Standard- and knowledge-based kinematic design in the early stages of product development
Agenda

• Introduction
  ‣ Airbus product portfolio
  ‣ High-lift technology
  ‣ The Bremen wing high-lift process
  ‣ A380 high-lift system

• Standards for kinematic design
• Re-use of kinematic standards with CATIA V5
• XML-based implementation – an open approach to KBE
• Case studies
• Summary & conclusion
Introduction – Airbus product portfolio

Competitive product portfolio:
More than 8,779 orders
more than 220 customers
more than 5,092 deliveries
Introduction – High-lift technology

Commercial aircraft takeoff and landing requirements

- Highest flight security and performance
- Short distance to takeoff and landing
- Noise reduction
- Resistance to gusts and maneuver loads

Bird in cruise flight...

... and flying slowly

Takeoff

Landing
Introduction - The Bremen wing high-lift process

Bremen
- 3,432 employees
- **High-lift center**, wing equipping, A400M fuselage design & assembly, small metal parts
- Wing engineering and design in a transnational and multidisciplinary environment

- **Structure Development**
- **Validation and Verification**
- **Wing Equipping**
- **Structural Assembly**
- **System Development**
- **Flight Physics**
- **Future Projects Office Technology Development**
- **Delivery to Final Assembly Line, Mise au Point & Product Support**

Bremen • 3,432 employees • **High-lift center**, wing equipping, A400M fuselage design & assembly, small metal parts • Wing engineering and design in a transnational and multidisciplinary environment
• A380 high-lift devices (droop nose devices, slats, flaps) and primary flight controls (aileron, spoilers)
Agenda

• Introduction

• Standards for kinematic design
  ‣ Modular methods for kinematic synthesis
  ‣ Modular methods for static analysis

• Re-use of kinematic standards with CATIA V5

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• Case studies

• Summary & conclusion
Modular methods for mechanism synthesis

- Composition of the 2D kinematic baseline using geometric methods according to Burmester
- Multiple concept variations by changing joint types in a matrix

\[
D(t) = DDS + D(\text{driven})DDS
\]

\[
\begin{array}{c|c|c|c}
AB & DD & DS & SD \\
\hline
DD & \includegraphics{dd1} & \includegraphics{dd2} & \includegraphics{dd3} \\
DS & \includegraphics{ds1} & \includegraphics{ds2} & \includegraphics{ds3} \\
SD & \includegraphics{sd1} & \includegraphics{sd2} & \includegraphics{sd3} \\
\end{array}
\]
Modular methods for static analysis

- Kinetostatic analysis using graphical methods
  
  Resulting force from two given forces

  Distribution of a single force to a system of three slidable supports

- Modular kinematic analysis according to VDI-2729
Agenda

- Introduction
- Standards for kinematic design
- **Re-use of kinematic standards with CATIA V5**
  - Kinematics template catalogue
  - Generic kinematic design process
- XML-based implementation – an open approach to KBE
- Case studies
- Summary & conclusion
Re-use of kinematic standards with CATIA V5

Kinematics template catalogue

- Elementary methods provided in 58 CATIA V5 Power-Copies and User-Features

A powerful and comprehensive toolbox – but how to get the pieces connected?

Aero-specific positioning of the 2D flap section curve

3 Position synthesis for a linkage... ... or a linear slider

Requirements

Design
Generic model structure

- derived from top-level view of the analyzed design process

A clear and straightforward guideline for kinematic modules – but how to assist users and assure quality right in CATIA V5?
Agenda

- Introduction
- Standards for kinematic design
- Re-using kinematic standards with CATIA V5
- **XML-based implementation – an open approach to KBE**
  - Validate, transform, exchange – what KBE can learn from XML
  - XML-based backbone for template-based design
- Case studies
- Summary & conclusion
XML-based Implementation – an open KBE

Validate, identify, transform – what KBE can learn from XML

- Tree-based aggregation of features to complex models

„Can I add a 2D flap setting here?“

„Where can I find the inputs required for my User-Feature?“

„I have received a model from my colleague. If it complies with our standard, I can start working with it right ahead!“

Types and Multiplicity of child nodes in an XML Schema

Identification of related nodes using XPath

Validation of the entire model structure using XML Schema
XML-based backbone for CATIA V5 model structures

- A flexible XML Schema provides all contextual Information about what belongs where
- Can easily be adapted to changing requirements or extended for specific needs
- Can be used for documentation and training
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• Case studies
  ▸ 3D master kinematic mechanism
  ▸ Joint angle examination
• Summary & conclusion
Case studies

3D master kinematic mechanism

- **Automatic transformation** from a structured skeleton to a 3D DMU simulation.

- **Full parametric associativity** from aerodynamic requirements to the 3D kinematic mechanism.
Case studies

Joint angle examination

- DMU kinematic model comprising automatically imported deflections from NASTRAN

![DMU kinematic model](image)
Summary & Conclusion

Knowledge-based kinematic design using templates...

- is a visual and intuitive way to an optimized kinematic baseline
- involves designers’ full experience and creativity instead of formal algorithms
- encourages designers to foster new concepts and eventually add new methods to the common library

*cadkinas* is presently being used successfully in the A350XWB kinematic design

*cadkinas*

CAD Kinematics Assistant
Summary & Conclusion

Standard-based kinematic design using XML/XSD...

- integrates powerful XML technologies for validation, identification and transformation right into CATIA V5
- implements a common standard instead of individual dialects of tree structures and naming
- assists engineers without restricting experience and creativity

Standard-based kinematic design:

a secure way to innovative results