JMAAB Vehicle Model Architecture
and Two-Way Connection

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Introduction
Model Based Development

Virtual World
- Plant Model
- Controller Model
- Validation
- Combination
- SILS
- HILS
- Rapid Prototype ECU

Real World
- Plant (Engine, Transmission etc.)
- Controller (Hardware, Software)
- Combination
- Validation
Component Oriented Modeling

Key Requirements
- partition based on actual parts composition
- standards to enable easy integration
Two-Way Connection
Simple Mechanical System

a schematic of the system

equation of motion for body $i$

$$T_{ext,i} + k_i (\theta_i - \theta_{i-1}) + k_{i+1} (\theta_{i+1} - \theta_i) = I \ddot{\theta}_i$$
Modeling with *Signal Flows*

Physical Architecture ≠ Model Architecture
Modeling with \textit{Two-Way Connection}

Physical Architecture = Model Architecture moving towards true \textit{component oriented architecture}
Signal ↔ Two-Way Adapter Block

No Change to Numerical Behavior

Two-Way Connection block in R2007a Simscape v1
Application

JMAAB Style Guidelines
& Vehicle Model Architecture
JMAAB Plant Model Style Guidelines

- Component Hierarchy
- Model Implementation
- Methods for Connecting Components
- Integration of Controller and Plant Models
- Use of Data Types
- Use of Coord. Sys., Unit Sys. and Physical Consts
- Methods for Model Parameterization
Vehicle Model Architecture

- Component Hierarchy

vehicle model architecture (template)
subsystem layers & component partitions

Level | Component Hierarchy
--- | ---
1 | Driver | Vehicle | Tire-Road | Environment
2 | Vehicle Ctrl | Vehicle Body
3 | Power Train | Chassis | Electricity
4 | Power Train Ctrl | Power Train Body
5 | Engine | Engine Mount | Transmission | Differential
Vehicle Model Architecture

- Model Implementation
  general rules for plant modeling in Simulink
  prohibited blocks and constructs, use of fonts and colors, etc.

- Methods for Connecting Components
  rules for use of signal lines, Goto/From blocks, bus signals
  for good readability
Guidelines for Closed-Loop Simulation

- Integration of Controller and Plant Models
  for use in the hardware-in-the-loop simulation
  streamlining of the workflow of closed-loop simulation
Other Guidelines

- Use of Data Types
  consistent choice of data types
  physical value, logical value, Switch block etc.

- Use of Coord. Sys., Unit Sys. and Physical Consts
  standard modeling practices among developers*
  *developers can span across OEM and suppliers.

- Methods for Model Parameterization
  consistent use of parameters
  workspace variables, M-files
Future Work for JMAAB PM-WG

- Further evaluation of the Style Guidelines with the vehicle model as a working example

- Identification of requirements for Two-Way Connection from the automobile engineering standpoint

- Benchmark of the vehicle model to examine the effectiveness of the style guidelines

- Consideration on Data Dictionary for Plant Models to enable smooth exchange of models
Conclusion

- Component oriented physical modeling
  two-way connection in R2007a Simscape

- Common rules for MBD plant modelers
  J MAAB Style Guidelines for Plant Models

- Test case in automobile industry
  vehicle model architecture
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