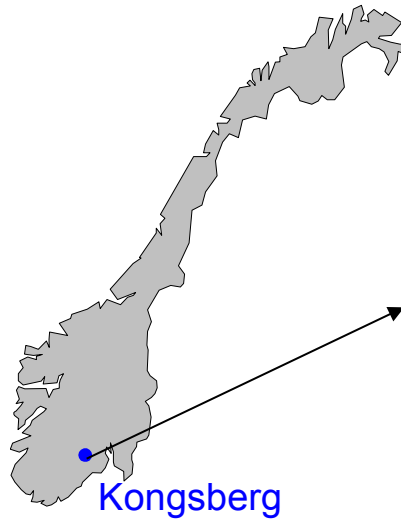# Set-based design –
the lean tool that eludes us;
Pitfalls in implementing set-based design
in Kongsberg Automotive

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Kongsberg Automotive (KA); a Global Company

Kongsberg

Revenues: close to **1.0 billion Euro** approximately **11,000 employees** in **20 countries** (2011)

KONGSBERG
AUTOMOTIVE

Interior Systems	Driveline Systems	Actuation & Chassis	Fluid Transfer Systems	Power Products Systems

From: http://www.kongsbergautomotive.com

Overview - Subjects discussed in this presentation

- Point-based design V.S. Set-based design

- Why set-based design?

- Some results from master project (interviews, employee feedback, multiple-choice, observations, literature research)

  – Examples of employees' understanding of the drawbacks of set-based design

  – What people think could be motivational factors for working set-based

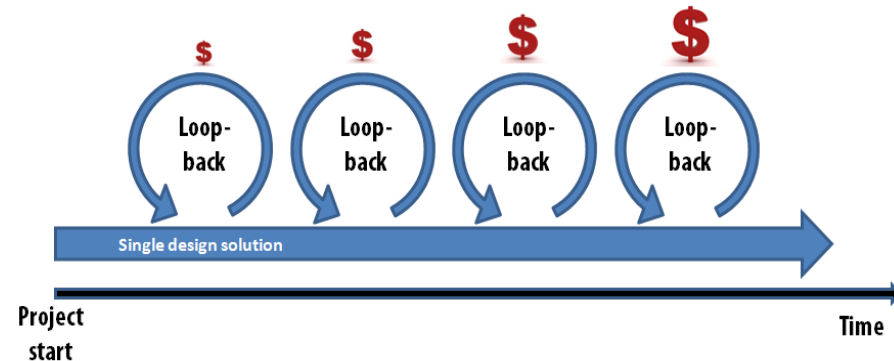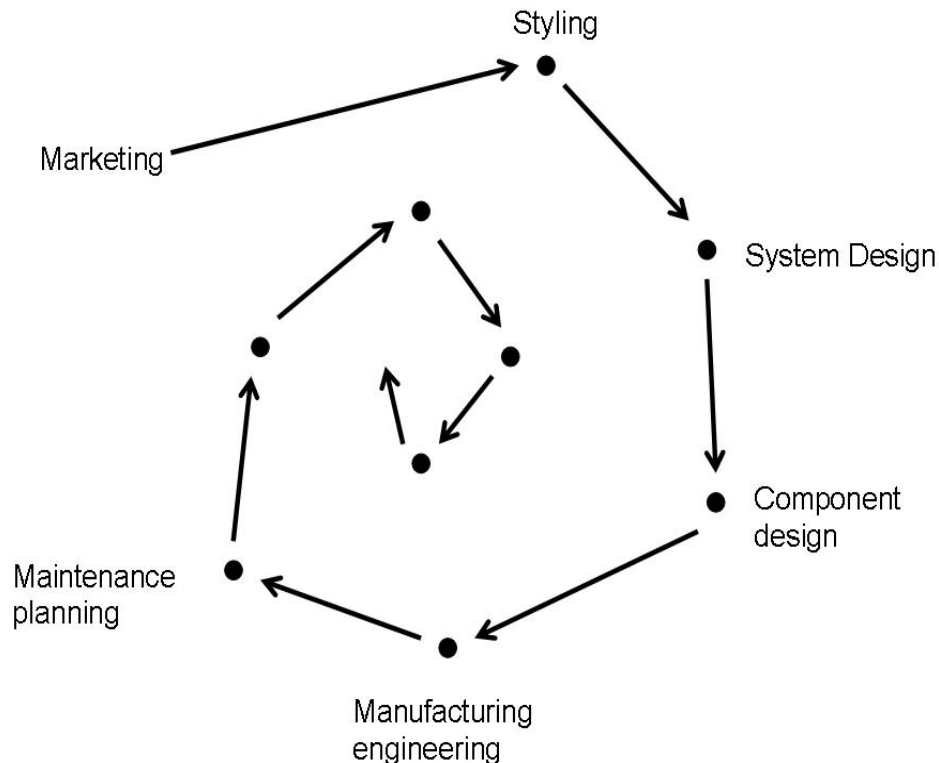# KA Product Development Principles

- Three principles in particular are closely related:
  - Capture and maintain knowledge
  - Set-based design
  - Make decisions based on knowledge
- This presentation will therefore discuss not only set-based design, but other related elements that help us see the bigger picture

Lean Product Development

- System Designer Entrepreneurial Leadership
  - A technical leadership paradigm that efficiently brokers the right knowledge into the right product
- Set-based Concurrent Engineering
  - **An exploration paradigm that generates extensive knowledge from many perspectives to maximize product alternatives with minimal risk**
- Responsibility-based Planning and Control
  - A management paradigm that provides efficiency, flexibility, and knowledge as the backbone for project execution
- Expert Engineering Workforce
  - A paradigm that assumes engineers have both the technical capability and access to the right knowledge to make the proper decisions to optimize the current product, while building the knowledge for future products

What do these figures represent?

Design Space

Styling

Marketing

System Design

Component design

Maintenance planning

Manufacturing engineering

Loop-back Loop-back Loop-back Loop-back

Single design solution

Project start

Time

This is how we are NOT supposed to do things.

What then, do you think these figures represent?

Marketing concept

Styling

Product design

Component 1

Component 2

Manufacturing System Design

Set-narrowing phase

Problem-correction phase
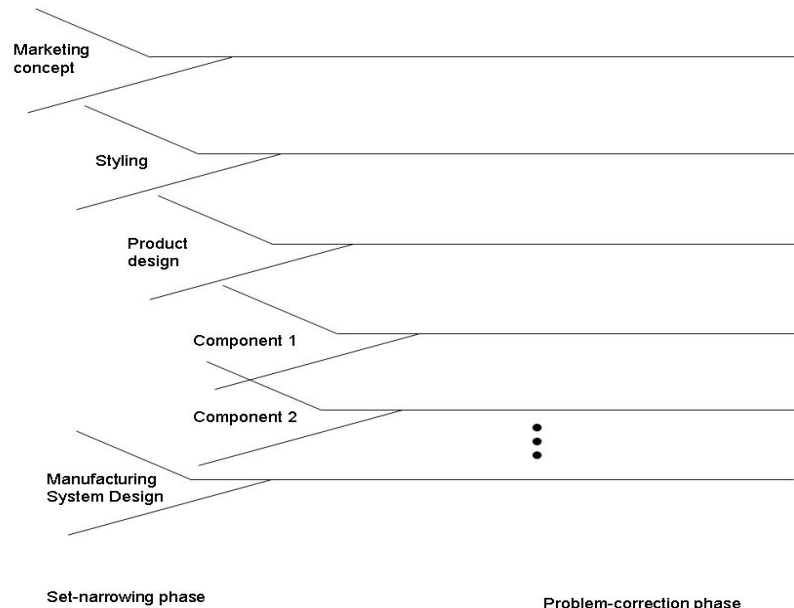
Note: Based on a sketch by Toyota's general manager of body engineering in 1993

STOP

STOP

Multiple solutions GO

STOP

STOP

Project start

Time
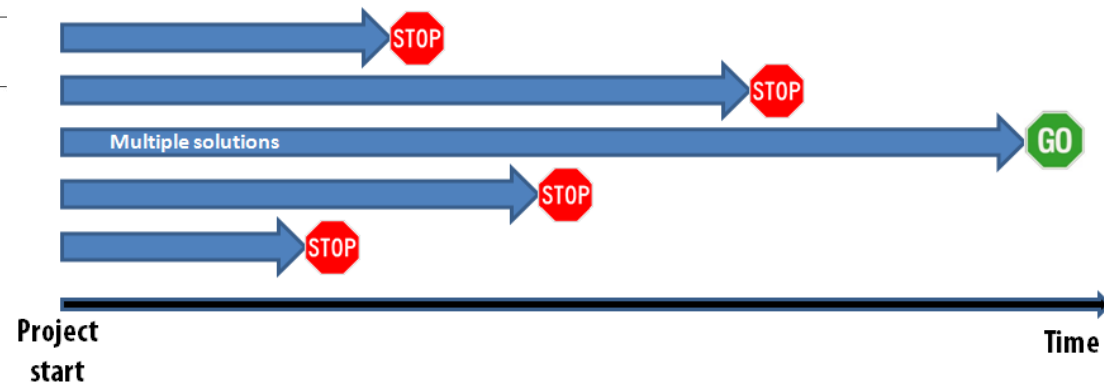
THIS is how we are supposed to do things.

Design space

- Considers the design perspectives proposed by different functions
- Converges towards the acceptable range of overlapping sets before selecting the best one
  - Minimizing future design and engineering changes further downstream
  - Eliminating a great deal of waste in the early stages of product design
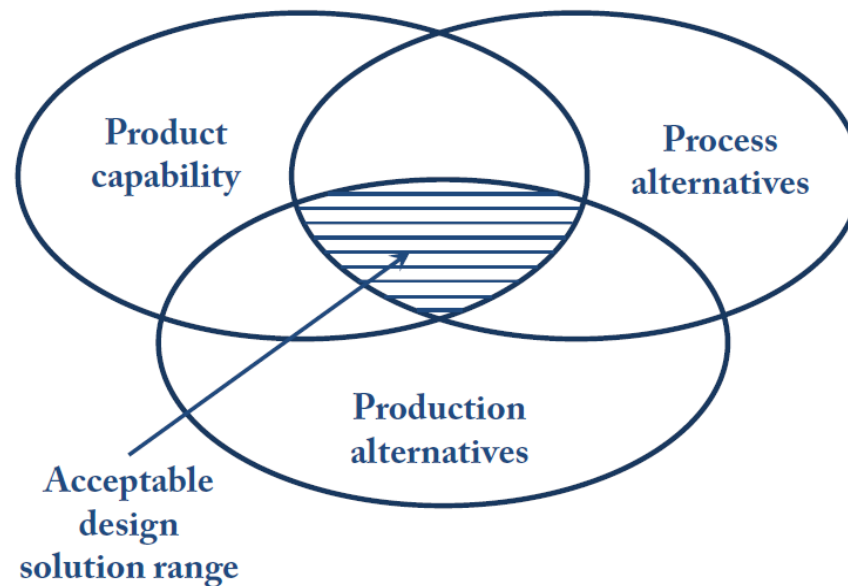
Guide to set-based engineering:

From "The lean development skills book":
- Divide the system into subsystems
- Treat the designers of connection systems as customers
- Chart the possible variations in environments
- Use targets and trade-off curves
  - Make targets broad to begin with, and narrow them as your knowledge increases
- Consider multiple concepts for each element
- Maintain proven concepts as members of the set until a new concept is proven feasible and more profitable across the range of possible environments
- Aggressively attack each concept, attempting to find its limitations as quickly and cheaply as possible by calculation, simulation, and test
  - Express those limitations as trade-off curves.
- Strengthen your test and evaluation organization
  - Find the quickest and cheapest way to kill the weak concepts
- Compute probabilities of success
- Carefully manage the timing of convergence (concept elimination) for each part of the system
  - Converge quickly where it is obvious
- Use trade-off curves to map the regions over which different approaches are superior or inferior
- Use comparison matrices to eliminate weak designs

Set-based concurrent engineering at Toyota

- The team defines a set of solutions, rather than a single solution, at the system level

- They define sets of possible solutions for various sub-systems

- They explore these possible sub-systems in parallel, using analysis, design rules, and experiments to characterize those parts of the design space

- They use this analysis to gradually narrow the set of solutions, converging slowly towards a single solution

- Once they have established the single solution for any part of the design, it is not changed unless absolutely necessary

Set-based concurrent engineering at Toyota

- Through set-based design, Toyota is front-loading its development process and delaying key decisions, which, paradoxically, results in faster product development

- The purpose of the front-loading is to identify all possible problems and to resolve them early on in the process, long before "the clay freeze"

- Ultimately, conflicts tend to be resolved by returning to "CUSTOMER SATISFACTION" criteria

Wishful thinking

Point-based V.S. Set-based

Multiple-choice

What is KA employees' understanding of Set-Based Design?

Propositions were given to employees,

who chose the ones they thought to be correct statements.

Here are the results!!

☺

Multiple-choice; What is set-based design?

In set-based design one might develop multiple alternative concepts on component-level (100%)

In set-based design one "eliminates" bad, poor or impossible solutions through test and analysis, amongst other things (95%)

Early testing of functions and components is part of set-based design (80%)

Set-based design entails that you make decisions based on knowledge as opposed to assumptions (80%)

In set-based design one often uses "targets" for designing, and develop more precise specifications along the way (75%)

In set-based design, some decisions are postponed as long as possible in order to base them on as much knowledge as possible (75%)
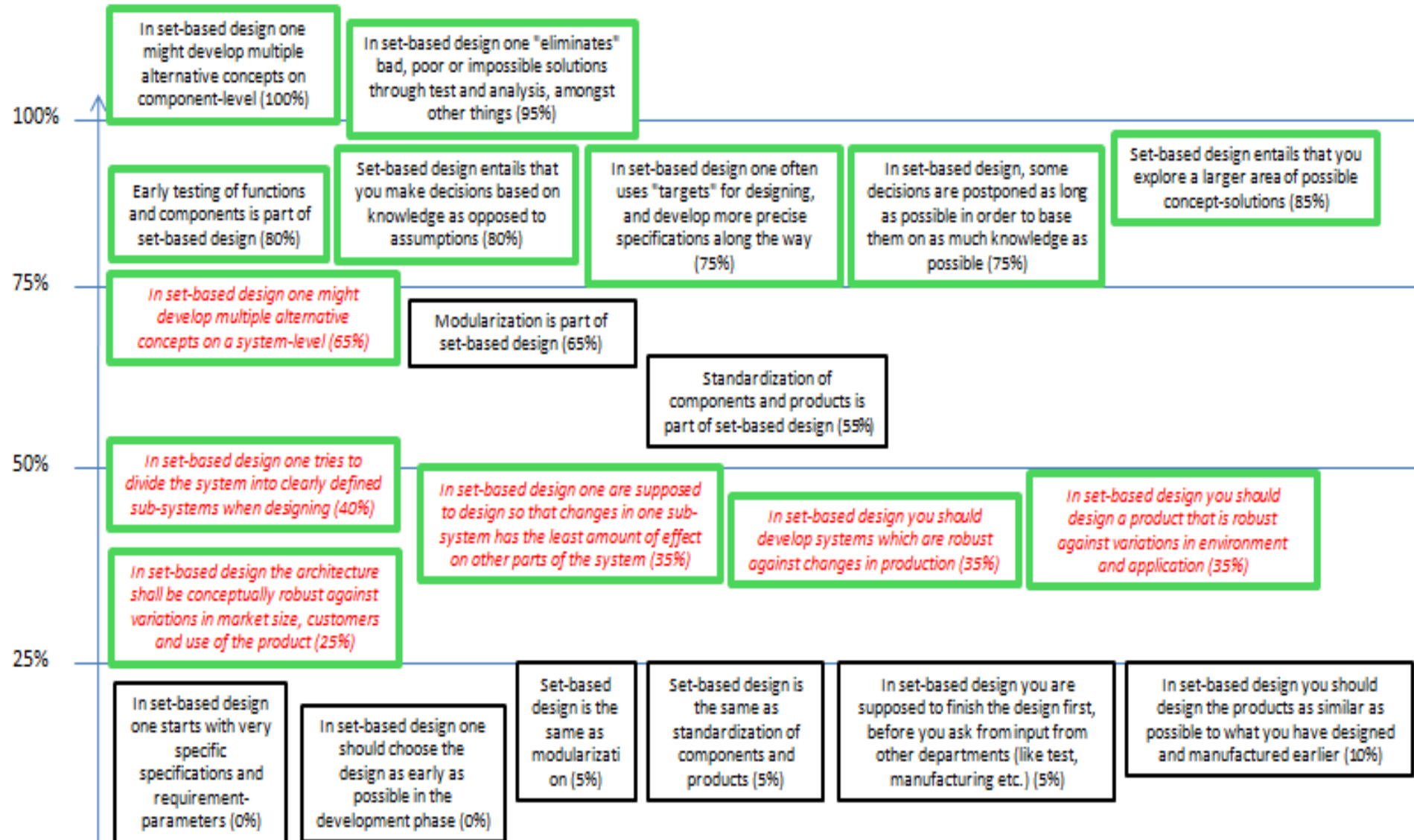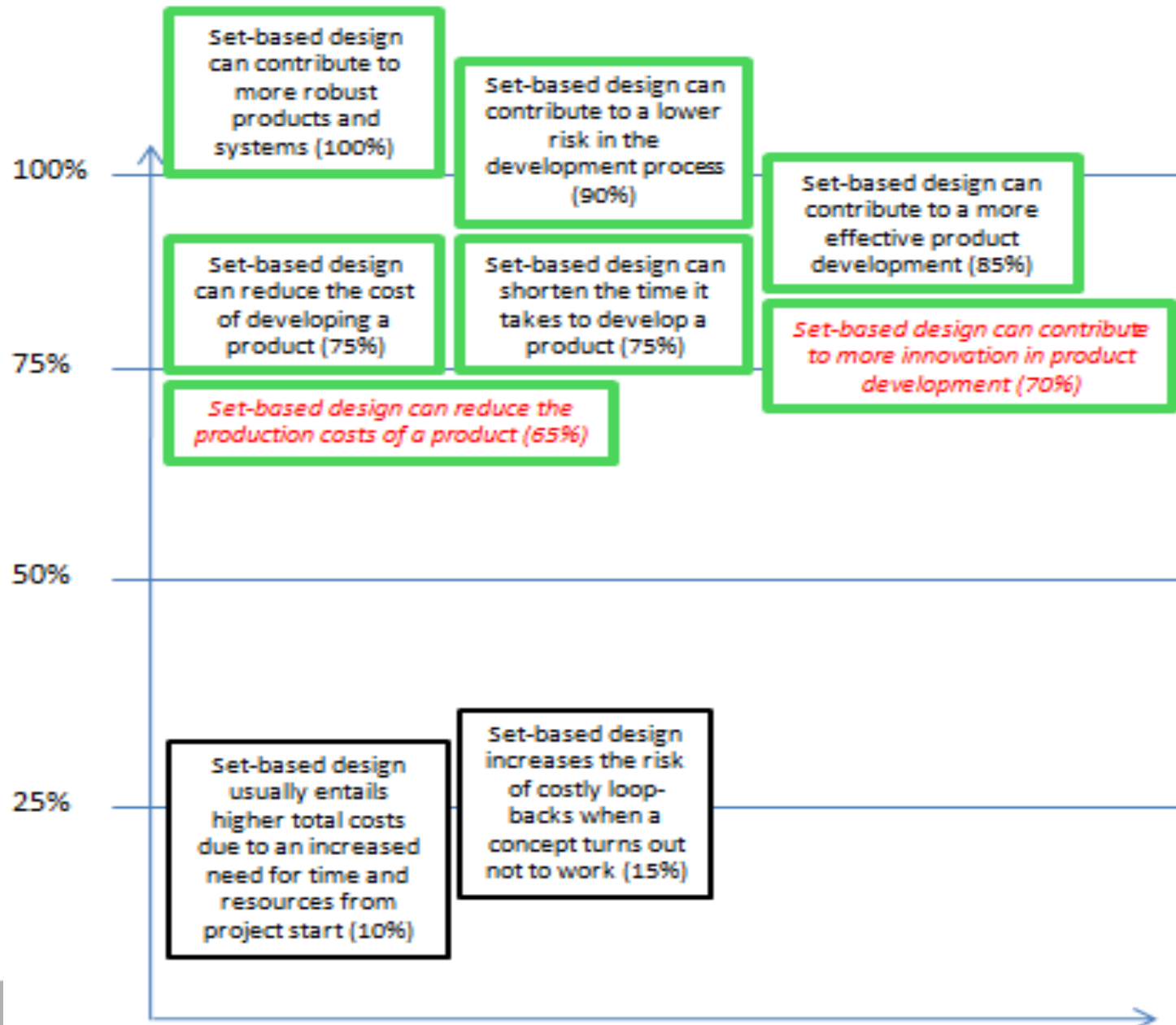
Set-based design entails that you explore a larger area of possible concept-solutions (85%)

In set-based design one might develop multiple alternative concepts on a system-level (65%)

Modularization is part of set-based design (65%)

Standardization of components and products is part of set-based design (55%)

In set-based design one tries to divide the system into clearly defined sub-systems when designing (40%)

In set-based design one are supposed to design so that changes in one sub-system has the least amount of effect on other parts of the system (35%)

In set-based design you should develop systems which are robust against changes in production (35%)

In set-based design you should design a product that is robust against variations in environment and application (35%)

In set-based design the architecture shall be conceptually robust against variations in market size, customers and use of the product (25%)

In set-based design one starts with very specific specifications and requirement-parameters (0%)

In set-based design one should choose the design as early as possible in the development phase (0%)

Set-based design is the same as modularization (5%)

Set-based design is the same as standardization of components and products (5%)

In set-based design you are supposed to finish the design first, before you ask from input from other departments (like test, manufacturing etc.) (5%)

In set-based design you should design the products as similar as possible to what you have designed and manufactured earlier (10%)

What are potential effects of set-based design?

Set-based design can contribute to more robust products and systems (100%)

Set-based design can contribute to a lower risk in the development process (90%)

Set-based design can contribute to a more effective product development (85%)

Set-based design can reduce the cost of developing a product (75%)

Set-based design can shorten the time it takes to develop a product (75%)

Set-based design can contribute to more innovation in product development (70%)

Set-based design can reduce the production costs of a product (65%)

Set-based design usually entails higher total costs due to an increased need for time and resources from project start (10%)

Set-based design increases the risk of costly loop-backs when a concept turns out not to work (15%)

100%
75%
50%
25%

Examples of employees' understanding of drawbacks and benefits of set-based design

- Perceived drawbacks:
  - Very resource- and time demanding to front-load projects
  - A threshold to overcome when implementing since it is a new way of working
  - When people/projects are seriously pressed for time, there will not be time to work set-based
  - Need commitment from all leaders

- Perceived benefits:
  - When the knowledge base grows, the job will become easier since we do not have to "reinvent the wheel"
  - Increased opportunity of a "wide" development effort with a safe solution at the bottom (baseline)
  - Less risk of loop-backs
  - Cheaper and more efficient development

Here we can also see that not all employees have the same understanding

Examples of employees' perceived motivational factors for working set-based

Motivational factors

- To see that it actually works (see the benefits with their own eyes) in projects
- Good A3 sessions
- If it allows for the use of employees' creativity and fantasy
- More time and less pressure in the development phase
  - You can feel safe about the results (risk reduction)
  - Less frightening to try something new
  - Save time by using something that you know work
  - Seeing improved efficiency in developing a new product
  - Less work at the end of development projects
  - Be spared from having to start over if a solution turns out not to work (as it might be in point-based design)
- (The feeling of) having the time to work set-based, not "drowning" in other tasks
- Method that makes development easier
- Development of more robust products

Common understanding of the point of the tools

- It is not enough to apply lean tools and principles to every process

- Frameworks: the mental constructs through which we see, interpret and act on the world

- Frameworks alter how the system is understood and therefore how to proceed with implementation

- If managers and program leaders fail to understand the frameworks, they consequently miss the point of the tools and therefore fail to achieve the expected results

- Therefore a COMMON understanding is important

How to get at common understanding

- The "network effect" (nodes and links)
  - Start on the top
- Change the thought processes of the employees
- Develop kaizen (continuous improvement) consciousness
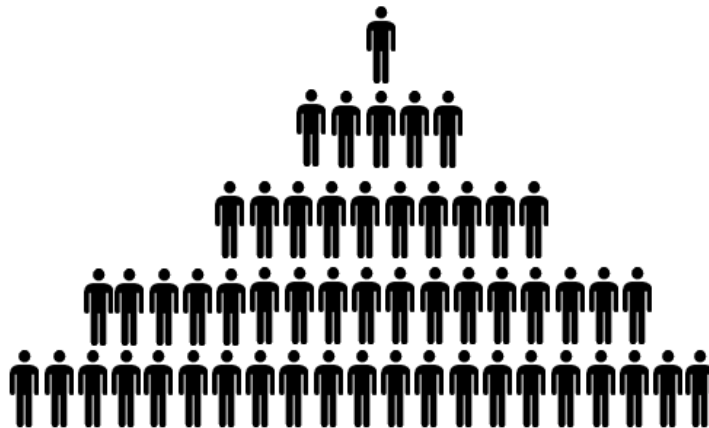
The right mindset

- <u>Wrong mindset</u>: Involving manufacturing early might impose inappropriately strict limitations on design, which would make the design work more difficult

- <u>Right mindset</u>: It is important to involve manufacturing early in order to avoid problems in production later, when it will probably be more expensive to make changes

- <u>Toyota</u>: manufacturing engineers produce detailed check-lists of what they can, or cannot do, which define the design space in a non-restricting way
  - Each parameter is obviously opened to debate, but ultimately, this gives designers a loose framework to operate with
  - Checklists serve as a concrete basis for communication between designers and production engineers

Thinking - problem solving - wisdom

- Confronting problems
- Doing a root cause analysis to solve the problem completely
- Value streams, cell designs, product launches, suppliers, and more do not improve on their own – they are the direct result of capable people (internal and external) identifying and solving problems and challenges in an ongoing basis
- Create an environment where people have to think, which brings with it wisdom, and this wisdom brings with it kaizen (continuous improvement) – Teruyuki Minoura, TPS veteran

Our aim with set-based

- Increased efficiency
- Robust solutions
- More possible customers
- Increased innovation
- Reduced risk
- Avoid loop-backs
- Gathering knowledge
- Better products

Summary
Main results from research

At the time of the research the employees showed:

- Some ambiguity as to what set-based design entails

- Quite strong agreement with regard to what the goals of set-based design are

- Perhaps a lack of motivation to work set-based because potential benefits were clear, but the actual gains were not visible yet

Summary
Further development

Now, one year later, I am confident the results would have been different due to:

- Increased focus on implementation of set-based design

- Education and training-sessions for employees

- Clear roles and responsibilities

- Focus on a better understanding of the tools, how to use them, and how they fit into the "bigger picture"

- Some benefits are also becoming visible

Thank you for your attention

Questions?