JAMBE general purpose model as controller models distribution platform

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Executive summary

I share the challenge of “JAMBE general purpose model (JAMBE generic model / Easy MIL) has been used as controller model distribution platform in NISSAN”.

• Our problem
  We sometimes lose the opportunity MBSE iteration.
  It took huge time to connect between PLANT model and CONTROLLER model, because CONTROLLER model was distributed standalone.

• Our solution trial
  1. CONTROLLER model is implemented to JAMBE generic model.
  2. It has been distributed as a easy model in the loop(MIL).
  3. Validator transfers necessary bare minimum CONTROLLER model from JAMBE generic model to validator’s target MIL.
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**Experience:**
10 years in Powertrain (Diesel) software engineer at German supplier.
20 years in Powertrain (Diesel/Gasoline/xEV) control system engineer at NISSAN.

**My home country:**
I have lived in Japan 98% of my life.
I had lived in Germany Stuttgart for 1 year.
CONTROLLER model distribution for validation had been stand-alone.

Implemented model distribution challenge using JAMBE generic model

Case study for ADAS virtual validation

Wrap-up

Future outlook / Collaboration with MBSE&PLM
Problem recognition

CONTROLLER model distribution for validation had been stand-alone.

To-be:

Ideal controller design process by model based development (MBD)

Controller design

Virtual validation

Trends / Expectation

More more SPEED!!!

To avoid reworking from right bank

Real controller

MIL simulation at left bank

NO

OK

MIL
Problem recognition

**CONTROLLER model distribution for validation had been stand-alone.**

### As-Is:

- **Can you share Controller model for MIL creation?**
  - Sure, immediately.

- **Mmm, I send Whole model at the moment, because not sure about target system well.**

- **There are too many interfaces to connect, and Speed is very slow.**

- **Virtual validation**

- **Q&A**

- **Controller design**

[What’s the problem?]

Controller model standalone distribution ➔ It takes huge time for MIL...

1. **Creation**
   Q&A for the model connection.

2. **Execution**
   Execution time of MIL simulation unnecessary control models implement.

- **Lose the opportunity...**

- **To the next process**
Problem

Problem recognition

- CONTROLLER model distribution for validation had been stand-alone.

Solution idea: JAMBE generic model uses as controller models distribution platform.

1. Decompose the controller model into the control function.
2. Implement to JAMBE generic model (MIL)
3. Distribute in-house as an easy MIL
4. Copy & paste to the target system

Prospect

- Controller model as a MIL distribution
  - It spends less time for MIL...

1. Creation
   - To reduce Q&A.
2. Execution
   - To be able to choose necessary control

Virtual validation
Implemented model distribution challenge using JAMBE generic model

About the model of JAMBE Generic(easy MIL)
JAMBE No20011 Generic Model/Electric Vehicle Electricity Consumption Model - MATLAB/Simulink

The model is available to everyone for free from JAMBE web site.
Our trial

- Implemented model distribution challenge using JAMBE generic model

About the controller model functional decomposition and implementation

Conceptual model diagram

*Powertrain controller*

- **Driving force**
  - Driving force setpoint
  - AD/ADAS co-operation
  - Drive mode detection
  - Drivability ...

- **Thermal**
  - Thermal management
  - Cooling setpoint
  - Thermal recovery
  - Thermal device control ...

- **Low voltage**
  - Low voltage control
  - Target voltage setpoint
  - Lead acid battery cont.
  - DCDC-Converter cont.

In-house controller models distribution

Implemented to JAMBE generic model

Trial
Our trial

- Implemented model distribution challenge using JAMBE generic model

[Why does NISSAN use JAMBE generic model for controller model distribution?]

⇒ It has stable foundations as good point.

**Good point 1.**
Energy domains are modeled based on physical networks.

**Good point 2.**
The modeling balance between resolution and runtime is well suited for distribution.
Why does NISSAN use JAMBE generic model for controller model distribution?

Good point 1. Energy domains are modeled based on physical networks. The controller is equipment of power estimation/adjustment from across variable (eg. Volt / Speed). ➔ Correct relationship between energy domains is important for correct simulation behavior.
Our trial

Why does NISSAN use JAMBE generic model for controller model distribution?

Good point 2. The modeling balance between resolution and runtime is well suited for distribution.

Modeling balance

- The enough energy domains are contains in the powertrain control area.
- The physical network between each energy domain is reproduced.

<table>
<thead>
<tr>
<th>Runtime</th>
<th>@WLTC mode (class3b) 1800[s]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td><strong>Time(s)</strong></td>
</tr>
<tr>
<td>Our trial</td>
<td></td>
</tr>
<tr>
<td>Controller : NISSAN Driving force model</td>
<td>700</td>
</tr>
<tr>
<td>Plant : JAMBE Generic model</td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td></td>
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<td>Controller : JAMBE Generic model</td>
<td>50</td>
</tr>
<tr>
<td>Plant : JAMBE Generic model</td>
<td></td>
</tr>
</tbody>
</table>

- It is acceptable speed for control behavior confirmation.
  (faster than 2.5 times than real plant)
We had to create wrapper models that fulfilled all controller inputs.

To give an example: There are many vehicle speed inputs for powertrain controller.

- **REAL**: Several kinds of vehicle speed input types
- **JAMBE generic model**: Just one type of vehicle speed

The controller behavior cannot be reproduced without correct inputs.

⇒ It needs to create a wrapper model for all controller inputs.
Case study for ADAS virtual validation

xEV autonomous driving Co-simulation had took place between ADAS control model and Powertrain control model. It could reproduce transient scene of regeneration.

Trade-offs between drivability and efficiency can be validated on the V-bank left.
Wrap-up

- There are prospects for improving in-house control models distribution.
- MBD can be proceeded by improving control model distribution.

Future outlook

- Expand the distribution area of control models as analysis model (MBD).
- Expand understanding using descriptive models (MBSE).

### Descriptive model (MBSE)

- **SysML**
  - [New problem recognition]
  - Requirement/Constraint/Architecture explanations are needed.
  - Expand understanding

### Analysis model (MBD)

- **Controller model**
  - Driving force
  - This Presentation
  - Other controls
  - Expand the distribution area

- **Plant model**
  - JAMBE generic
  - MBx way will be established
Thank you for your attention.