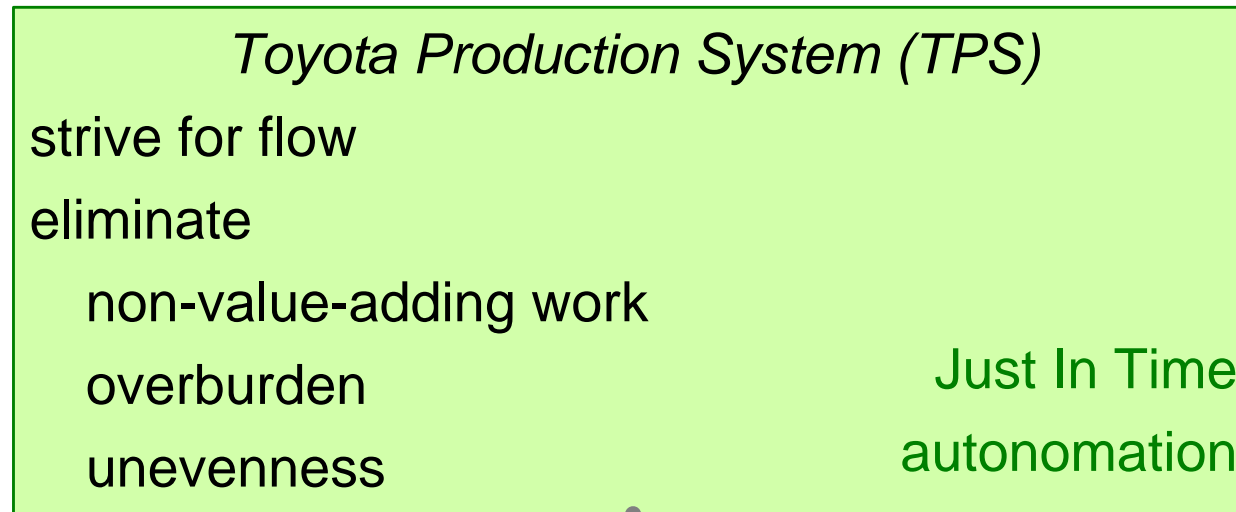
The last presentation will look back at all presentations.

# Time to Harvest! Figure Of Contents™

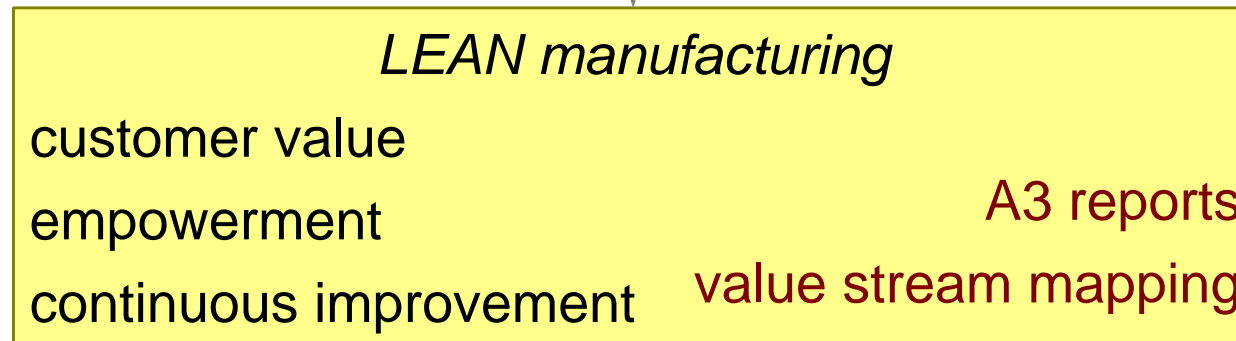


# LEAN Manufacturing

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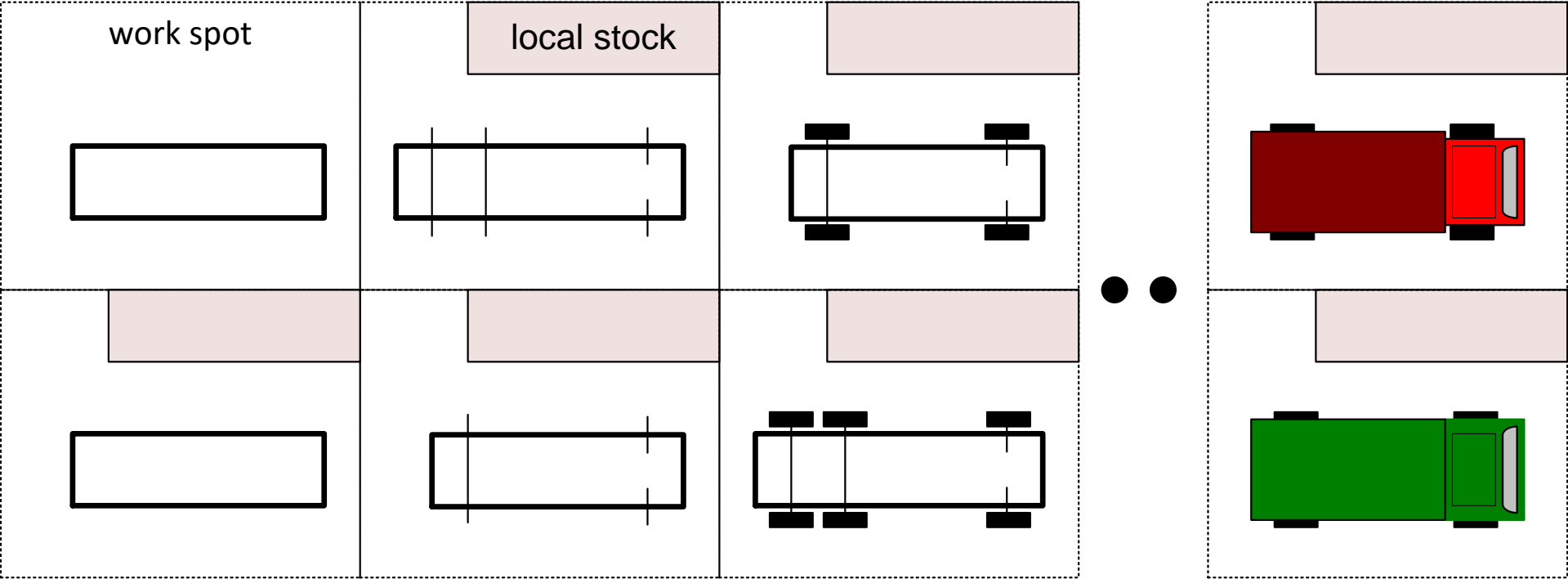


↓ evolved into



result: organic flow manufacturing  
efficient, flexible, short cycle times

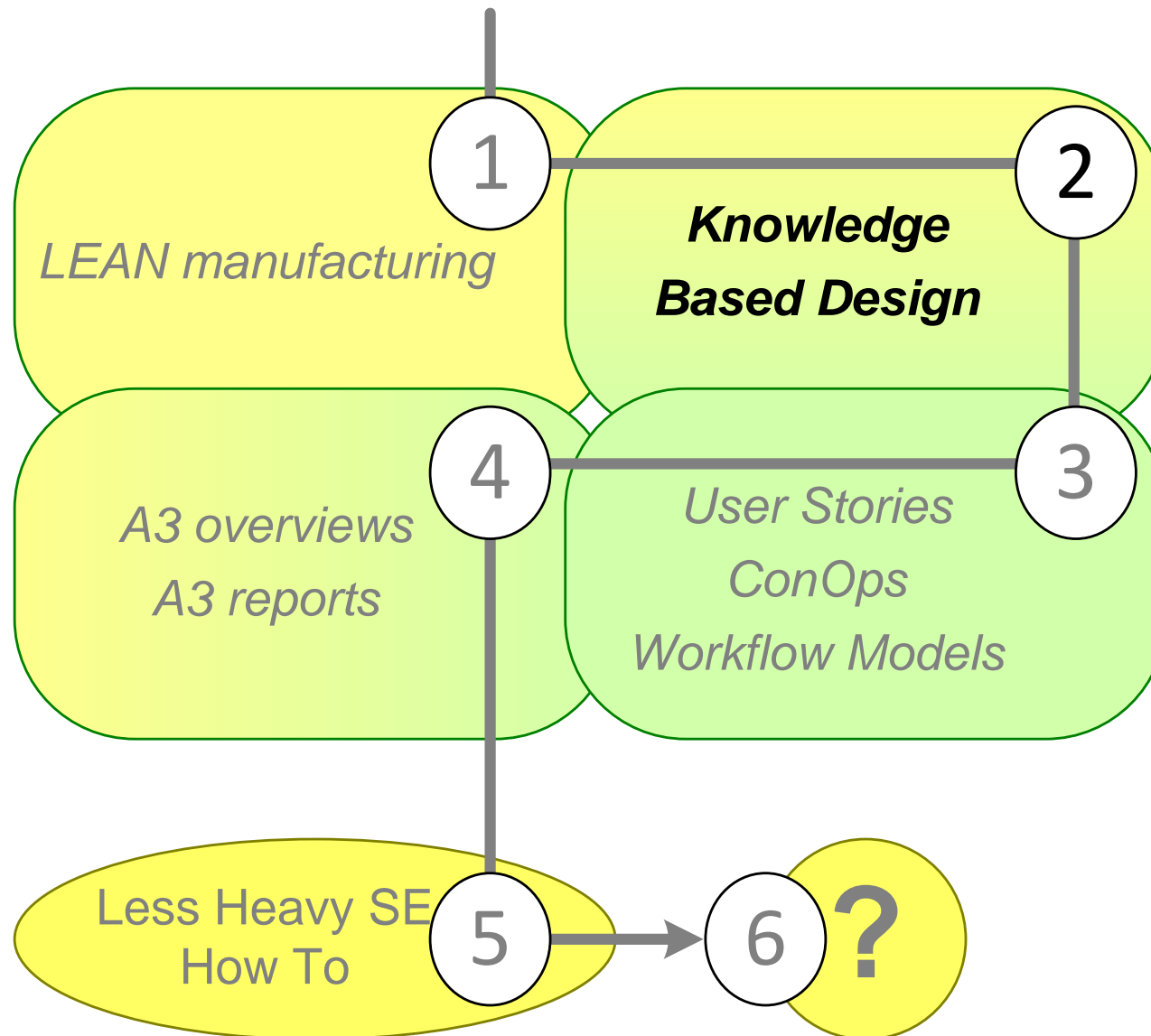
# Example of LEAN Manufacturing in Automotive



scheduling white board

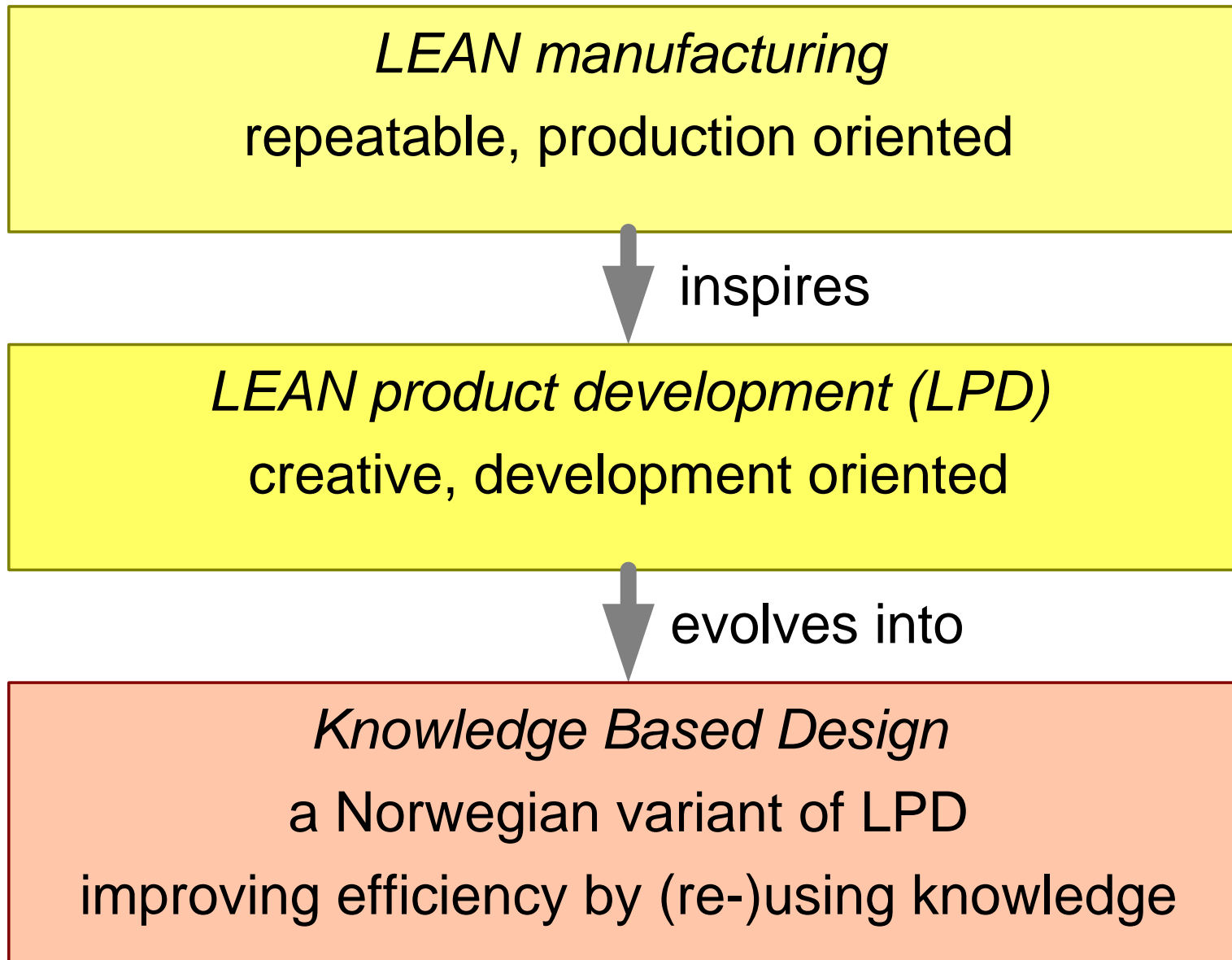
One heart beat  
 Every truck is unique  
 Local scheduling  
 Many practical local solution  
 by Continuous Improvement

# Knowledge Based Design

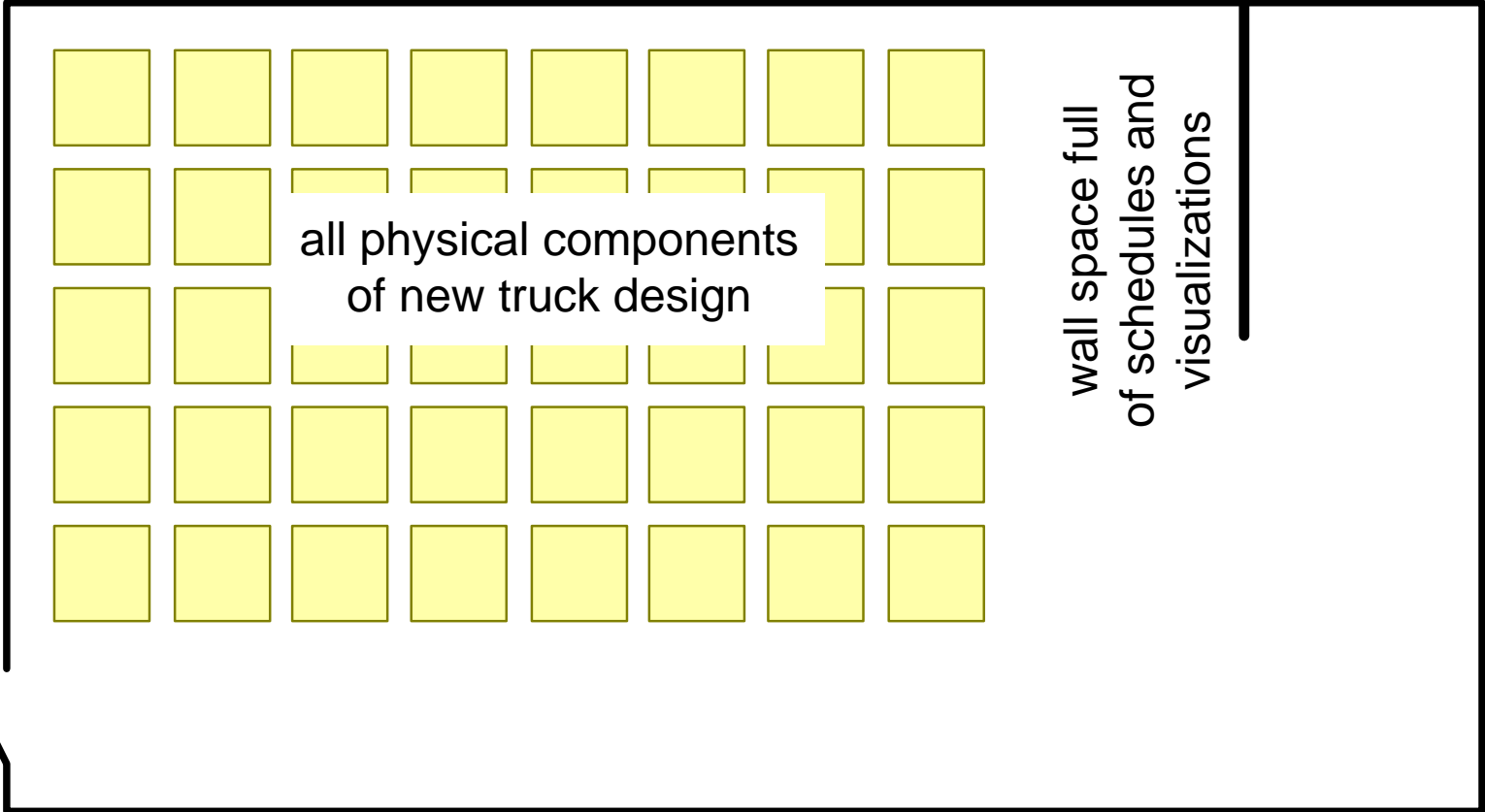


# Knowledge Based Design

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# Example of LPD in Automotive



development supported by team location  
tactile and visual support  
developers drive trucks themselves (customer understanding)

# Reflections on Knowledge

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Knowledge is abstract and intangible.

is data in a computer knowledge?  
are text and figures in a book knowledge?

Value is obtained when knowledge is applied properly.

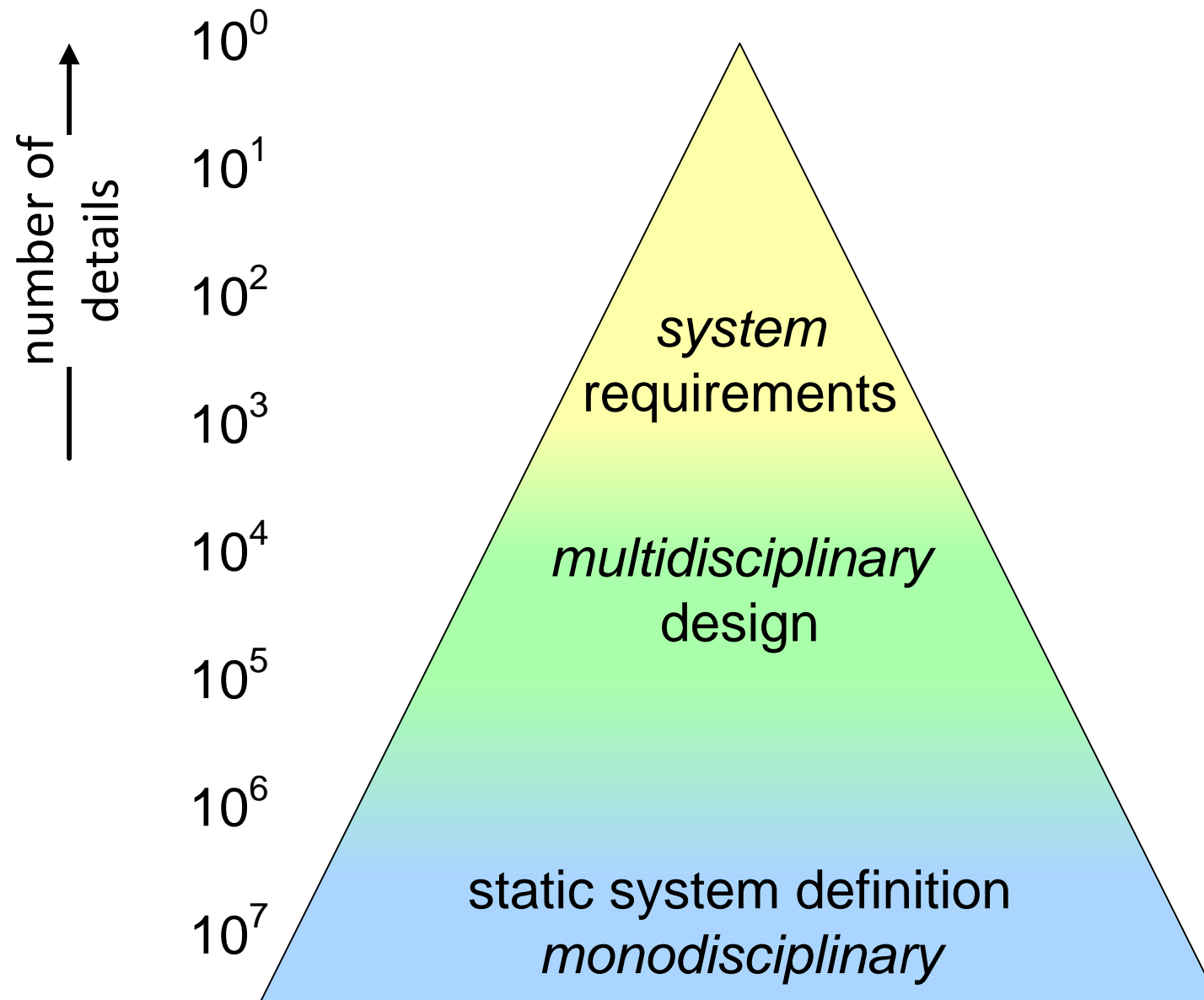
competence = knowledge + skills

Humans need experience to develop skills.

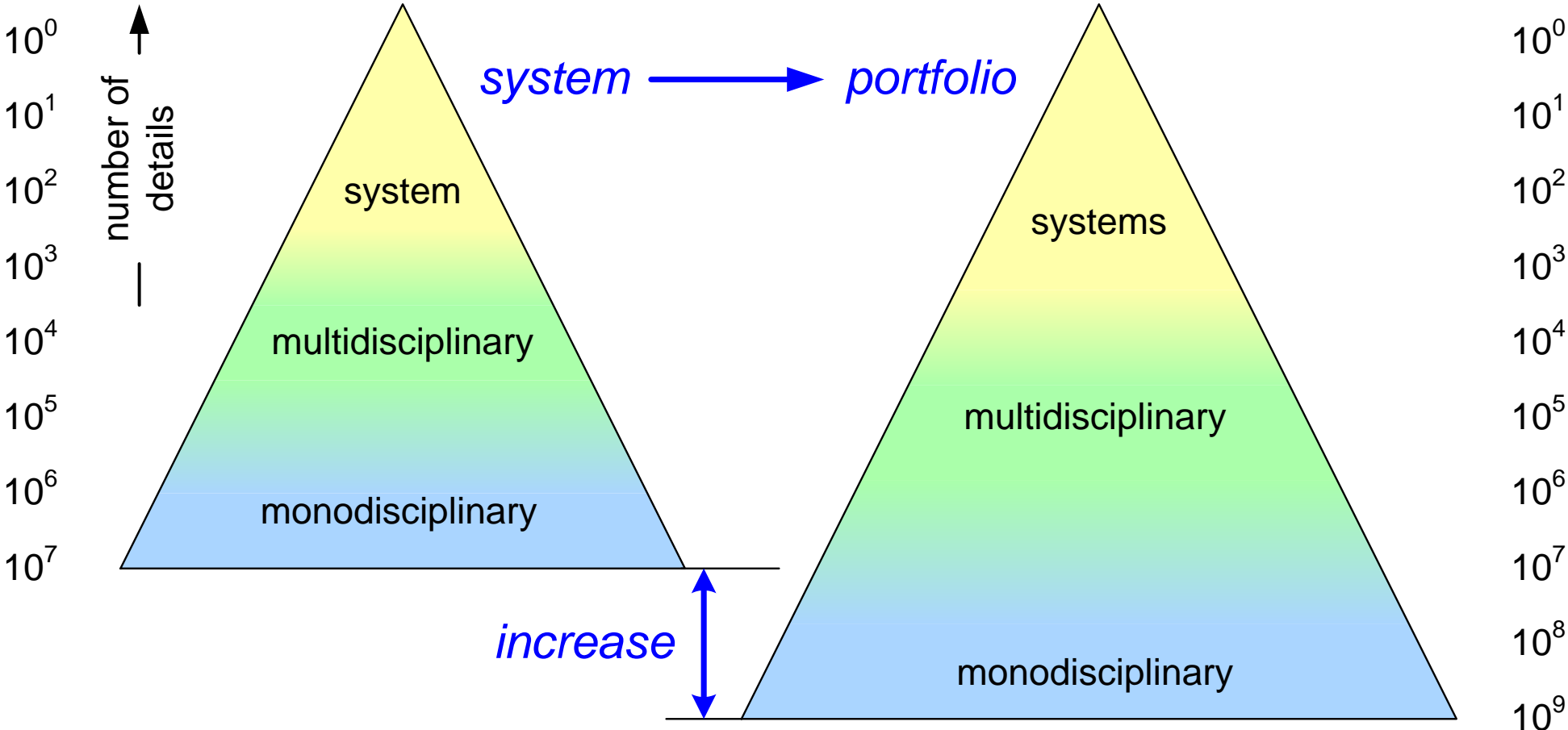
skills are practical, developed by doing

Skills and experience are complementary to knowledge.

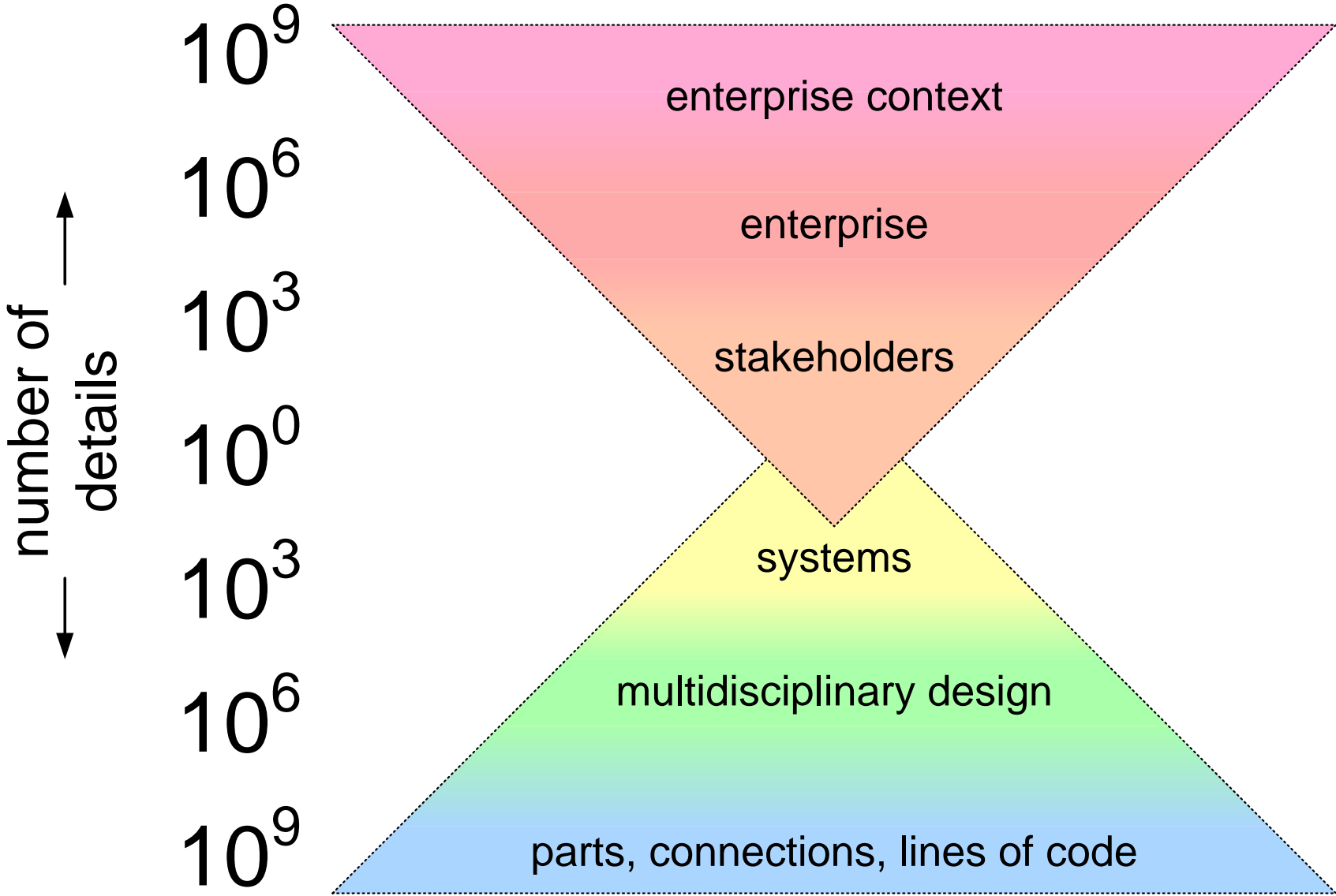
# Level of Abstraction Single System



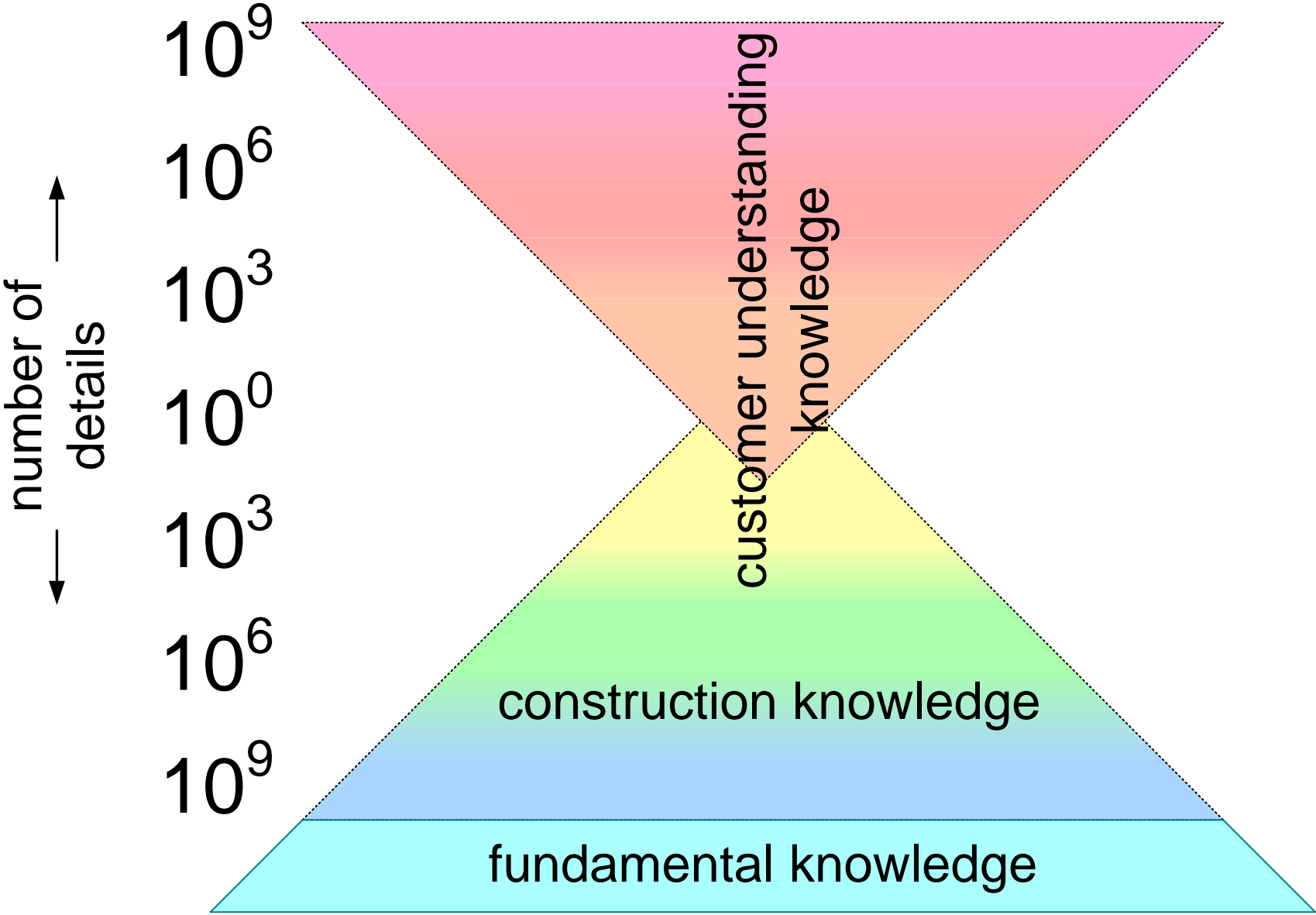
# From system to Product Family or Portfolio



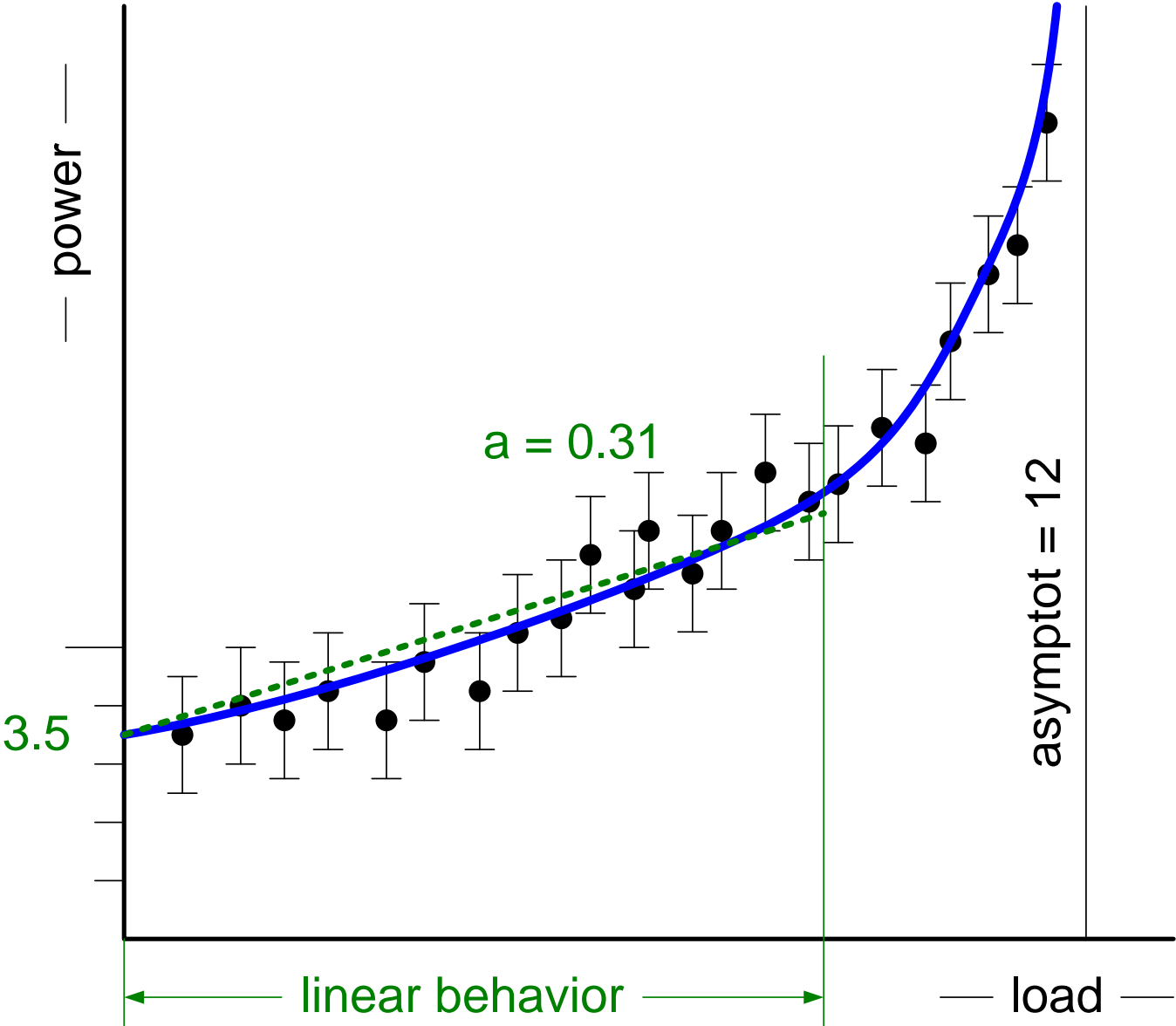
# Product Family in Context



# Knowledge at Multiple Levels

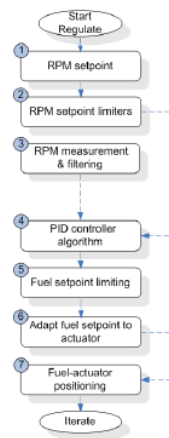
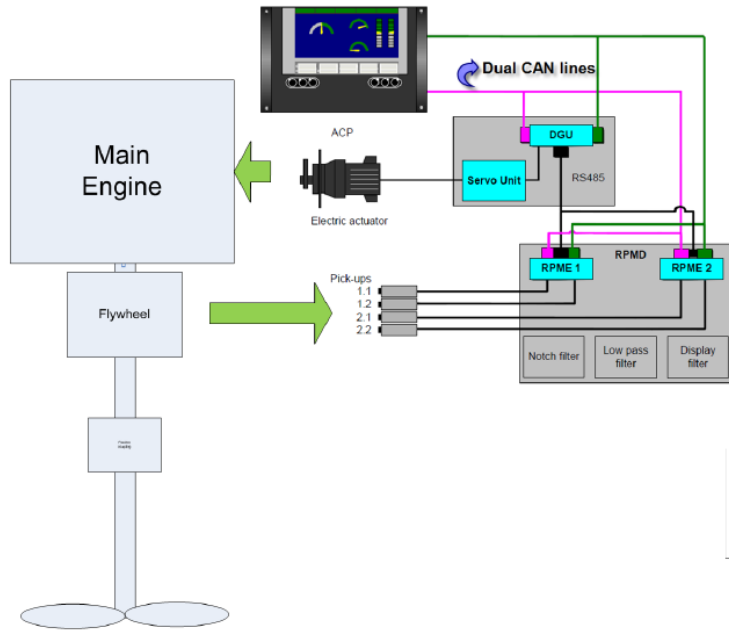


# Example of Fundamental Knowledge



# Example of Construction Knowledge

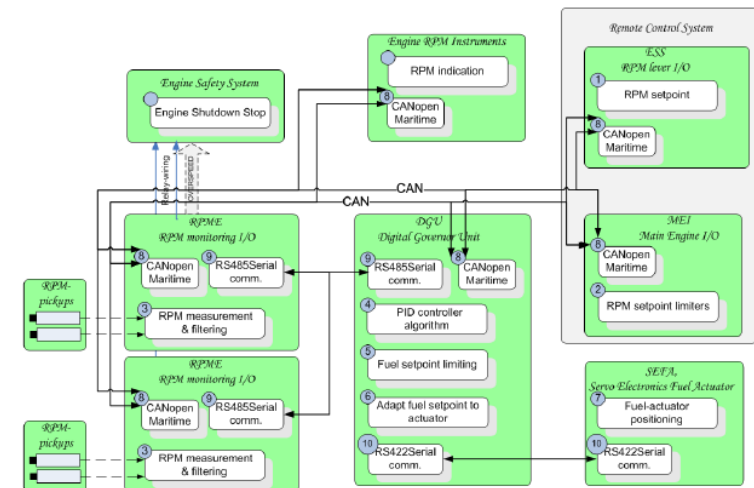
## Digital Governor System



## Digital Governor System: Top Architecture Overview "Reverse Architecting"

March 2011

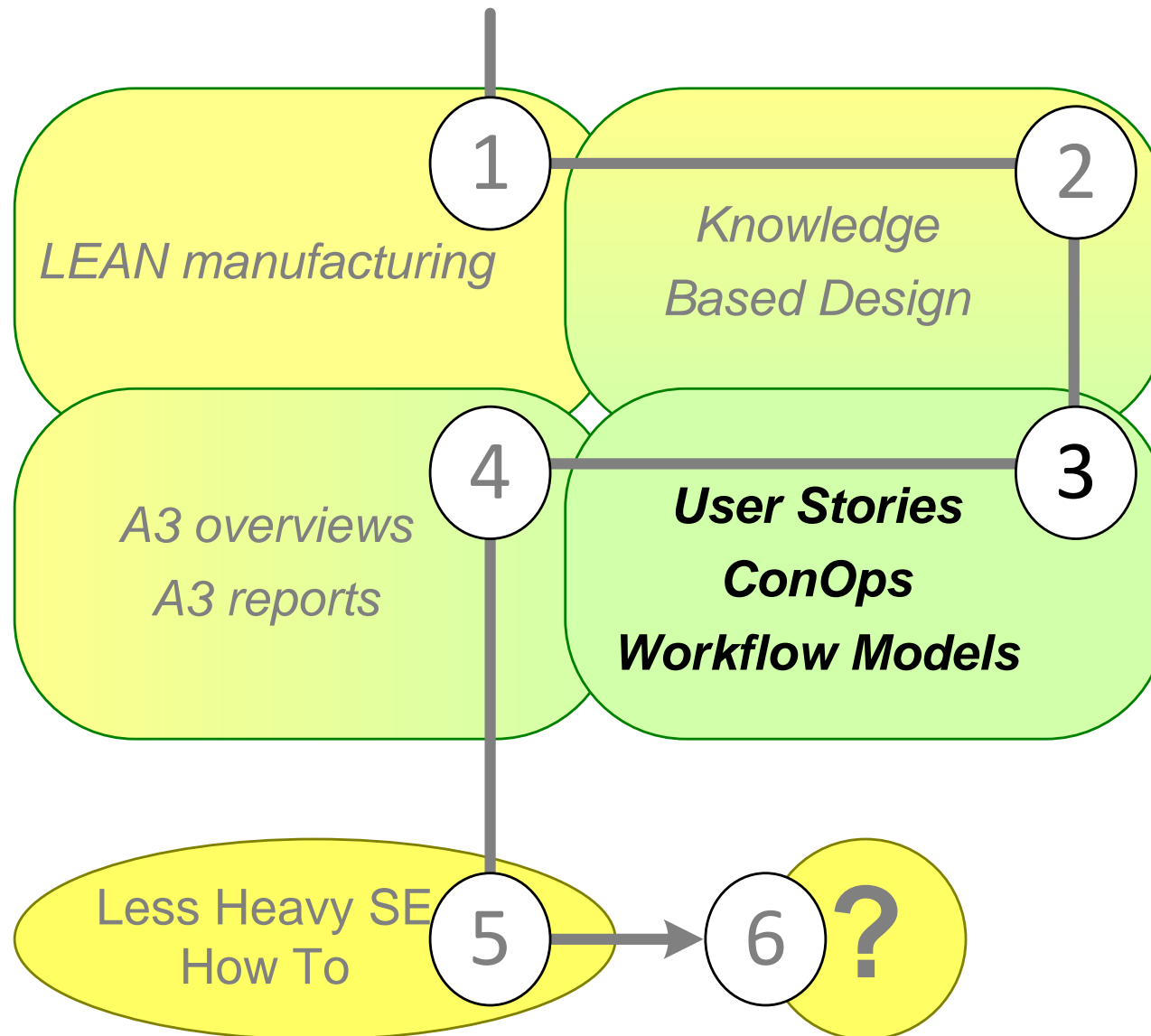
Physical & Functional Overview / Function Allocation



source: Bjørnar Wiulsrød  
 SESG presentation  
 March 2011

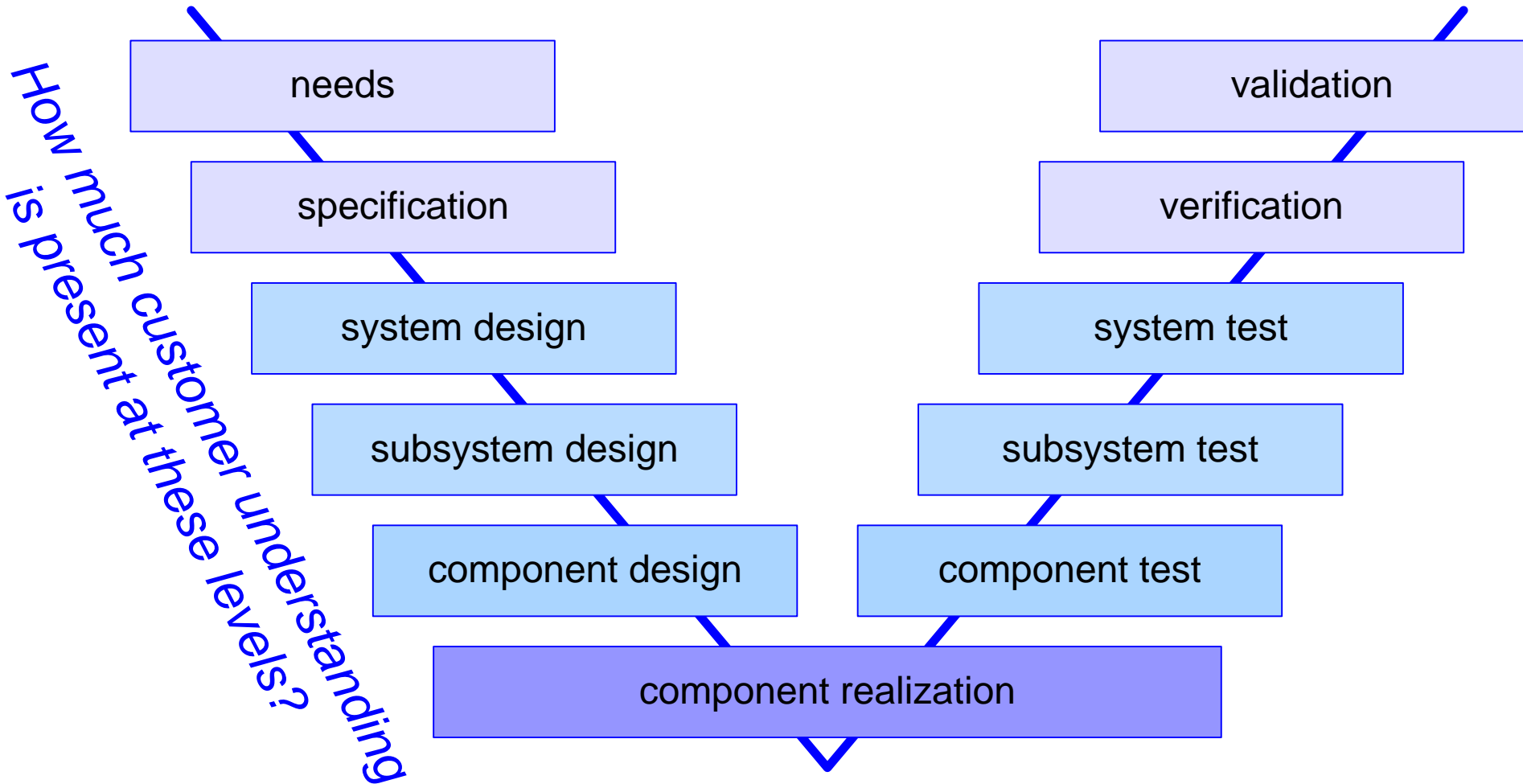
[http://www.gaudisite.nl/SESG\\_Wiulsrød%EF%BF%BDa3overviews.pdf](http://www.gaudisite.nl/SESG_Wiulsrød%EF%BF%BDa3overviews.pdf)

# Customer Understanding



# How well do Your Engineers Understand Your Customer?

*In every hand-over and every conversion knowledge is lost*



# Methods to Capture Customer Understanding

## *User Stories*

Specific stories to explore specification and design.

Contain social and environmental details to make engineers aware

## *ConOps*

*Concept of Operations*, used in Defense Domain

Factual description of Operational use, a.o. with scenarios

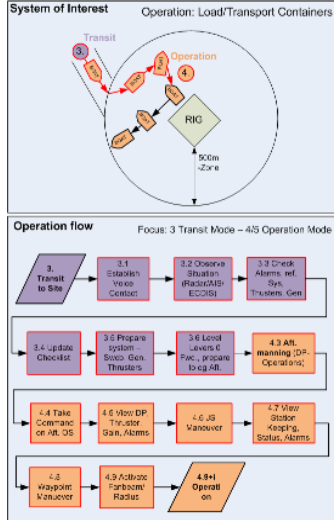
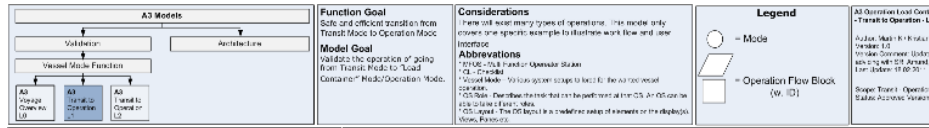
## *Work Flows*

Systematic description of user operations.

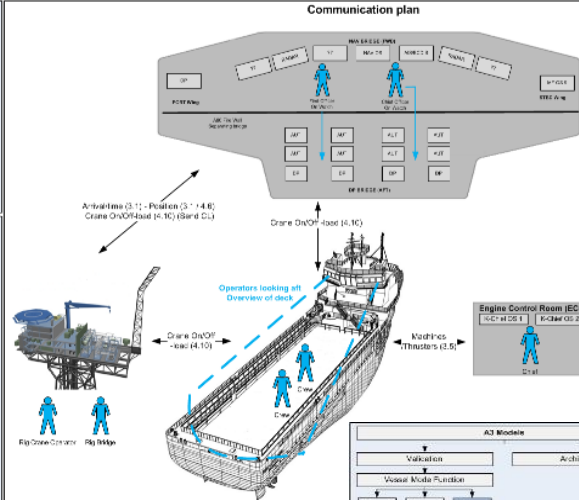
Annotated with Where, When, Who, What

*This is one class of methods, there are many more methods*

# Example of Customer Knowledge



workflow



operations

geographical

source: master project papers  
Kristian Frøvd and  
Martin Kruse

**A3 Models**

**Function Goal**  
Safe and efficient transition from Transit Mode to Operation Mode

**Model Goal**  
Validate the operation of going from Transit Mode to Load Container? Mode/Operation Mode.

**Considerations**  
There will exist many types of operations. This model only covers one specific example to illustrate work flow and user interaction.

**Abbreviations**  
\* MPOS - Multi-Function Operator Station  
\* CL - Control  
\* Visual Mode - Validation systems setup indicated for the current vessel operation.  
\* OS Block - Describe the task that can be performed at the OS. An OS can be global or site specific.  
\* OS Layout - The OS layout is a predefined setup of elements on the displays, views, etc.

**Legend**  
○ = Mode  
□ = Operation Flow Block (w. ID)

**A3 Operation Level Context - Transit to Operation - L2**  
Author: Martin Kruse, 17 October 2021  
Version: 0.1  
User: User name: MS, User: User name: MS, User: User name: MS, User: User name: MS  
Scope: Transit - Operation  
Smaller: Smaller, Version: 0.1

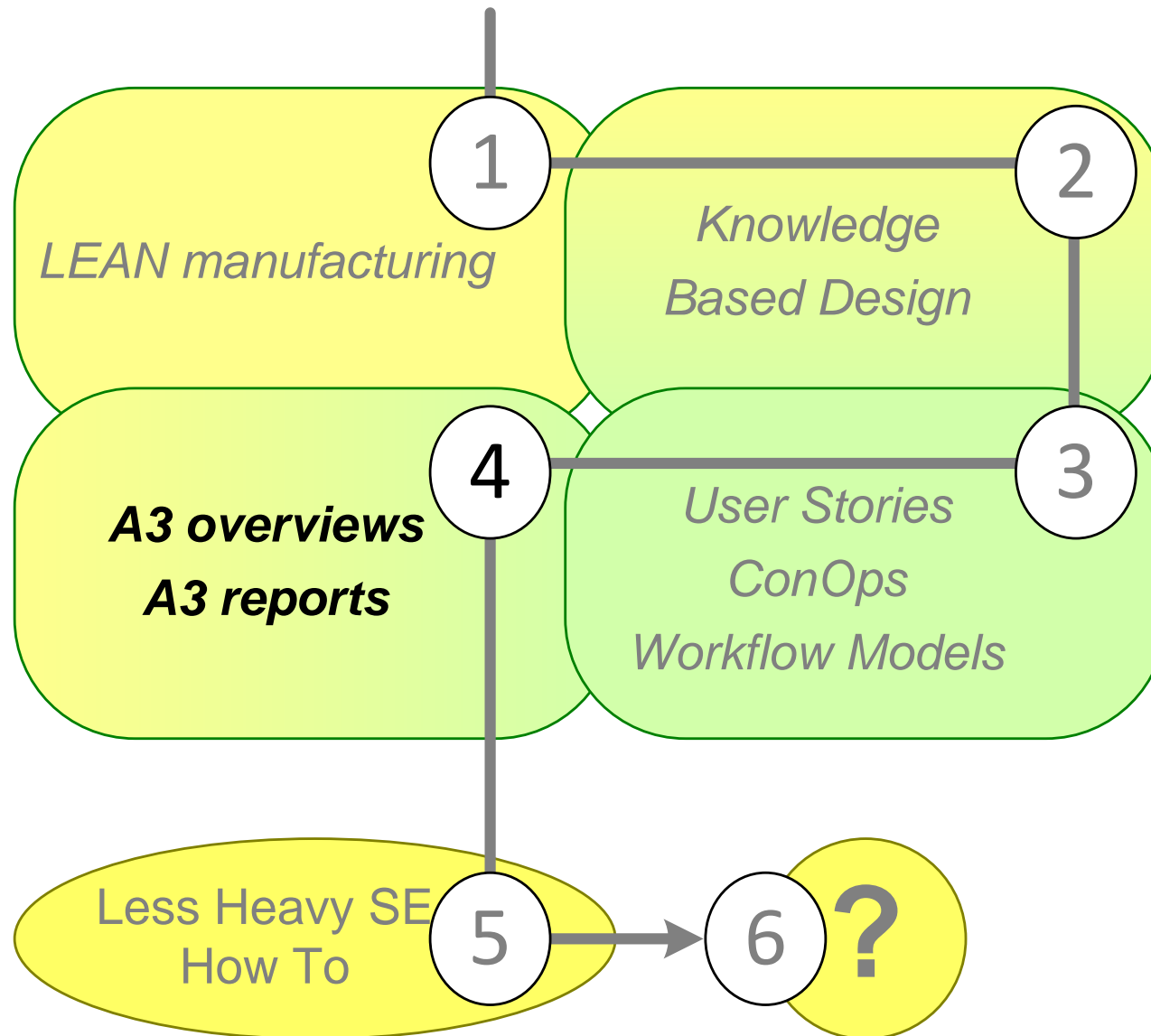
**Observations from Viking Energy**

**Transit - Fac. Bridge**  
Transit/Navigation Operators also focused on 2x motor screens w/ different resolutions. All control except route might come from DP-OS.

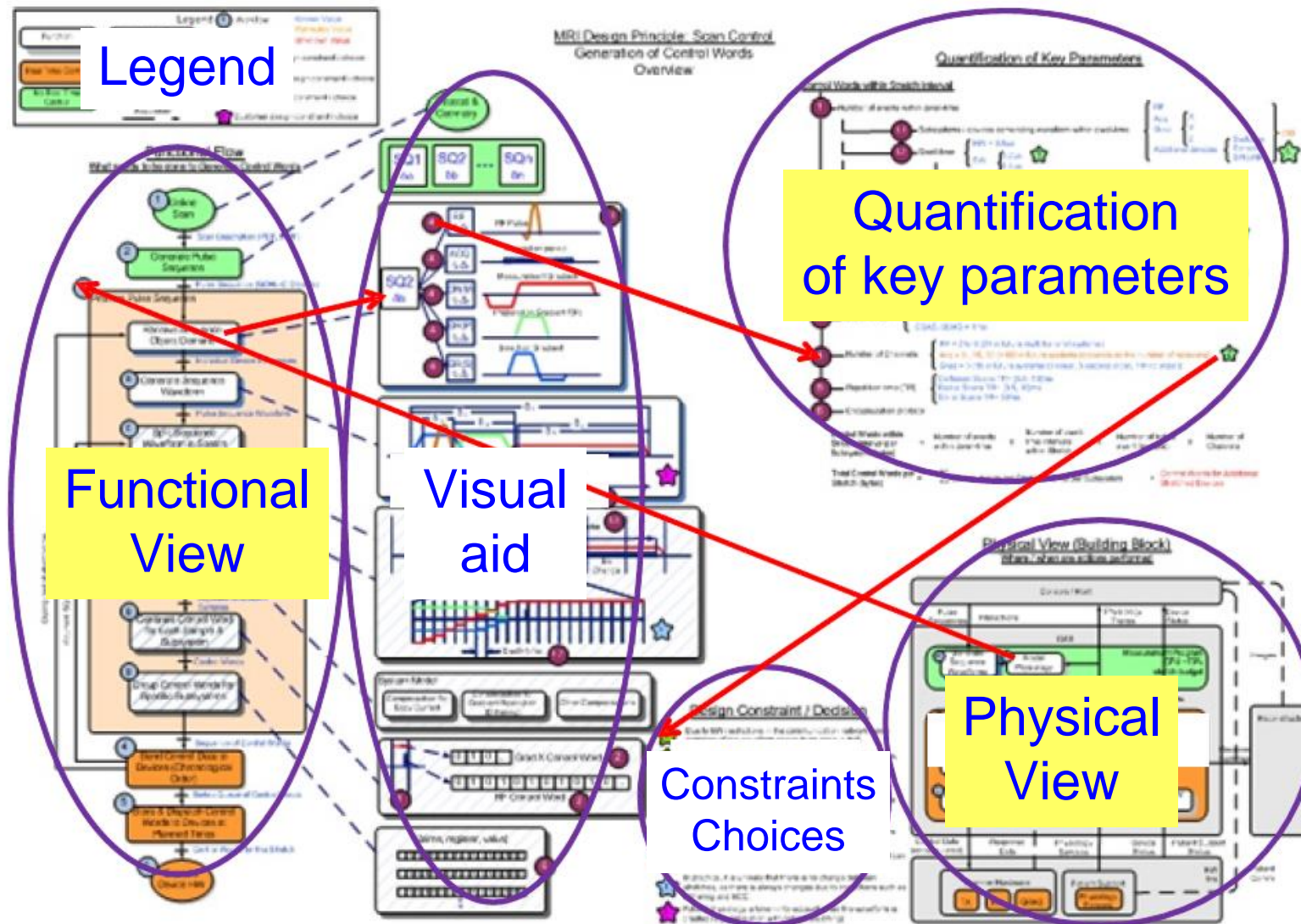
**AR - Bridge**  
AR - Bridge Chair (x2)  
This picture shows left AR - Bridge Control position, when operators are going from Transit to Operation those positions are manned, also this position is also used for radio communication.

**AR - Bridge Screens (During Operations)**  
Picture 1 and 2: Left and right DP view. This was the same at all times. Additional observations: Wind Sensor (Digital CCTV View. At this point both Operators seats in each chair will have same setup: Fac. Bridge Horizontal MRU Roll View.

# A3 Overviews and A3 Reports



# A3 Overview Fundamentals



A3 Architecture Overviews Focusing architectural knowledge to support evolution of complex systems  
 by: Daniel Borches and Maarten Bonnema, INCOSE 2010

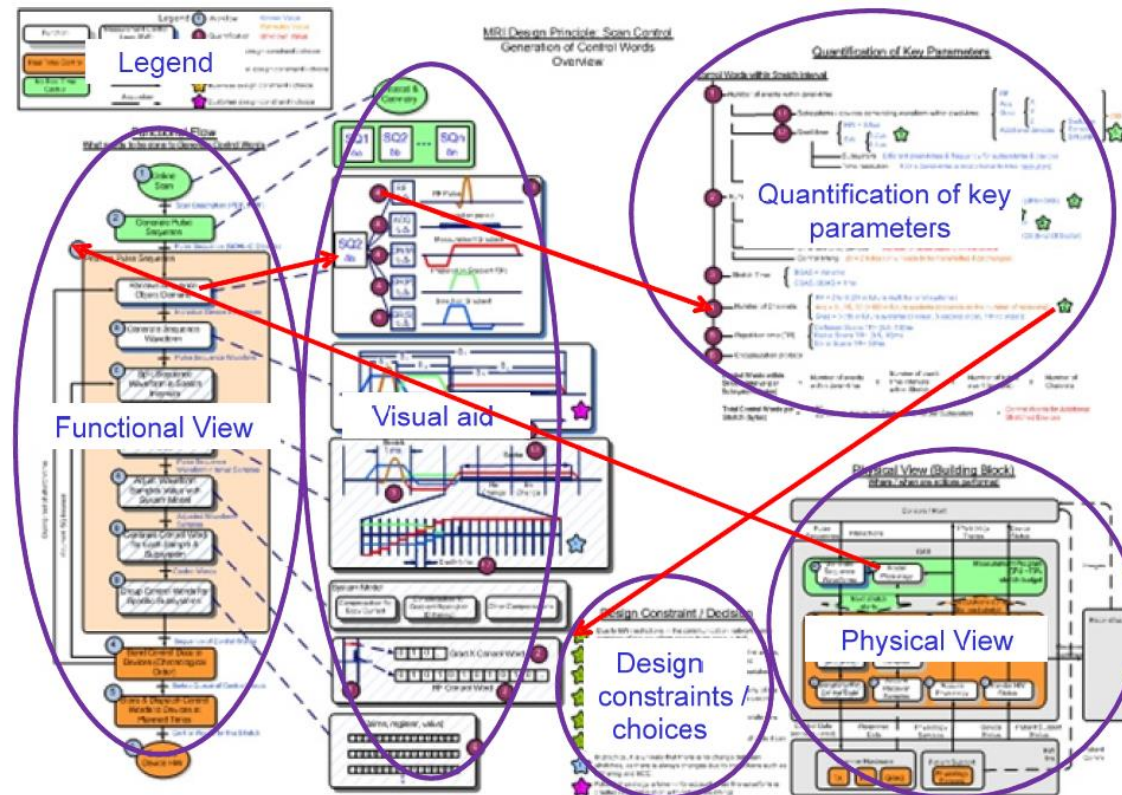
# A3 Overview Fundamentals (2)

multiple related views

quantifications

one topic per A3

capture "hot" topics



source: PhD thesis Daniel Borches <http://doc.utwente.nl/75284/>

digestible  
(size limitation)

practical  
close to stakeholder experience

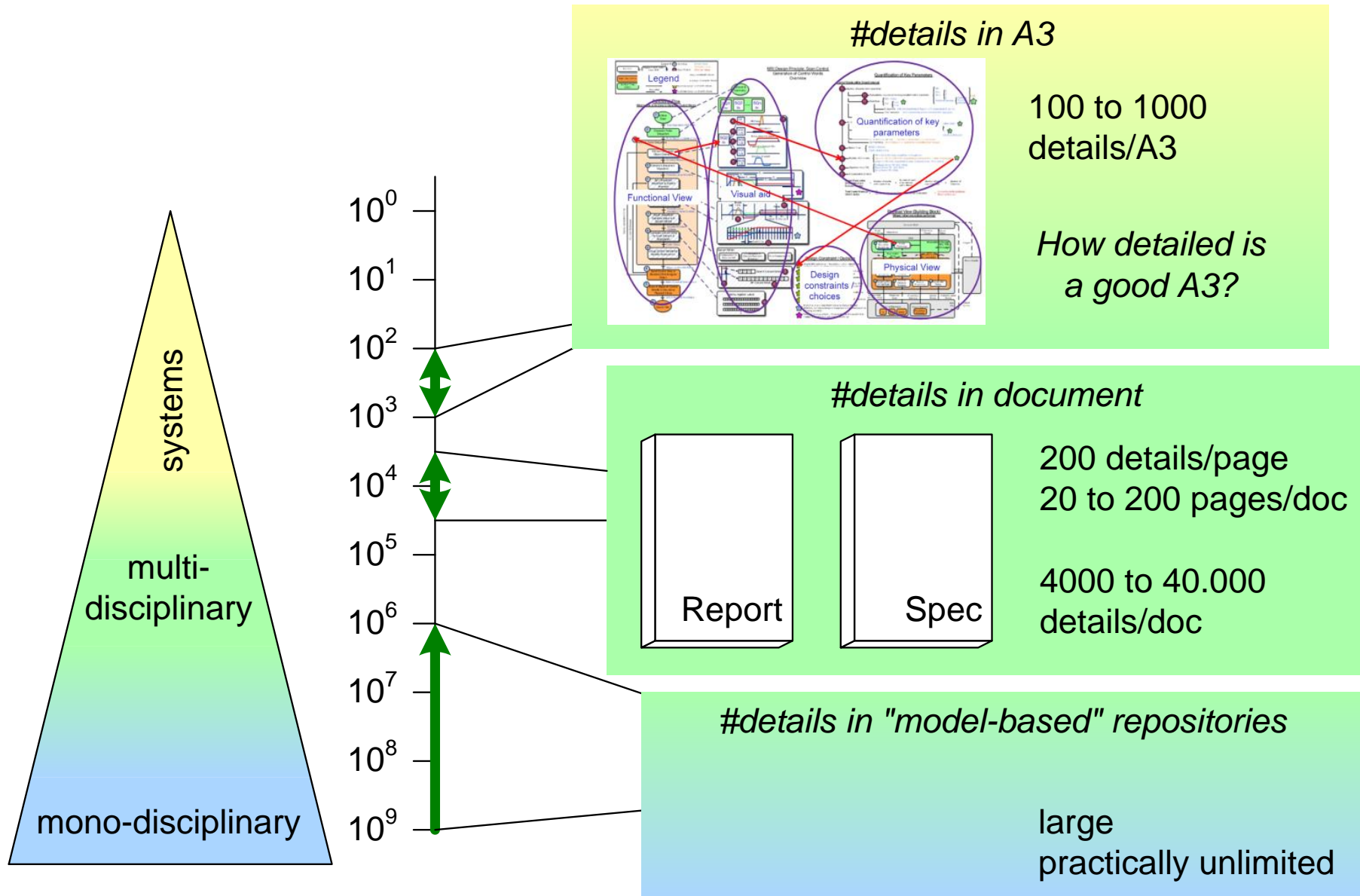
# Evaluation of Conventional Design Spec

## Results of Questionnaire System Design Specification

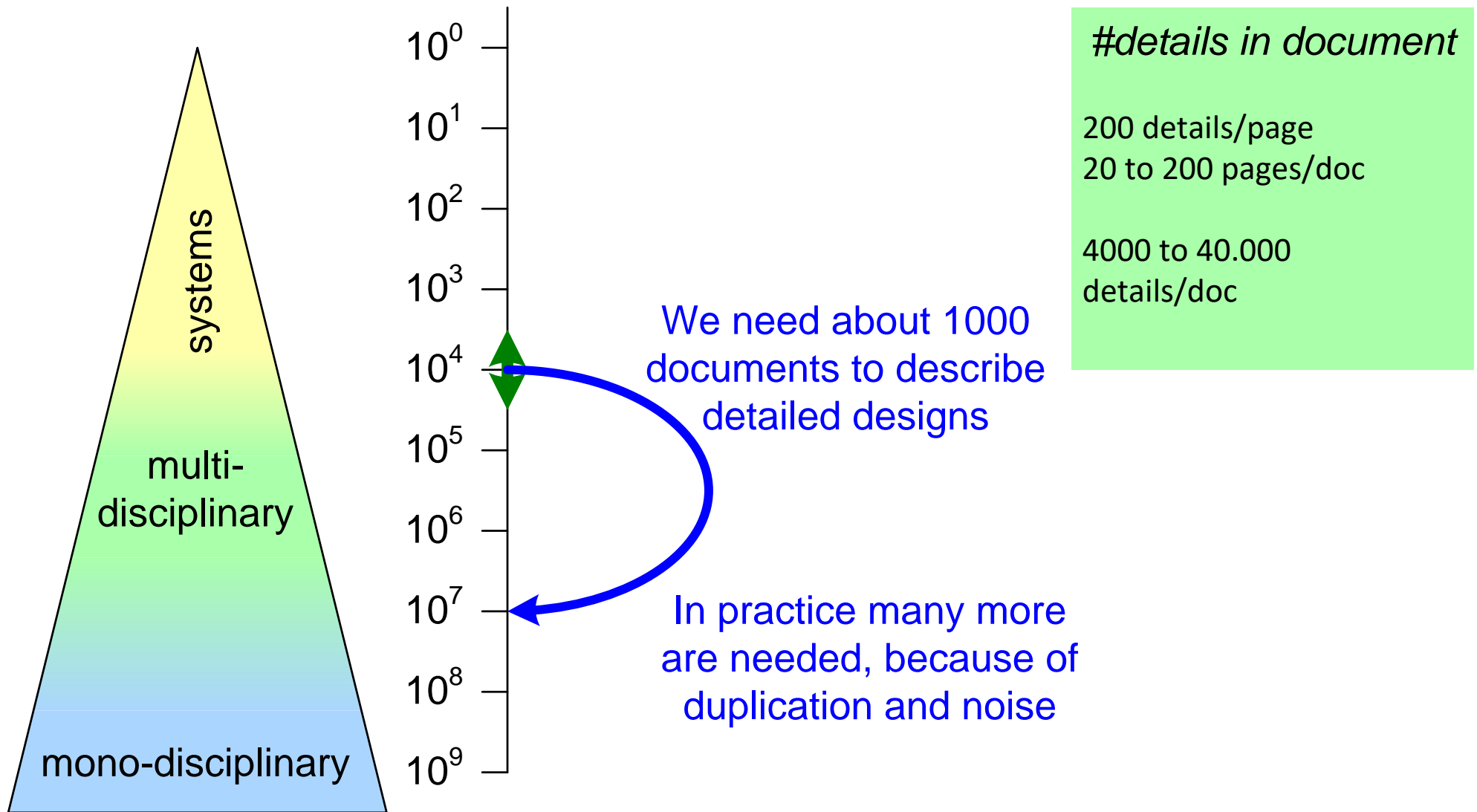
Statement 4: Current SDS document is useful for your work					
General Response		Strongly Agree/Agree per Job Title		Strongly Agree/Agree per Experience	
Strongly Agree	0%	Manager/ Leader	50%	<5 Years	75%
Agree	29%	Architect	40%	5 <Years< 10	23%
Disagree	40%	Engineer	30%	10 <Years< 20	22%
Strongly Disagree	14%	Designer	0%	Since MR Proton	22%
Don't Know	17%	Domain Expert	50%	(> 20 Years)	
		Other	0%		
Statement 5: The SDS delivers what you expect from a system specification					
General Response		Strongly Agree/Agree per Job Title		Strongly Agree/Agree per Experience	
Strongly Agree	0%	Manager/ Leader	25%	<5 Years	50%
Agree	26%	Architect	20%	5 <Years< 10	31%
Disagree	49%	Engineer	40%	10 <Years< 20	11%
Strongly Disagree	6%	Designer	0%	Since MR Proton	22%
Don't Know	20%	Domain Expert	50%	(> 20 Years)	
		Other	33%		

Source: PhD thesis Daniel Borches <<http://doc.utwente.nl/75284/>>

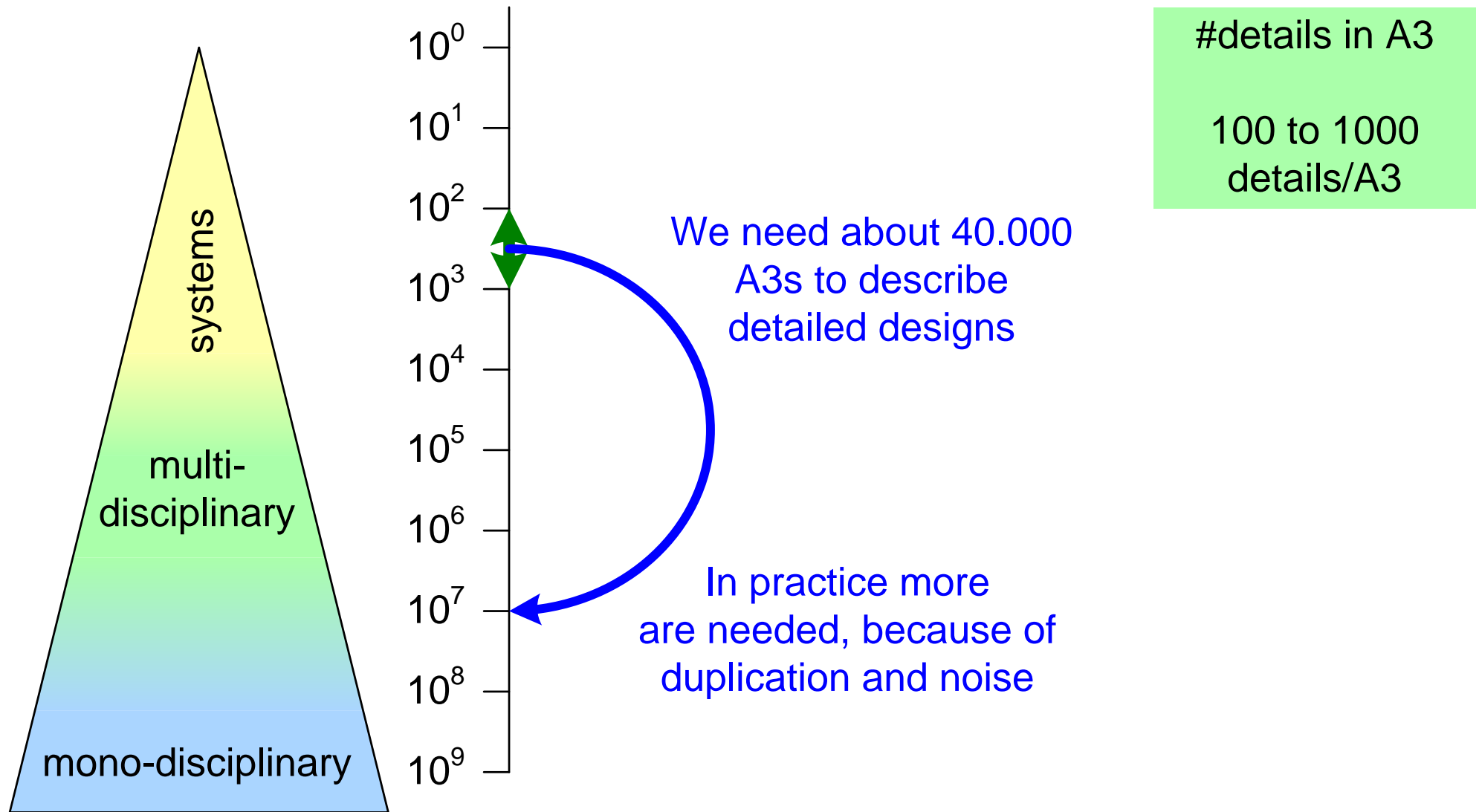
# Amount of Data per Medium



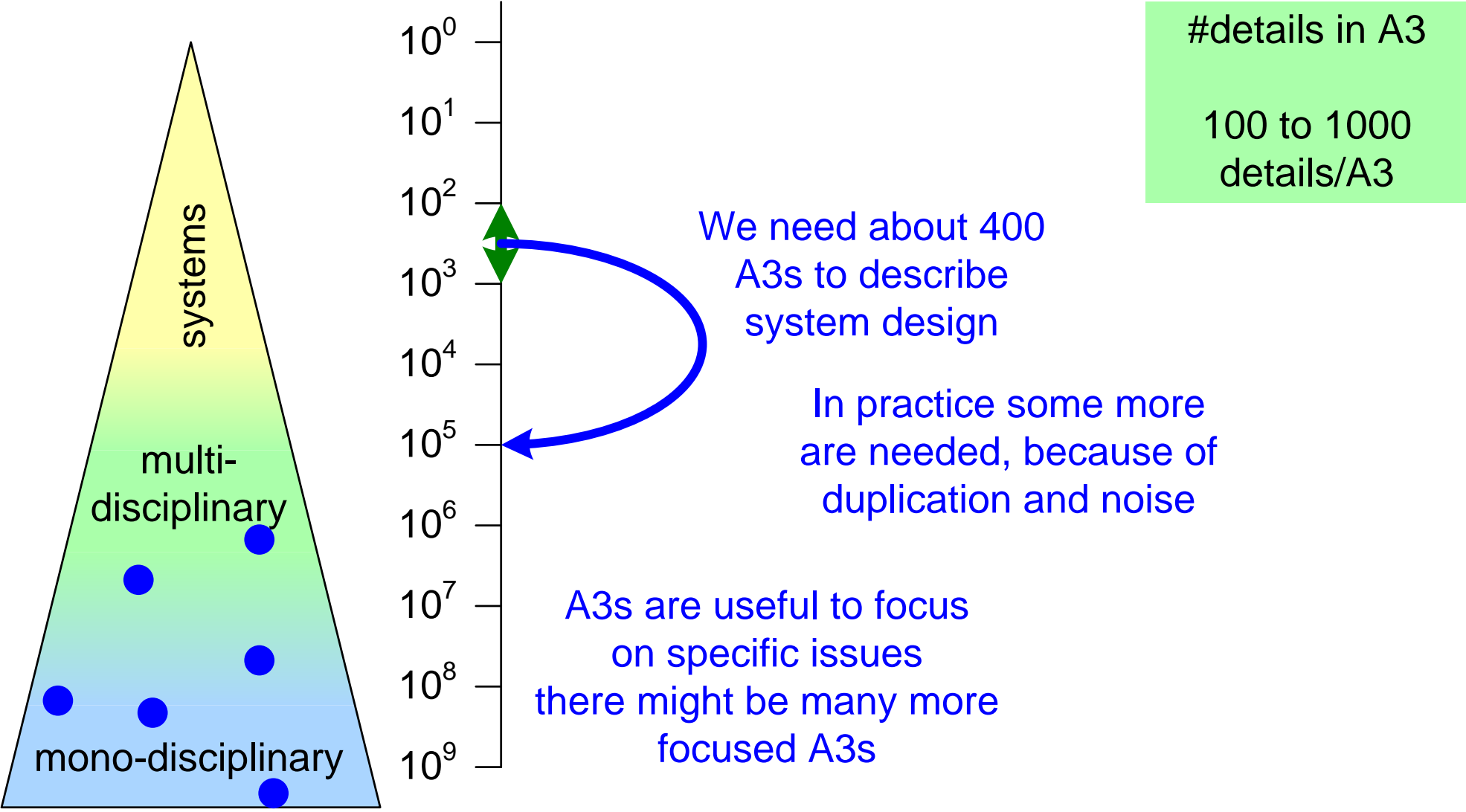
# Number of Conventional Documents



# What If we Use A3s for all Detailed Designs?



# What If we Use A3s for System Design?



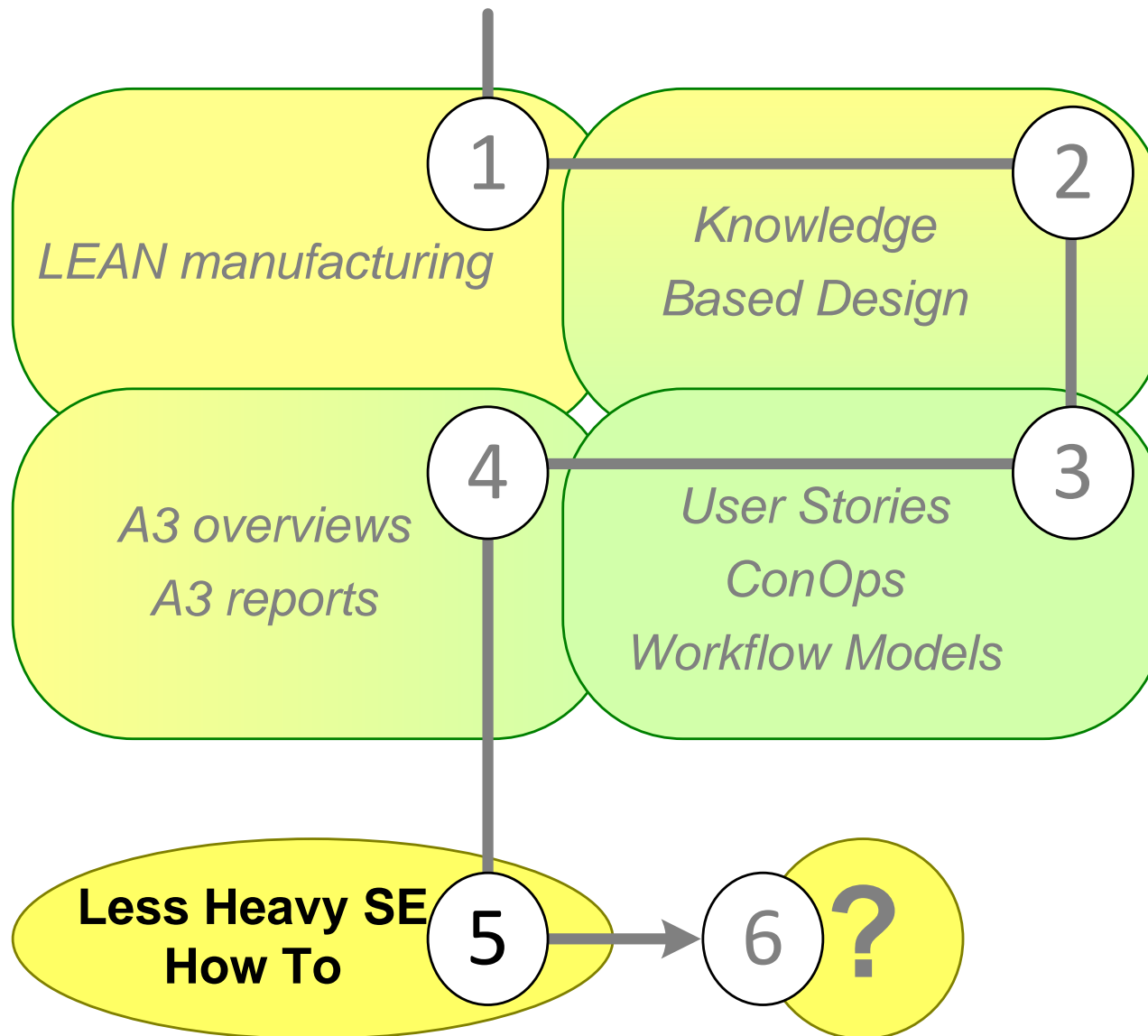
We need documents **and** A3s **and** data bases

We need to design documentation structure

We need conventions for use    **naming, meta information,  
structure, storage**

A3s fit in broader context

A3s are practical and work well



# Light Weight How To

1. Reduce the rule set to the (business) essential

Understand

- your customer
- your customer's customer etcetera

ConOps  
user stories  
work flows

$$\text{weight}(\text{architecture}) = \sum_{\text{all rules}}$$

minimize number of mandatory rules

agile

f ( level of **enforcement** ,

empower, delegate

LEAN

**scope** (impact) ,

minimize implementation details  
focus on essential concepts

A3

**size**,

Apply design principles on architecture  
and documentation

systems  
thinking

level of **coupling** or  
number of dependencies )

Multi-view architecting

A3

