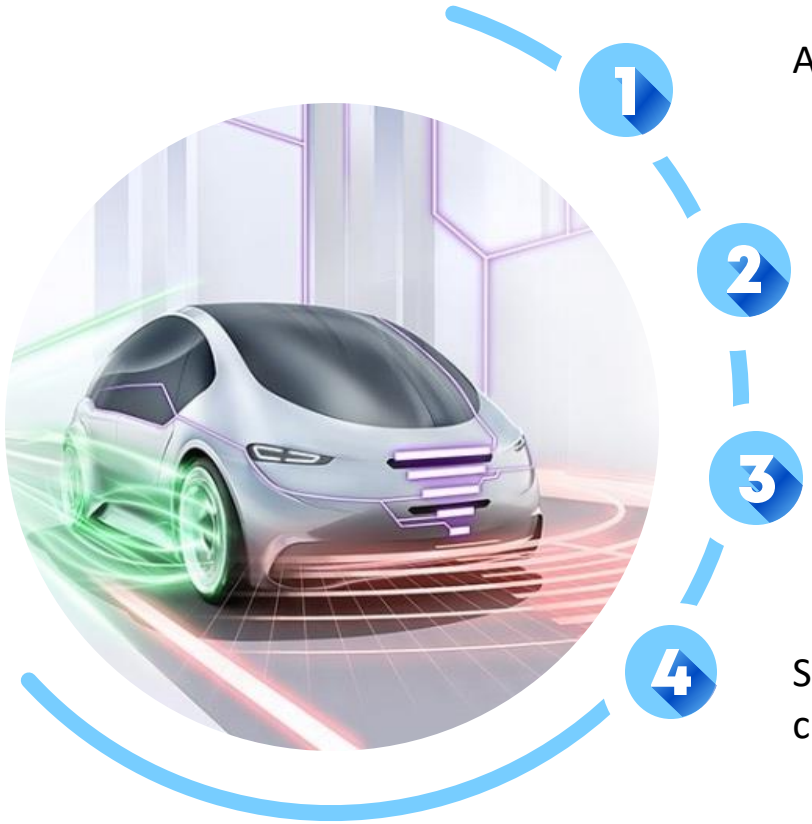
# New reality in SW development

Berlin, November 7, 2024

Roland Berger

# Agenda

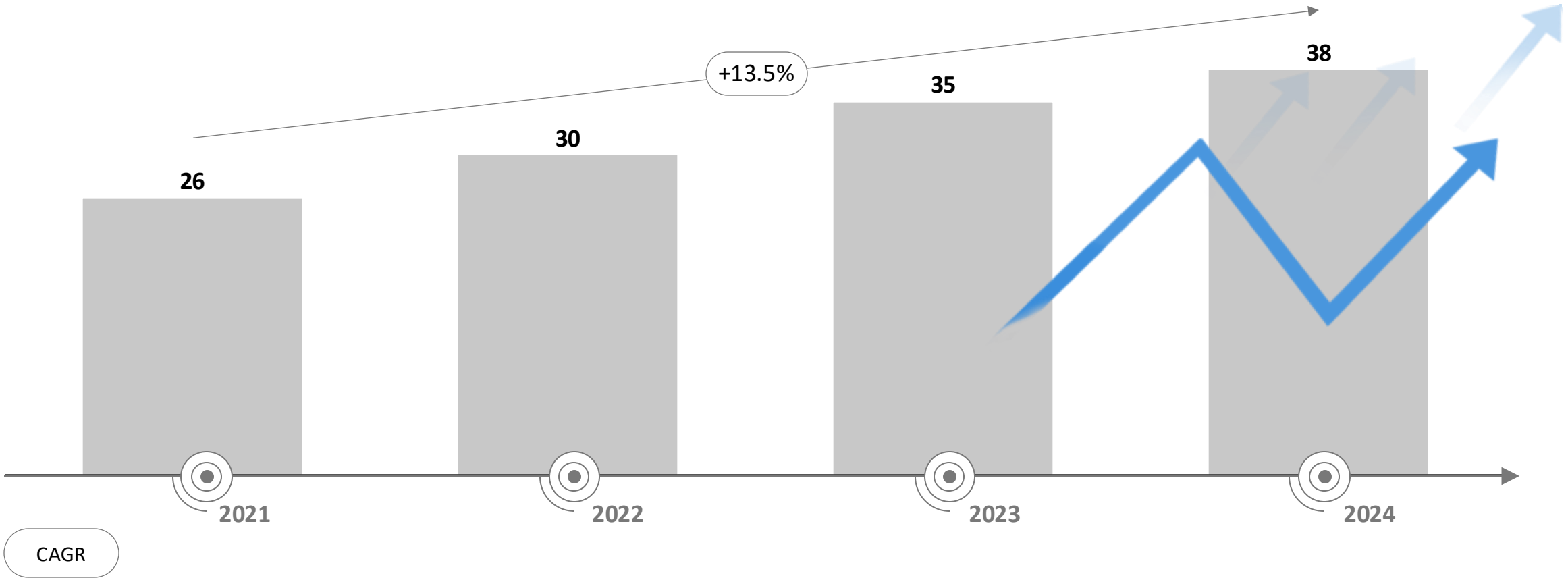


1. Automotive market condition – SW budgets will only minor grow
2. OEMs will implement SDV until 2030 for cost and speed reason
3. SDV requires a company transformation
4. SDV implementation causes a growing inhouse SW development share – A solution for cross OEM reuse is recommended

# 1. Automotive market condition – SW budgets will only minor grow

# SW development budgets of OEMs grow since 2021 with ~14% CAGR to USD 38bn

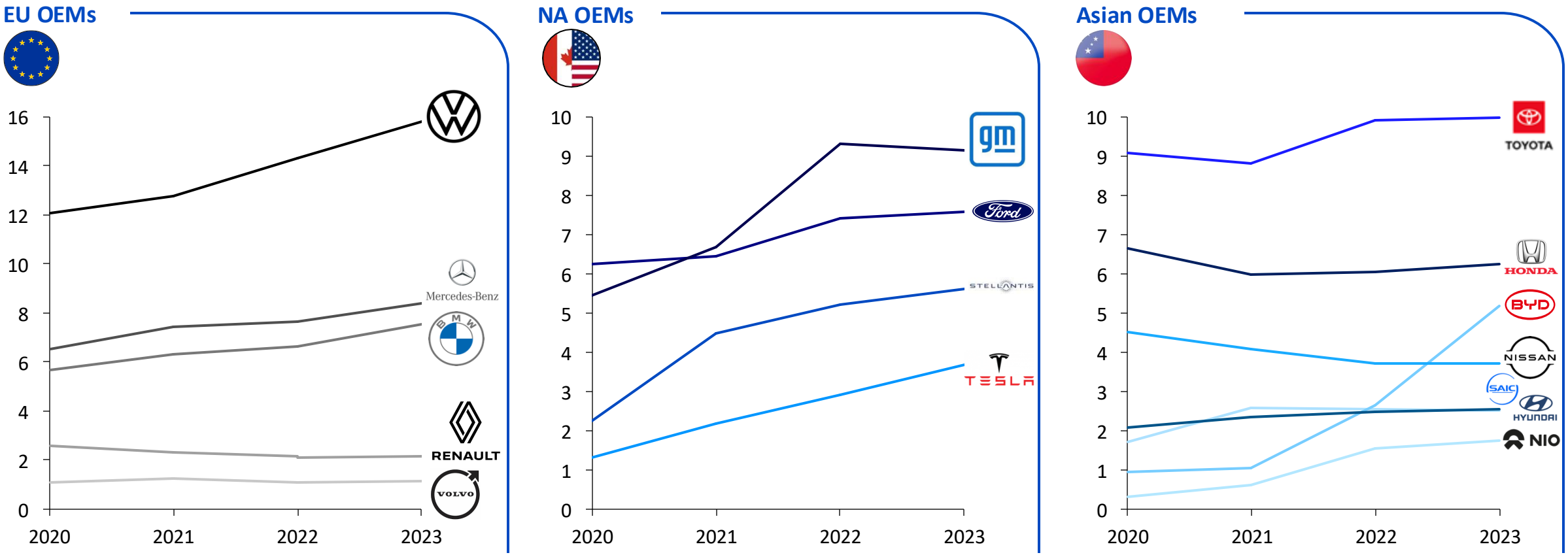
OEMs' SW development budgets [USD bn]




Source: Expert interviews; Roland Berger SW market model

# OEMs' R&D budgets grew at the same time by EUR 25 bn – Especially in NA and EU

OEMs' R&D budgets [EUR bn]




Source: CapitalIQ

# But the party in over: OEMs worldwide are forced to announce global profit warnings due to the market slow-down and increased competitive pressure

Profit warnings in the Automotive industry [Selection]

> *Volkswagen does not expect to be able to offset **restructuring costs** and other **unexpected expenses** of up to **EUR 1.7 bn** in 2024, and therefore adjusts the **annual forecast** by -0.5 pts.*
>
> Volkswagen Group, September 2024

> *Mercedes-Benz **cuts its full-year margin target** for the second time in less than two months due to weaking **Chinese car market**.*
>
> Mercedes-Benz, September 2024

> *Ford expects to hit the **lower end** of its full-year **profit guidance** due to **global price war**, fueled by **overcapacity**, a flood of **new EV nameplates** and massive **compliance** pressure.*
>
> Ford, October 2024

> *Porsche expects **weaker returns** this year due to the **costly rollout** of new models, **high development spending** in a challenging global economy and **supply chain disruptions**.*
>
> Porsche, July 2024

> *Stellantis **revised** its **2024 financial guidance** to reflect decisions to **significantly expand remediation actions** for North American performance issues, as well as **deteriorating global industry dynamics**.*
>
> Stellantis, September 2024

> *BMW Group **adjusts guidance** for **2024 financial target** due to **higher R&D, personnel and manufacturing costs** as well as **delivery stops** and warranty cases.*
>
> BMW Group, October 2024

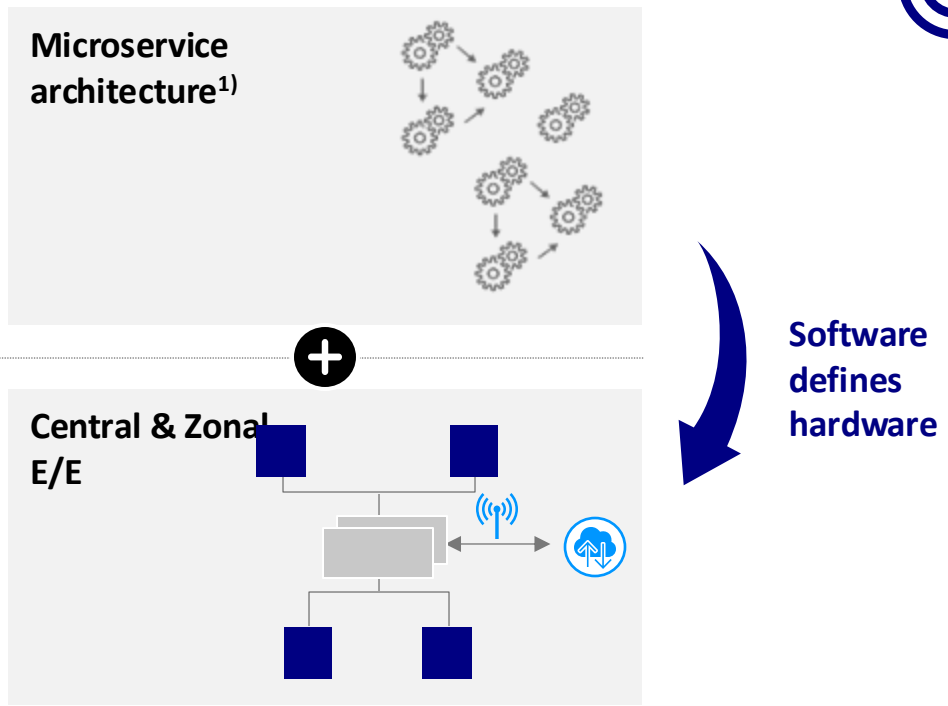
Source: Company information, Press research

# 2. OEMs will implement SDV until 2030 for cost and speed reason

# All OEMs target a Central & Zonal E/E architecture with microservice based SW architecture to improve cost and time to market

Target picture for around 2030

## OEMs will use Software defined vehicle (SDV) …




## … and plan to realize:

### Reduced cost

- **One-off savings** in the long-term because of lower complexity, virtualization possibilities and high abstractions level
- **Material cost savings:** Realized through centralization of computing and strong simplification of wiring harness

### Faster time to market

- **Faster time to market for new features** is named as a key reason to use more radical architectures and approaches

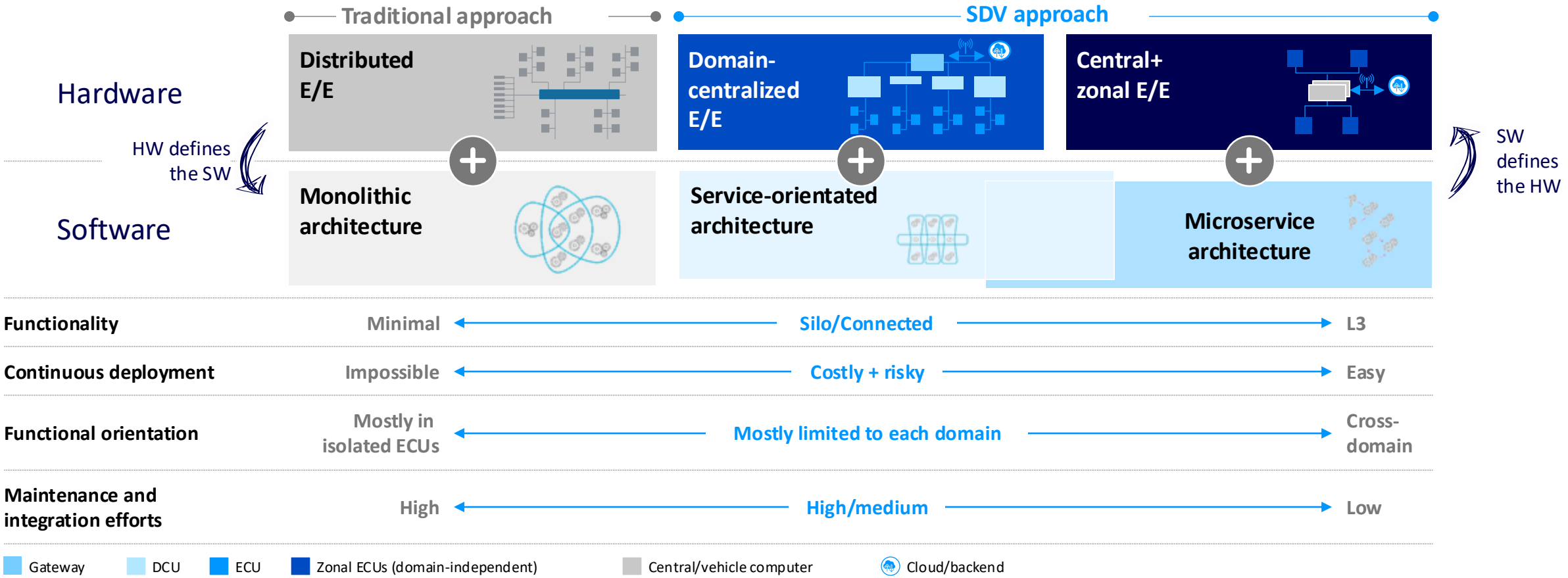
Zonal ECUs (domain-independent) | High performance central/vehicle computer | Cloud/backend

1) Very high level of HW abstraction

Source: Industry expert interviews, Roland Berger

# Zonal E/E architecture together with microservice architecture enables rapid, frequent & reliable deployment of SW with low maintenance & integration effort

Definition of 'traditional' vs. SDV' approach




1) SDV: Software-defined vehicle

Source: Roland Berger

# A direct switch to the central architecture immediately brings the benefits of SDV but comes at a high risk – Intermediate step can reduce initial costs & risk

Benefits & challenges of the approaches for E/E architecture evolution

## Evolutionary approach

Distributed → Domain-centralized → Central+ zonal

| Benefits | Challenges & limitations |
|---|---|
| **Proven domain-specific processes and tools** and flexibility to apply selected proven approaches in individual domains | **Limitations to drive innovations** for vehicles in the field due to variant complexity and computing power solely dedicated to domains |
| **No R&D reorganization** for domain architecture necessary | **Increased midterm costs** due to two complex E/E changes and high effort in virtualization and testing with domain-centralized architecture |
| **Optimized short-term costs** due to higher share of reusable SW and bigger potential supplier base | Increased risk and long time for large **OTA updates** |

## Direct approach

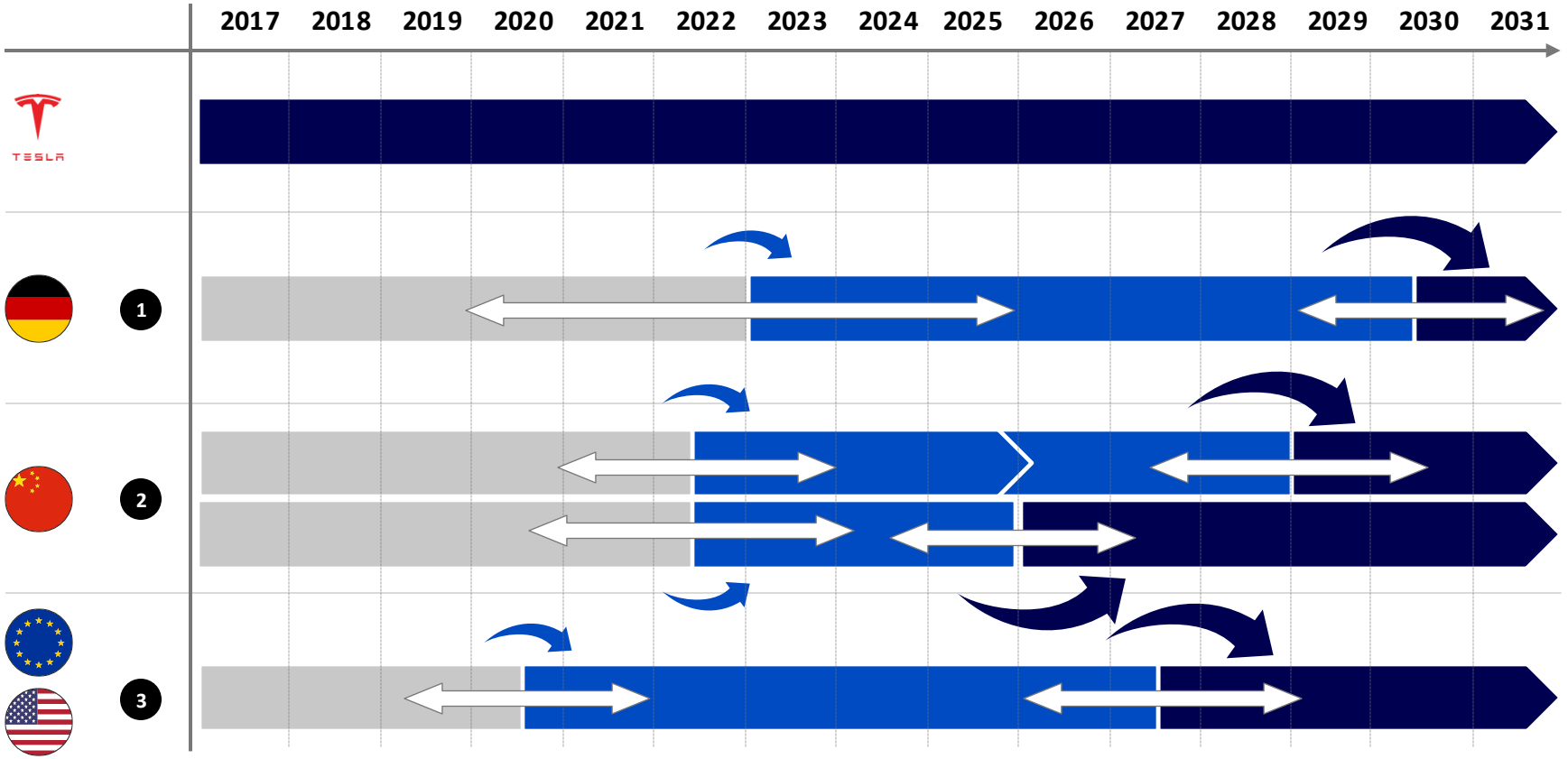
Distributed → Central+ zonal

| Benefits | Challenges & limitations |
|---|---|
| **Easier handling of OTA Updates** | Requires **strong organizational and cultural change** |
| **Only one E/E change** over time required to handle limitations in legacy ECUs, new feature and legislation requirements | **High initial costs** due to necessary HW changes and limited number of qualified collaboration partners |
| **Lower maintenance costs** and more reliable deployment of SW | **High risk** due to complexity and novelty – delay of E/E architecture launches likely |

Indicative

# Chinese OEMs expect to switch early to Central & Zonal Architecture ('25/'26), German OEMs switching '29

Timeline of SDV transformation[1)] of OEMs groups




**SOP of Architecture** summarized by OEM group: Distributed Domain Architecture Central & Zonal Architecture Introduction time span

Small transformation step towards Domain centralized

Radical transformation step towards Central & Zonal Architecture

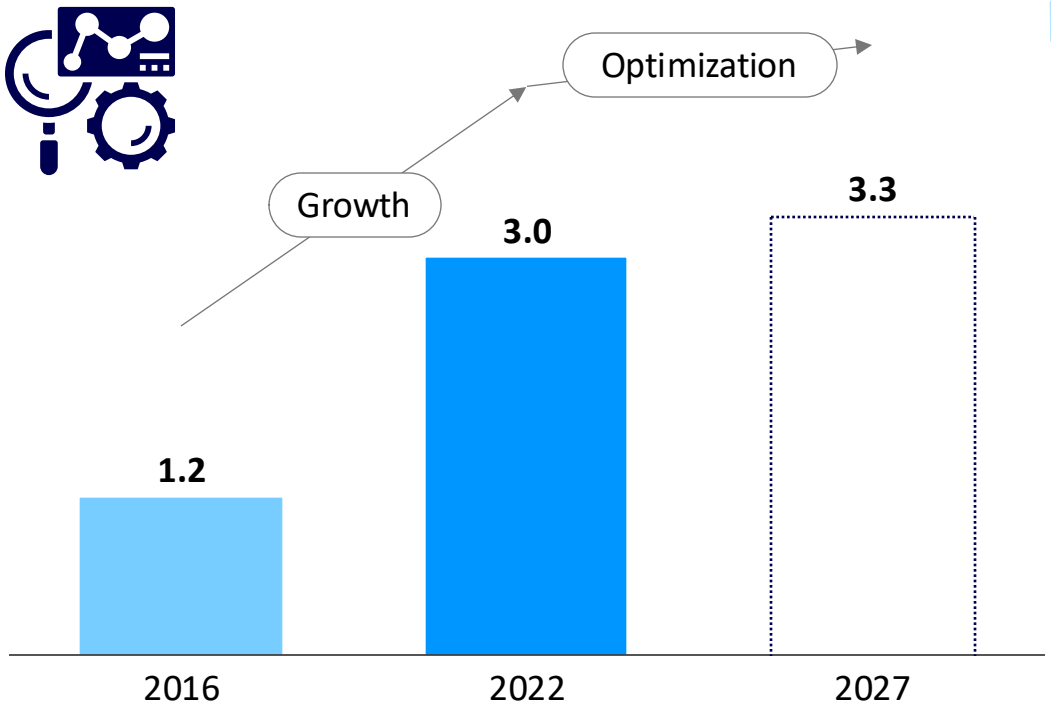
1) SOP of first vehicle with new EE architecture

- Tesla implemented a radical approach because of lacking legacy
- Legacy OEMs need to transform architecture, organization and processes – magnitude of change requires usually intermediate transformation steps
- German competitors finalize transformation rather late (~2030)
- Chinese and American/ French OEMs are transforming more progressively

# The transition towards SDV and a parallel feature growth will requires major invests

Example: SW budget of NA OEM [EUR bn]

## SW budget evolution[1)]




## Key drivers of SW budget growth

Allocated budget

| | |
|---|---|
| **SDV platform** | High technical ambitions with investigations on **microservices** and **container solutions** |
| **ADAS & IVI** | Ambition to develop high number of features and create a seamless **digital experience for the end customers** and implement a SDV monetization strategy with in-car subscriptions |
| **Cloud services** | Need to rely on cloud environment for **SW development** and support the **monetization strategy** by delivering one-to-one personalized interactions[2)] |

Historic development | Current budget based on expert interviews | Estimated projection based on expert interviews

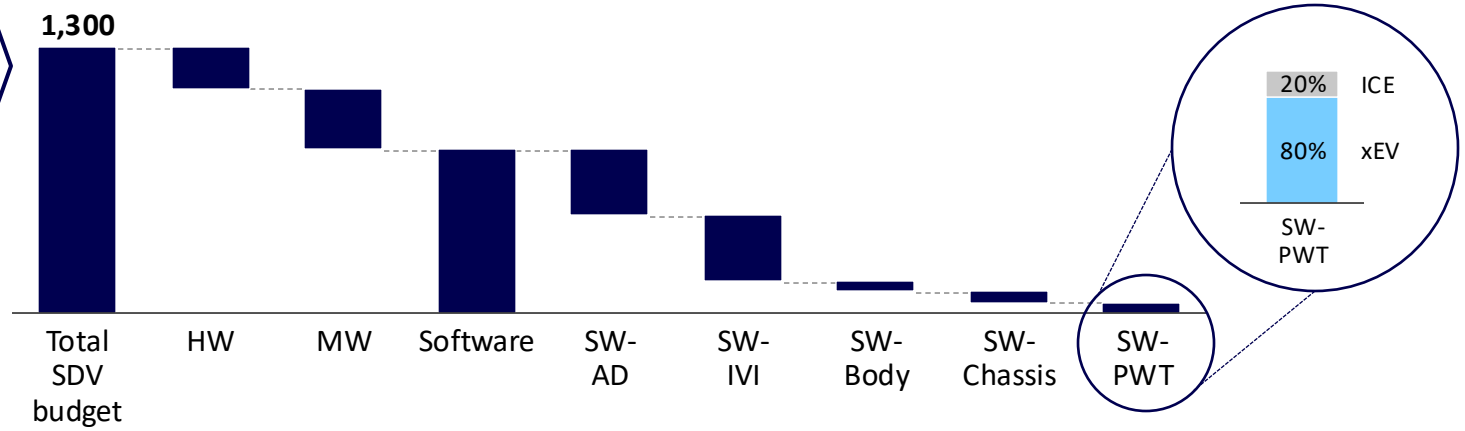
1) Estimates; 2) GM will use Adobe Experience Cloud to unify customer insights and orchestrate experiences across online and offline touchpoints in real time

Source: Expert Interviews, Roland Berger

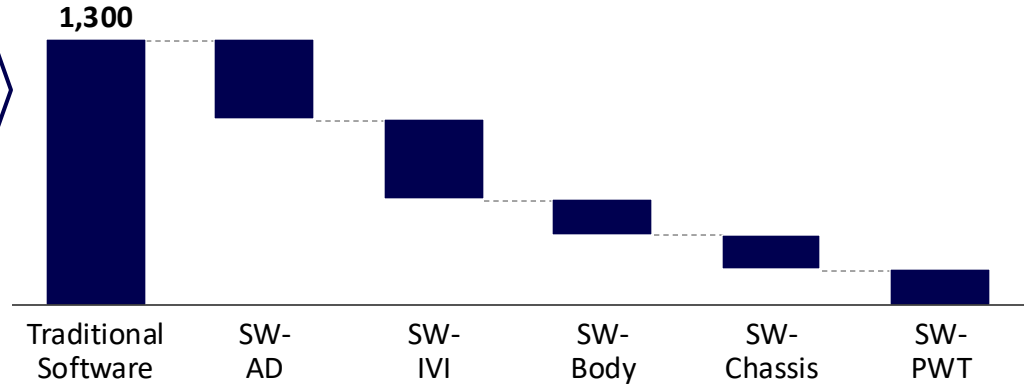
# The SDV transition could be realized by having parallel teams and budges

Example: SW budget of NA OEM [EUR m, 2022]

**SDV budget**




**Traditional SW budget**




**Others**

**Toolchain**
EUR 75 m

**Cybersecurity**
EUR 125 m

**Cloud services**
EUR 200 m

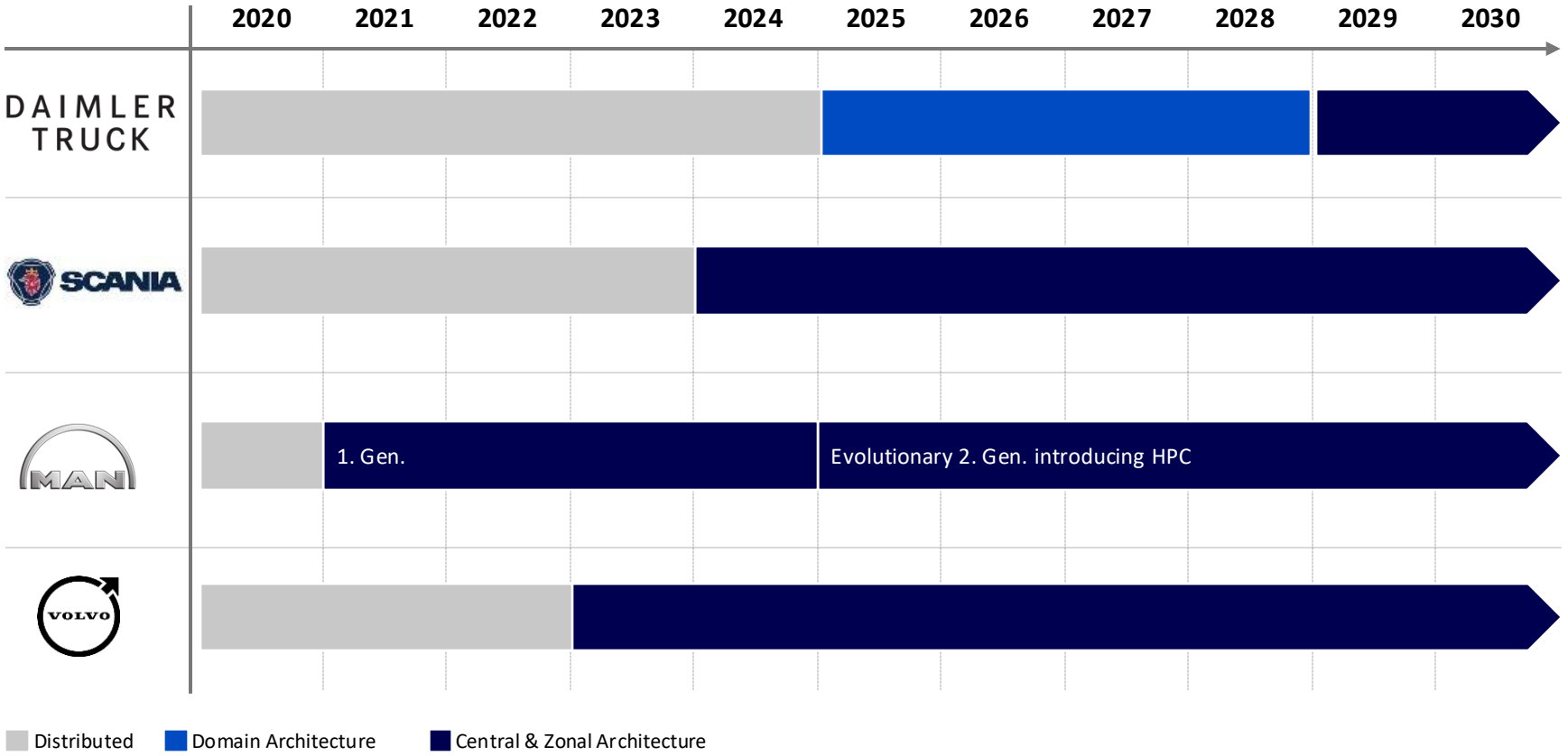
## Comments

- Overall **high SW budget** aligned with ambitions on SW monetization
- Willingness of **in-house development** leading to **high labor cost** (at least 7,000 SW engineers mainly located in the US)
- **Hunger for SDV**, with about half of the SW budget dedicated
- Focus on **ADAS** and **IVI** features development to create visible value for the customers

Source: Expert Interviews, Roland Berger

# Sidenote: Commercial vehicle OEMs are quicker in the transition to SDV

E/E architecture transition timelines (First use of new E/E architectures)




Note: Graphic shows expected year of launch of new E/E architectures – Legacy architectures are not necessarily replaced and might be used longer

Source: Expert Interviews

## Key takeaways

- All major Western OEMs **switch to SDV approach** with the respective E/E architectures (domain centralized, central + zonal)
- Competitors use **different approach for** their evolution **of E/E architectures**
  - Daimler Truck uses inter-mediate step from 2025 onwards and switches to central + zonal architectures in 2029
  - MAN, Volvo and Scania switch directly to the zonal architecture in 2021 and 2023/2024 respectively
- OEMs are **partnering with suppliers** to master the discipline of SDVs
  - Amazon Web Services for Cloud platforms
  - Here and Waymo for application SW
  - Autosar for OS & MW

# 3. SDV requires a company transformation

Non-exhaustive

# The new architecture needs a more holistic End to End view, resulting in a need for organizational and processual adaptions

Minimal requirement for adapted approach

## Organizational requirements

- **Cross-domain collaboration**
- **Cross-function collaboration** (Avoid silo-thinking)
- **End-2-end feature responsibility**
- **Responsibility for feature development and operation** phase after vehicle SOP

### Solution space[1]:

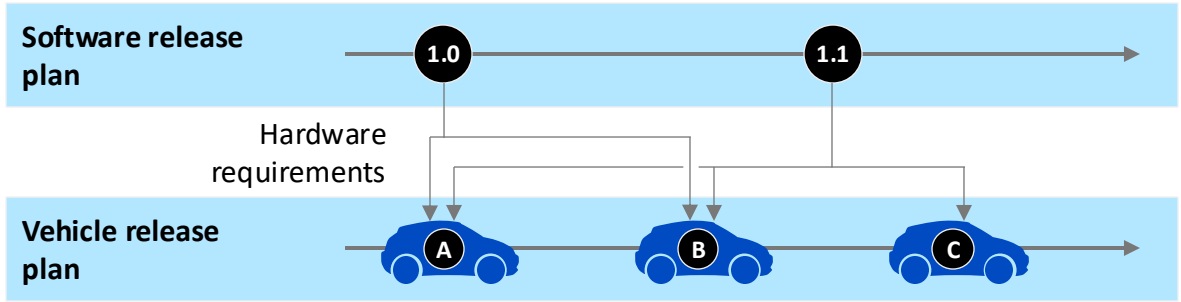
1. **Cross-domain project organization**
2. **Building new SDV organization**

Deep dives

i HR adaptation incl. **developing and hiring new skills and career development path**

## Processual requirements

ii **Software release plan as hardware guidance**




iii **Model-based systems engineering** is essential to handle product complexity

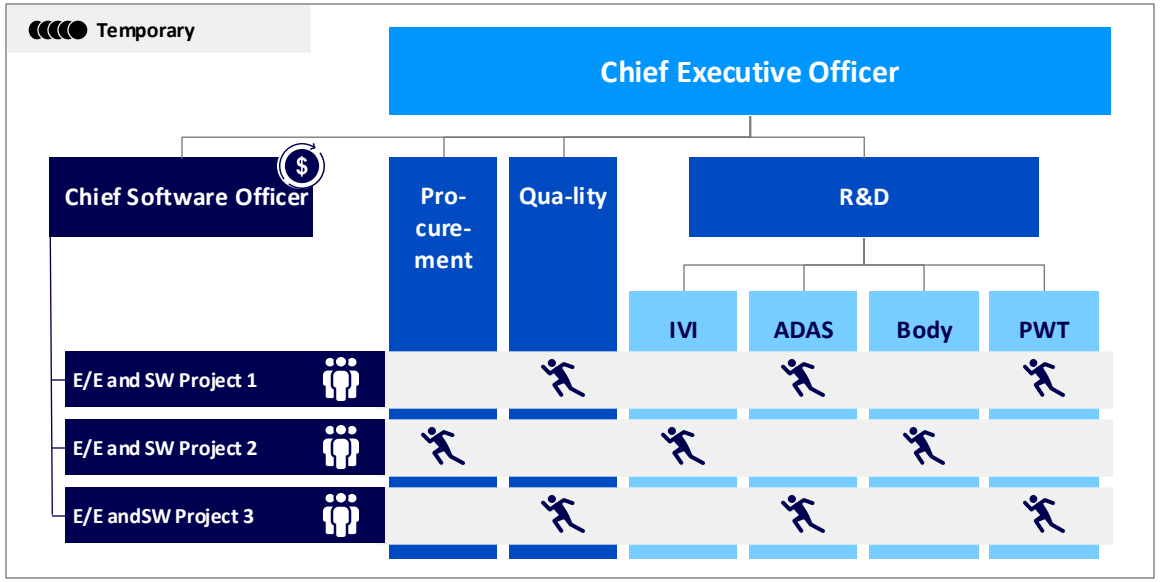
iv **Agile Dev-Ops. processes are necessary** to leverage full SDV potential

v **Performance management necessary** to measure success

1) Deep-dive available in the backup

# Low effort of implementing a cross-domain agile project organization delivers low payback of on time-to-market, quality and cost benefits

## Deep dive - Cross-domain project organization




- SW and E/E experts are organized in the domain divisions
- Project teams are staffed with experts from line organization (domain divisions) for the project duration and work as agile team
- Experts from project teams fulfill tasks both for the agile project team and for the non-agile line organization

## Advantages and Challenges[1)]

### People

- ⊖ Difficult project staffing with the best experts
- ⊖ Hierarchical leadership still with line functions

### Speed/Time

- ⊕ Fast implementation of approach due to limited changes in overall organization
- ⊖ High coordination effort necessary across different domains due to end-to-end responsibility
- ⊖ Reduced speed due to unclear prioritization between conventional and agile daily workflow

### Budget/Invest

- ⊕ Low investment by using established project organization
- ⊖ Agile project needs own budget for prioritization and long-term perspective within organization

### Quality

- ⊖ Project team must be set-up long-term to ensure feature operation after SOP

### Examples

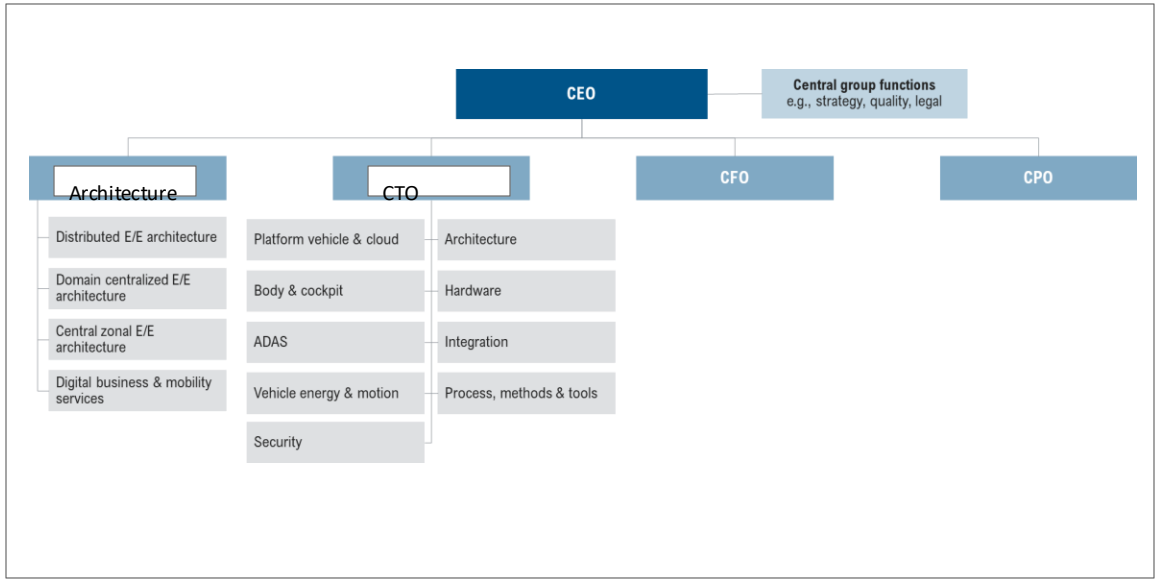
Ongoing HW/SW projects (selection) | Budget responsibility | Experts staffed into project teams | ⊕ Advantages | ⊖ Challenges

1) Solution has to fulfill organizational requirements for SDV (see previous page)

Source: Expert Interviews

# Building new SDV organisations leverages time-to-market, costs and quality benefits of a scaled agile framework

## Deep dive - New SDV organizations




- All SW and E/E experts are organized in a scaled agile framework
- Electronic and hardware departments and partners sometimes have a non-agile organization
- Product owner responsible for working results & project success
- Managers responsible for employee leadership

## Advantages and Challenges[1)]

### People

⊖ Ambitious transformation of automotive company required: Strong willingness of people and new skill level required to change to agile processes

### Budget/Invest

⊕ Lower number of people due to Lean software development

⊖ High investment for re-organization

⊖ Initial slow-down of value creation

### Speed/Time

⊕ End-to-end responsibility enables customer centric value creation

### Quality

⊕ Focus on development phase and long operation phase after SOP reflected in agile organization (DevOps)

### Examples

CARIAD

VOLVO

TESLA

⊕ Advantages ⊖ Challenges

1) Solution has to fulfill organizational requirements for SDV (see previous page)

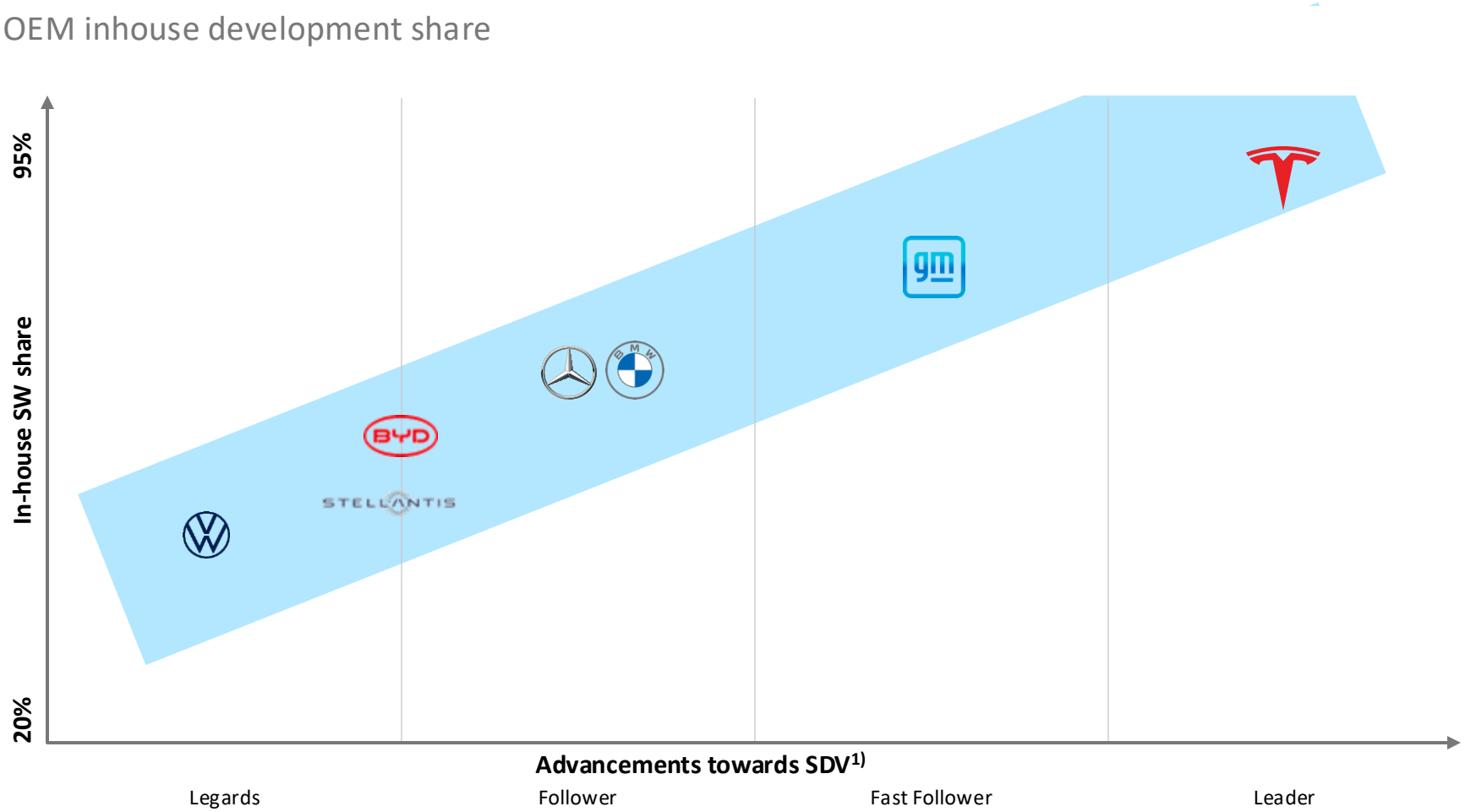
Source: Roland Berger, Expert interviews

# 4. SDV implementation causes a growing inhouse SW development share – A solution for cross OEM reuse is recommended

Indicative

# Today, advanced architecture and SW approaches require a high in-house SW development by OEMs

OEM inhouse development share



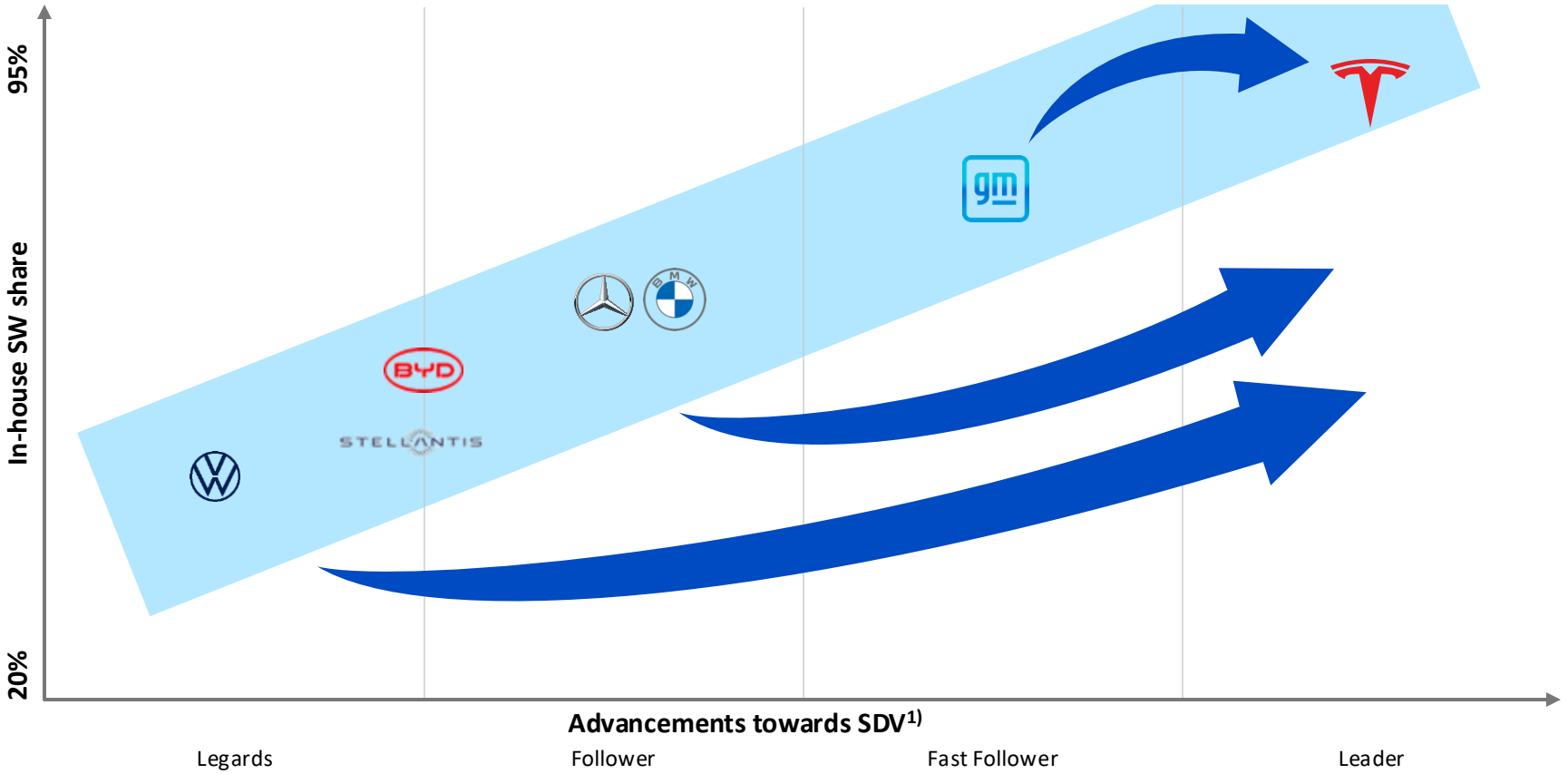

1) Based on scoring model considering complexity SW architecture, tech level in SW architecture, feature level ADAS and IVI, challenges in integration, process, CICD processes, centralization of EE architecture

- OEM's **leading in SW development** have **high in-house development share**
- **Limited supplier capabilities** are one important reason for OEM inhouse development
- With emerging industry standards, a **de-coupling** of in-house share and OEM technology position is possible

Indicative

# Most OEMs follow lighthouse Tesla and plan to increase in-house SW development as part of their SDV approach

OEM inhouse development share

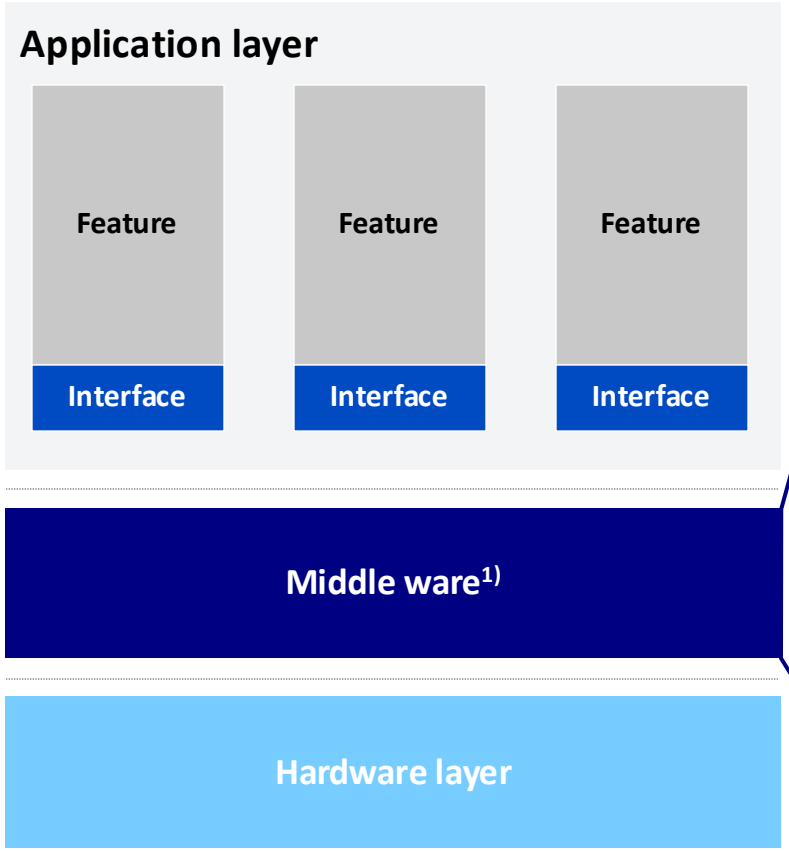



- Across the industry, OEMs plan to **grow SW developer pool** and in-house SW development share as part of SDV strategy
- Some OEMs aim for up to **80% in-house development share** – share close to Tesla
- OEMs don‘t expect the impact of standards **before 2030**

1) Based on scoring model considering complexity SW architecture, tech level in SW architecture, feature level ADAS and IVI, challenges in integration, process, CICD processes, centralization of EE architecture

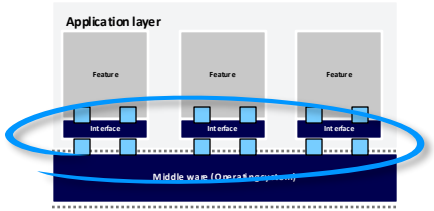
# Cross OEM middle ware will emerge in the long term as they reduce architecture and feature development cost

Long term trends middle ware

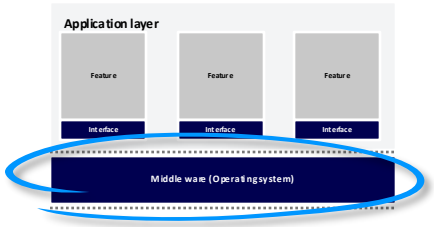



## Options for cross OEM middle ware

**Open standards**
OEMs agree on all key interfaces



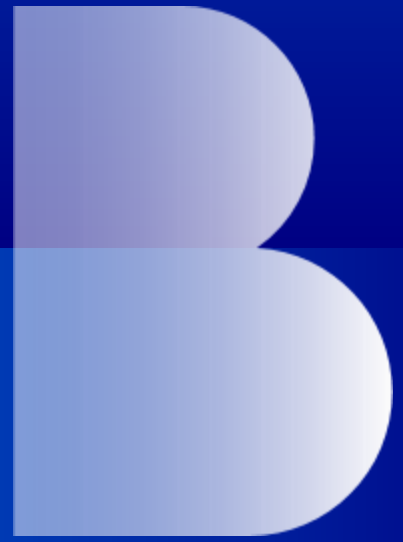

**Open-source middle ware**
Middle ware solution is open source and maintained by partners




## Benefits

- **Lower development cost** for E/E and SW architecture at OEMs
- **Reuse** of **applications and functions** across OEMs **reduces development efforts**
- Therefore, supplier **can compete and realize cost savings** for OEMs due to cross selling
- **OEMs** can **focus** on **differentiating features**

1) including operating system



Roland
Berger