Tutorial Architectural Reasoning Using Conceptual Modeling

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

Conceptual models are models that are sufficiently simplified to help architects to understand, reason, communicate, and make decisions. The abstraction level of these models ranges from back-of-the-envelope to simple visualizations, mathematical formulas, and limited spreadsheet models. These models range from critical system internals, to life cycle issues, to customer value analysis. In this tutorial, we show and exercise how different representations and views are used complementary to communicate, discuss, and analyze at a level that supports architecting. Main challenge is balance the need for detail to ensure credibility and the need to keep the model limited for the sake of communication, discussion, and analysis.

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April 3, 2023
status: draft
version: 0.2

Tutorial, Course and Reading Material

Course Material

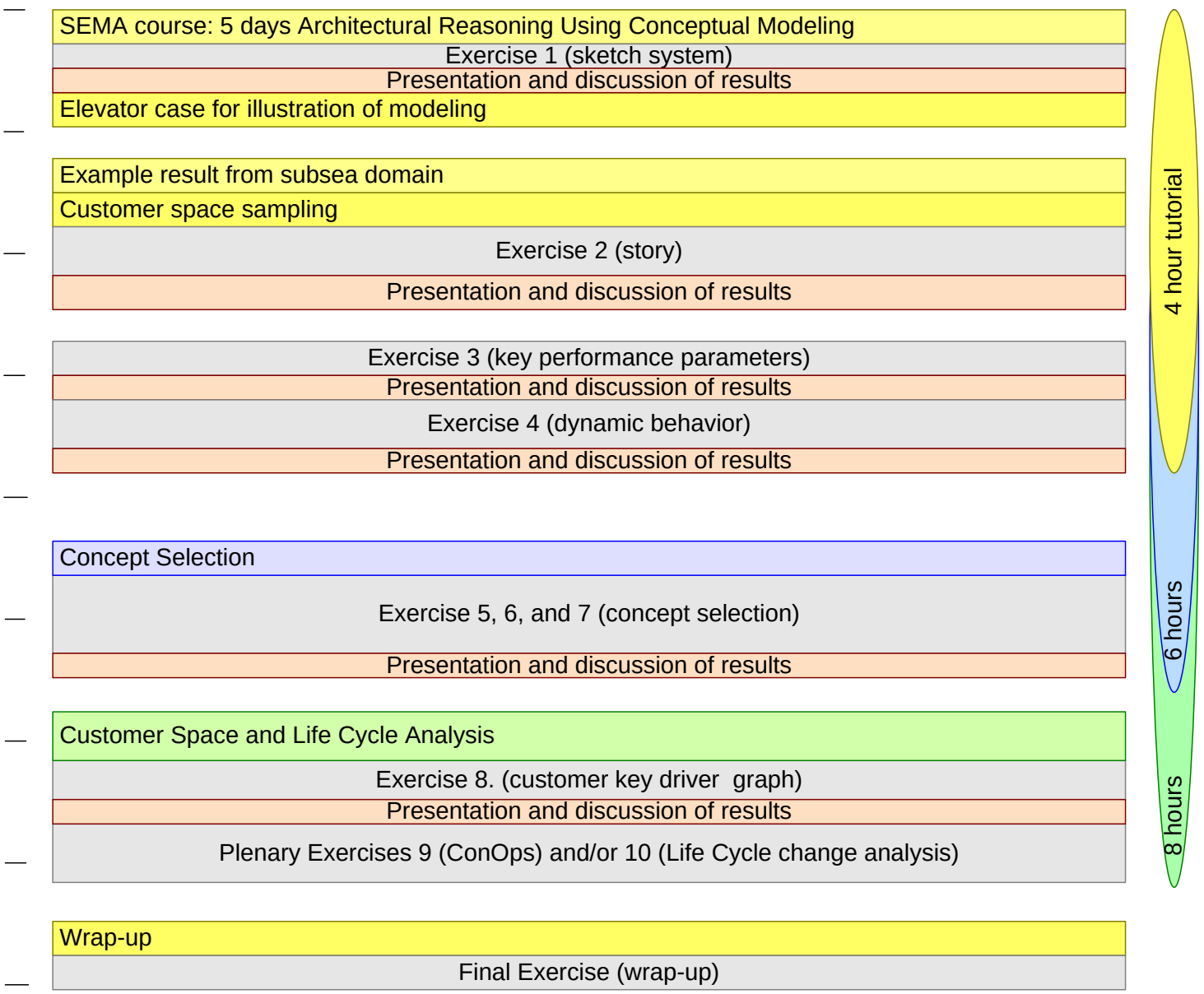
Tutorial http://www.gaudisite.nl/info/TutorialARconceptualModeling.info.html
SEMA course http://www.gaudisite.nl/SEMAmaterial.html

Reading Material

Elevator http://www.gaudisite.nl/CIRP2014_Muller_TeachingConceptualModeling.pdf
Subsea example http://www.gaudisite.nl/INCOSE2015_MullerEtAl_SubseaOverviewA3.pdf A3 http://www.gaudisite.nl/SSMEoverviewA3.pdf
Customer space sampling http://www.gaudisite.nl/StoryHowToPaper.pdf
Customer Key Driver Graph http://www.gaudisite.nl/KeyDriversHowToPaper.pdf
Life Cycle Analysis http://www.gaudisite.nl/MAlifeCyclePaper.pdf

Gaudi Site http://www.gaudisite.nl/

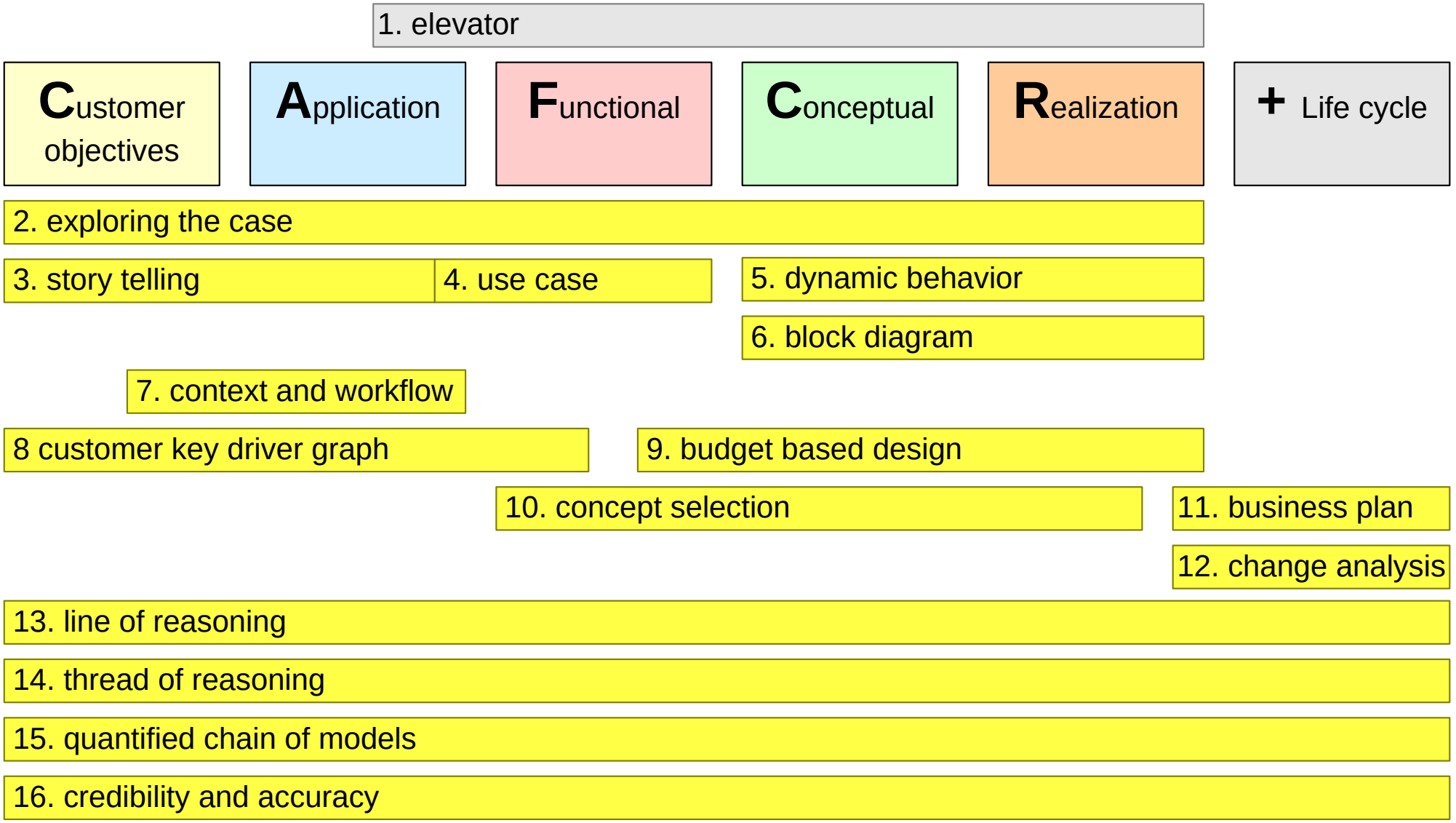
An (over?)Optimistic Program of the Tutorial



Course Program of the 5-day SEMA Course

day 1	introduction to modeling	exploring the case
day 2	sample customer space	functions and parts
day 3	customer space analysis	quantification and concepts
day 4	business and life cycle	integration and reasoning
day 5	modeling	wrap-up

Assignments during the 5-day SEMA Course



SEMA Basic Philosophy

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Abstract

This presentation explains the basic philosophy behind the SEMA course. The SEMA course in the first place is a course that provides an approach to architectural reasoning. Core to architectural reasoning is the ability to make conceptual models and to use them in conjunction. The course discusses how to make conceptual mdoels, how to get input, and how to use them for analysis. Modeling is put in broader perspective, such as model evolution, simuation, and validation.

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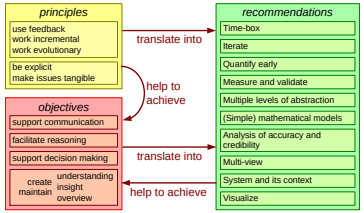


You will mostly be working!

One **Case** during the course and the home work assigment

Work in **teams** if possible

Select a case close to **your day-to-day practice**

Learning by Doing

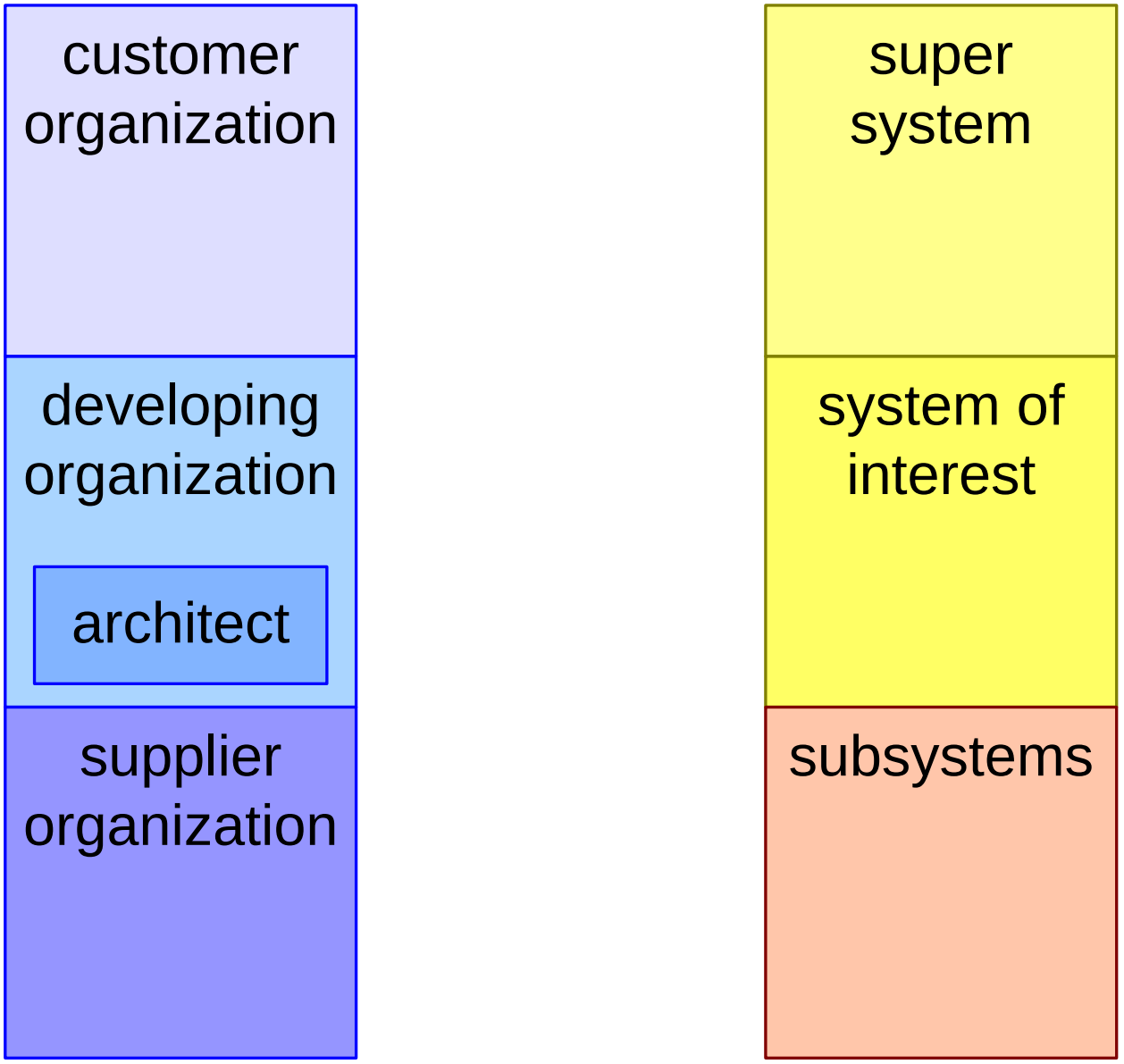
Some theory, apply on case

Case = System of interest + developing organization + some innovative change

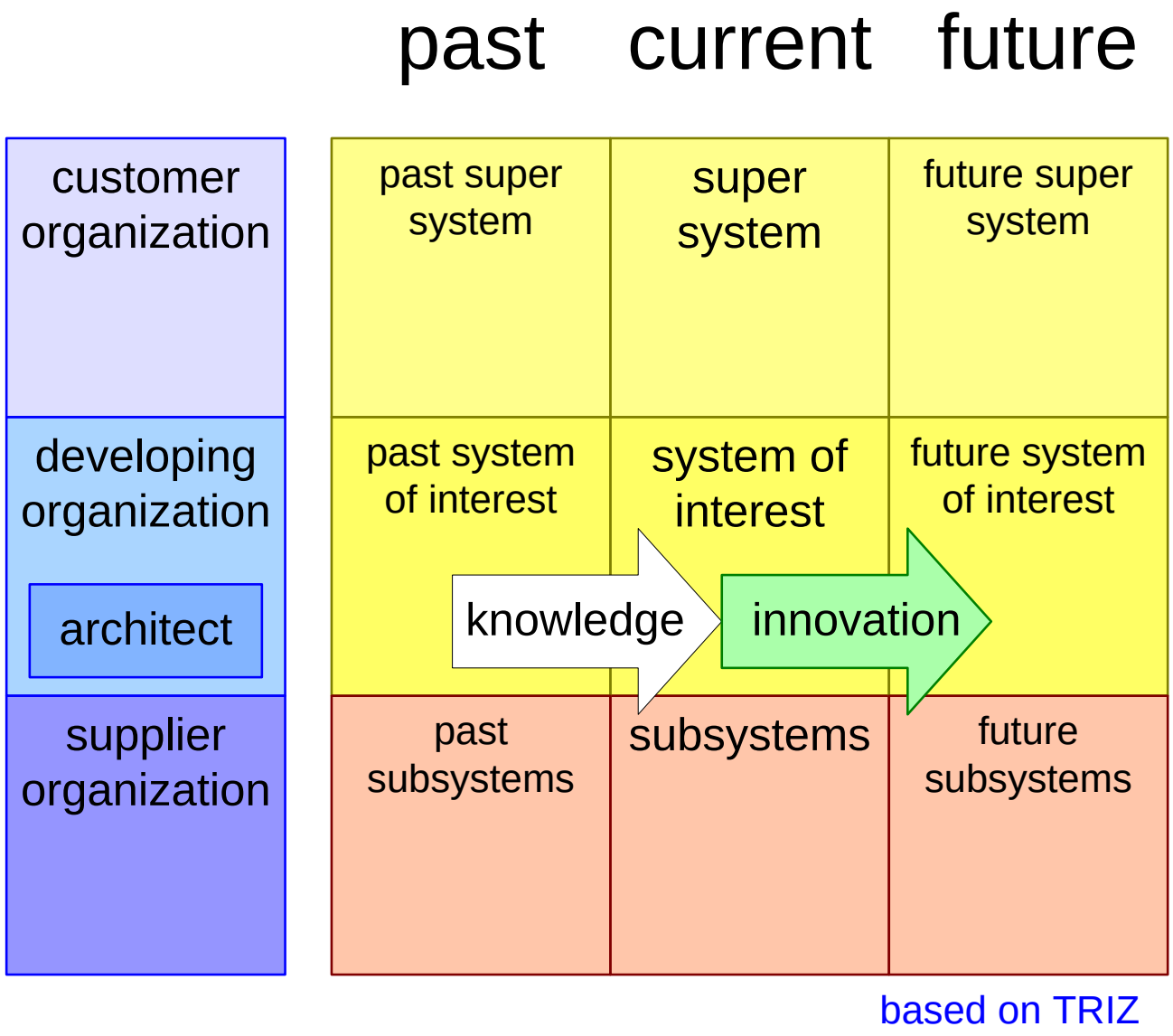
Choice of case is critical!

Our Primary Interest

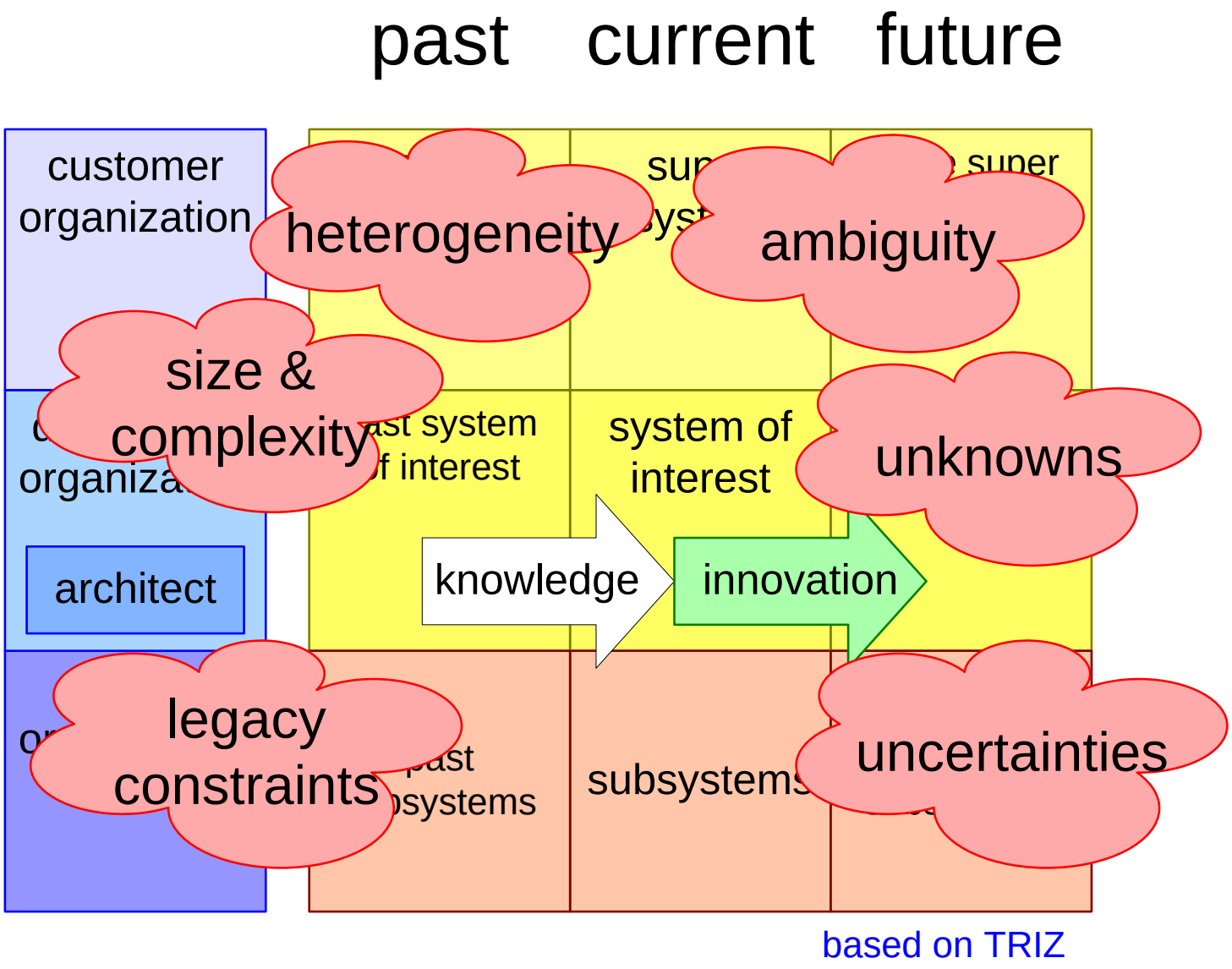
Context, Zoom-out and Zoom-in



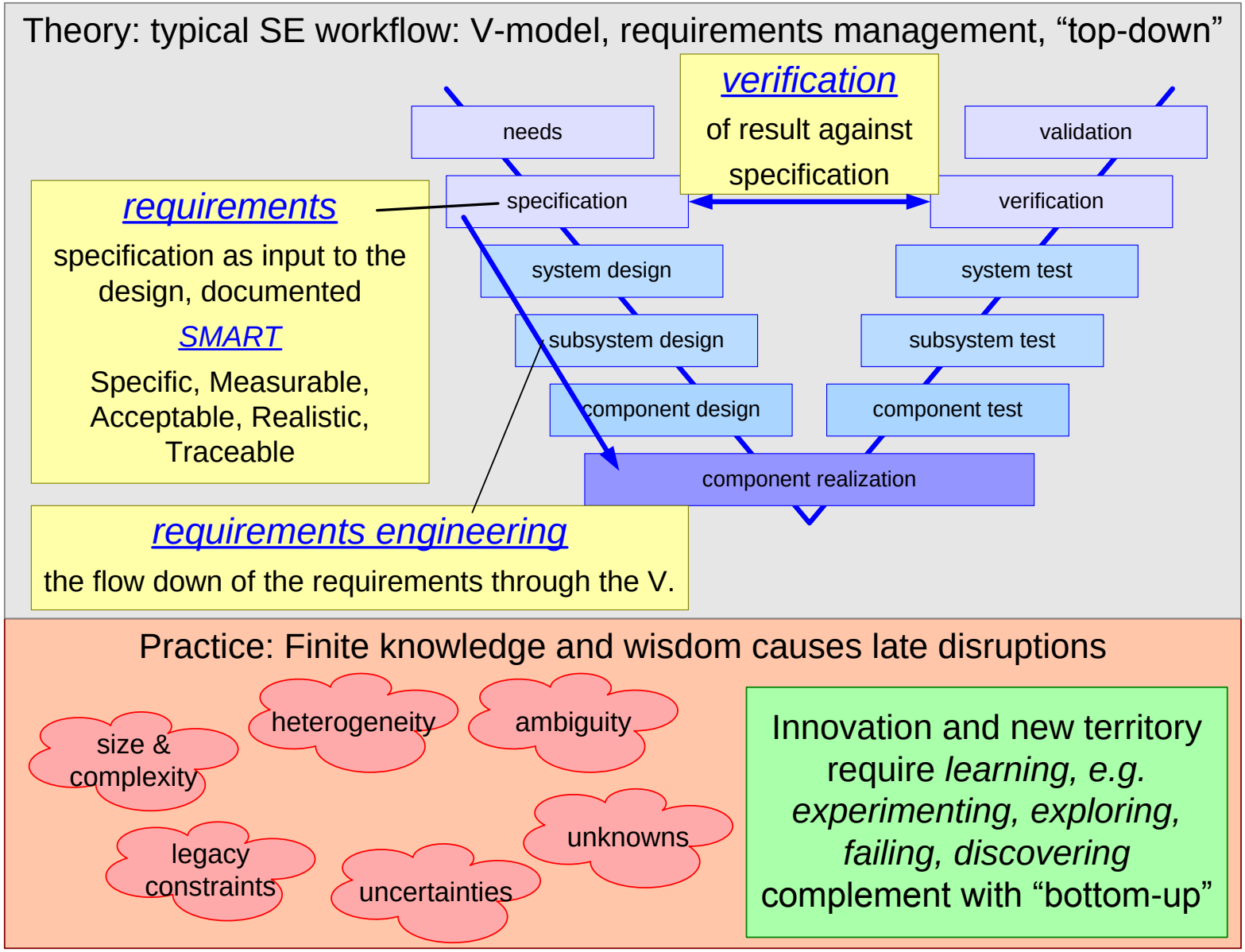
Adding the Time Dimension



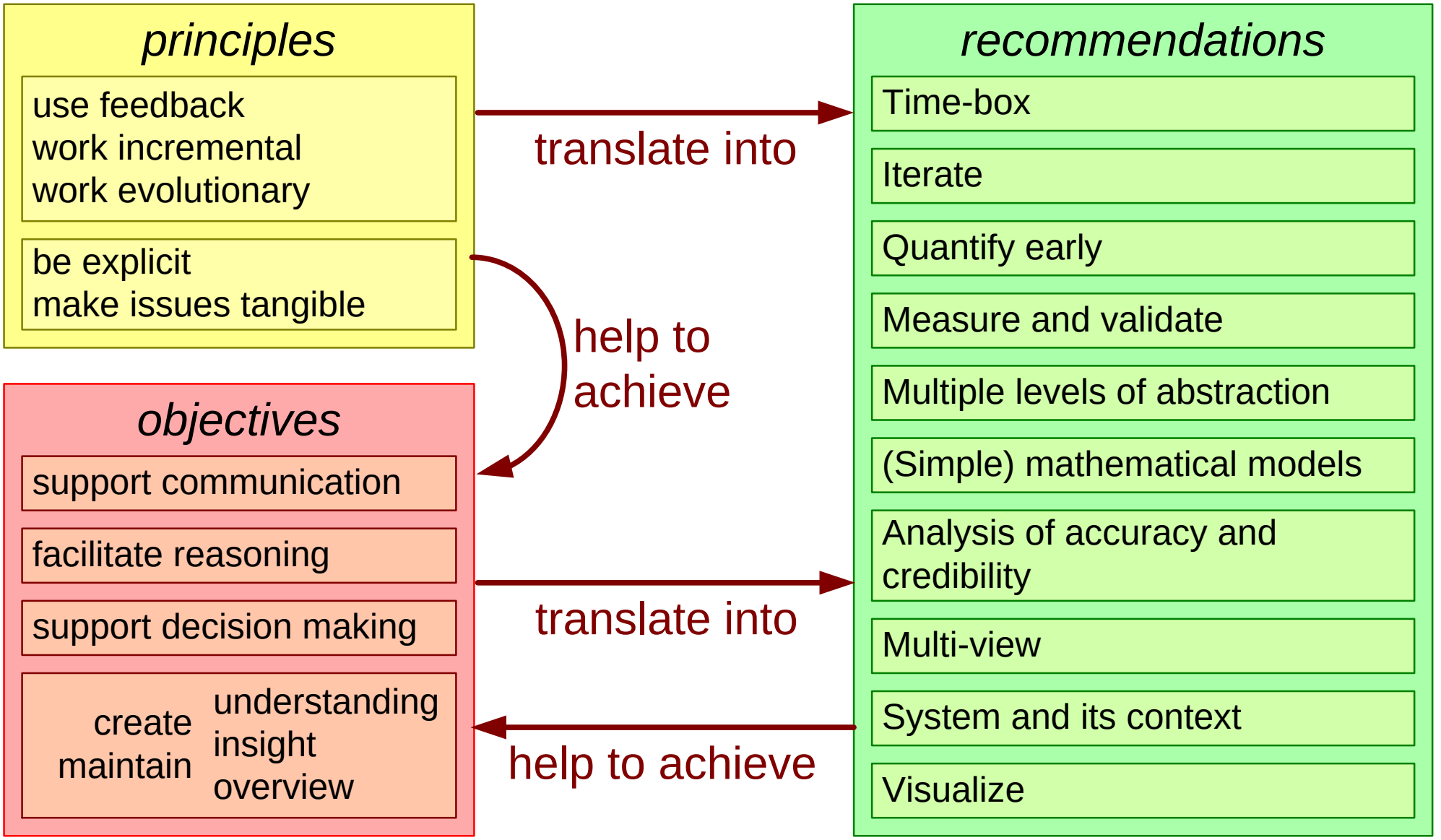
Challenges


past current future
customer organization
heterogeneity
ambiguity
size & complexity
unknowns
architect
knowledge
innovation
legacy constraints
uncertainties
subsystems
based on TRIZ

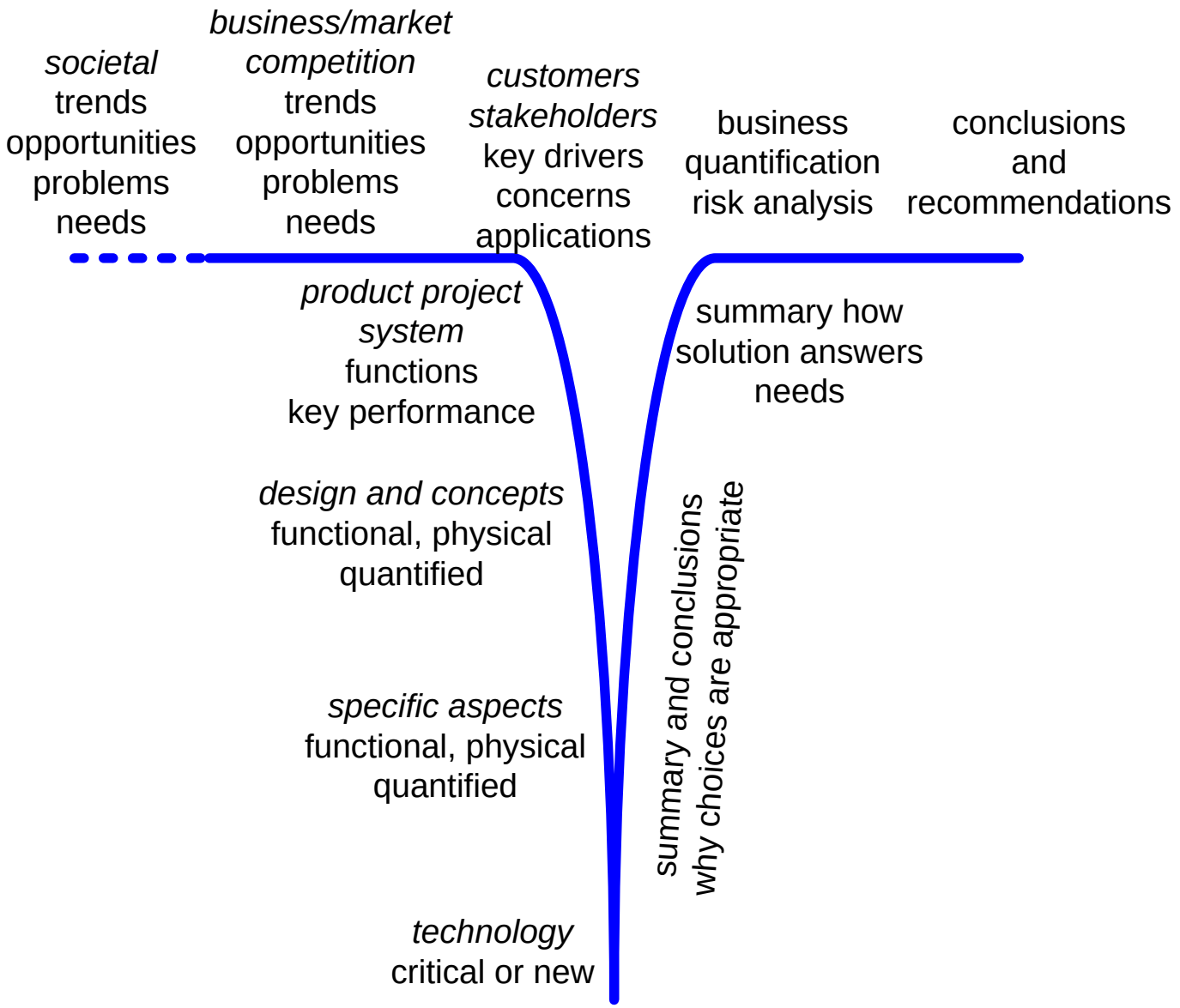
From Theory to Practice



Recommendations as Common Thread



Final Delivery: Presentation to Top Management



Recommendations for Exercises

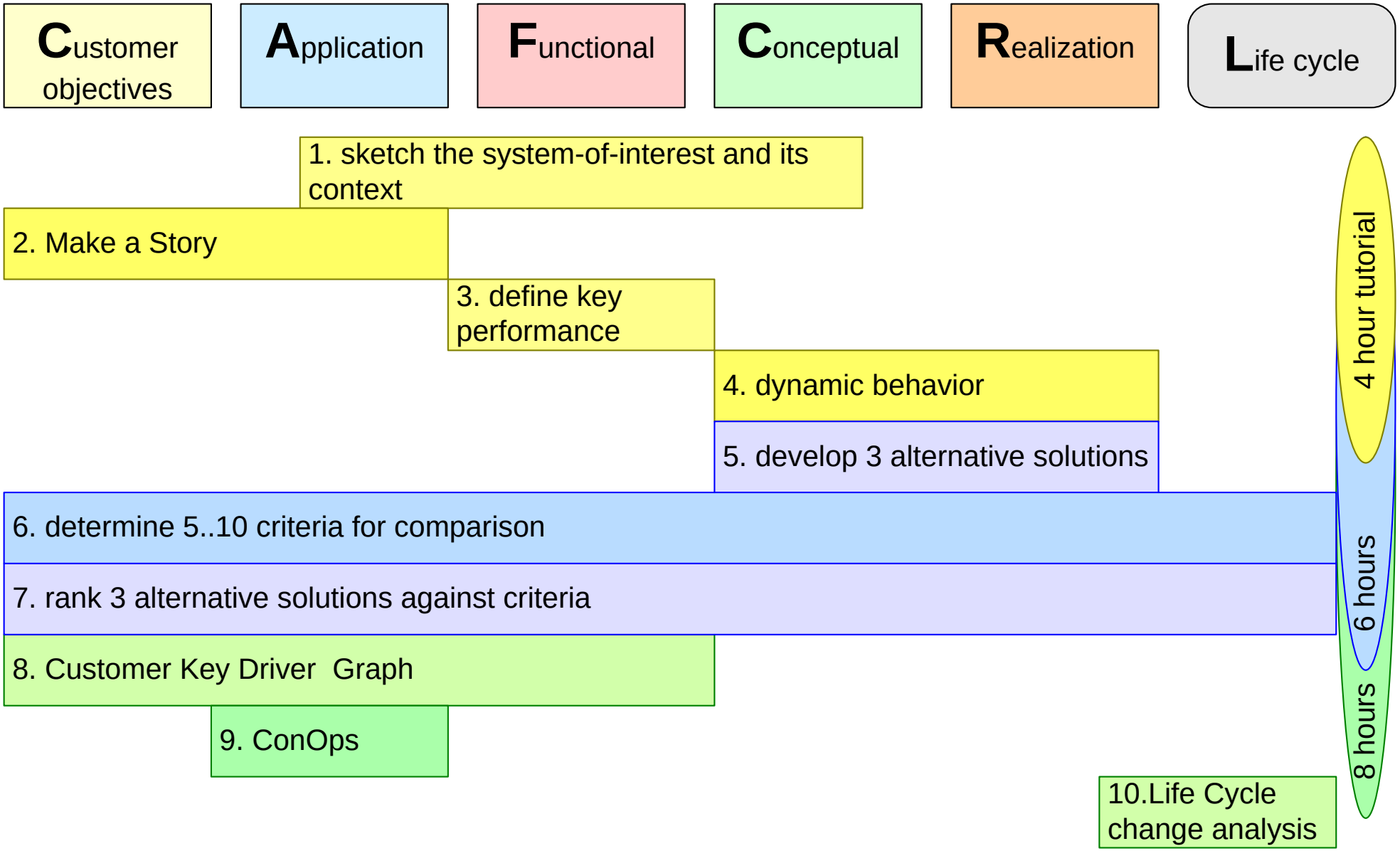
Do	Do **not**	Because
• start sketching/drawing as soon as possible	• write long texts .	• sketches stimulate sharing and discussion
• use shared large sheets of paper (e.g. flip-over)	• immediately capture electronic	• sharing and discussion help to explore faster
• number the flip-overs and add a title		• remembering the order gets challenging
• annotate (add notes) during discussions	• have nice but volatile discussions	• information and insight is quickly lost
• use yellow note stickers and flip-over markers	• write with pen or pencil	• stickers are easily (re)moved
• be open for ideas and surprises	• Do not stick to the first solution	• you hopefully discover a lot; increased insight will change problem and solution

Exercise Sketch the System-of-Interest

Sketch the **System-of-Interest** in its **context**

- Show some of the internals of the system-of-interest
- Indicate the boundary of the system-of-interest

Exercises during the Tutorial



Elevator Case: Learning Goals

To understand the need for

- various views, e.g. physical, functional, performance
- mathematical models
- quantified understanding
- assumptions (when input data is unavailable yet) and later validation
- various visualizations, e.g. graphs
- understand and hence model at multiple levels of abstraction
- starting simple and expanding in detail, views, and solutions gradually, based on increased insight

To see the value and the limitations of these conceptual models

To appreciate the complementarity of conceptual models to other forms of modeling, e.g. problem specific models (e.g. structural or thermal analysis), SysML models, or simulations

Case Takes about 2 Hours

warning

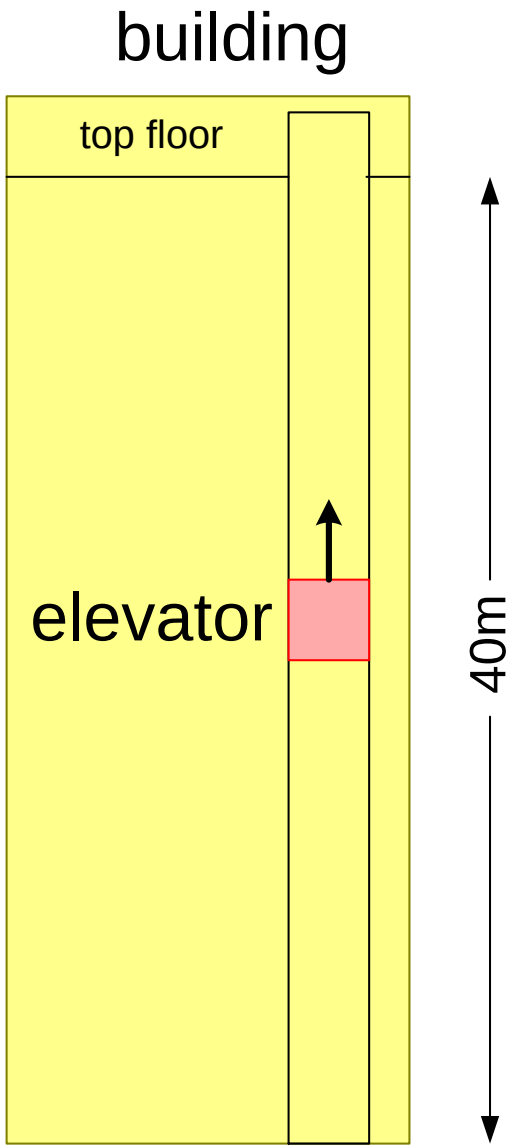
This presentation starts with a trivial problem.

Have patience!

Extensions to the trivial problem are used to illustrate many different modeling aspects.

Feedback on correctness and validity is appreciated

The Elevator in the Building



inhabitants want to reach
their destination fast and comfortable

building owner and *service operator*
have economic constraints:
space, cost, energy, ...

Elementary Kinematic Formulas

S_t = position at time t

v_t = velocity at time t

a_t = acceleration at time t

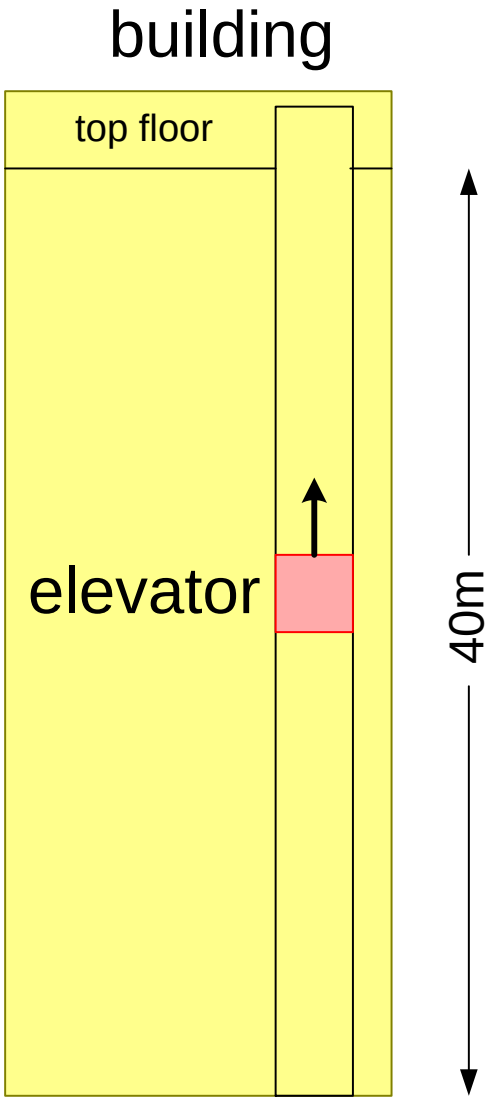
j_t = jerk at time t

$$v = \frac{dS}{dt} \qquad a = \frac{dv}{dt} \qquad j = \frac{da}{dt}$$

Position in case of uniform acceleration:

$$S_t = S_0 + v_0 t + \frac{1}{2} a_0 t^2$$

Initial Expectations



What values do you expect or prefer for these quantities? Why?

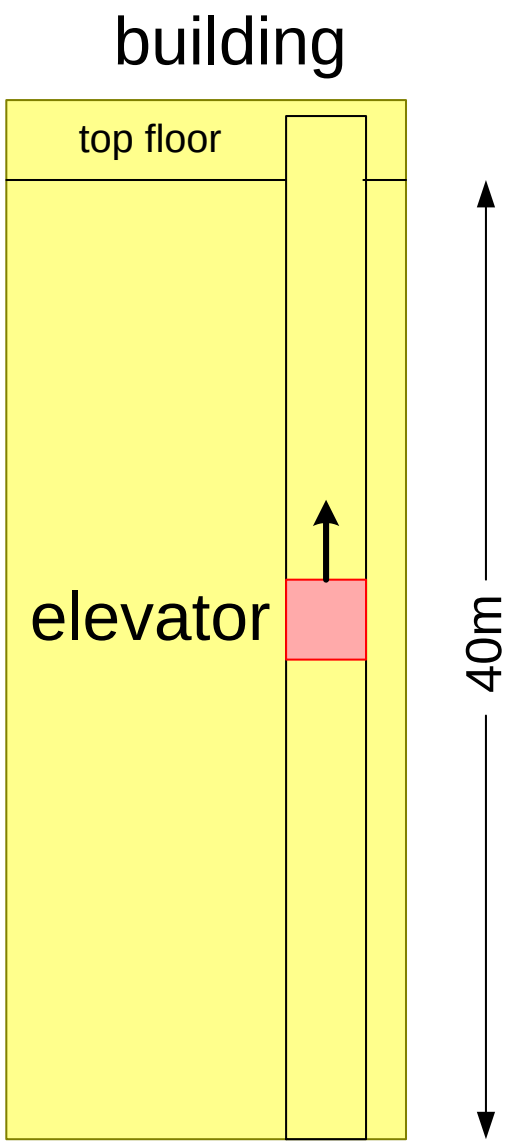
$t_{top\ floor}$ = time to reach top floor

v_{max} = maximum velocity

a_{max} = maximum acceleration

j_{max} = maximum jerk

Initial Estimates via Googling



Google "elevator" and "jerk":

$t_{top\ floor}$ ~= 16 s

v_{max} ~= 2.5 m/s

a_{max} ~= 1.2 m/s^2 (up)

12% of gravity; weight goes up

relates to motor design and energy consumption

j_{max} ~= 2.5 m/s^3 — relates to control design

humans feel changes of forces
high jerk values are uncomfortable

numbers from: http://www.sensor123.com/vm_eva625.htm
CEP Instruments Pte Ltd Singapore

Exercise Time to Reach Top Floor Kinematic

input data

$S_0 = 0m$ $S_t = 40m$

$v_{max} = 2.5\ m/s$

$a_{max} = 1.2\ m/s^2$ (up)

$j_{max} = 2.5\ m/s^3$

elementary formulas

$$v = \frac{dS}{dt} \qquad a = \frac{dv}{dt} \qquad j = \frac{da}{dt}$$

Position in case of uniform acceleration:

$$S_t = S_0 + v_0 t + \frac{1}{2} a_0 t^2$$

exercises

$t_{top\ floor}$ is time needed to reach top floor without stopping

Make a model for $t_{top\ floor}$ and calculate its value

Make 0^e order model, based on constant velocity

Make 1^e order model, based on constant acceleration

What do you conclude from these models?

Models for Time to Reach Top Floor

input data

$S_0 = 0m$ $S_{top\ floor} = 40m$

$v_{max} = 2.5\ m/s$

$a_{max} = 1.2\ m/s^2$ (up)

$j_{max} = 2.5\ m/s^3$

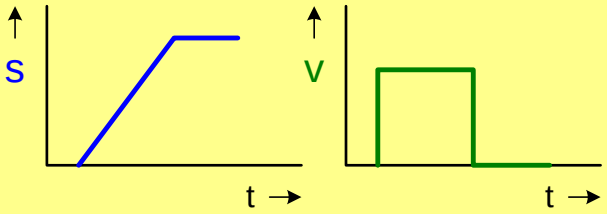
elementary formulas

$v = \frac{dS}{dt}$ $a = \frac{dv}{dt}$ $j = \frac{da}{dt}$

Position in case of uniform acceleration:

$S_t = S_0 + v_0 t + \frac{1}{2} a_0 t^2$

0th order model

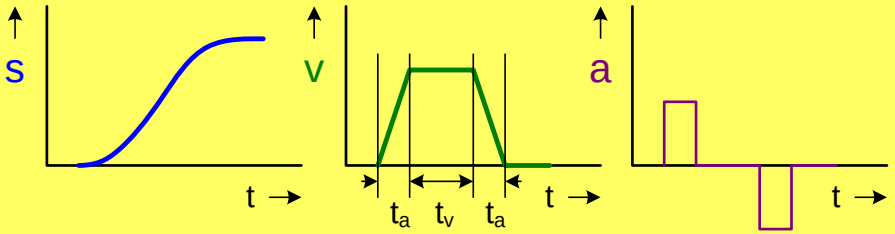


$S_{top\ floor} = v_{max} * t_{top\ floor}$

$t_{top\ floor} = S_{top\ floor} / v_{max}$

$t_{top\ floor} = 40/2.5 = \mathbf{16s}$

1st order model



$t_{top\ floor} = t_a + t_v + t_a$

$t_a = v_{max} / a_{max}$

$S(t_a) = \frac{1}{2} * a_{max} * t_a^2$

$S_{linear} = S_{top\ floor} - 2 * S(t_a)$

$t_v = S_{linear} / v_{max}$

t_a ~= 2.5/1.2 ~= 2s

$S(t_a)$ ~= 0.5 * 1.2 * 2^2

$S(t_a)$ ~= 2.4m

t_v ~= (40-2*2.4)/2.5

t_v ~= 14s

$t_{top\ floor}$ ~= 2 + 14 + 2

$t_{top\ floor}$ ~= **18s**

Conclusions Move to Top Floor

Conclusions

v_{max} dominates traveling time

The model for the large height traveling time can be simplified into:

$$t_{travel} = S_{travel}/v_{max} + (t_a + t_j)$$

Exercise Elevator Performance

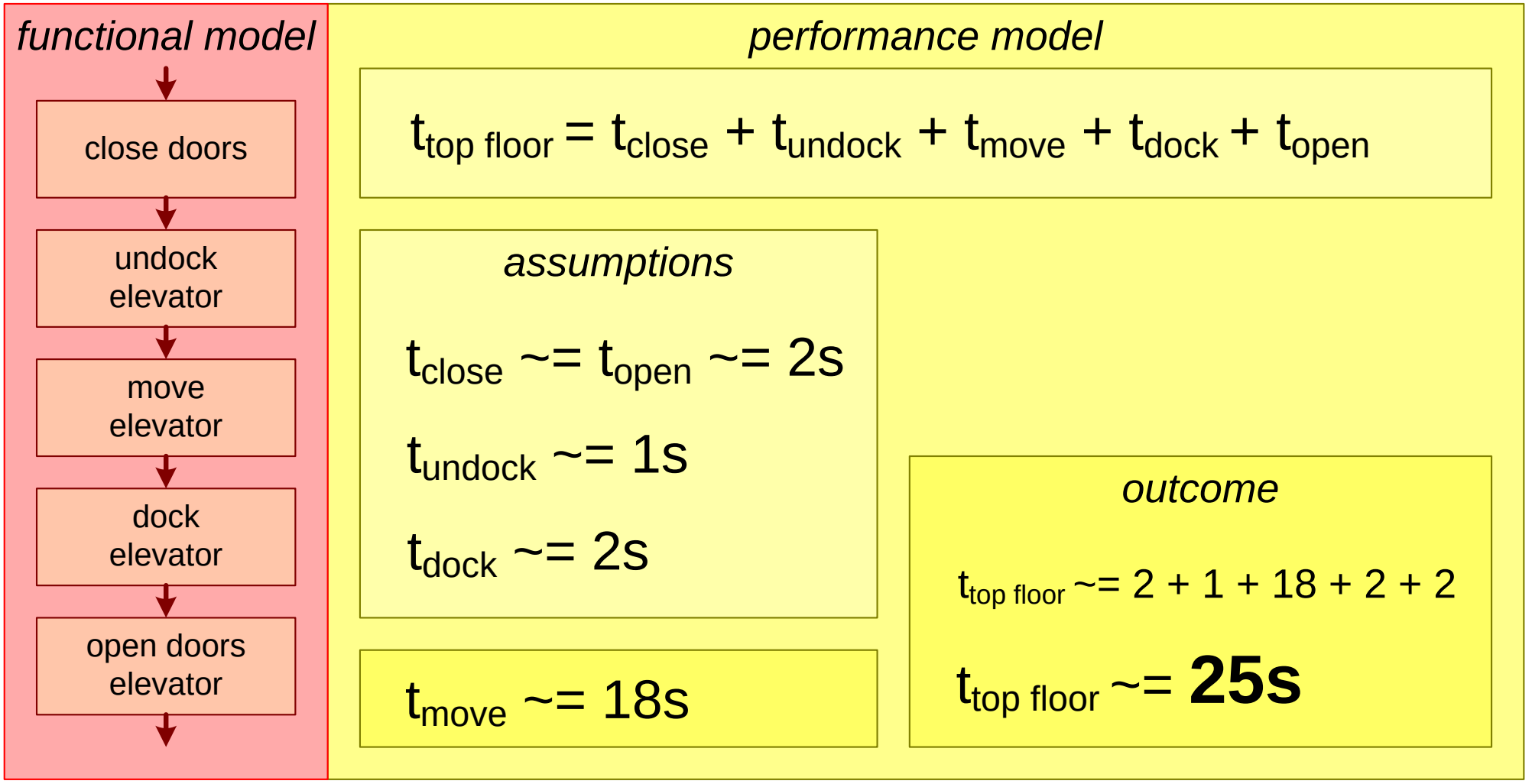
exercise

Make a model for $t_{\text{top floor}}$

Take door opening and docking into account

What do you conclude from this model?

Elevator Performance Model



Conclusions Performance Model Top Floor

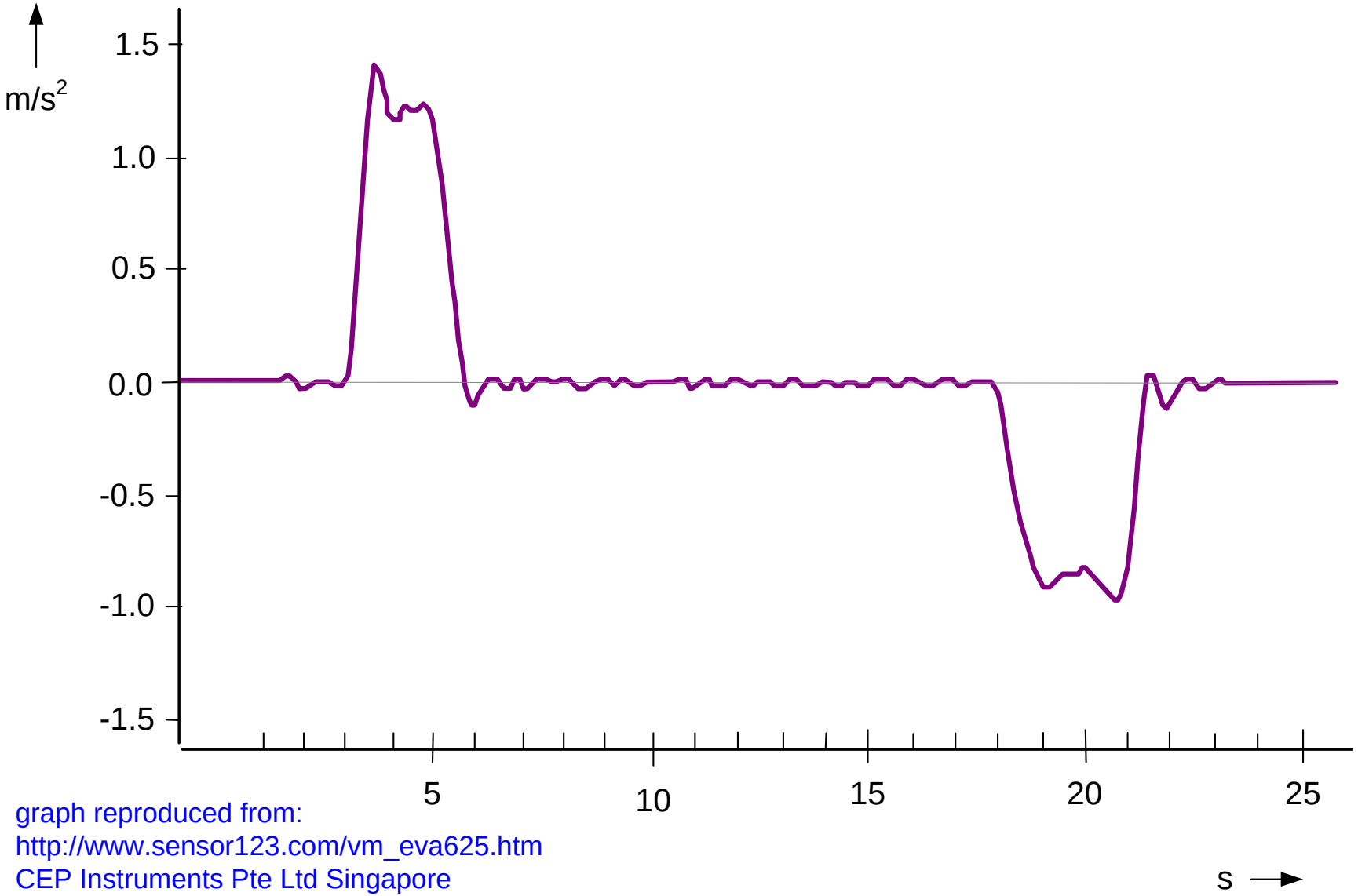
Conclusions

The time to move is dominating the traveling time.

Docking and door handling is significant part of the traveling time.

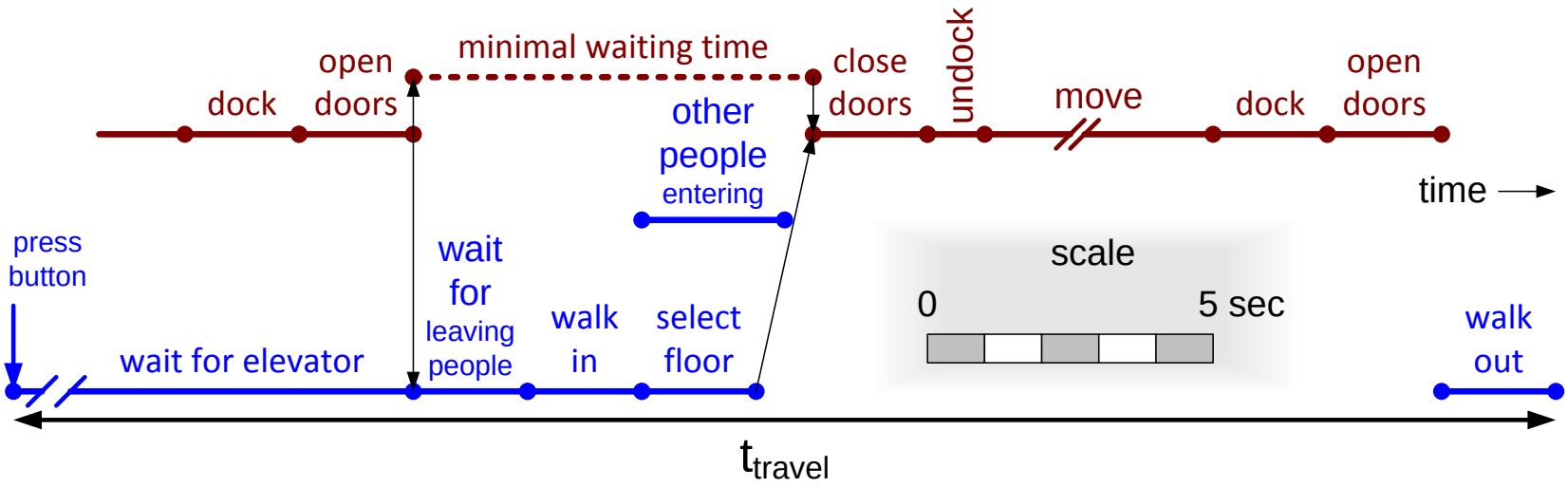
$t_{top\ floor} = t_{travel} + t_{elevator\ overhead}$

Measured Elevator Acceleration



graph reproduced from:
http://www.sensor123.com/vm_eva625.htm
CEP Instruments Pte Ltd Singapore

Time Line; Humans Using the Elevator



assumptions human dependent data

$t_{wait\ for\ elevator}$ = [0..2 minutes] depends heavily on use

$t_{wait\ for\ leaving\ people}$ = [0..20 seconds] idem

$t_{walk\ in} \sim= t_{walk\ out} \sim= 2$ s

$t_{select\ floor} \sim= 2$ s

assumptions additional elevator data

$t_{minimal\ waiting\ time} \sim= 8$s

$t_{travel\ top\ floor} \sim= 25$s

$t_{travel\ one\ floor} \sim= 11$s

outcome

$t_{one\ floor} = t_{minimal\ waiting\ time} + t_{walk\ out} + t_{travel\ one\ floor} + t_{wait}$

$t_{top\ floor} = t_{minimal\ waiting\ time} + t_{walk\ out} + t_{travel\ top\ floor} + t_{wait}$

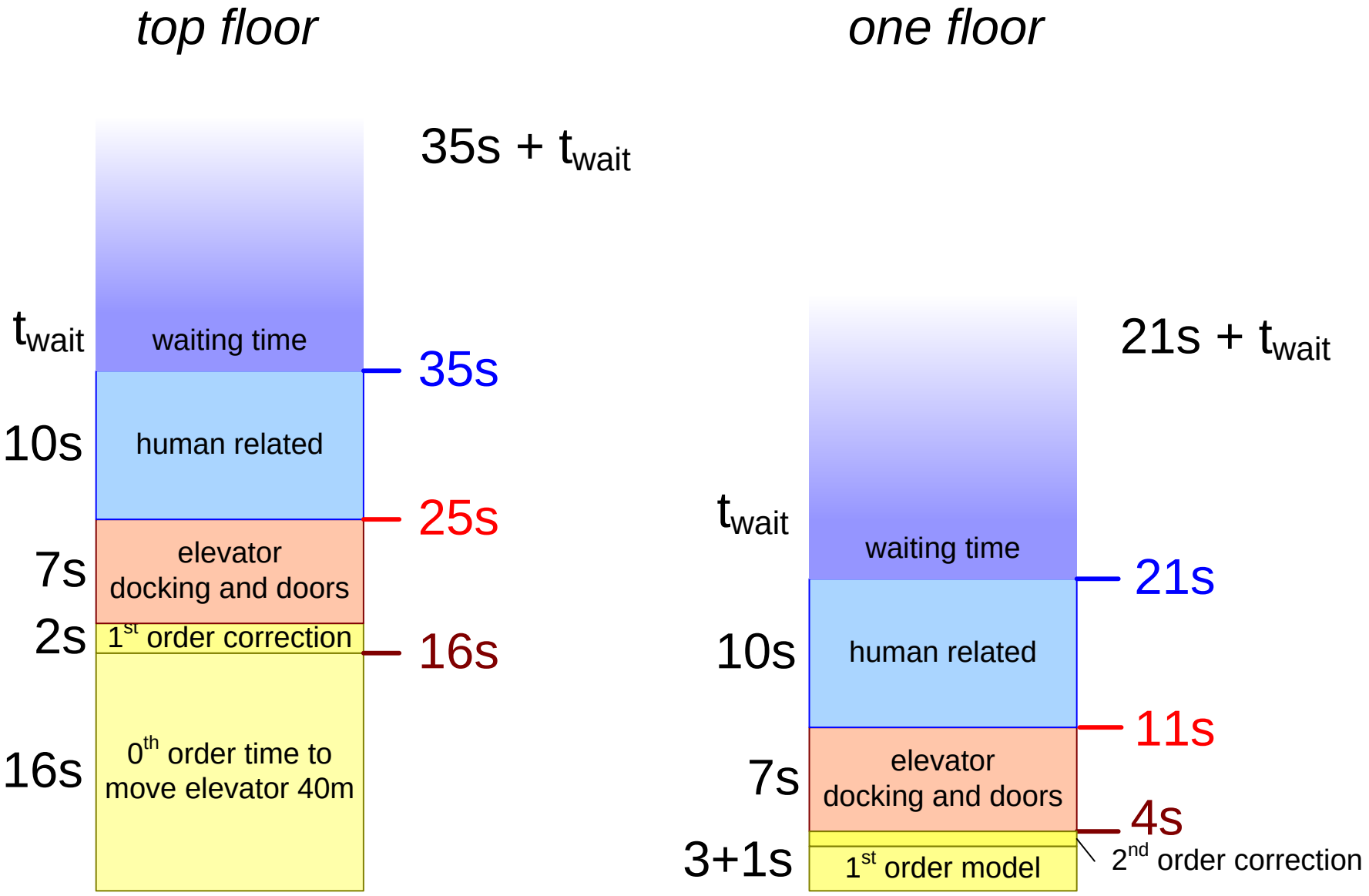
$t_{one\ floor} \sim= 8 + 2 + 11 + t_{wait}$

$\sim= \mathbf{21\ s} + t_{wait}$

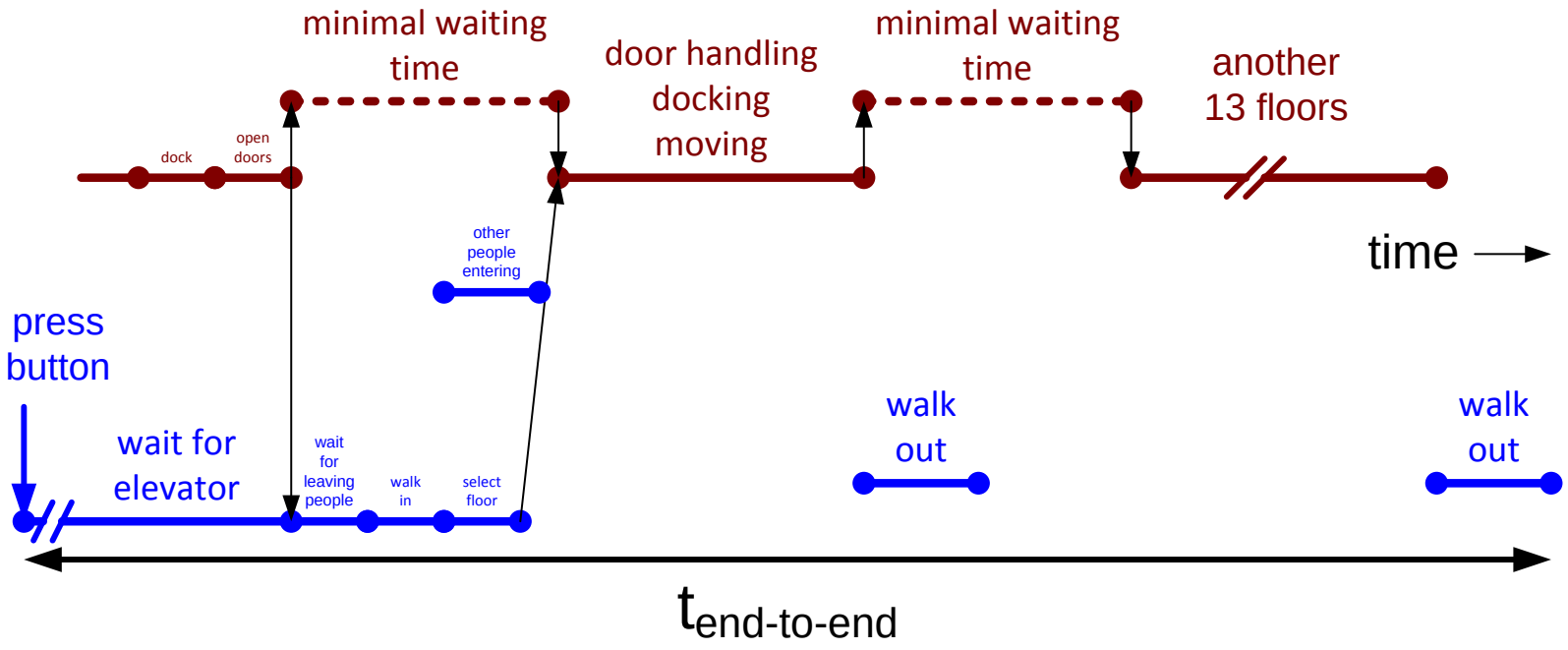
$t_{top\ floor} \sim= 8 + 2 + 25 + t_{wait}$

$\sim= \mathbf{35\ s} + t_{wait}$

Overview of Results for One Elevator



Multiple Users Model



elevator data

$t_{min\ wait}$ ~= 8s

$t_{one\ floor}$ ~= 11s

$t_{walk\ out}$ ~= 2s

$n_{floors} = 40\ div\ 3 + 1 = 14$

$n_{stops} = n_{floors} - 1 = 13$

outcome

$t_{end\text{-}to\text{-}end} = n_{stops}\ (t_{min\ wait} + t_{one\ floor}) + t_{walk\ out} + t_{wait}$

$\sim= 13 * (8 + 11) + 2 + t_{wait}$

$\sim= \mathbf{249\ s} + t_{wait}$

$t_{non\text{-}stop} \sim= 35\ s + t_{wait}$

Multiple Users Desired Performance

Considerations

desired time to travel to top floor ~< 1 minute

note that $t_{wait\ next} = t_{travel\ up} + t_{travel\ down}$

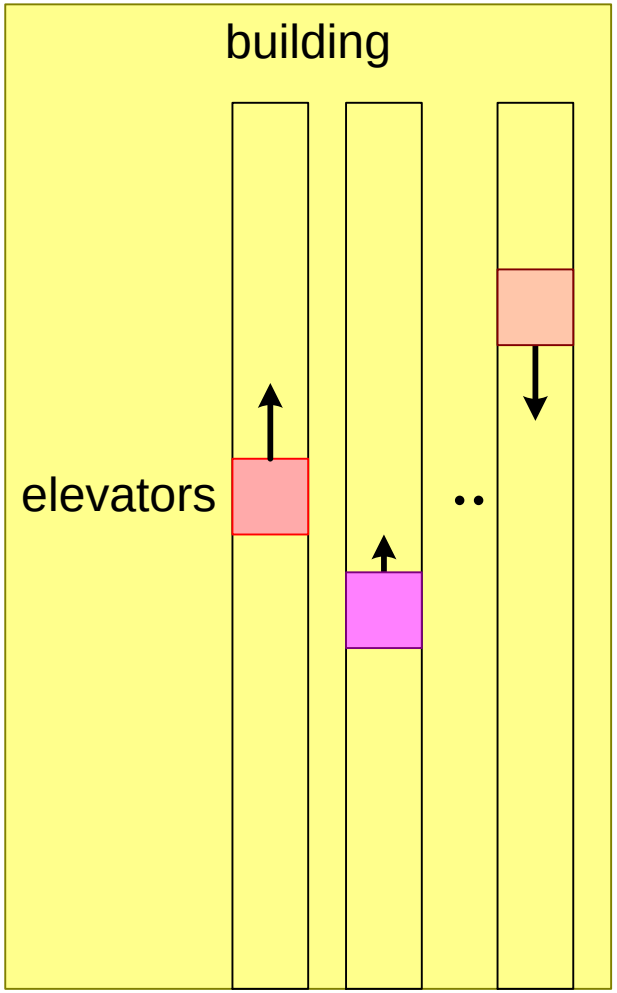
if someone just misses the elevator then the waiting time is

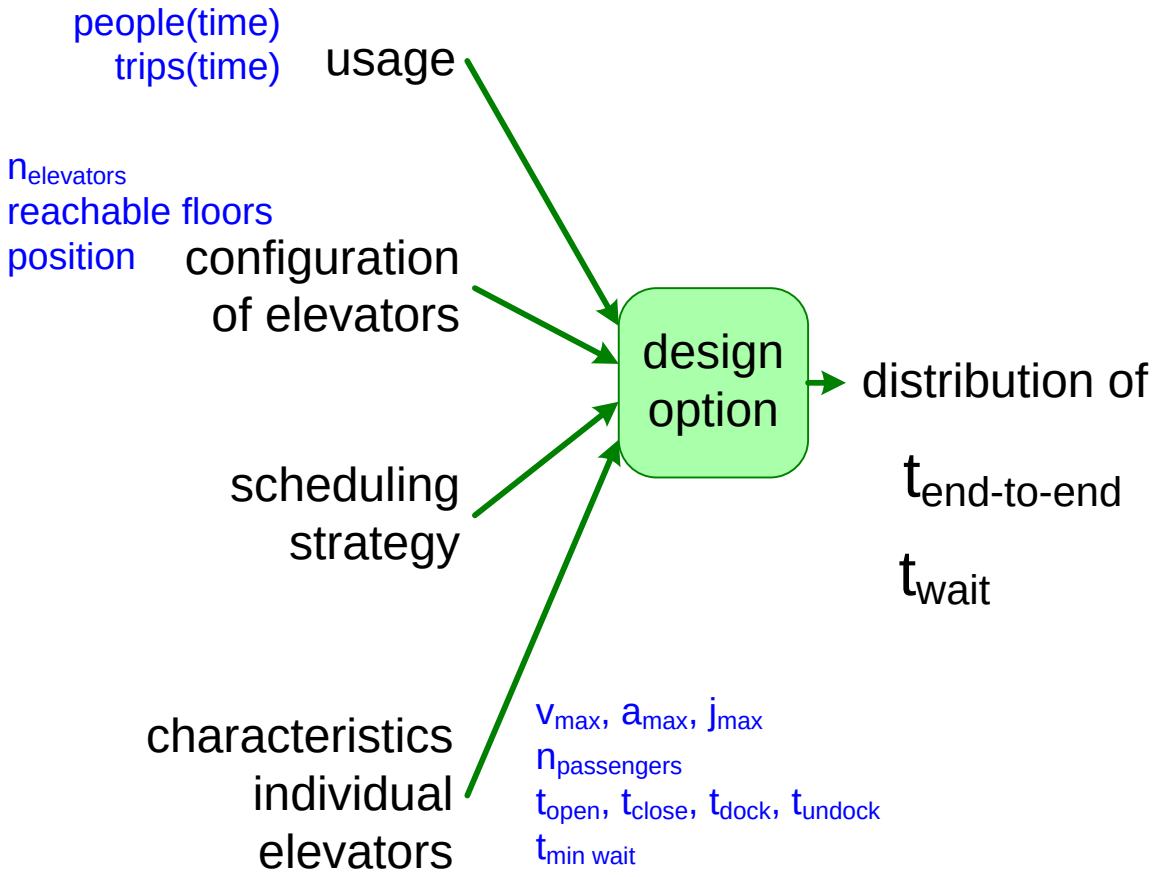
missed trip, return down, trip up

$t_{end\text{-}to\text{-}end}$ ~= 249 + 35 + 249 = 533s ~= 9 minutes!

desired waiting time ~< 1 minute

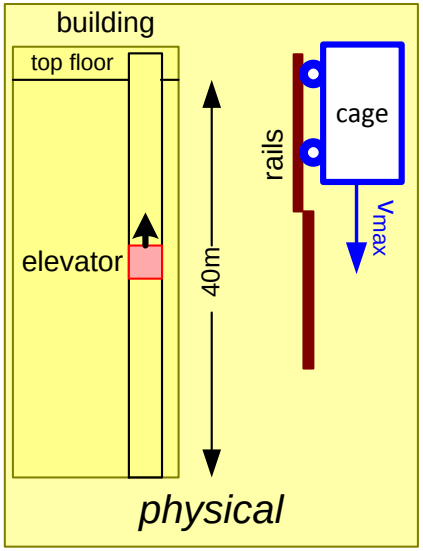
Design of Elevators System

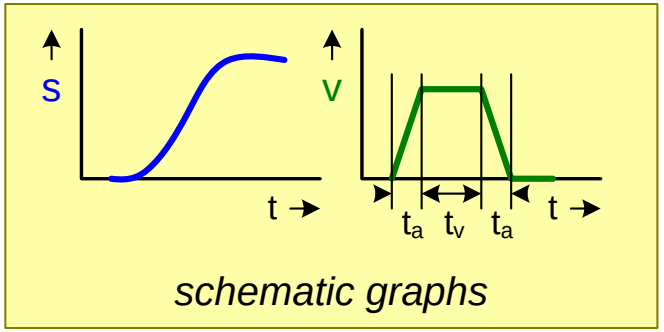


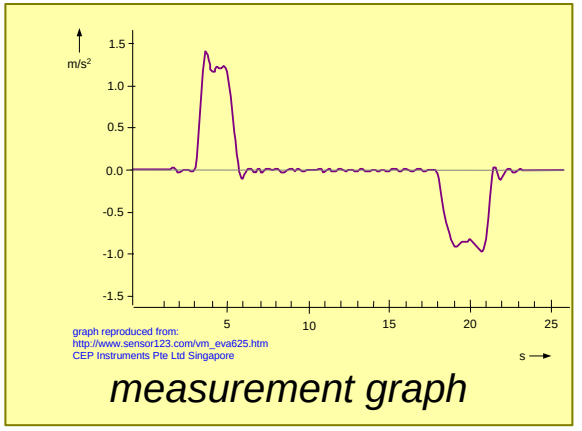


Design of a system with multiple elevator requires a different kind of models: oriented towards logistics

Summary of Visualizations and Representations



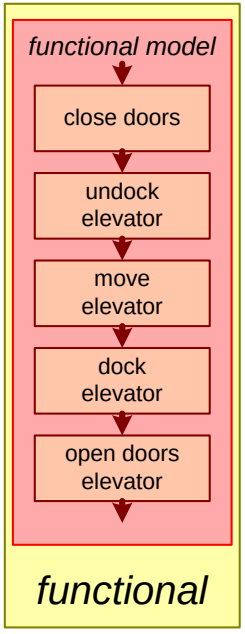


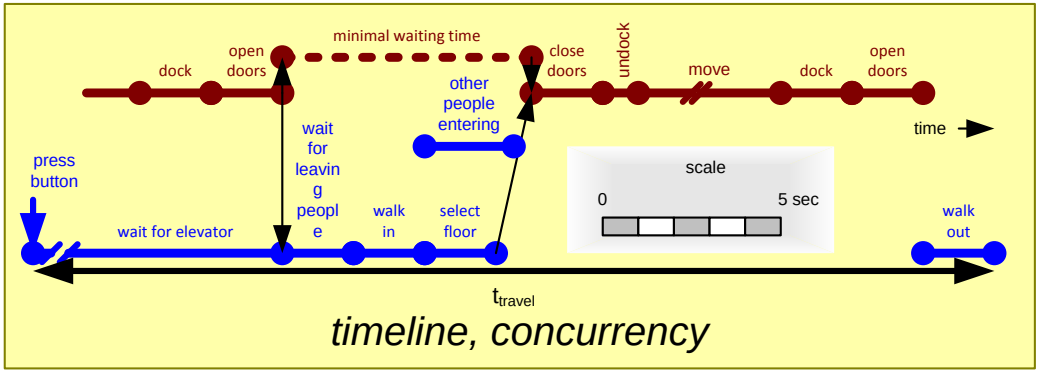


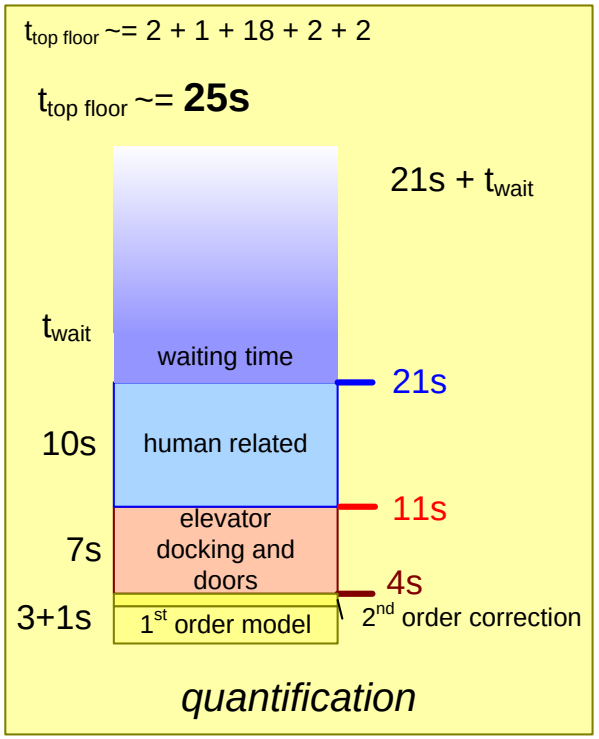
$S_t = S_0 + v_0 t + \frac{1}{2} a_0 t^2$

$t_{top\ floor} = t_{close} + t_{undock} + t_{move} + t_{dock} + t_{open}$

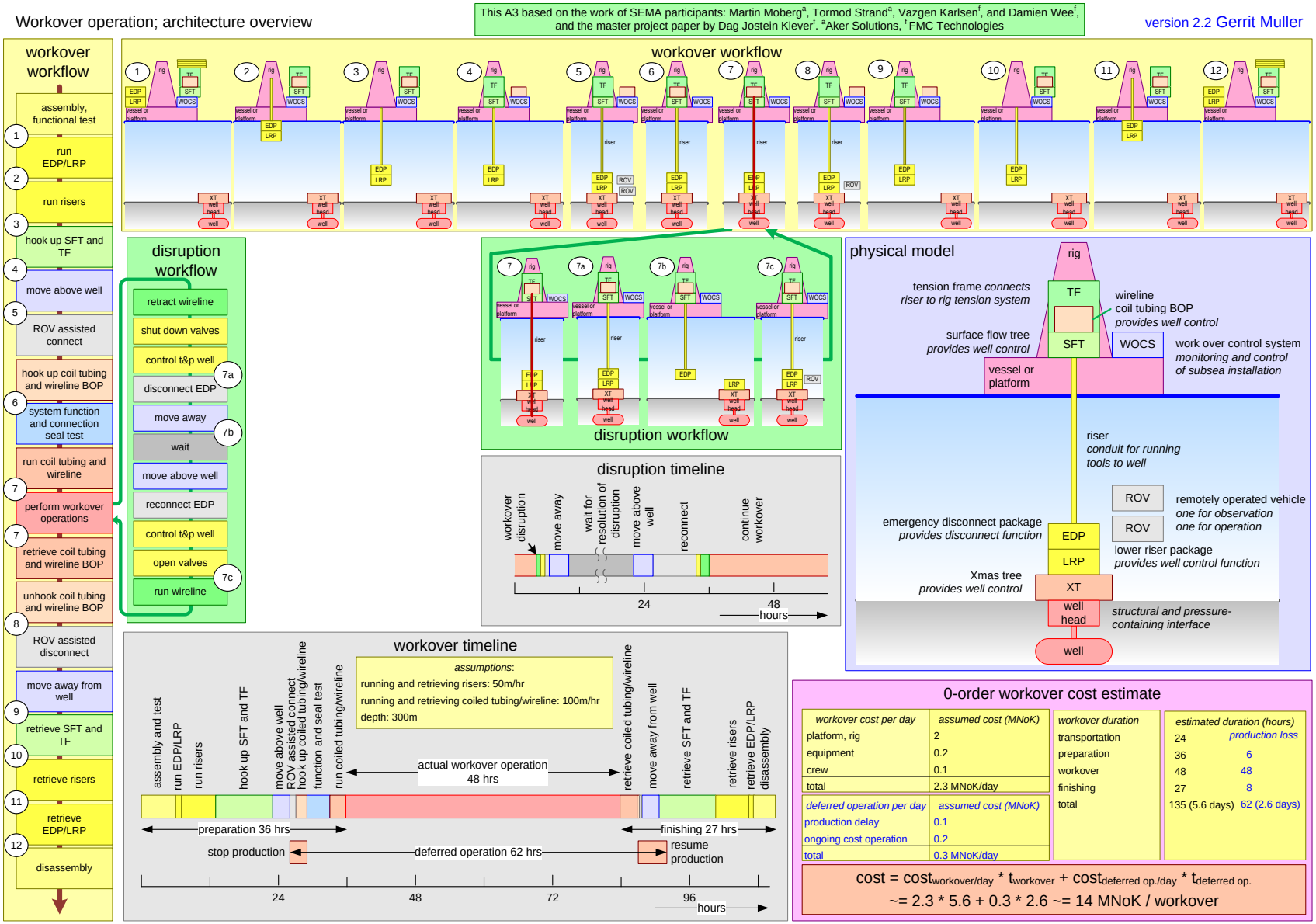
mathematical formulas







SubSea Modeling Example (A3)



SEMA Methods Overview

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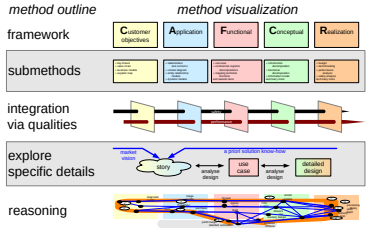
Abstract

This presentation provides an overview of the SEMA course: Architectural Reasoning Using Conceptual Modeling. This course uses the CAFCR+ model with 6 views. Qualities connect all views. Threads-of-reasoning capture the architectural reasoning across views and qualities. Conceptual models visualize and capture the context, the system and its design. Quantification is a means to make problem and solution space tangible.



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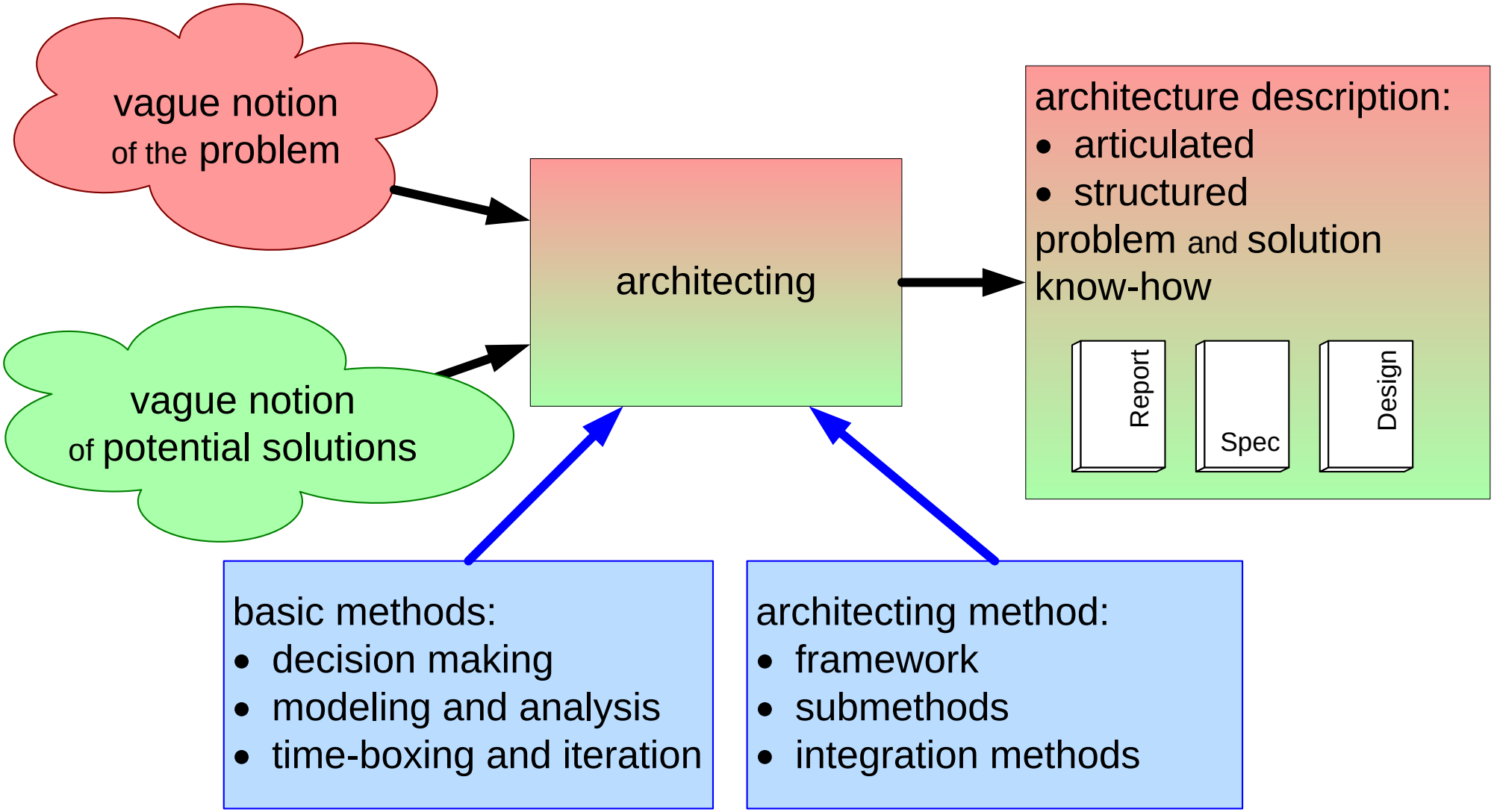
status: preliminary draft
version: 0

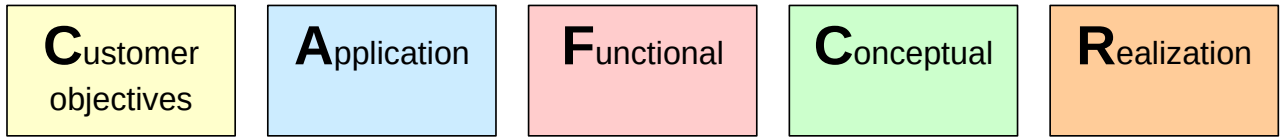
From vague notions to articulate and structured



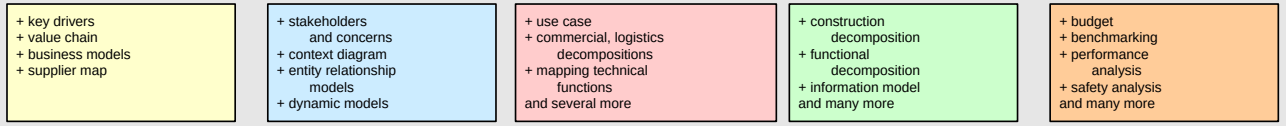
Overview of architecting method

method outline *method visualization*

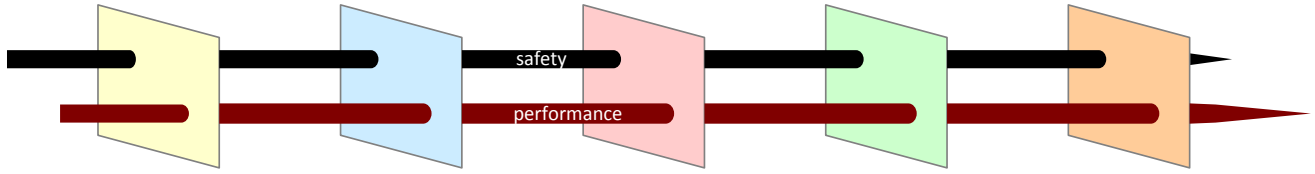
framework



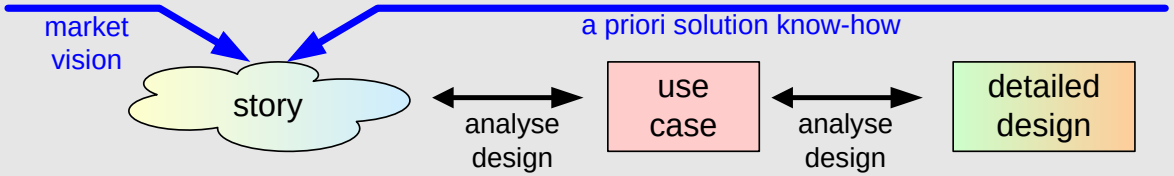
submethods



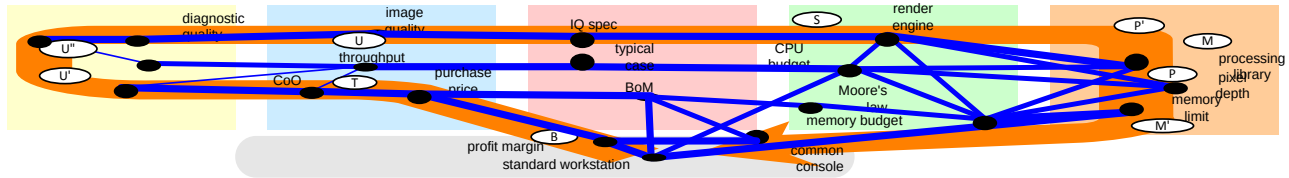
integration via qualities



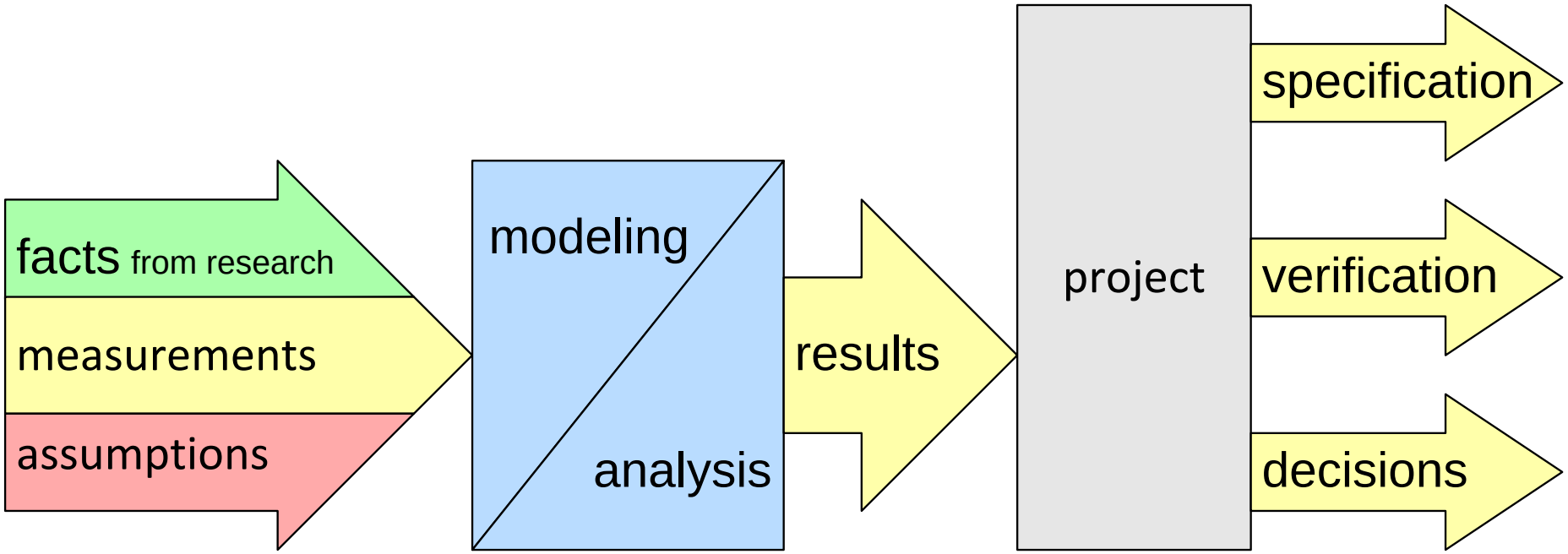
explore specific details



reasoning



Purpose of Modeling



uncertainties
unknowns
errors

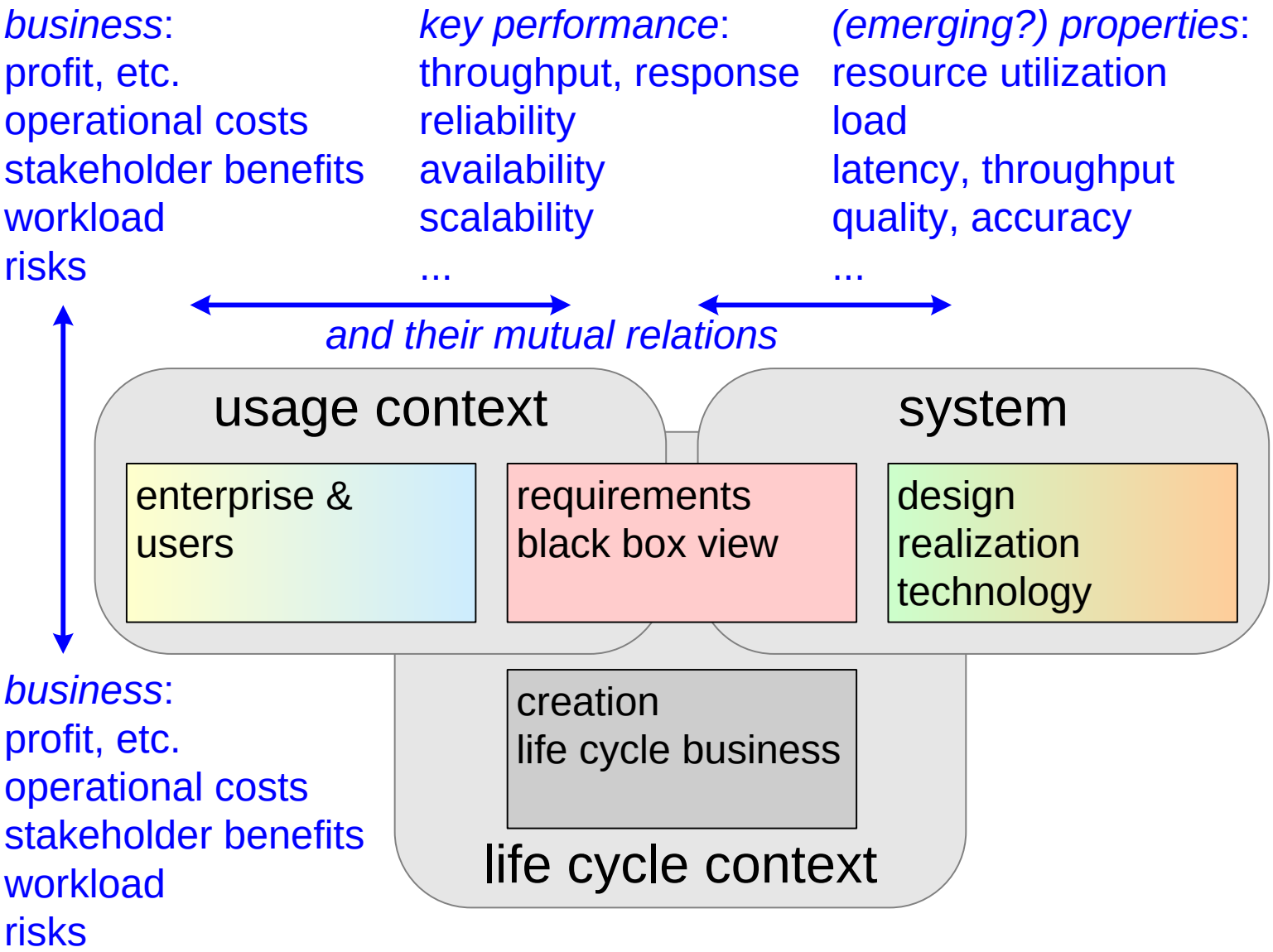
→

accuracy
working range
credibility

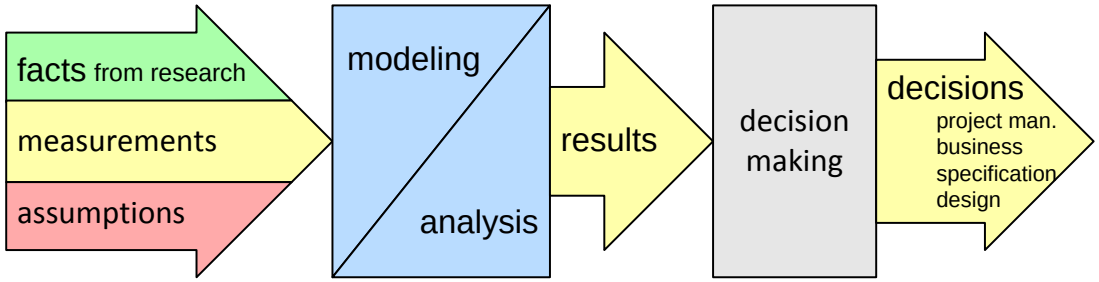
→

risk
customer satisfaction
time, cost, effort
profit margin

What to Model?

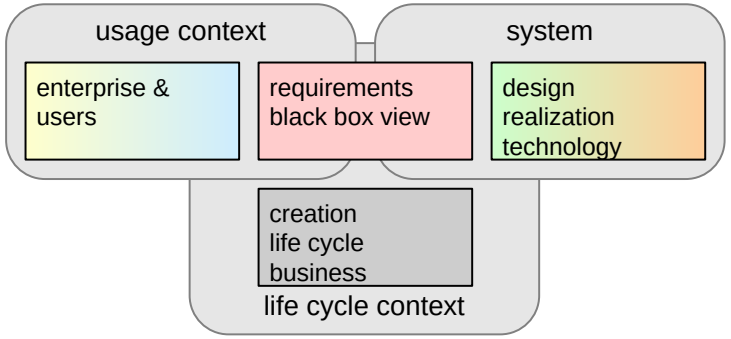


Overview of Modeling Approach



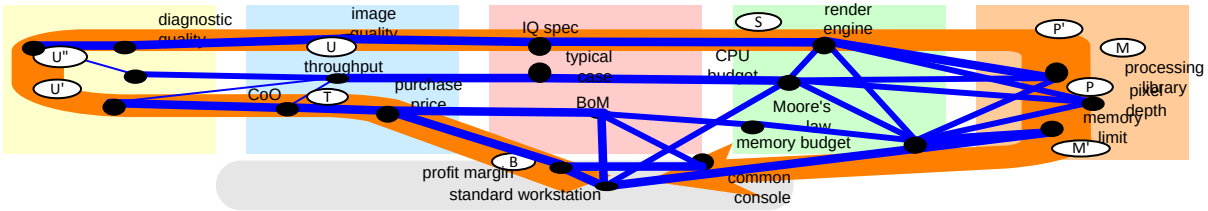
collect input data

model and analyse relevant issues



for different stakeholders& concerns

integration and reasoning



Short introduction to basic “CAFCR” model

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

Abstract

The basic “CAFCR” reference model is described, which is used to describe a system in relation to its context. The main stakeholder in the context is the customer. The question “Who is the customer?” is addressed.

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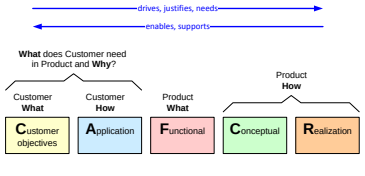
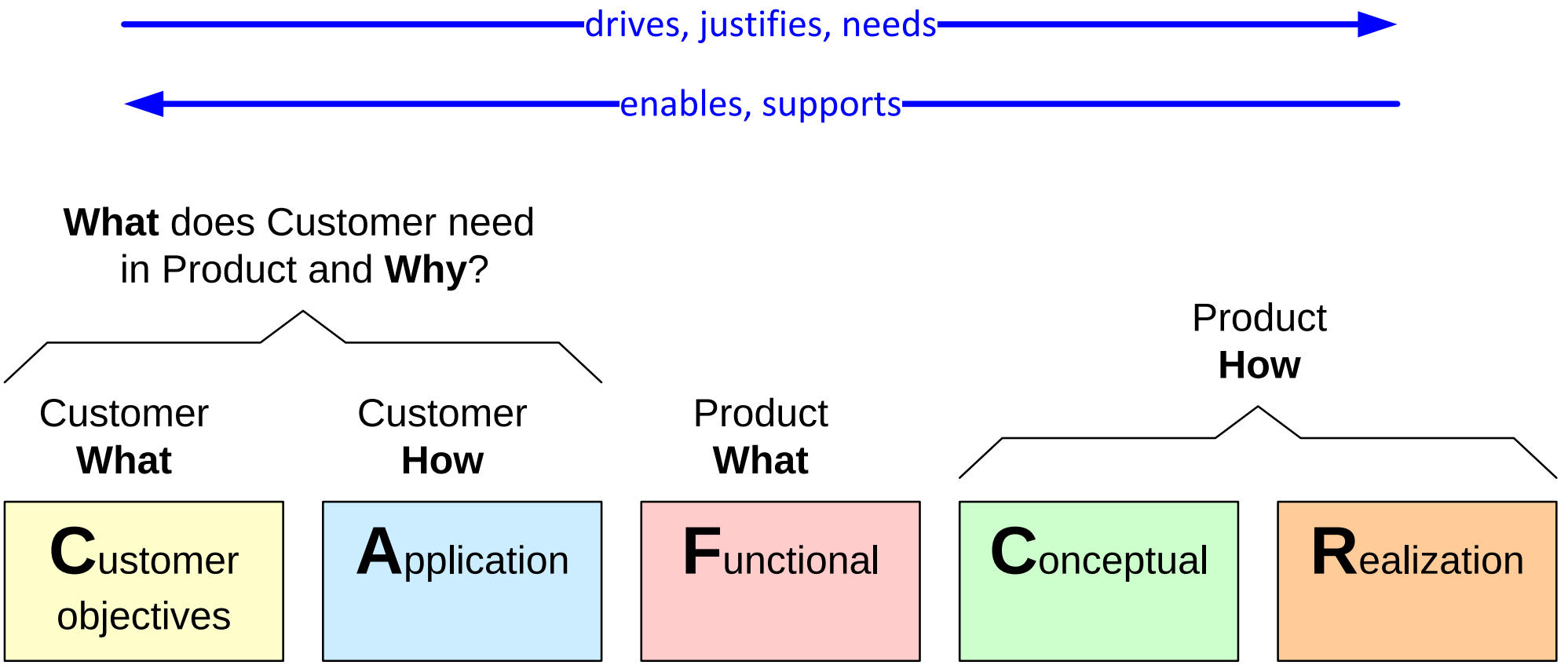
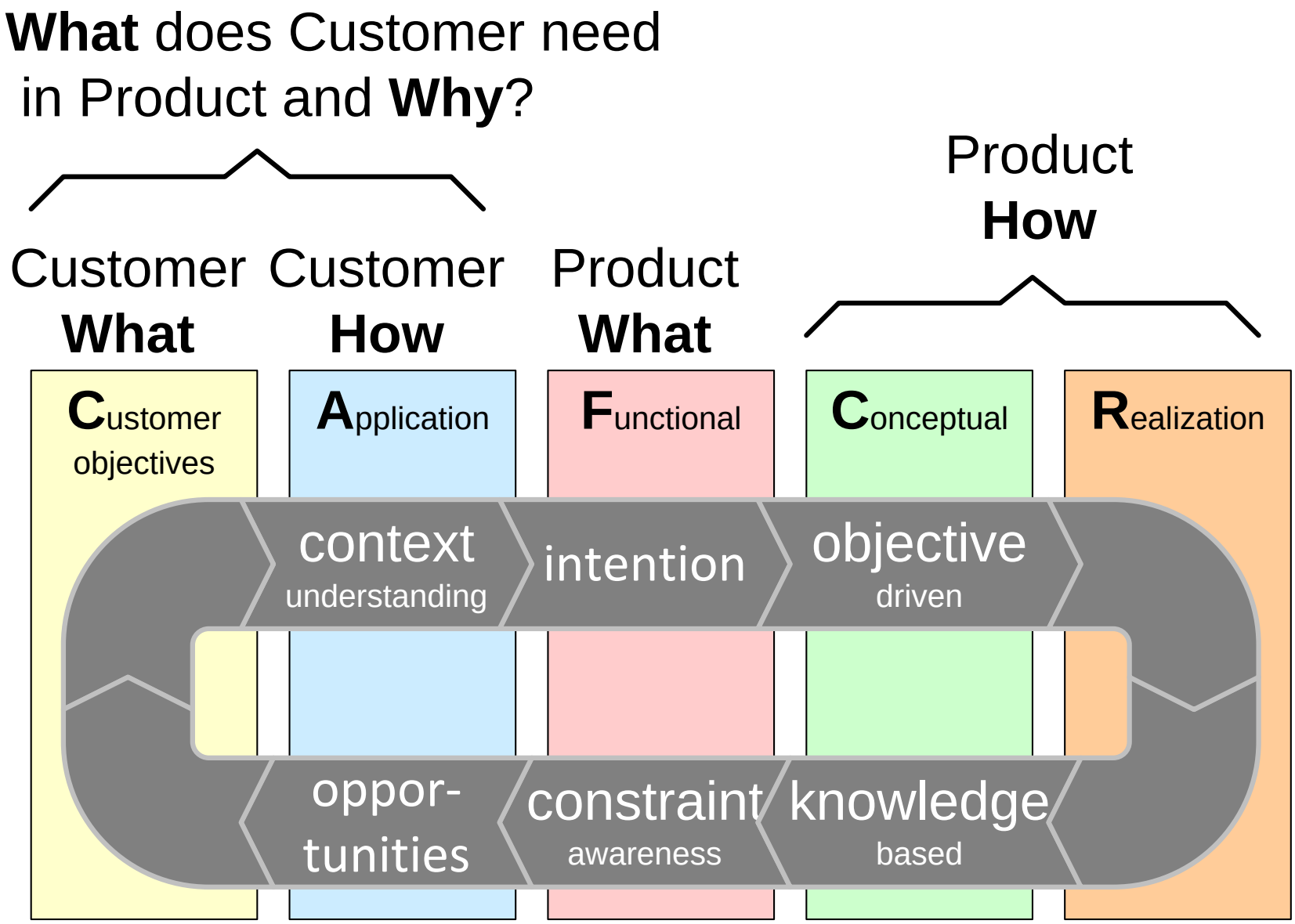


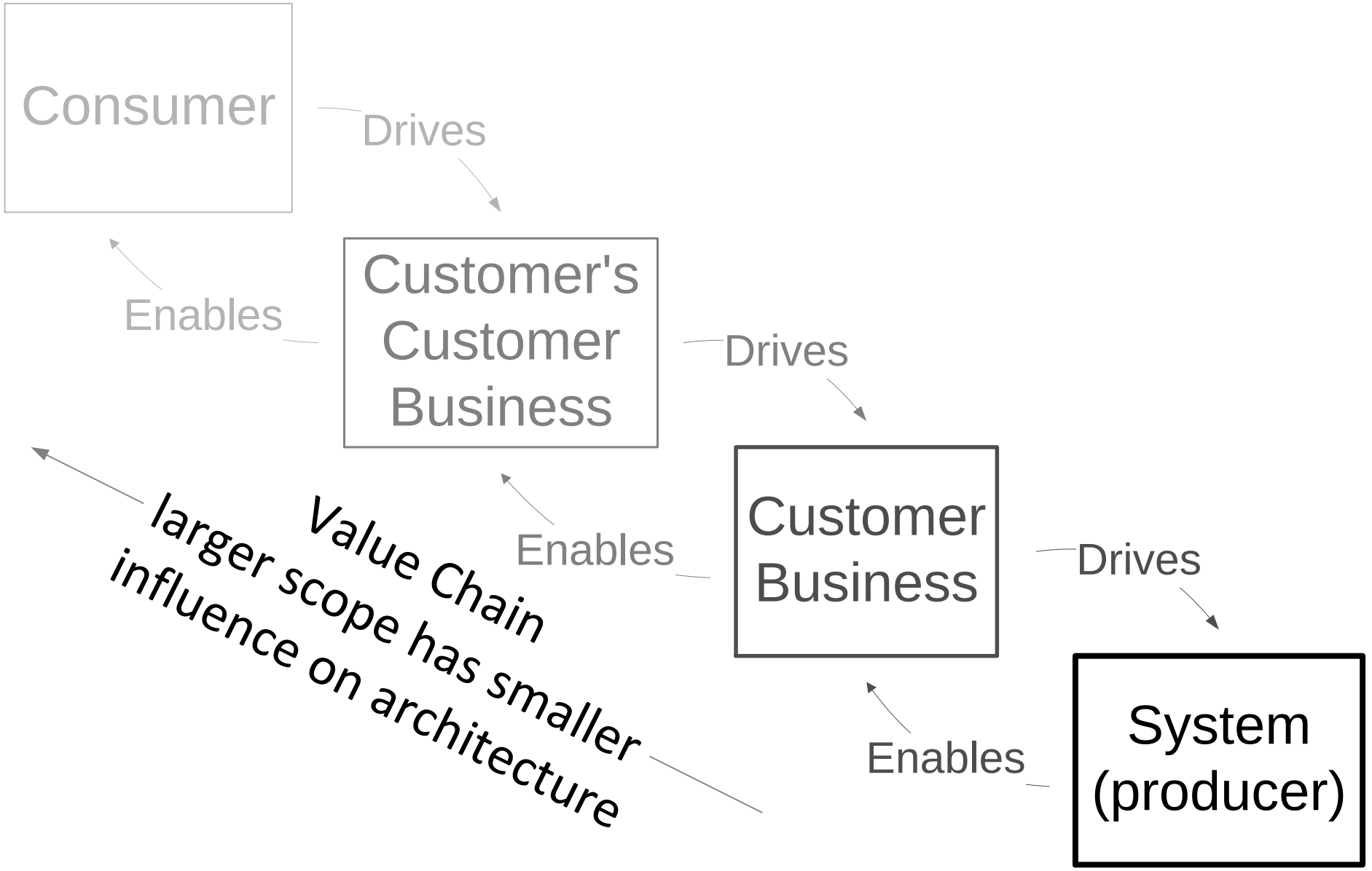
The “CAFCR” model



Integrating CAFCR



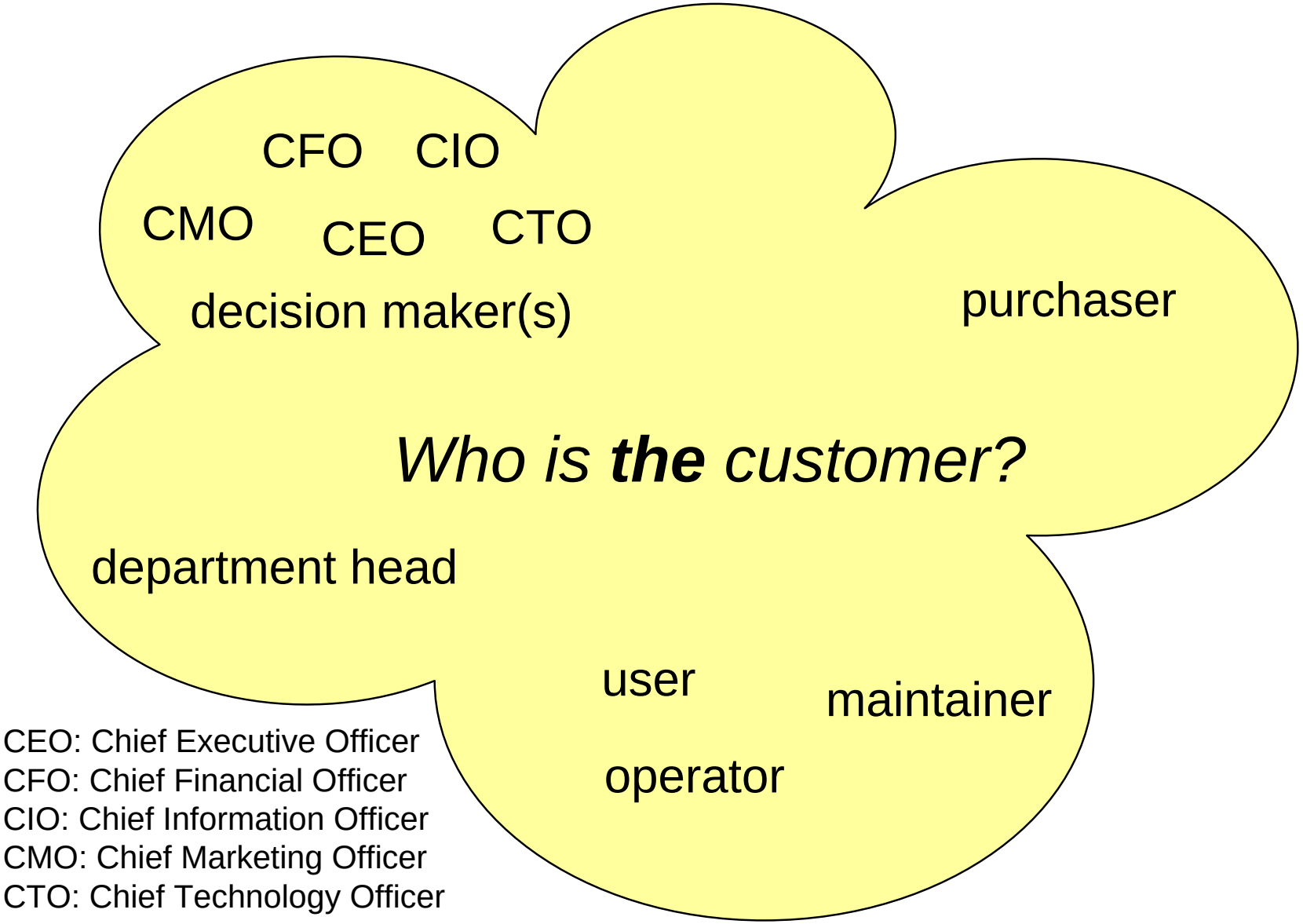
CAFCR can be applied recursively



Market segmentation

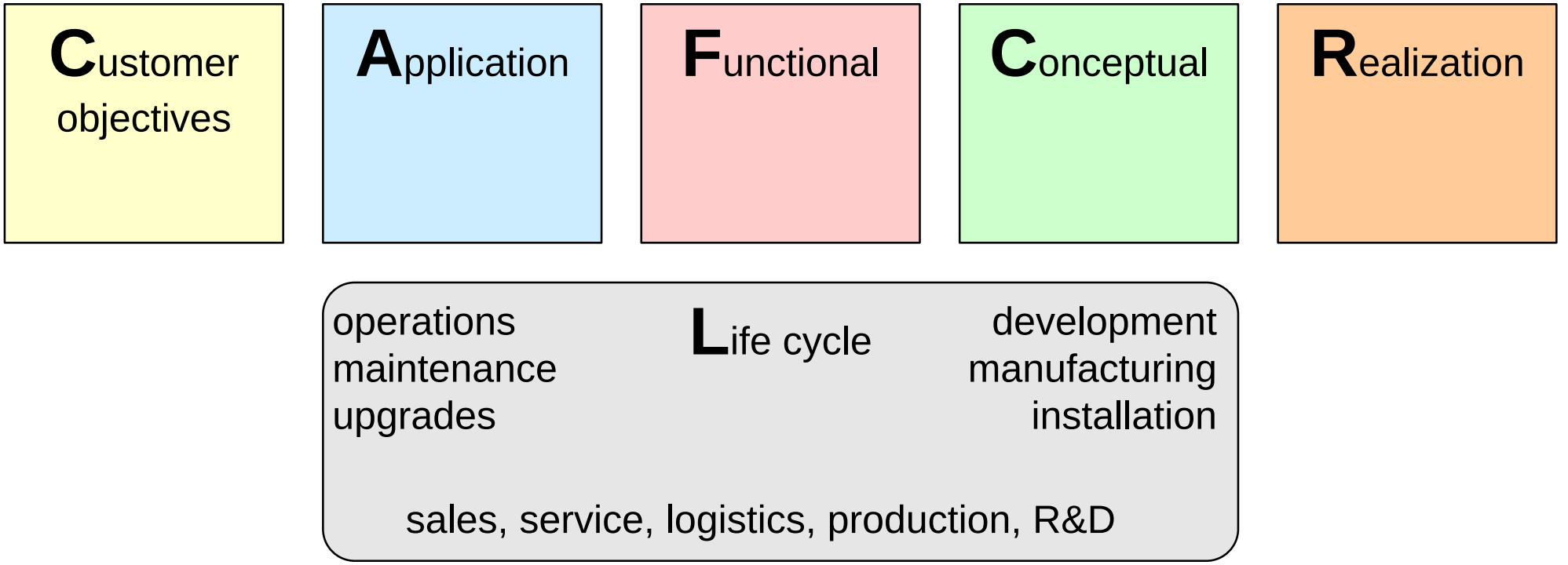
segmentation axis	examples
geographical	USA, UK, Germany, Japan, China
business model	profit, non profit
economics	high end versus cost constrained
consumers	youth, elderly
outlet	retailer, provider, OEM, consumer direct

Example of a small buying organization



CEO: Chief Executive Officer
CFO: Chief Financial Officer
CIO: Chief Information Officer
CMO: Chief Marketing Officer
CTO: Chief Technology Officer

CAFCR+ model; Life Cycle View



Story How To

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

A story is an easily accessible story or narrative to make an application live. A good story is highly specific and articulated entirely in the problem domain: the native world of the users. An important function of a story is to enable specific (*quantified, relevant, explicit*) discussions.

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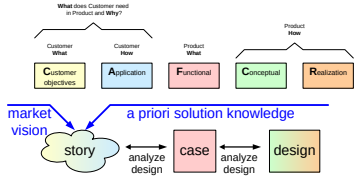
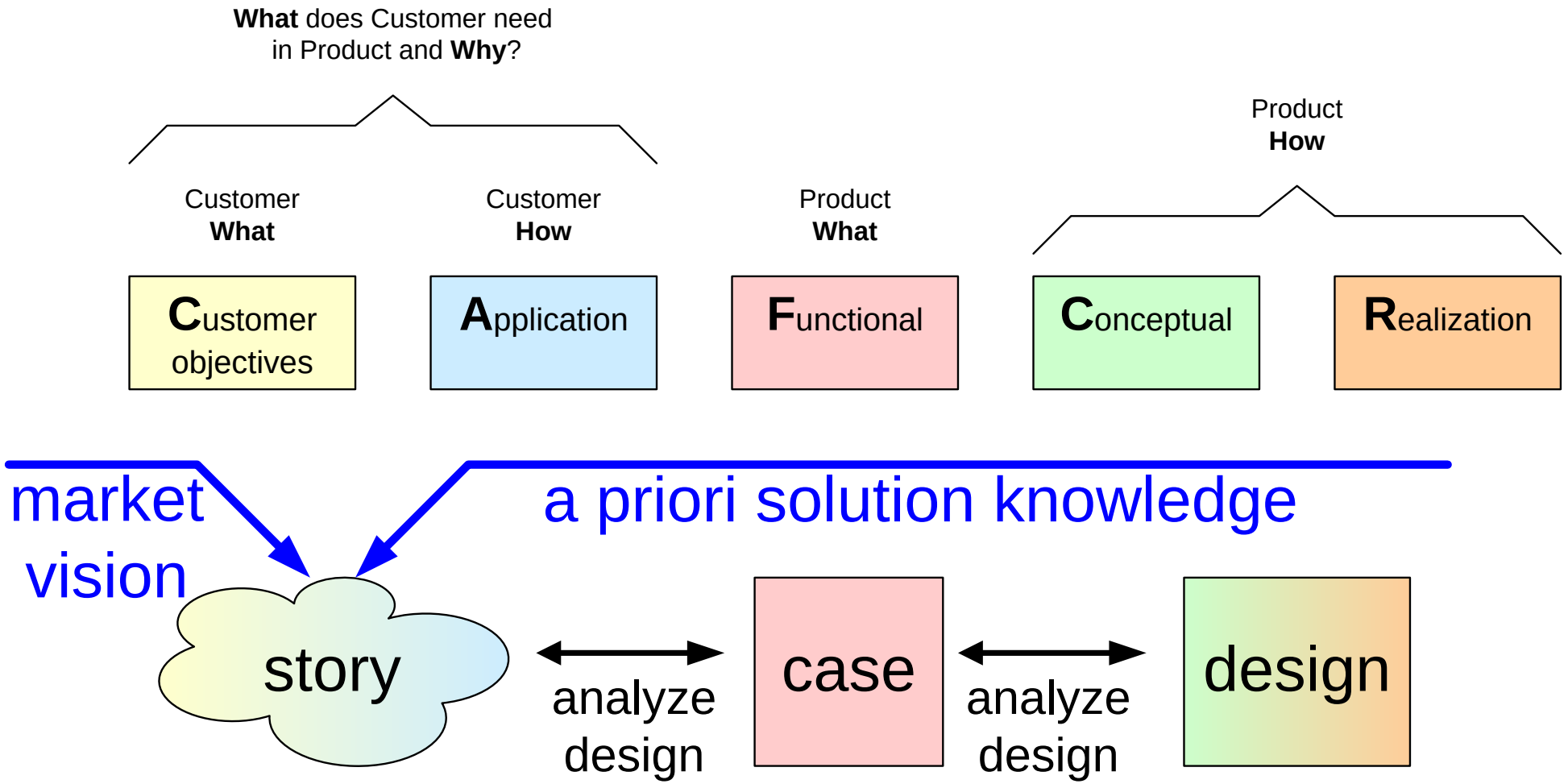
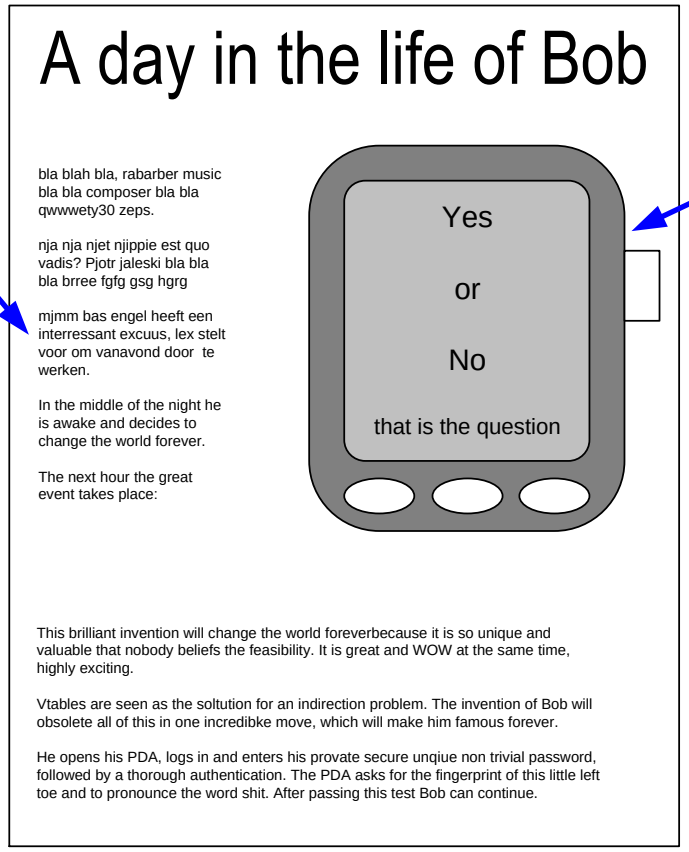


From story to design



Example story layout

ca. half a page of plain English text



draft or sketch of some essential appliance

Points of attention

- purpose — What do you need to know for specification and design?
- scope — “umbrella” or specific event?
- viewpoint, stakeholders — Define your stakeholder and viewpoint f.i. user, maintainer, installer
- visualization — Sketches or cartoon Helps to share and communicate ideas
- size (max 1 A4) — Can be read or told in few minutes
- recursive decomposition, refinement

Criteria for a good story

Customer objectives / Application

- accessible, understandable

"Do you see it in front of you?"

Customer objectives / Application

- valuable, appealing

attractive, important

"Are customers queuing up for this?"

Conceptual / Realization

- critical, challenging

"What is difficult in the realization?"

"What do you learn w.r.t. the design?"

Application

- frequent, no exceptional niche

"Does it add significantly to the bottom line?"

Application / Functional

- specific

names, ages, amounts, durations, titles, ...

Example of a story

Betty is a 70-year-old woman who lives in Eindhoven. Three years ago her husband passed away and since then she lives in a home for the elderly. Her 2 children, Angela and Robert, come and visit her every weekend, often with Betty's grandchildren Ashley and Christopher. As so many women of her age, Betty is reluctant to touch anything that has a technical appearance. She knows how to operate her television, but a VCR or even a DVD player is way to complex.

When Betty turned 60, she stopped working in a sewing studio. Her work in this noisy environment made her hard-of-hearing with a hearing-loss of 70dB around 2kHz. The rest of the frequency spectrum shows a loss of about 45dB. This is why she had problems understanding her grandchildren and why her children urged her to apply for hearing aids two years ago. Her technophobia (and her first hints or arthritis) inhibit her to change her hearing aids' batteries. Fortunately her children can do this every weekend.

This Wednesday Betty visits the weekly Bingo afternoon in the meetingplace of the old-folk's home. It's summer now and the tables are outside. With all those people there it's a lot of chatter and babble. Two years ago Betty would never go to the bingo: "I cannot hear a thing when everyone babbles and clatters with the coffee cups. How can I hear the winning numbers?!". Now that she has her new digital hearing instruments, even in the bingo cacophony, she can understand everyone she looks at. Her social life has improved a lot and she even won the bingo a few times.

That same night, together with her friend Janet, she attends Mozart's opera The Magic Flute. Two years earlier this would have been one big low rumbly mess, but now she even hears the sparkling high piccolos. Her other friend Carol never joins their visits to the theaters. Carol also has hearing aids, however hers only "work well" in normal conversations. "When I hear music it's as if a butcher's knife cuts through my head. It's way too sharp!". So Carol prefers to take her hearing aids out, missing most of the fun. Betty is so happy that her hearing instruments simply know where they are and adapt to their environment.

source: Roland Mathijssen
Embedded Systems Institute
Eindhoven

Value and Challenges in this story

Customer objectives

Application

Value proposition in this story:

quality of life:

active participation in different social settings

usability for nontechnical elderly people:

"intelligent" system is simple to use

loading of batteries

Conceptual

Realization

Challenges in this story:

Intelligent hearing instrument

Battery life — at least 1 week

No buttons or other fancy user interface on the hearing instrument, other than a robust On/Off method

The user does not want a technical device but a solution for a problem

Instrument can be adapted to the hearing loss of the user

Directional sensitivity (to prevent the so-called cocktail party effect)

Recognition of sound environments and automatic adaptation (adaptive filtering)

source: Roland Mathijssen, Embedded Systems Institute, Eindhoven

Exercise StoryTelling

Create a story

as text + sketch or as cartoon

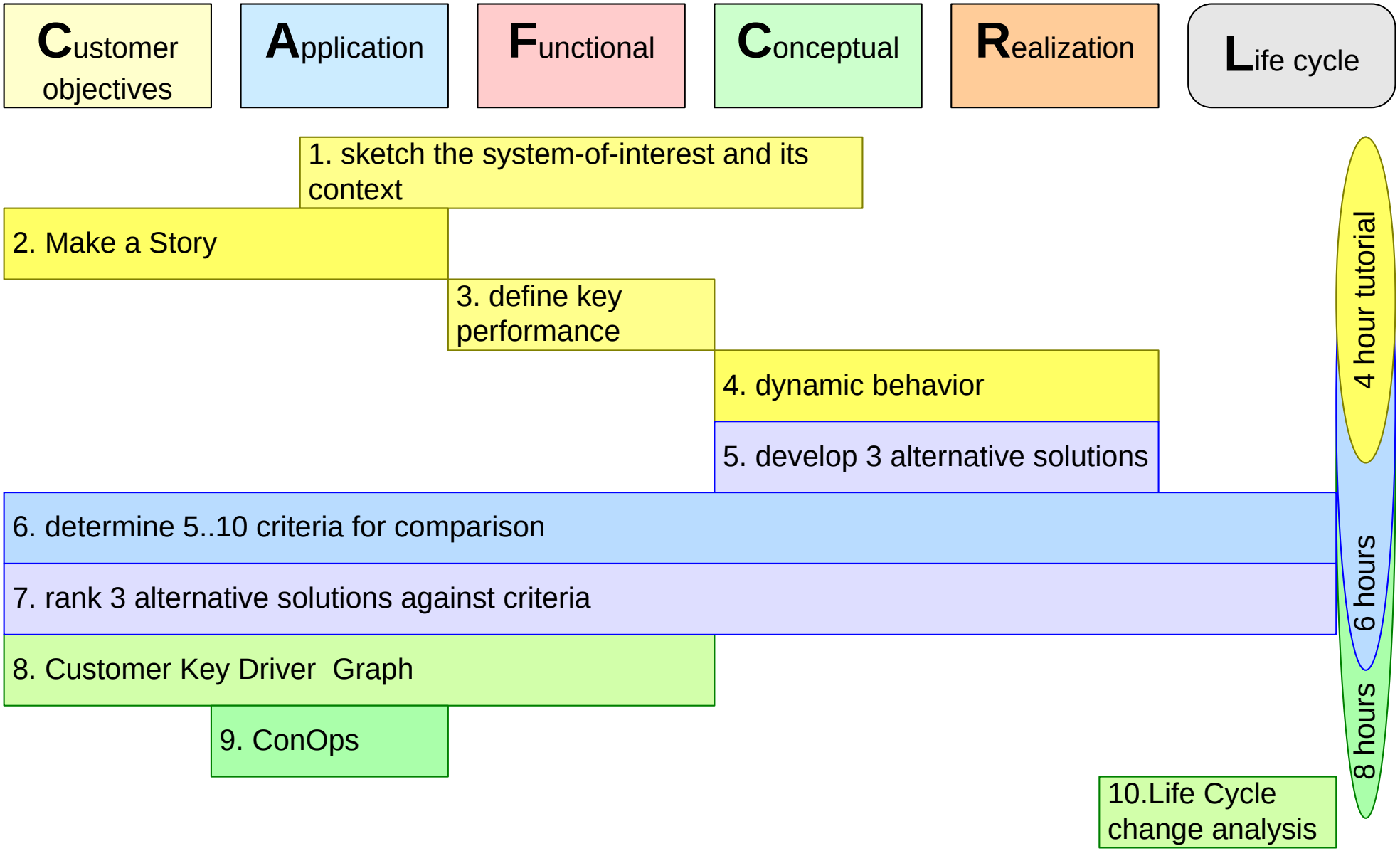
Use the criteria

be highly specific!

envision the future value proposition

Enjoy!

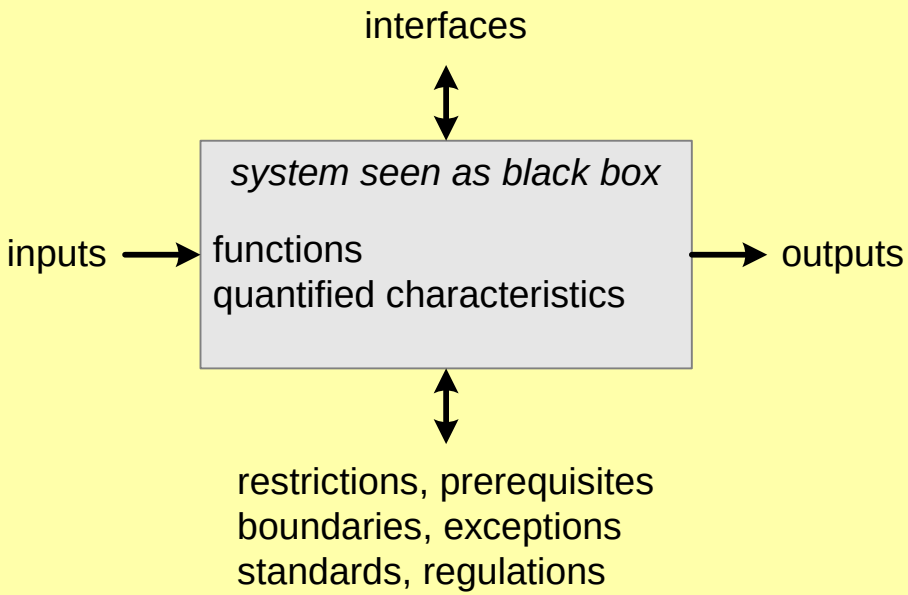
Exercises during the Tutorial



Exercise Key Performance Parameters

Make specification overview with ~10 **SMART** Key Performance Parameters (or functions or interfaces)

determine at least one use case



use case
typical use with relevant context data (quantified!)

- **S**pecific quantified
- **M**easurable verifiable
- **A**chievable (Attainable, Action oriented, Acceptable, Agreed-upon, Accountable)
- **R**ealistic (Relevant, Result-Oriented)
- **T**ime-bounded (Timely , Tangible, Traceable)

Exercise Dynamic Behavior

Capture the **dynamic behavior** of the **internals** of your system in **multiple** diagrams.

Diagrams that capture dynamic behavior are among others:

- Functional flow (of control or information, material or goods, or energy)
- Activity or sequence diagrams (e.g. with “swimming lanes”)
- State diagrams

Concept Selection, Set Based Design and Late Decision Making

by *Gerrit Muller* University of South-Eastern Norway-NISE
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www.gaudisite.nl

Abstract

We discuss a systems design approach where several design options are maintained concurrently. In LEAN Product Development this is called set-based design. Concentioanl systems engineering also promotes the concurrent evaluation of multiple concepts, the so-called concept selection. Finally, LEAN product development advocates to keep options open as long as feasible; the so-called late decision making.

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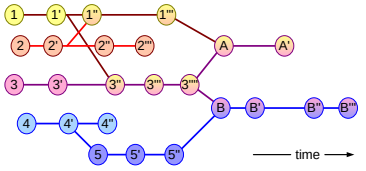
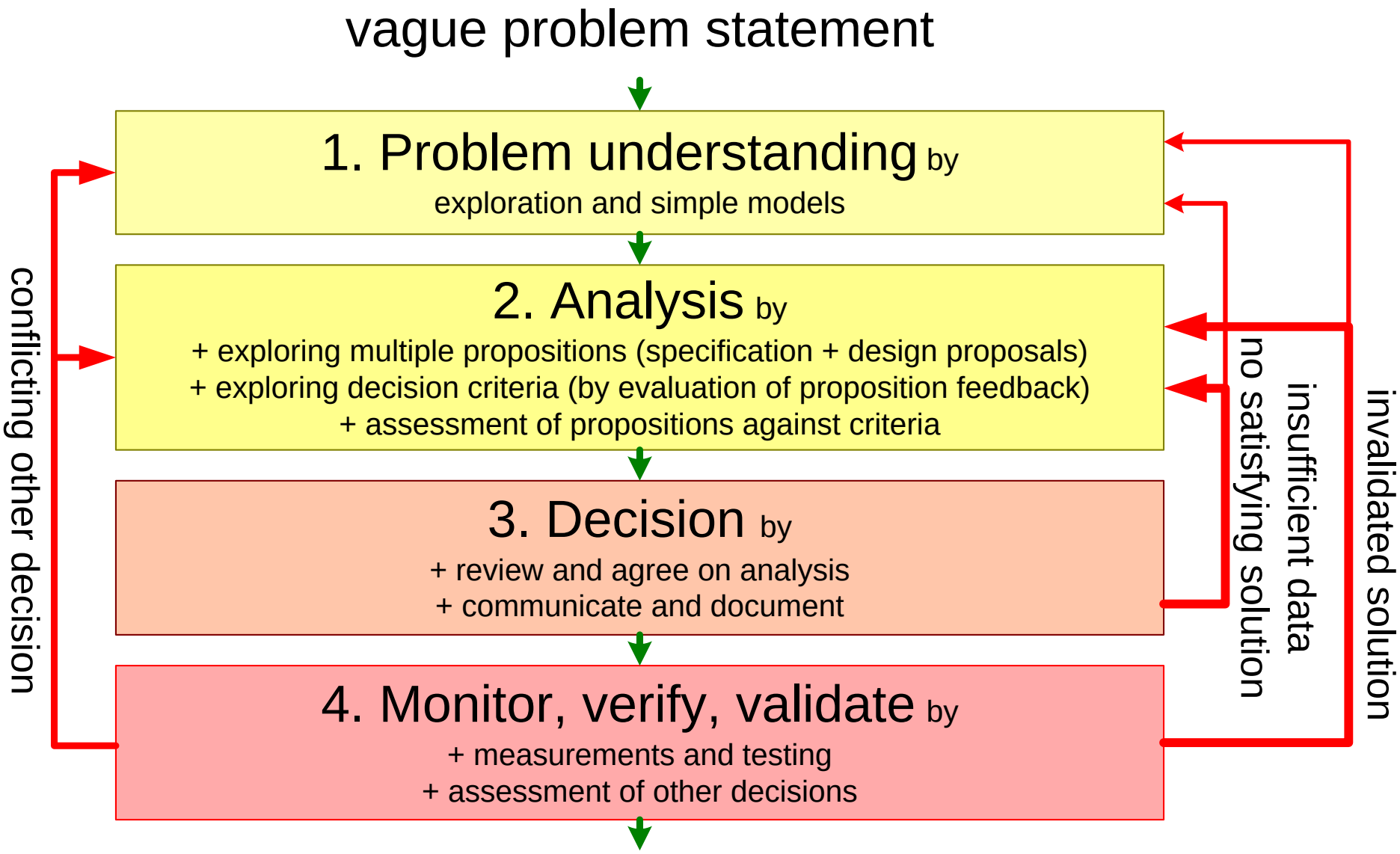
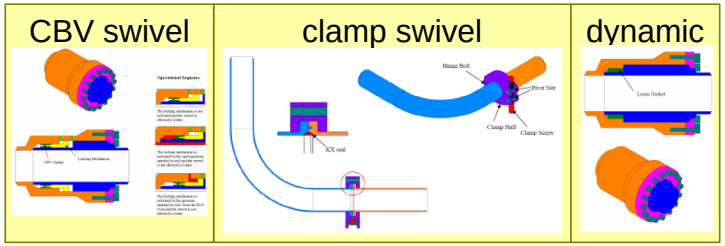


Problem Solving Approach



Examples of Pugh Matrix Application

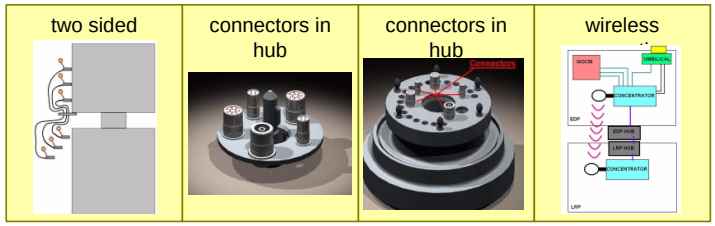
Swivel concept selection



evaluation criteria	weight	CBV		clamp		dynamic	
Maturity	10						
Development level		5	50	2	20	2	50
Cost	20						
Hardware cost		4	80	2	40	5	100
Development cost		5	100	2	40	2	40
Design robustness	25						
Design life							
swivel cycles		5	125	3	75	3	75
pressure cycles		5	125	4	100	5	125
Pressure range		4	100	4	100	4	100
internal		2	50	5	125	2	50
external		4	100	4	100	4	100
Temperature range							
Installation	20						
Initial installatio/retrieval		2	40	3	60	4	80
Connection/disconnection		2	40	4	80	5	100
Operation	25						
Swivel resistance		1	25	4	100	5	125
Spool Length Short		1	25	4	100	5	125
Spool Length Long		3	75	5	125	5	125
Hub loads		2	50	4	100	5	125
Σ points			985		1165		1290

from master paper Halvard Bjørnsen, 2009

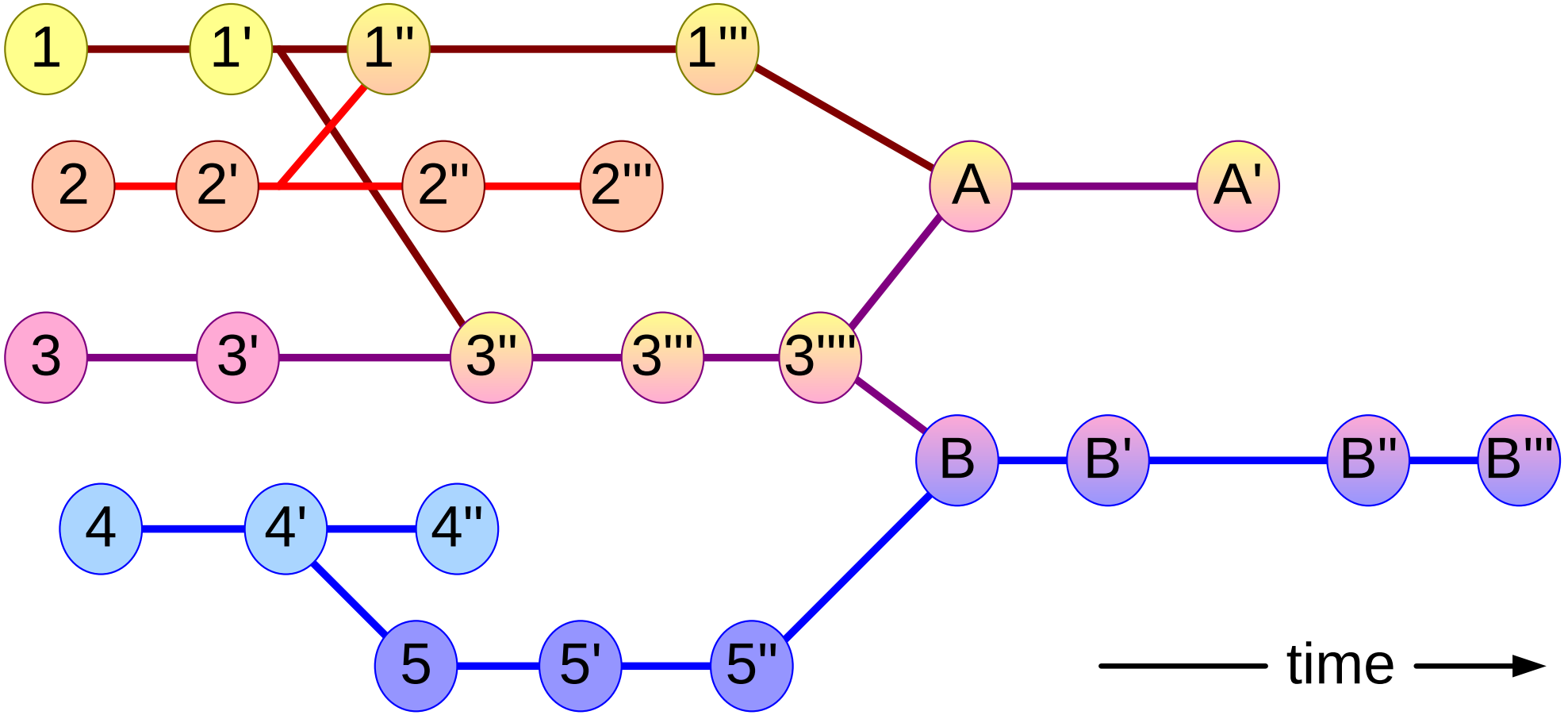
EDP-LRP connection



Evaluation Criteria	Score	Concepts 1	2	3	4
Time to connect					
Need for ROV		-	+	+	+
Design		-	+	+	+
Robustness					
Connector design		-	S	S	+
Number of parts		-	-	+	+
Handle roll-off		+	-	S	+
Influence other		+	S	-	S
Redundancy					
Design		+	-	-	S
Interchangeability		+	-	-	-
Cost					
HW cost		-	-	-	-
Manufacturing cost		S	S	-	S
Engineering cost		+	-	S	-
Service cost		-	+	+	+
Maturity		-	-	S	+
Σ-		7	7	5	3
ΣS		1	3	4	3
Σ+		5	3	4	7
Pos.		3	4	2	1

from master paper Dag Jostein Klever, 2009

Evolution of Design Options



Conclusions

Evolving multiple concepts increases insight and understanding (LEAN product development: set-based design, SE: Pugh matrix)

Articulation of criteria sharpens evaluation

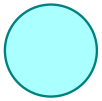
The discussion about the Pugh matrix is more valuable than final bottomline summation

Delaying decisions may help to keep options (Lean Product Development: late decision making, finance: real options)

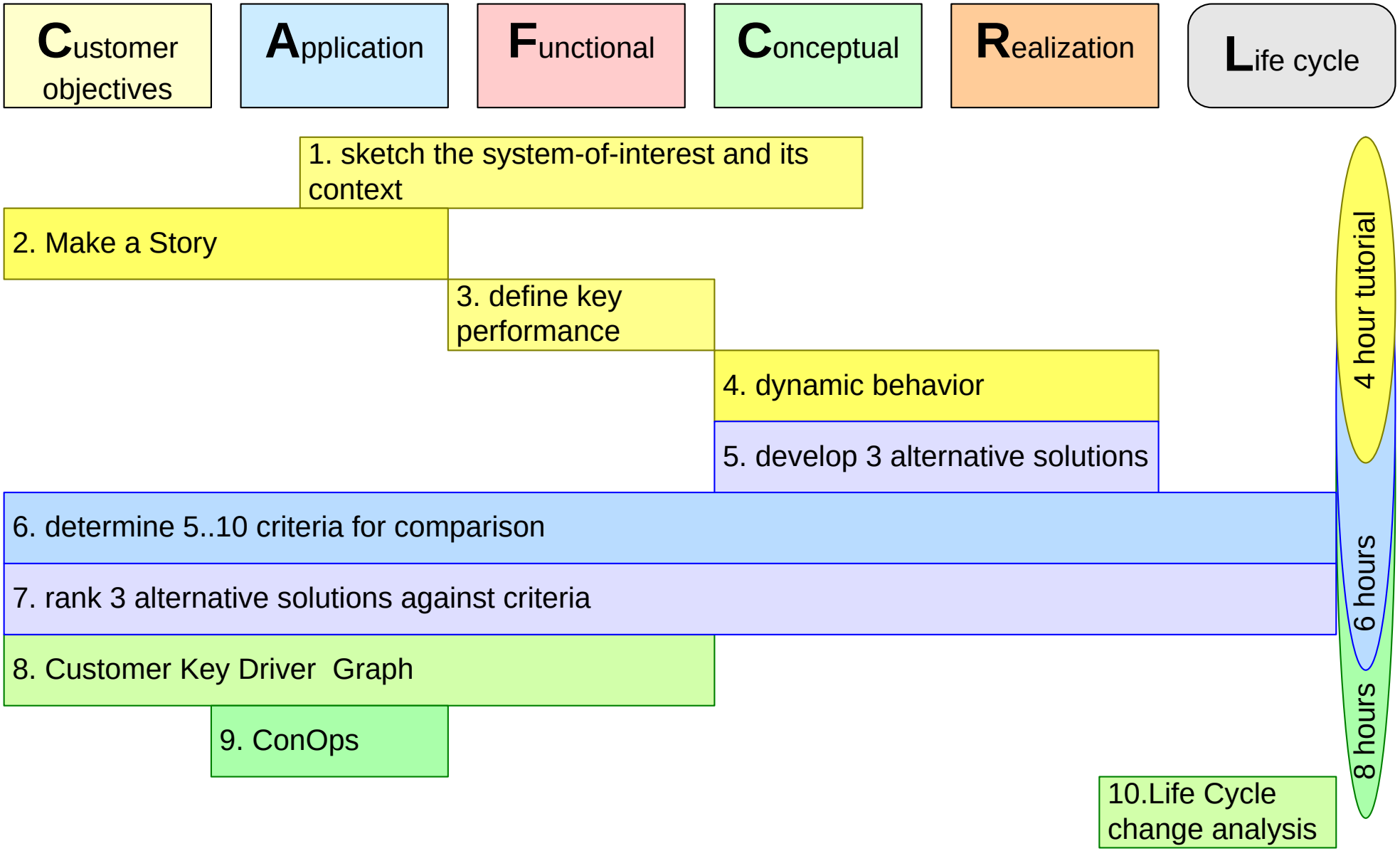
Exercise Concept Selection

Make a **decision matrix** for one of the **concept selections**.

- define at least 3 concepts
- define 7 to 10 criteria for selection
- score the concepts against the criteria, for example using a scale from 1 to 5: 1 = very poor, 5 = very good
- recommend a concept with a rationale

	concept 1 	concept 2	concept 3
criterion 1	1	3	5
criterion n	4	4	2
			best, because ...

Exercises during the Tutorial



Module 34, Architectural Reasoning Customer Space Analysis

by *Gerrit Muller* University of South-Eastern Norway-NISE
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www.gaudisite.nl

Abstract

This module provides methods and techniques to analyze the customer space.

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Methods to Explore the Customer Perspective

by *Gerrit Muller* University of South-Eastern Norway
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www.gaudisite.nl

Abstract

This presentation provides a set of techniques to explore the customer perspective. The main purpose is for an organization to understand its customer sufficiently. Architects need this level of understanding to guide specification and design.

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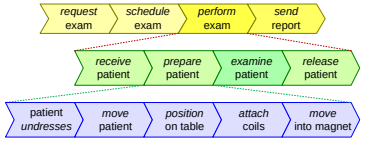
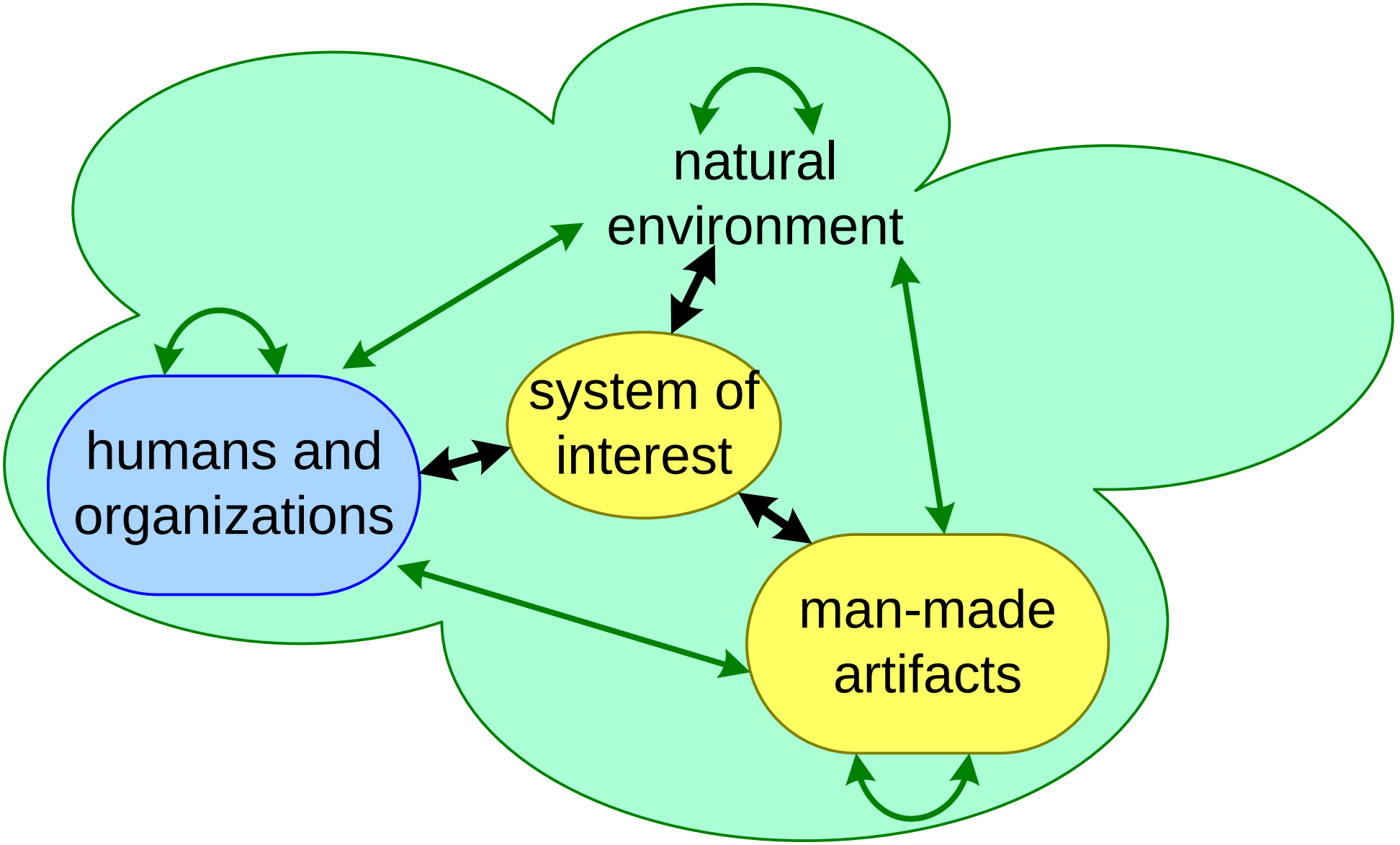


Overview of methods

what	story telling, scenario	http://www.gaudisite.nl/info/StoryHowTo.info.html	
who	stakeholders and concerns	*humans* *organizations*	autonomous behavior emotions
how	system context diagram	*human-made artifacts*	
	workflow		
when	timeline	from seconds to years	
where	map	from nanometers to kilometers	
why	customer key driver graph	http://www.gaudisite.nl/info/KeyDriversHowTo.info.html	
financial	productivity model cost of ownership model money flow		

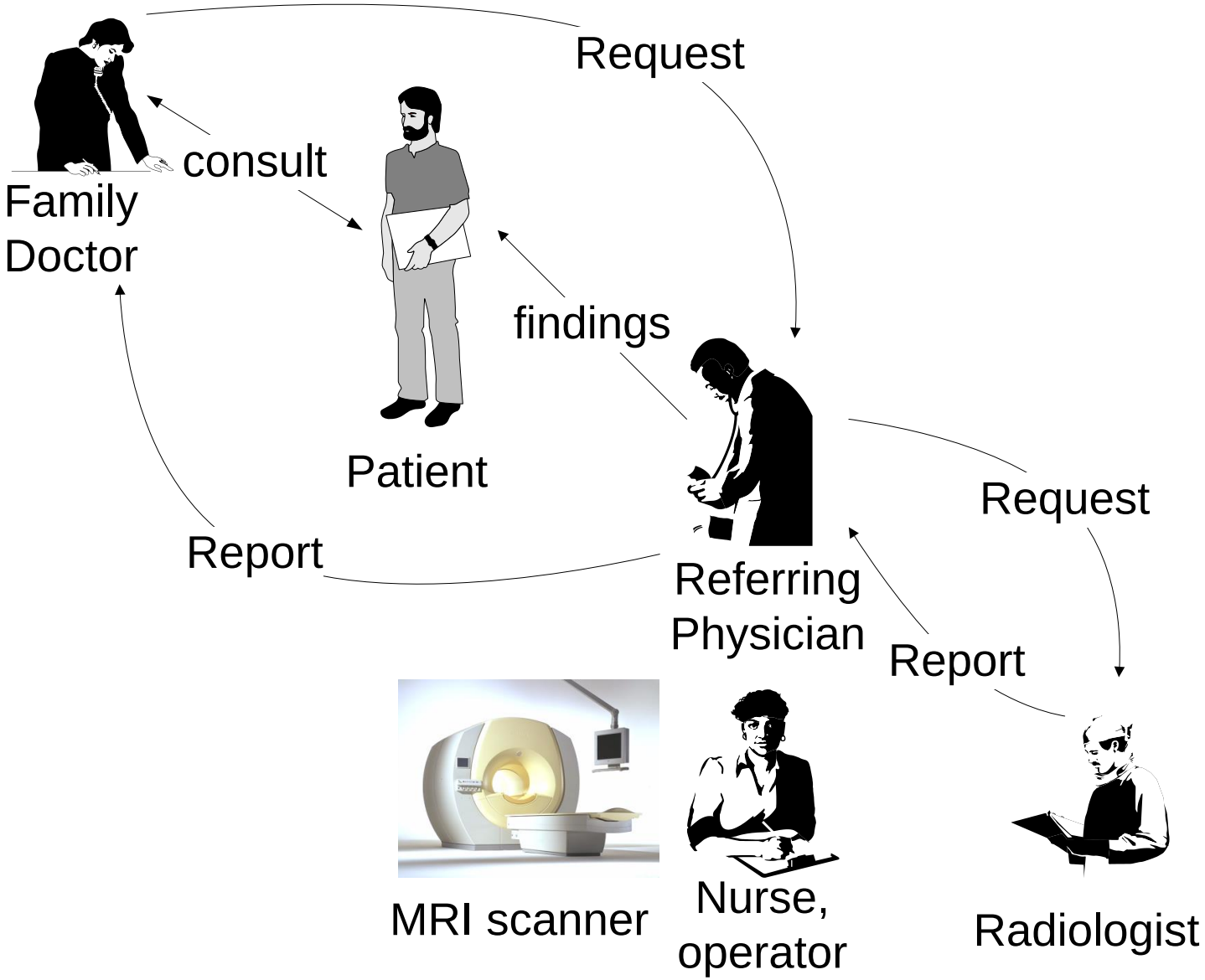
Various Perspectives on Context



Scenario: Patient George

- Patient George has continuous headache.
- His family doctor has send him to the Neurologist.
- The Neurologist wants to exclude the possibility of a tumor and requests an MRI examination.
- The Radiologists does not see any indication for a tumor.
- The Radiologist sends his report to the Neurologist.
- The Neurologist discusses his findings with the patient and sends a report to the family doctor.

From Complaint to Diagnosis



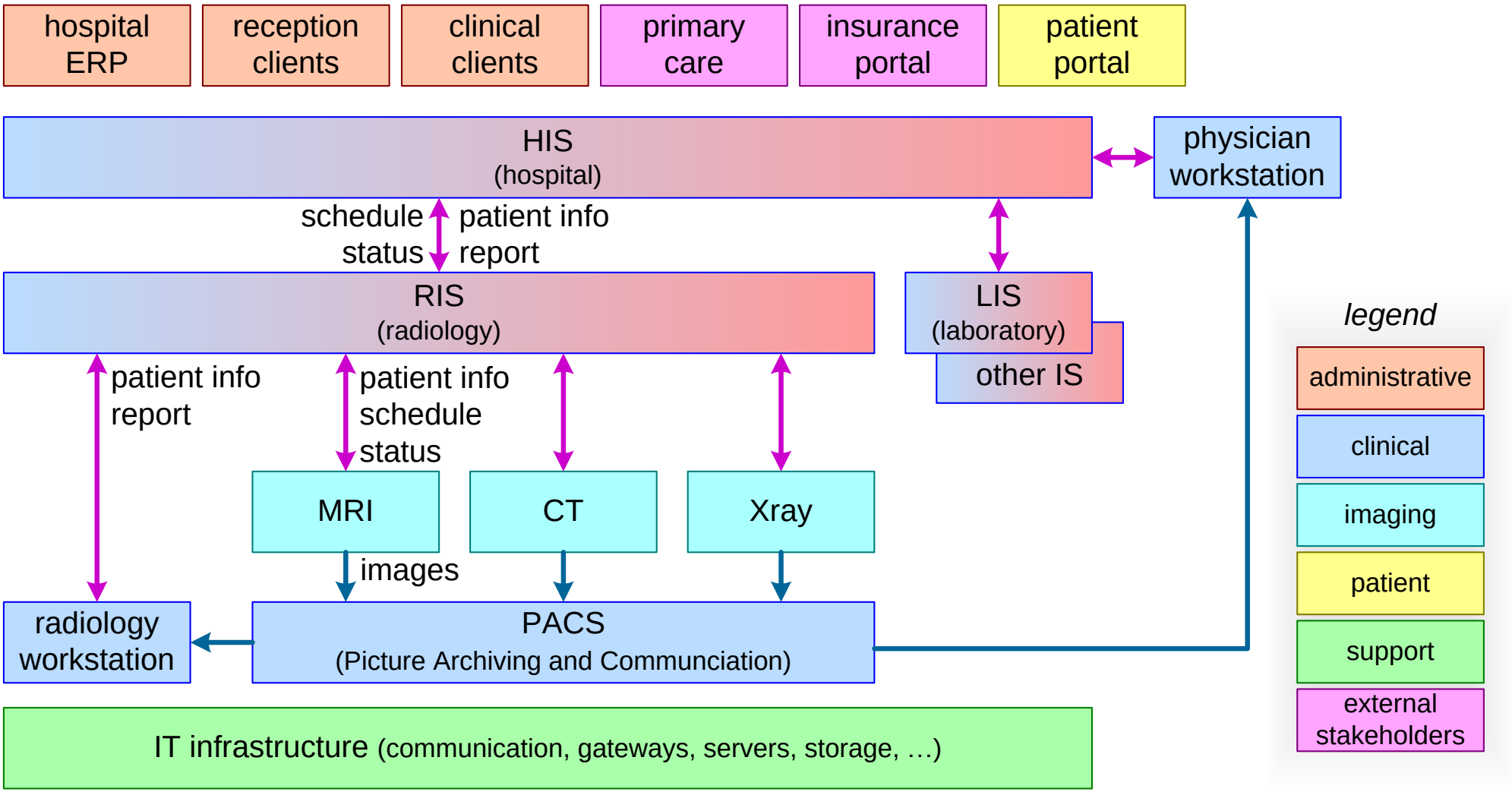
Stakeholders and concerns MRI scanner

government *cost of care*	financial dir. *cash flow cost of op.*	insurance *cost of care*	administration *patient id invoice*
general practitioner *patient*	ref. physician *diagnosis treatment*	radiologist *diagnosis reimburstment*	nurse *patient ease of work*
patient *comfort health*			inspection *quality*
family *support*			operator *ease of use*
IT dep. *conformance security*	facility man. *space service supp.*	maintainer *accessibility safety*	cleaner *accessibility safety*

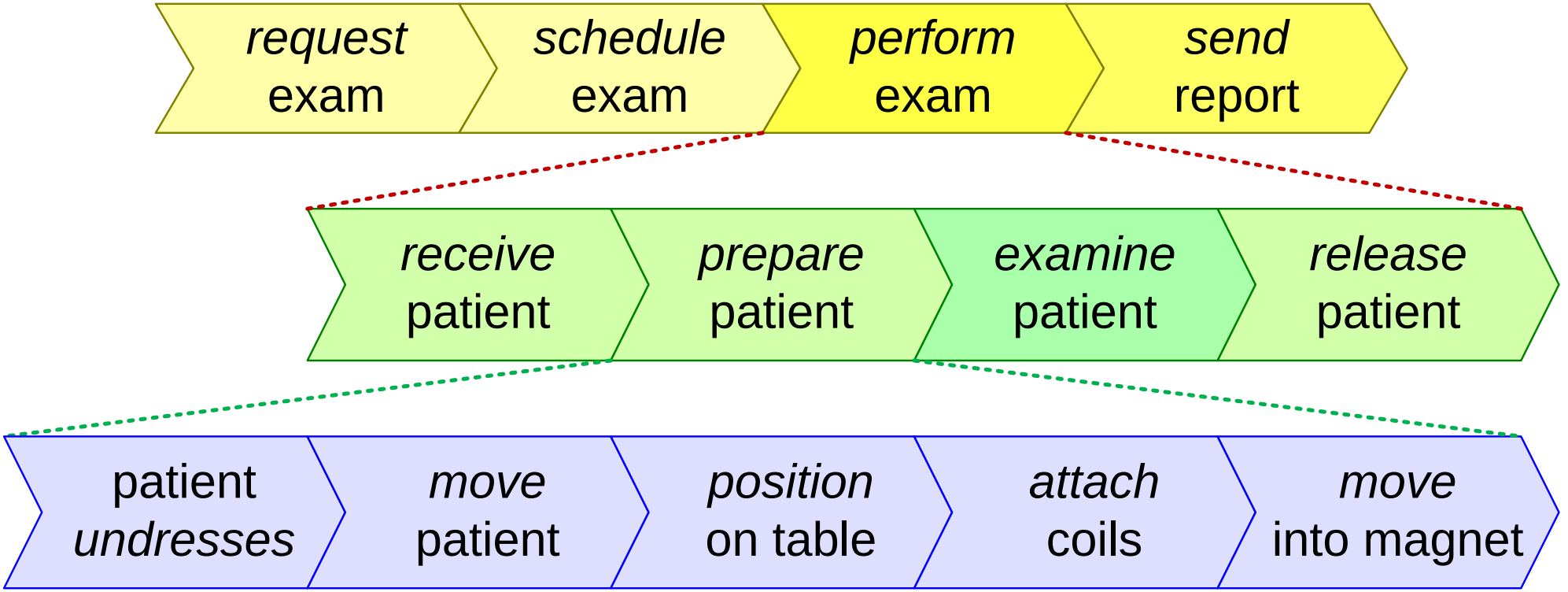
legend

- administrative
- clinical
- patient
- support

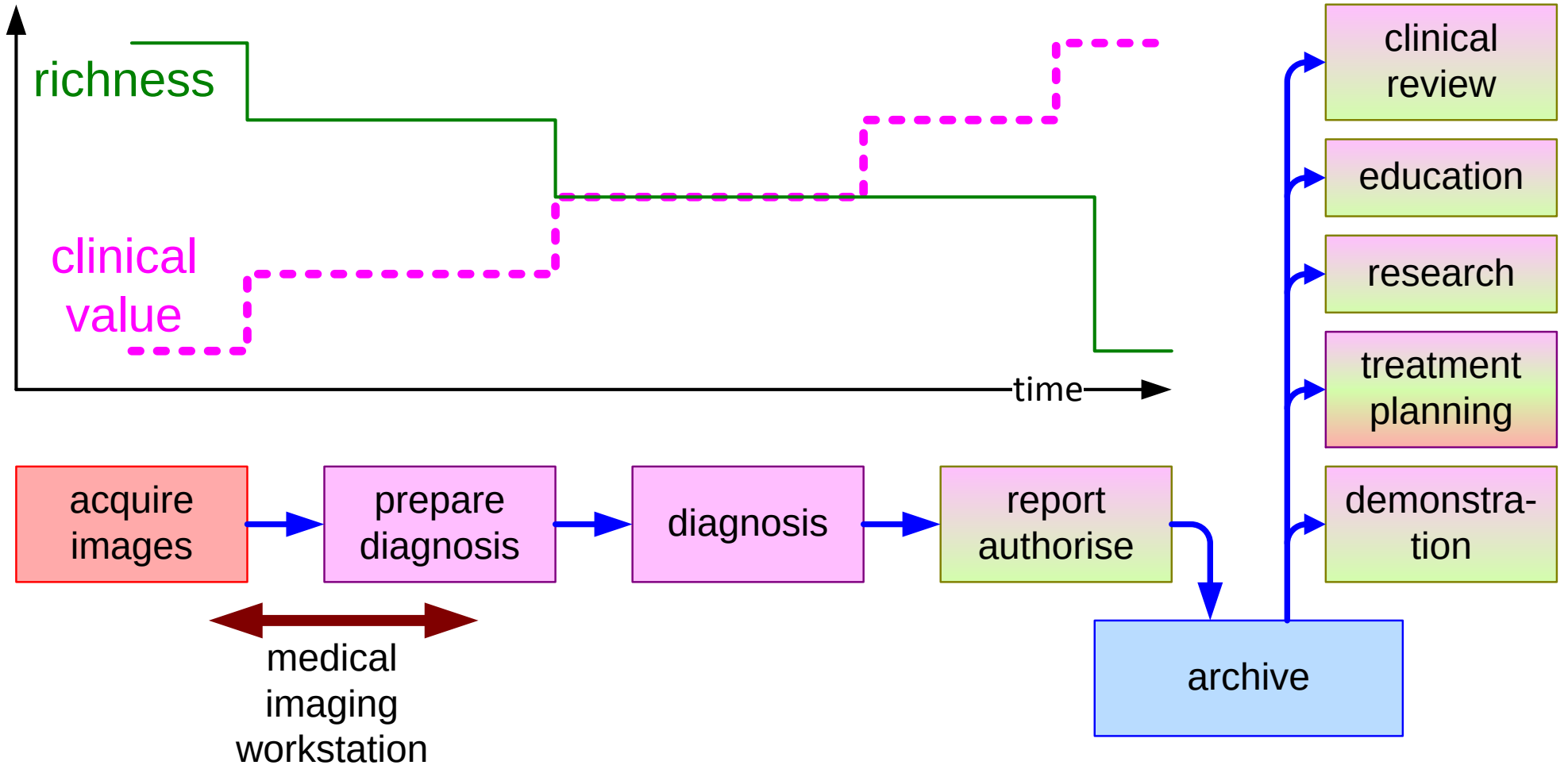
Context of MRI



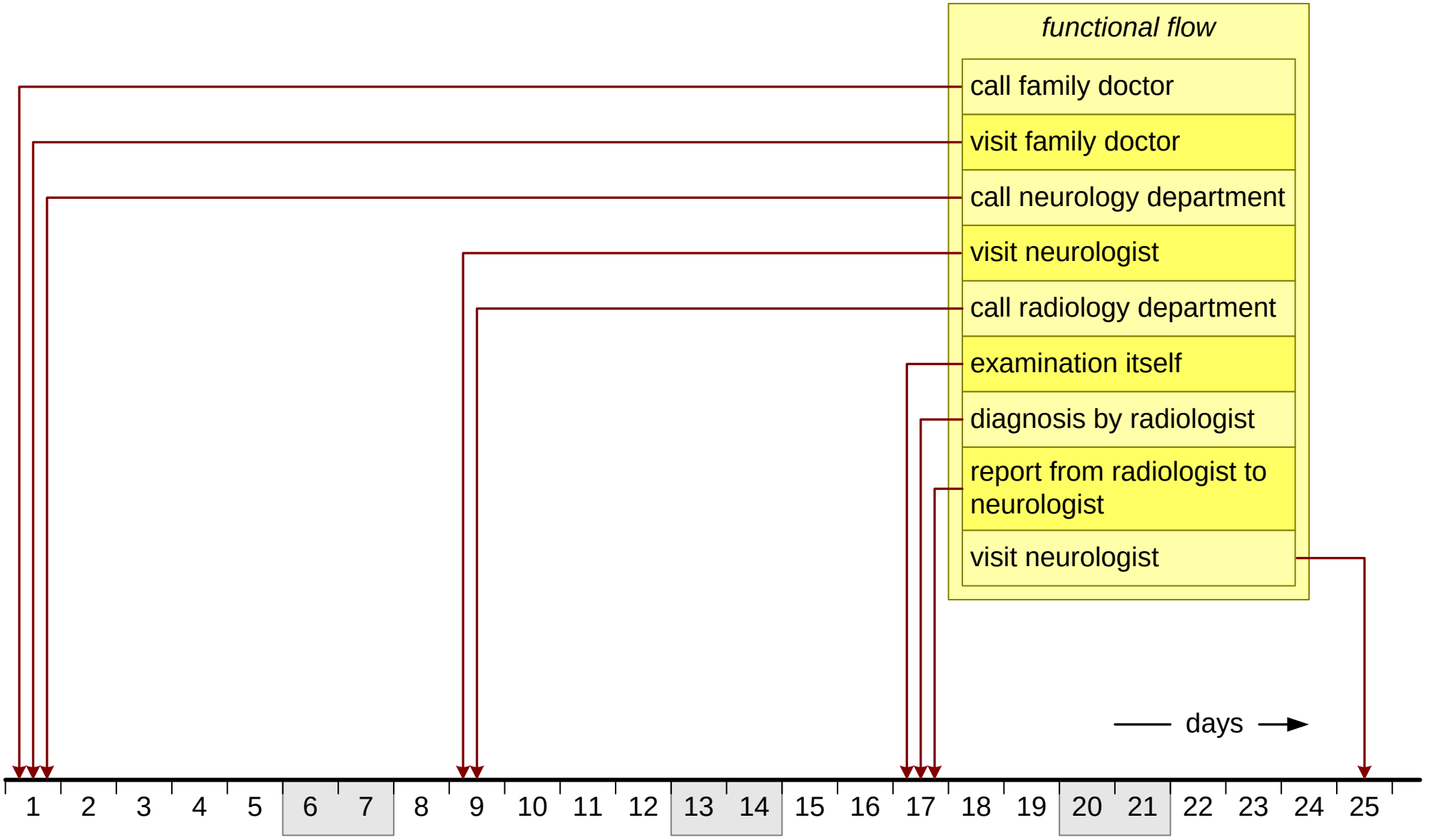
Workflow


request exam
schedule exam
perform exam
send report
receive patient
prepare patient
examine patient
release patient
patient undresses
move patient
position on table
attach coils
move into magnet

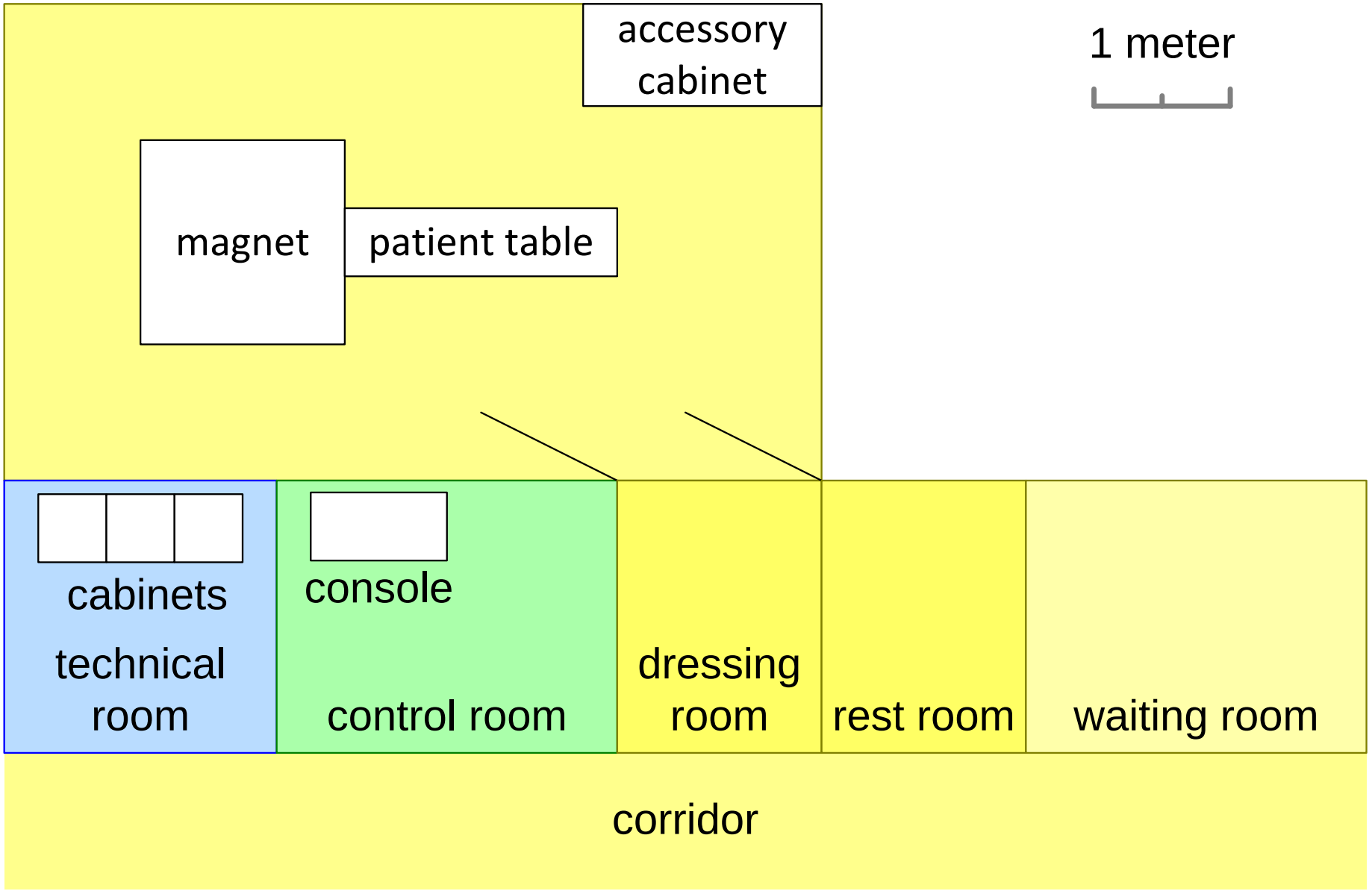
Clinical Information Flow



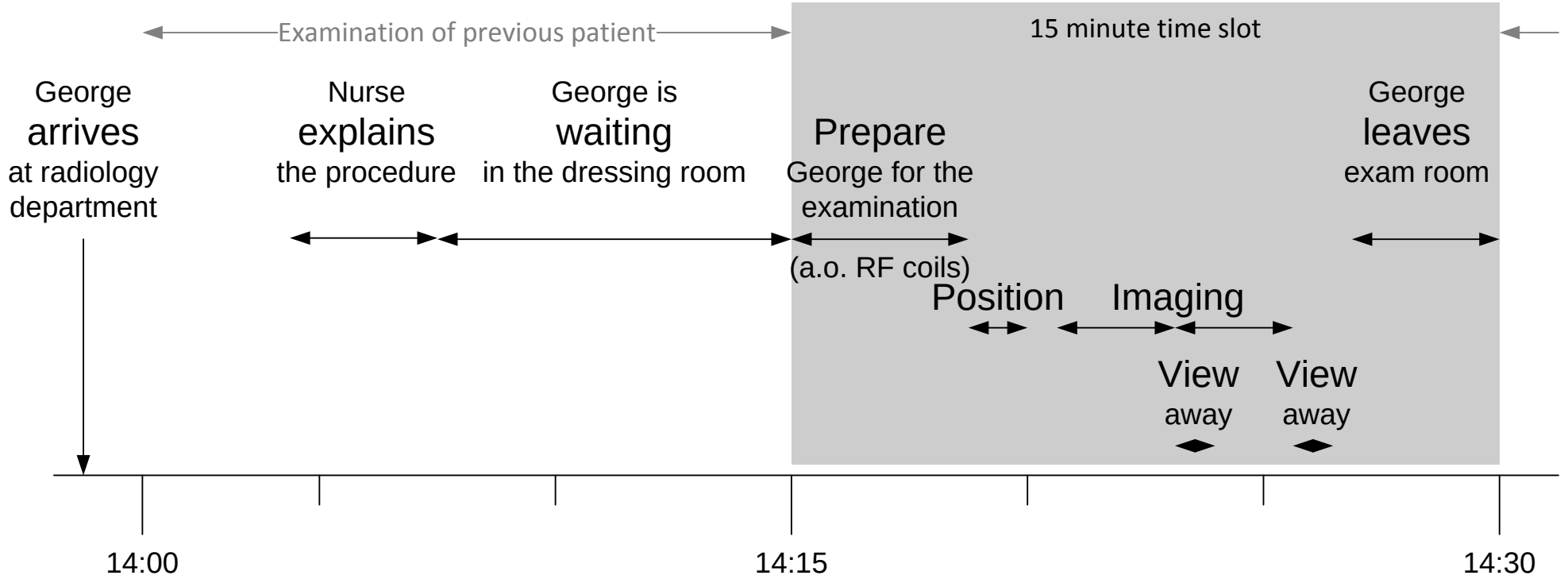
weeks view: from Complaint to Diagnosis



Room Layout


accessory cabinet
1 meter
magnet
patient table
cabinets
technical room
console
control room
dressing room
rest room
waiting room
corridor

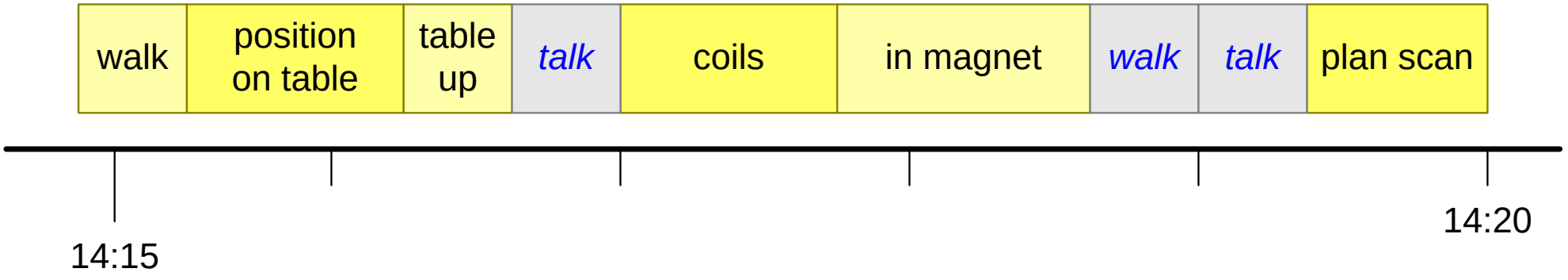
half hour view: Examination



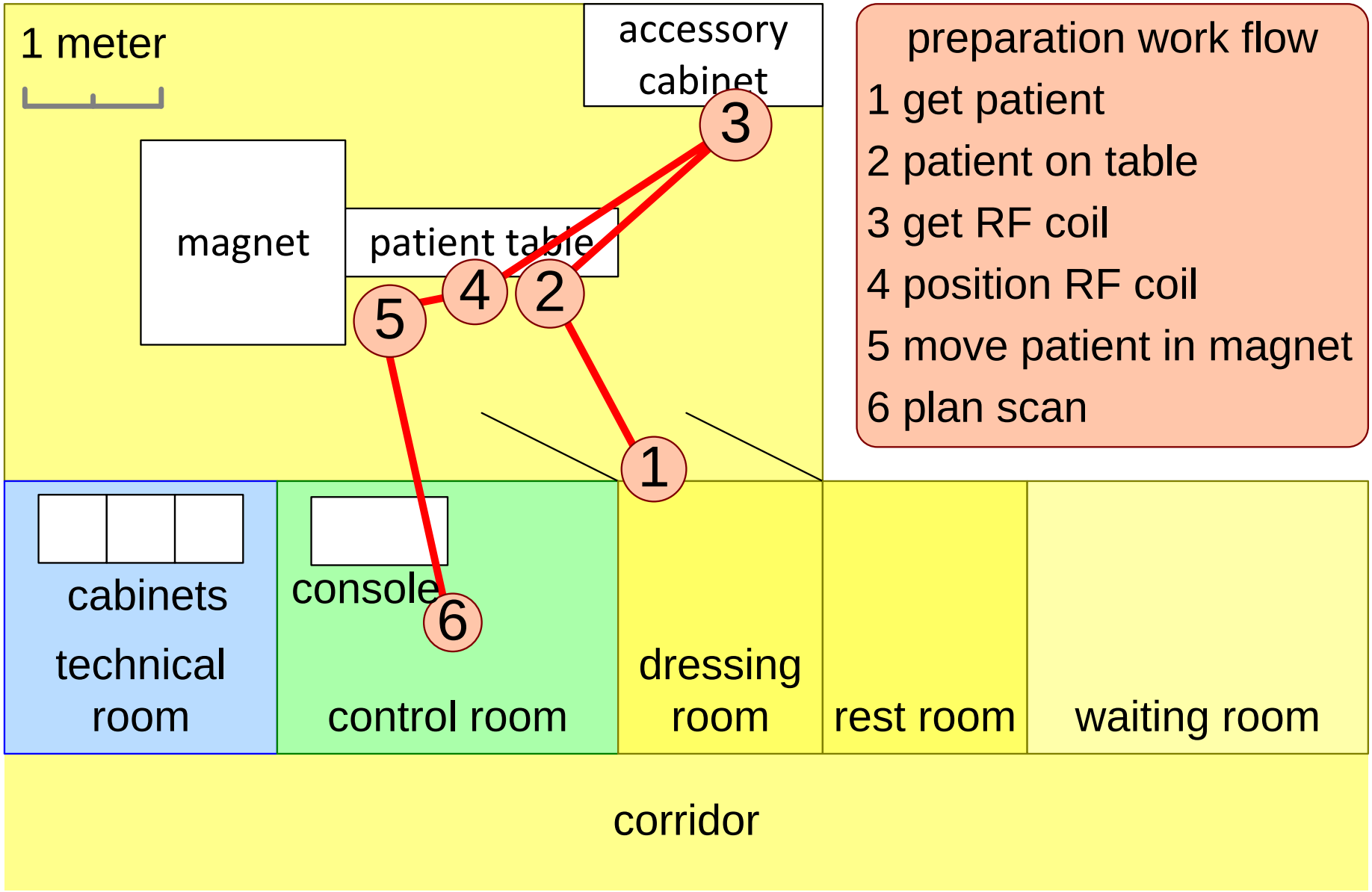
5 minute view: Patient Preparation (1 operator)

functional procedure

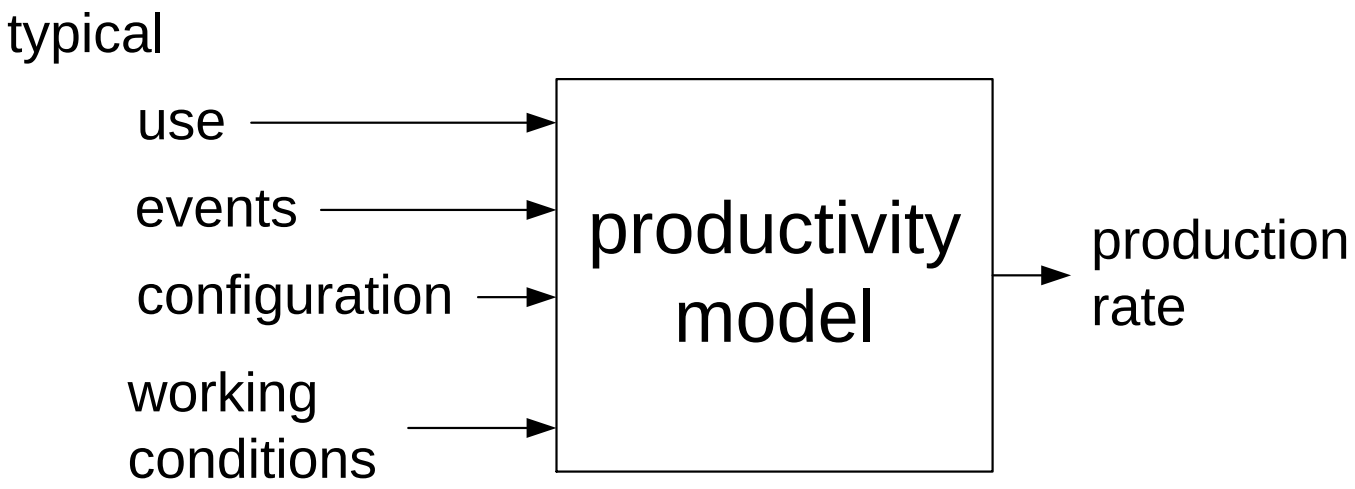
walk from dressing room to table
position patient on table
move table upwards
position coils and connect
move table and patient into magnet
make plan scan



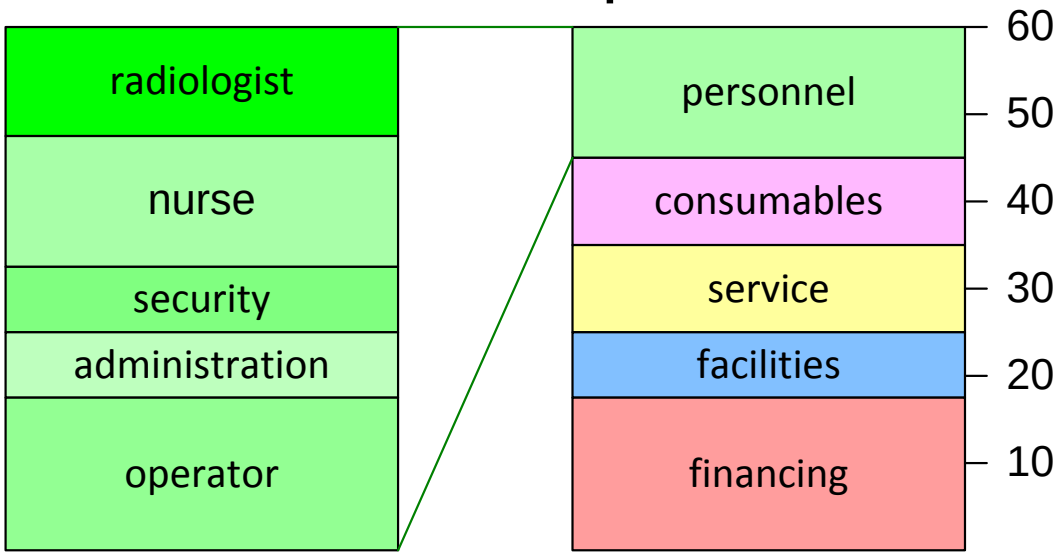
Patient Preparation Work Flow



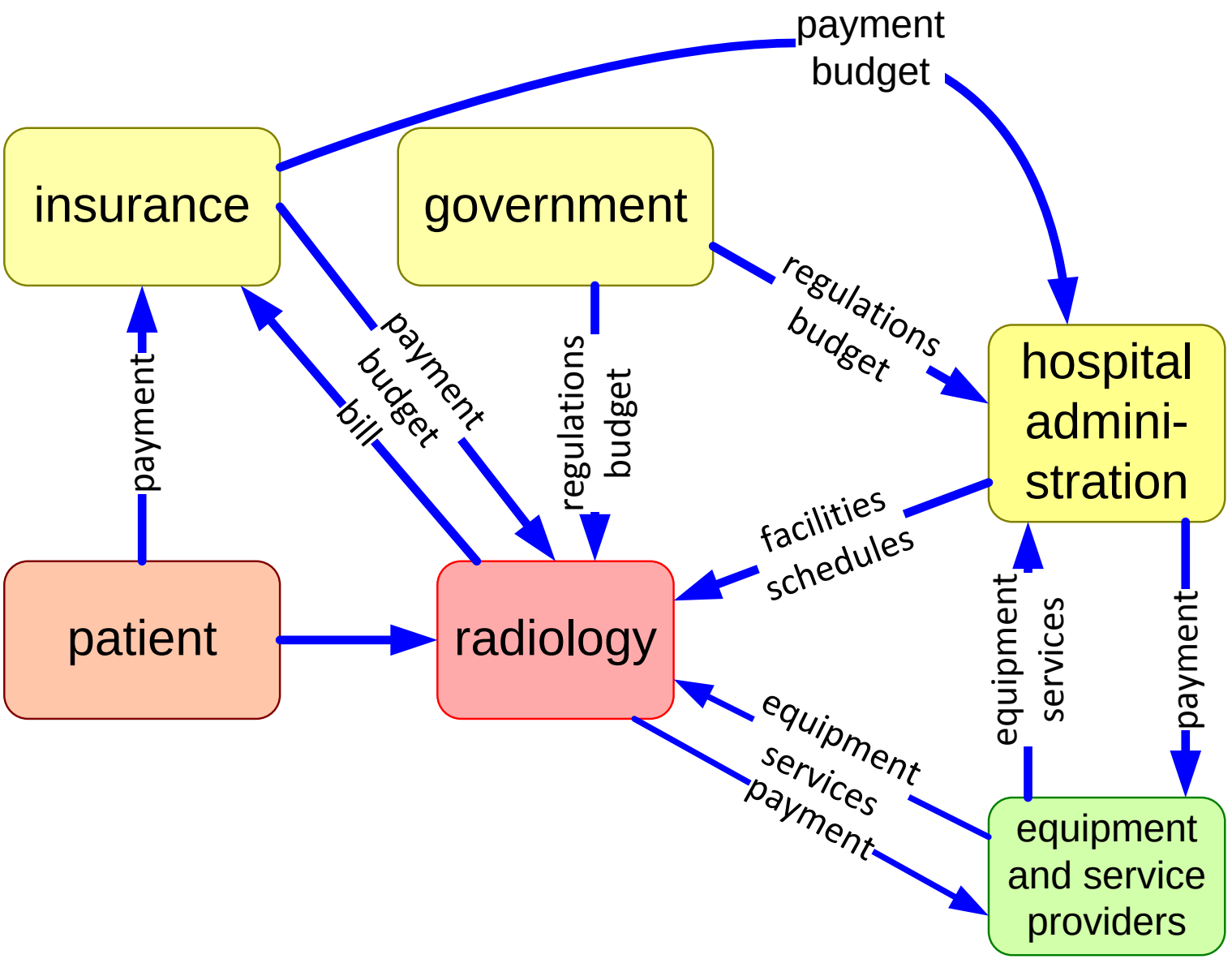
Productivity and Cost models



Cost Of Ownership model



The financial context of the radiology department



Make a **context diagram**, showing the **systems** and their **relations** in the **customer space**

- typically, tens of systems are relevant for customers

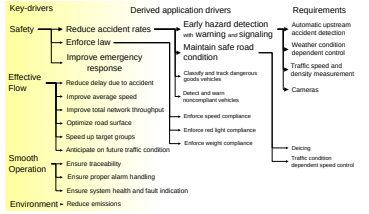
Capture one or a few main **workflows** in the customer space

Key Drivers How To

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

Abstract

The notion of ”business key drivers” is introduced and a method is described to link these key drivers to the product specification.



Note: the graph is only partially elaborated for application drivers and requirements

Distribution

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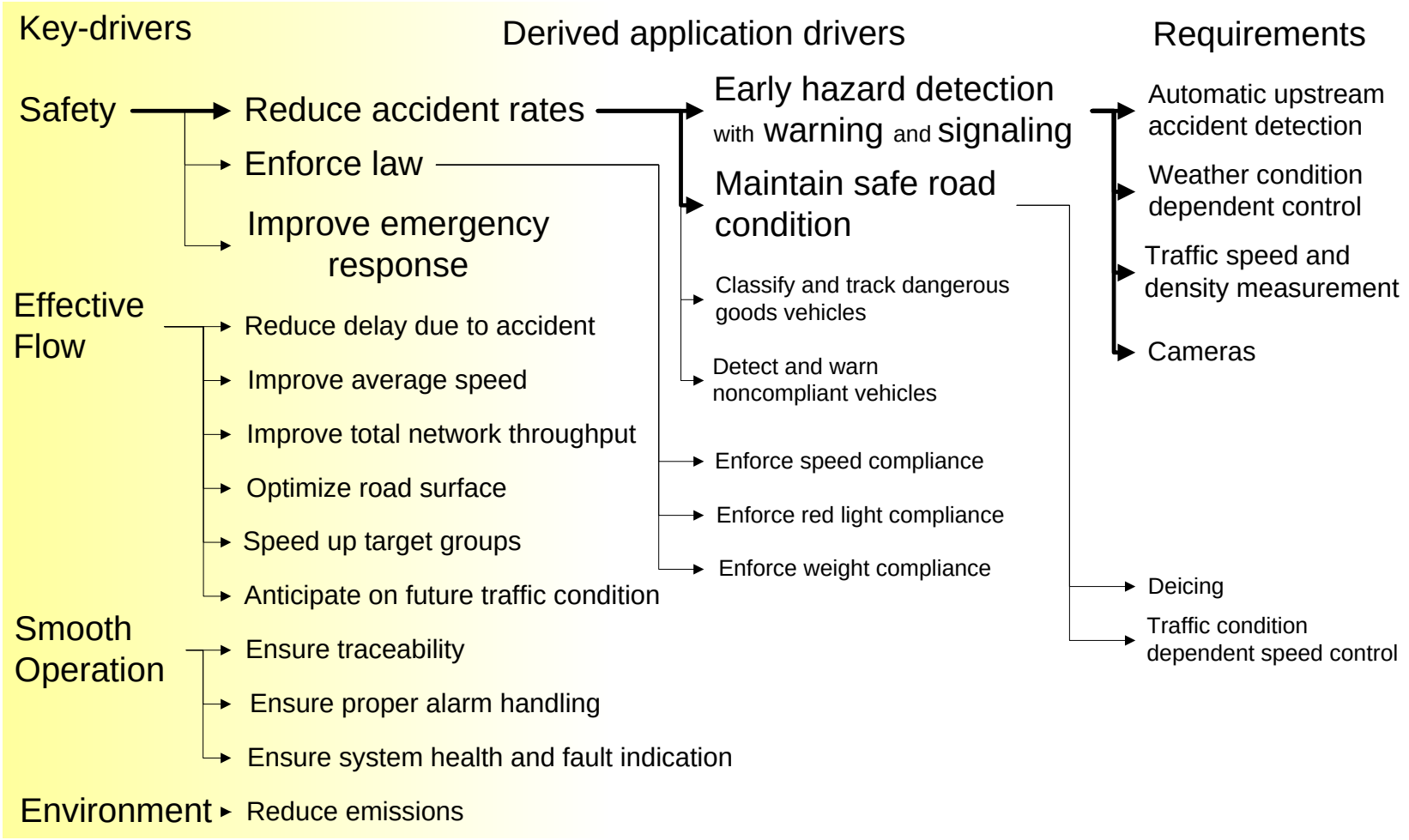
April 3, 2023
status: draft
version: 0.2

Example Motorway Management Analysis



Note: the graph is only partially elaborated for application drivers and requirements

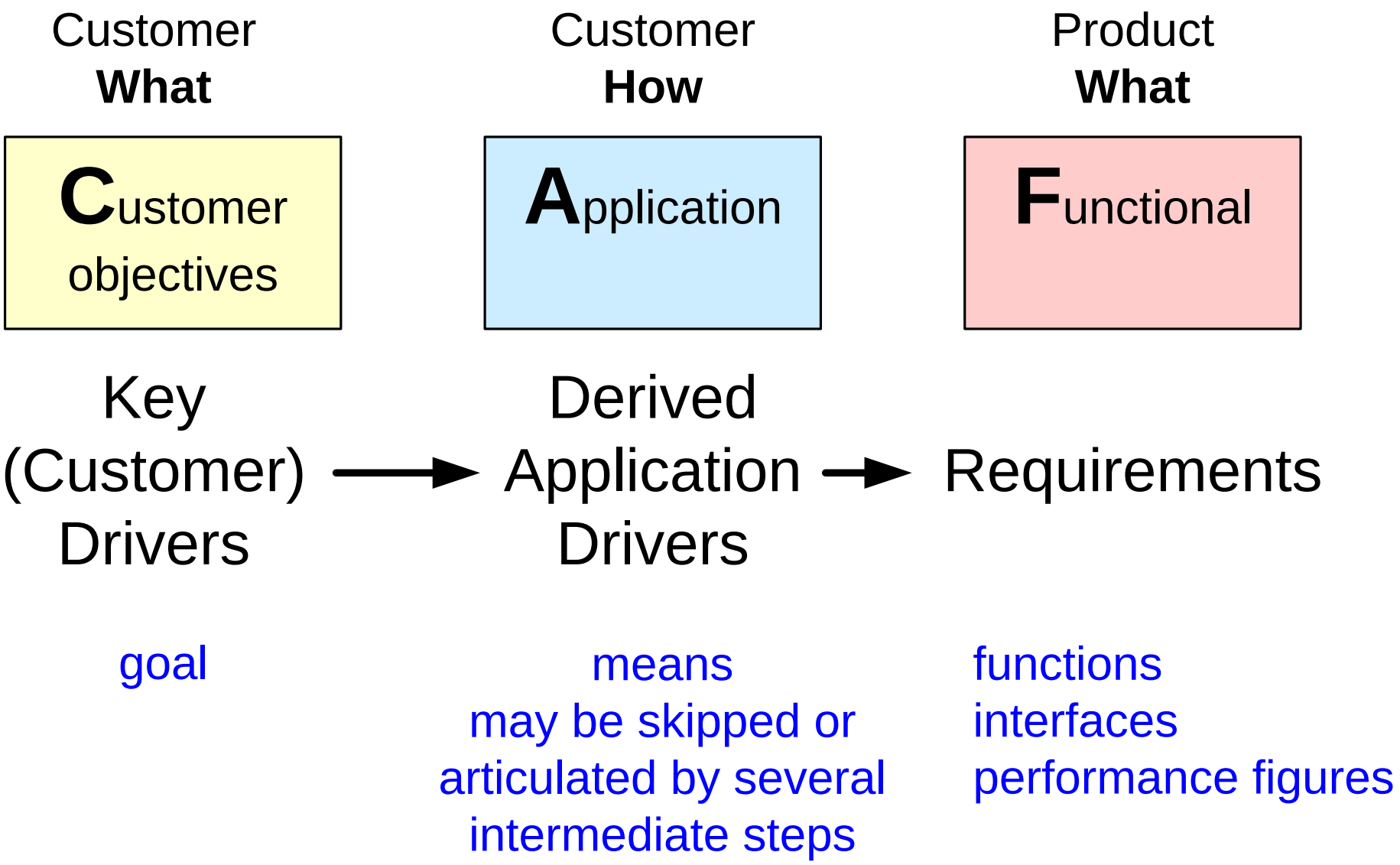
Method to create Key Driver Graph

• Define the scope specific.	in terms of stakeholder or market segments
• Acquire and analyze facts	extract facts from the product specification and ask why questions about the specification of existing products.
• Build a graph of relations between drivers and requirements by means of brainstorming and discussions	where requirements may have multiple drivers
• Obtain feedback	discuss with customers, observe their reactions
• Iterate many times	increased understanding often triggers the move of issues from driver to requirement or vice versa and rephrasing

Recommendation for the Definition of Key Drivers

• Limit the number of key-drivers	minimal 3, maximal 6
• Don't leave out the obvious key-drivers	for instance the well-known main function of the product
• Use short names, recognized by the customer.	
• Use market-/customer- specific names, no generic names	for instance replace "ease of use" by "minimal number of actions for experienced users", or "efficiency" by "integral cost per patient"
• Do not worry about the exact boundary between Customer Objective and Application	create clear goal means relations

Transformation of Key Drivers into Requirements

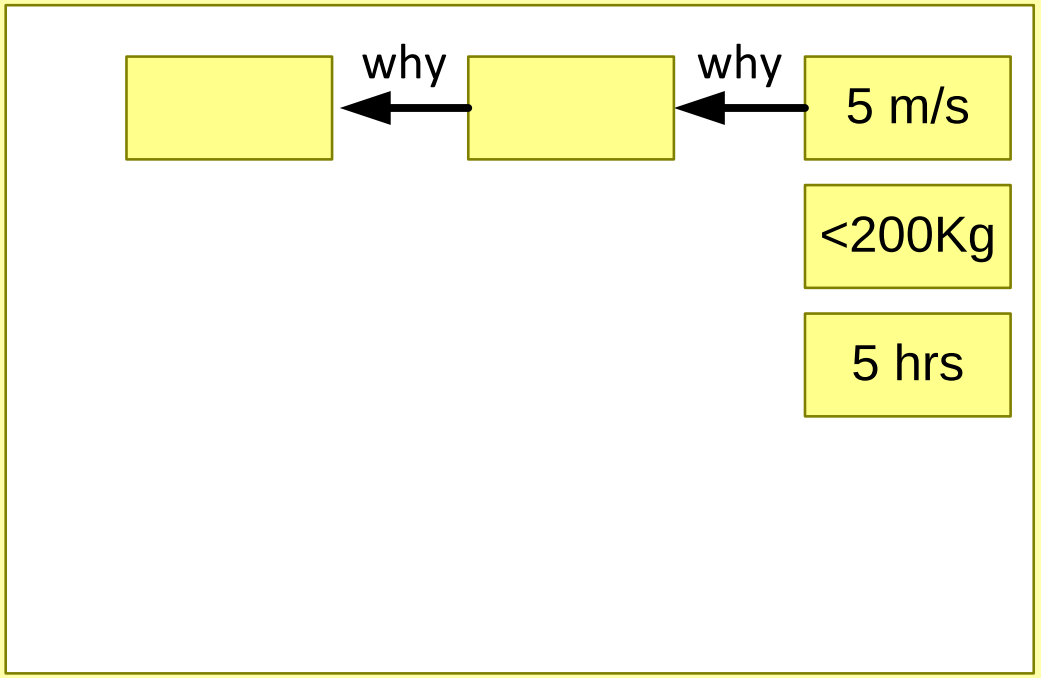


Exercise Customer Key Driver Graph

Make a **customer key driver graph**

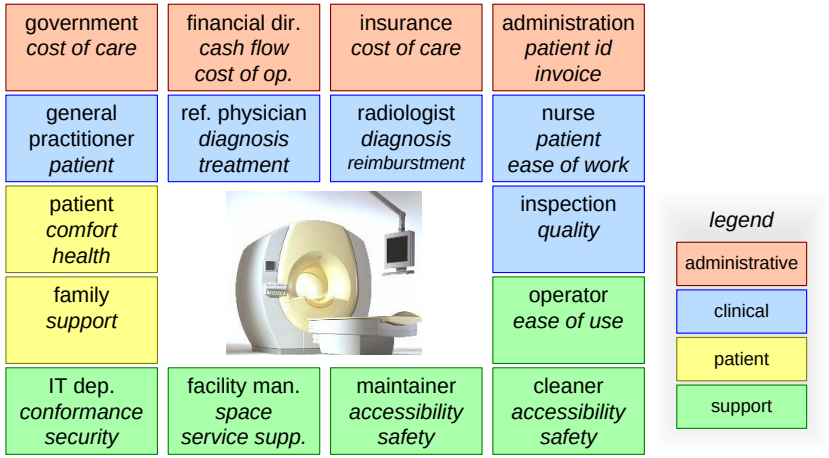
Use yellow note stickers

Start at the right hand side

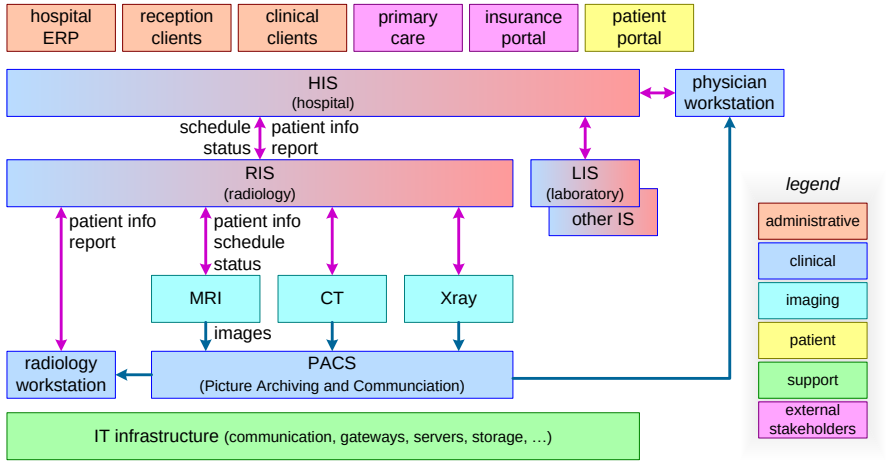


Analysis Methods and Techniques

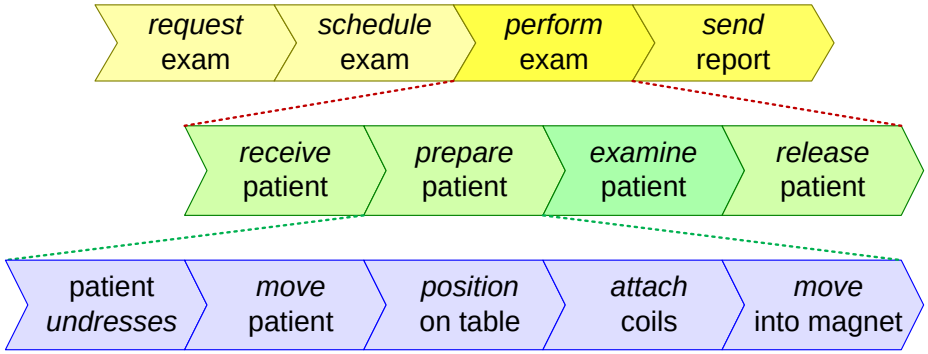
Stakeholders and Concerns (Who)



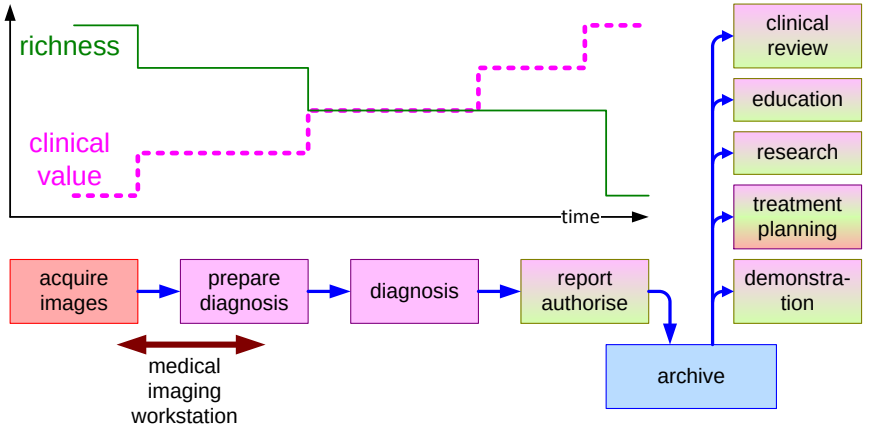
Context Diagram (what sytems)



Workflow (what dynamics)

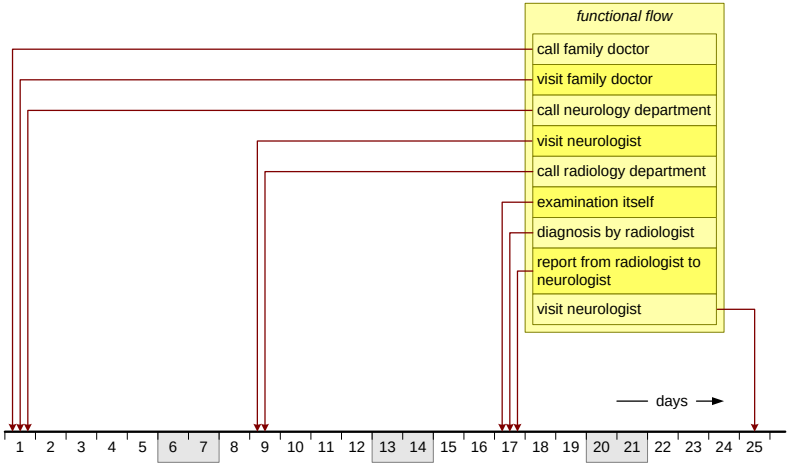


Information Flow

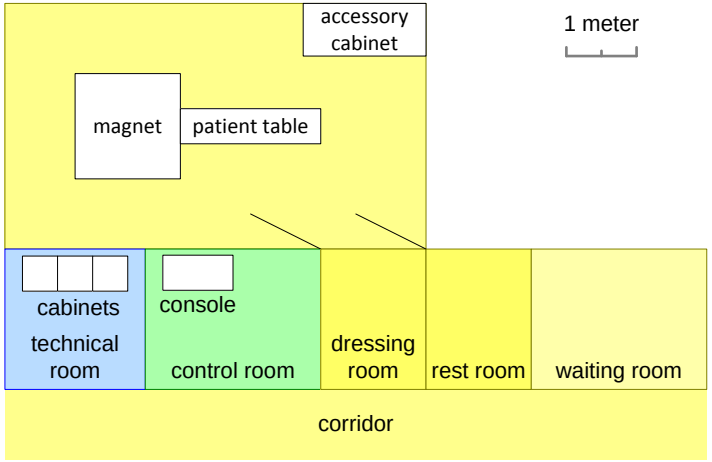


More Analysis Methods and Techniques

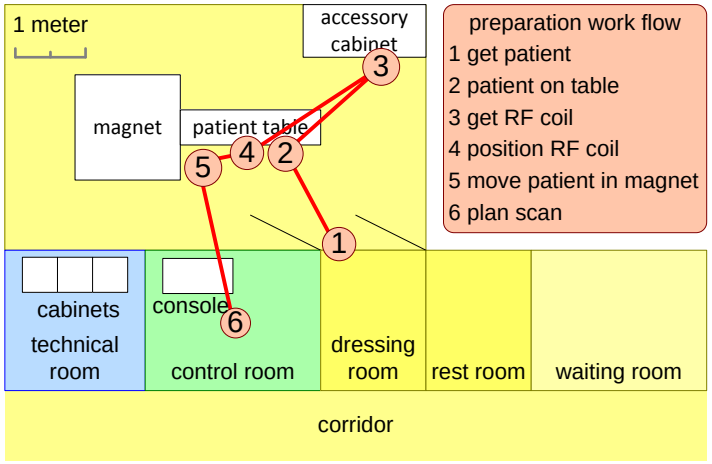
Timeline (when, what, who)



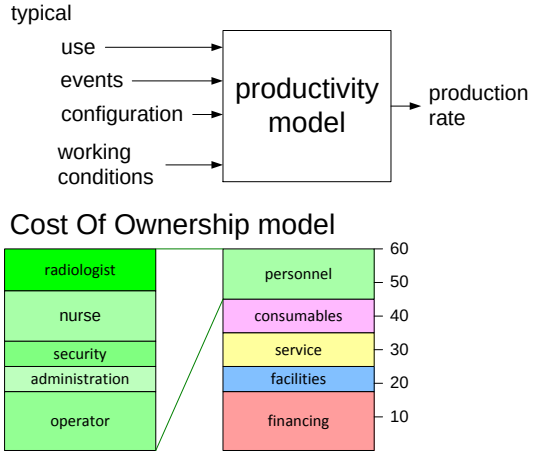
2D or 3D map (where)



Annotated map (where, what)

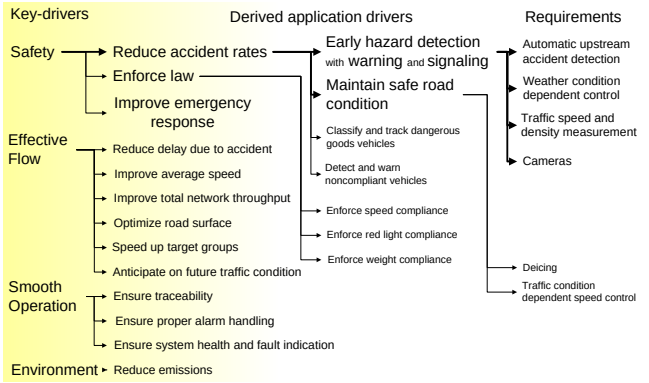


Cost Models



Customer Key Driver Graph

Focus on Customer World



Note: the graph is only partially elaborated for application drivers and requirements

Specific Scope, Fact Based

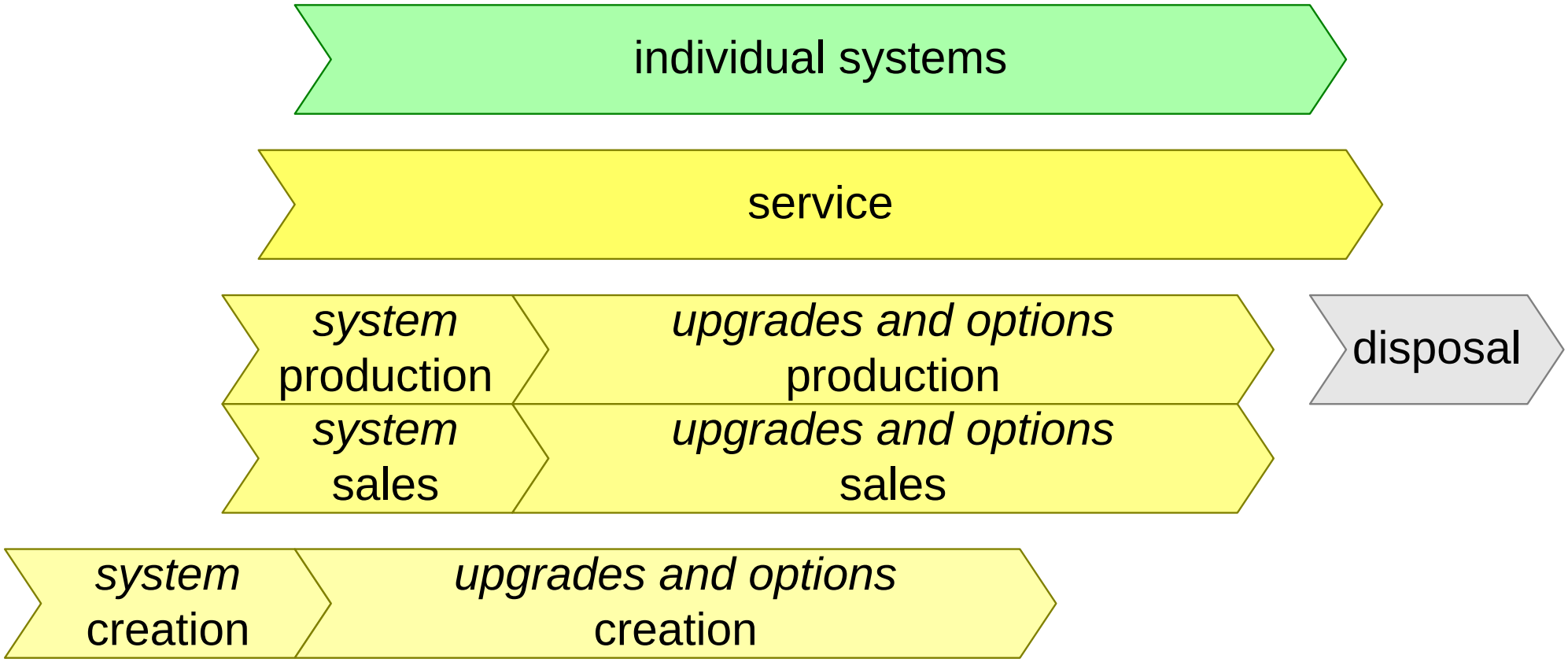
• Define the scope specific.	in terms of stakeholder or market segments
• Acquire and analyze facts	extract facts from the product specification and ask why questions about the specification of existing products.
• Build a graph of relations between drivers and requirements by means of brainstorming and discussions	where requirements may have multiple drivers
• Obtain feedback	discuss with customers, observe their reactions
• Iterate many times	increased understanding often triggers the move of issues from driver to requirement or vice versa and rephrasing

3 to 6 Key driver, Capture Tensions

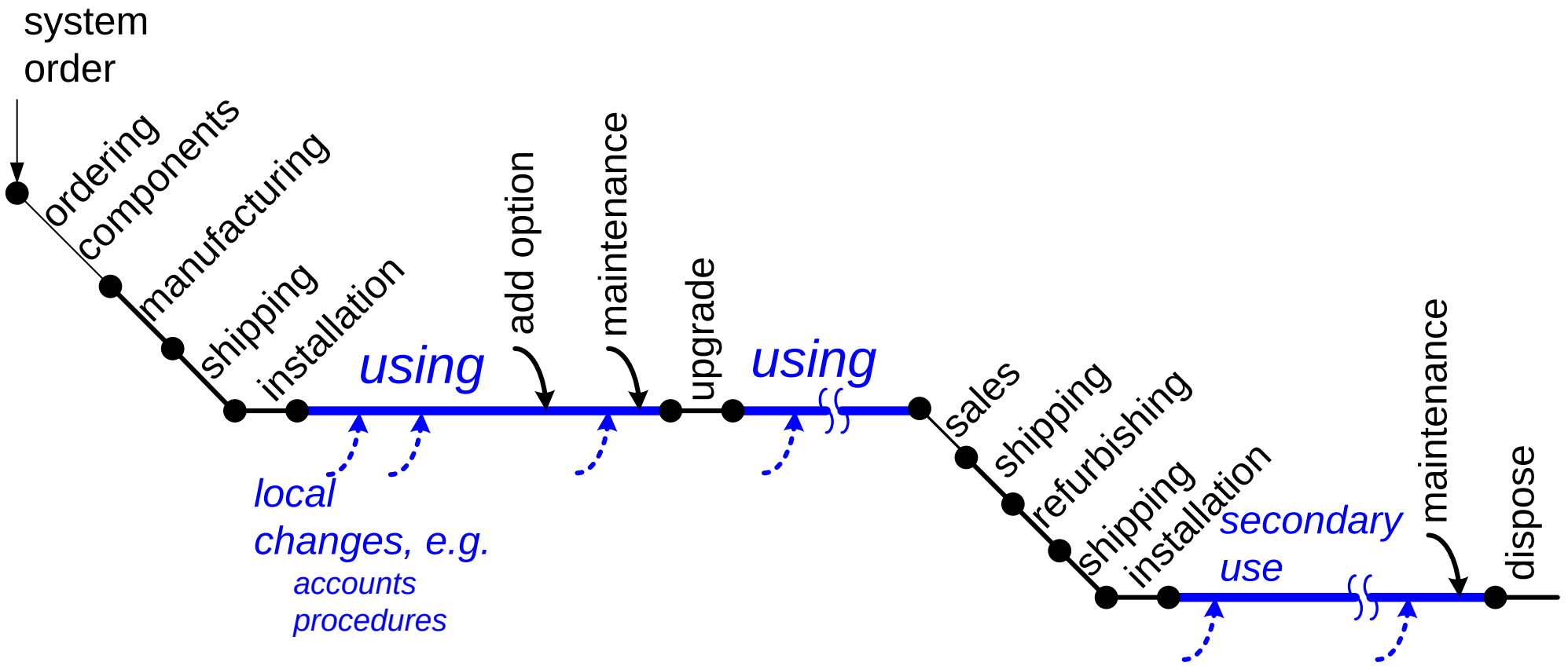
• Limit the number of key-drivers	minimal 3, maximal 6
• Don't leave out the obvious key-drivers	for instance the well-known main function of the product
• Use short names, recognized by the customer.	
• Use market-/customer- specific names, no generic names	for instance replace "ease of use" by "minimal number of actions for experienced users", or "efficiency" by "integral cost per patient"
• Do not worry about the exact boundary between Customer Objective and Application	create clear goal means relations

intentionally left blank

Product Related Life Cycles



System Life Cycle

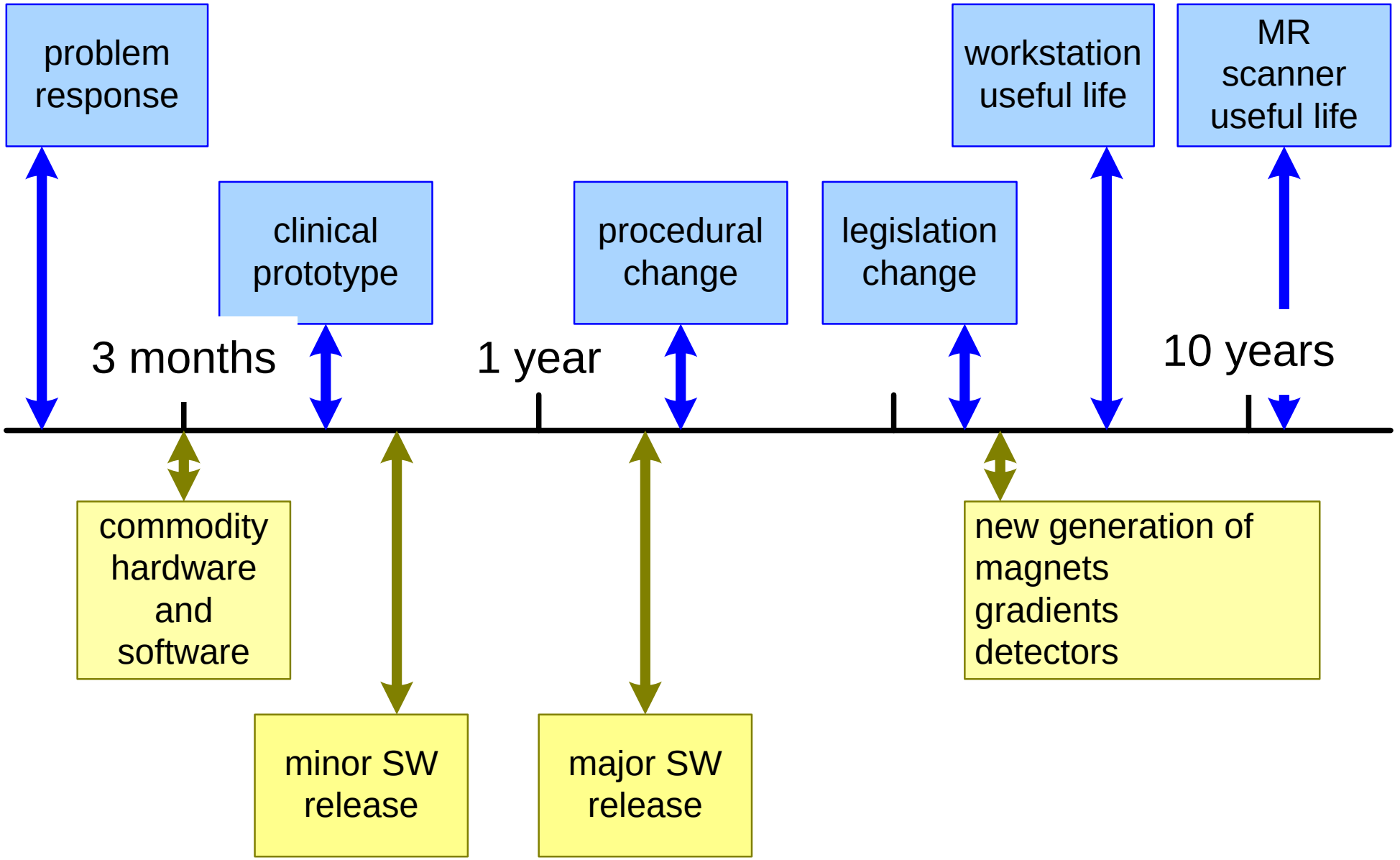


Approach to Life Cycle Modeling

Identify potential life cycle changes and sources	
Characterize time aspect of changes	how often how fast
Determine required effort	amount type
Determine impact of change on system and context	performance reliability
Analyse risks	business

see reasoning

Example of Time Scale Model for Changes



Exercise Life Cycle

Analyze the **evolution** during the **lifecycle**.

- identify sources of change in customer context, life cycle context, and technology
- make a list of changes
- determine per change the expected rate of change and the required response time to the change
- optional: determine effort, impact, and risks per change

Qualities as Integrating Needles

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

Abstract

Many stakeholder concerns can be specified in terms of qualities. These qualities can be viewed from all 5 “CAFCR” viewpoints. In this way qualities can be used to relate the views to each other.
The meaning of qualities for the different views is described. A checklist of qualities is provided as a means for architecting. All qualities in the checklist are described briefly.

Distribution

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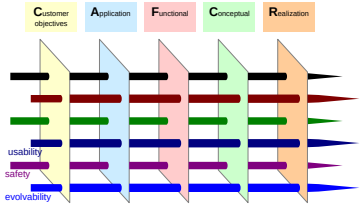
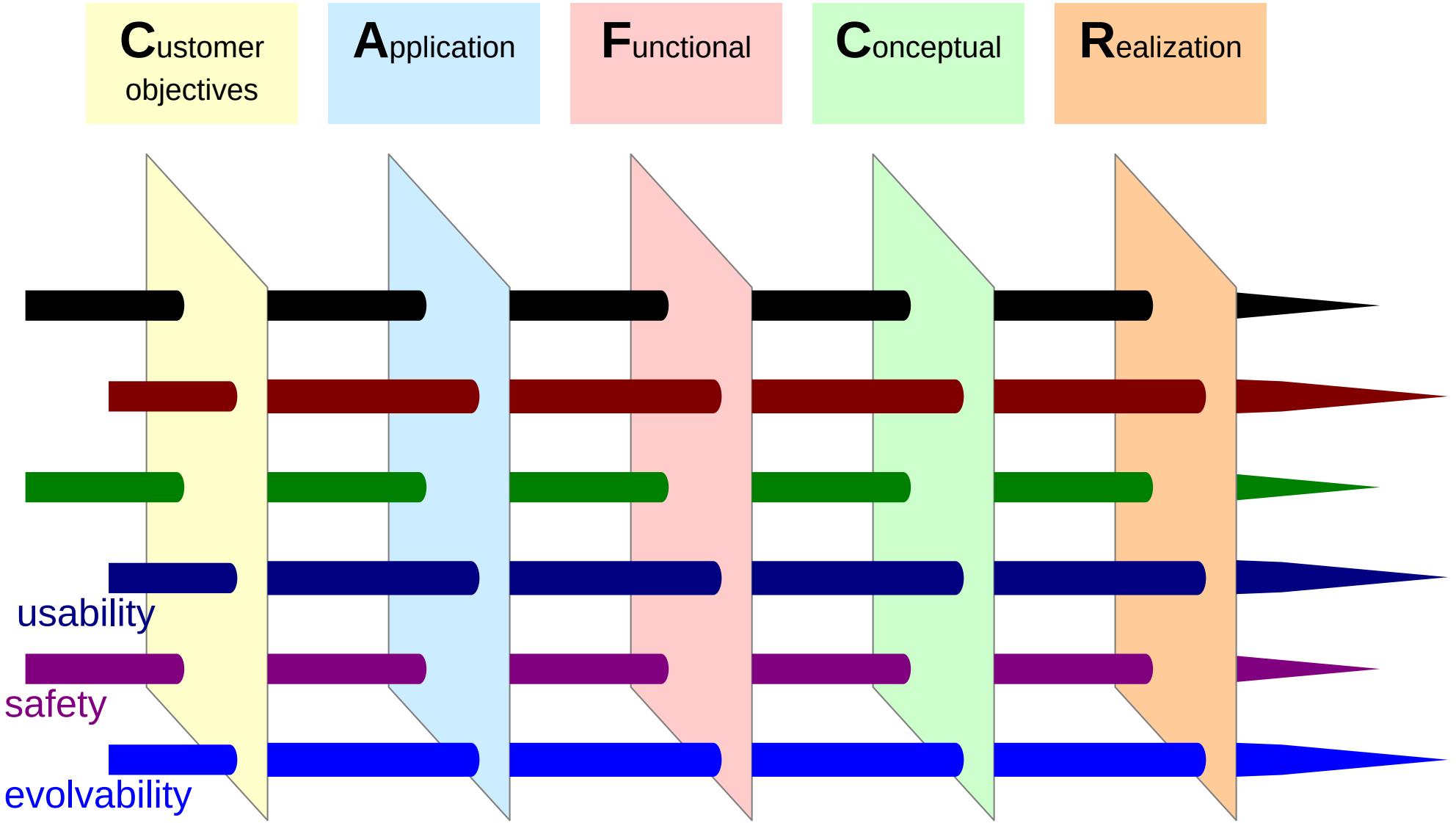
April 3, 2023
status: finished
version: 1.3



Quality needles as generic integrating concepts



Security as example through all views

Customer objectives	**A**pplication	**F**unctional	**C**onceptual	**R**ealization
sensitive information trusted	selection classification people information authentication badges passwords locks / walls guards administrators	functions for administration authentication intrusion detection logging quantification	cryptography firewall security zones authentication registry logging	*specific* algorithms interfaces libraries servers storage protocols
	desired characteristics, specifications & mechanisms			
 not trusted	social contacts open passwords blackmail burglary fraud unworkable procedures	missing functionality wrong quantification	holes between concepts	bugs buffer overflow non encrypted storage poor exception handling
			threats	

Quality Checklist

usable
- usability
- attractiveness
- responsiveness
- image quality
- wearability
- storability
- transportability

dependable
- safety
- security
- reliability
- robustness
- integrity
- availability

effective
- throughput or productivity

interoperable
- connectivity
- 3rd party extendible

liable
- liability
- testability
- traceability
- standards compliance

efficient
- resource utilization
- cost of ownership

consistent
- reproducibility
- predictability

serviceable
- serviceability
- configurability
- installability

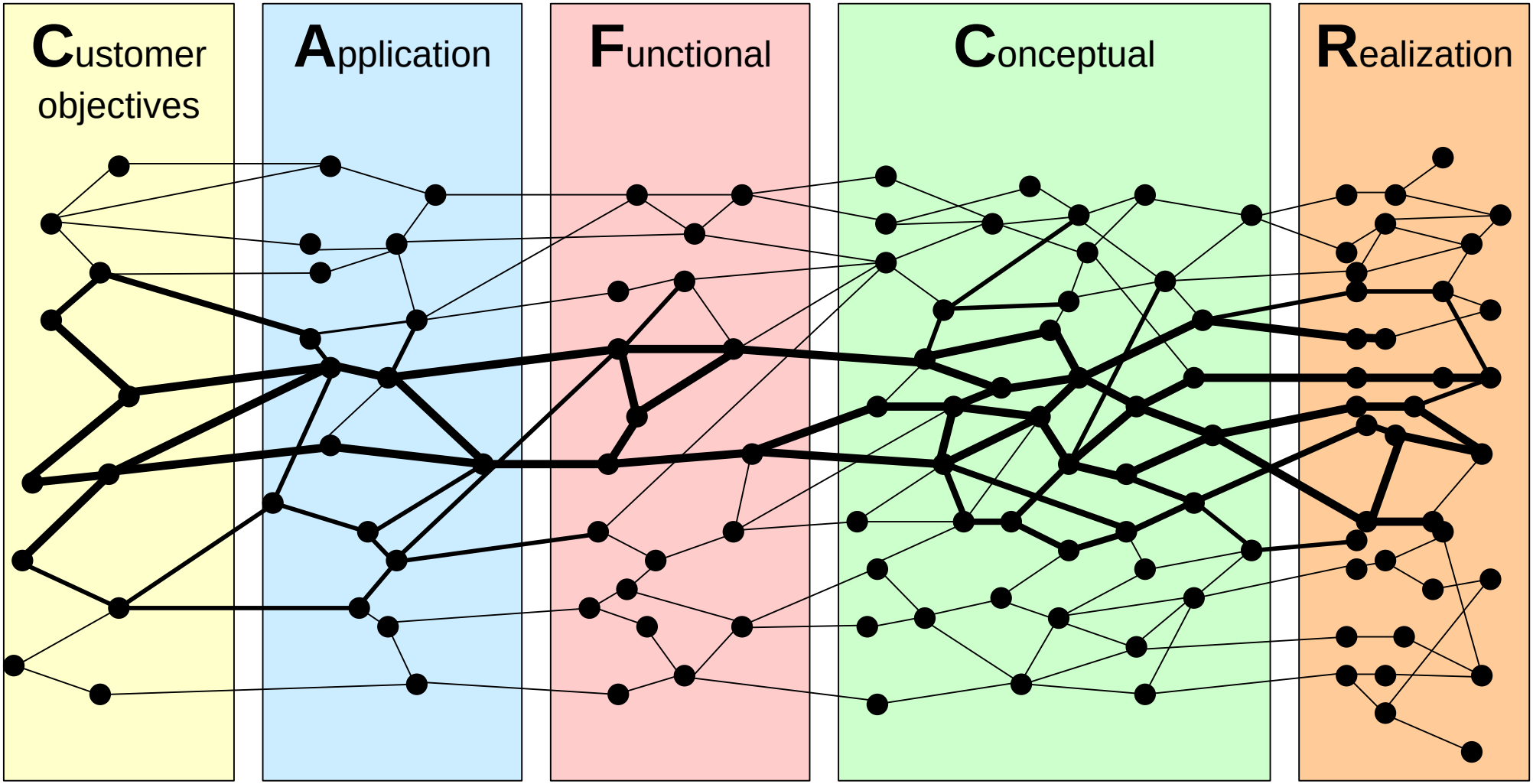
future proof
- evolvability
- portability
- upgradeability
- extendibility
- maintainability

logistics friendly
- manufacturability
- logistics flexibility
- lead time

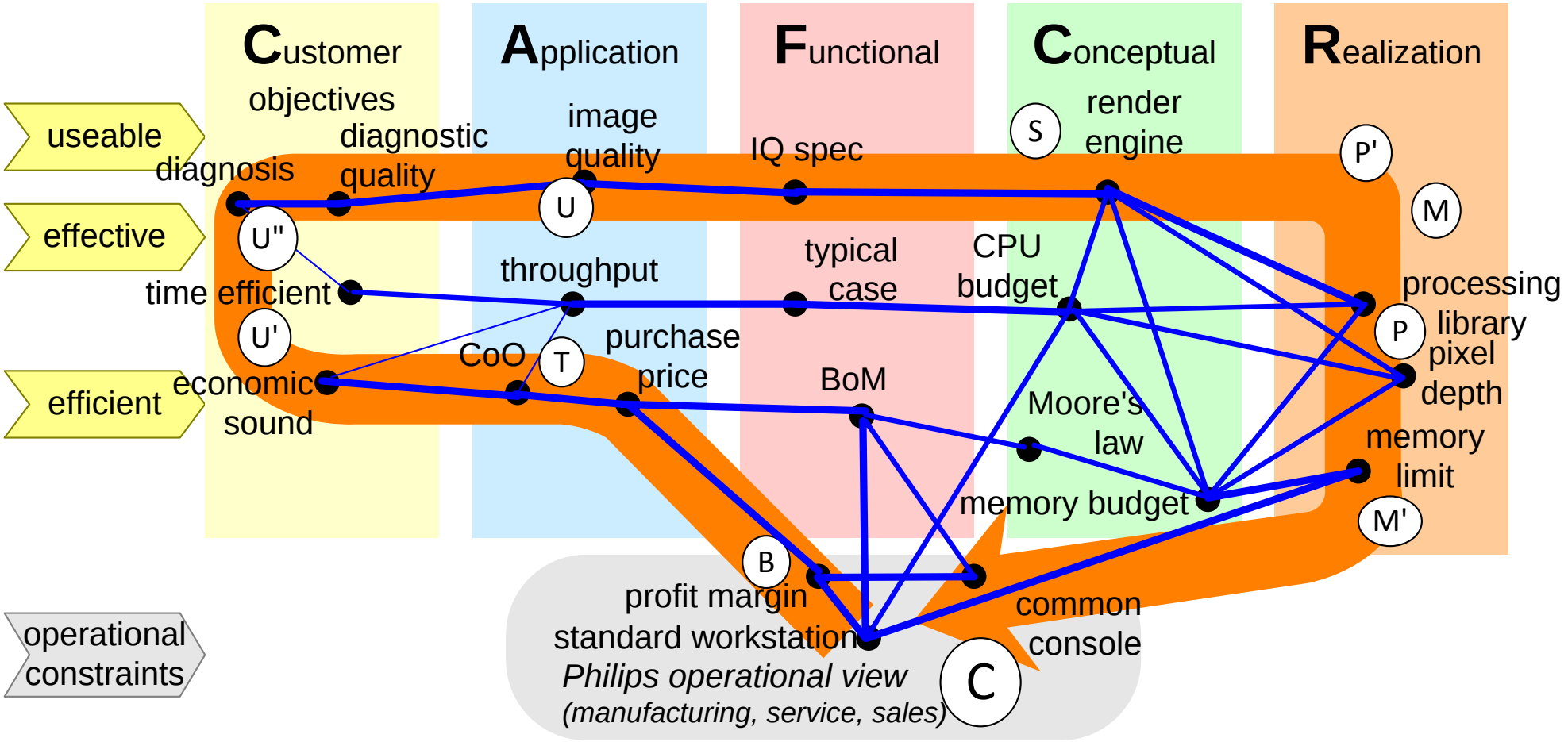
ecological
- ecological footprint
- contamination
- noise
- disposability

down to earth attributes
- cost price
- power consumption
- consumption rate (water, air, chemicals, et cetera)
- size, weight
- accuracy

Thread of Reasoning



Thread of Reasoning Example



cost revisited in context of clinical needs and realization constraints; note: original threads are significantly simplified

Consolidating Architecture Overviews

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

Abstract

This presentation provides guidelines and means to capture architecture overviews. Main challenge is to maintain the overview across multiple views. Architecture Overview A3s One support multi-view. Another challenge is to make an overview accessible for a wide range of stakeholders. The architecture description should therefor be visualized such that it fits the mental model of the audience.

Distribution

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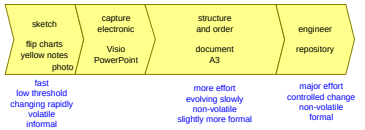
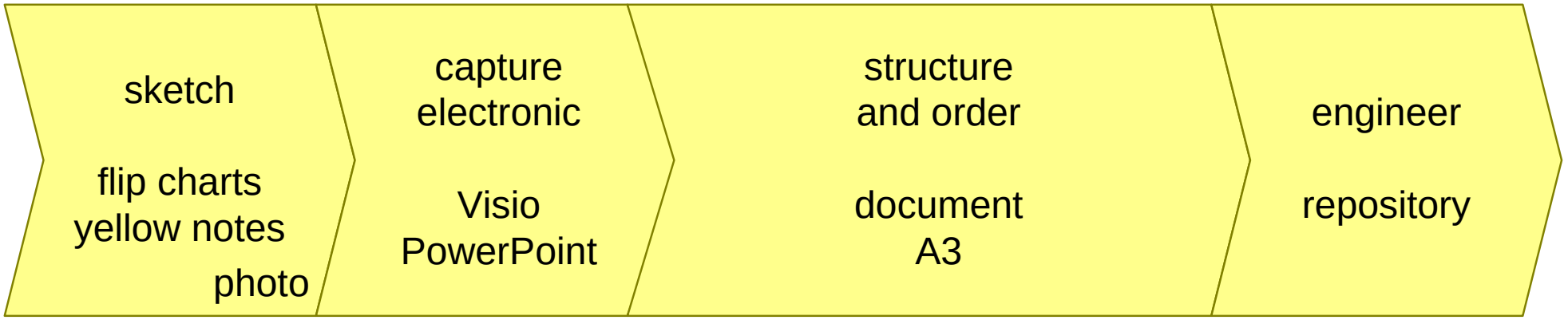
April 3, 2023
status: preliminary draft
version: 0.2



Maturing an Architecture Description

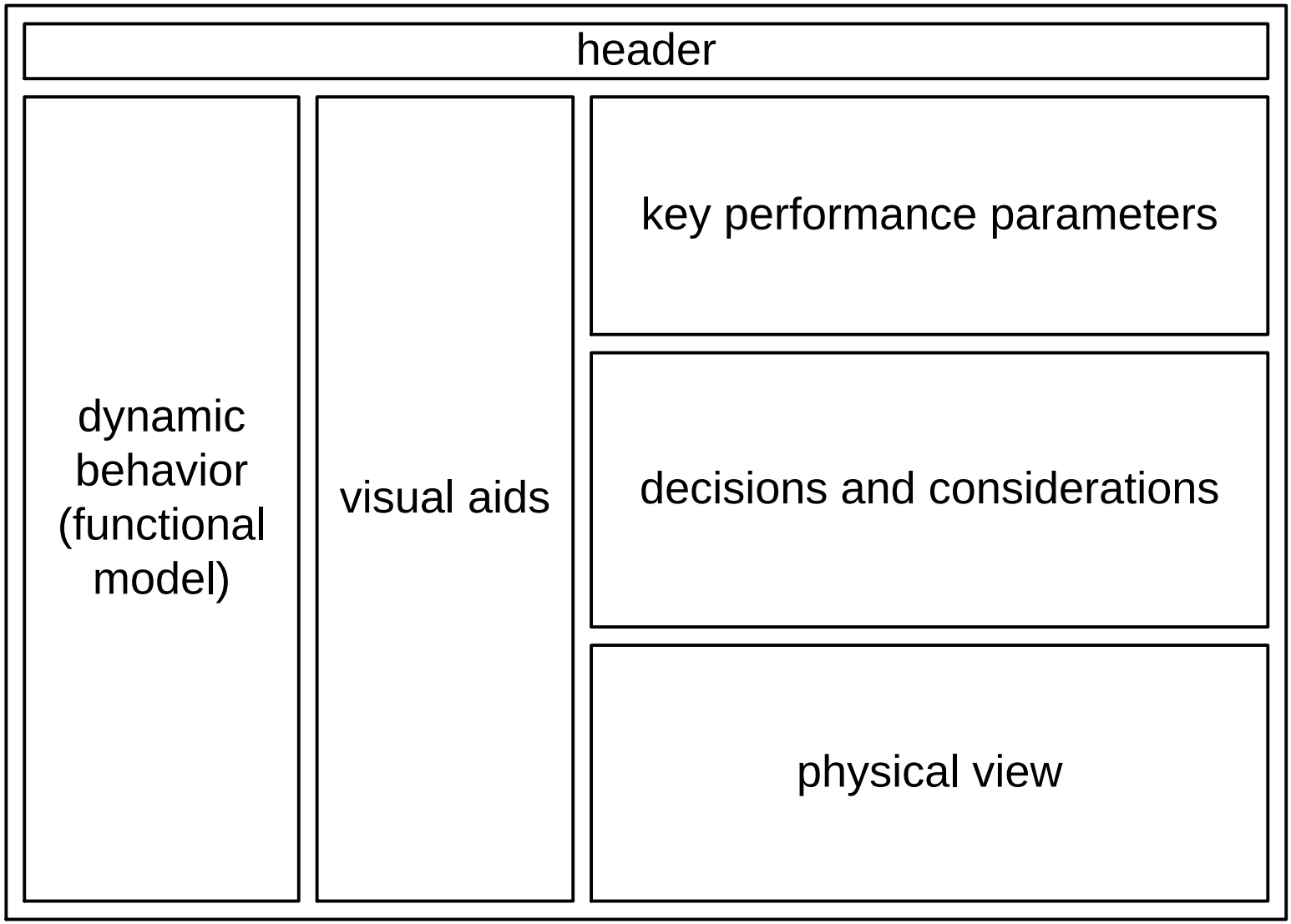


fast
low threshold
changing rapidly
volatile
informal

more effort
evolving slowly
non-volatile
slightly more formal

major effort
controlled change
non-volatile
formal

Architecture Overview A3



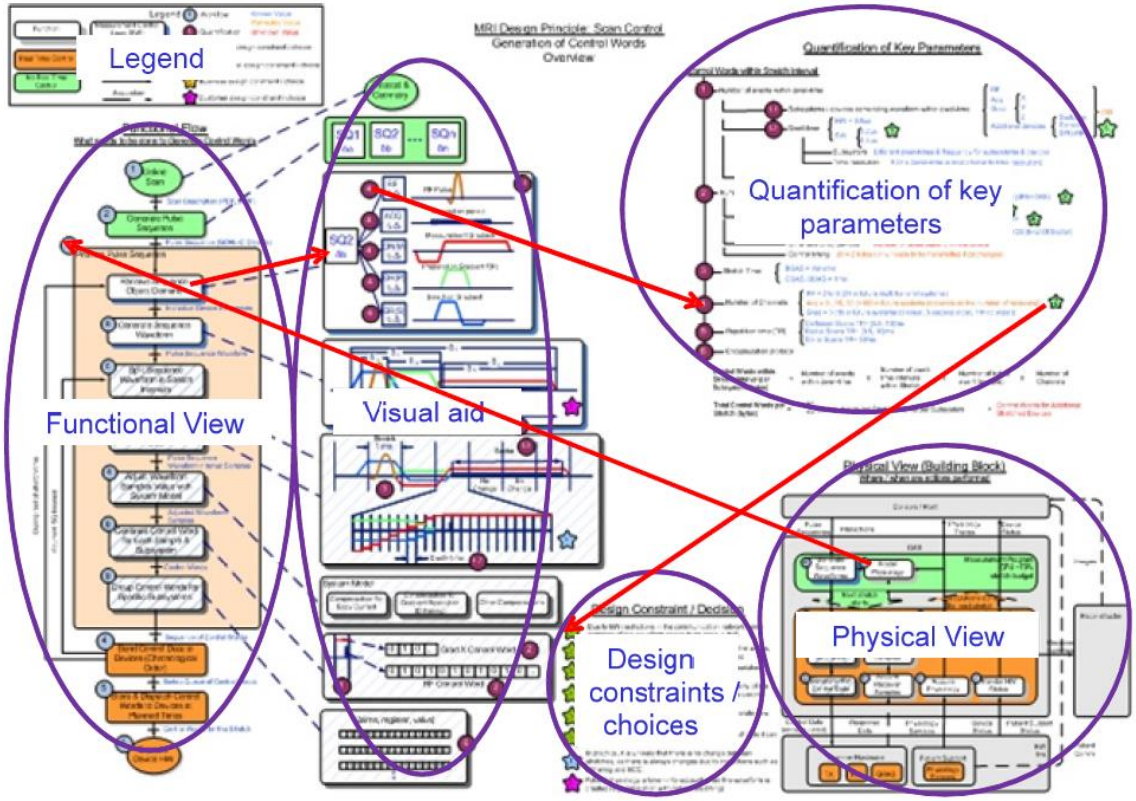
simplified from http://www.gaudisite.nl/BorchesCookbookA3architectureOverview.pdf

A3s to Capture Architecture Overviews

multiple related views

quantifications

one topic
per A3



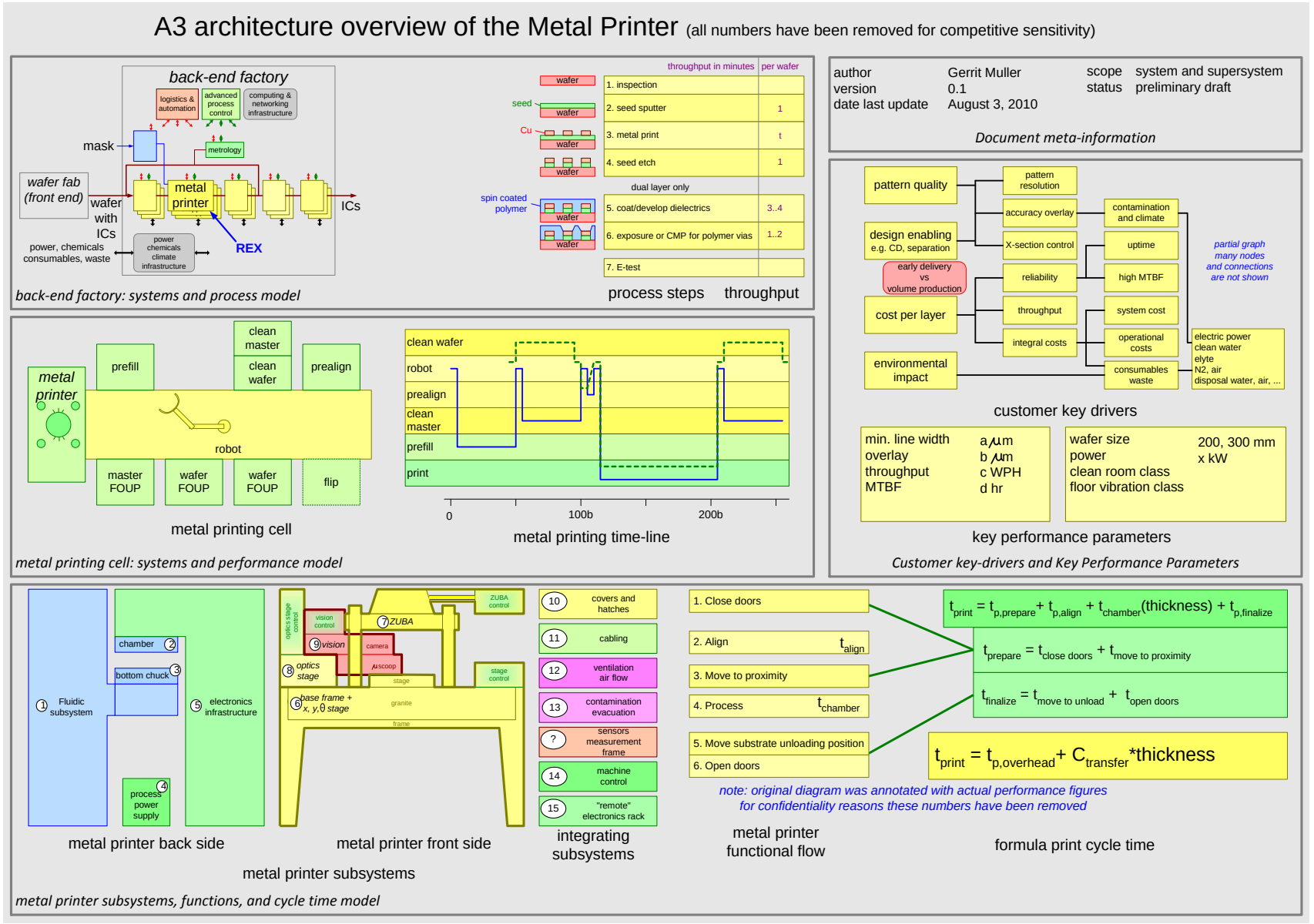
source: PhD thesis Daniel Borches http://doc.utwente.nl/75284/

capture
"hot" topics

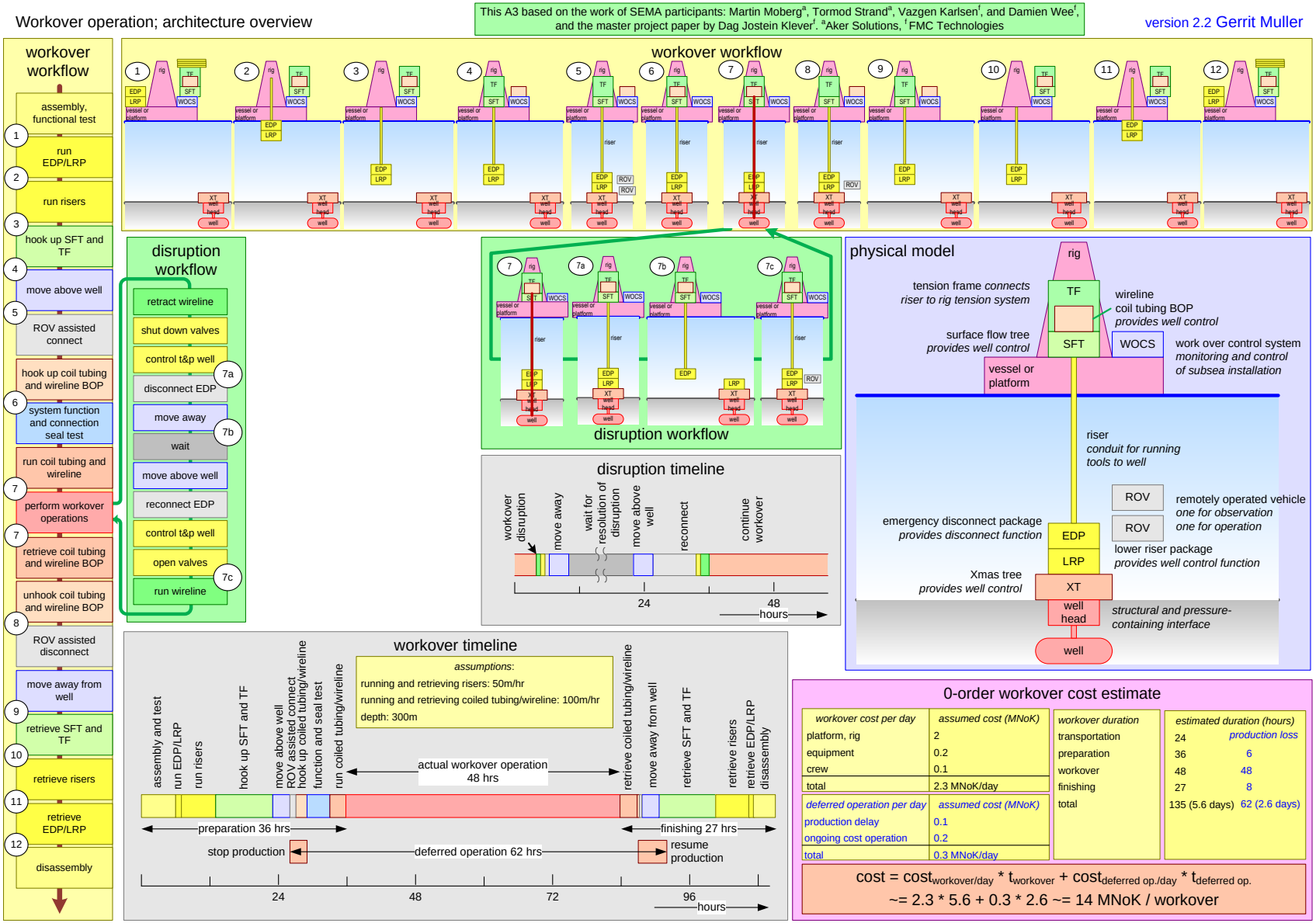
digestable
(size limitation)

practical
close to stakeholder experience

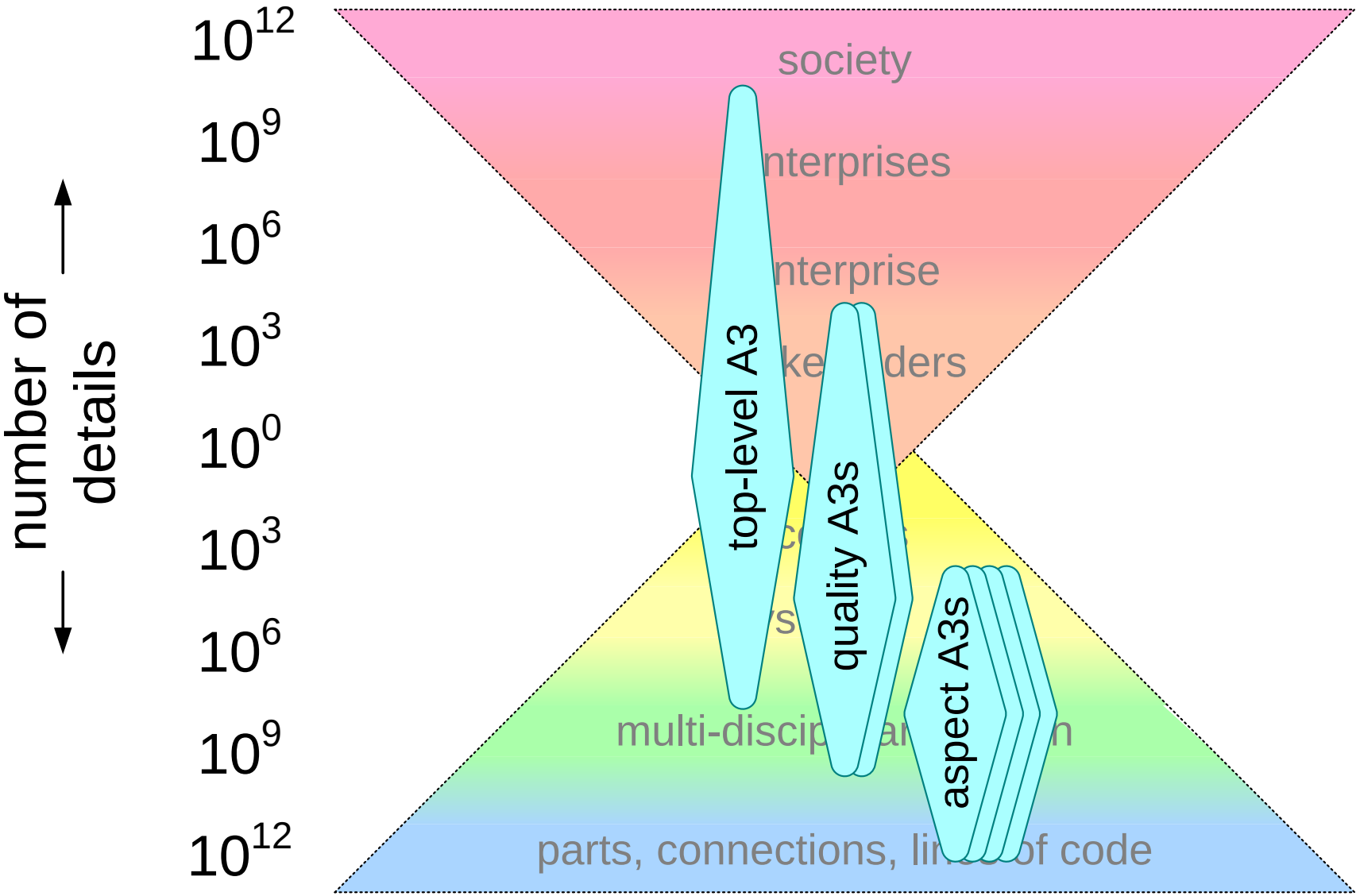
Example of A3 Architecture Overview



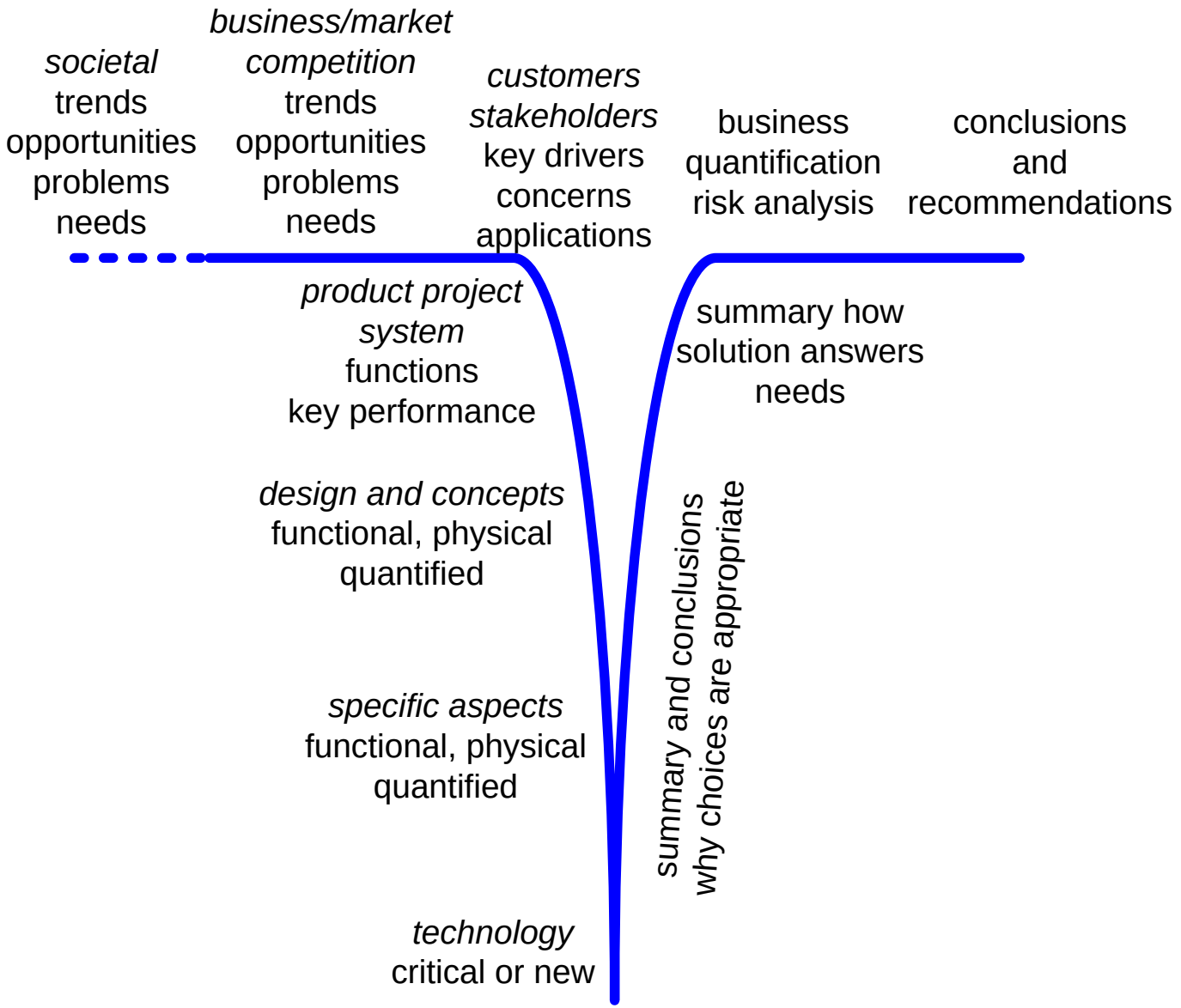
Example of SubSea A3 Architecture Overview



Multiple Levels of A3s



T-shape Presentation



Guidance from ArchitectingForum.org

1.1 One of several prerequisites for architecture creative synthesis is the definition of **5-7 specific key drivers** that are critical for success, along with the rationale behind the selection of these items

2.1. The essence of a system can be captured in about **10 models/views**

2.2. A **diversity** of architecture descriptions and models is needed: languages, schemata and the degree of formalism.

2.3. The level of **formality** increases as we move closer to the implementation level.

from http://www.architectingforum.org/bestpractices.shtml

Exercise Wrap-Up

Capture your work done during the course, e.g. **make photos** of the flip charts.

Make a list of **questions**, **assumptions**, biggest **uncertainties** and **unknowns**

Make a list of **lessons learned**

Make a plan for the **homework**