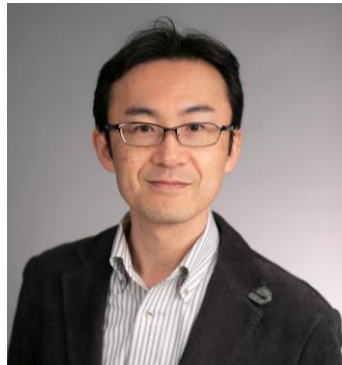


JAMBE Model Exchange for Vehicle Development



Takahiro Mochihara

JAMBE

(TOYOTA MOTOR CORPORATION)



Junichi Ichihara

JAMBE

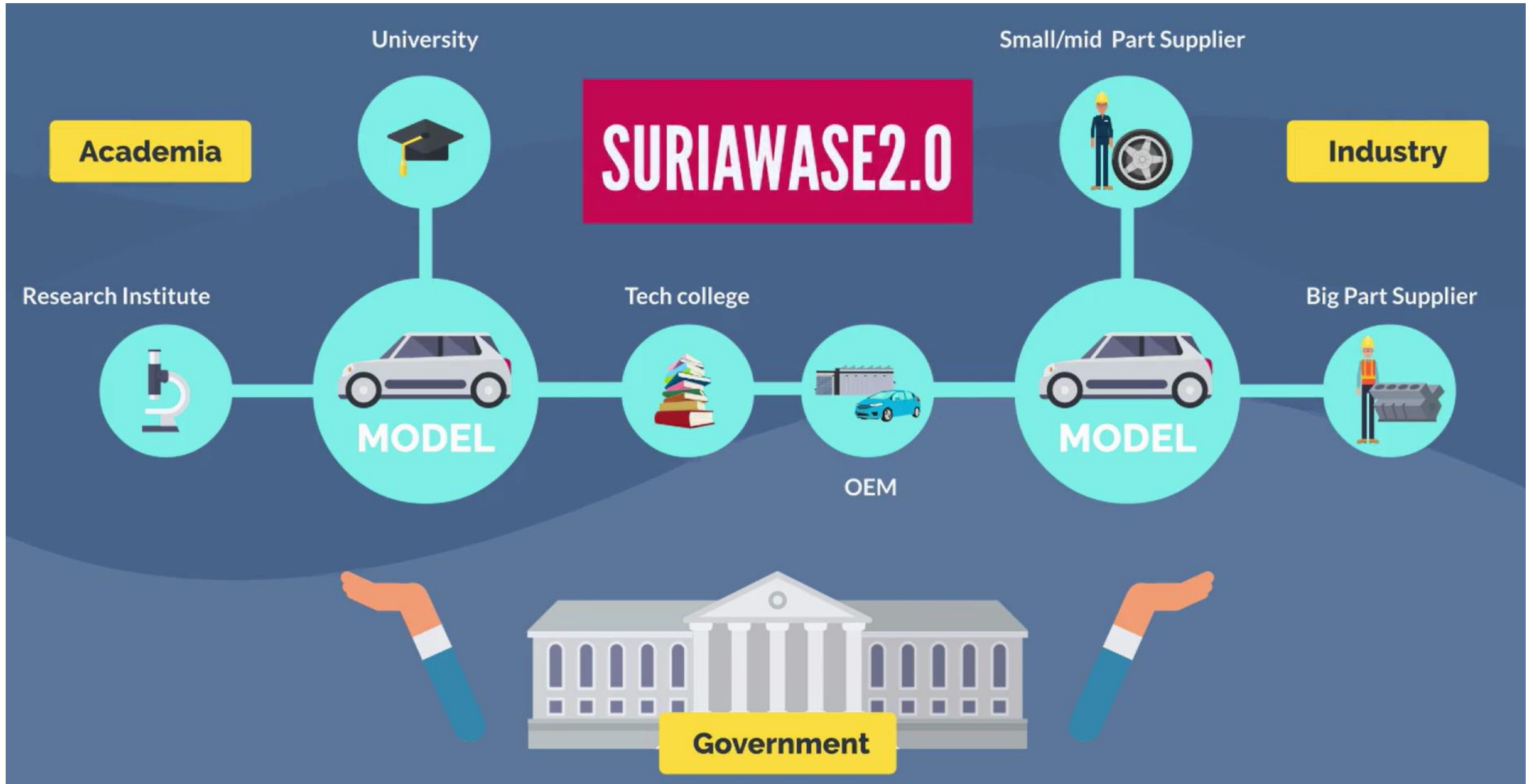
(AZAPA CO.,LTD)

Agenda

- 1. JAMBE introduction short video (5min)**
- 2. Introduction of JAMBE & SURIAWASE2.0**
- 3. Challenges & Solutions in Model Exchange**
- 4. Details of JAMBE Activities**
- 5. Future Direction of JAMBE**

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SURIAWASE = Harmonization

Establishment History of JAMBE

FY2015~FY2017

Study group of ideal approaches to model utilization in the automotive industry



FY2015

➤ Verification of usefulness of **Plant Model I/F Guideline**

FY2016

➤ Creation of **Guideline-Compliant Model 1.0** (METI Model 1.0) for fuel economy evaluation

FY2017

➤ METI Model 1.0 **Use Case Creation**
 ➤ International Collaboration
 ➤ Human Resource Development

↑
「SURIAWASE2.0」
 advocated by the Ministry of Economy, Trade and Industry (METI)

FY2018~FY2020

Study group of ideal approaches to model utilization in the automotive industry (cont.)



■ **Strategic initiatives to establish JAMBE**

- Plant & control model I/F strategy study
- Activity area studies for CASE scenario
- International Collaboration
- Human Resource Development



3year project funded by **METI** (FY2018~FY2020)

- **Expansion of I/F Guidelines**
- **Expansion of Guideline-compliant models**

FY2021~FY2022

FY2023~

Japan Automotive Model-based Engineering center (**JAMBE**)



■ **Establishment of JAMBE**

- Creation of **Model Exchange Process Guideline 1.0** (FY2021~FY2022)

■ **Organizational form change**

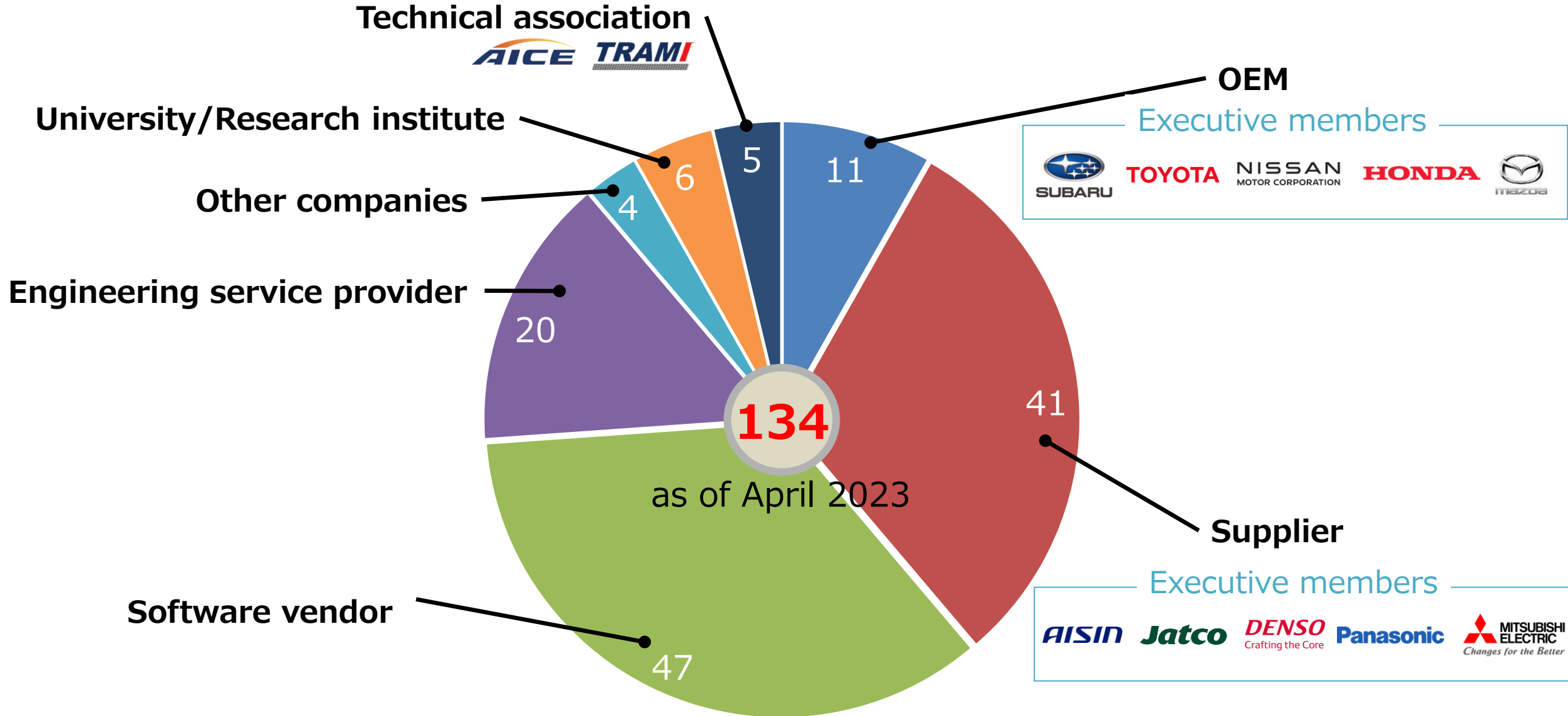
- (from consortium to general incorporated association)
- **Reinforcement of organization system** (FY2023~)

What we want to be = SURIAWASE2.0

What is SURIAWASE2.0 ?

A strategy to enhance the highly coordinated development between companies throughout the supply chain by using virtual simulations (MBD) instead of using physical prototypes.

Composition of Member companies



Participating companies list (as of April 2023)

Executive members

AISIN CORPORATION、 JATCO Ltd、 SUBARU CORPORATION、 DENSO CORPORATION、 TOYOTA MOTOR CORPORATION、 Nissan Motor Co., Ltd.、 Panasonic Automotive Systems Co., Ltd.、 Honda Motor Co., Ltd.、 Mazda Motor Corporation、 Mitsubishi Electric Corporation

Lead members

AZAPA Co., Ltd.、 NTT DATA ENGINEERING SYSTEMS Corporation、 AutoForm Japan K.K. 、 Continental Automotive Corporation、 SUZUKI MOTOR CORPORATION、 DAIHATSU MOTOR CO., LTD. 、 TOSHIBA DIGITAL SOLUTIONS CORPORATION、 transcocosmos inc. 、 Microsoft Japan Co., Ltd. 、 NEXTY ELECTRONICS CORPORATION、 PwC Consulting LLC、 Hitachi Astemo, Ltd. 、 HUAWEI TECHNOLOGIES JAPAN K.K. 、 MITSUBISHI MOTORS CORPORATION、 YAZAKI Corporation

Partner members

IDAJ Co., LTD.、 IPG Automotive K.K. 、 AdvanceSoft Corporation、 ARGO GRAPHICS Inc. 、 ALPS ALPINE CO., LTD. 、 ANSYS Japan K.K. 、 ITOCHU Techno-Solutions Corporation、 Integration Technology Co., Ltd. 、 AVL JAPAN K.K. 、 A&D Company, Limited、 eXmotion Co., Ltd. 、 SCSK Corporation、 NSW Inc. 、 FEV Japan Co., Ltd. 、 MCOR Co.,Ltd. 、 OTSL Inc. 、 Ono Sokki Co., Ltd. 、 GAIO TECHNOLOGY Co., Ltd. 、 Cybernet Systems Co., Ltd. 、 Siemens K.K. 、 JSOL Corporation、 ZUKEN Inc. 、 ZUKEN Modelinx Inc. 、 Secondmind K.K. 、 Tata Elxsi Limited、 CHUOZUKEN Co., Ltd. 、 dSPACE Japan K.K. 、 TechnoStar Co., Ltd. 、 Digital Arts Inc. 、 Digital Solutions Inc. 、 DIGITAL PROCESS LTD、 Information Services International-Dentsu, Ltd. 、 toshiba information systems japan、 Toshiba Electronic Devices & Storage Corporation、 Toray Engineering D Solutions Co.,Ltd. 、 Toyota Technical Development Corporation、 National Instruments Japan Corporation、 Cadence Design Systems, Japan、 NewtonWorks Corporation、 Neorium Technology Co., LTD. 、 PERSOL EXCEL HR PARTNERS Co., Ltd. 、 PERSOL CROSS TECHNOLOGY CO., LTD. 、 HAGIWARA ELECTRONICS CO., LTD. 、 PTC Inc. 、 Hitachi Industry & Control Solutions, Ltd. 、 Fujitsu Limited、 Progress Technologies, Inc. 、 MAC SYSTEMS CORPORATION、 Mazda Engineering & Technology Co., LTD. 、 RYOMO SYSTEMS CO., LTD. and an other company

Regular members

AISAN INDUSTRY CO., LTD.、 Crystal CO.,LTD. 、 KYB Corporation、 SAGINOMIYA SEISAKUSHO, INC. 、 Sumitomo Rubber Industries, Ltd. 、 TOKAI RIKA Co.,Ltd. 、 TOYOTA INDUSTRIES CORPORATION、 TOYODA GOSEI Co., Ltd. 、 Partner Co.,Ltd. 、 Hitachi Solutions, Ltd. 、 Hino Motors,Ltd. 、 HIROTEC Corporation、 FUKOKU CO., LTD. 、 MEIDEN

Associate members

accenture、 iASYS Technology Solutions K.K. 、 ETHERMO Co.,Ltd. 、 ISUZU MOTORS LIMITED、 EXEDY Corporation、 HKS CO., LTD. 、 NOK CORPORATION、 Canon IT Solutions Inc. 、 KOZO KEIKAKU ENGINEERING Inc. 、 Satyam Venture Engineering Services Private Limited、 Joyson Safety Systems Japan K.K. 、 Sumitomo Wiring Systems, Ltd. 、 Dassault Systèmes, K.K. 、 DI SQUARE Corp. 、 T.RAD Co., Ltd、 TOKYO R&D Co., Ltd. 、 TOKYO ROKI CO.,LTD. 、 NHK SPRING CO., LTD. 、 Federal-Mogul Japan K.K. 、 MIKUNI CORPORATION、 YUTAKA GIKEN CO.,LTD、 UNIPRES CORPORATION and 8 other companies

Academia members

Hiroshima Institute of Technology、 Japan Aerospace Exploration Agency and 4 other organizations

Model distribution collaborative organizations

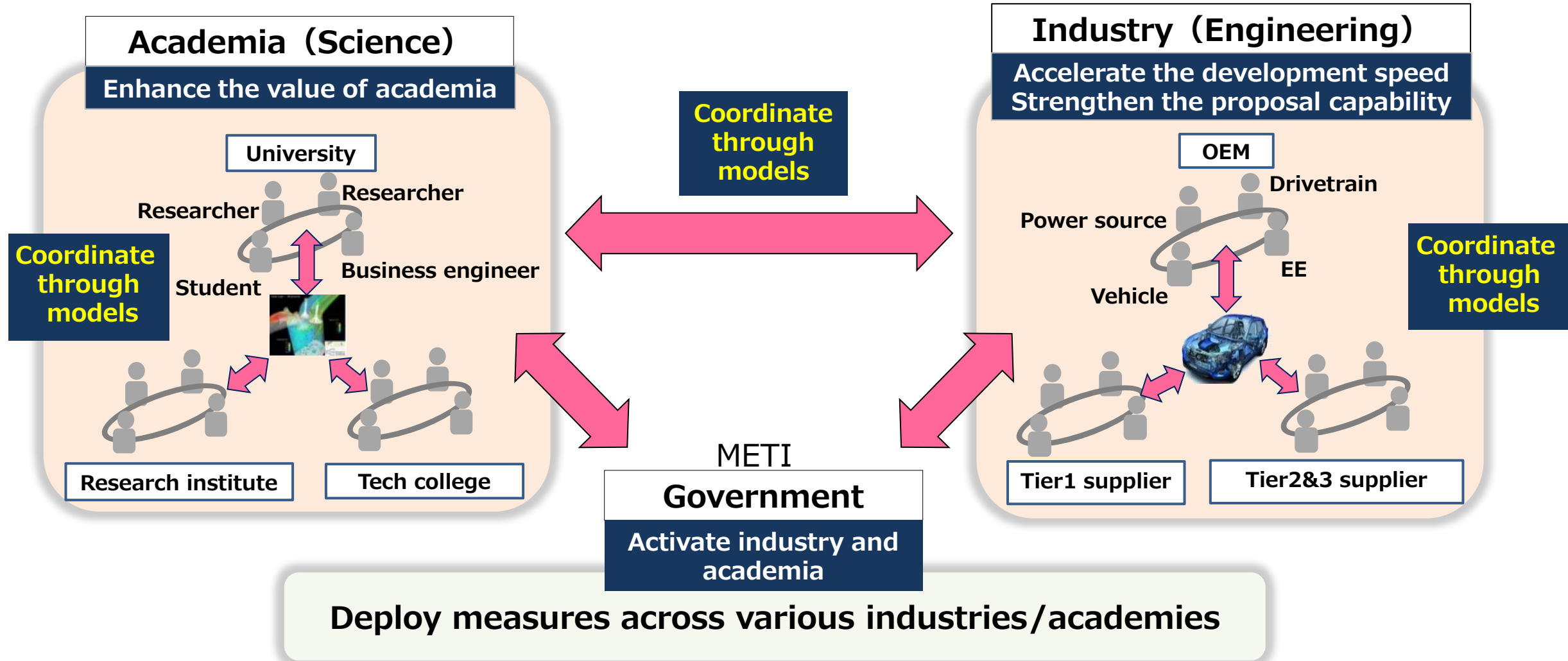
the Research Association of Automotive Internal Combustion Engines、 Transmission Research Association for Mobility Innovation

MBD promotion collaborative organization

The Oita Prefecture Automobile Industry Association、 Hiroshima Industrial Promotion Organization、 Hamamatsu Agency for Innovation, Next-generation vehicle Center Hamamatsu

What is SURIAWASE2.0 ?

A strategy to enhance highly coordinated research/development activities between companies throughout the supply chain by using virtual simulations (MBD) instead of using physical prototypes = **SURIAWASE2.0** advocated by METI in 2017



To realize SURIAWASE2.0, promote MBD & model exchange, and solve common problems.

SURIAWASE2.0 Concept

To lead “automotive development revolution”, it is imperative to raise the development ability of automotive industry.
By enhancing SURIAWASE ability utilizing model-based virtual simulation,
be the world most advanced development center.

Spread/Promote MBD

Publish functions/information of institutes relevant to MBD dissemination.

Promote Model Exchange

Forming guidelines/one voice, serve as the contact for international collaboration.

3 pillars of JAMBE Activities

Solve Common Issues

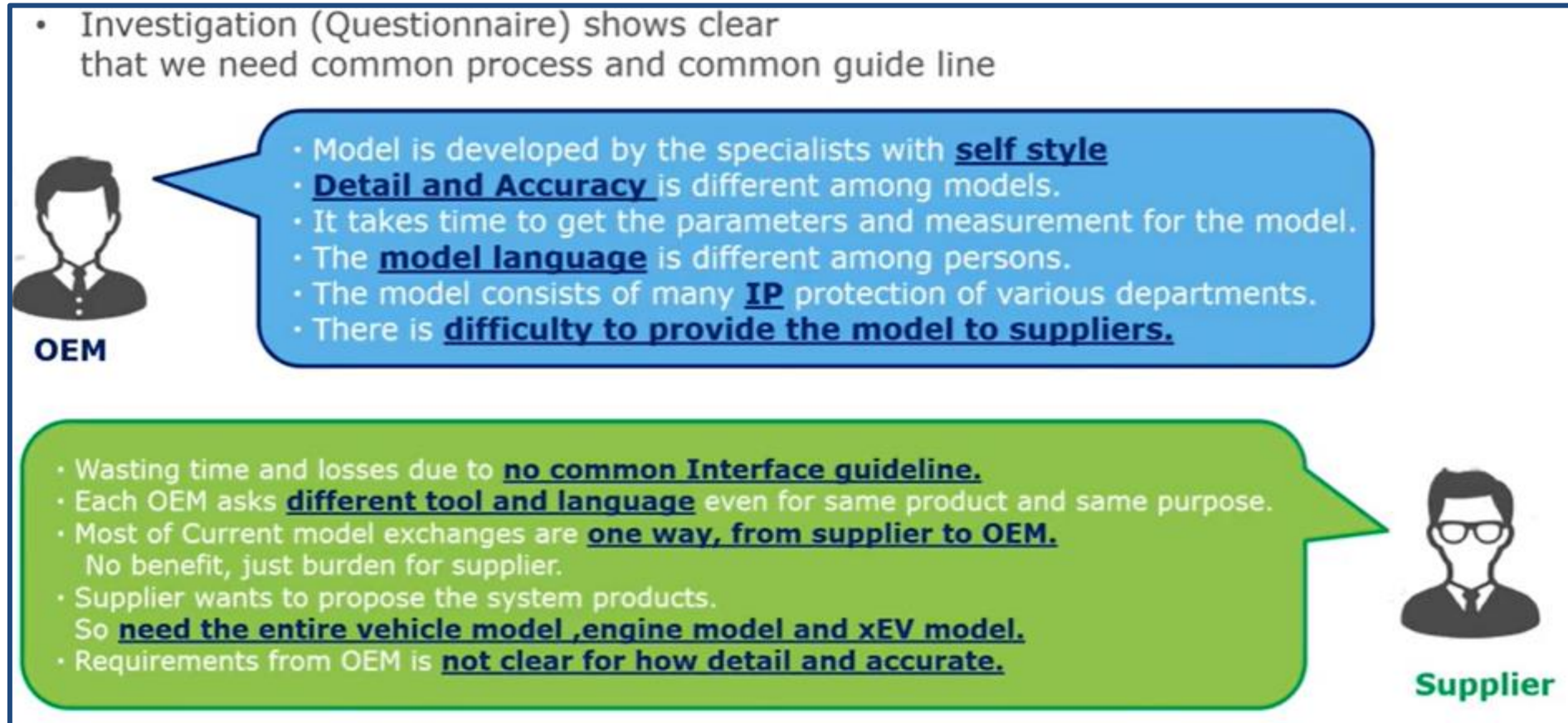
Identifying new common issues, solve what each company is struggling with.

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Challenges for Model Exchange

There are many challenges and difficulties to promote model exchange.



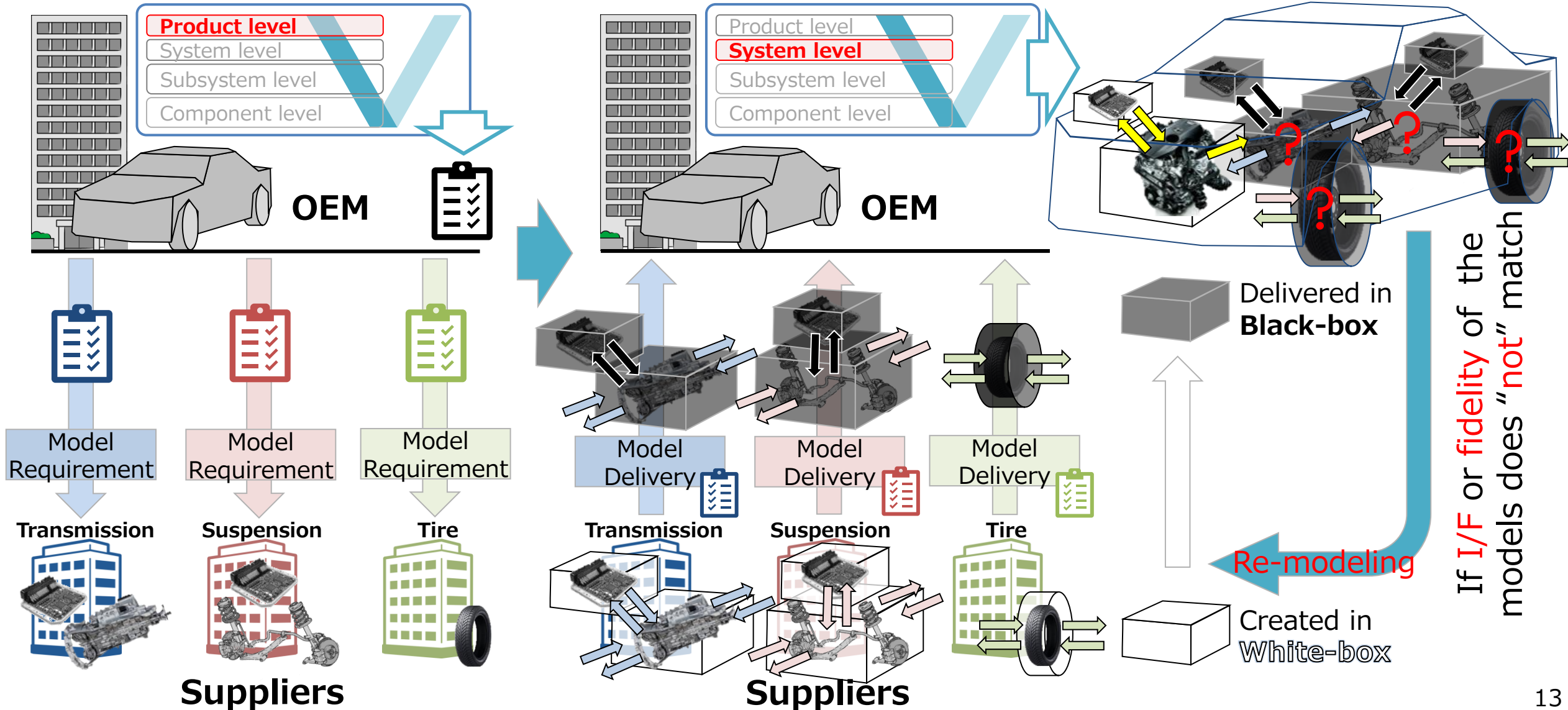
Issue No.1
No guideline or standard
for model interface

Issue No.2
No IP free
vehicle generic model

Issue No.3
No common process
for model exchange

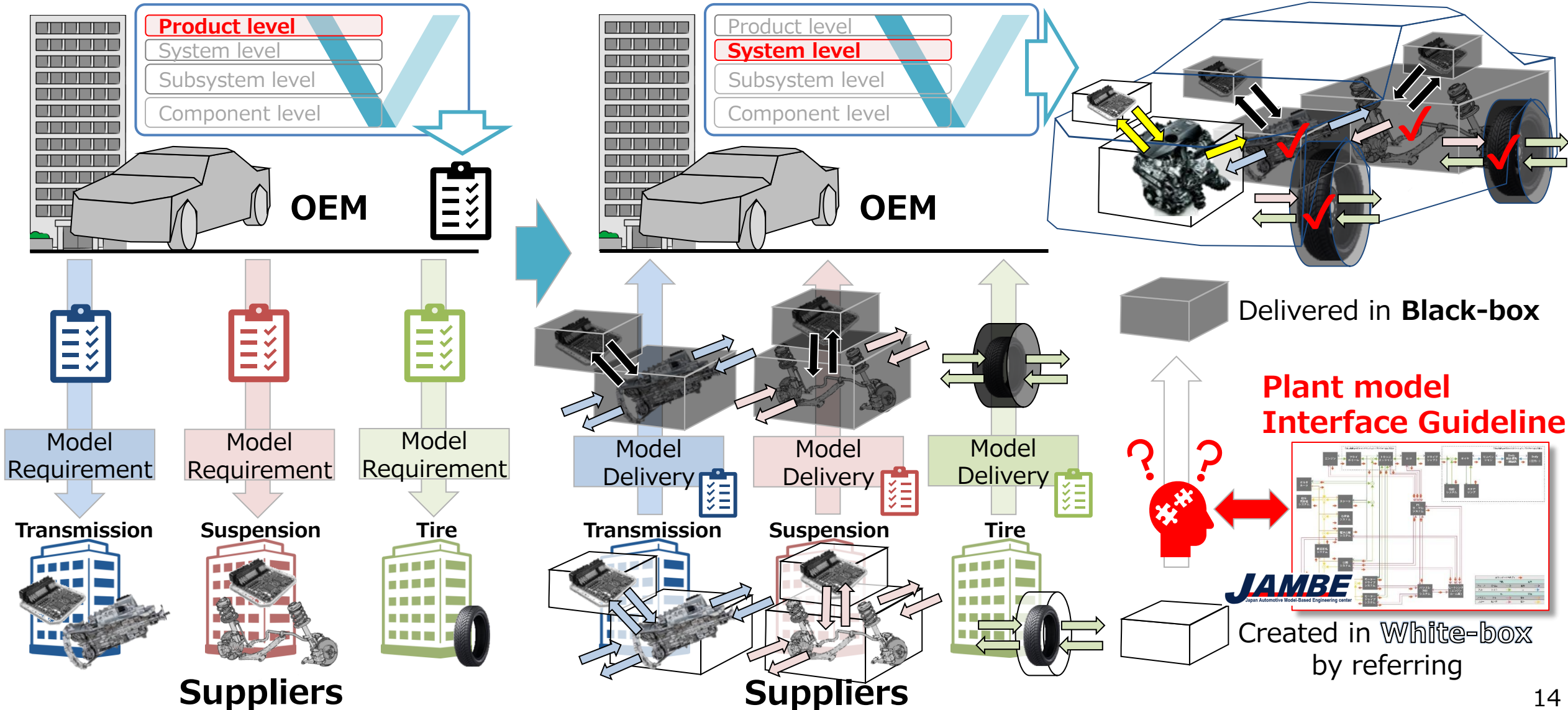
Typical challenge in Model Exchange

Difficulty in handling black-box models causes inefficiency in vehicle development



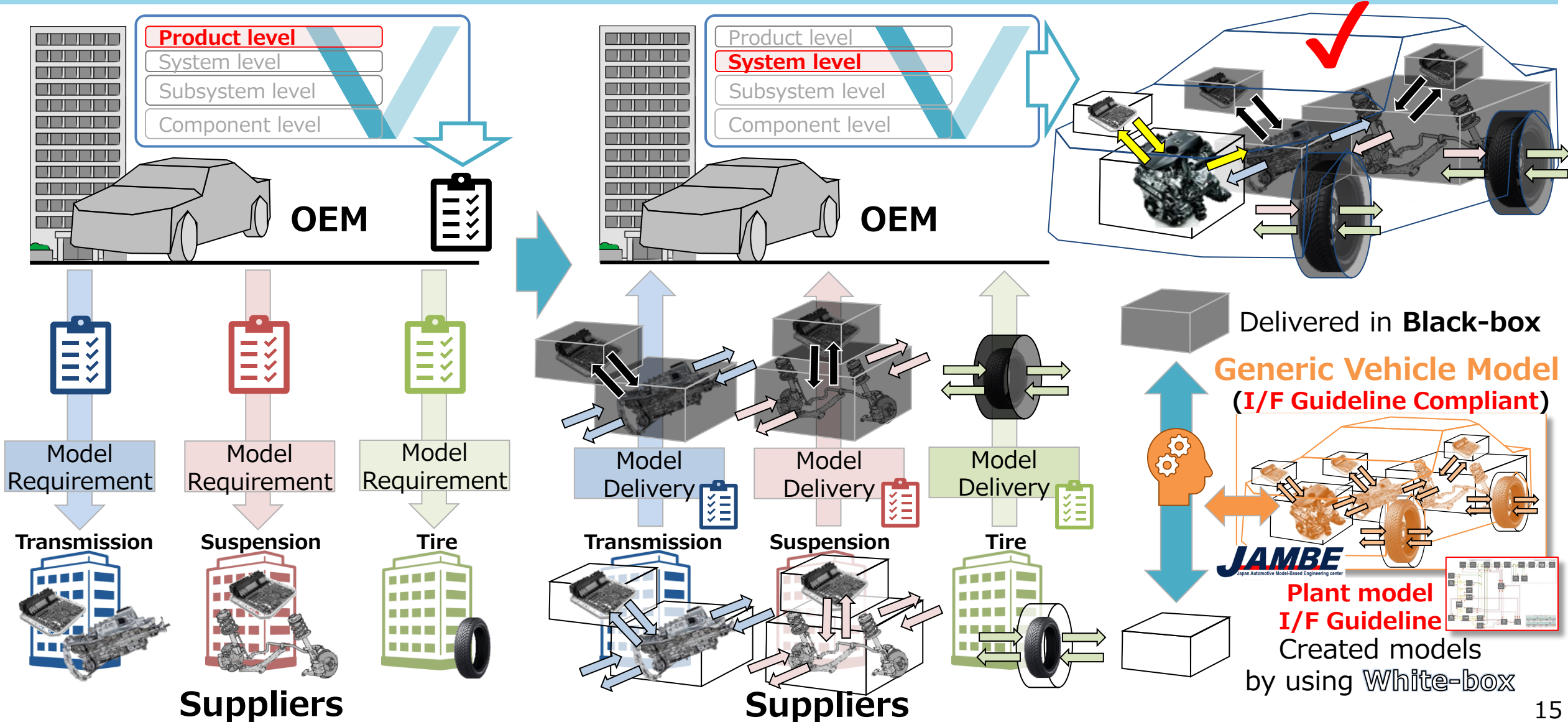
Solution 1 to the Model Exchange issues

Plant model Interface guideline are released to reduce the risk of rework due to interface inconsistencies.



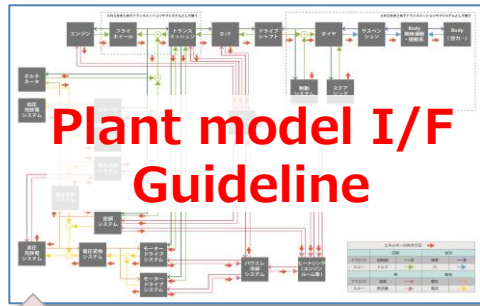
Solution₂ to the Model Exchange issues

Guideline compliant white-box model with control (Generic Vehicle Model) are shared with all.



Generic Vehicle Models (Guideline Compliant)

8 IP free Generic Vehicle Models are released from 2017~2022 by JAMBE



Guideline compliant

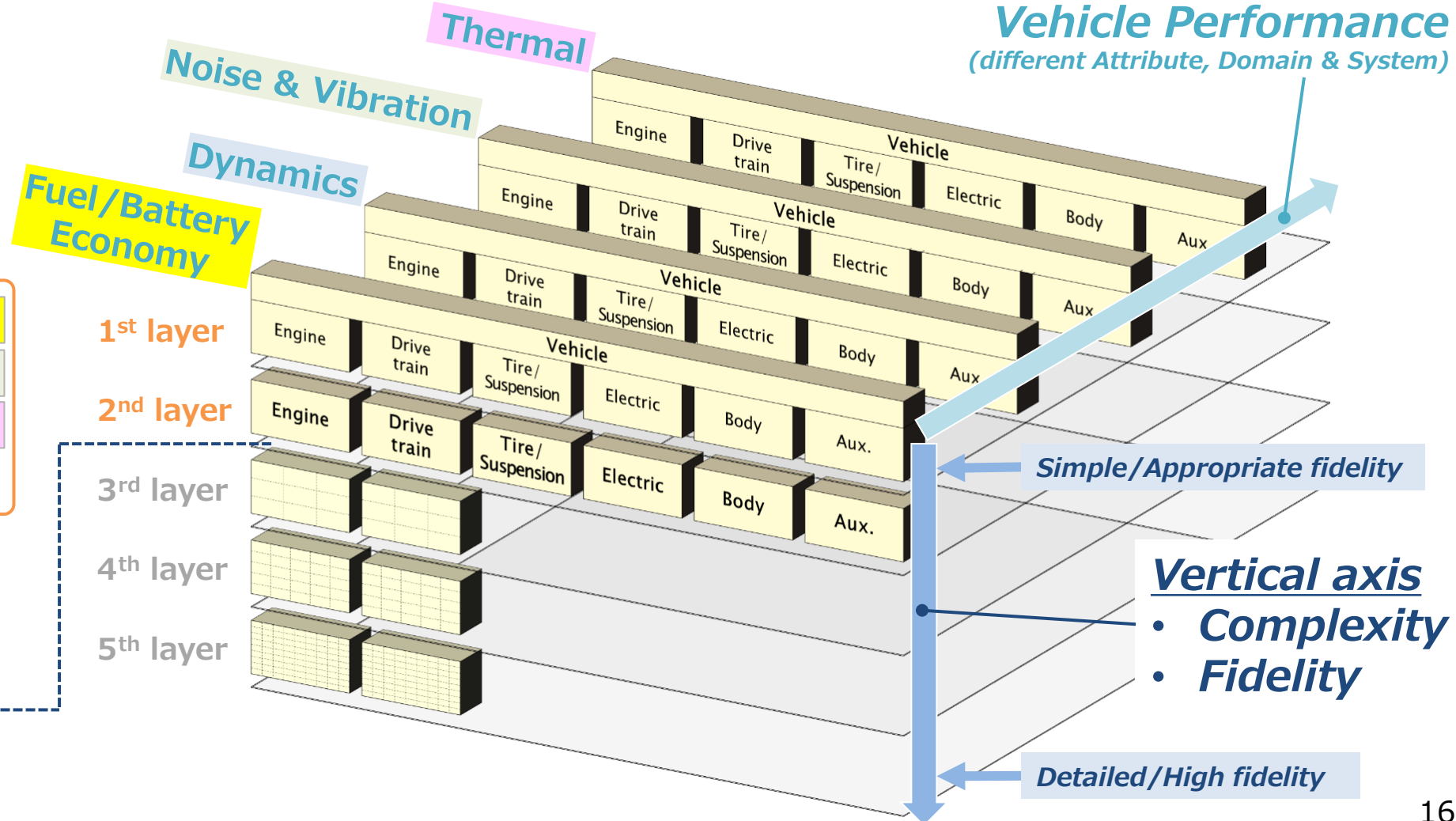
Series HEV	BEV	ICE(CVT)
Series-Parallel HEV I		ICE(CVT)
Series-Parallel HEV II		ICE(CVT)
		ICE

Generic vehicle Model (Boundary)

Detail Model (Core)

Cubic Layered Models

Horizontal axis
Vehicle Performance
 (different Attribute, Domain & System)



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Details of JAMBE Activities

JAMBE is working for these three issues regarding the model exchange among OEMs and suppliers.

Investigation (Questionnaire) shows clear that we need common process and common guide line

- Model is developed by the specialists with **self style**
- Detail and Accuracy is different among models.
- It takes time to get the parameters and measurement for the model.
- The model language is different among persons.
- The model consists of many IP sections of various departments.
- There is difficulty to provide the model to suppliers.

Meeting time and issues due to **no common interface guideline**. Each OEM asks **different tool and language** even for same product and same purpose. Most of current model exchanges are **one way, from supplier to OEM**. No benefit, just burden for supplier. Supplier has to provide the system product. So **need the entire vehicle model and the model and eEV model**. Requirements from OEM is **not clear for how detail and accurate**.

Issue No.1
No guideline or standard for model interface

Issue No.2
No IP free vehicle generic model

Issue No.3
No common process for model exchange

Issue No.1
No guideline or standard for model interface

Issue No.2
No IP free vehicle generic model

Issue No.3
No common process for model exchange

Plant model Interface Guideline

Physical Domain	Across Variable			Through Variable		
	Quantifier	UNIT		Quantifier	UNIT	
Electrical	Voltage	V	V	Current	I	A
Translational	Velocity	v	m/s	Force	F	N
Rotational	Angular Velocity	M	rad/s	Torque	M,T	Nm
Heat	Temperature	T	K	Heat flow	Q	W
Thermal fluid	Temperature	T	K	Enthalpy flow rate	dH	J/s
	Pressure	P	N/m ²	Mass flow rate	Q _m	kg/s

Basic Principles for across & through variables.

Subsystem Interface Definition Documents

Plant Model I/F Guideline

Guideline Compliant Model

Guideline compliant Models

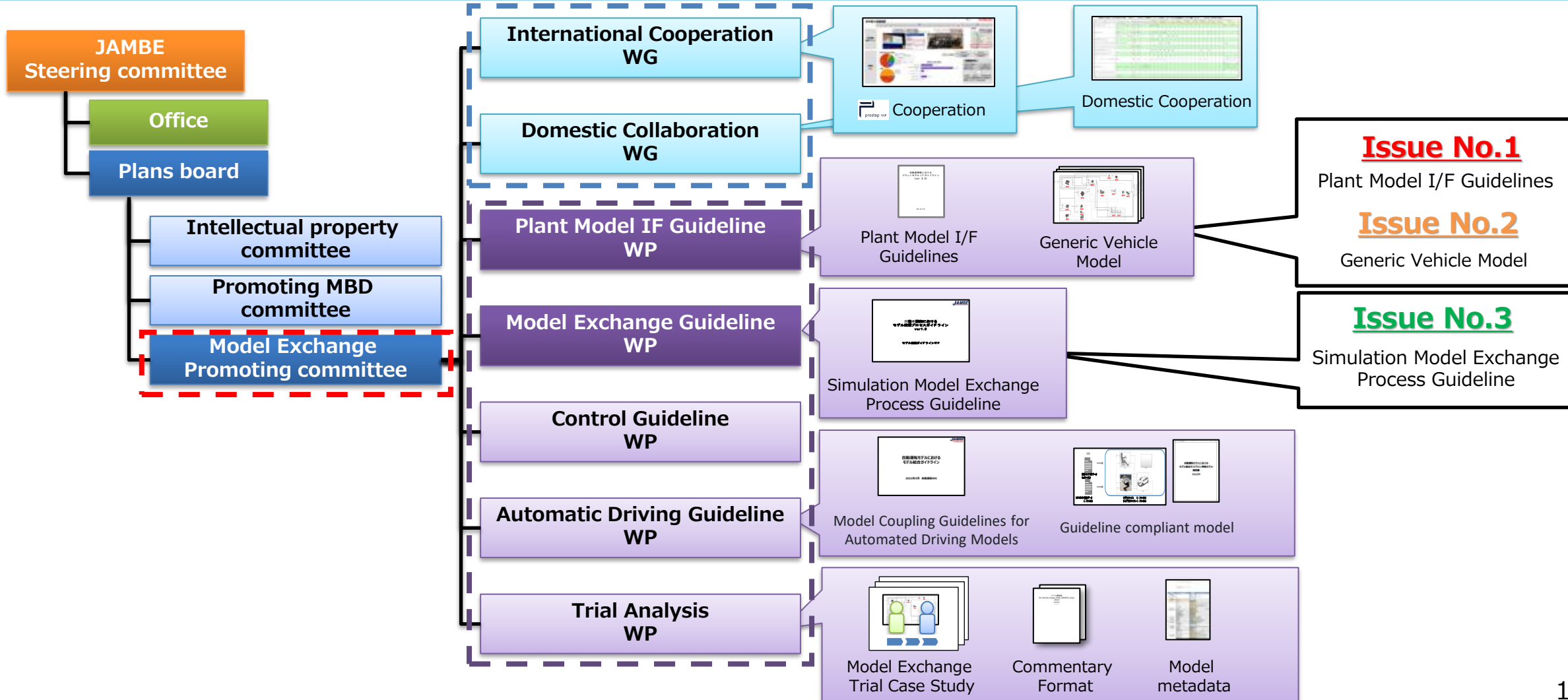
Simulation Model Exchange Process Guidelines for Vehicle Development (ver.1.0)

Simulation Model Exchange Guideline Work-Package

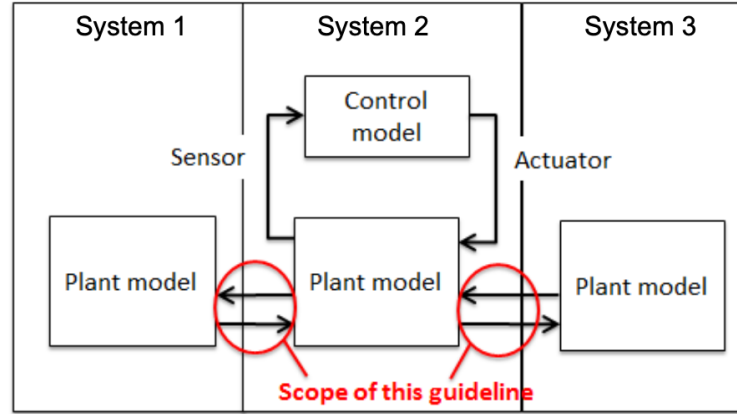
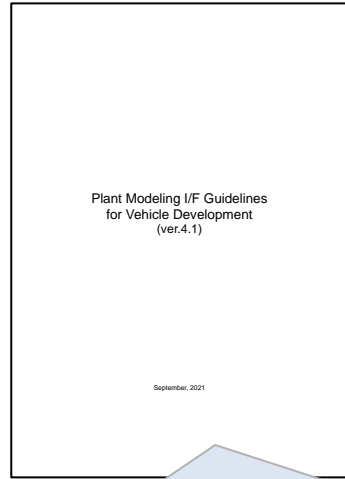
Simulation Model Exchange Process Guideline

Activities of JAMBE's Committee

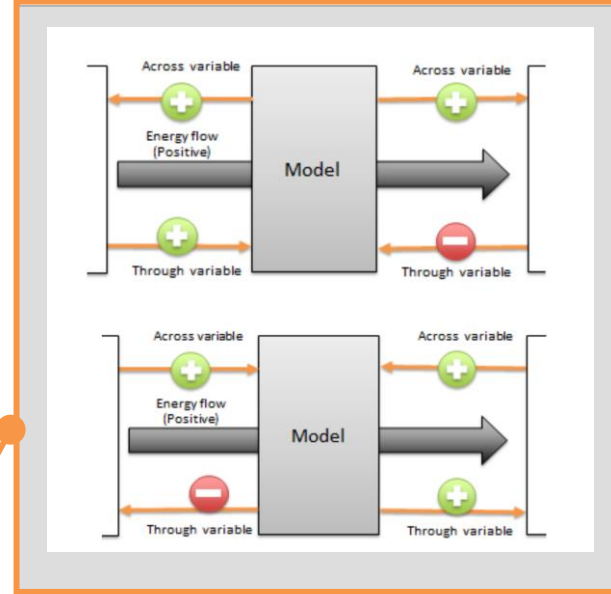
JAMBE's model exchange activities are being conducted by two working groups(WGs) and five work packages (WPs) of the **Model Exchange Promotion Committee**. Activities are being carried out to work for issues within the WGs and WPs.



Five Basic Principles based on energy flow as the Guideline Essence



Scope of Plant model Interface guideline



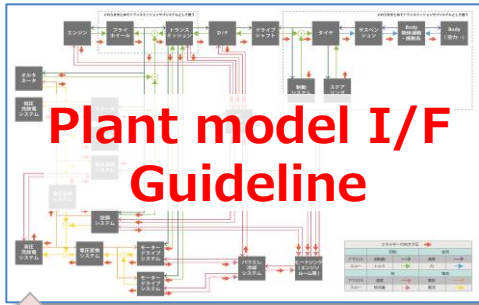
Basic principles

- 1st Plant models shall be connected using across variables and through variables. Across variables and through variables shall be in the opposite direction.
- 2nd The direction of flow from energy source to energy sink shall be considered as the positive direction of energy flow.
- 3rd The overall Interface will be defined based on the Interface of elements which store through and across variables.
- 4th A Through variable shall be regarded as positive when its input/output is in the same direction as the positive flow of energy.
- 5th 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

Physical Domain	Across Variable		Through Variable	
	Quantifier	UNIT	Quantifier	UNIT
Electrical	Voltage	V	Current	I
Translational	Velocity	v	Force	F
Rotational	Angular Velocity	ω	Torque	M, T
Heat	Temperature	T	Heat flow	ϕ
Incompressible fluid	Pressure	P	Volume flow	q_V
	Pressure	P	Mass flow rate	q_m
Thermal fluid	Temperature	T	Enthalpy flow rate	dH
			Specific Enthalpy	h

8 IP free Generic Vehicle Models are released from 2017~2022 by JAMBE



Guideline compliant

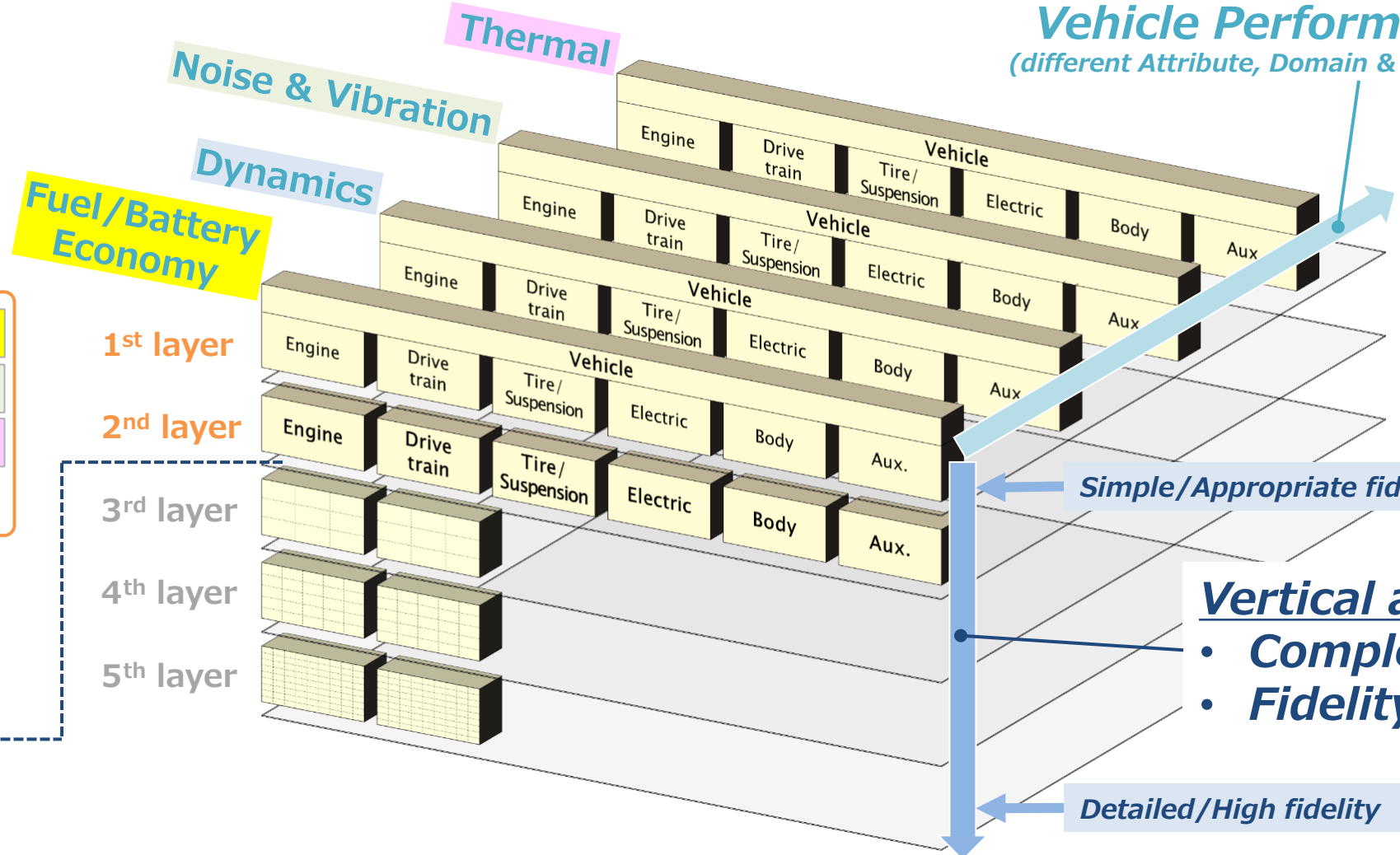
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Horizontal axis
Vehicle Performance
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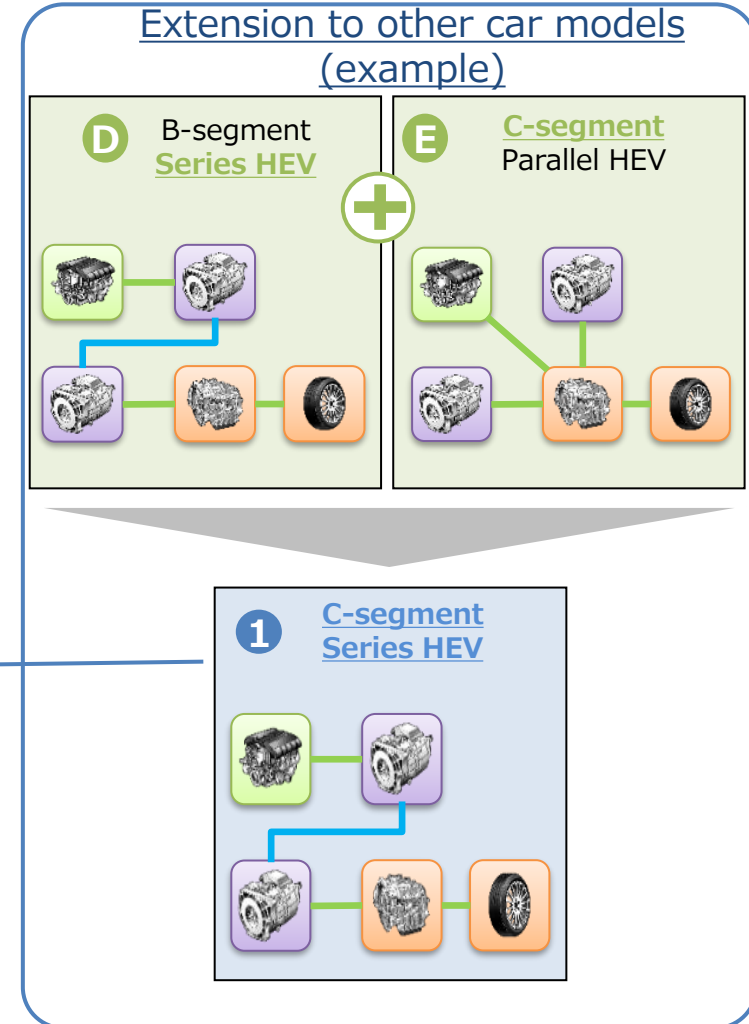


- Activities from 2017-2022 did result in a total of 6 guideline generic models: 2 ICE, 3 HEV, and 1 BEV

X : Generic Vehicle Model reference model for guideline
 X : Expanded

Areas for expanded vehicle models

power train	vehicle segment		
	Compact car B-segment	Sedan C-segment	SUV D-segment
ICE (MT)			
ICE (CVT)	A reviewed by Company A	B	→
ICE (AT)			
BEV	←	C	→
Series HEV	D reviewed by Company D	1 Extended model	→
Parallel HEV	↓		
Series Parallel HEV	←	E reviewed by Company E	F reviewed by Company F
FCV			
Misc *1:⇒ENG, T/M			



*1 : Regarding the plant model, the engine (AICE), transmission AT, and DCT (TRAMI) are prepared by the engineering group (published)



[Fuel economy] Parallel HEV Vehicle

Functions (calculations)

- Fuel consumption
- High voltage & low voltage SOC
- Regenerative braking

Two-motors parallel HEV vehicle

Engine displacement : 1.8L NA

No Steering, 1-wheel model

No.	Sub system	Functions
A	Driver	Accelerator/brake opening calculation
B10C	Vehicle control ECU	• Target Engine/Motor Torque calculation • Target engine speed calculation • Regenerative brake force calculation
B11C	Engine control ECU	Throttle opening calculation
B14C	Brake control ECU	Braking Force Calculation
B21C	Motor drive control ECU (power generation)	back emf/Current calculation 3 rd layer: Inverter ASSY, Motor ASSY
B22C	Motor drive control ECU (drive)	back emf/Current calculation 3 rd layer: Inverter ASSY, Motor ASSY
B32C	DC-DC convertor control ECU (Boost)	Boost voltage calculation
B11P	Engine	Engine torque generation
B12P	Transmission	Reduction (gear ratio)
B13P	Differential gear	Final reduction (gear ratio)
B14P	Brake	Brake torque generation
B15P	Tire	Torque to driving force conversion
B16P	Vehicle resistances	• Air/hill climbing resistance calculation • driving force → vehicle speed calculation
B21P	Motor drive (power generation)	• DC⇒AC current conversion • Power generation
B22P	Motor drive (drive)	• DC⇒AC current conversion • Motor torque generation
B31P	High-voltage battery	Voltage supply according to SOC
B32P	DC-DC convertor (Boost)	Boost voltage from high-voltage battery
B33P	High-voltage electrical component	Calculation of (equivalent) power consumption of high-voltage electrical equipment
B34P	DC-DC convertor	Voltage drop from high-voltage battery
B35P	Low-voltage battery	Voltage supply according to SOC
B36P	Low-voltage electrical component	Calculation of (equivalent) power consumption of low-voltage electrical equipment

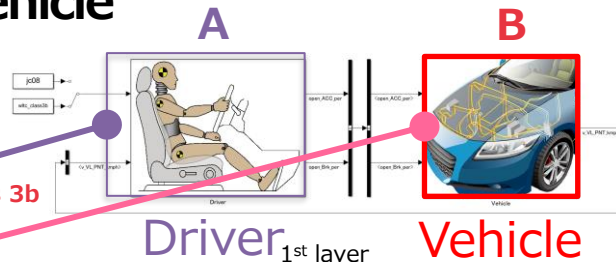
B**C : Controller model

B**P : Plant model

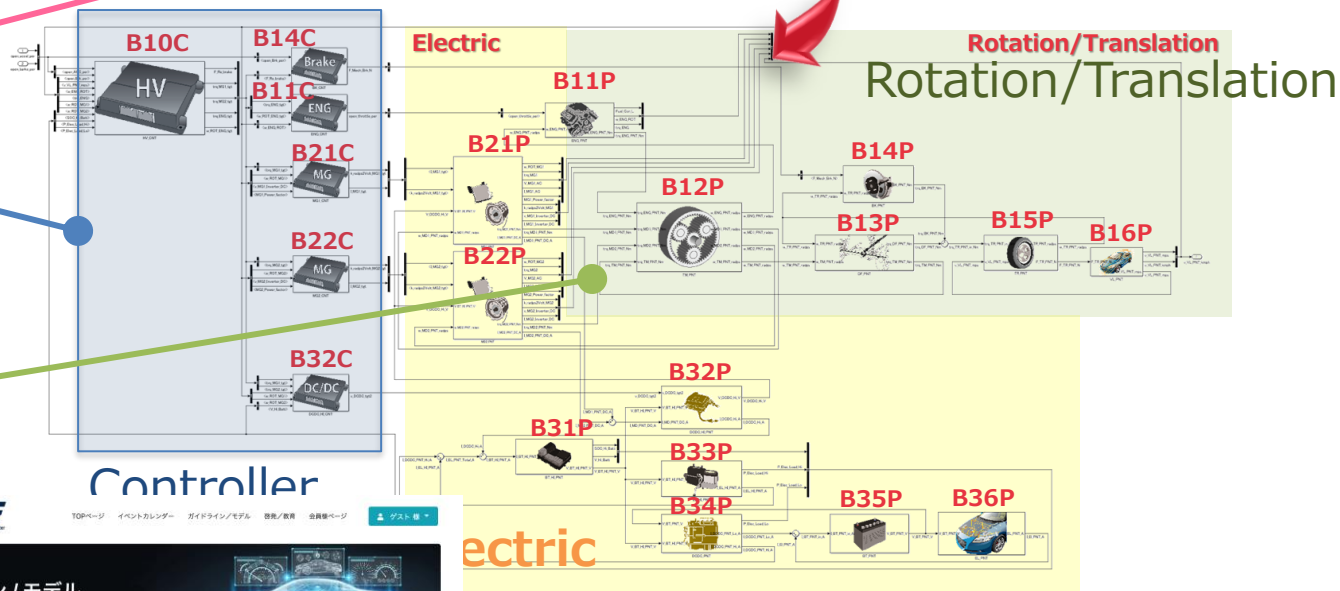
Vehicle

Driving test conditions

- Jc08
- WLTC Class 3b



Tool environments : MATLAB@/Simulink@



2nd layer (Vehicle model 1st layer)



Q キーワード検索 - Keyword search

日本語 - Japanese 英語 - English

詳細検索 ▲ 検索キーワードを入力してください - Enter a search keywords

検索条件をクリア

カテゴリ - Category 対象1 - Target1 対象2 - Target2

種類 - Type 作成機関 - Authoring agency 作成年(日) - Year(from) 作成年(日) - Year(to)

検索 検索条件をクリア

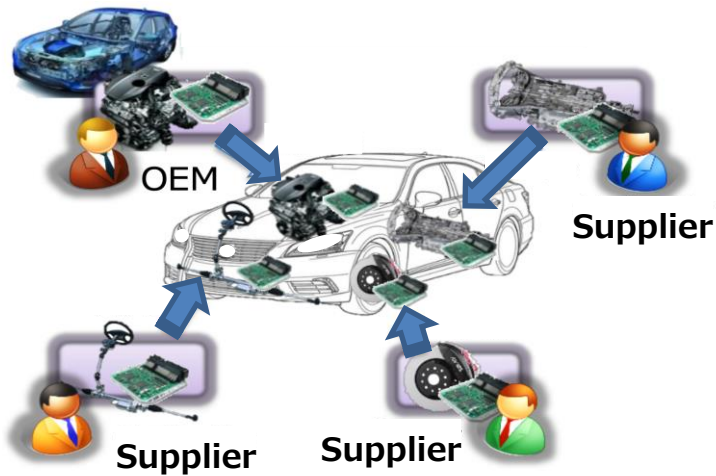
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Simulation Model Exchange Process Guideline

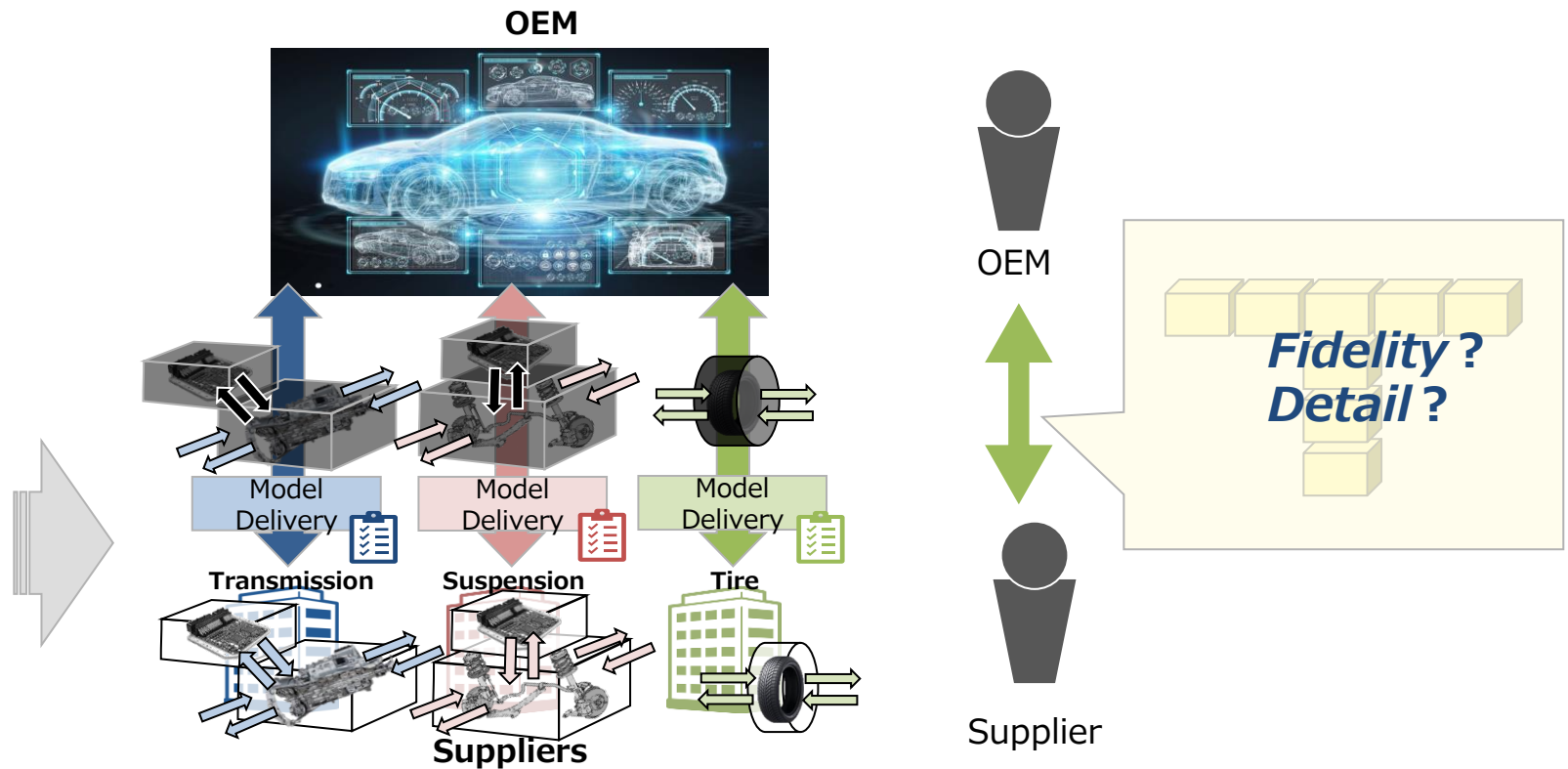
Guideline for realization of SURIAWASE 2.0 through model exchange



Current Status



Ideal Goal

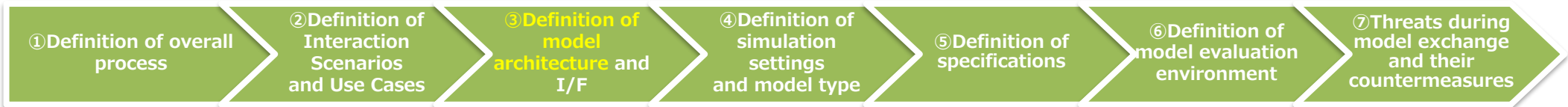


Suriawase(harmonize) with prototype parts

Suriawase 2.0 by model

Approach to issues in model exchange process

Reference images of the two guidelines (PSI GL, plant I/F GL) in seven approaches are shown below.



 	PSI GL	 SmartSE Reference Process (AnnexE)	 Interaction Scenario and Use Case	 Boundary And Core Model	 Specification and implementation steps for the standardization	 SmartSE Reference Process (AnnexE)	 IP Protection in Collaborative Simulation Modeling
	Plant I / F GL			 GL-compliant model		 Validation of model connections	



Refrence

Example of SURIAWASE2.0



PSI GL	 4-layer approach	 Generic System Vehicle Model	 Simulation System Architecture for HAD	
Plant I / F GL			 Performance simulation architecture	 Basic principles

Use cases of JAMBE guideline/models in 2022



● Utilize JAMBE model
○ Not utilize JAMBE model

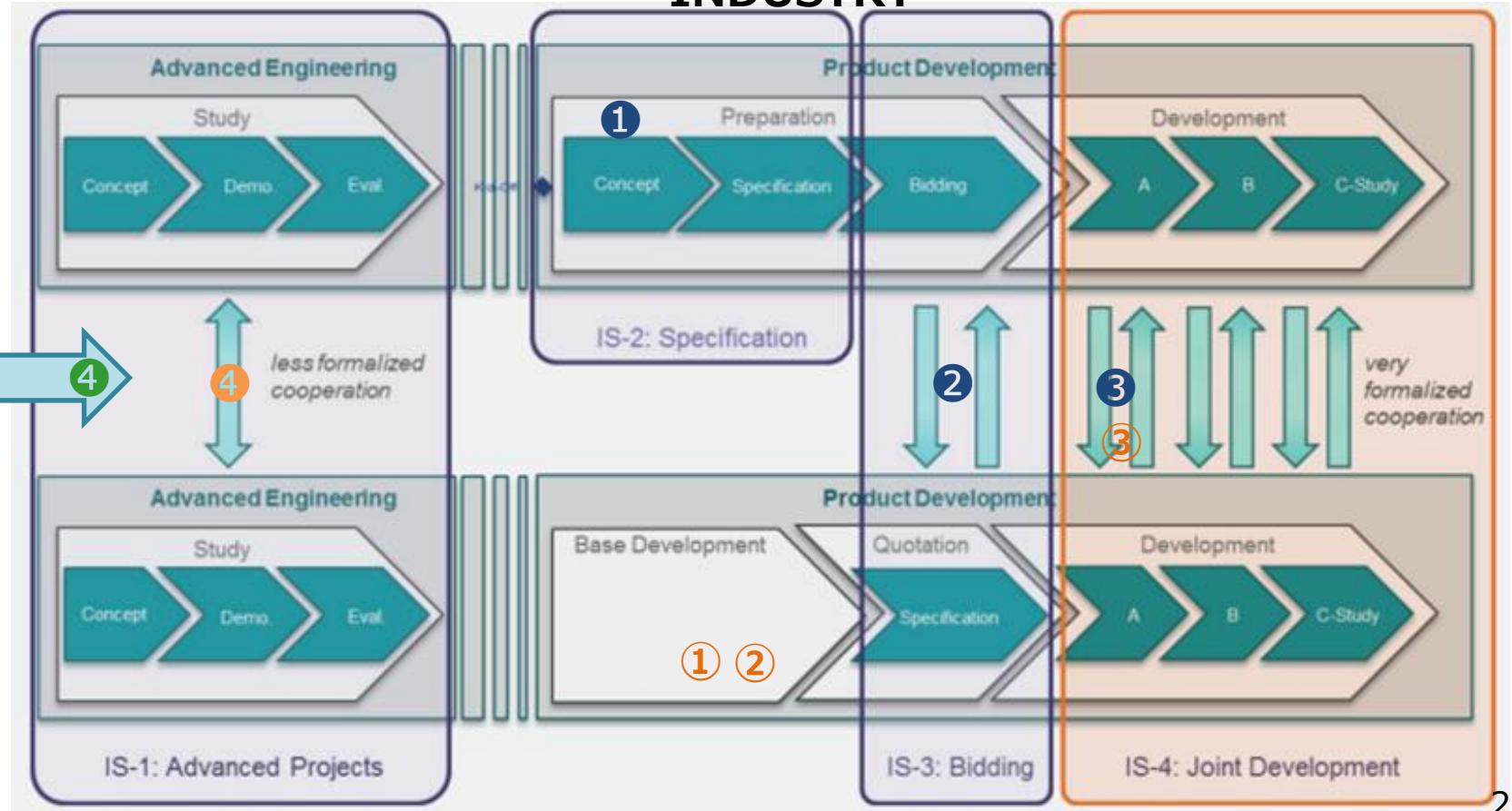
- JAMBE presents the case studies of the use of JAMBE guidelines/models at the public forum .
- The figure shows the 10 reported cases of utilization in 2022, plotted in the V-shape of the prostep ivip and the development phase.
- Examples of **actual applications in development of Industry** and **in research of academia** were presented.

INDUSTRY



OEM

SUPPLIER



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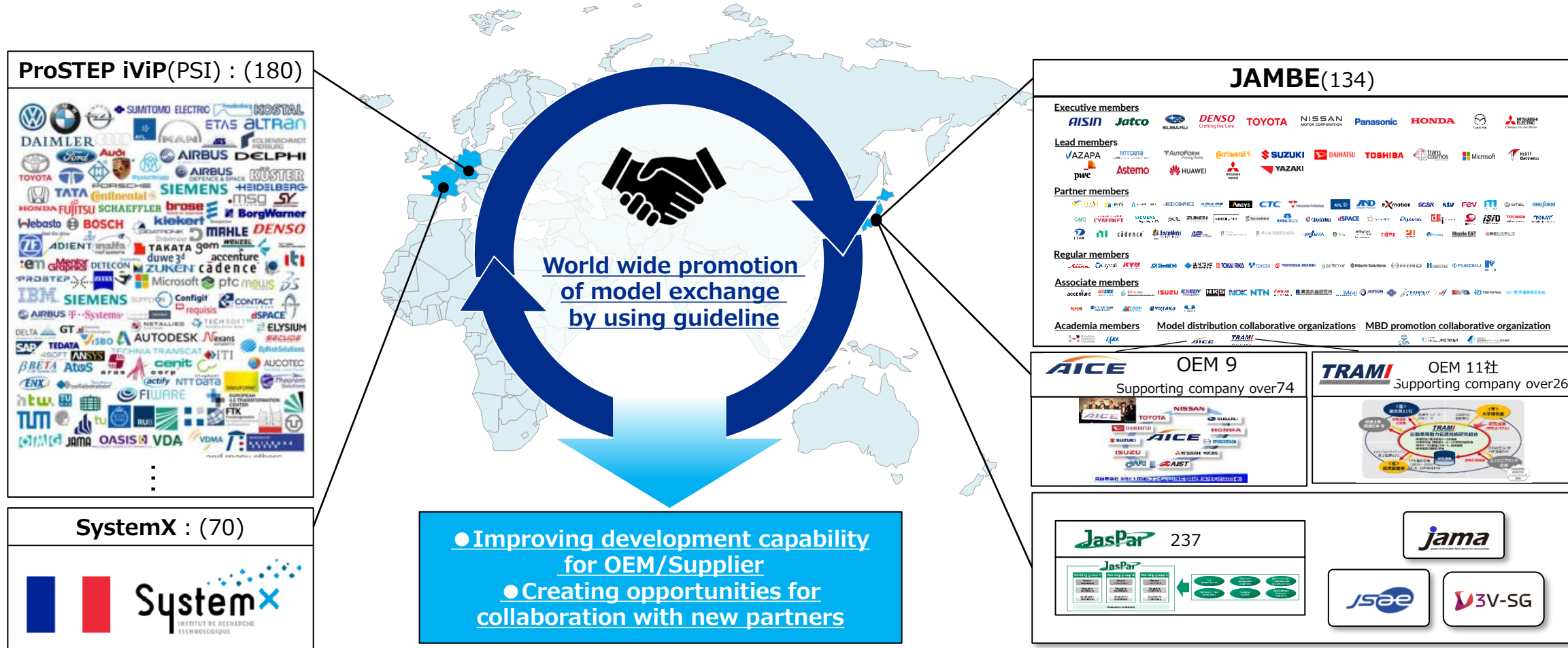
Grand Summary:

The evolution of promotion to the model exchange among industry and academia in Japan was presented.

JAMBE Future activity plans are to

1. Promote the expansion of the Generic vehicle model as a reference with partner organizations in order to promote model exchange for automotive development.
2. Extend examples such as multi-supplier collaboration
3. Deepen cooperation with prostep ivip and IRT SystemX and promote the model exchange in the supplier chain (Especially Meta Data)

Thank you very much for your kind attention!



※METI : 11 has been taken over by the new organization JAMBE from 2022

