Challenges towards New Software Platform for Automated Driving and High Computational ECU's

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Who am I ?

Project General Manager @TOYOTA (E/E Architecture Development Div.)

Engaged in In-House Development of Chassis Control Systems (ESC, 4WS)

2 Times assigned to Toyota Motor Europe (Electronics Systems for European Vehicles)

Responsible for Basic Software development for All Toyota Vehicles.

Engaged in AUTOSAR activities and served as a Steering Committee Member from TOYOTA

Developed AUTOSAR based BSW into All Toyota Vehicles

Currently on second assignment from TOYOTA to IAI Corporation.

Assistant Director at IAI, developing software for industrial robots.

Today's Agenda

- TOYOTA E/E Architecture Evolution and Software Platform(BSW)
- Technical Trends and Next Generation E/E Architecture
- Challenges towards New Systems(CASE) Development
- Summary

Technical Trends : E/E Architecture Technologies

Application


Connected

ADAS

ePF

LAN・Power source

Zone
(Backbone NW)

Optical

HD BaseT

BSW

SOA

IoT

Overlay NW

Cloud

TSN

New vehicle state

VLAN

AVB(gPTP)

BigData

CAN-FD

DoIP

OTA4.0

SD

ECU認証

Ethernet

ARXML

SOME/IP

Secure Boot

OTA3.0

TSS

T-CONNECT

C-ACC

Domain

KVM

IDS/IDPS

BAC
DBC

OTA2.0

SecOC

CAN

Phase 5

E2E

G－Book

Ethernet

ETC

OTA1.0

Phase4

CAN-FD

AUTOSAR NM

STEP4

OSEK NM

STEP3

CS:Tier1 Self sourced
Acceptance Test

CAN

STEP1,2

CS:TMC supply
Conformance Test

12PF

15PF

19PF

2XPF

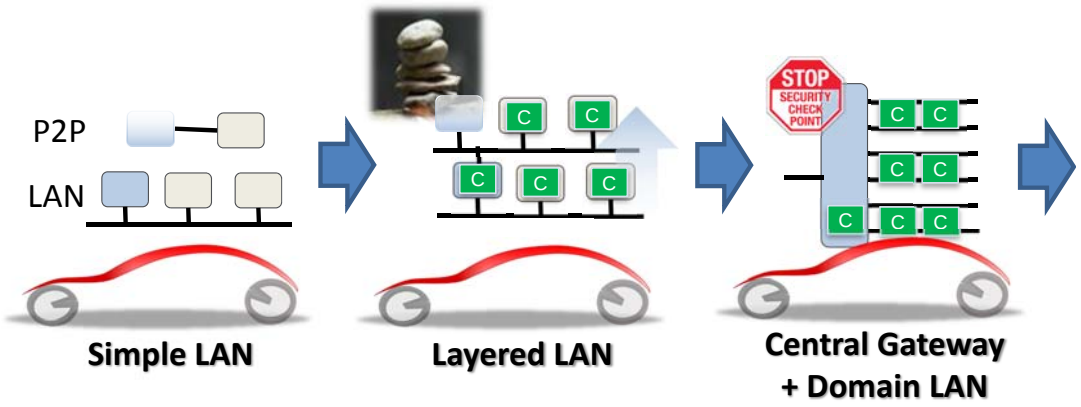
Safety and Security

High Speed Communication
(Ethernet, CAN-FD)

Standard

Business model

E/E Architecture Evolution



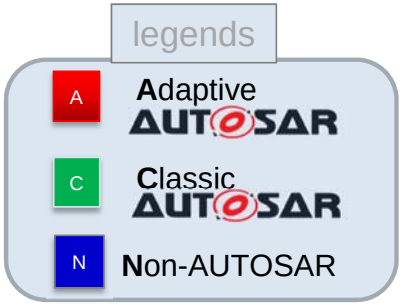
Simple LAN

Layered LAN

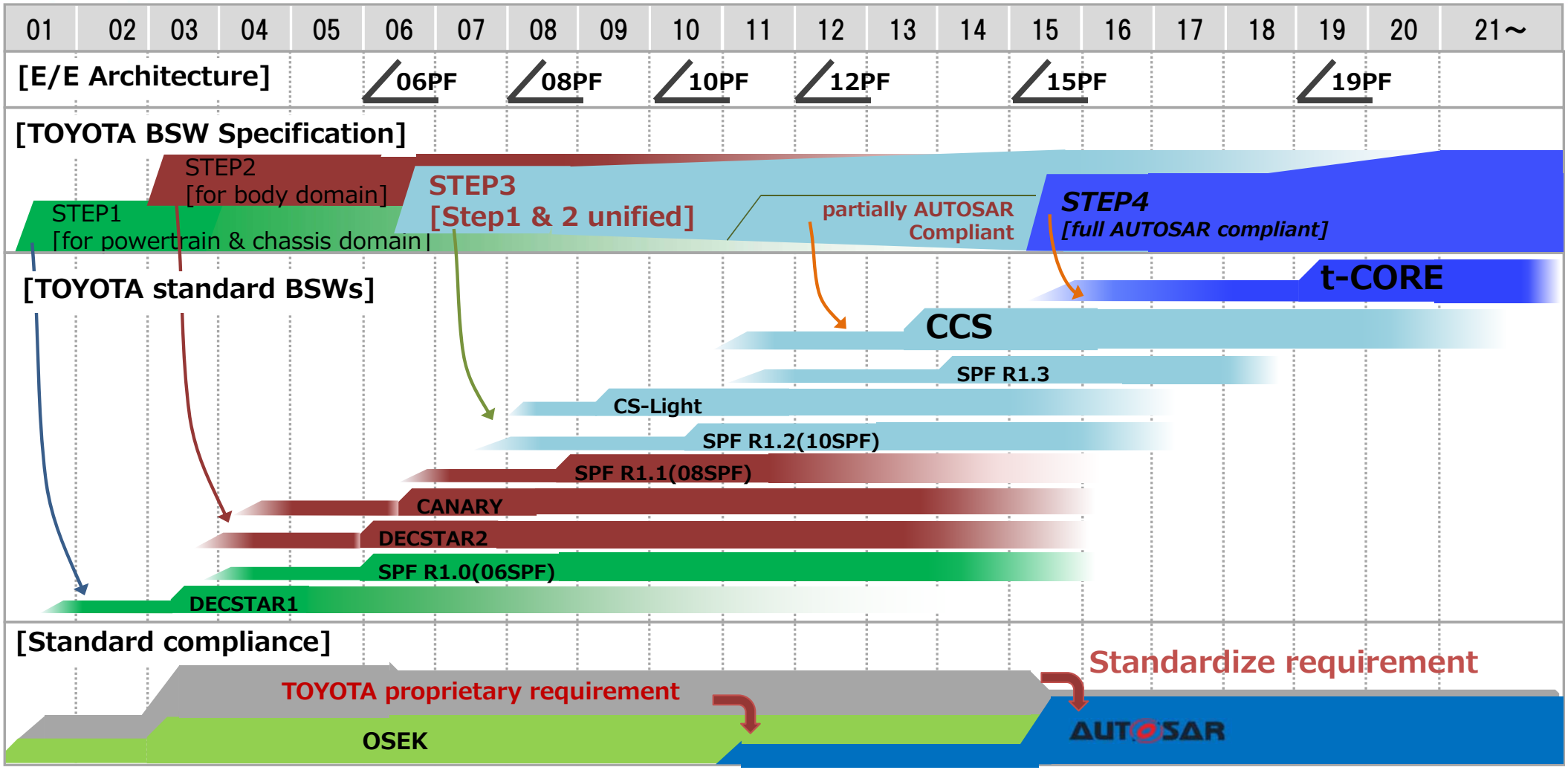
Central Gateway
+ Domain LAN

E/E Architecture evolved in order to meet
- **Complex System Requirement**
- **Development effort reduction**

Connected ECU's utilize Common Software Platform (Basic Software)



Toyota E/E Architecture Evolution and AUTOSAR BSW migration



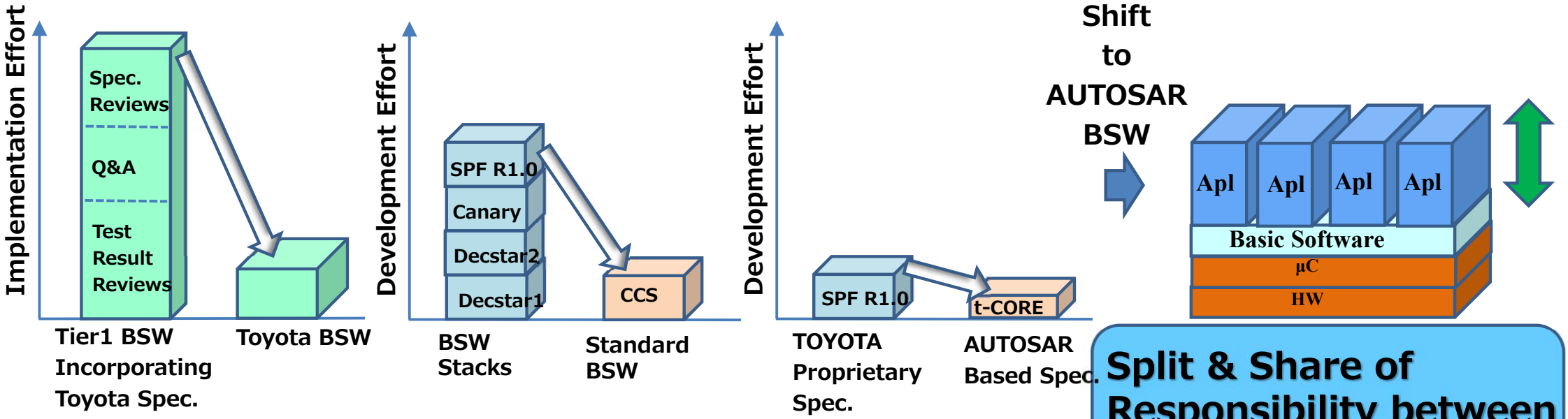
Benefit of AUTOSAR Standard BSW

Proprietary Specification ⇨ Standard Specification

Proprietary Software ⇨ Standard Software

Common understanding of Spec.(Functions)

Common usage of Implementations



Split & Share of Responsibility between OEM, Tier1, Tier2

◆TOYOTA standard BSW with full AUTOSAR compliance

◆Support TNGA (TOYOTA New Global Architecture) requirement

◆More than 82 ECU, 27 Tier-1 Projects (including in-house development)

◆Business model for efficient Software development
(BSW: Global BSW Vender,　Application:OEM)

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Technical Trends : Development Process

Modular approach
creates Many Variants

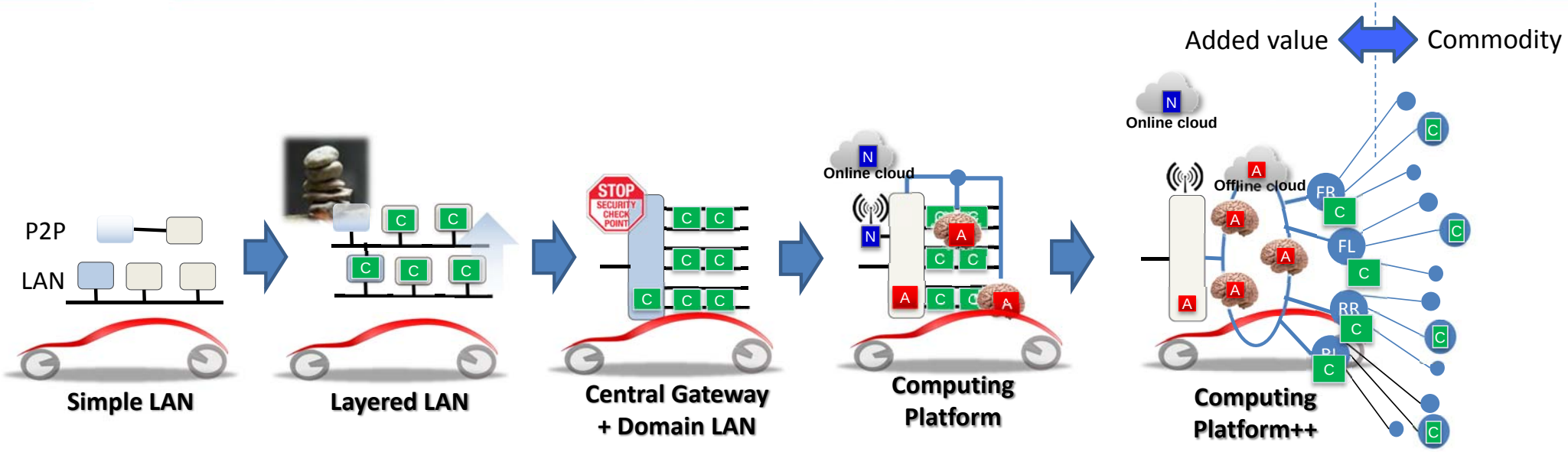
System / Software become too Large
(Cross Domain Functionality)

Tier-1 Development Process need to be Agile
(streamlined product line strategy)

OEM has to cope with
1) “large variant set” (including smaller vehicle)
2) “systems’ engineering” for global optimization
3) short sprint release “repeatedly”

Potential measure on
E/E Architecture
1) Open System (on demand)
2) Centralization
3) Frequent Update (OTA)

E/E Architecture Evolution



legends

- A: Adaptive AUTOSAR
- C: Classic AUTOSAR
- N: Non-AUTOSAR

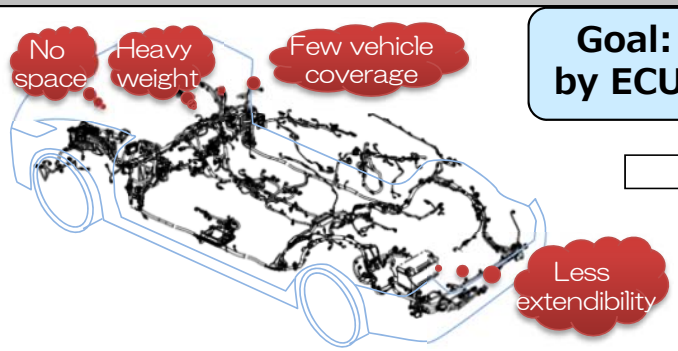
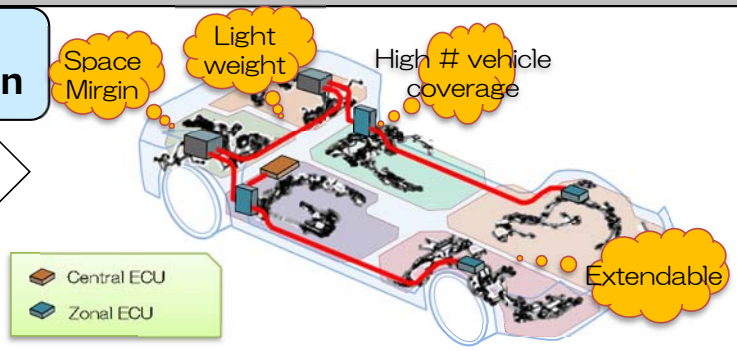
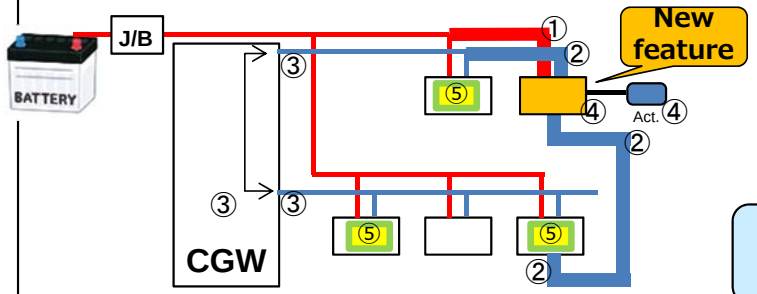
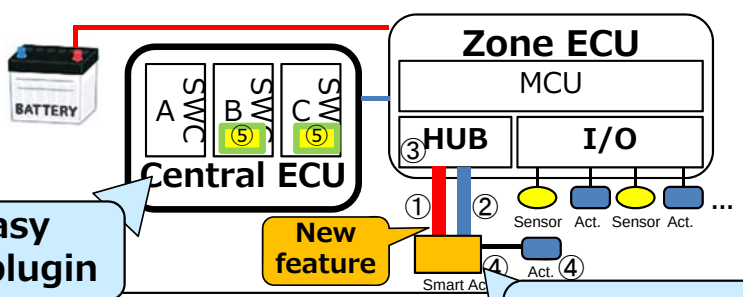
E/E Architecture may need

- **Central ECU**
- **Brain ECU**

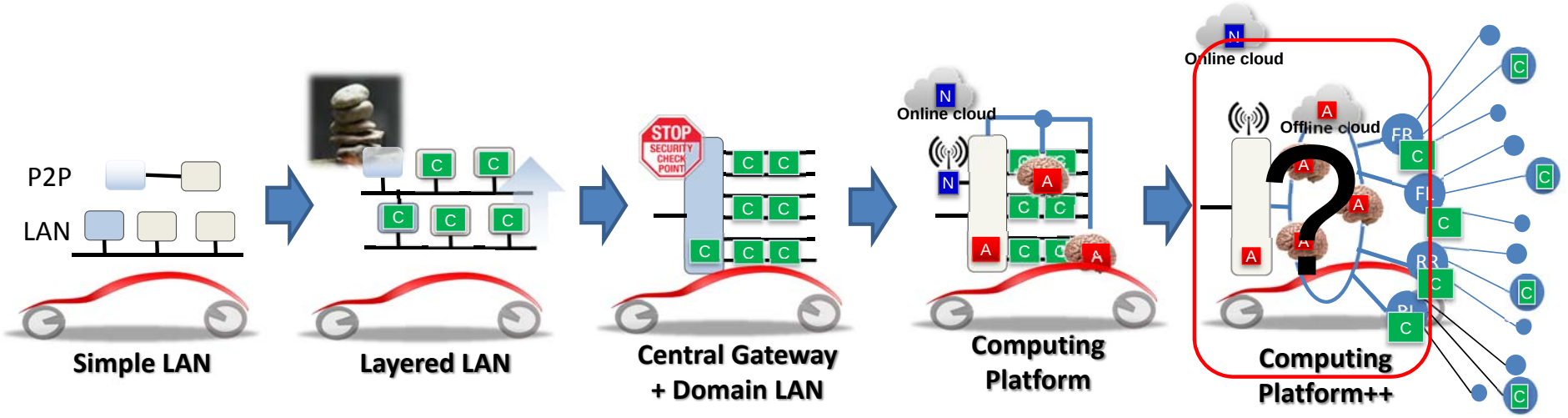
Functions could be distributed to Zone ECU

Future E/E Architecture: Central & Zone Concept

Central & Zone Concept is recognized as ultimate goal of Physical E/E Architecture

	Current Architecture (Domain based)	Next Gen. (Central and Zone)
Physical	 **Goal: Cost down by ECU integration**	
Impact image on change		 **Goal: Easy software plugin** **Goal: Localize physical changes**
Power	①Dedicated, additional wire and route required	①Minimized wire under Zone
Network	②Dedicated, additional wire and route required ③Negotiation effort on network design	②Minimized wire under Zone ③Localized change (i.e. comm. matrix)
Mounting	④Redesign on additional ECU	④Spared space for additional ECU
Logical	⑤Software changes on distributed ECUs	⑤Software change only on Central ECU

E/E Architecture Evolution



legends

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Open question :

- how to migrate toward Central & Zone Architecture
- Timelines for Introduction

A Possible Migration Scenario

Speed (Time to market)

Development

Deployment

Cost

Hardware consolidation

Flexibility

Localize OTA change

Autonomous

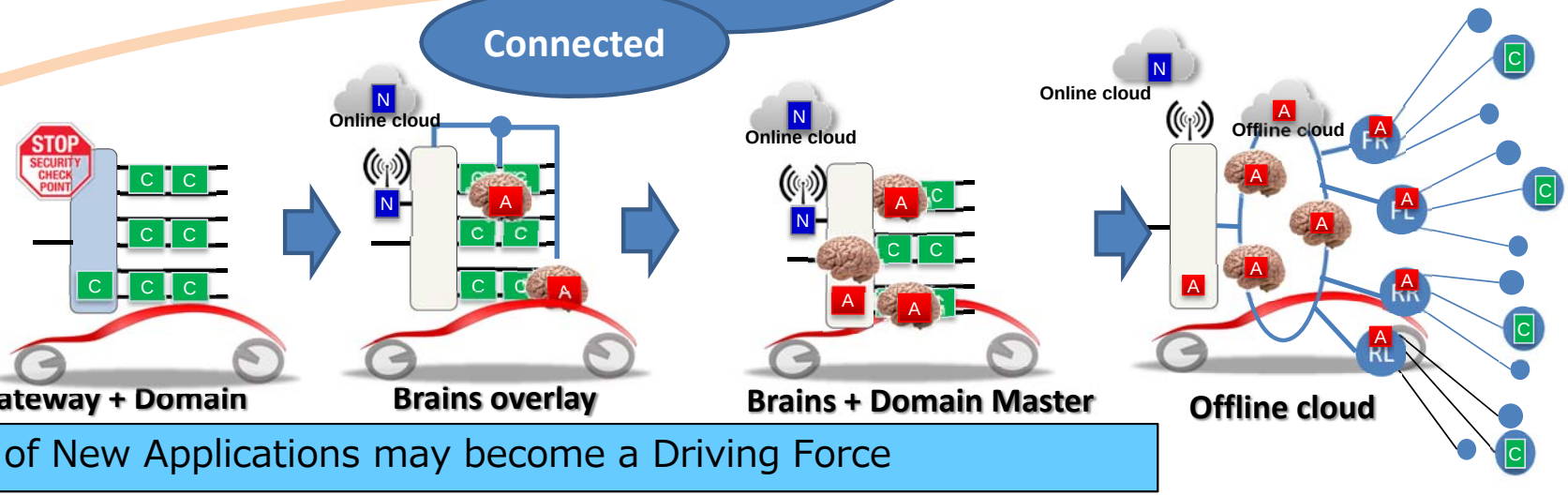
AI

EV (Regulation in various countries)

Car Share

MaaS service

Connected



Introduction of New Applications may become a Driving Force

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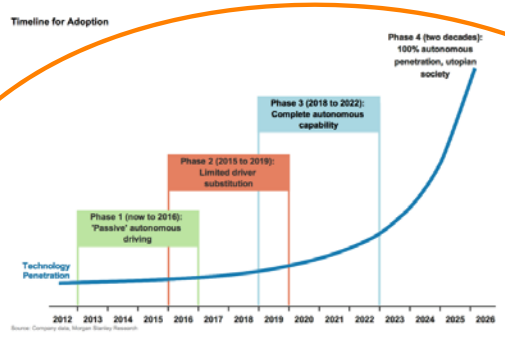
Application Driver for Future E/E Architecture : CASE

Size / Complexity

Vehicle as a part of IoT

Connected



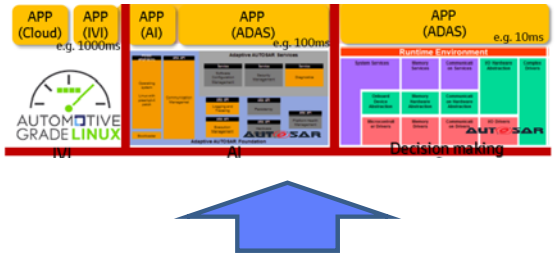
Lv3, Lv4, …

Autonomous

Source : Morgan Stanley Research chargedevs.com

Electrification

Shared



Infotainment | Body | ADAS | Powertrain / Chassis

Let’s have a brief look at the actual development status

Highway Automated Driving System

It seems to be working well….

How to Validate/Verify the System … Globaly

142 Billion Km(on road test)
Necessary for Full AutoDriving

May take 2700years
(Avr Spd 60Km/h)

Total Road Extension (Global)
≒36 Million km
（Calculated from 2013 World Factbook）

Comprehensive Validation
is Necessary

Test Cases should cover all the Roads Globally
=>Condensed/Compressed Validation Method Necessary

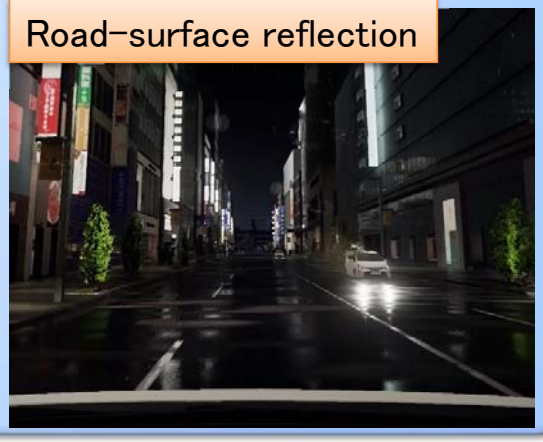
Utilizing Virtual Environment for Verification Coverage

Verifying "Recognition"

Utilizing computer graphics images

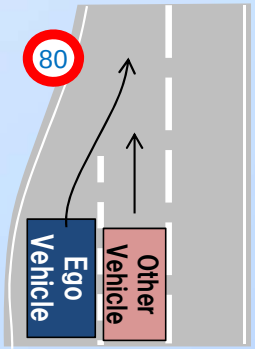
Backlight

Road-surface reflection

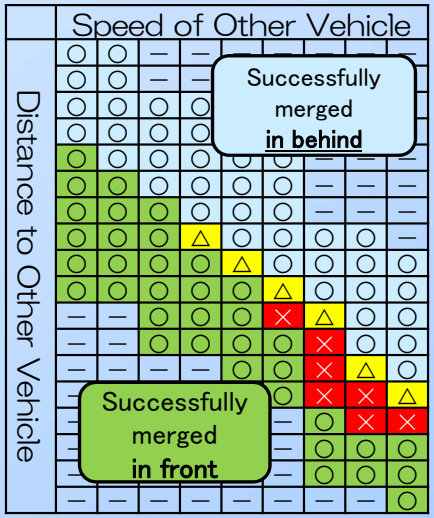


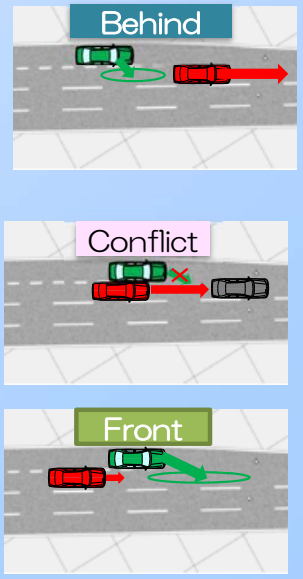
Verifying "Planning/Control"

Simulation is effective for matrix-style verification (Automatic, Re-usable, Rare scene)



e.g. Merging on highway (Ariake IC)
Result from MILS evaluation





Utilize to develop algorithm for Planning/Control performance

Accumulated Data and Simulation is the key for Verification coverage

Driving Scene in Backlight

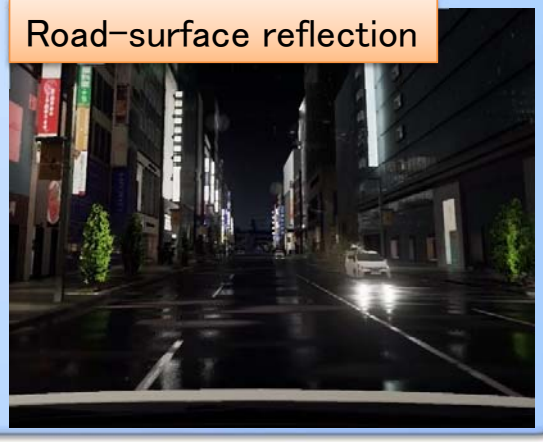
Utilizing Virtual Environment for Verification Coverage

Verifying "Recognition"

Utilizing computer graphics images

Backlight

Road-surface reflection



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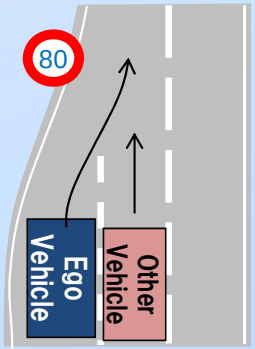

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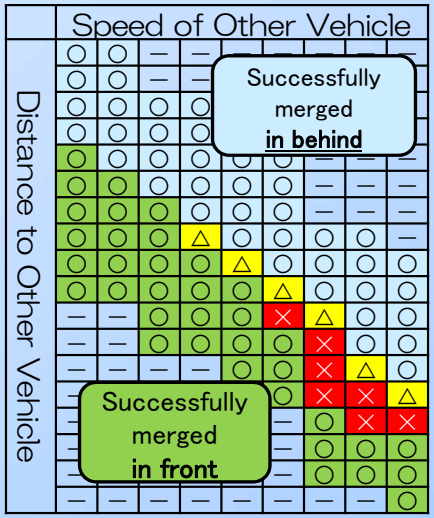
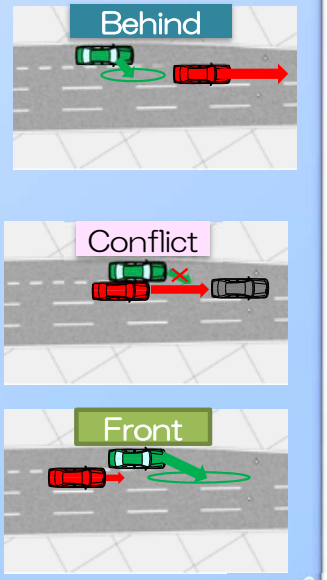




Utilize to develop algorithm for Planning/Control performance

Accumulated Data and Simulation is the key for Verification coverage

Enabling Technologies for CASE Systems Development

Research → **Pre-development** → **Development & Series Production**

e.g. Deep learning server
e.g. Voice recognition

backend
onboard

Optimize

e.g. trunk server

getting closer

Central Unit

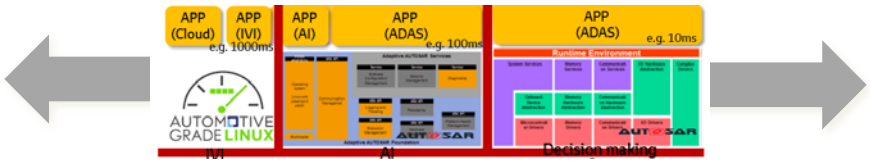
Hardware update

Virtual Environment (PC base)

Mass Production ECU

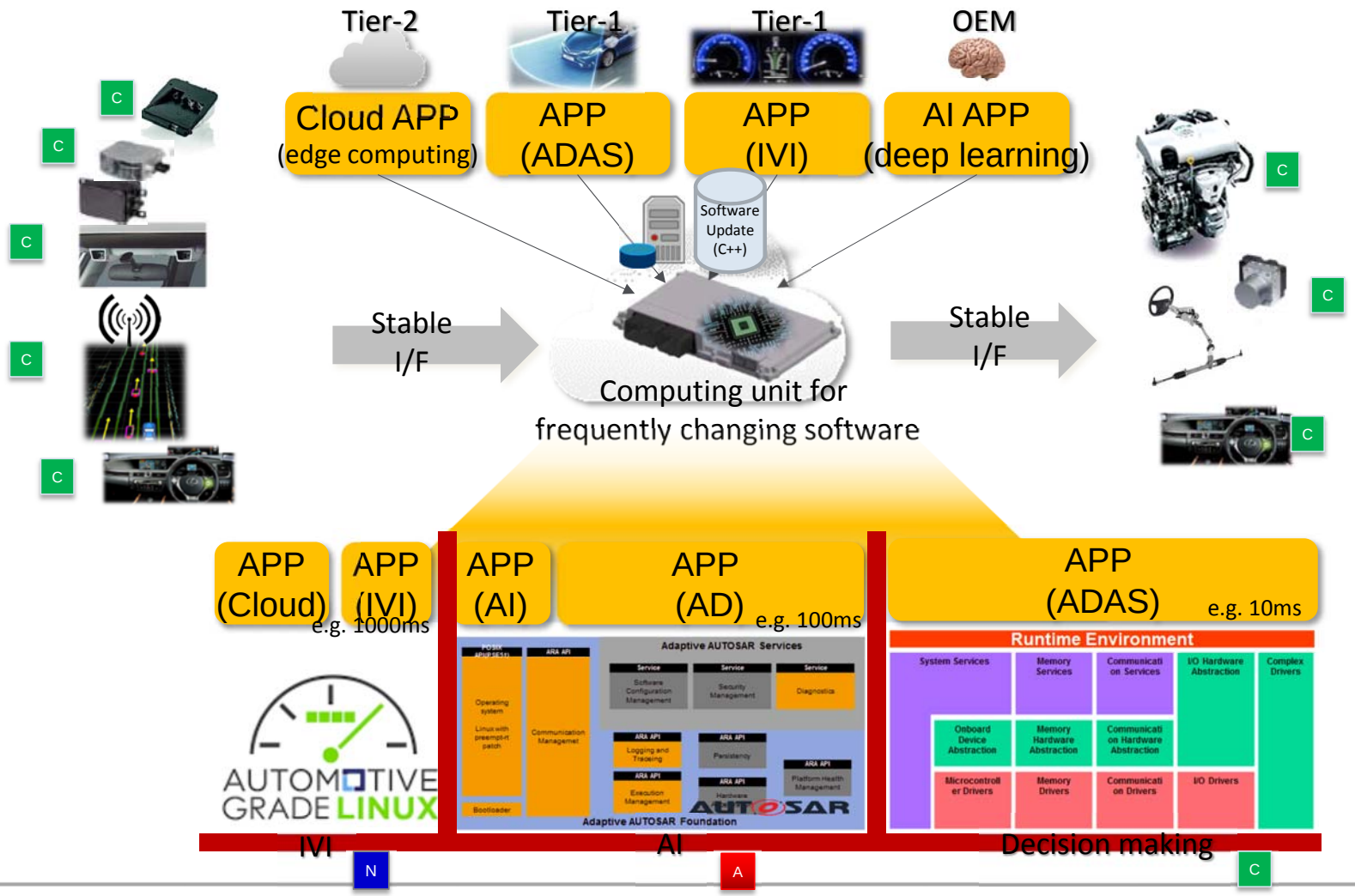
Scaling Computational Power

Application → Functionality Checked → **Application** → Real-Time, Performance Checked → **Application** → **Deployment ready**



Same Functionality between different Computing Platforms

Enabling Technologies for CASE Systems Development



Key software (for OEM) may be executed on adaptive PF. Scalable software (extended features) are located at central ECU

Split & Share of Responsibility between OEM, Tier1, Tier2

Summary

- E/E Architecture May Evolve to Central & Zone Conept
- Migration from Domanin LAN Architecture my be enabled by Adapting CASE Systems into the Architecture
- Verification & Validation of CASE System only possible with utilization of Vertual Technology
- Software Platform (Adaptive AUTOSAR) must support same functionality between Virtual Environment to Mass Production ECU’s
- Work Split & Share between OEM, Tier1, Tier2 essential for the success of Future Software Platform and E/E Architecture

Thank you very much for your attention !