LABCAR-VDYM V5.0
the bridge between Vehicle Component and ECU Development

Dr.-Ing. Gerd Wittler, SIMPACK User Meeting 2004
Agenda

• Introduction

• LABCAR-VDYM V5.0 Basic Product

• LABCAR-VDYM V5.0 Add-Ons

• LABCAR-VDYM V5.0 Model Validation

• Summary
## Introduction

### Motivation LABCAR-VDYM V5.0

<table>
<thead>
<tr>
<th>Vehicle Development</th>
<th>ECU Development</th>
<th>Vision</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD</td>
<td>FEM</td>
<td>ABS, ASC, ESP, EHB</td>
</tr>
<tr>
<td>CFD</td>
<td>MBS</td>
<td></td>
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</tbody>
</table>

**Vision**

- Reuse validated MBS handling models for model-based ECU development

**Advantages**

- Avoid effort setting up additional real-time models for SiL and HiL
- Compliant behavior between detailed MBS models and real-time models
- Reduce efforts and costs caused by real car testing
Introduction
Modular and Extendable DVE Modelling Solution

LABCAR-VDYM V5.0

GUI & Model Controller

Driver

Environment

Customised Model Component

Brake

Engine Drive-train

Parameter

Model Composer

Model- Components Library

Engineering Solution

Customised Model Component

Customer Model
Introduction
Modular Modelling Solution

- Model Components contain ...
  - Model data (Simulink blocks)
  - Unified interface (inputs/outputs)
  - Parameter data
  - Graphical User Interface
  - Open source code (SIMPACK component closed source)

- Model Components Library
  - 3 SIMPACK vehicle dynamics components
  - ABS-brake model, simplified brake
  - Automatic driver and drive-train model
  - Environment and engine model
Introduction
LABCAR Software Architecture

LABCAR AUTOMATION

 Tau Tester
 Simulink

 DVE Model

 DVE real

 INCA
 INCA
 DTS

 UuT

 LABCAR Operator

 LABCAR-PA

 TS Tools
 Unit under Test
 Other ETAS Products
 3rd party Products
 DVE: Driver, Vehicle, Environment
Introduction
LABCAR-VDYM V5.0 Overview Product Data Model

Simulation model is completely based on Matlab / Simulink
All vehicle dynamics components are generated out of the MBS tool SIMPACK
LABCAR-VDYM V5.0 - Basic Model Composer & Library Browser

Model Composer
• for automatic configuration of LABCAR-VDYM Simulink Model Components

Library Browser
• for manual configuration of LABCAR-VDYM Simulink Model Components
LABCAR-VDYM V5.0 - Basic
Simulink Modular Model Structure

Driver
• Automatic/Manual Drivetrain
• Lateral and Longitudinal Controller
• Gear Switch Logic
• etc.

Vehicle Model
• SIMPACK Vehicle Dynamics (Semi-Trailing Arm Model)
• Engine
• Drivetrain (Automatic/Manual)
• Brake

Environment
• Course
• Friction
• Altitude
LABCAR-VDYM V5.0 - Basic Graphical User Interfaces

Driver GUI

Environment GUI

Vehicle Dynamics GUI
LABCAR-VDYM V5.0 - Basic Graphical User Interfaces
LABCAR-VDYM V5.0 - Basic
LABCAR-PA - Parameterisation Assistant Parameter Files

Parameter Import/Export
View Modified Parameter in Red Colour
View Values and Attributes
View Parameter History

Parameter Read/Write to Real-Time Target
View Tree Structure
XML-File Format

Note
- LCMPAss Data Files are offered together with LABCAR-VDYM V5.0
- LCMPAss *Software* is an *additional* Product
LABCAR-VDYM V5.0 - Basic Documentation Features

- Interactive Views in Simulink Model
  - Block C-Source Code of S-Functions (not for Vehicle Dynamics Components)
  - Block PDF-Documentation
  - Block Parameters

- Online PDF Documentation with working instructions
LABCAR-VDYM V5.0
Overview Model Extension Add-Ons

**LABCAR-VDYM V5.0 Basic**
(Semi-Trailing Arm Suspension)

**LABCAR-VDME1**
Vehicle Dynamics Model Extension 1
- Look-Up Table Suspension

**LABCAR-VDME2**
Vehicle Dynamics Model Extension 2
- Macro Joint Suspension

**Add-On: LABCAR-VDME1**
Look-Up Table Suspension

**Add-On: LABCAR-VDME2**
Macro Joint Suspension

Look-Up Tables

Physical Structure
Add-On: LABCAR-VDME1
VDYM Extension 1- Look-Up Table Suspension

Higher model accuracy:
- Wheel movement is described by look-up-tables
- Description is possible for any suspension type

Efficient parameterisation:
- Import data from SIMPACK and ADAMS/Car (LABCAR-SPCA required)
Add-On: LABCAR-VDME2 V1.0
VDYM Extension 2- Macro Joint Suspension

**Higher Accuracy:**
- Additional suspension types supported

**Efficient parameterisation:**
- Use geometric and physical data for model parameterisation
- Use data exported by SIMPACK
Add-On: LABCAR-VDME2 V1.0
Supported Suspension Types for Macro Joint

<table>
<thead>
<tr>
<th>Suspension Type</th>
<th>Add-Ons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five Link Suspension</td>
<td>Add-On Macro-Joint</td>
</tr>
<tr>
<td>MC-Pherson</td>
<td>Add-On Macro-Joint</td>
</tr>
<tr>
<td>MC-Pherson Dissolved</td>
<td>Add-On Macro-Joint</td>
</tr>
<tr>
<td>Double Wishbone</td>
<td>Add-On Macro-Joint</td>
</tr>
<tr>
<td>Double Wishbone Dissolved</td>
<td>Add-On Macro-Joint</td>
</tr>
<tr>
<td>Swing-Axis</td>
<td>Add-On Macro-Joint</td>
</tr>
<tr>
<td>Quadra-Link</td>
<td>Add-On Macro-Joint</td>
</tr>
<tr>
<td>Integral-Axis</td>
<td>Add-On Macro-Joint</td>
</tr>
<tr>
<td>Twist Beam</td>
<td>INTEC Engineering</td>
</tr>
<tr>
<td></td>
<td>(as Rigid Body Model)</td>
</tr>
<tr>
<td></td>
<td>(as reduced FE-Model)</td>
</tr>
</tbody>
</table>

INTEC Engineering
## LABCAR-VDYM V5.0
### Characteristics of the Model Extension Add-Ons

<table>
<thead>
<tr>
<th>Add-On: LABCAR-VDME1</th>
<th>Add-On: LABCAR-VDME2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Look-Up Table Suspension</strong></td>
<td><strong>Macro Joint Suspension</strong></td>
</tr>
</tbody>
</table>

**Modeling**
- Based on Look-Up Tables
- Based on physical principles

**Parameterization**
- Based on test bed data or data exported from MBS tool (e.g. SIMPACK)
- Based on technical design data (physical parameters)

**Range of validity**
- Depends on accuracy of test bed data, interpolation between the data points
- Non-linear behavior of kinematics

**Flexibility**
- New look-up tables required for each suspension type
- Change suspension types by changing parameters
Add-on: LABCAR-ACM V5.0
Animation Connector for LABCAR Models

- Animation-Tool based on Open Inventor
- Animation/Generation of all Roads
- Several Vehicle Types available
- Free Camera Positioning
- Free Scenery Definition using VRML
- Offline/Online Animation

- Course Overview
- Display all Course Types
LABCAR-VDYM V5.0 Model Validation
ETAS Hardware-in-the-Loop Testsystem

- Built up a ABS-HiL test-system for model and system validation
- Extensive tests using LABCAR-VDYM V5.0 and LABCAR-RTPC
- Running long term test using LABCAR-AUTOMATION
LABCAR-VDYM V5.0 Model Validation
ETAS ABS Hardware-in-the-Loop Testsystem - Results

my-Split Braking with ABS

my-Split Braking without ABS
LABCAR-VDYM V5.0 Model Validation
SIMPACK DAE against VDYM V5.0 Evaluation

• Model Component Test
  • Comparison SIMPACK (implicit model equation, DAE) against symbolic C-Code (explicit model equations, ODE, using Euler 1ms)
  • Comparison against reference simulation data of previous model versions
  • Based on a defined test manoeuvre

SIMPACK DAE Model against Euler Model, Macro Joint Model
LABCAR-VDYM V5.0 Model Validation
Measurement against Model

- Parameterisation of a entire vehicle model (Macro Joint Model)
- Validation of measurement data against simulation data

Slalom on Wet Surface (Measurements/Simulation)
## Others

### Real-Time Calculation Effort on ETAS Hardware

<table>
<thead>
<tr>
<th>Model</th>
<th>LABCAR-RTPC (2.0 GHz, PC)</th>
<th>ES1130.1 (366 MHz, VPPC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LABCAR-VDYM V5.0 (Semi-Trailing Arm Model)</td>
<td>0.25 ms</td>
<td>1.25 ms</td>
</tr>
<tr>
<td>LABCAR-VDME1 V1.0 (Look-Up Suspension Model)</td>
<td>0.4 ms</td>
<td>n.a.</td>
</tr>
<tr>
<td>LABCAR-VDME2 V1.0 (Macro-Joint Suspension Model)</td>
<td>0.7 ms</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

- Calculation effort for 1 Euler integration step
- Complete DVE-vehicle model (Driver, Vehicle, Environment), Spline course
Others

Current Engineering Projects

SIMPACK Real-Time
Motorbike integrated in LABCAR-VDYM V5.0

SIMPACK Real-Time
Truck Model integrated in LABCAR-VDYM V5.0
LABCAR-VDYM V5.0
Summary

• Open and extendable solution by
  • Model available in Simulink, open source
  • Engineering Solution by INTEC for every customer requirement

• Higher model accuracy possible by Add-Ons:
  • Look-Up Table Suspension Model
  • Macro Joint Suspension Model

• Increasing efficiency for parameterization by
  • Parameter interface to MBS tools (SIMPACK)
  • LABCAR-PA Parameterization Assistant, GUIs
Thank you for your attention!
Your questions are welcome!