Requirements-driven Development and Verification of Mechatronic Systems

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Agenda

- Initial situation
- Motivation, objectives
- Use cases
- Approach
- Requirements-driven verification
- Results
Initial situation

- The product development process for mechatronic products is mainly determined by mechanical engineering
- Hardly synchronized processes
- Missing coordination and collaboration support
- Late identification of deficits

Need to act
- interdisciplinary information flow, coordination and verification
- integrative system development
- function oriented simulation of system behaviour
- methods and tools for testability against dynamically changing requirements
- support of process oriented verification and diagnostics
Consortium of MI KADO

“Mechatronics collaboration platform for requirements-driven verification and diagnostics“

Sponsored by the

Federal Ministry of Education and Research

Project coaching

Projekträger Forschungszentrum Karlsruhe (PTKA)

Coordination

Fraunhofer Institut Produktionsanlagen und Konstruktionstechnik

Duration: October 2006 - March 2009

End users

System vendors

CADSYS

Research institutes

Fraunhofer Institut Produktionsanlagen und Konstruktionstechnik

Associated partners

imk automotive

LIEBHERR

SITEC

PDItec
Objectives

- Synchronized system development
- Interdisciplinary requirements management system
- Interdisciplinary information exchange, coordination and adjustment
- Verification of product development at any time

More reliable mechatronic products
**Dimensions of virtual product creation and MI KADO approach**

<table>
<thead>
<tr>
<th>Interdisciplinary development process</th>
<th>Mechanics</th>
<th>Electronics</th>
<th>Software</th>
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<tbody>
<tr>
<td><strong>Domain specific knowledge</strong></td>
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<tr>
<td>Product, system, module</td>
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<td><strong>Product Creation Process layer</strong></td>
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<td>Development tools</td>
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<td>Process management, RM/RE, Function-oriented Design, FMU</td>
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<td><strong>PLM application layer</strong></td>
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<td>Information management</td>
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<td>Collaboration platform</td>
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<td>Multi disciplinary PDM</td>
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<td><strong>IT infrastructure (SOA, Grid, Web-Services …)</strong></td>
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Research approach within mechatronic modelling schema

Reference: Gausemeier, Jürgen: "Specifying the principle solution of tomorrows mechanical engineering products;" presentation manuscript; May 15, 2006
Use cases in MIKADO

- Multi disciplinary requirements management
- Small series production
- Control system for sunroof
- Adjusting device for automobile interior equipment
- Intelligent Area Controller
- Data acquisition and control for photovoltaics
- Software-controlled project planning
- (Vehicle) seat development

⇒ a total of more than 180 requirements for project content
Approach

- Automated measurement of the degree of maturity at any time
- Early determination of divergences by comparison of requirements with state of development
- Functional Mock-Up
- Mechatronics collaboration platform for interdisciplinary team work and tool integration
- Integrated process management within the collaboration platform

Requirements Model

- Development status
- Test management
- Process management
- Requirements network
- Integration of third-party software

Synchronisation of development and requirements

Need for changes

Mechatronics collaboration platform
Approach

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Mechatronics collaboration platform

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**Functional Mock-Up  FMU**

**Definition**

Functional Mock-Up = on the basis of DMU – validation of functional properties in respect to requirements

**The challenge**

- Complete, regarding all product functions
- Including all disciplines
- Suitable effort in all development phases
- Coupling of heterogeneous CA-Systems

**Potential**

- FMU enables synchronisation of interdisciplinary development processes – through validation
Product-oriented verification and diagnostic tools - realisation

Requirements management (FOD)

Selection, test and transfer parameter

Processing of validation with FMU

Feedback of validation results and documentation
FMU - Automated validation with functional Prototypes

- Validation data is stored in cooperation platform
- Access through WebServices

- Easy integration
- Services location-independent
- Tests do not require user interaction
- Regression tests
- No CAD knowledge necessary
- Expandable
Dimensions of FMU

FMU models
- Digitale patterns & Prototypes
- Reference configurations
- Controller
- Circuits

FMU methods
- Requirement mod.
- Integrators
- Test procedures
- ...

Validation of functional properties

FMU Processes
- Preprocessing
- Interdiscipl. reviews
- Change management
- ...

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Objectives of automated functional testing

• **Automated „Functional Mock-Up“ tests**
  - Simplified test execution
    • Reducing test effort
    • Increasing amount of tests
    • No knowledge of specialized software needed
  - Early, development accompanying tests
    • Increase of quality
    • Reduction of development time

• **Integration of requirements management (FOD) and FMU validation in the overall process**
  - Advanced process control / process optimization
  - Uniform data model / data availability
  - Traceability
Example „roof system“

- Interactive coupling with control
- Design using CAD
- Controller development using Ascet
- Simulation in CAD
- Early development accompanying tests
- Functional and safety aspects
Software coupling principle of different disciplines

Solution

Data

Wrapper

Libraries

Macros

ETAS
ASCET
V5.2

direct
coupling

Microsoft Visual Studio 2005
C# Projekt

Electrical
Engineering

mechatronic
management

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Interactive test-scenario

- Interactive simulation environment embedded in the CAD-system
- No CAD-knowledge necessary
- Coupling of distinct software components
- I.e. CAD + controller layout
- Potential for simulation in virtual reality
Application potential

Dynamische Kollisionsprüfung
FMU

Dynamische Ampelsicht
Einklemmschutz
Ampelsicht

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Challenges and Success stories

Challenges

• Specification of an holistic information model for the integration of domain specific information models
• Creating of integration mechanisms between tools

Success stories

• Integrated tool landscape
• Application-oriented configurable
• No need for local installation, tools can be used over internet
• Best practices by three end users
Results

Examples for applications
• Mechanical and plant engineering
• Automotive engineering
• Energy industry
• Facility management

Process solutions
• Implementation strategies
• Reference models
• Process guideline

Products
• Mechatronics collaboration platform
• Mechatronic PDM
• Functional Mock-Up
• Interdisciplinary requirement management system
• Function oriented verification and diagnostic system
• Tool for process modelling, analysis and evaluation

Services
• IT-Consulting
• Implementation and optimization of developed software tools
• Individual software development
Thank you for your attention

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Prozess solutions
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