NISSAN
MOTOR CORPORATION

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.

Mr. Atsushi Saito

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Powertrain and EV Control Technology Department

- **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 1year.

Agenda

Problem

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

Trial

■Implemented model distribution challenge using JAMBE generic model

Case study

■Case study for ADAS virtual validation

Wrap-up

■Wrap-up
■Future outlook / Collaboration with MBSE&PLM

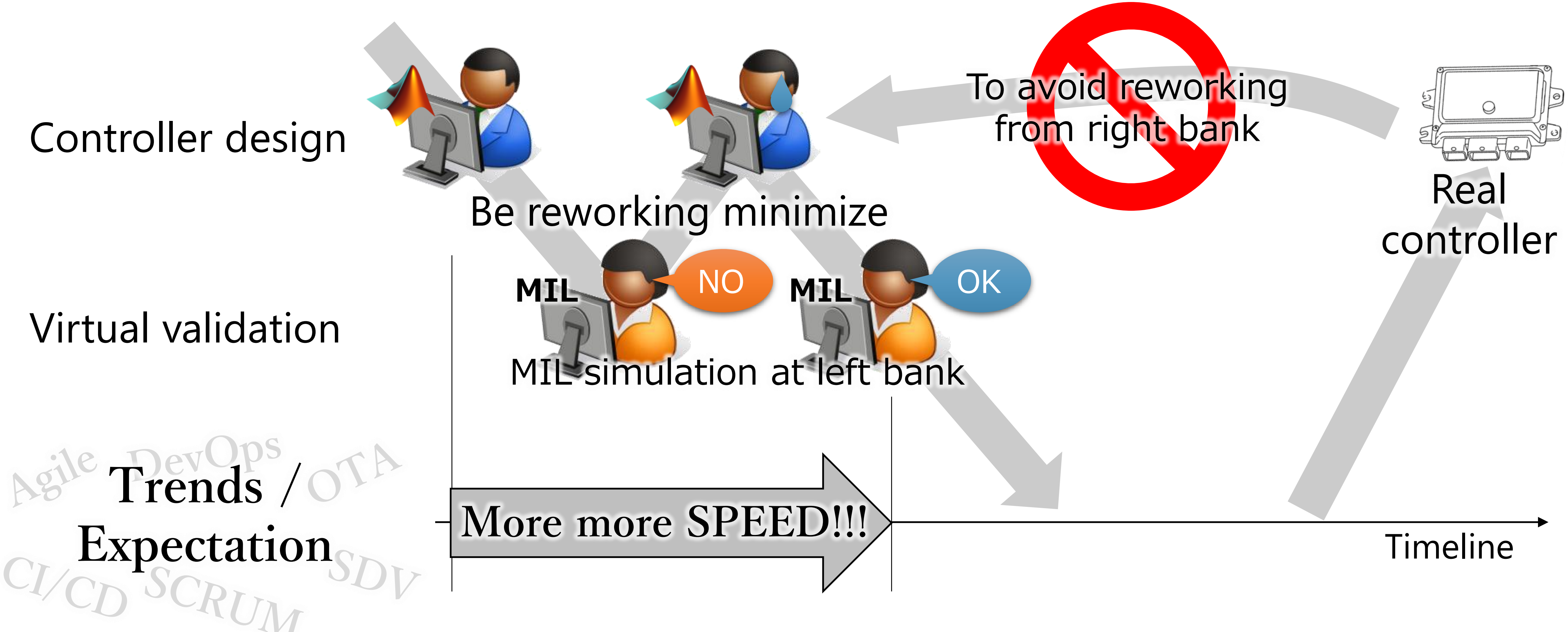
Problem

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

Agile DevOps OTA CI/CD SCRUM SDV

To avoid reworking from right bank

Real controller

Be reworking minimize

MIL NO

MIL OK

MIL simulation at left bank

More more SPEED!!!

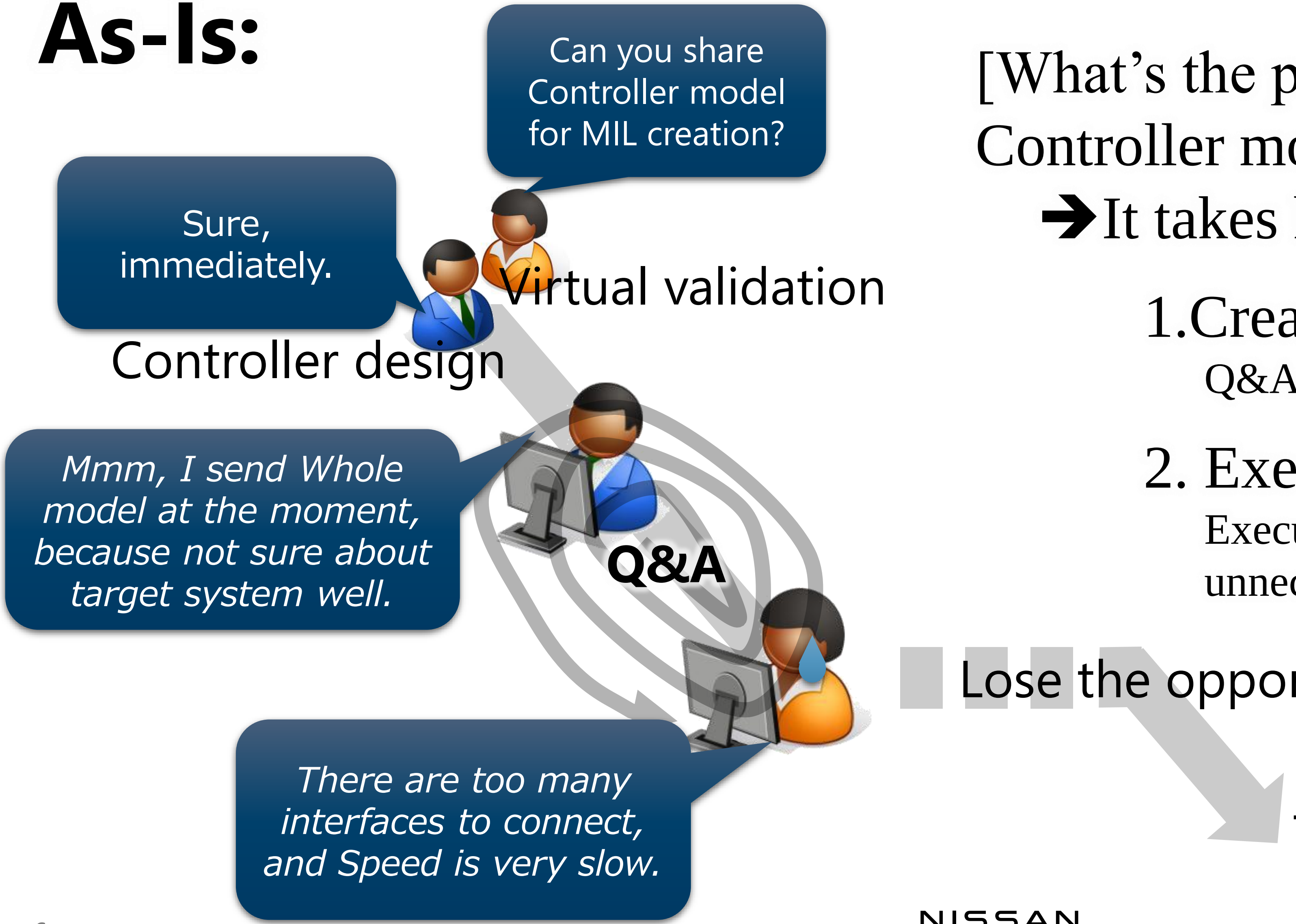
Timeline

Problem

Problem recognition

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

As-Is:



Can you share Controller model for MIL creation?

Sure, immediately.

Virtual validation

Controller design

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

Q&A

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

Lose the opportunity…

To the next process

[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

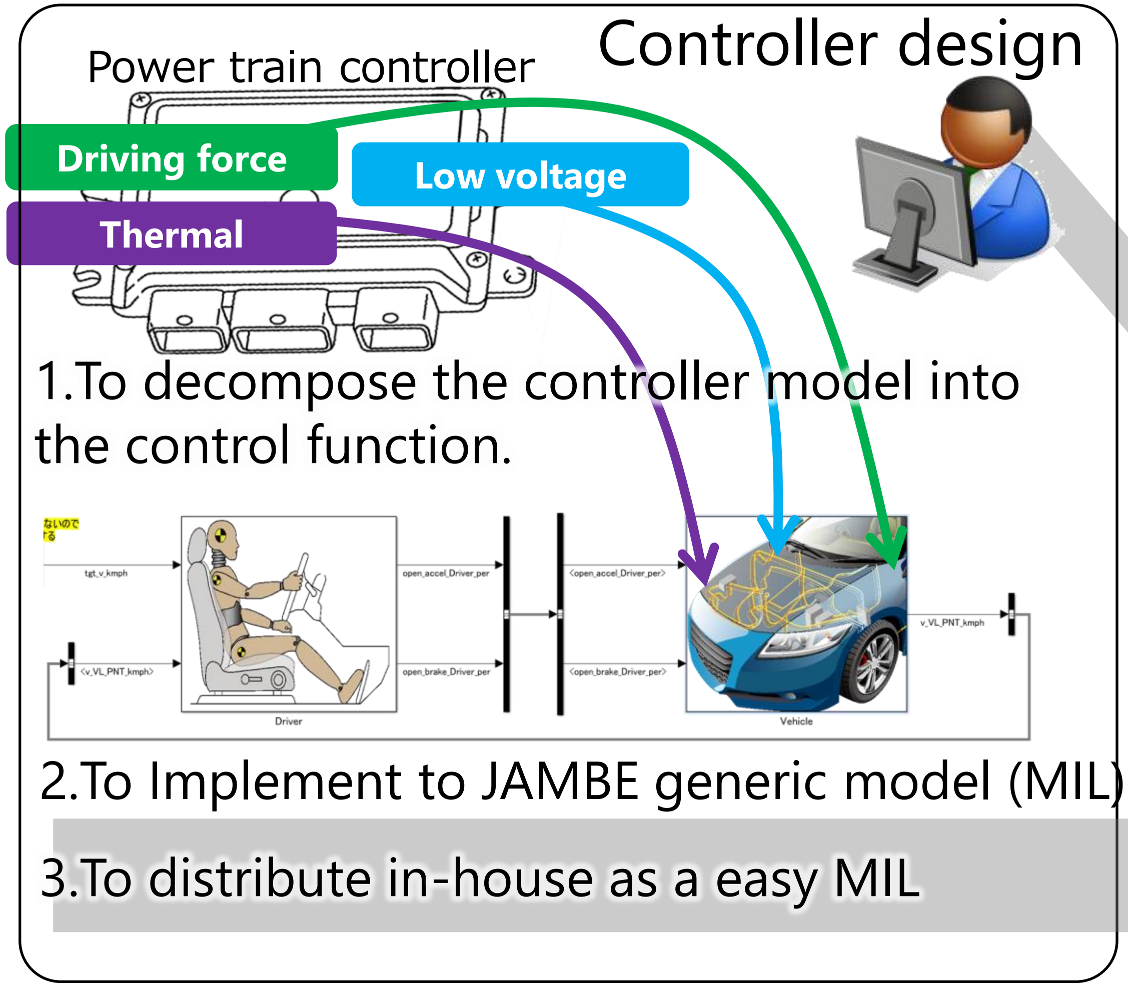
unnecessary control models implement.

Problem

Problem recognition

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

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


Power train controller
Driving force
Low voltage
Thermal
ないので
る
tgt_v_kmph
<v_VL_PNT_kmph>
Driver
open_accel_Driver_per
open_brake_Driver_per
<open_accel_Driver_per>
<open_brake_Driver_per>
v_VL_PNT_kmph
Vehicle

Controller design

1.To decompose the controller model into the control function.

2.To Implement to JAMBE generic model (MIL)

3.To distribute in-house as a easy MIL

[Prospect]

Controller model as a MIL distribution

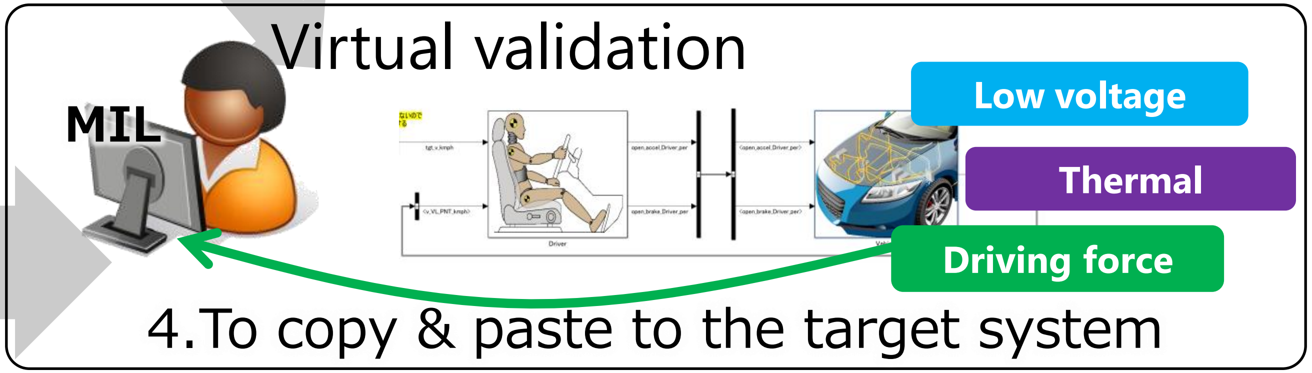
➔It spends less time for MIL…

1.Creation

To reduce Q&A.

2. Execution

To be able to choose necessary control


MIL
Low voltage
Thermal
Driving force

Virtual validation

4.To copy & paste to the target system

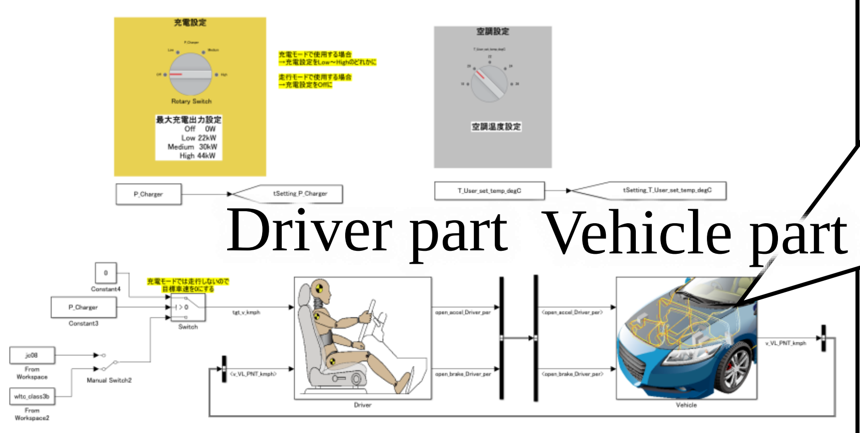
Trial Our trial

■Implemented model distribution challenge using JAMBE generic model

About the model of JAMBE Generic(easy MIL)

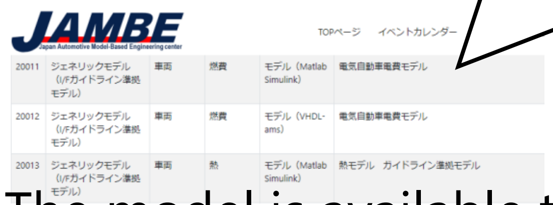
JAMBE No20011 Generic Model/Electric Vehicle Electricity Consumption Model - MATLAB/Simulink

1st layer


充電設定
Rotary Switch
最大充電出力設定
Off 0W
Low 22kW
Medium 30kW
High 44kW
空調設定
空調温度設定
P_Charger
T_User_set_temp_degC
Driver
Vehicle

Driver part

Vehicle part



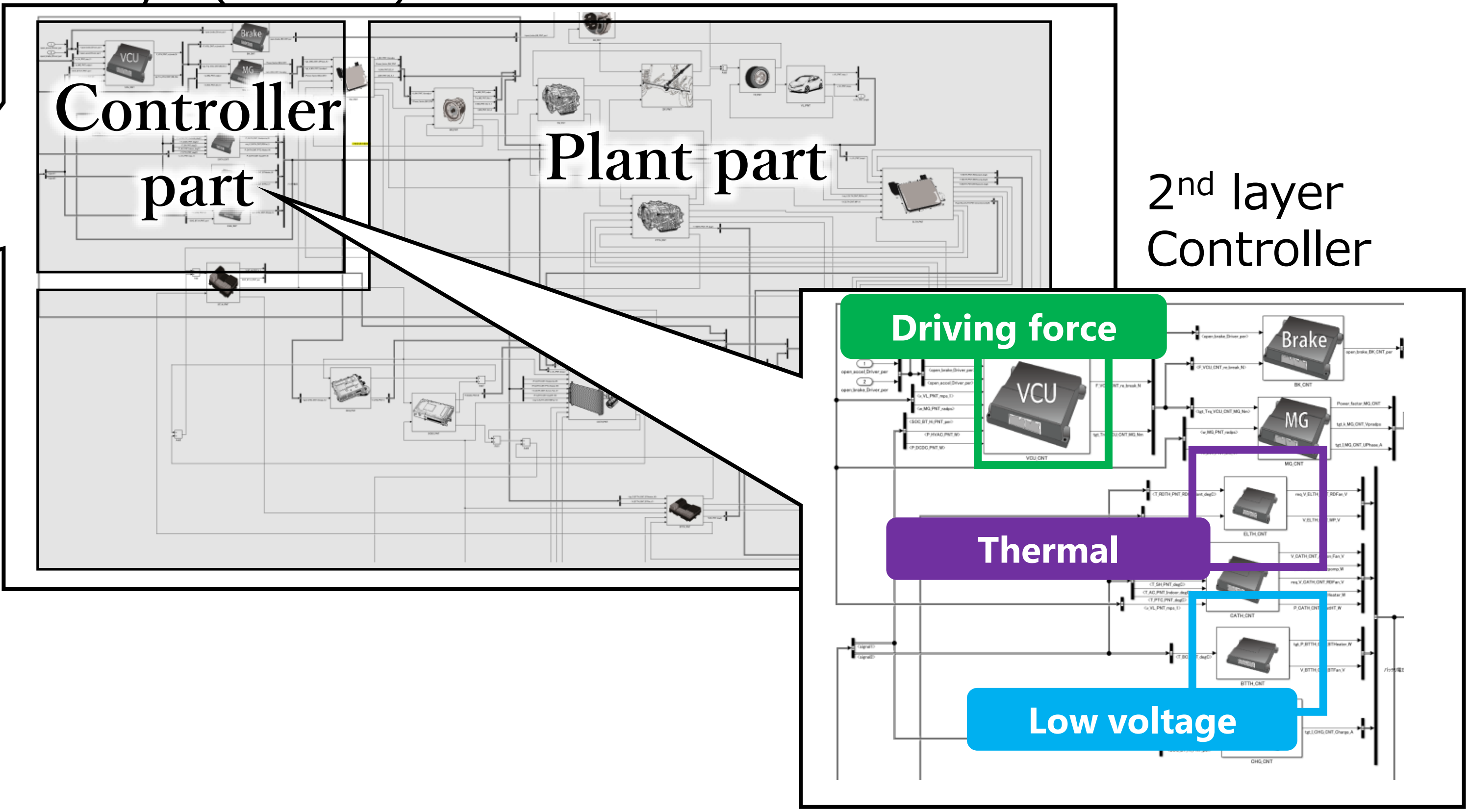
JAMBE
Japan Automotive Model-Based Engineering center

TOPページ　イベントカレンダー

20011	ジェネリックモデル（I/Fガイドライン準拠モデル）	車両	燃費	モデル（Matlab Simulink）	電気自動車電費モデル
20012	ジェネリックモデル（I/Fガイドライン準拠モデル）	車両	燃費	モデル（VHDL-ams）	電気自動車電費モデル
20013	ジェネリックモデル（I/Fガイドライン準拠モデル）	車両	熱	モデル（Matlab Simulink）	熱モデル　ガイドライン準拠モデル

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

2nd layer(Vehicle)


VCU
Brake
MG
VCU
Brake
MG

Controller part

Plant part

2nd layer Controller

Driving force

Thermal

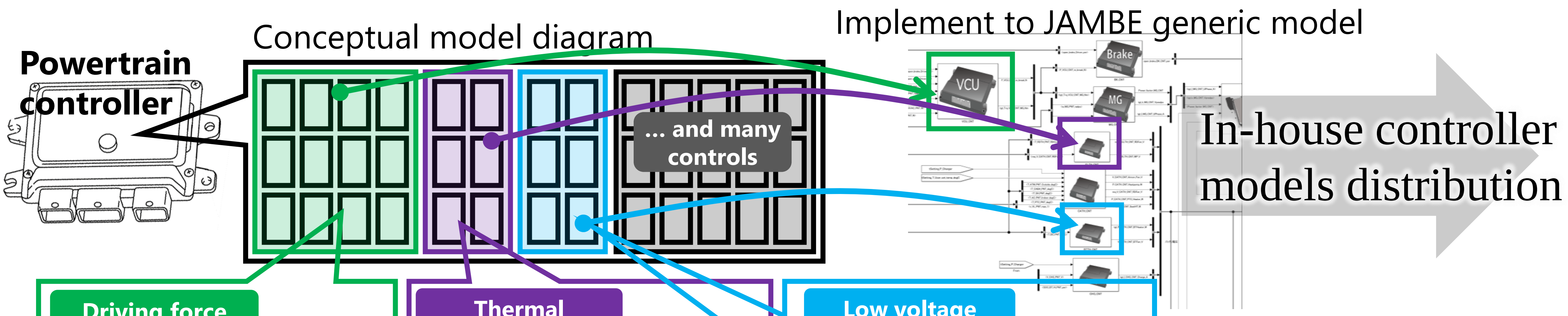
Low voltage

Trial

Our trial

■Implemented model distribution challenge using JAMBE generic model

About the controller model functional decomposition and implementation


Powertrain controller
Conceptual model diagram
... and many controls
Implement to JAMBE generic model
Brake
VCU
MG
In-house controller models distribution

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.

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.

Trial

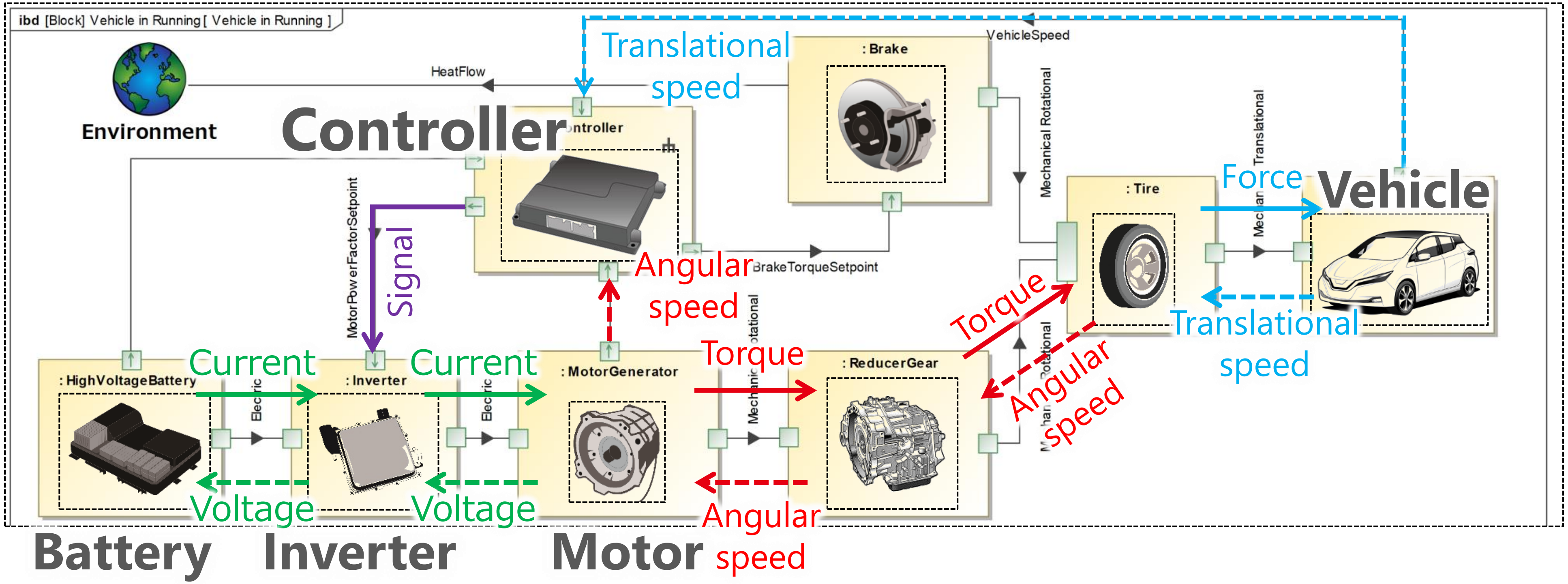
Our trial

■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.


ibd [Block] Vehicle in Running [Vehicle in Running]
Environment
HeatFlow
Translational speed
Controller
:Controller
MotorPowerFactorSetpoint
Signal
Angular speed
BrakeTorqueSetpoint
VehicleSpeed
: Brake
Mechanical Rotational
: Tire
Force
Translational
Mechanical
Vehicle
Translational speed
Torque
Angular speed
: HighVoltageBattery
Current
Electric
Voltage
: Inverter
Current
Electric
Voltage
: MotorGenerator
Torque
Mechanical Rotational
Angular speed
: ReducerGear
Mechanical Rotational
Battery
Inverter
Motor

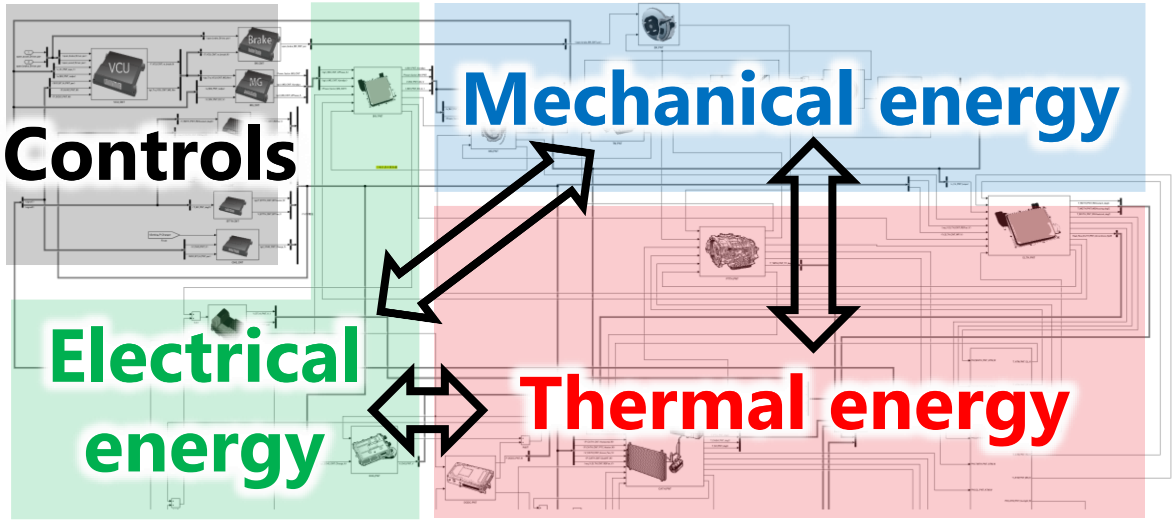
Trial

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


Brake
VCU
MG
Controls
Mechanical energy
Electrical energy
Thermal energy

■The enough energy domains are contains in the powertrain control area.

■The physical network between each energy domain is reproduced.

Runtime

@WLTC mode (class3b) 1800[s]

Model	Time(s)
Our trial Controller : NISSAN Driving force model Plant : JAMBE Generic model	700
Reference Controller : JAMBE Generic model Plant : JAMBE Generic model	50

- It is acceptable speed for control behavior confirmation.
(faster than 2.5 times than real plant)

Trial

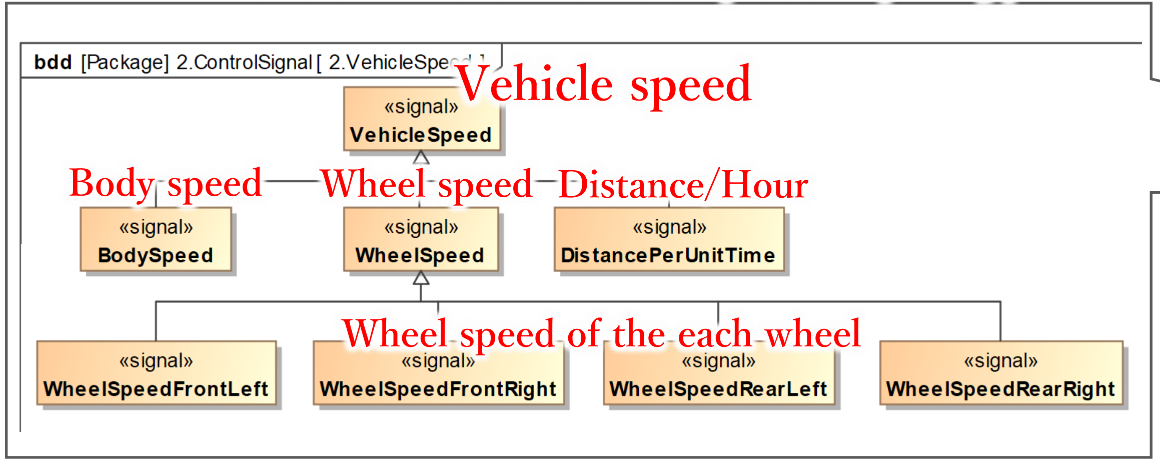
Our trial

■Implemented model distribution challenge using JAMBE generic model

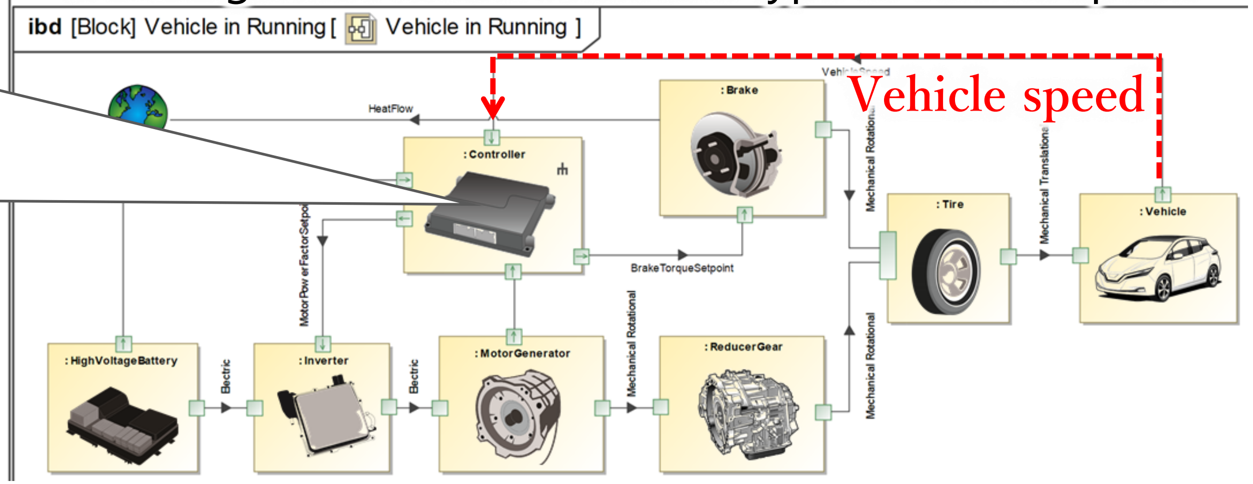
[Tough job point]
We had to create a wrapper models that fulfilled all controller inputs.

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

REAL : Several kind of vehicle speed input type


bdd [Package] 2.ControlSignal [2.VehicleSpeed]
Vehicle speed
«signal»
VehicleSpeed
Body speed
Wheel speed
Distance/Hour
«signal»
BodySpeed
«signal»
WheelSpeed
«signal»
DistancePerUnitTime
Wheel speed of the each wheel
«signal»
WheelSpeedFrontLeft
«signal»
WheelSpeedFrontRight
«signal»
WheelSpeedRearLeft
«signal»
WheelSpeedRearRight

JAMBE generic model : Just one type of vehicle speed


ibd [Block] Vehicle in Running [Vehicle in Running]
VehicleSpeed
Vehicle speed
HeatFlow
: Controller
: Brake
: Tire
: Vehicle
BrakeTorqueSetpoint
MotorPowerFactorSetpoint
Mechanical Rotational
Mechanical Translational
: HighVoltageBattery
: Inverter
: MotorGenerator
: ReducerGear
Electric
Electric
Mechanical Rotational
Mechanical Rotational

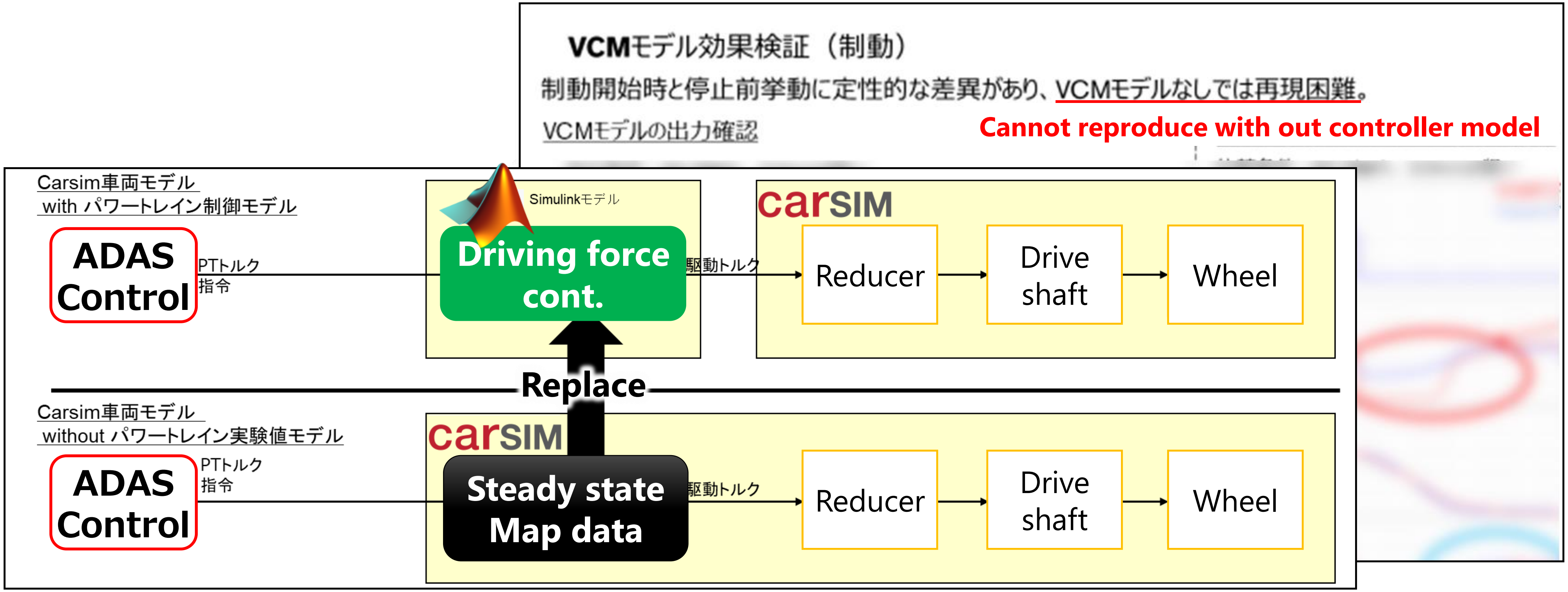
The controller behavior cannot be reproduced without correct inputs.
➔It needs to create a wrapper model for all controller inputs.

Case study

■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.



VCMモデル効果検証（制動）

制動開始時と停止前挙動に定性的な差異があり、VCMモデルなしでは再現困難。

VCMモデルの出力確認

Cannot reproduce with out controller model

This case study

Carsim車両モデル
with パワートレイン制御モデル

ADAS Control
PTトルク指令
Simulinkモデル
Driving force cont.
駆動トルク
carSIM
Reducer
Drive shaft
Wheel

Replace

Before

Carsim車両モデル
without パワートレイン実験値モデル

ADAS Control
PTトルク指令
carSIM
Steady state Map data
駆動トルク
Reducer
Drive shaft
Wheel

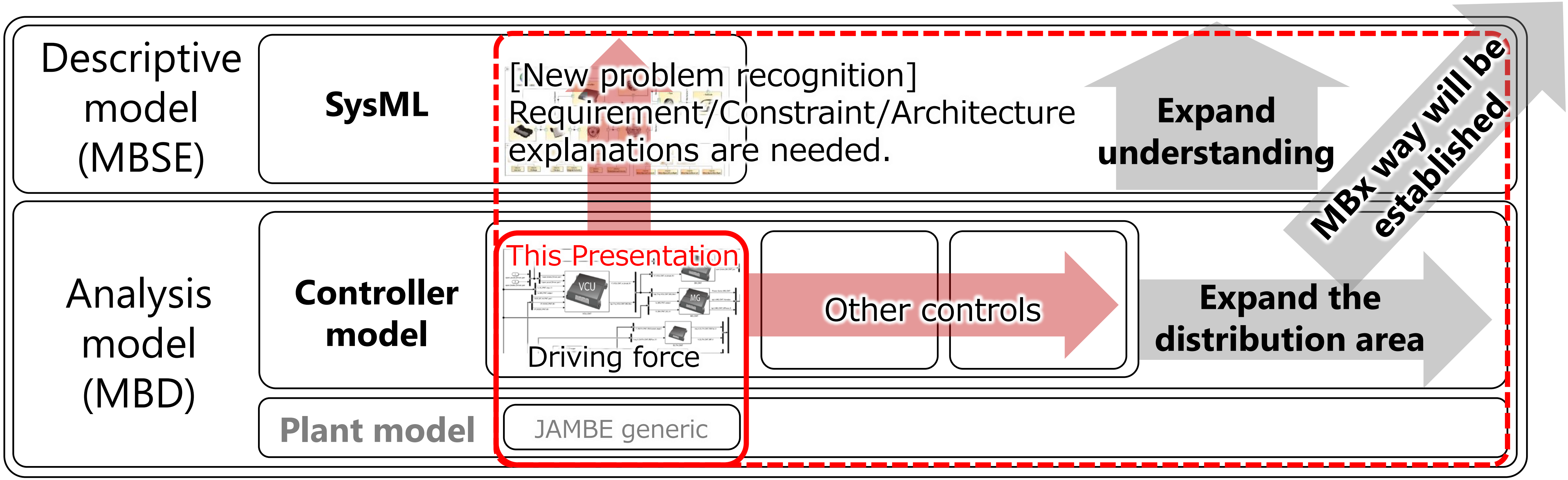
Wrap-up

■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
MBx way will be established
Analysis model (MBD)
Controller model
This Presentation
VCU
MG
Driving force
Other controls
Expand the distribution area
Plant model
JAMBE generic

Thank you for your attention.