# JMAAB Vehicle Model Architecture and Two-Way Connection



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David Sampson
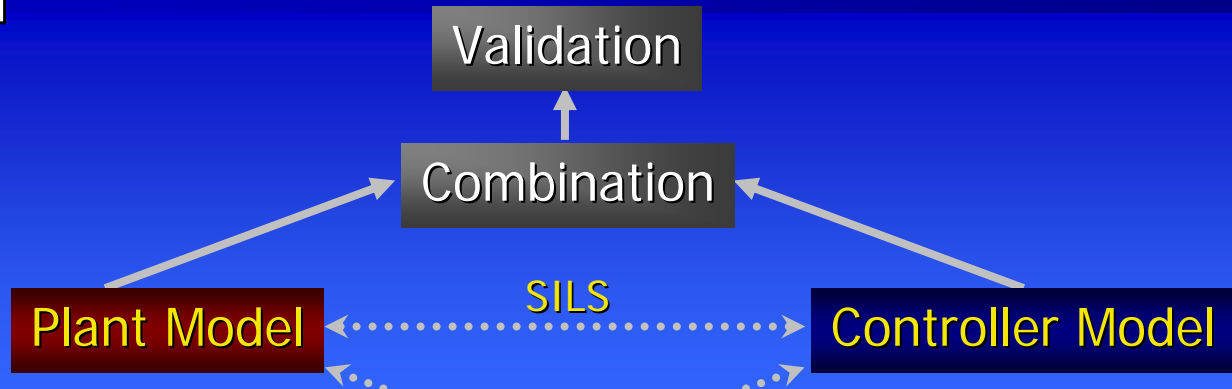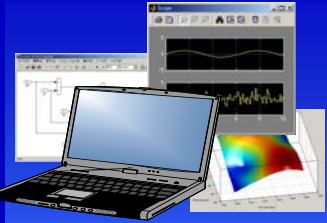*The MathWorks, Ltd*

# Contents

1. Introduction

2. Two-Way Connection

3. Application – Guidelines & Vehicle Model

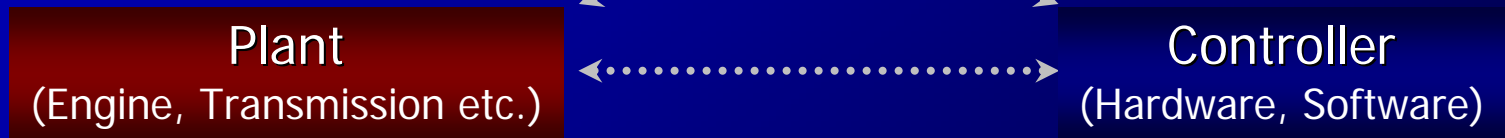4. Future Work

5. Conclusion

# Introduction

# Model Based Development
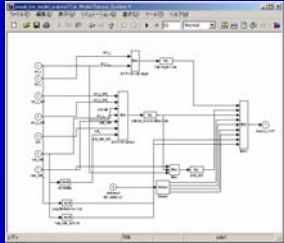


**Virtual World**

Validation

Combination

Plant Model        SILS        Controller Model

Rapid Prototype ECU        HILS

**Real World**

Plant
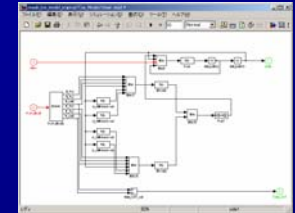(Engine, Transmission etc.)        Controller
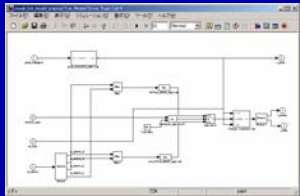(Hardware, Software)

Combination

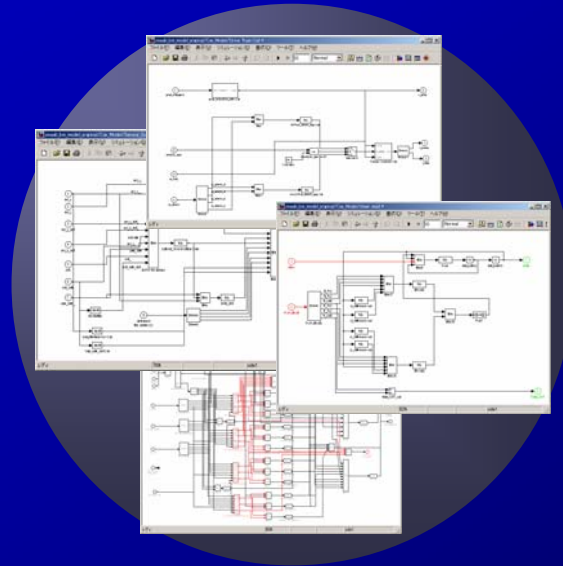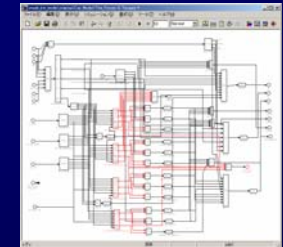Validation

# Component Oriented Modeling



Component A

Component C

A large, complete plant model

Component B

Component D

Key Requirements
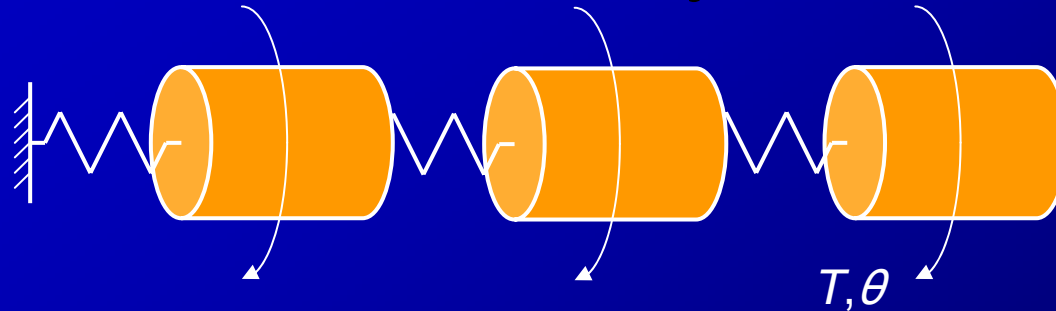- partition based on actual parts composition
- standards to enable easy integration

# Two-Way Connection

# Simple Mechanical System

## a schematic of the system



$T,\theta$

## equation of motion for body $i$

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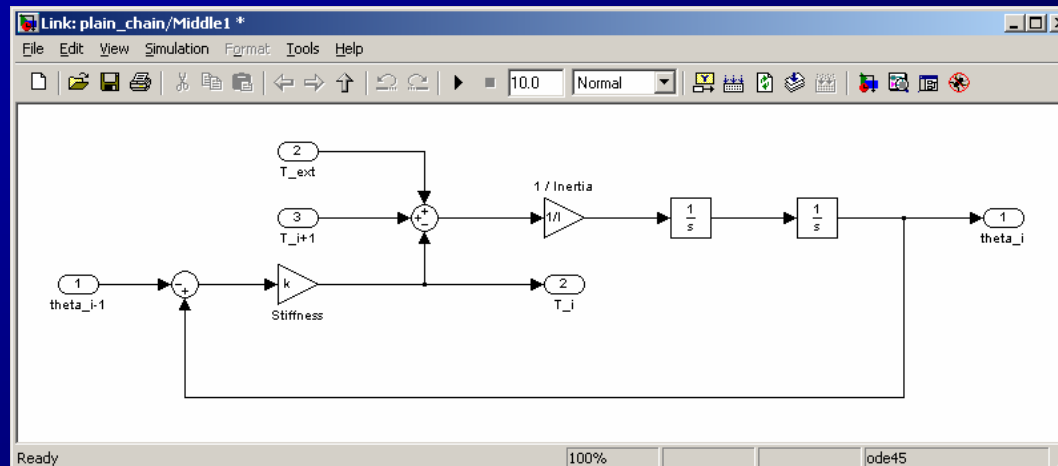
# Modeling with *Signal Flows*



$T, \theta$
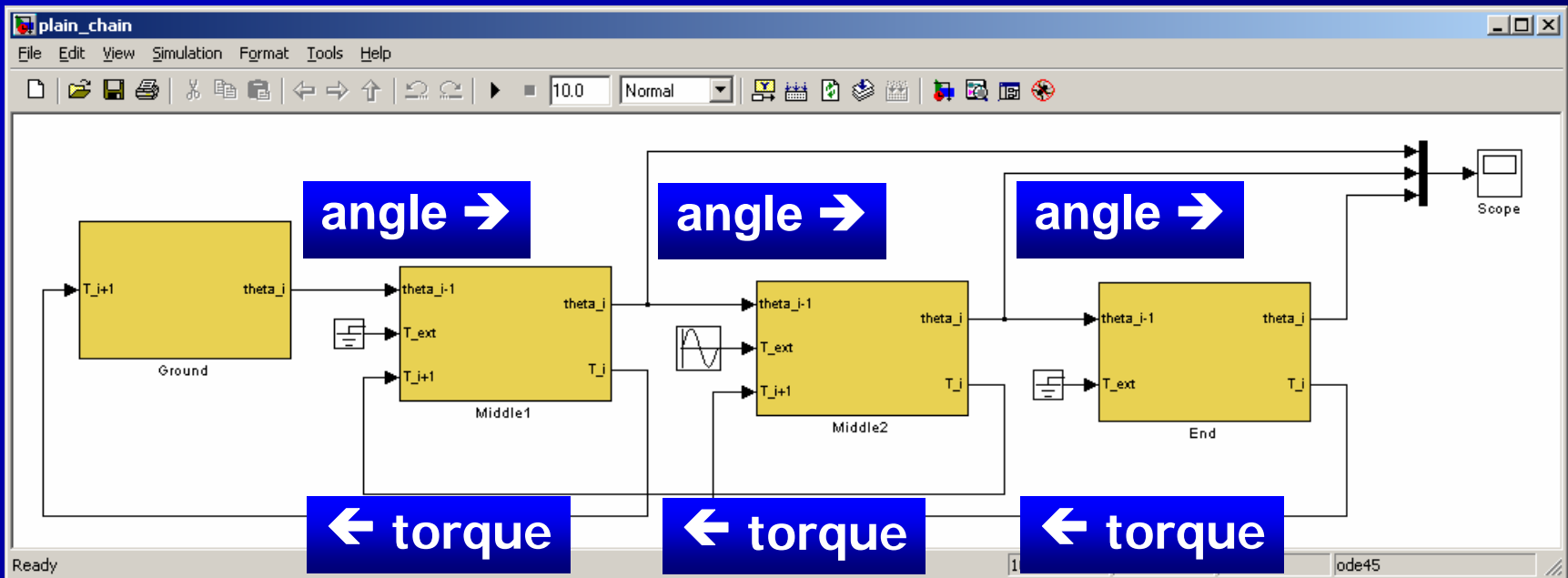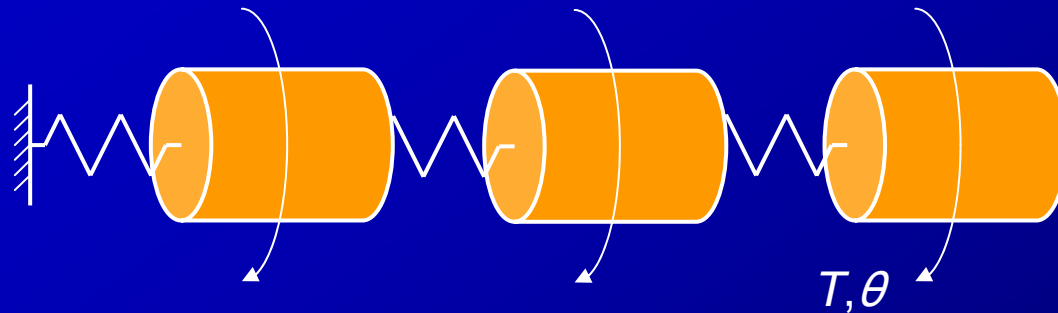
**Physical Architecture ≠ Model Architecture**

# Modeling with *Two-Way Connection*
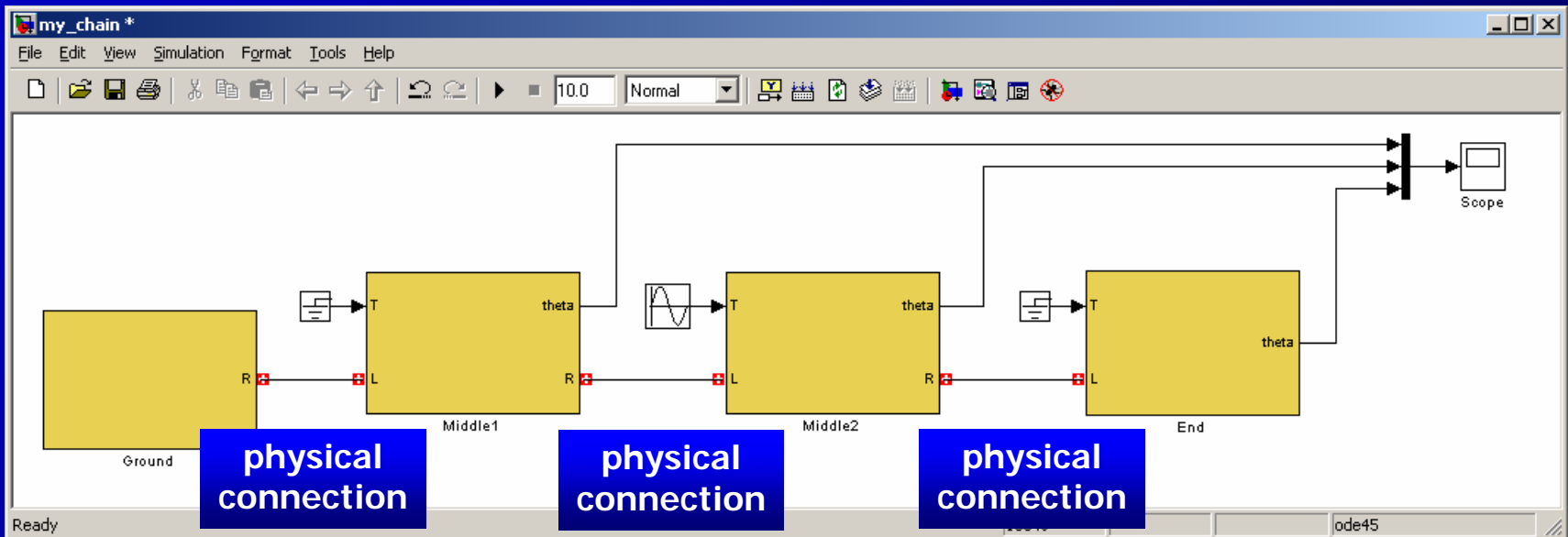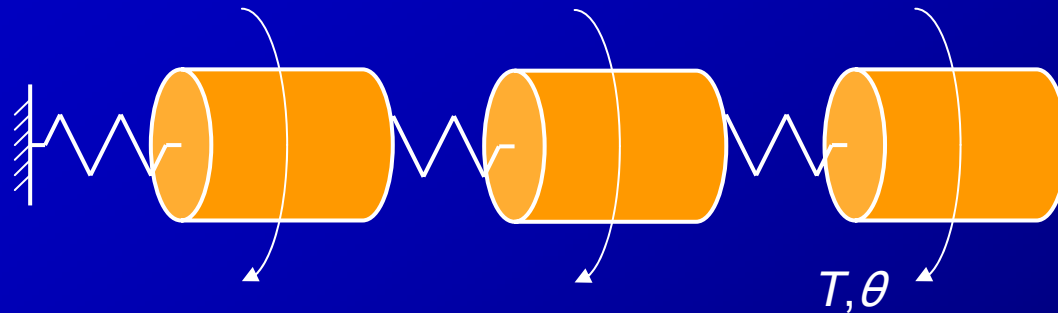


**Physical Architecture = Model Architecture**
**moving towards true *component oriented architecture***

# Signal ⇔ Two-Way Adapter Block
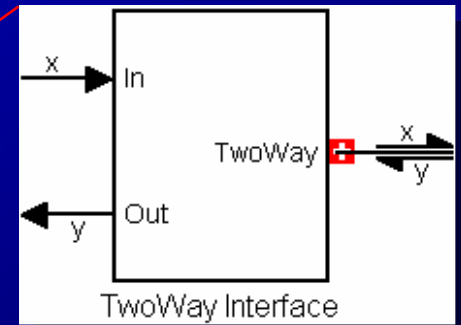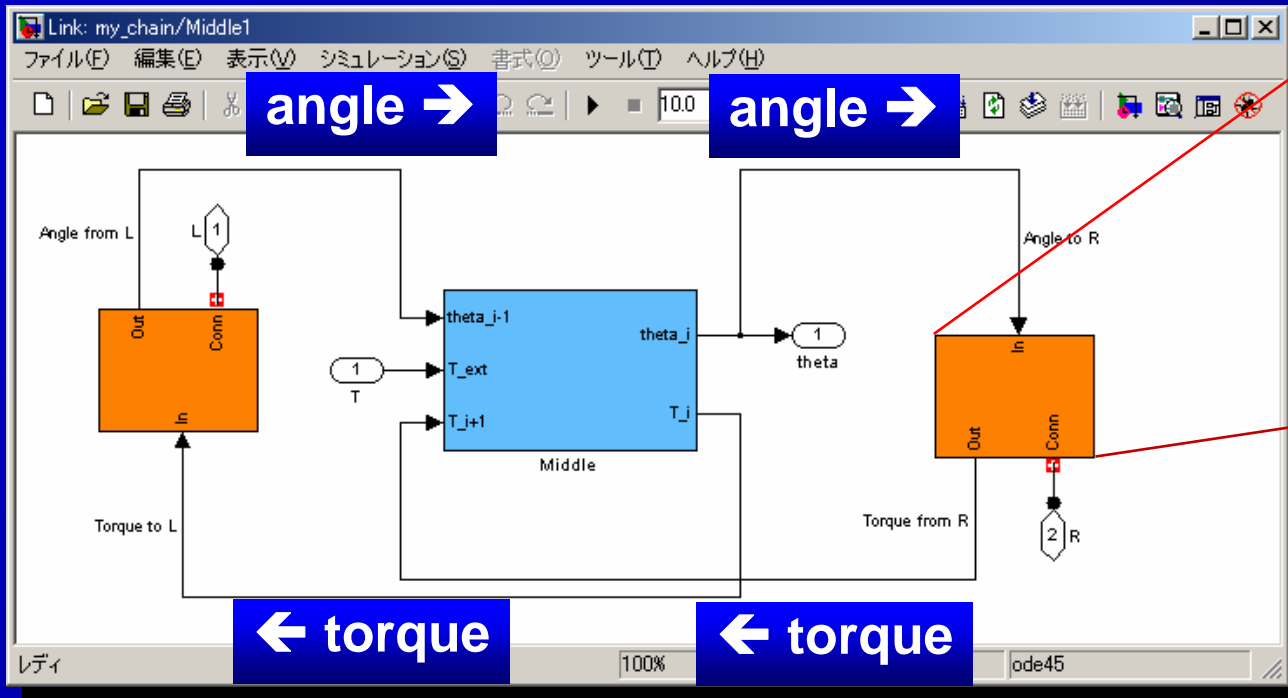


No Change to Numerical Behavior

**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**

**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 |
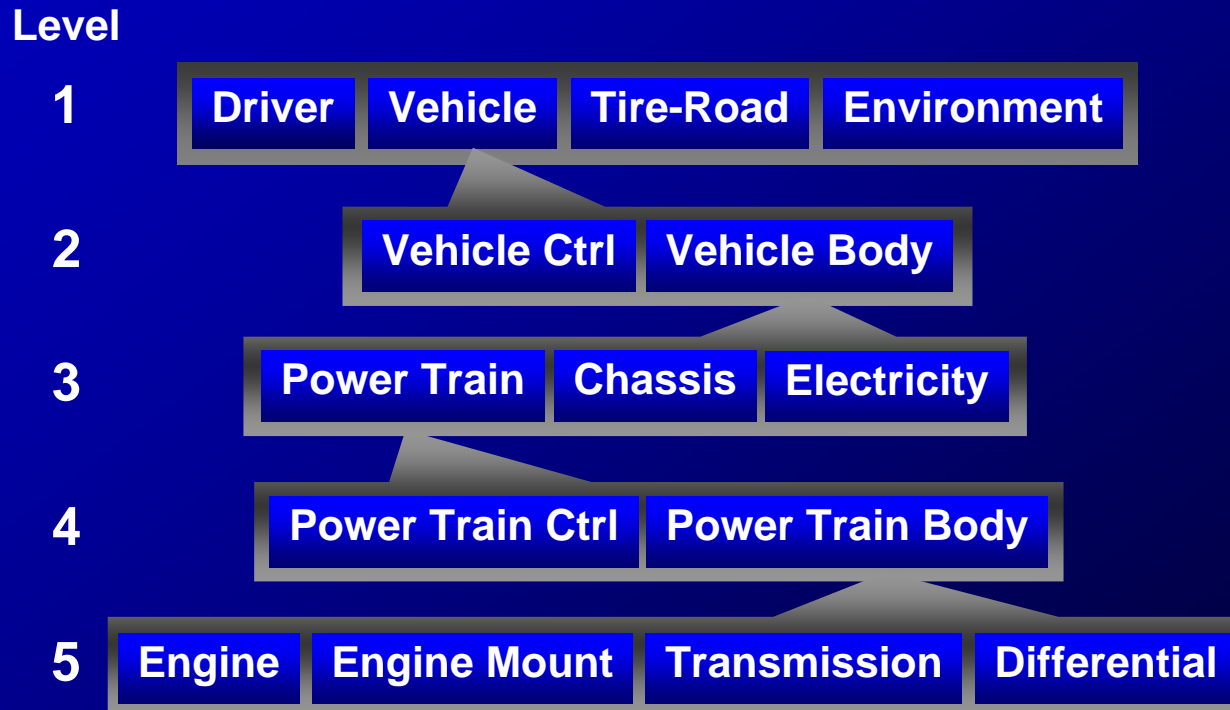
# Vehicle Model Architecture

- 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
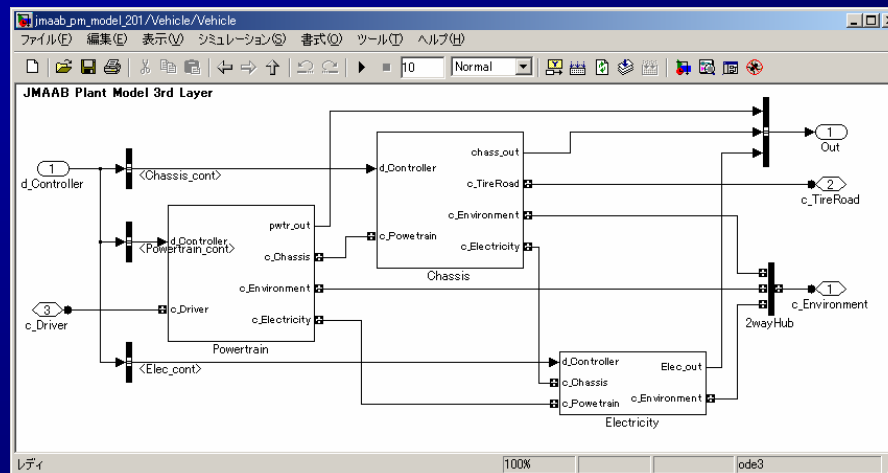
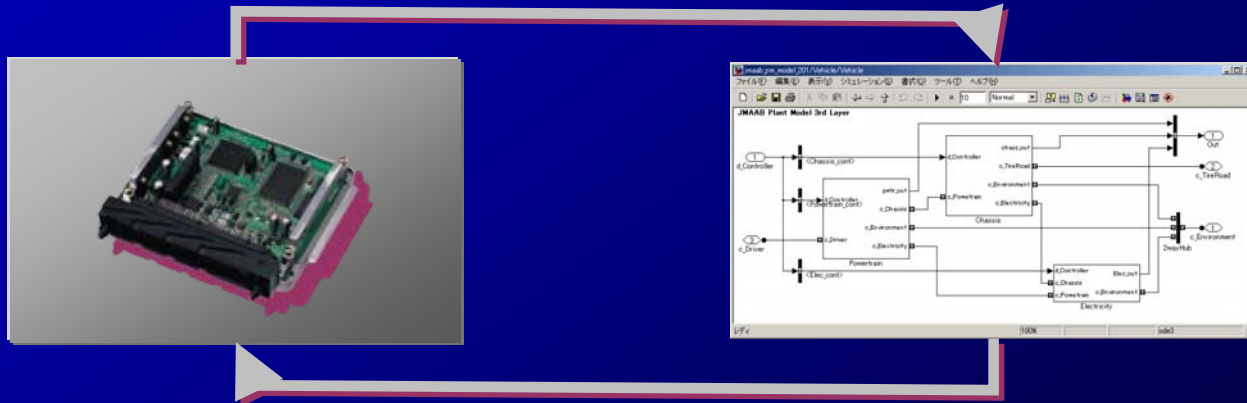# Guidelines for Closed-Loop Simulation

- 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
  JMAAB Style Guidelines for Plant Models

- Test case in automobile industry
  vehicle model architecture

18

# *Thanks to...*

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