MBtech

Mercedes-Benz technology

Dimensional Management of Mechanical Assemblies

Dimensional Management Forum 2005 at DaimlerChrysler in Sindelfingen
21st April 2005

⓪ Table of Contents

❶ Introduction

❷ Dimensional Management - a cycle process

❸ Mechanical Assemblies - a complex application area

❹ Tolerance compensation and adjusting mechanisms

❺ Summary

⓪ ❶ Introduction

assembly robustness *validation* **geometrical coupling** ISO 2768 - mK

⊥ Ø0,02 A B C

operational variation **working groups** assembly sequence

▱ 0,01 ISO 8015

reference point system *geometrical sensitivity*

tolerance analysis design parameter **functional requirements** // Ø0,1 Ⓜ A B

ISO 10579 - NR **Dimensional Management** DIN ISO 1101

⊕ Ø1,0 A B C

⊕ Ø0,4 A B C
⊕ Ø0,1 A

sources and main contributors tolerance chains 41.8 ± 0.2

ASME Y14.5M-1994 *manufacturing variation* product characteristics

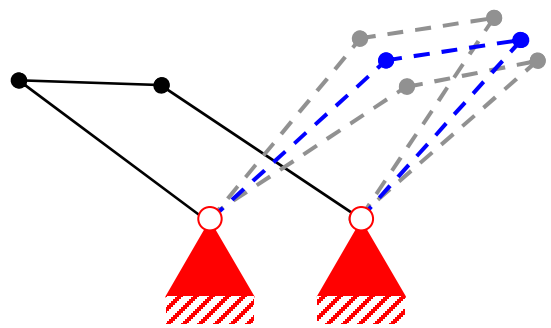
⌓ 1,0 A B C prototyping **simultaneous engineering**

◎ Ø0,06 Ⓜ A Ⓜ DIN 7167 **assembly planning** *insensitivity to variation*

⓪ ❶ Introduction

Dimensional Management is a challenging job to have and to do - especially in the case of Mechanical Assemblies:

- high degree of dependence
- boundary conditions change over time
- high precision assemblies



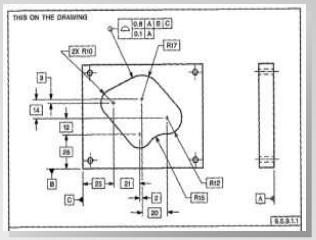
- geometrical, structural and operational coupling
- one ‘output’ has many ‘inputs’
- high manufacturing costs

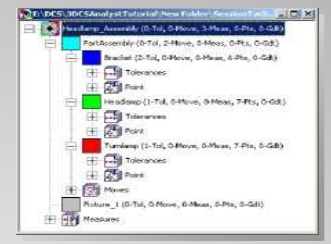
Are all this facts really necessary in their highly constrained requirements? ?

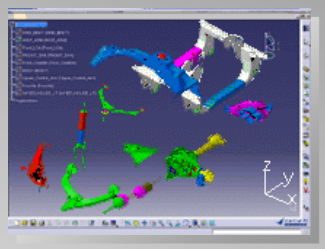
!
- robust product and process design
- simultaneous engineering
- an early solution in the concept phase

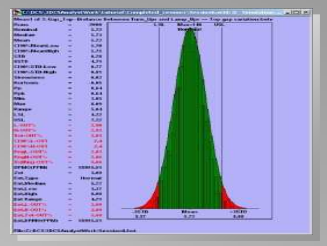
Dimensional Management … accompanying the entire ‘product developing process.’

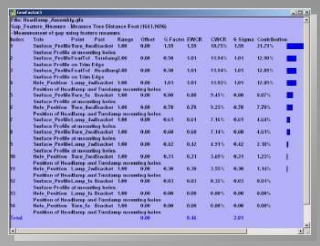
⓪ ❶ ❷ Dimensional Management – a cycle process









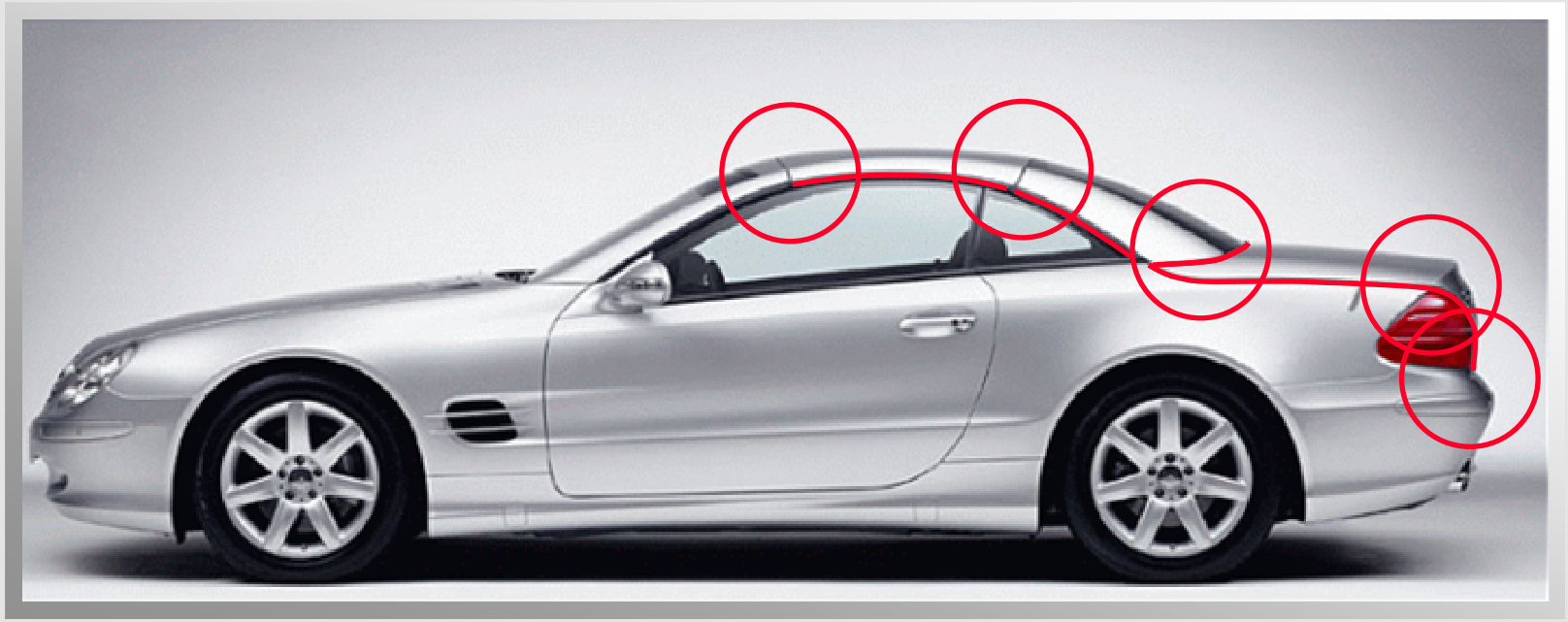


Product Characteristics & Requirements → **Assembly Planning Clamping- & Fixing-Concept (SFK)** → **Assembly Process Process Parameter** → **Tolerance Analysis** → **Sensitivity Analysis**

Working Groups (AFT[1]) Update - Redefining

1) AFT = Assembly, Function and Tolerances

⓪ ❶ ❷ ❸ Mechanical Assemblies – a complex application area



Example: SL R230 'Roof Mechanism (RHT = Retractable Hard Top)'

					Position '6'
• Catch ar • Gap/Flus • Structur	• Constric • Structur • Hard sto	• Constric • Structur	• Constric • Structur	• Constric • Structur • Hard sto	• Catch areas • Gap/Flush, Down-/Offset • Structural effects

⓪ ❶ ❷ ❸ Mechanical Assemblies – a complex application area

Key aspects of ‘movable‘ assemblies:

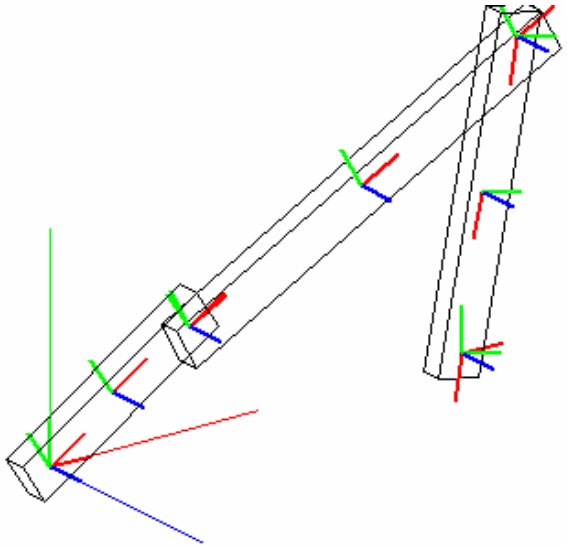
Static Assembly:
one fix position
constantly

⟷

Mech. Assembly:
multiple positions
over time

Additional key aspects to consider:

- **geometrical parts dimensions and quality**
- **joint types**
- **drive mechanism attributes**
- **electrical positioning systems (sensors)**



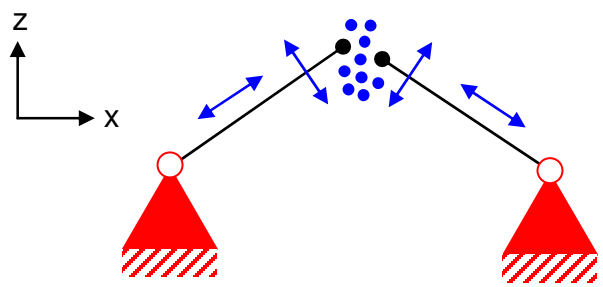
Ref. freeCAD

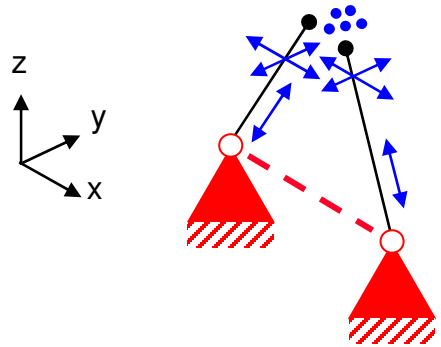
⓪ ❶ ❷ ❸ Mechanical Assemblies – a complex application area

Dimensional aspects:

Regarding the dimensional aspects of Mechanical Assemblies - especially of kinematic linkages - the following example shows a principle problem of the theoretical simulation method.

<u>Problem:</u>
The degrees of freedom of an assembly with <u>rigid</u> parts.





2-dimensional variation (in x, z)
-> ‚point cloud'
-> <u>one</u> mathematic solution !

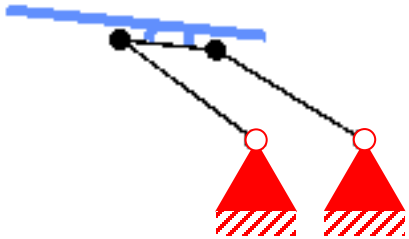
3-dimensional variation (in x, y and z)
(Problem: closed chain – – –)
-> <u>no</u> simple mathematic solution!

⓪ ❶ ❷ ❸ Mechanical Assemblies – a complex application area

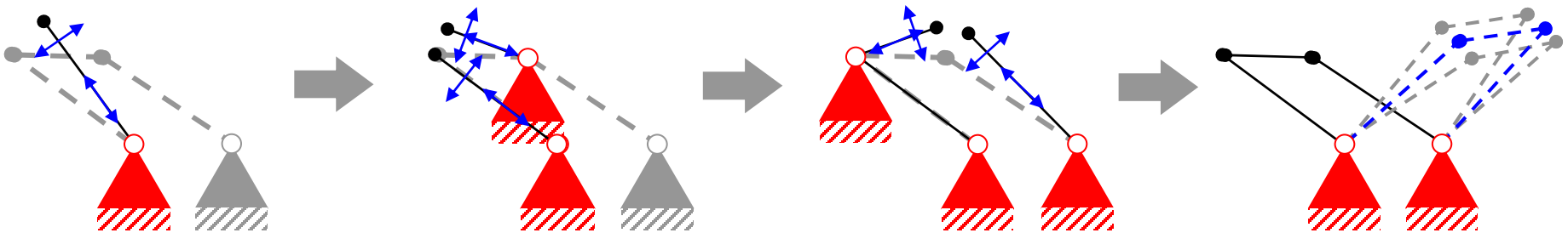
Background: Special features and requirements of kinematic linkages

Example: ‚4-bar linkage'

- only ‚revolute' joints
- iterative steps are required for building-up the assembly
- not only 3-dimensional variation … but in addition the variation in time!
- changing geometrical transmission ratios over time



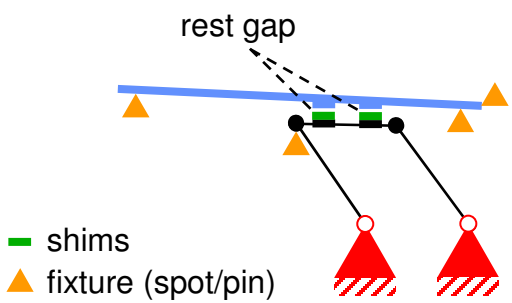
Schematic illustration of the iterative method (step-by-step) to build-up a ‚4-bar linkage' with variation:



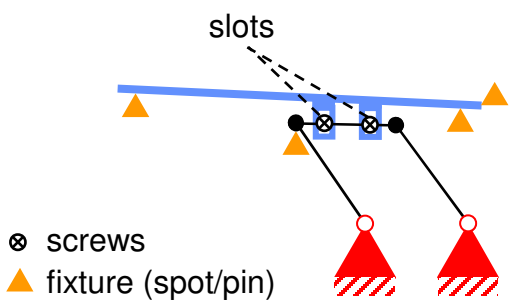
⓪ ❶ ❷ ❸ ❹ Tolerance Compensation and Adjusting Mechanisms

Adjusting Mechanisms

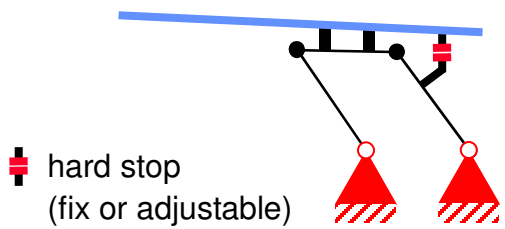
shims



regulating screws



hard stops



<u>Problematic situations:</u>

- **Adjustment mechanisms like shimming are often ‚discrete', i.e. at the end of the adjustment a certain rest failure is still remaining.**
- **Time of occurrence and balance of the adjustment of certain product characteristics which can have several functions in different part positions over time (e.g. convertible roof systems).**

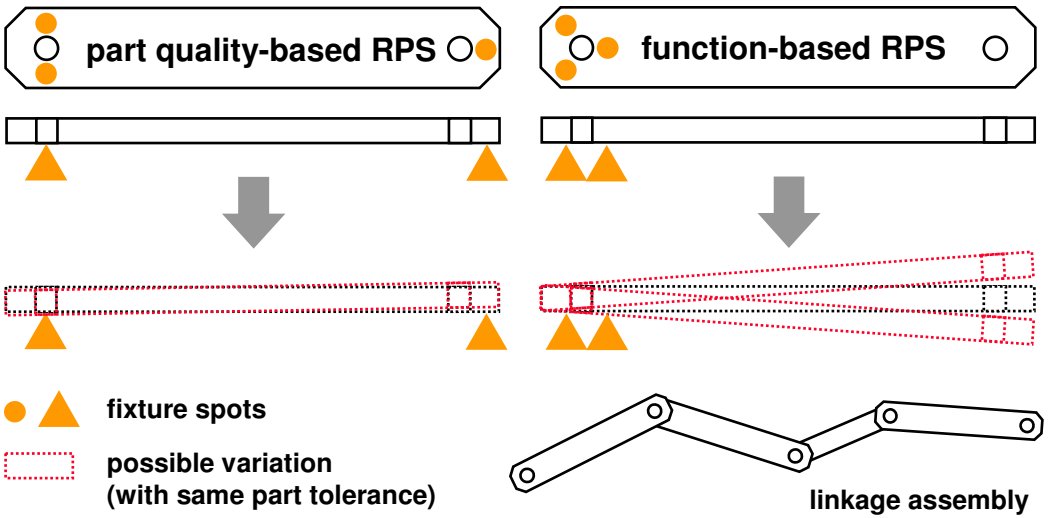
⓪ ❶ ❷ ❸ ❹ Tolerance Compensation and Adjusting Mechanisms

Reference Point System (RPS)

- **The Reference Point System:**
  The most important basis variable in the definition of parts.
- **Definition of the locating scheme:**
  Example: '3-2-1 method'
- **Function-based definition of the RPS:**
  The location scheme of parts in the assembly is an essential factor for the right choice of the part RPS.

"You can have good quality parts, but a poor quality assembly!"

<u>The choice of reference points and the effect on variation:</u>



<u>One</u> global „over-all" reference point system in which all other local reference point and positioning systems are strictly defined in a <u>function-based</u> way.

⓪ ❶ ❷ ❸ ❹ Tolerance Compensation and Adjusting Mechanisms

Tolerance compensation

By means of tolerance chains …

- Avoid long tolerance chains.
  (Shortest, ideal case: One „output“ has one „input“.)
- Integrate suitable compensations methods already in the product design and assembly process to break the chains.

→ This kind of methods are often ‚cost-neutral‘.

→ In addition, it allows you to enlarge your part tolerance limits.

→ You can reduce your manufacturing costs.

By means of fixtures …

Practical experience shows that over-all variations of an assembled product often are fixture related quality problems.

Use fixtures …

→ to find additional solutions for design problems.

→ to realize suitable subassembly extents.

→ to break and minimize tolerance chains.

→ to eliminate unnecessary tolerances especially in case of key product characteristics (KPCs).

Design and development of components and assemblies with the ability to suppress variation!

❶ ❷ ❸ ❹ ❺ **Summary**

Summary and Target …

Due to the huge amount of aspects relating the Dimensional Management of Mechanical Assemblies everyone who is involved in the product development process has to be included in finding common solutions for this important and elementary subject.

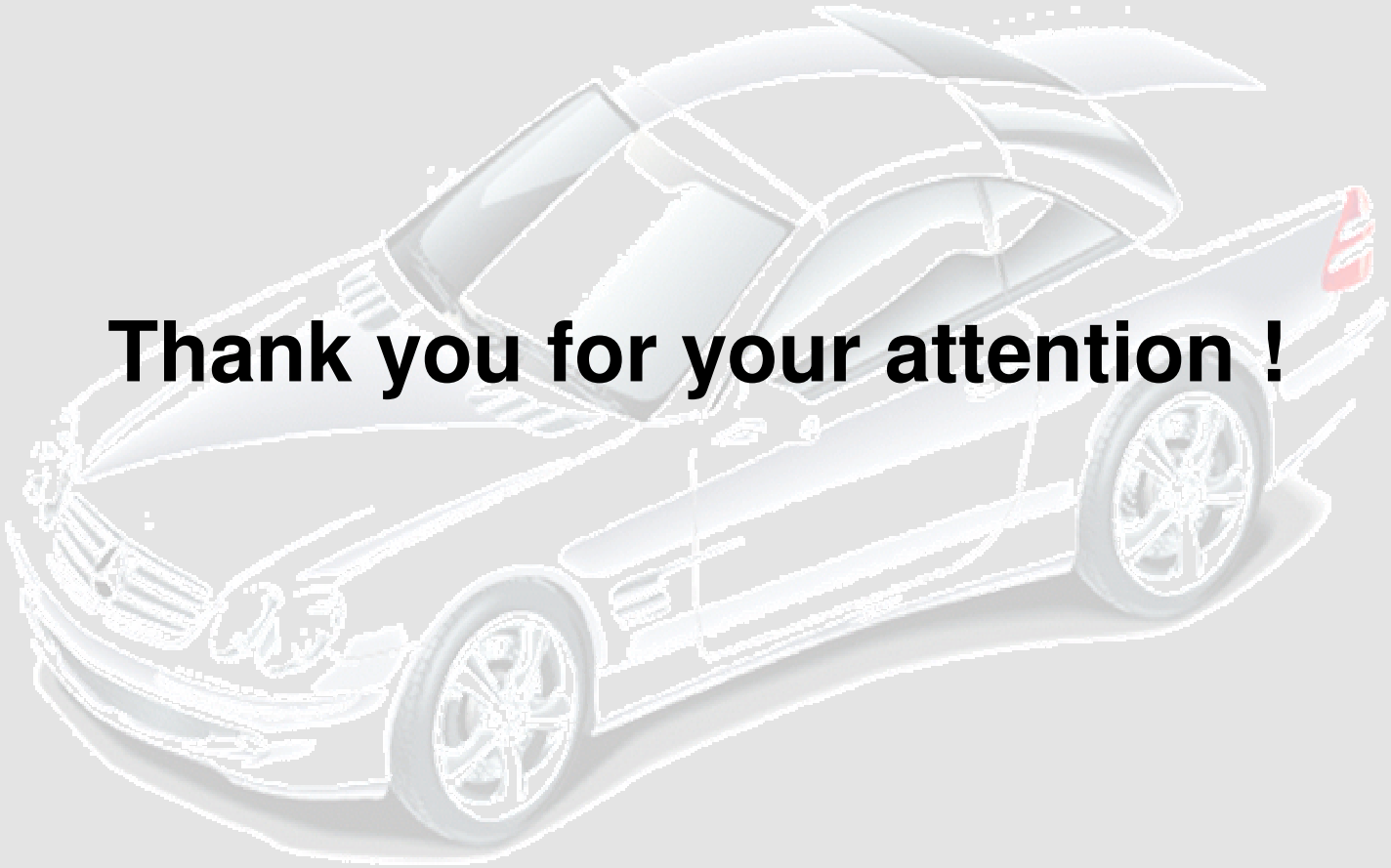
→ In this context, CAD integrated tools are an obvious solution to get a real common database and to keep the overview. Multiple, nearly same activities have to be done only once and everybody can really set up on the work of the other one. Thereby, errors are avoided … costs and time are saved.

→ The compromise solution is a typical ‚trade-off':

- **What is constructionally feasible and how much does it cost?**
- **Which product characteristic is more important?**
- **Which effort is necessary concerning producibility and assembling process?**
- **How simple the total situation can be solved?**

„Everything should be as simple as it is, but not simpler."

(Albert Einstein)



Thank you for your attention !