Contents:

1. METI MBD WG

2. 2019 METI Proposal
   New Guide Line (Thermal, Flow, Pressure)
   METI Fuel Consumption Model w/Thermal

3. METI Guideline Use case
1. METI MBD WG – Introduction –

- Participants
- Background
- Vision
- Direction & Results
- Last year corroboration outcome
- Our future activity scope
- Schedule
- METI MBD WG Org. Structure
METI MBD WG -Introduction-

Study group on how to use models in the automobile industry

- **OEM**
  - Toyota
  - Nissan
  - Honda
  - Mazda

- **Supplier**
  - Denso
  - Aisin AW
  - Jatco
  - Melco
  - Hitachi-AMS
  - Panasonic

- **Engineer Service**
  - AZAPA

- **Secretariat**
  - Arthur D.Little
  - Environmental Partnership Council
MBD (Model-based Development) is the Key for survival

- Method to advance development by using simulation without prototyping vehicles as much as possible
- Accelerate development (reduce development resources and improve accuracy)
- In the future, essential for the development of autonomous vehicles

MDB application process

Effect of MBD

Note: In control system development point of view.
Our MBD process scope is much wider as PSI’s V diagram.
Vision

SURIAWASE 2.0 Vision

- We will upgrade the internal and external relationship among industries and companies, accurately and at high speed through the use of “thorough simulation” and the “fusion of science and engineering” to strengthen the development capability of the whole country.
- We also simultaneously attained human resource development by improving supplier productivity and deepening industry-university collaboration, making it the world’s most advanced development base.

World’s most advanced development base

Research
(Science)

- Enriching research environment
- Improve the appeal of academics!

Development
(Engineering)

- Cutting-edge science, offered as a simulation model
- Combining elemental technologies
- Sublimation of the current model

Academy

Industry

Domestic level

1. Common guideline · model
2. Human resource development
3. Introduction support

On the next slide
METI MBD WG -Introduction-

**Direction**
- To realize the MBD through model exchange
  - Define I/F guidelines independent of tool and language
  - Offer Guidelines-compliant model to promote understanding of the guidelines

Plant model I/F Guideline

Guidelines-compliant model
METI MBD WG  -Introduction-

Last year collaboration

• METI WG proposed our plant model interface guideline to SystemX and PeoSTEPivip(PSI) through the workshops.
• PSI with consideration with SystemX has released.

METI MBD WG -Introduction-

■ Activity Scope

• METI MBD WG has plans to expand guidelines to other areas from layer of fuel consumption simulation.
• We hope cooperation with you about the items below. (explain in detail later)
  – Interface guidelines in・・・
    • Vehicle model for other attributes
    • Detailed engine model
    • Detailed transmission model

Horizontal axis
Expansion of Attribute
or Domain or System

Vertical axis
Expansion of Fidelity

Low Fidelity
(OEMs use)

High Fidelity
(Suppliers use)

Released!

Accelerate development of next-generation cars (3 years subsidy)

New Domain
(under review)

International Standard

Support to promote MBD

Prostep ivip
SystemX

Layer1
Layer2
Layer3
Layer4
Layer5

Open
Closed

Human Resource Dev.

I/F Guideline and compliant model
METI MBD WG -Introduction-

■ METI MBD WG and Related Organization

METI MBD WG does not have regal basis in comparison with PSI and System X.
#Considering Operable organization by oneself
=> Now we have a plan to establish more firm body.

Our Activity in Japan

- METI
- Organizing Committee: Each companies Executive
- Secretariat: EPC, AZAPA, ADL
- Working Group: Toyota, Nissan, Honda, Mazda, Denso, Aisin AW, Jatco, Melco, Hitachi-AMS, Panasonic, AZAPA
- Guideline Update
- METI Model Update

- JSAE
- JAMA
- JAPIA

- ICE Tech WG (AICE)
- Transmission Tech WG (TRAMI)
- Battery Tech WG
- ??? Tech WG
 METI MBD WG  -Introduction-

- Important Web page

<METI HP>
- Automotive industry policy

- METI_MBD_WG Activity page

<EPC>
- EPC HP you can reach our latest results
  [https://epc.or.jp/sim_2018model_english](https://epc.or.jp/sim_2018model_english)
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2. 2019 Year METI Proposal

- The Scope of our Guideline
- Recapture of 2018 Year METI Proposal

- 2019 Year METI Proposal -
- New Gide Line (Thermal, Flow, Pressure)
- METI Fuel Consumption Model
2. 2019 Year METI Proposal

The scope of our Guideline

Point: Semantic rules with tool independency for Automotive

A. Plant Model I/F Guidline (In Scope)

B. Modeling Tools I/F Standards (Out of Scope)

C. Modeling Language Unification (Out of Scope)
2. 2019 Year METI Proposal

- Recapture of 2018 Year METI Proposal

1) Plant Modeling I/F Guidelines for Vehicle Development

  - Basic Principle

  - Example Guideline for Automobile Systems Details of the guideline for each physical domain

  - Examples of Subsystem I/F (interface) Definition Documents in regards to Automobile development
### Five Basic Principles

<table>
<thead>
<tr>
<th></th>
<th>Basic principles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1st</strong></td>
<td>Plant models shall be connected using across variables and through variables. Across variables and through variables shall be in the opposite direction.</td>
</tr>
<tr>
<td><strong>2nd</strong></td>
<td>The direction of flow from energy source to energy sink shall be considered as the positive direction of energy flow.</td>
</tr>
<tr>
<td><strong>3rd</strong></td>
<td>The overall I/F will be defined based on the I/F of elements which store through and across variables.</td>
</tr>
<tr>
<td><strong>4th</strong></td>
<td>A Through variable shall be regarded as positive when its input/output is in the same direction as the positive flow of energy.</td>
</tr>
<tr>
<td><strong>5th</strong></td>
<td>For input/output, the SI units system and the SI derived unit system shall be used. For the quantifiers, the JIS standard shall be applied.</td>
</tr>
</tbody>
</table>
2. 2019Year METI Proposal

- Example Guideline for Automobile Systems (for fuel efficiency)
2. 2019 Year METI Proposal

- Example of Subsystem Interface (I/F) Definition Documents
-2019 Year METI Proposal-

New Guideline (Thermal)
METI Fuel Consumption Model w/Thermal
## New Guideline on Five Basic Principles

<table>
<thead>
<tr>
<th>Basic principles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1st</strong></td>
</tr>
<tr>
<td><strong>2nd</strong></td>
</tr>
<tr>
<td><strong>3rd</strong></td>
</tr>
<tr>
<td><strong>4th</strong></td>
</tr>
<tr>
<td><strong>5th</strong></td>
</tr>
</tbody>
</table>
First principle
Plant models shall be connected using across variables and through variables. Across variables and through variables shall be in the opposite direction.

Across variable and through variable in thermal fluid domain

<table>
<thead>
<tr>
<th>Physical Domain</th>
<th>Across Variable</th>
<th>Through Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical</td>
<td>Potential/Voltage</td>
<td>Current</td>
</tr>
<tr>
<td>Translational</td>
<td>Velocity</td>
<td>Force</td>
</tr>
<tr>
<td>Rotational</td>
<td>Angular Velocity</td>
<td>Torque</td>
</tr>
<tr>
<td>Heat</td>
<td>Temperature</td>
<td>Heat flow</td>
</tr>
<tr>
<td>Thermal fluid</td>
<td>Temperature</td>
<td>Mass flow rate</td>
</tr>
<tr>
<td></td>
<td>Pressure</td>
<td>Enthalpy flowrate</td>
</tr>
</tbody>
</table>

Physical domains which are not shown in Table 2 shall be discussed and determined in the future.
Fifth principle (unit and quantifier)
For input/output, the SI units system and the SI derived unit system shall be used. For the quantifiers, the JIS standard shall be applied.

### Unit of across variable and through variable

<table>
<thead>
<tr>
<th>Physical Domain</th>
<th>Across Variable</th>
<th>Through Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantifier</td>
<td>UNIT</td>
</tr>
<tr>
<td>Electrical</td>
<td>Voltage</td>
<td>V</td>
</tr>
<tr>
<td>Translational</td>
<td>Velocity</td>
<td>v m/s</td>
</tr>
<tr>
<td>Rotational</td>
<td>Angular Velocity</td>
<td>ω rad/s</td>
</tr>
<tr>
<td>Heat</td>
<td>Temperature</td>
<td>T K</td>
</tr>
<tr>
<td>Thermal fluid</td>
<td>Temperature</td>
<td>T K</td>
</tr>
<tr>
<td></td>
<td>Pressure</td>
<td>P N/m²</td>
</tr>
</tbody>
</table>
2. 2019 Year METI Proposal

- Example Guideline for Automotive Thermal System

![Diagram of automotive thermal system](image)
2. 2019 Year METI Proposal

- Example Guideline for Automobile Systems

![Diagram of automobile systems](image)
2. 2019Year METI Proposal

- Examples of Subsystem I/F (interface) Definition Documents in regards to Automotive Thermal System

- Energy source

- Energy sink

- Model function overview
  - Function overview
    - The heat quantity from eng. model is received, and heat storage and heat dilution in the eng. are simulated.
  - 1. Heat capacity: Eng. block / Coolant / Oil

- Subsystem I/F Definition
  - Subsystem Name: Eng. (P/T thermal)

- Plant model I/F
  - **Input**
    - Name | Unit | Polar direction | Description
    - Heat flow rate T1 | W | Input side = positive | Heat flow rate from eng. heat source to eng. thermal
    - Heat flow rate T2 | W | Input side = positive | Heat flow rate from eng. thermal to T/M
    - Heat flow rate T3 | W | Input side = positive | Heat flow rate eng. thermal to high temp. cooling system

  - **Output**
    - Name | Unit | Area | Description
    - Temp. T1 | K | | Temp. of eng. cylinder head
    - Temp. T2 | K | | Temp. from eng. thermal to T/M
    - Temp. T3 | K | | Temp. of eng. coolant
    - Heat flow rate T4 | W | Input side = positive | Heat flow rate from eng. block to heat sink

  - **Energy direction**
    - Name | Energy positive direction | Description
    - Heat E1 | Input | Energy from eng. heat source
    - Heat E2 | Output | Thermal energy from eng. thermal to T/M
    - Heat E3 | Output | Thermal energy from eng. thermal to high temp. cooling system
    - Heat E4 | Output | Thermal energy from eng. thermal to heat sink

- Note
  - Although the energy I/F to the heat sink (outside air) is one, there may be multiple I/Fs according to the verification contents.

- Table
  - var | Contents | Company name | Prepared by | Date
  - 01 | Initial version | A|A|PA | Junichi Ichihara | Mar 6th, 2019
Guideline Compliant Model

Creation of thermal model
Creation of simulation to understand the thermal guidelines
Engine, transmission, differential gears, power train thermal system, external ambient model creation.
2. 2019 Year METI Proposal

- Download site information
  https://epc.or.jp/sim_2018model_english

The Guidelines and the Vehicle Performance Simulation Model for FY 2018’s Subsidy for Building Simulation Platforms to Accelerate Development of Next-Generation Vehicles have been released

Today, we have released the following information regarding the Guidelines and Vehicle Performance Simulation Model for FY 2018’s Subsidy for Building Simulation Platforms to Accelerate Development of Next-Generation Vehicles.

1. Purpose of the subsidy
This project aims to build a stable and appropriate energy supply & demand system that fits both the domestic and international economy, society, and environment. In order to accomplish that, the EPC will subsidize a portion of expenses needed to build vehicle performance assessment models, so that private organizations can efficiently lead development of vehicles by simulating the entire vehicle and not building actual vehicles for assessments. The EPC will also engage in projects to promote wide-scale use of vehicle performance assessment models, with the aim of accelerating development of next-generation vehicles.
ProSTEP/SystemX/METI Meeting
2019/9/17 with SystemX in Paris
2019/9/24 with ProSTEPivip in Darmstadt
2019/10/17 System Engineering Day Tokyo

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3. METI Guide Line Use case

- Outcome up to last year
- Vision through model exchange

- CASE1: Application to powertrain controller development
- CASE 2: Model Exchange inside the supplier company

- Road Map for “SURIAWASE 2.0”
- The scope of our Guideline
- To achieve the Goal
3. METI Guide Line Use case

■Outcome up to last year

(1) Established the guideline.
“Plant Model I/F Guideline for Automobile Development ver.1.0” and “Guideline Handbook ver. 1.0” were released.

(2) Released the model ver. 1.0 compliant to the guideline.
- Simulation model for FE performance
- Based on • 1.5L CVT vehicle

(3) Created the model handbook.
- How to use models
- Handbook for models conforming to the guideline
- Model description method
3. METI Guide Line Use case

Vision through model exchange

- Suppliers develop each product on “whole vehicle” viewpoint
- Period-shortening and cost-cutting of model development

OEM / suppliers develop each product using the common vehicle model
3. METI Guide Line Use case

**Case1: Application to powertrain controller development**

Model exchange for the models of powertrain-SILS/HILS

**Vehicle model**

Drivetrain-SILS

- Engine (C, H)
- Engine control

Drivetrain-HILS

- Engine
- Transmission

Vehicle model

Transmission (C, H)

- Engine control

Transmission system

- EFI-ECU
- ECT-ECU

OEM / supplier exchange mutually the component models based on the role of vehicle development
3. METI Guide Line Use case

- Technical issues in model exchange
  
  Not only OEM, but also Supplier Confirmed BENEFITS (Development Efficiency and Deep understanding the control strategy) with some technical issues.

  There are some issues such as different model structure, simulation tool constraint and confidential information concealment among companies.

  1. Division of non-causal model
    
    >> Transforming the numerical formula from DAE to ODE by inserting 1st order transfer function

  2. Implementation to HILS of control model
    
    >> Reducing the computing cost by shifting the task timing

  3. Concealment of control model
    
    >> Providing the object files to supplier by compiling the controller soft (c-files) separately
3. METI Guide Line Use case

CASE 2: Model Exchange inside the supplier company

Realizing MODEL Plug and Play

Vehicle Level
- Torque
- Thermal
- Elec
- Refrigeration Cycle (Heat fluid motor)
- Compressor (Mech / Heat fluid)
- Cooling water system (Heat fluid motor)
- Vehicle (Mech, Fluid, Combustion, Elec)
- Environment (Outside, Driving Condition)

System Level
- Power Train
  - Engine system
  - Transmission system
- Thermal
  - Cooling system
  - Heat exchanger
- Electrical
  - Electrical system
- Electronic
  - Electronics control system

Component Level

Model Plug and Play by utilizing the guideline compliant models
3. METI Guide Line Use case

Compatibility among the development model and the guideline compliant models
3. METI Guide Line Use case

Road Map for “SURIAWASE 2.0”
Consensus Process between OEM and suppliers through models.

Ideal Goal

1D Model 3D Model

MBD promotion (OEM&Tier1)

Model Exchange promotion (Tier&Tier2,3…)

MBD promotion (Tier2,3…)

Model Exchange promotion (Tier&Tier2,3…)

Step 1

OEM Tier1 Tier2以降

MBD promotion (OEM&Tier1)

Model Exchange promotion (OEM&Tier1)

Current

OEM Tier1 Tier2以降

35
3. METI Guide Line Use case

The scope of our guideline (METI activity)

- Semantic rules with tool independency for Automotive

A. Plant Model I/F Guidline (In Scope)

B. Modeling Tools I/F Standards (Out of Scope)

Vehicle level templates

Physical Phenomenon A

Physical Phenomenon B

Physical Phenomenon C

FMU

Dymola

Simulation X

Simplorer

SystemVision

Modelica

VHDL-AMS

ProSTEP/SystemX activity

C. Modeling Language Unification (Out of Scope)
3. METI Guide Line Use case

To achieve the Goal="SURIAWASE2.0"

To realize the front loading development through the model circulation
(avoid different model for the same product. Reduce supplier burden)

Next Step: METI MBD WG will try 2\textsuperscript{nd} PDCA with not only METI Guideline but also ProSTEP and SystemX activity.

- **【2F】**
  Production Development Model

- **【1F】**
  Common simple high level model
  (Ex: 1.5L EFI × 5AT)

- **【1F】** METI model guideline & the guideline compliant Models
  (国内標準車両モデル)

- **【0F】** ProSTEP/SystemX Collaboration

- **Detailed rules**
  - Plant Model I/F Gideline
  - Architecture FMI IP

- **General**
  - Detail