

Design Margins

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The Problem



- Design optimisation aim to meet but not exceed multiple requirement to make product cheaper or lighter
- Margins are “surpluses” above the parameter requirements
- Margins provide a room for manoeuver
- If a margin is used up, change will propagate across other parts
- Understanding and planning margins is critical for companies
- Margins have many names: room for growths, tolerance, buffer
- We need to capture and model margins systematically to manage design processes effectively

Overview

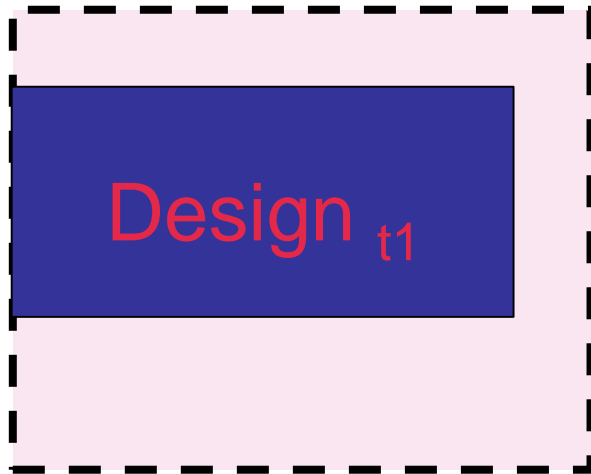


- Starting point
 - Product planning
 - Engineering change
 - Freeze
- Types of Margins
- Model of Margins
- Outlook
- Conclusions

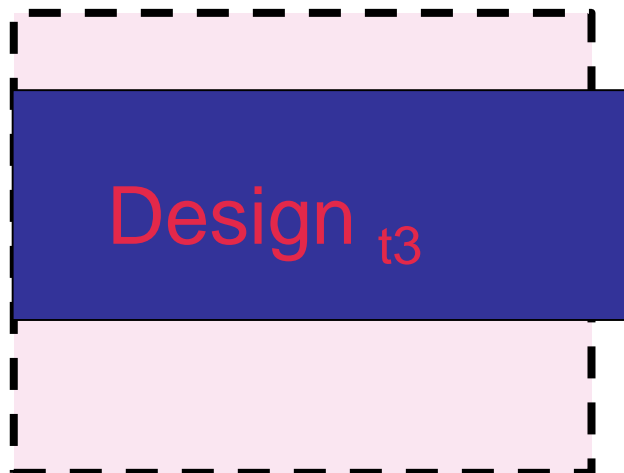
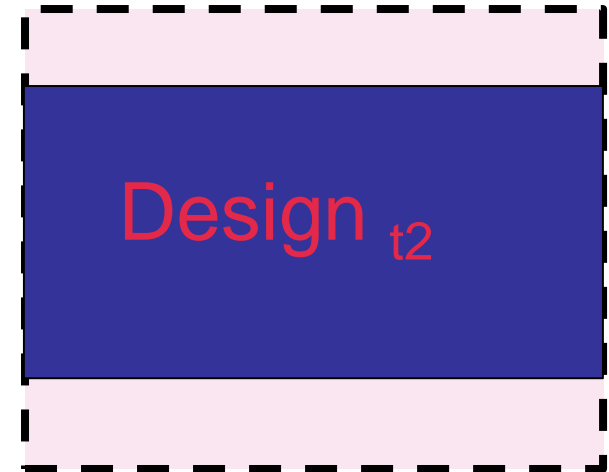
Background



Erosion of margins in design



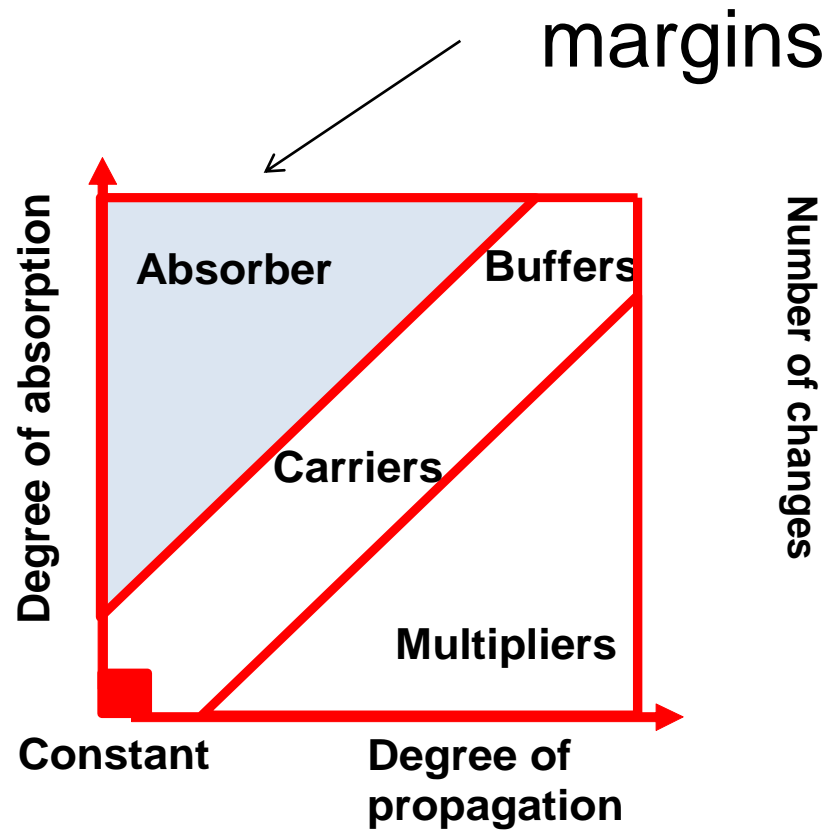
Margin get
smaller over
Time



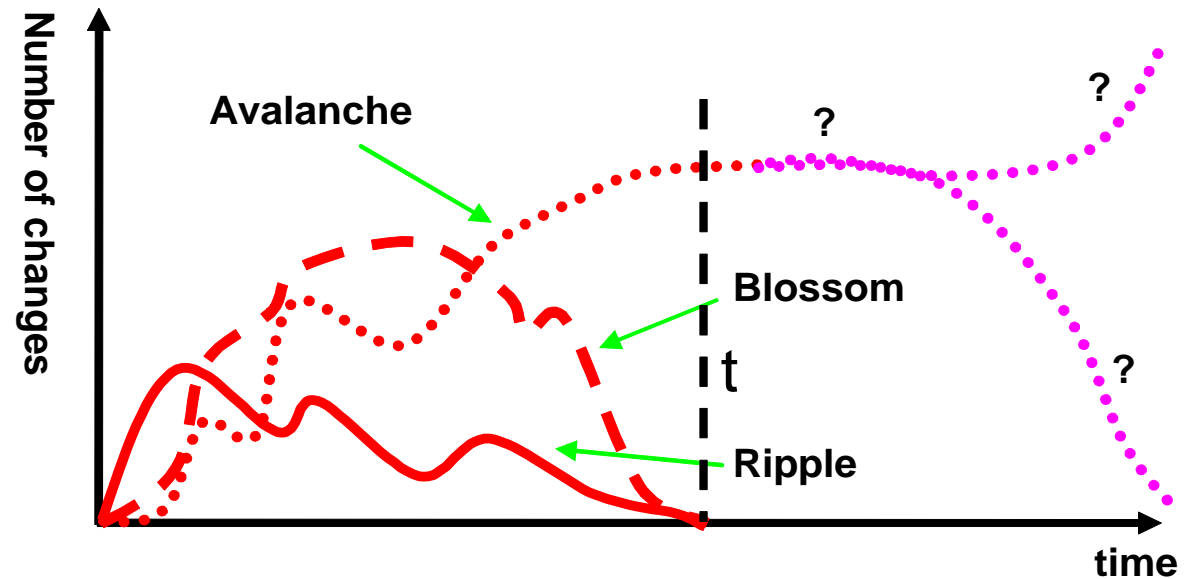
Last change
pushed design
over the edge



Change Propagation

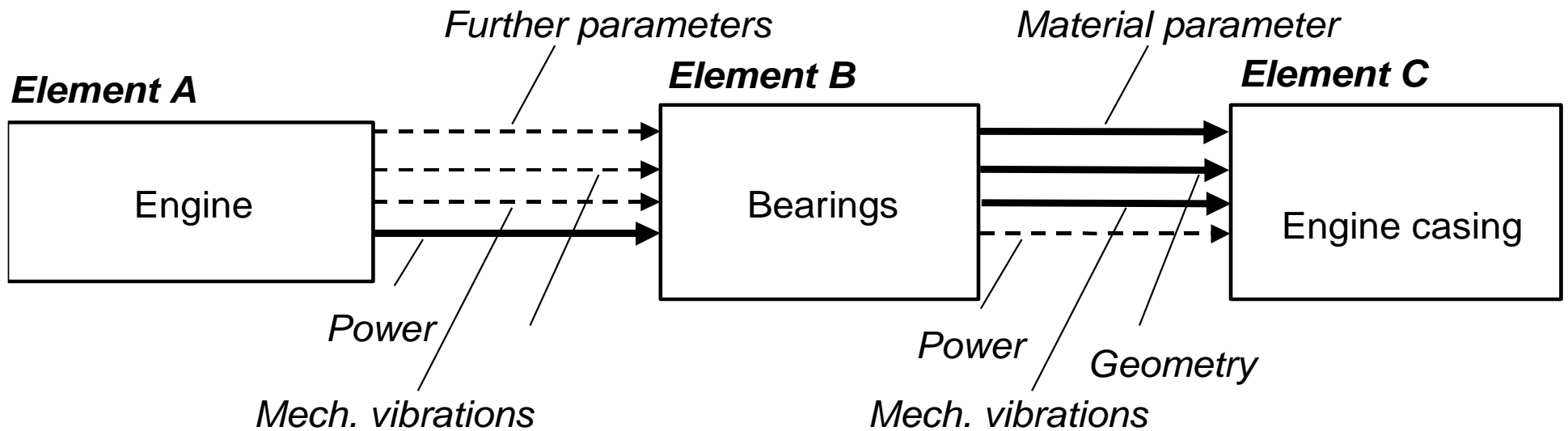




Classification of component behaviour



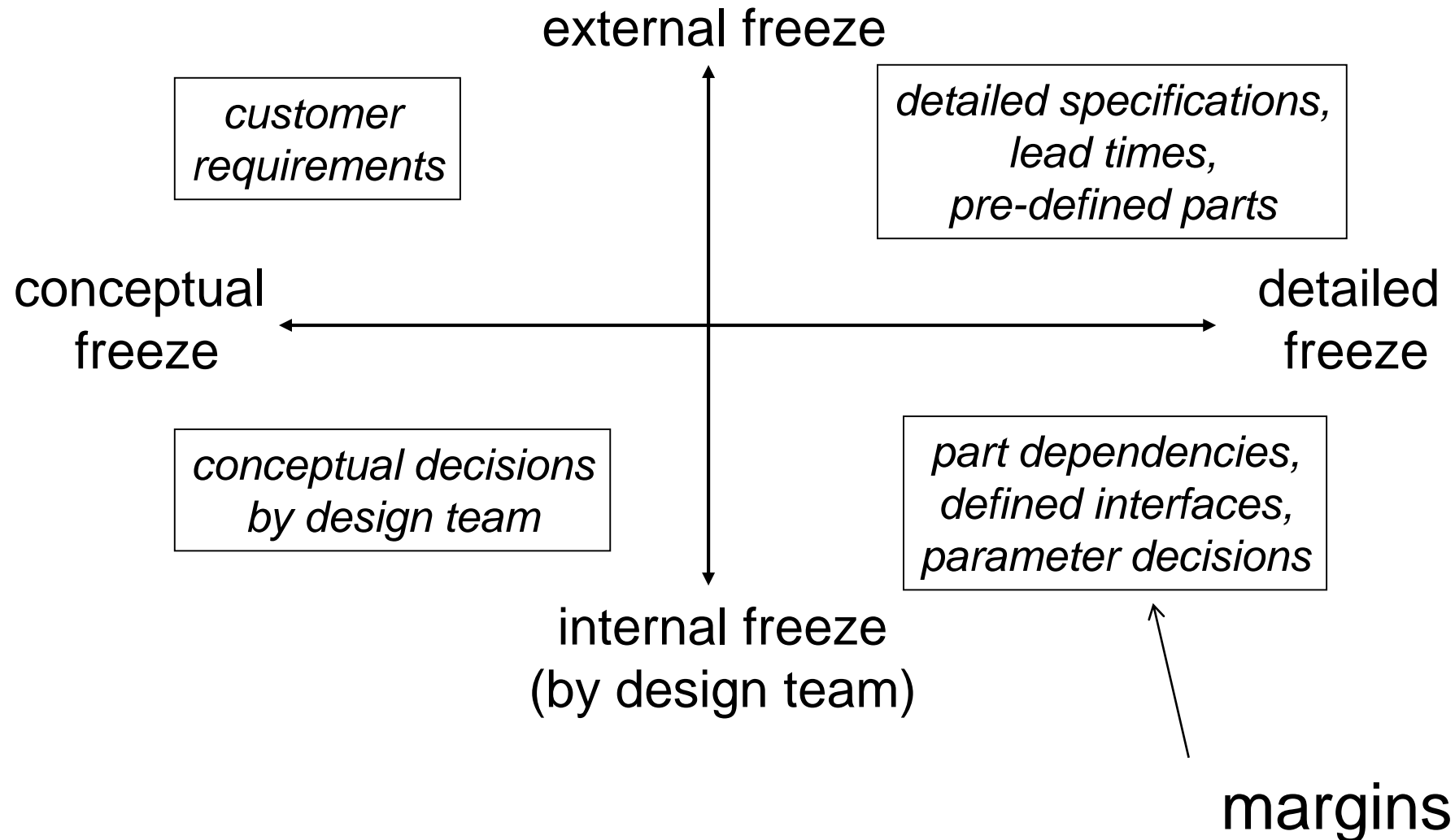
Classification of process behaviour

Component Connectivity



Legend:  *Change relevant parameter*
 *Change irrelevant parameter*

Component Freeze



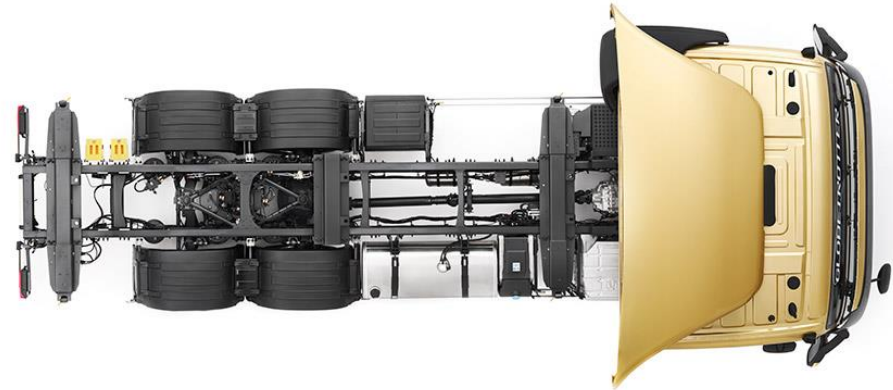
Empirical Study



The Interviews



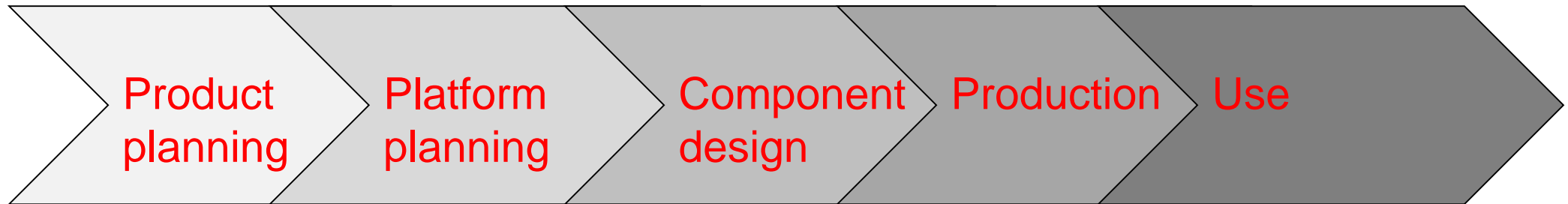
- Eight interviews in October 2013
 - Platform
 - Brand
 - Design engineers
 - Analysis engineers
 - Feature experts
 - Simulation engineers.
- Chassis team in Volvo trucks
- Analytical focus on margins and concepts of margins
 - Summary of interviews
 - Identification of key quotes
 - Abstraction and falsification of theoretical concepts



Margins in design process



Margins are discussed in different ways



Room for growth

Platform Steps Change
Safety margins propagation
Overdesign Clearances
Communality Designed in
vs optimisation flexibility

Robust design
Tolerances
Overdesign
(cost)

Failures in use
Overdesign
(robustness)

Overdesign



- In product planning for core components
 - Future generations
 - Different brands
- New applications in the future
- Avoiding unnecessary changes during design process
- Different use conditions
- Customer misuse

Safety margins and requirements



- Safety margins are planned into the product requirements,
- Safety margins are add explicitly to the component
- Depend on the use case including extreme scenarios
- Safety margins are hidden

Tolerances



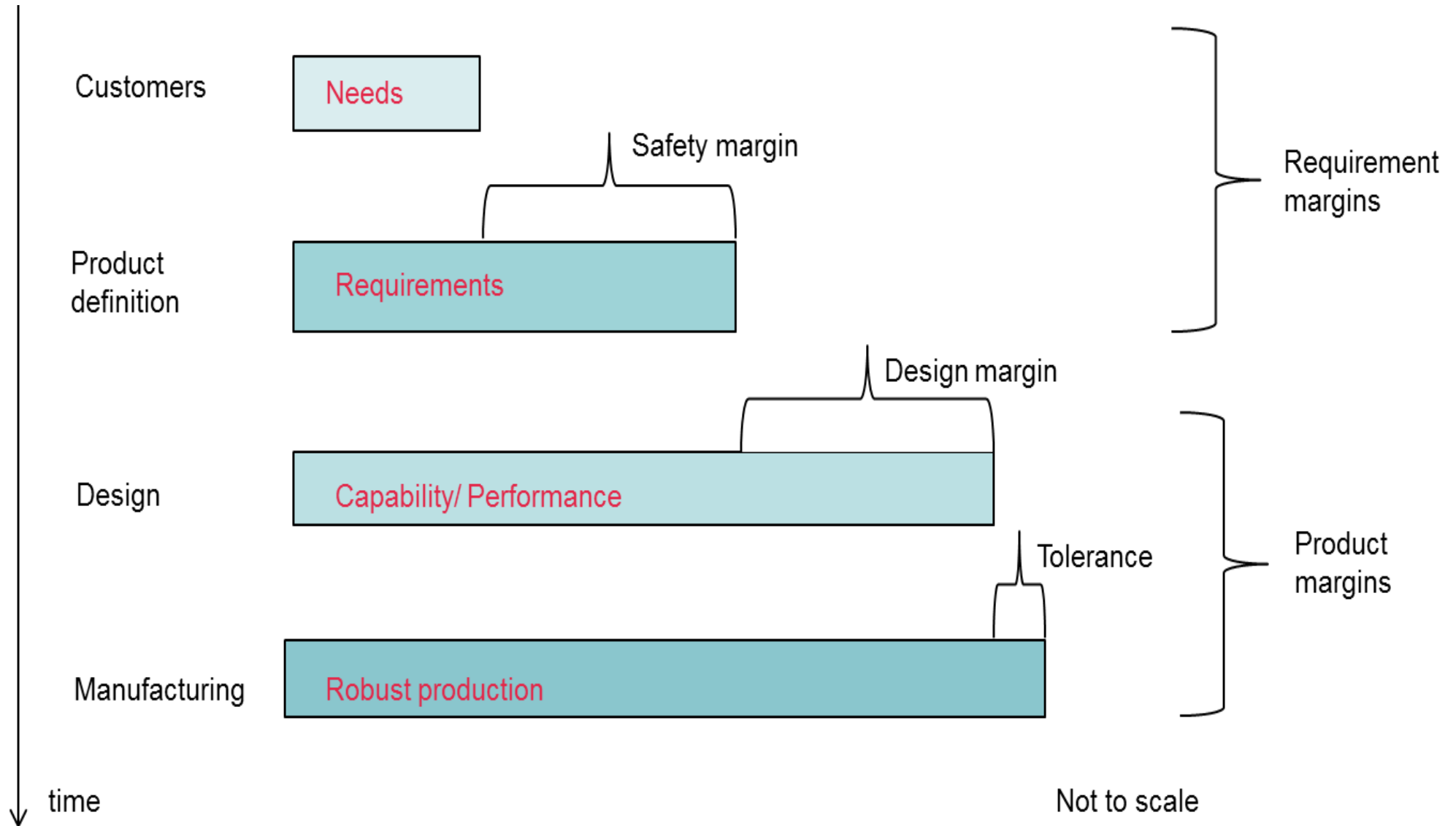
- Exist for manufacturing and assembly
- Can test all the combination
- Careful tolerances for engine and gear shift, but for other components

Clearances

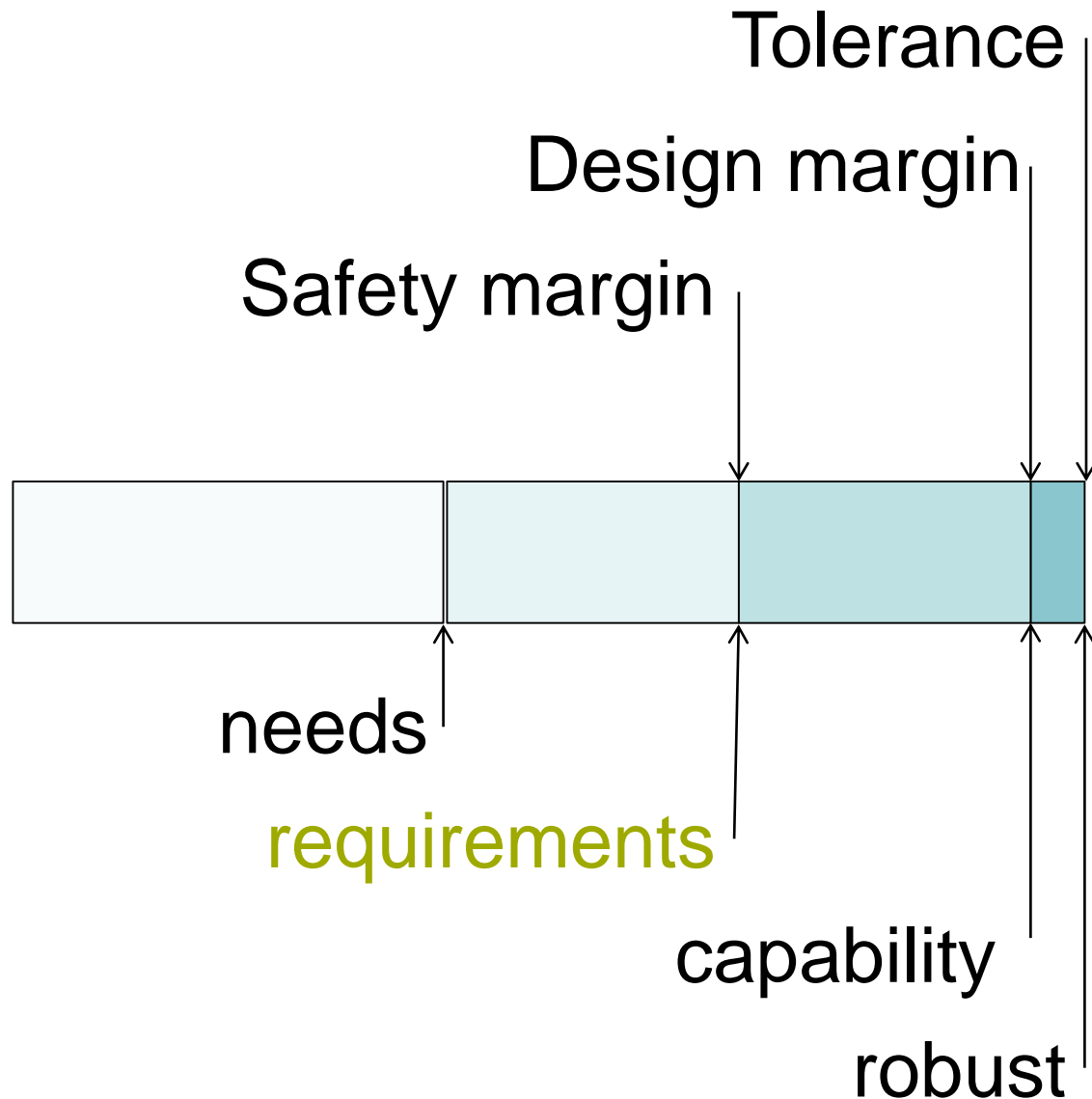


- Clearances are very important in
 - Engineering change
 - Integration of features
 - Optimising a product
- Thinking about clearances
 - Margins (of what?)
 - Requirements (of what?)
 - Constraints (on what ?)
- Competition between teams

Different Concepts of Margins



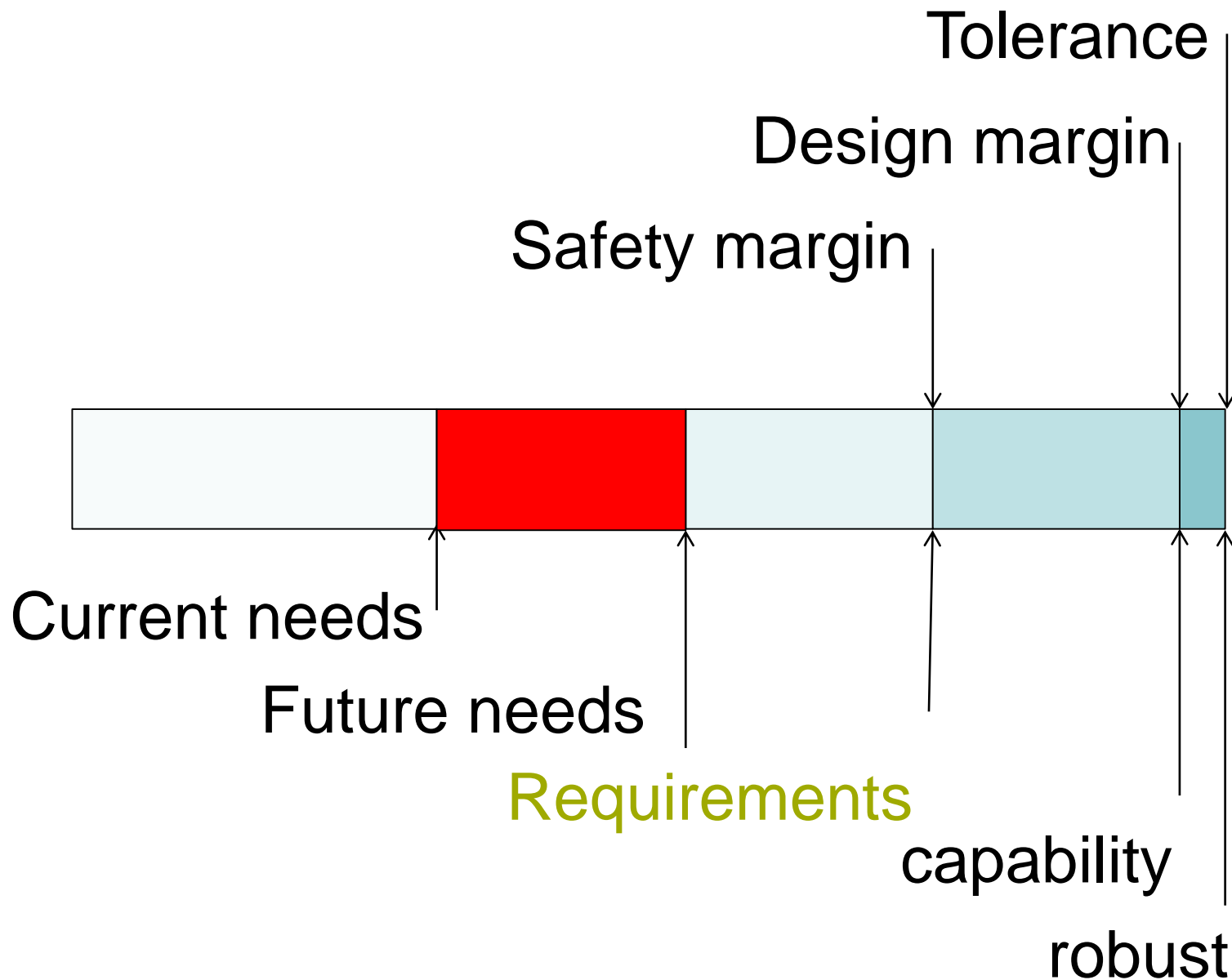
Margins and requirements



Perspectives

- New generation Margins cater for uncertainty
- Engineering change Margins allow change

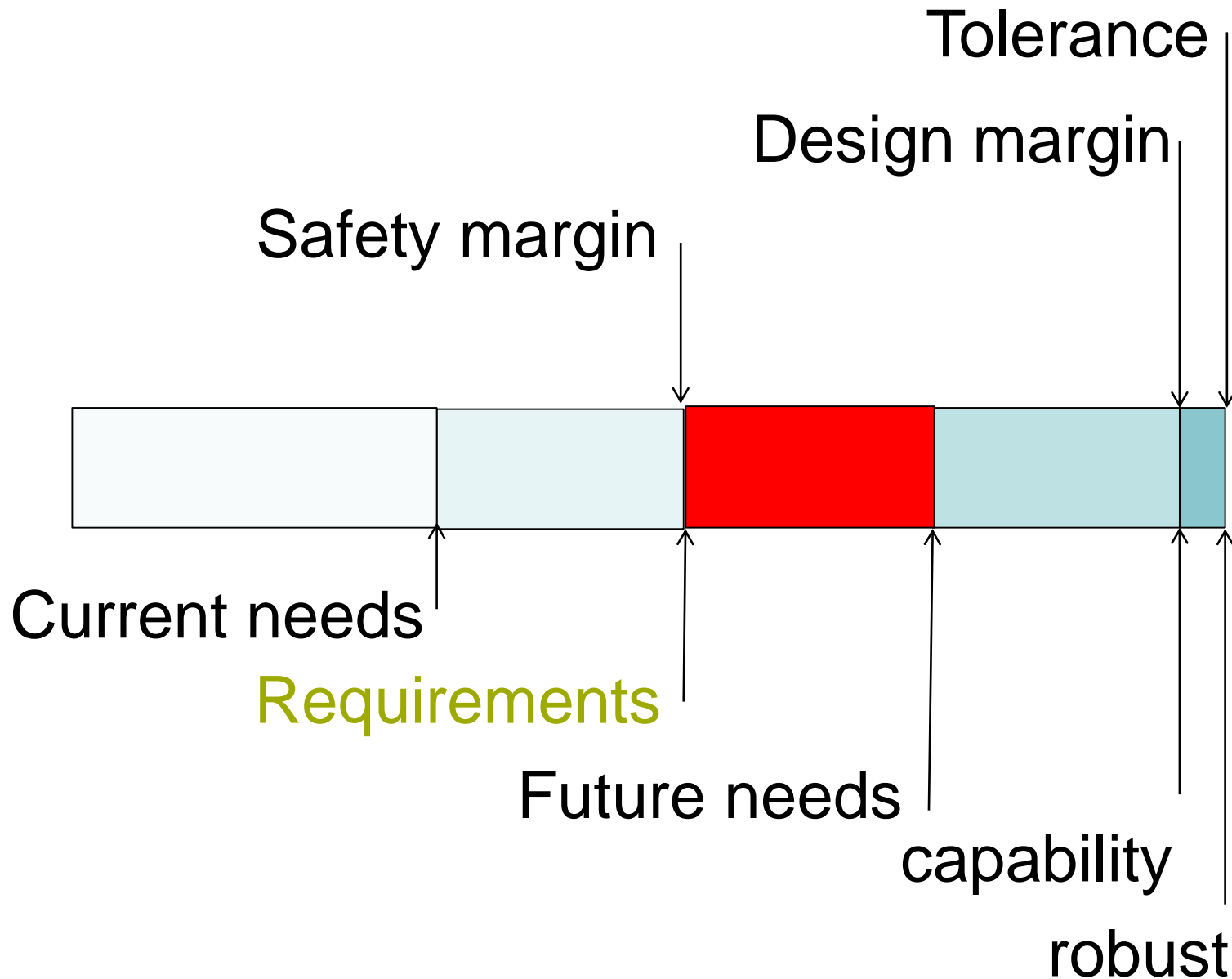
Overdesign: Room for growth



Perspectives

- Product planning
- Design might not be aware of these margins

Overdesign: avoiding change



Perspectives

- Product development

Designed in flexibility



- Products can create margins through being tunable, i.e. drill holes specifically rather than predrilling them.

So if I give you another example, we have... a shock absorber here installed on a bracket, it is on the frame rail, something like this... That bracket is positioned attached with only one hole... in that position you will see it sitting like this, and then sitting like that in another position. That height I think... have a valuation of... well I calculate lowers that... 32 different positions.

In height and in length wise as well. One bracket.

- Margins in systems by adapting those components that “can do up”
- Creation of system margins by replacing components

There could be margins in the feature that you were certain, rubber stiffness, the vibrations get too much and then you can create some margin by introducing a softer rubber and you can do for all or for a few or part.

- Margins are traded off against each other

Margins as mitigation across different perspectives



Margins

Brand identity ↔ Communalinity

Features ↔ Features

Product optimisation ↔ Platform optimisation

Product cost ↔ Process cost

Product cost ↔ Use contexts

Knowing margins



- Designers don't know about the margins built into the requirements
- Margins on features usually not known
- Designers have a sense of margins of their own components against their requirements
- This understanding is quite localised
- Margins are not explicitly communicated

Margins testing



- Physical testing to see the product meets the requirements
- Simulation is life testing, i.e. until it breaks

It's a bit different here. When we analyse we calculate what will the life be, so we analyse really until the end, until it breaks. Of course it doesn't matter for us, it takes just as long time

- Simulation finds margins
- Feedback only on whether the targets are met or not
- They could track changes in margins through project, but don't do so

Margins testing



- No warning for small margins of safety in the moment

sometimes they know that and sometimes it's sort of an unknown because we pass the test but we don't know by how much we passed it. That's a problem I think that it's not always testing to failure. I always say that a successful component test always ends in complete failure. (FO)

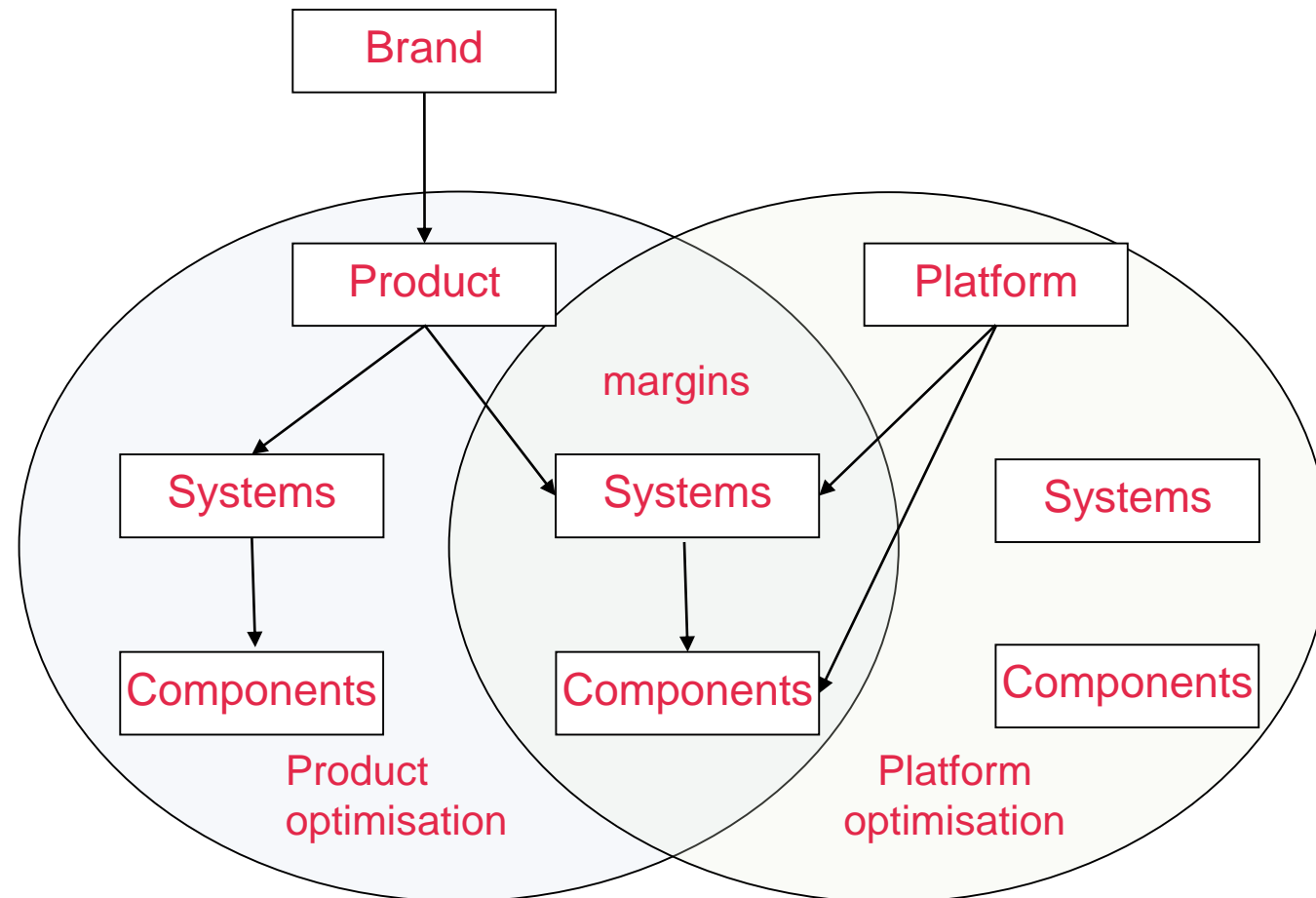
- Margins could be identified in a few hours on request
- Supplier also only test to requirement and not to failure so margins are not known

I'm fed up with this, yeah we fulfil the requirement, we don't have a problem and then...but then you don't know where the borderline is ...But test to fail then ... know you really don't if you have one percent margin or if you have 150% margin.(SS)

Optimisation and margin



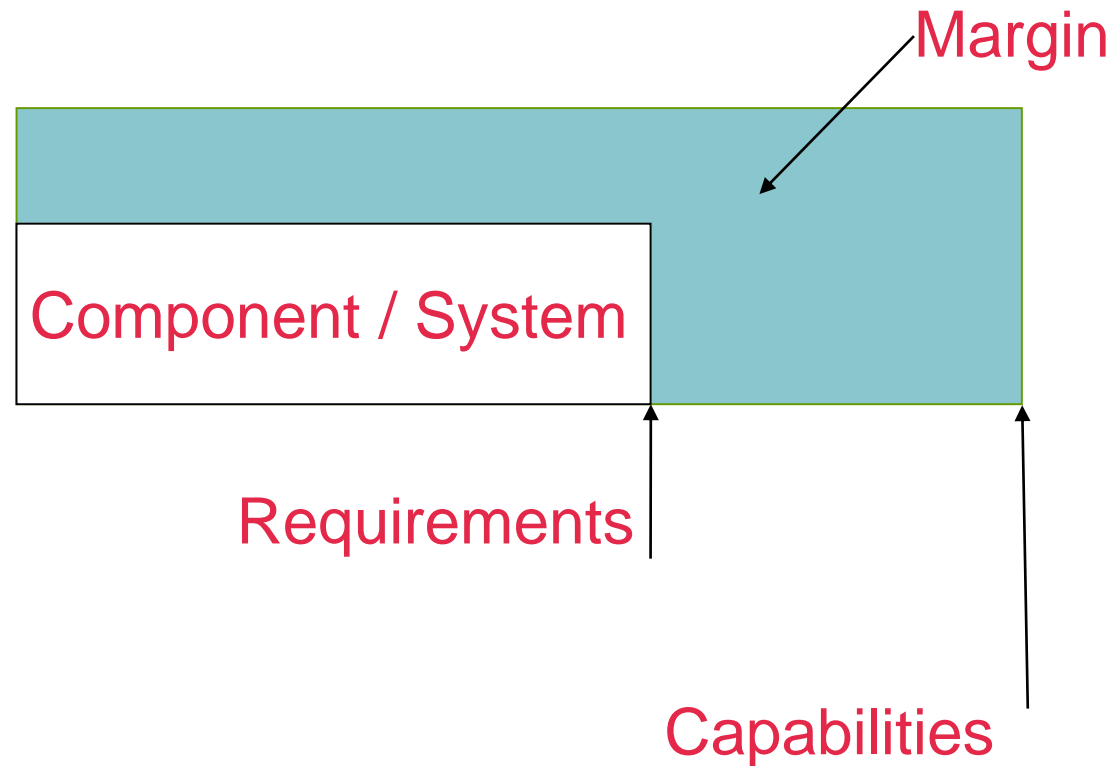
- Trade-off between optimal solution and communality across the platform



Definition of Margin



With requirements

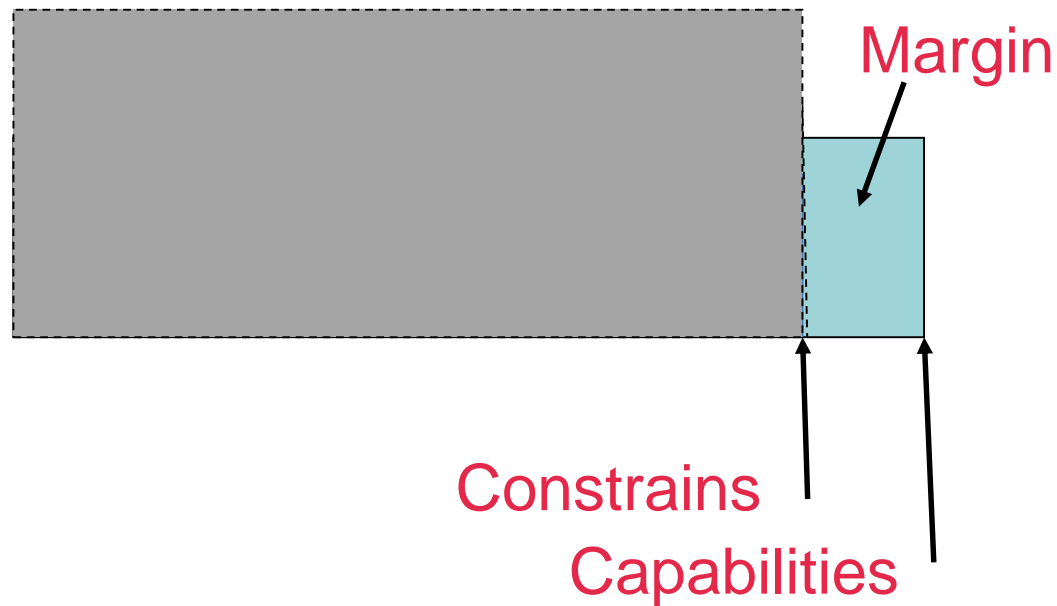


$$M (P) = \text{Cap}(P) - R (P).$$

Definition of Margin



With constraints

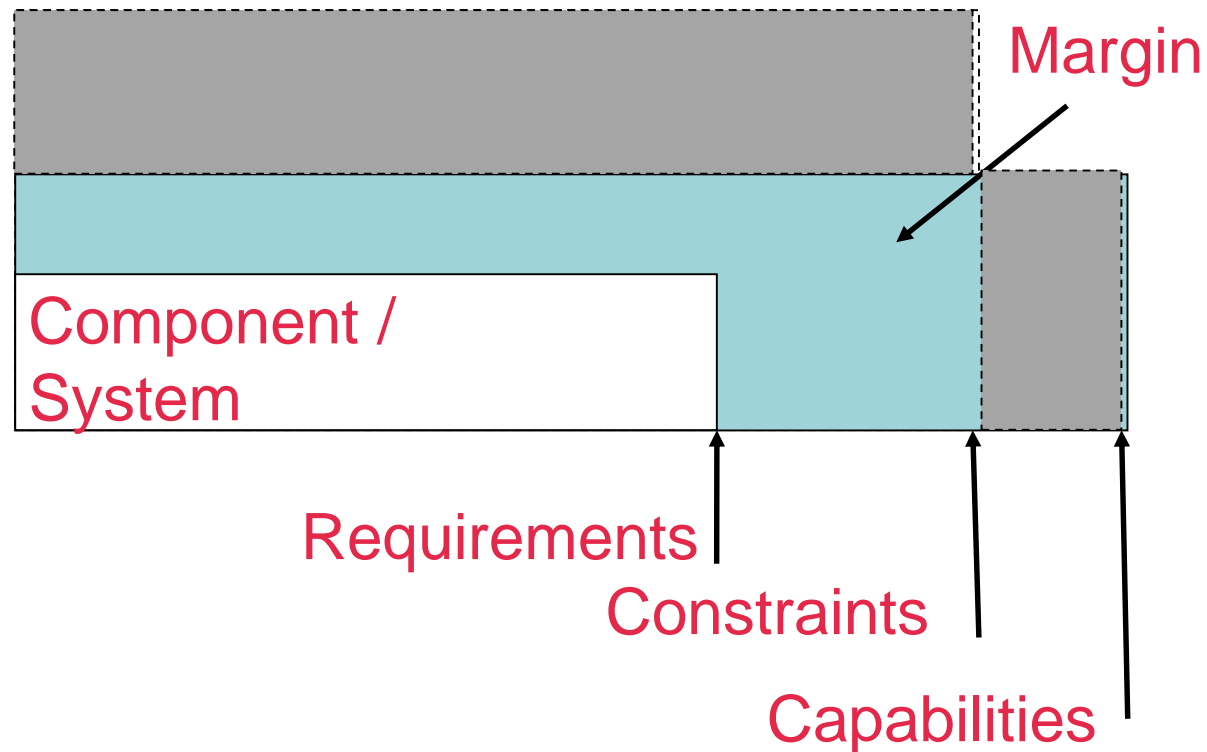


$$M(P) = \text{Cap}(P) - \text{Const}(P)$$

Definition of Margin



With requirements and constraints

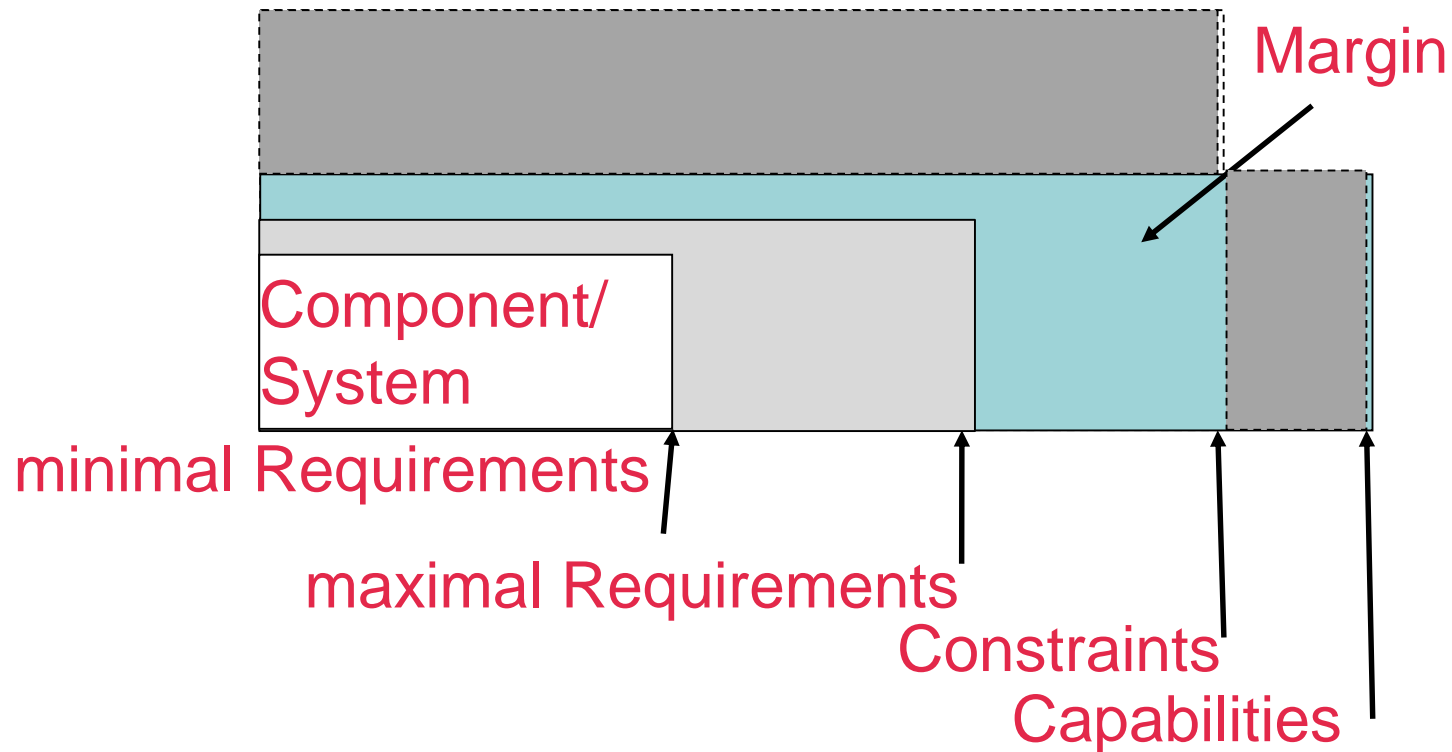


$$M (P) = \text{Cap}(P) - R (P).$$

Definition of Margin

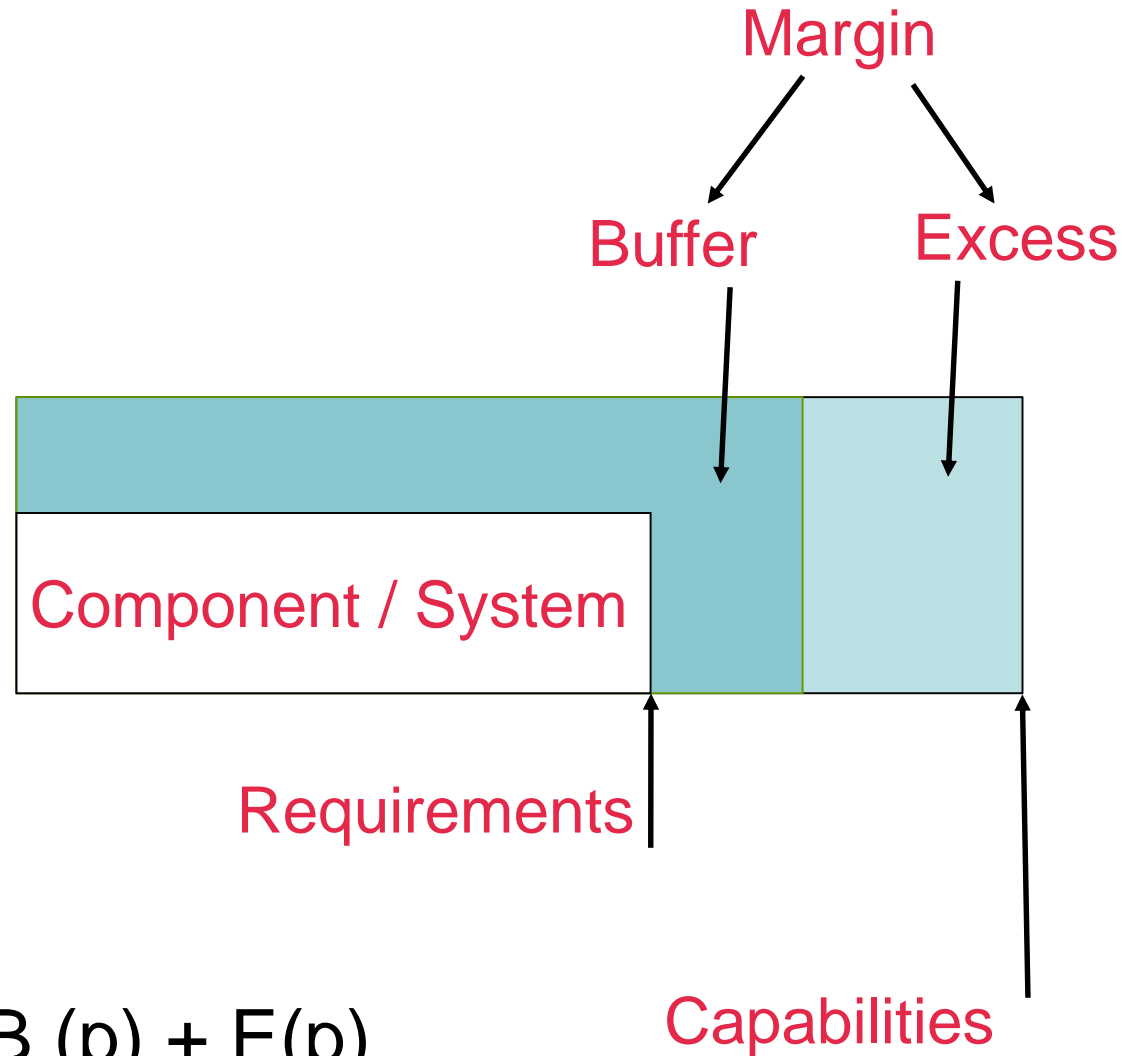


With ranges of requirements



Margins can vary for the same component

Margins and Uncertainties



$$M (P) = B (p) + E(p)$$

Margins and Uncertainty

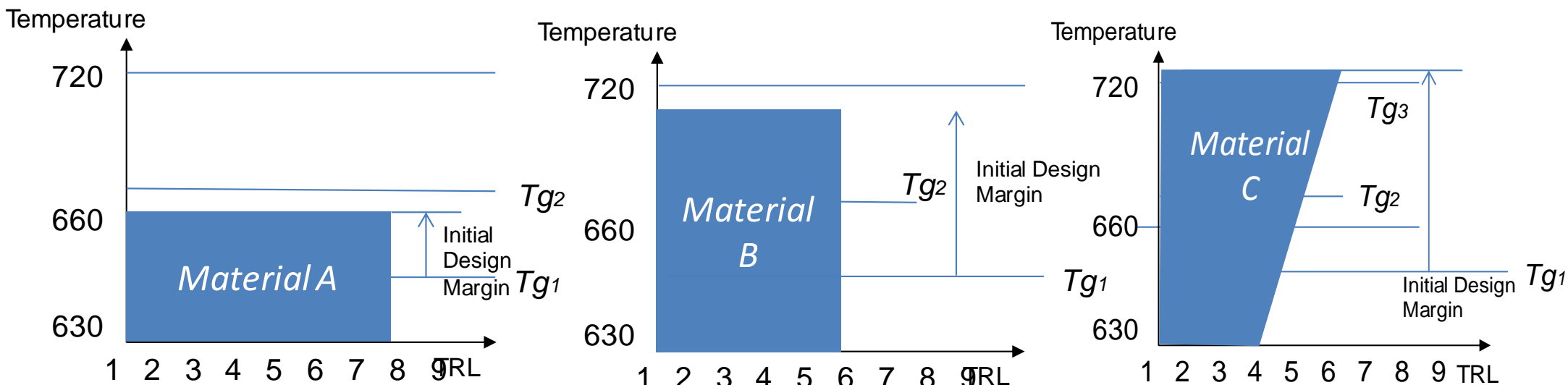


- Buffers
 - Safety margins
 - Tolerances
- Excess
 - Overdesign
 - Room for growth
- Excess provides designers with space to manoeuvre
- Designers must reduce uncertainty to increase excess
 - Better requirement analysis
 - Better testing
 - Platform architecture

Sharing margins



- Customers are unclear about requirements
- Suppliers are unsure about what they can offer, in terms of margins on existing solutions
- Companies are reluctant to disclose uncertain information
- Explicit modelling and communication of margins can reduce iteration



Change Management



- When making changes designers look for where they can make changes and try to minimise changes
- Margins allow them to make changes that do not propagate or don't become multiplier
- No explicit support for modelling margins
 - Flagging up critical components
 - Prediction change propagation better

Further work



- Case study of change processes in Volvo cooling system to analyse how exactly margins affect change behaviour
- Modelling margins
 - Margin index for components
 - Aggregation of margins
 - Margins in relationship
- Change predication with accurate margins

Product Planning



- Products evolve over generations
- Controlled innovation through technology infusion at particular points
- Unplanned changes increase cost and risk
- Design for flexibility
- Most companies need to consider a product platform

Conclusions



- Understanding margins allows change prediction
- Companies should communicate margins