9TH INTERNATIONAL DESIGN STRUCTURE MATRIX CONFERENCE, DSM'07
16 – 18 OCTOBER 2007, MUNICH, GERMANY

PRODUCT STRUCTURES DESIGNED FOR VARIANTS

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Keywords: product variety, product structure optimization, design for variants

1 INTRODUCTION

The diversity of product variants is increasing in most industry segments, driven by the trend from a vendor-determined market to a buyer's market. This diversity is combined with a shifting of added value from manufacturers to suppliers. Since the early phases of the product development process have a significant impact on all succeeding phases, methods to cope with product variance are most effective when focusing on this initial stage. [1]
Traditional types of bills of material are rarely capable of structuring products with a substantial number of variants. European car manufacturers implemented solutions which are based on the STEP Application Protocol (AP) 214. These solutions are doing a better job at managing the relevant data, but we believe that users are not enabled to take active control of product variety, yet.
Two areas are addressed in this presentation, where significant improvements could be achieved by guiding users to

- identify the right number of product variants
- define the right product structure (in terms of levels and width).

The approach described in this presentation focuses on assembled-to-order products with a very large number of variants. With some adaptations it can be applied to engineered-to-order products, too.

2 THE CHALLENGE OF PRODUCT VARIETY

There are many reasons why the number of variants is increasing (see examples in [1]), typically with very different demands and thus resulting in the picture of a "long thin tail":

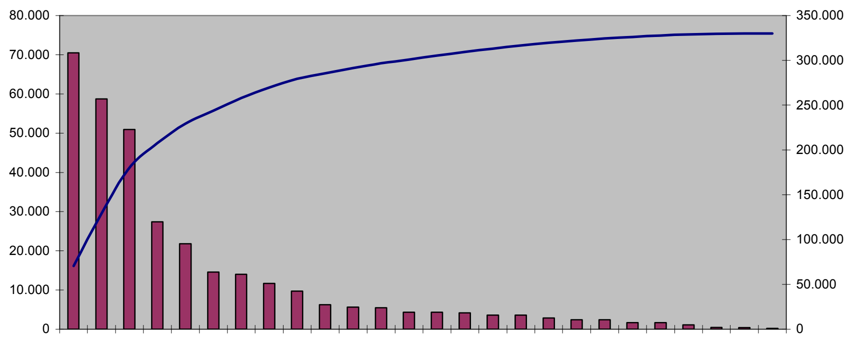

Figure 1. Demand for Product Variants – "Long thin Tail"

Without a doubt it is beneficial to avoid – respectively eliminate – product variants which are not contributing to the commercial success. Consulting activities in this area help companies to make the necessary decisions, but are typically limited to the product level.
Unfortunately the required analysis does not become part of the daily practice, but is conducted at singular points in time only, allowing product variety to quickly grow in the meantime – or the wrong product variants to be removed.
Another challenge is that the effort for thoroughly analyzing the variety on lower levels of a product (with huge amounts of assemblies and parts) is typically too high, and thus skipped. As a consequence the product development teams have limited ability to cope with product variety successfully.

3 APPROACH

To overcome challenges as described in the previous chapter, we suggest the following approach:

3.1 Options and Option Values

Define and agree on product options and available option values as a common language across disciplines (e.g. marketing, product management, systems engineering and development).
The following figure shows the options and option values for a car seat:

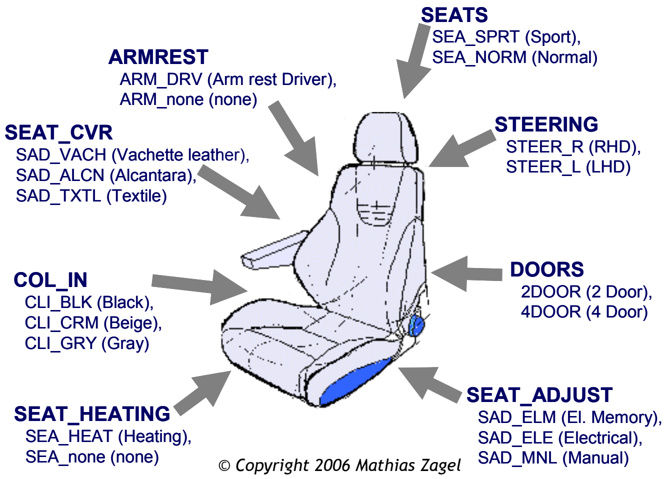

Figure 2. Car Seat with Options & Option Values

The ability to combine option values is typically limited by technical constraints or marketing/product management driven constraints. These constraints have to be captured along with the options and option values.

3.2 Conceptual Product Structure

Implement a conceptual product structure for the relevant product, which is independent of the items that are used for an individual product. The conceptual product structure is the basis for all information that is created or captured during the early development phase. Information that may be associated with the product components in this structure includes requirements, functional views etc.
But what is the "right" structure, and how can companies be supported in finding it? Decomposing the system (the corresponding product – in our example a car seat) into its components and identifying their interfaces is an approach that should be adopted from systems engineering. By capturing if and how the product components interact (see [2] for a good overview of types of interaction), we gain the right insight for suggesting an improved structure by using the power of a Design Structure Matrix.

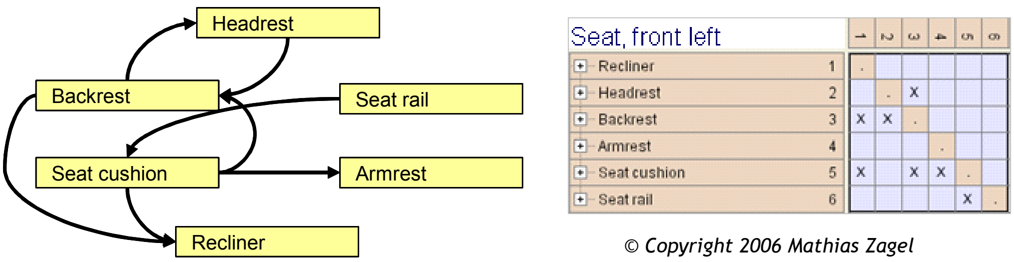

Figure 3. Product Components of Car Seat with Their Interfaces

However, for products with a large number of expected variants it is not sufficient to just analyze the interfaces between the product components. The next sections will show how the influence of options and option values is taken into consideration, too.

3.3 Understanding Variety on each Product Level

A key imperative for taking active control of variety is to understand which options respectively option values are the drivers for variety on every level of the product. When taking all relevant constraints into consideration, this will allow to calculate the resulting variety for each product component and thus to identify immediately the impact of e.g. adding another cover to the car seat.
Different from a singular analysis, this mechanism enables process owners to take immediate action and prevent unwanted variety from the very beginning.

3.4 Tying it together in an extended DSM

An extended Design Structure Matrix (DSM) is a suitable tool to analyze both aspects simultaneously: the interaction of product components via their interfaces and the influence of options (respectively option values) on the product components.

	Seat, front left		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Components	Recliner	1	.													
	Headrest	2		.	X											
	Backrest	3	X	X	.											
	Armrest	4				.										
	Seat cushion	5	X		X	X	.									
	Seat rail	6					X	.								
Options	ARMREST (Armlehne)	7				X			.							
	SEAT_CVR (Sitzbezug)	8		X	X	X	X			.						
	COL_IN (Farbe innen)	9		X	X	X	X				.					
	STEERING (Lenkung)	10				X		X				.				
	SEAT_HEATING (Sitzheizung)	11					X						.			
	SEATS (Sitzform)	12		X	X		X							.		
	DOORS (Tueren)	13	X												.	
	SEAT_ADJUST (Einstellung)	14						X								.

Figure 4. Extended DSM with Interfaces and Influencing Options

The extended DSM in figure 4 (created with Lattix LDM, www.lattix.com) just displays the top level product components and the options. It can be expanded to show lower level product components and the options values. The actual granularity reflects all levels of the conceptual product structure, interfaces, options, and options values.

With some experience it is possible to spot areas of improvements (e.g. components which should be combined and such that should be separated) when exploring the DSM. More importantly the DSM methodology allows for automatic partitioning and clustering, which greatly helps users in finding the product structure with is best designed for variants.

By providing additional information (even if it was of preliminary nature only), such as expected part costs, development costs, storage costs, delivery times etc. it becomes possible to choose the product structure that is not only best designed for variants, but satisfies commercial goals likewise.

4 CONCLUSION

The described approach shows a solution for companies suffering from increasing product variety in the following ways:

- The impact of new options respectively additional option values on each level of a product structure is made transparent, allowing to take immediate action (rather than performing laborious and costly analysis every now and then).
- Determining a product structure which is designed for variants (via an extended DSM).
- Additionally taking commercial information into consideration, it is possible to optimize the product structure according to commercial aspects, too.

REFERENCES

[1] Zagel, Mathias. Übergreifendes Konzept zur Strukturierung variantenreicher Produkte und Vorgehensweise zur iterativen Produktstruktur-Optimierung. Schriftenreihe VPE, Band 1, Herausgeber: Prof. Dr.-Ing. Martin Eigner. 2007 (Technische Universität Kaiserslautern)

[2] Ulrich, Karl: The role of product architecture in the manufacturing firm, in: Research Policy, Vol. 24, Issue 3, 1995, Pages 419-440

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9TH INTERNATIONAL DSM CONFERENCE

Product Structures designed for Variants

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Agenda

- Increasing Diversity of Product Variants
- External vs. Internal Variance
- Conceptual Product Structure
- Extended DSM: Revising the Product Structure
- Holistic approach for Product Structure Optimization

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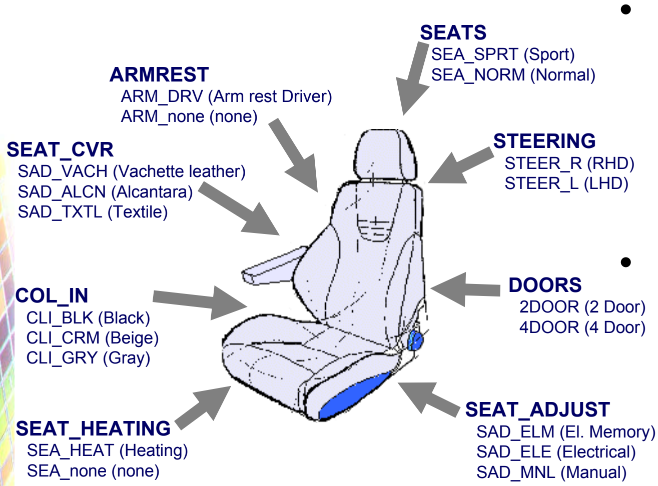
Increasing Diversity of Product Variants

Source: Swatch AG
Siemens Audiologische Technik GmbH
Dell Inc.
ZF Friedrichshafen AG

- Built-to-Stock
- Engineered-to-Order
- Assembled-to-Order

External Variance (Sample: Seat, front left)



- Options & option values
  - Define product characteristics
  - Simplify communication across disciplines
- Products variants are unique combinations of option values

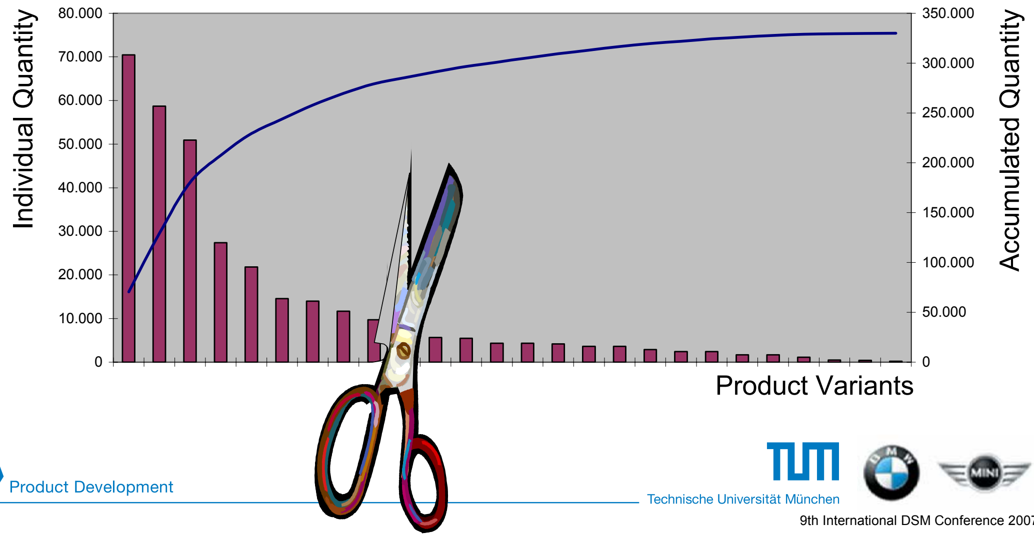
$$\mathbf{Var}[\ldots] = \prod_{i=1}^{n} (\mathrm{OPT}_i)$$

n = Number of Options
i = Index
OPT_i = Values in Option i

2*3*3*2*2*2*2*3 = **864**

The Inevitable Long (Thin) Tail

- Varying demand for individual product variants
- Reduce external Variance
  - Avoid/eliminate product variants not contributing to commercial success



Options, Option Values & Constraints

ARMREST
ARM_DRV (Arm rest Driver)
ARM_none (none)

COL_IN
CLI_BLK (Black)
CLI_CRM (Beige)
CLI_GRY (Gray)

DOORS
2DOOR (2 Door)
4DOOR (4 Door)

SEAT_ADJUST
SAD_ELM (El. Memory)
SAD_ELE (Electrical)
SAD_MNL (Manual)

SEAT_CVR
SAD_VACH (Vachette leather)
SAD_ALCN (Alcantara)
SAD_TXTL (Textile)

SEAT_HEATING
SEA_HEAT (Heating)
SEA_none (none)

exclude

enforce

SEATS
SEA_SPRT (Sport)
SEA_NORM (Normal)

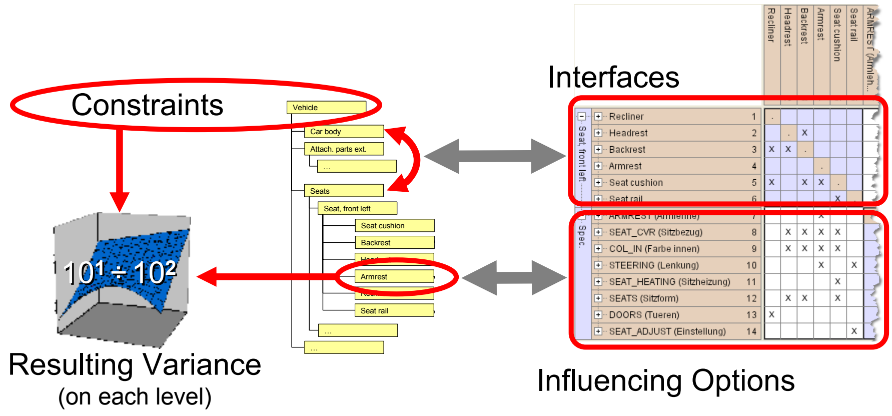
STEERING
STEER_R (RHD)
STEER_L (LHD)

- Technical constraints
- Marketing/product management
  - Enforcing desired combinations
  - Avoiding undesired combinations

Reduced external variance
for Seat, front left: **576** (-33%)

Product Structures Designed for Variants

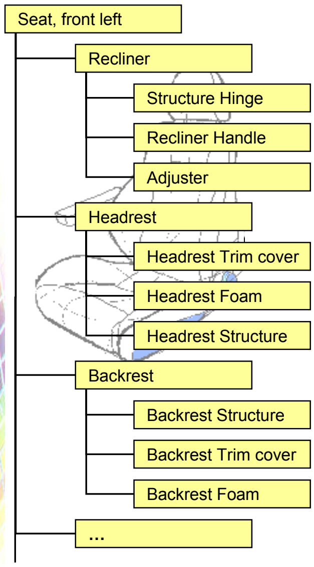
Determine Variance **Design Structure Matrix (DSM)**



Approaches to Reduce Internal Variance

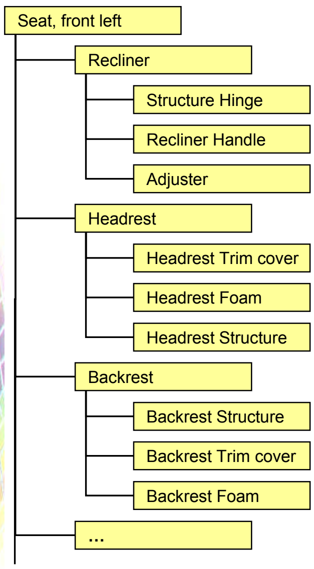
- Assume external variance is fixed
- Leverage reuse of parts/assemblies
  - „Multi functionality“, oversize components
  - Utilize symmetry of components
  - Standardize geometry elements
  - Decouple interfaces
  - Remove functionality
  - Relocate functionality
- Modify product structure (→ level of configuration)
  - Decompose product component
  - Move product component within product structure
  - Integrate product components

Conceptual Product Structure



- Decompose in (abstract) Product Components
  - Neutral, independent of items used
- Capture information from early development phase
  - Requirements
  - Functional views
  - Interfaces
  - Influencing options

DSM: Interfaces between Product Components

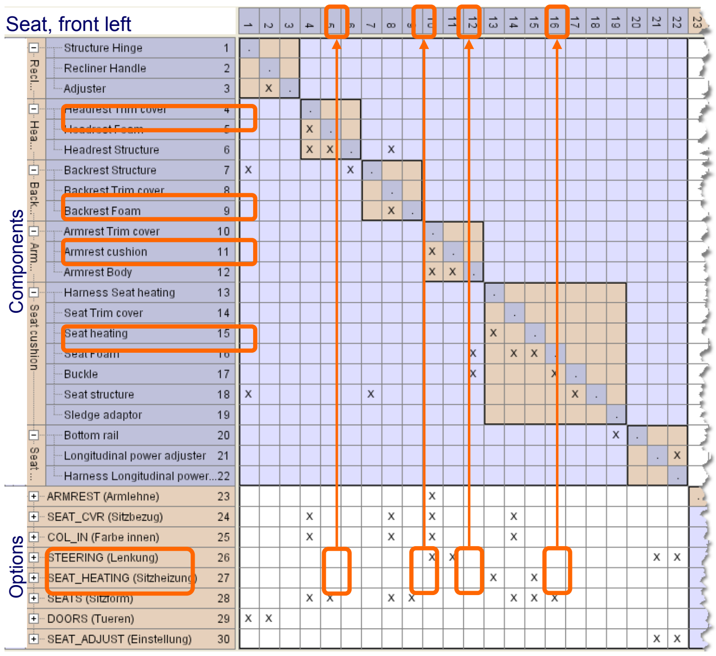


Seat, front left			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Recl...	Structure Hinge	1	.																					
	Recliner Handle	2		.																				
	Adjuster	3		X	.																			
Hea...	Headrest Trim cover	4				.																		
	Headrest Foam	5				X	.																	
	Headrest Structure	6				X	X			X														
Back...	Backrest Structure	7	X					X	.															
	Backrest Trim cover	8								.														
	Backrest Foam	9								X	.													
Arm...	Armrest Trim cover	10										.												
	Armrest cushion	11										X	.											
	Armrest Body	12										X	X	.										
Seat cushion	Harness Seat heating	13													.									
	Seat Trim cover	14														.								
	Seat heating	15													X		.							
	Seat Foam	16												X		X	X	.						
	Buckle	17												X				X	.					
	Seat structure	18	X						X										X	.				
	Sledge adaptor	19																			.			
	Longitudinal power adjuster	20																				.	X	
	Harness Longitudinal power ...	21																					.	
	Buttom rail	22																			X			.

(DSM created with Lattix LDM)

Extended DSM: Interfaces & Influencing Options

- Capture
  - Interfaces
  - Influence of options on each level
- Basis to revise structure



(DSM created with Lattix LDM)

Variance for Initial Product Structure

- Seat, front left — 576
  - Recliner — 2
    - Structure Hinge — 2
    - Recliner Handle — 2
    - Adjuster — 1
  - Headrest — 15
    - Headrest Trim cover — 15
    - Headrest Foam — 2
    - Headrest Structure — 1
  - Backrest — 15
    - Backrest Structure — 1
    - Backrest Trim cover — 15
    - Backrest Foam — 2
  - ...

- High internal variance
  - Several components affected
- Coupled interfaces between major components

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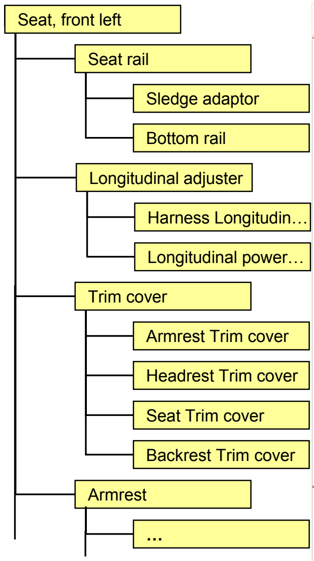
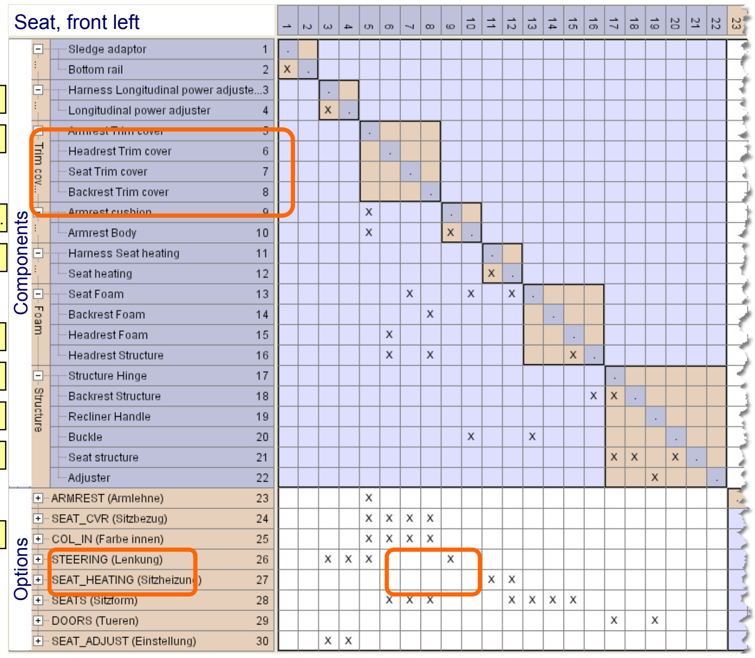
Revising the Product Structure





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Variance for Revised Product Structure

Seat, front left	576
Seat rail	1
Sledge adaptor	1
Bottom rail	1
Longitudinal adjuster	2
Harness Longitudin…	2
Longitudinal power…	2
Trim cover	15
Armrest Trim cover	15
Headrest Trim cover	15
Seat Trim cover	15
Backrest Trim cover	15
Armrest	1
…	

- Reduced internal variance
  - Same external variance (576)
  - High variance is limited to very few components
- No coupled interfaces between major components
- Re-assess when changing
  - Options (option values)
  - Constraints

Holistic Product Structure Optimization

- Capture relevant information for product components
  - Average part cost
  - Estimated design/documentation/maintenance costs
  - Make or buy
  - Pre-assembly (yes/no/quantity threshold)
  - …
- Algorithms to determine key figures
  - Overall assembly duration (→ delivery time)
  - Total part costs
  - Total storage/inventory costs
  - Overall development costs
  - Changeability

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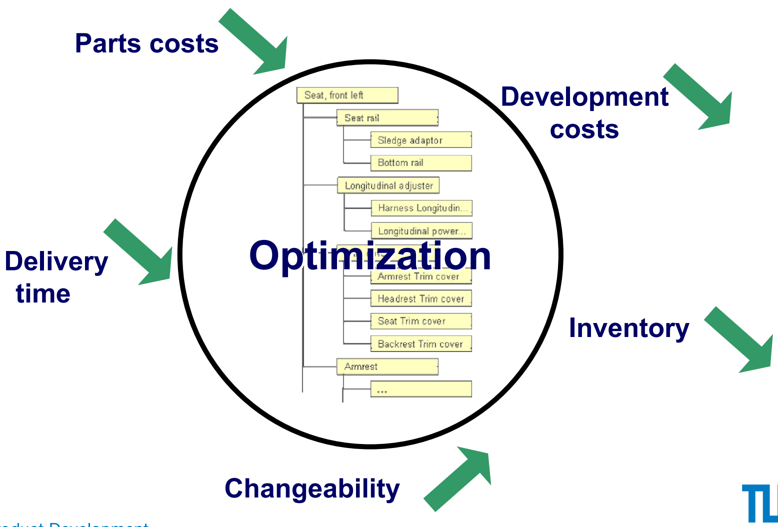
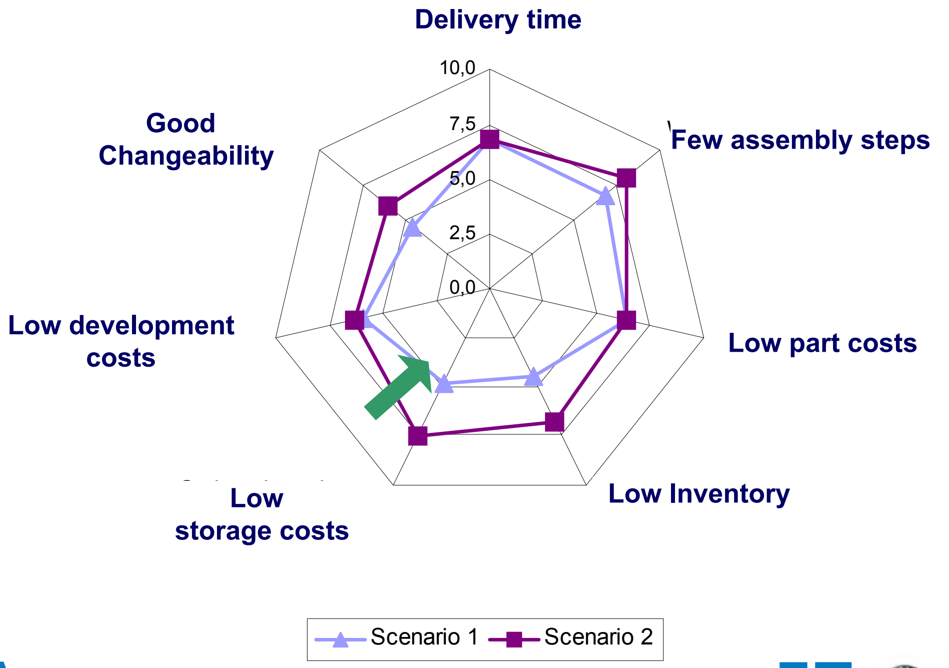
Holistic Product Structure Optimization

- Assess product structure → Key figures
- Analyze key figures → Select suitable modifications
- New assessment, compare results



Comparing Alternative Product Structures



Conclusion

- Approach shows a solution for companies suffering from increasing number of product variants
  - Impact of new options respectively additional option values is made transparent
    - On each level of a product structure
    - Allowing to take immediate action
  - Determining a product structure designed for variants
    - Extended DSM
  - Holistic product structure optimization
    - Taking commercial information into consideration, too
    - Extensible framework