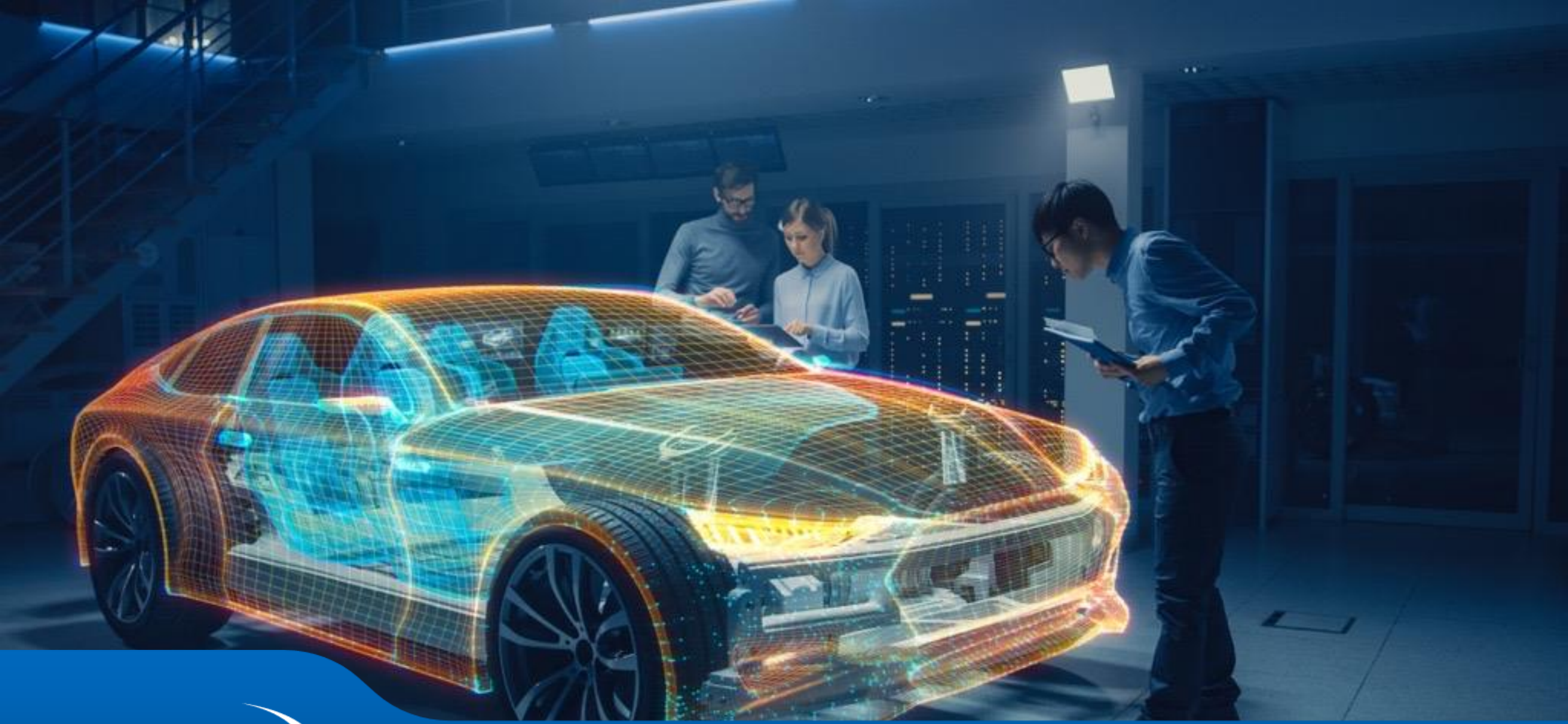


June 2023 403-23

Software-Defined Vehicle: Organization and Strategies

About SBD Automotive

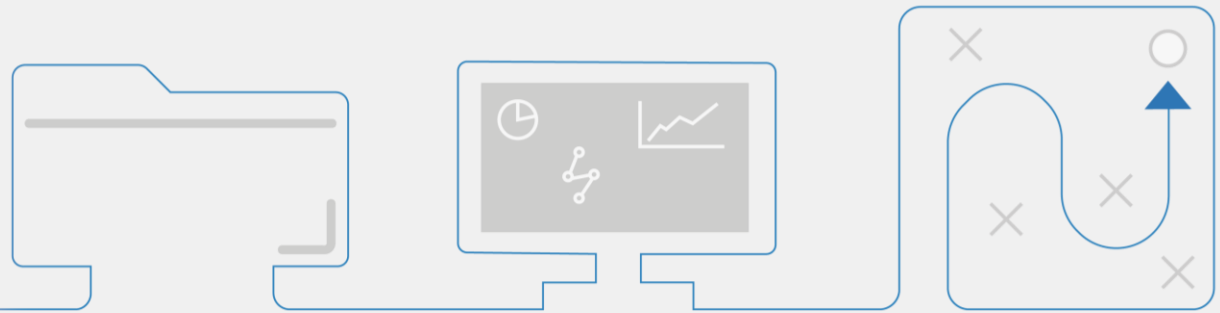
Management & technology consultants to the automotive industry for over 20 years

Our expertise:

- Connected
- Autonomous
- Shared Mobility
- EV
- Cybersecurity
- Anti-theft

Our role:

As our industry faces... **Uncertainty** ▶ We provide our clients with... **Data** ▶ **Insight** ▶ **Advice**



Seeing Beyond Data

Turning data into actionable advice

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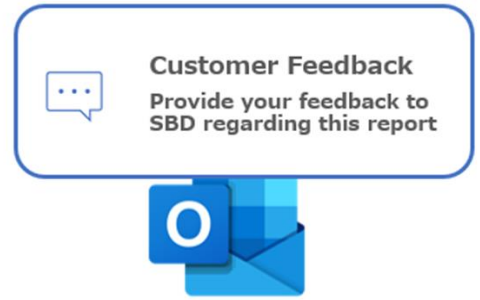

Total number of pages - 110

Introduction

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Introduction

The transition towards software-defined vehicles is already providing car makers with many opportunities that would not have been possible to capitalize on before the industry's uptake of new technologies. The transition is creating new opportunities for OEMs to break established automotive paradigms (such as 'Build vs Buy' or 'Waterfall vs Agile') to deliver benefits such as rapid pace of deployment and better customer experiences.

At the center of this innovation is the opportunity to leverage these technologies to shift feature monetization from point-of-sale to after-sales and requires a strategic realignment for car makers, which will increasingly need to consider the overall ecosystem and how to adapt their own organizations to fit the new world of 'a smartphone on wheels'.

Embedding these new experiences into the vehicle, with room to develop and expand them over its lifecycle, will require a strategic realignment across the industry.

OEMs, vehicle brands, and new automakers will increasingly need to consider the overall ecosystem – understanding how best to adapt their individual organizations toward the SDV's technological promises and stance as a potential 'third living space'.

In this report, our experts map out the different strategies used to incorporate software-defined vehicles into new vehicle line-ups. In doing so it understands how key industry players are organizing themselves as they prepare for SDV development, while identifying the strategies and business models being pursued by stakeholders today. It likewise highlights the challenges and constraints of SDV development from an organizational perspective.

Rather than focusing on head-count or reporting hierarchies, SBD's analysis focuses on the required culture shifts and a holistic focus on outcomes.

Section	Content
Bird's Eye View	In September 2023 (following the release of the *Securing the Software Defined Vehicle* Report), and again in December 2023 (following the release of the *Software Defined Vehicle Forecast* Report), this report shall be updated on the SBD Automotive Portal with an additional 'Bird's Eye View' chapter which pulls out the key points from across the layers of the Software Defined Vehicle.
Executive Summary	Consideration of the struggles of today's ways of working and steps to take to shift to new ways of working.
The Basics	What do you need to know about Software Defined Vehicles?
Case Studies	Examples from across OEMs and the supply base on today's state of the art of organization & strategy to deliver SDVs.
Analysis	Nine paradigms are considered in terms of today's way of working and how this spectrum of options will be opened-up with the introduction of SDVs
Recommendations	Detailed steps for OEMs and partners to deliver the five key benefits of a Software Defined Vehicle

External Perspectives

To increase the impact of SBD Automotive's report on Organization and Strategies for the Software Defined Vehicle, we have asked for some external perspectives from some experts and included their viewpoints at times in the report.

changemaker

Jason Craker – Transformation Director and Automotive Sector Lead
Jason has significant experience as a hands-on, global CDIO operating in fast moving, customer focused environments. He has as a significant interest in how this traditional industry is transforming into an emerging mobility sector, addressing the shift to sustainable transport with digital enabled customer services at its core.

Jason leads Changemaker's Automotive Practice having previously been responsible for establishing the global digital eco-system for Polestar as their Chief Digital Information Officer.

AlixPartners

Himanshu Khandelwal - Partner & Managing Director
Himanshu has over 25 years in management consulting and automotive industry with a focus on value driven approach to complex transformations in product development, manufacturing, sales, and service. Prior to joining AlixPartners, Himanshu served as Automotive Partner and Managing Director at EY and IBM Global Business Services.

Shea Burns - Partner
Shea has more than 20 years of experience in management consulting, engineering, manufacturing, and quality in the global light-vehicle, commercial-vehicle, and off-highway-equipment industries. Before joining AlixPartners he was vice president of consulting at AVL.

iPROCESS

Florian Rohde – Managing Partner
Florian worked for several years in the "classic" automotive world at Siemens and Continental before he implemented a continuous validation concept at Tesla in his role as senior manager of the vehicle firmware validation.

After Tesla, Florian served as director of system integration and validation at NIO.

Florian joined iProcess as Managing Partner in 2019 as an acknowledged SDV expert supporting the industry transition to the vehicle 4.0.

> Many industries and organization have consumed extensive effort to deliver Digital transformations programs, the Automotive industry is no different. The major difference is that the Automotive industry is in the process of digitalizing its internal (enterprise), external (customer journey) and also their product (vehicle). Without doubt the most complex transformation being to deliver a true digital product with the delivery of a SDV. The question is have we got a well defined and common view of what is a SDV and what does the future look like...

> While SDV offers significant long-term value to customers, OEMs are also eyeing the potential benefits, such as increasing and retaining market share, cost reduction through software reuse across multiple platforms, shorter product development cycles, potential increases in residual value, and upselling opportunities to drive new revenue streams. This shift necessitates the collaboration of OEMs, auto suppliers, technology partners, and other ecosystem stakeholders to fulfill the promises that SDV holds.

> We are seeing the automotive industry on the largest quantum leap since electronics changed cars from a pure mechanical product to an ECU based system. Software defined vehicles bring so many opportunities for engineers to shape the mobility of the future, yet it requires adaptation of the players involved, and it also welcomes new players. At iProcess we are working closely with established OEMs and suppliers looking to make the transition as well as with newcomers starting their automotive journey.

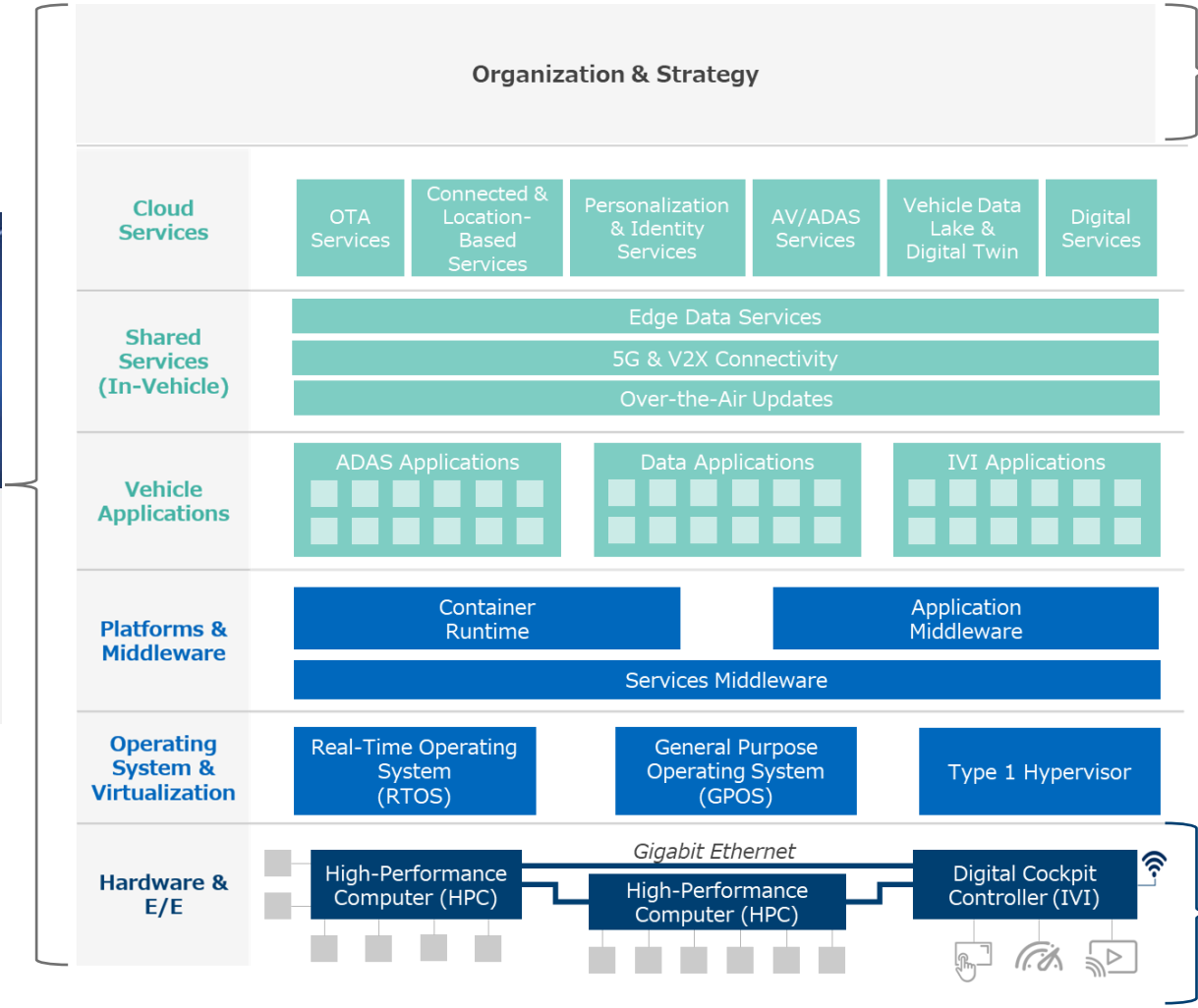
Birds Eye View

This report is one of four 2023 reports that look at different layers and enablers of the Software Defined Vehicle. In September 2023 (following the release of the *Securing the Software Defined Vehicle* Report), and again in December 2023 (following the release of the *Software Defined Vehicle Forecast* Report), this report shall be updated on the SBD Automotive Portal with an additional 'Bird's Eye View' chapter which pulls out the key points from across the layers of the Software Defined Vehicle.

Securing the SDV

Cybersecurity within the software defined vehicle, from chip to cloud

September 2023



SDVs: Organizations & Strategies

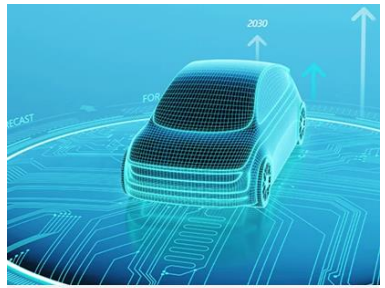
How OEMs are re-organizing themselves to achieve agile and effective team

Learn more

E/E Architecture Guide

Right decisions on E/E architecture leads to increased vehicle safety, security, and system usability

Learn more



SDV Forecast

Forecasting the alignment of the enablers for the different layers of the Software Defined Vehicle

December 2023

Executive Summary

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You and your colleagues struggles with today's way of doing things

Start of Production is delayed again as that new feature still isn't ready

Why is it so hard to get Engineering to continue to maintain this service?

Dealers are a relic of a past before the internet

We know what software was on it at build but not today

We don't do Agile, but when we do it's Waterfall!

We're switching our supplier again - and to a different one to our other new model.

A good test driver cannot be replaced by anything

I need a cheaper version of that commodity for my vehicle-line

Today's ways of working are constantly growing in complexity and are becoming unsustainable. The industry needs new ways of working to deliver five key benefits of Software-Defined Vehicles.

Nine new ways of working for the Automotive Industry

New Ways of Working	Current Ways of Working	On the Journey to New Ways of Working
Delivering Experiences	Delivering Commodities & Features	**Battery as a Service** - A choice of batteries are offered to choose to be dynamically swapped depending upon the customer's intended usage.
	Delivering Services	
Information to All Innovation from All	Commercially Defined Competitive Products	**Buses & Stagecoaches** - Coachbuilders sell to service providers and seek their insight on customer needs from the service providers as they are closer to the customer.
	Innovative Features through Technologies	
FaaS+	Point of Sale	**Premium Sound through Software** - A standard hardware platform is delivered on all vehicles with a later, optional improved audio quality able to be deployed through an OTA update.
	Aftersales	
Lifetime Delivery	Product Delivery	**Distinguishing Advanced Users** - Service is tuned by factors including which options they've purchased and whether the user has selected 'Advanced User' as an option. This helps to diversify offerings with technology leaders and majority users.
	Service Operations	
Empowering, Informed Leadership	Vehicle Line Leadership	**Prioritizing Brand Requests** - CARIAD develops software for multiple brands in the VW group and acts as an integrated software tier-1 supplier. Brands are still in the dominant position when it comes to the point of making decisions.
	Functional Leadership	
Transformed Service & Sales Model	Third Party Sales & Service	**Mobile OEM Units** - Ford Explorers are deployed across the United States providing local support to customers where Ford owns the customer experience and local dealers provide the parts.
	Dealerless Sales & Maintenance	
Deterministic Agile & Smart Choices	Waterfall	**Vehicle package OTAs** - Over the air update of embedded controller firmware and UI software with full vehicle UX modification. Mechanical components initially using prototype manufacturing processes to shorten lifecycle.
	Agile	
Modular Creation & Ownership	Insource / Build	**Vehicle Virtual Testing** - Audi outsourced its SIL testing to Israel's autonomous vehicle simulation startup Cognata, but the key development is conducted in-house. This is example is also across VW with verification commonly outsourced.
	Outsource / Buy	
Continuous Twin	On-Vehicle Verification	**Siemens Digital Twin Vehicle Testing** - The digital twin and simulated environment allows CAD modelling, CAE simulation for almost all parts within a vehicle including the vehicle itself. This enables greater reduction of time to market.
	In-Loop Verification	

Not Pick ‘n’ Mix: 5 steps in unison, to deliver 5 benefits

STEP ONE Clearly identified **owners** empowered to deliver

STEP TWO **Skillsets** in place including informed leaders

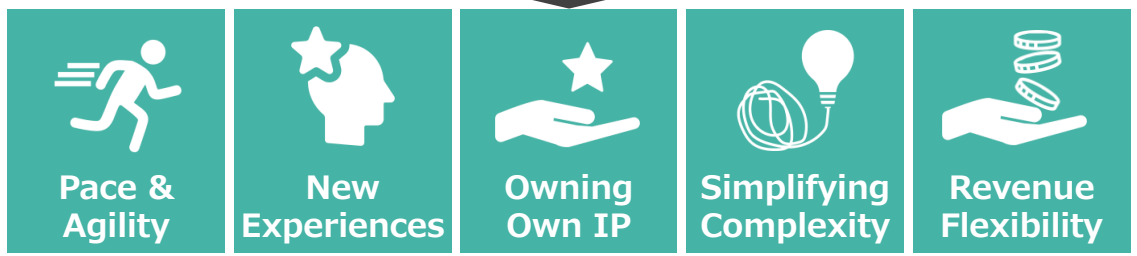
STEP THREE Process & strategy for **modular software** architecture

STEP FOUR Process & strategy for getting data **in and out** of vehicle

STEP FIVE Process & strategy for **continuous** development and testing

- Lifetime Experiences
- Configuration Management
- Over the Air Updates
- Features as a Service
- Digital Twin

Delivering 5 Benefits



Detailed consideration is required to achieve the required enablers

Pace & Agility

- R&D member subscription to feature development.
- Collect customer feedback anytime and anywhere.
- Collaboration and Communication through defined channels and with a continuous toolchain.
- Cross-functional training and knowledge transfer.
- Empowered feature leads so that improvements don't go through long approval.
- Bring existing dealer network, service, and OEMs closer together.
- Switch to agile while maintaining a deterministic approach.
- Make automated testing a part of the continuous integration process.

New Experiences

- Third-party app integrations and the creation of an app store.
- Data and analytics integration with centrally available data from single vehicles and statistics from fleets.
- Learn from service with feedback loop from the frontline workers into R&D

Owning Own IP

- For OEMs to take on high-level SW development they need to add skills, specifically software skills.
- A new collaboration standard between OEM and suppliers is needed.
- Gathering information about the real-world use of the product in real-time through fleet data logging.
- Integrating essential SDV features with data in and out of the car

Simplifying Complexity

- Vehicle configurations must be always known.
- Software can serve most / all platforms without modification thanks to a common software base.
- Reaction to unforeseen issues through modular software and continuous integration and validation.
- Organized split between HiL / SiL / Integration levels with open integration between all levels.
- Fast solutions to cybersecurity incidents.
- Push of configuration testing to the lowest possible integration level.

Revenue Flexibility

- Vehicle platforms architected to grow features over time, with a Lifetime product vision rather than for SoP.
- The vehicle needs to be architected to accept FaaS at scale and architected to be delivered to an understood sufficient level of resources.
- The software needs to be architected to handle FaaS with
  - Modular software.
  - Feature switches.
  - Stable backbone software.
- Customers need to be educated about upsale options later during ownership

The Basics

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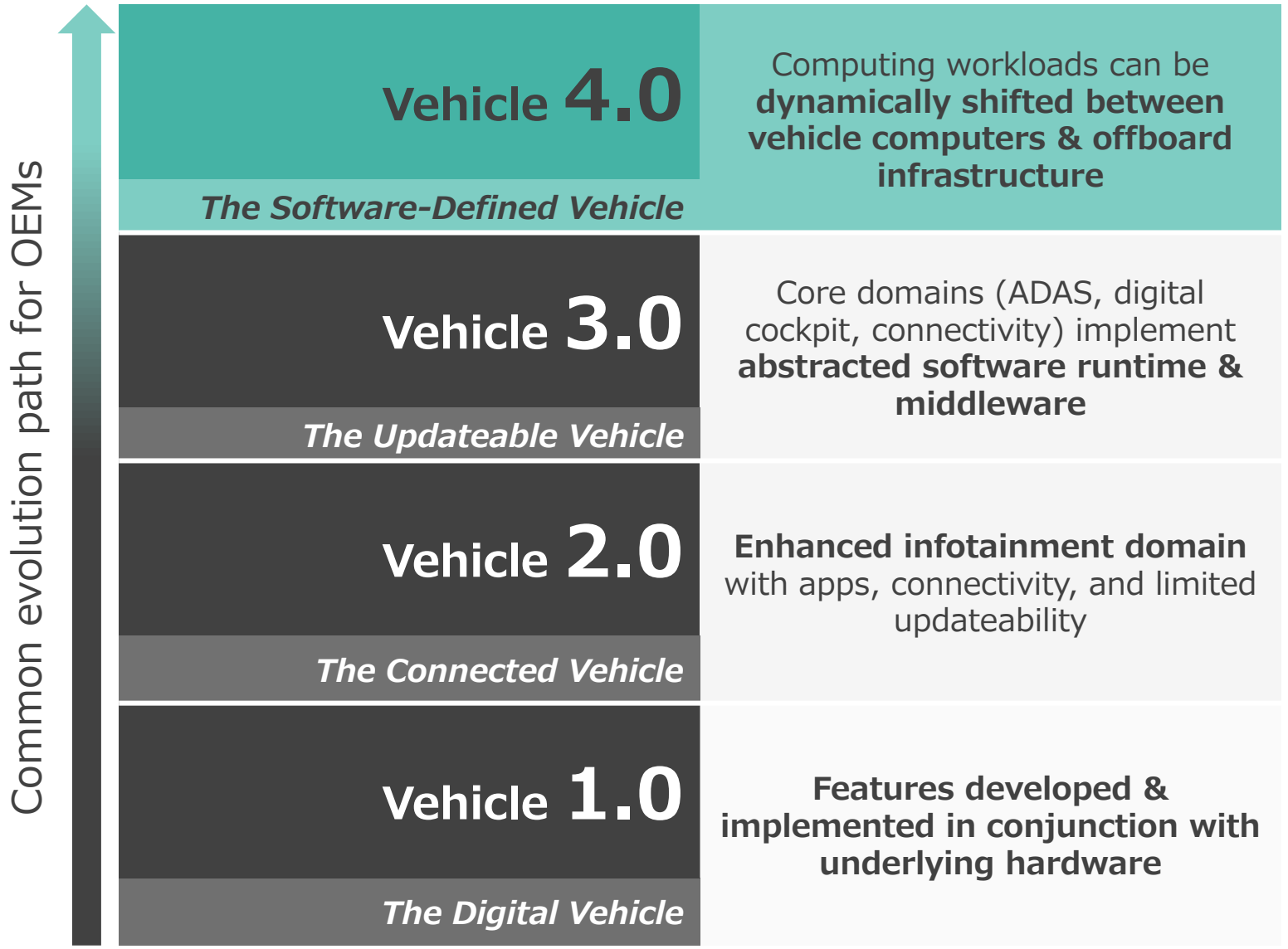
Software-Defined Vehicles: What you need to know

1	**SDVs will allow software to be designed, developed, and tested independently of the vehicle's hardware**	• **Coupling** is the level to which software is written for a specific solution • **Hardware abstraction** describes the system architecture which allows the software to run with little to no coupling with the underlying hardware • **Updateability** is one of the most important benefits of abstraction
2	**SDVs will require multiple layers of hardware and software across different domains in order to implement this separation**	• **Middleware** implements the services which separate hardware-specific functionality from higher-level software • **High-performance computers (HPCs)** in vehicles offer significant computing resources which allow virtualization, containerization, and middleware to support software applications
3	**SDVs will allow OEMs to dynamically implement new business models & customer experiences much faster than before**	• **Vehicle 3.0 (Updateable)** represents the state-of-the-art for some OEMs • **Vehicle 4.0 (Software-Defined)** requires further enhancement of cloud integration, connectivity, and continuous integration toolsets/processes
4	**SDVs will create significant disruption in the traditional automotive electronics supply chain while creating new "blue oceans"**	• **Tier 1 suppliers** are threatened by ECU consolidation and OEM internal development trends but have platform & partnership opportunities elsewhere • **Software, service, and cloud providers** all play important roles in SDV delivery
5	**Much of the core SDV software stack will be non-differentiating, making standards & open-source software attractive to OEMs**	• **Adaptive AUTOSAR** enjoys widespread development and adoption as a "middleware" platform, particularly for ADAS/AV systems • **Apollo and Autoware** offer open-source autonomous driving software components & platforms, best implemented with SDVs

Software-Defined Vehicles aren't here yet



All eyes are fixed on a future requiring much preparation

Today's state of the art

Rapidly rolling out

Still today's incumbent

Benefits of a Software-Defined Vehicle

Pace & Agility

- SDV brings agility to keep up with consumers' fast-changing demand by enabling agile and continuous software delivery
- The agile delivery of experience is enabled by software components separately developed from hardware
- The flip side of the enabler for agility is the OEM's organizational setup and maturity in the agile mindset

New Experiences

- SDV consistently brings new experiences to car owners through continuous software updates
- Can be tailored to customer persona; the flexible software-defined functionality brings customized experiences for personal vehicle owners, fleet owners, regional differences, brand differentiations
- Experiences to customers become more personalized with consistent learning and adaption

Owning Own IP

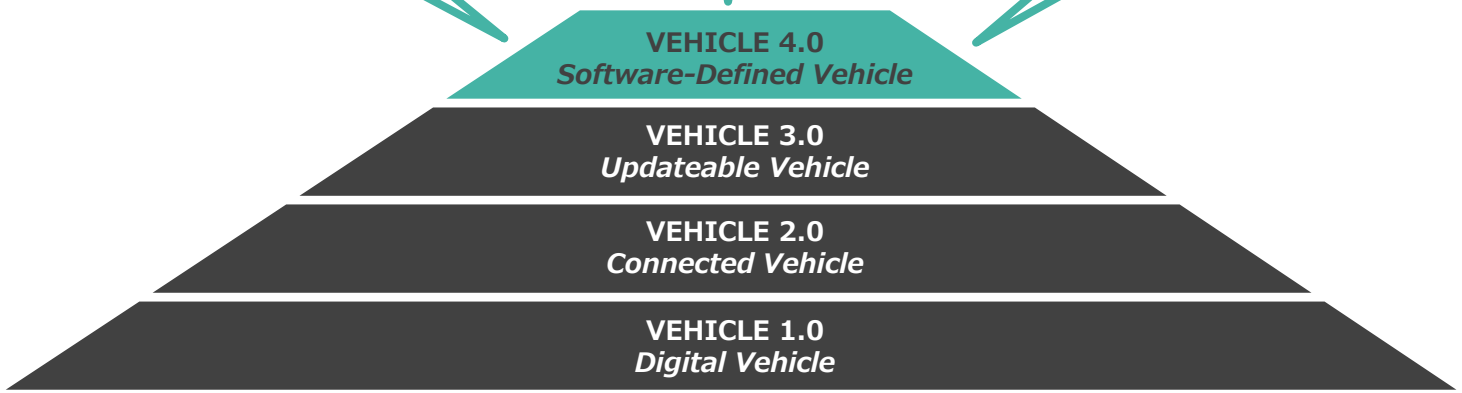
- OEMs are increasingly desiring ownership of selected IP on their vehicles
- This own IP takes out the cost of licensed software components
- OEM could sell own IP to other OEMs desiring to build up their own software stack
- Some OEMs could expand business with white-label vehicle platforms with standardized software components

Simplifying Complexity

- SDV greatly reduces hardware complexity by ECU consolidation and zonal consolidation in E/E architecture
- Organizationally, complexity needs to also be removed, against the current trajectory
- Although SDVs are of course complex, the decoupling between systems and the commoditization of systems requires new strategies and organization

Revenue Flexibility

- SDV will open revenue stream after the vehicle purchase to OEM
- Feature-as-a-Service (FaaS) could bring sizeable revenue stream to OEM by offering flexible consumption of service to customers
- SDV could accelerate data utilization – not a sizeable direct revenue source, but can be new oil to OEMs' business



Case Studies

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Chapter Introduction

This chapter acts somewhat like a literature review introducing key players in the existing state of the art and considering the advantages and challenges to their solutions.

This chapter lays the foundations for the Analysis chapter where such case studies (and others) are used to consider the current practices of various existing paradigms, and to help us understand how these paradigms will be 'broken open' with new ways of working.

What types of companies are considered in this chapter?

- OEMs seeking to deliver software in new ways
- Tier ones offering FaaS and OTA solutions
- OEMs offering services
- Tesla's organization structure

Android Automotive OS

The Company ▶ Various **When** ▶ 2017 **The Approach** ▶ Adopting Android Automotive OS

Overview

Historically, Automobile manufacturers have struggled to keep up with the technological advancements of smartphones and applications. This means that software functionalities in cars, such as navigation and general infotainment systems, can feel outdated a few years after the vehicle is released.

Android Automotive is continuously being developed and is available publicly, OEMs can expand and customize the OS system. One benefit is it requires lower development, integration, and maintenance costs for infotainment (with a huge ecosystem), and Alphabet will regularly release patches and annual major upgrades. Using Android Automotive can also ensure the continuation of user habits while designing the Android-style HMI for in-car use.

However, OEMs still need to invest in the hardware spec to a certain level and consider the customization cost if they need to customize the HMI and UX without utilizing GAS (Google Automotive Services). In addition, porting the original OS to AAOS is also a time-consuming and labor-intensive process.

Achievements

- Utilize abundant Android ecosystem
- Has Android VHAL (Vehicle hardware abstraction layer)

Obstacles

- Difficult to port the legacy OS to AAOS
- Android teams are still preforming OEM specific development for each deployment, drawing large resources of their own – this means an OEM desiring Android Automotive may be told that they have no capacity at this time to support

OEMs

Disruptors	Single brand OEMs	Multi brands OEMs

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	Engineering
Marketing	Cyber	IT

Layers

Cloud Services	Shared Services	Vehicle Applications
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

Design	Verify	Launch
Manufacture	Operation	

BMW's FaaS development

The Company ▸ BMW **When** ▸ 2021 **The Approach** ▸ Hardware pre-embedded + Software updates

Overview

BMW is strengthening its software development capabilities by **establishing its own software division (Car IT) and JVs with other regional companies**, including the new R&D joint venture with China's "Archermind Technology" for the development of on-board software for its vehicles sold in the Chinese market, and the joint venture "Critical Techworks" established with CRITICAL in Portugal.

BMW started making some vehicle features through paid services, giving customers the option to activate certain techy features by paying periodical fees. The features include seat heating, steering wheel heating, and ACC (Automatic Cruise Control). The vehicle architecture enables the initial decoupling of software and hardware; hence the software can be configured after the point of sale and enable the new hardware-based features.

This also requires a **service-oriented mindset** in software development and collaboration among the function planning team, software development team, marketing team and sales team. The **agile and BizDevOps transformation** initiated in 2019 enabled the successful feature roll-out.

Achievements

- New revenue opportunities
- Simplified vehicle assembling process
- Reduce the selling price of vehicles

Obstacles

- Complexity in cross-departmental collaboration
- Resistance from customers

OEMs

Disruptors	Single brand OEMs	**Multi brands OEMs**

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	**Engineering**
Marketing	Cyber	**IT**

Layers

Cloud Services	Shared Services	**Vehicle Applications**
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

Design	Verify	Launch
Manufacture	**Operation**	

BMW's agile development in BMW central IT

The Company ▶ Various **When** ▶ 2020 **The Approach** ▶ BMW adopts agile SAFe development method

Overview

BMW's Agile Working Model is based on cherry-picked features from Scrum, LeSS, and SAFe® that suited the company. At first, there was a lot of trial and error to understand what worked for them, and sometimes the work on the collaboration model itself had to take the front seat to actual coding.

At first, BMW wanted to use LeSS solely for its organization, but BMW realized applying a single framework for its large organization is not applicable, as it will cause a split in knowledge when it comes to complex system development. SAFe is the total opposite of that – meaning as much Framework as possible, which BMW found more suitable for their organization compared to the less structured framework provided by LeSS.

Achievements

- Agile feature delivery
- Agile mindset ingrained to entire organization including leaders
- Structured organization and work cadence

Obstacles

- Disruption in the organization and work cadence at the learning phase

OEMs

Disruptors	Single brand OEMs	Multi brands OEMs

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	Engineering
Marketing	Cyber	IT

Layers

Cloud Services	Shared Services	Vehicle Applications
Platform & Middleware	OS & Virtualization	Hardware & E/E

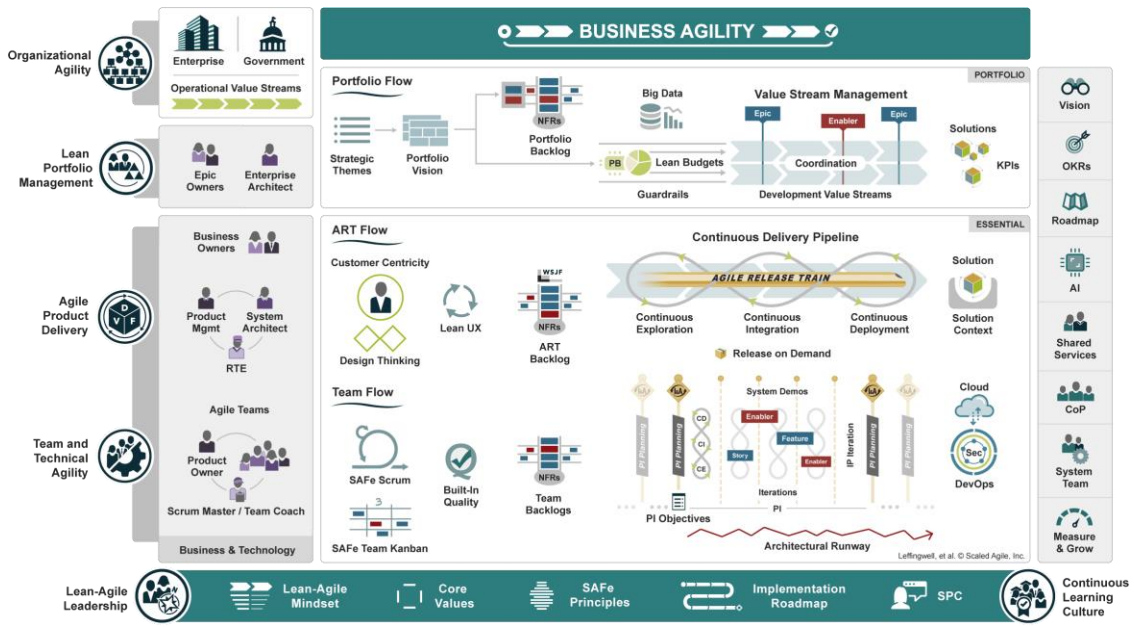
Lifecycle

Design	Verify	Launch
Manufacture	Operation	

What is SAFe?

The Company ▸ BMW

When ▸ 2020



The Approach ▸ BMW adopts SAFe development method

SAFe is a set of organizational and workflow patterns for implementing agile practices at an enterprise scale. SAFe promotes alignment, collaboration, and delivery across large numbers of agile teams. The key difference between SAFe and LeSS is that LeSS provides as little framework as possible as opposed to SAFe, which provides as much framework as possible.

SAFe is based on 10 underlying Lean-Agile principles that have evolved from Agile principles and methods, Lean product development, systems thinking, and observation of successful enterprises. Based on these 10 principles, SAFe is more suitable for agile software delivery in larger organizations working on large systems composed of many pieces of features with more distributed decision-making encouraged.

Within the SAFe framework, the development proceeded with the Planning Interval (PI). The PI is a cadence-based timebox in which Agile Release Train (ART) delivers continuous value in alignment with PI Objectives.

SBD Insight

BMW first introduced LeSS and tried to adopt it as an entire company – however, they found it difficult as the LeSS lacks the structure which caused huge disruption. The LeSS goes well with the one of key agile principles, “start with small”, while the lack of structure will likely cause organizational discomfort.

SAFe provides a more structured framework where many workforces can find their place. This is the reason SAFe goes well with large organizations where it needs structure to orchestrate individual processes.

In general, SAFe would be more suited for the automotive industry, allowing a ‘milder’ transition to an agile organization. However, it is recommended that the team should learn less-structured agile first and bring their mind up to the disruptive mindset.

CARIAD
A VOLKSWAGEN GROUP COMPANY

SBD

CARIAD's operation and its issues

The Company ▸ CARIAD

When ▸ 2020

The Approach ▸ Operating as a tier-1 to multiple VW group brands

Overview

Established in 2020, VW group was aiming to use CARIAD as its software solution pioneer and contribute largely to their new models' development. CARIAD has a clear business definition: developing a unified, scalable new software platform, advanced driver assistance systems and autonomous driving capabilities, as well as next-generation intelligent connectivity features. The specific business includes two major areas: E^3 electronic-electrical architecture (including the VW.OS operating system) and VW.AC (Volkswagen Cloud Services).

CARIAD was designed to be an independent SW development company, but in 2022 they reached cooperation with several companies including Bosch, Qualcomm, etc. to jointly develop software to improve its competitiveness and efficiency. Different brands in the VW group will assign development tasks to CARIAD and CARIAD needs to prioritise the tasks based on their availability and timing, the developing process in CARIAD is not efficient, which caused delays for several VW models' release.

The multi-brand complexity aggravated the contradictions in the work methods and approaches that car companies themselves face in software development, for example, the waterfall vs agile, etc. CARIAD is not the owner of the platforms they developed - they deliver the software to the brands and then it is the brands' call on how to utilize them.

Achievements

- Integrate the R&D resource of the Large Group
- Experts in software
- Common software between new and existing EE platforms

Obstacles

- Multiple brands complexity
- Different launching demand
- Features planning conflict
- Acting like a tier-one without the expertise and practices of a tier-one

OEMs

Disruptors	Single brand OEMs	**Multi brands OEMs**

Partners

Silicon providers	Tier-1	**SW integration providers**

Organization

Product planning	UX	Engineering
Marketing	Cyber	**IT**

Layers

Cloud Services	Shared Services	**Vehicle Applications**
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

Design	**Verify**	Launch
Manufacture	Operation	

CARIAD's operation and its issues

The Company ▸ CARIAD

When ▸ 2020

The Approach ▸ Operating as a tier-1 to multiple VW group brands

External support

- BOSCH — AD/ADAS SW
- Qualcomm — SoC SW
- Horizon Robotics — SW
- Luxoft — SW
- ThunderSoft — SW

CARIAD

CARIAD needs to

1. Manage the software development for different brands **simultaneously**
2. Prioritise the tasks **based on their availability and plan**
3. Coordinate the internal and external development **resources**
4. Adapt themselves to different development pace

Tasks from VW Group

- **E³ 1.1** — SW development for **MEB**
- **E³ 1.2** — SW development for **PPE**
- **E³ 2.0** — SW development for a new, unified platform **SSP** across the entire VW group

Customer

SBD Insight

Before CARIAD was established, all the brands were working independently towards a clear launch timing, but in CARIAD, they need to consolidate the resources to catch different software development timings, which led to some misalignment within the group.

The challenging point is that CARIAD is not a supplier in a traditional sense and CARIAD is not a 100% in-house organization, as they use many external software suppliers (including VW-owned software companies) to help them, the distribution of the tasks to each stakeholder is not clearly defined in the process.

Ford's "complexity reduction" action

The Company ▸ Ford **When** ▸ 2023 **The Approach** ▸ Model line-up reduction to cater customer expectations

Overview

> We have a lot of complexity relative to the customer and also inside our company. And we can cut the customer-facing complexity like we have, but it takes time to work that down to parts on the line, to the manufacturing line, It just takes time to work through that and that's what we'll do.
>
> **Jim Farley - CEO of Ford**

The electrification of the traditional OEMs is not always a smooth process, Ford is one of them. From 2021 – 2023, The Ford electric vehicle business is expected to accumulate a loss of 6 billion US dollars. The CEO of Ford said it is related to the difficulties in understanding customers' needs in the new era and implementing changes.

Ford is **simplifying its product offerings and reducing complexity in order to improve efficiency and profitability**. Ford also announced that its upcoming EV models will be eligible for federal tax credits, which can significantly reduce the cost of purchasing an electric vehicle. This move is part of Ford's broader strategy to accelerate its transition to electric mobility and compete in the growing EV market. By implementing the change, Ford will consolidate the D&R resource to **rethink how to build cars that better meet customers' expectation.**

Achievements

- Consolidate the R&D resources
- The transition to customer-centric vehicle development
- Bringing Service experience 'in-house' with Explorers deployed providing local support to customers where local dealers provide the parts

Obstacles

- Multi-model management
- No separate EV development team

OEMs

Disruptors	Single brand OEMs	**Multi brands OEMs**

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	Engineering
Marketing	Cyber	IT

Layers

Cloud Services	Shared Services	Vehicle Applications
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

Design	Verify	Launch
Manufacture	Operation	

Harman's in-vehicle on-demand service

The Company ▸ Harman **When** ▸ 2022 **The Approach** ▸ In-vehicle FaaS

Overview

Harman unveiled its Harman Ready on Demand, which is a software platform for delivering branded audio value, feature enhancement, upgrades and monetization opportunities in an easy-to-use app. **Customers can unlock future upgrades and expanded experience at any time via in-app purchases, including the "Infinity audio".**

Unlike the unconventional vehicle audio systems, which cannot be updated or become outdated months or years after production as technology improves, the new service model enables customers to experience a higher standard audio system without additional hardware retrofit. This is based on Harman's "Software-enabled Branded Audio" plan, which is also aligned with Harman's strategy that helps OEMs to **reduce the time to market and maintain competitive hardware offerings through the vehicle lifecycle**.

> Ready on Demand transforms the traditional complex retrofit upgrade process for audio into something quick and easy for consumers, who can now create and customize their in-vehicle listening experience with just a few clicks, even after the initial vehicle purchase, all built on Harman's audio, system integration and user interface development expertise.
>
> **Armin Prommersberger - Senior Vice President of Product Management**

Achievements

- Potential revenue can be generated
- Feature enhancements for customers

Obstacles

- Hackers stealing features

OEMs

Disruptors	Single brand OEMs	Multi brands OEMs

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	Engineering
Marketing	Cyber	IT

Layers

Cloud Services	Shared Services	Vehicle Applications
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

Design	Verify	Launch
Manufacture	Operation	

JLR's Pivi development

The Company ▸ JLR

When ▸ 2020

The Approach ▸ OEM and Tier-1 supplier jointly develop IVI system

Overview

> Pivi Pro is a testament to the incredible work within our software engineering teams. Developing this with LG Electronics allowed us to really focus on what our customers want in their infotainment system, something that is really important for us
>
> **Peter Virk, Former Director of Connected Car and Future Technology for JLR**

JLR's P-IVI includes removable hardware with key chipsets which reduced the complexity of the rest of the vehicle, as the hardware can be updated and replaced "separately" if necessary. It also allows the development process more flexible as the hardware will have less impact to the overall timing plan.

The P-IVI has its own battery to be an "always on" modem for infotainment connectivity which is separate and can be changed far more freely than the Telematics and OTA modem which must be eCall homologated.

Achievements

- Innovative features development through suppliers
- Understand customers' need through cooperation with specialists

Obstacles

- Cross-team cooperation
- Development pace and timing plan

OEMs

Disruptors	Single brand OEMs	**Multi brands OEMs**

Partners

Silicon providers	**Tier-1**	SW integration providers

Organization

Product planning	**UX**	**Engineering**
Marketing	**Cyber**	IT

Layers

Cloud Services	Shared Services	**Vehicle Applications**
Platform & Middleware	**OS & Virtualization**	Hardware & E/E

Lifecycle

Design	Verify	Launch
Manufacture	Operation	

JLR's Pivi development

The Company ▶ JLR **When** ▶ 2020 **The Approach** ▶ OEM and Tier-1 supplier jointly develop IVI system

JLR's P-IVI is jointly developed by JLR and LG Electronics, which will replace InControl in all Jaguar and Land Rover models. In the co-development, LG is mainly responsible for the multi-device connection and HMI customization, working with JLR engineering teams to implement some new features in the system.

P-IVI also has now integrated Alexa, where JLR engineers directly worked with Amazon's team to make sure the feature is presented to users seamlessly.

In this case, innovative features developed through collaboration with specialists at an efficient pace & agility way can ensure brand differentiation, as well as satisfy customers' expectations.

SBD Insight

JLR's P-IVI development adopted some "unconventional" design ideas. In a way, it allows them to have more flexibility in the development process together with some external suppliers.

Designing a system with abundant functionalities for customers in an efficient way is the key to achieving the goal for OEMs, as they need to consider the linkage with other sub-systems, homologation, and the subsequent testing process, etc.

There is no indication at time of writing, however, of JLR launching a 5G hardware update to customers to utilize this opportunity.

Mobileye's role transformation

The Company ▸ Mobileye

When ▸ 2022

The Approach ▸ From "Chip + Algorithm" supplier to the technology collaborator

Overview

As one of the major AV/ADAS technology suppliers, Mobileye occupied a significant market share in the industry and became the first choice for some OEMs in the 2010s when they plan to deploy AV/ADAS features on their models, however, many OEMs chose to stop using Mobileye solutions in the recent years, including BMW, Tesla, NIO, Li Auto, etc.

Mobileye was a **typical representative of the "black box" solution**. In simple terms, it acted as a **solution provider to automakers**, offering integrated hardware and software for intelligent driving solutions. Automakers are unable to grasp the core technology and accumulate data, and they may not even be able to **modify the properties of the "black box."** They have to request changes from Mobileye, which results in a low position and efficiency for the automakers in terms of modifying specific functionalities in a timely manner.

In order to reverse the situation, in July 2022, Mobileye launched its EyeQ Kit, which allows OEMs to **utilize Mobileye's technologies while deploying their differentiated code and HMI tools on the platform**. Meanwhile, Mobileye also announced some **"deep collaboration"** with some OEMs, joining early-stage R&D and collaborating with automotive engineers to develop solutions.

Achievements

- OEMs have more flexibility in their product configuration
- More revenue can be potentially generated in the "co-development" phase

Obstacles

- Potential conflicts in joint-development
- The dominance position lost

OEMs

Disruptors	Single brand OEMs	Multi brands OEMs

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	Engineering
Marketing	Cyber	IT

Layers

Cloud Services	Shared Services	Vehicle Applications
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

Design	Verify	Launch
Manufacture	Operation	

NIO’s battery as a service

The Company ▶ NIO

When ▶ 2020

The Approach ▶ Battery as a service – battery rental to customers

Overview

Car owners have the option to independently purchase ownership of the vehicle shell without the battery and then use the battery through a leasing arrangement. In simple terms, it means treating the battery as an asset and allowing many users to lease it.

NIO’s battery as a service is **initiated by the NIO commercial team**, the aim is to reduce the threshold of purchasing a NIO and better interact with the battery swapping service for customers. Currently, NIO has 30,000+ BaaS customers. The main feature of NIO's BaaS (Battery as a Service) model is the joint establishment of a battery asset management company with battery manufacturers (such as CATL) and financial backers (such as Guotai Junan and Hubei Science and Technology Investment Group). The battery asset management company is primarily responsible for the operation and management of battery swapping stations, as well as the recycling of used batteries. **The responsibility for operating the swapping stations is shifted from the automotive company to the battery asset management company.**

However, customers who chose the BaaS option are concerned of the vehicle residual value as rarely there will be some buyers to buy the vehicles under the policy.

Achievements

- To reduce the threshold of purchasing a car
- Flexible battery upgrade options
- Increase the resale value

Obstacles

- Complex collaboration with the financing company and other stakeholders

OEMs

Disruptors	Single brand OEMs	Multi brands OEMs

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	Engineering
Marketing	Cyber	IT

Layers

Cloud Services	Shared Services	Vehicle Applications
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

Design	Verify	Launch
Manufacture	Operation	

Tesla's shadow mode

The Company ▸ Tesla **When** ▸ 2015 **The Approach** ▸ Algorithm training/verification in fleet-level

Overview

The Shadow Mode is a feature implemented by Tesla, initially for their Automatic Emergency Braking feature. While a person is driving, the system, including the sensors, continues to operate but does not participate in vehicle control. Instead, it validates the decision-making algorithms. In "Shadow Mode," the system continuously simulates decision-making and compares it with the driver's behaviour**. If they are inconsistent, the scenario is considered a "Noteworthy scenario" and triggers data feedback.**

Some other OEMs are also planning to launch similar verification methods on their vehicles. Without implementing the Shadow Mode functionality, other automobile manufacturers fundamentally differ from Tesla in terms of hardware embedding and cost recovery. Tesla combines the Shadow Mode with hardware embedding. Even if users do not activate ADAS-related features, Tesla's Shadow Mode runs in the background, effectively making the vehicle owners part of the test data collection. **The "cost of loss" incurred by Tesla due to users not opting for ADAS features is far smaller than the benefits gained from vehicle owners acting as a data source.**

Achievements

- Utilize Tesla vehicle owners as validation resources
- Reduce the potential road data collection cost

Obstacles

- Privacy data processing issues
- Establish a comprehensive cloud-based system, including mechanisms for uploading and downloading data, edge computing, and cloud services

OEMs

Disruptors	**Single brand OEMs**	Multi brands OEMs

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	**Engineering**
Marketing	Cyber	**IT**

Layers

Cloud Services	Shared Services	**Vehicle Applications**
Platform & Middleware	OS & Virtualization	**Hardware & E/E**

Lifecycle

Design	**Verify**	Launch
Manufacture	Operation	

Tesla's continuous integration and validation pipeline (1/2)

The Company ▶ Tesla **When** ▶ Since 2012 **The Approach** ▶ Continuous software development and delivery

Overview

Tesla runs an end-to-end integrated continuous toolchain that allows them to generate software releases within a workday if necessary. It also powers their 2-week sprint release cadence as well as a significant number of unplanned releases.

The entire system is a ticket-based agile process visible to every member of Software R&D. Software developers receive their tasks through a Jira ticket, execute their work packages and commit the code through a bitbucket frontend into the git repository. Suppliers deliver compiled hex files committed by the r integration peer at Tesla. The Jenkins CI server picks up every single commit and builds a vehicle package. The vehicle package is a .tar.gz file that contains all hex files for any configuration possible as well as UI assets and supporting documentation. The Jenkins CI server sends the packages into a proprietary database called Tesla Garage where they are available to all R&D members. All downstream XiL systems are informed by an MQTT broker about new packages available including their tagging for restrictions and target platforms. A query provides all changes between the new package and any given legacy package in order to generate the right test coverage.

Achievements

- ~150 customer releases / year
- Immediate integration feedback
- High agility and flexibility

Obstacles

- Customer fatigue when rolled out too often
- Fragile toolchain need full time administration

OEMs

Disruptors	Single brand OEMs	Multi brands OEMs

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	Engineering
Marketing	Cyber	IT

Layers

Cloud Services	Shared Services	Vehicle Applications
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

Design	Verify	Launch
Manufacture	Operation	

Tesla's continuous integration and validation pipeline (2/2)

The Company ▶ Tesla **When** ▶ Since ~2015 **The Approach** ▶ Continuous software development and delivery

The receiving test infrastructure, also orchestrated by a Jenkins CI server, will find suitable available resources (Component HiL, System HiL, Static ViL, Dynamic ViL) and reserve them, when on top of the queue it will configure the test bench according to the requirements such as market or power configuration and will execute the tests on all levels in parallel. The majority of configuration options in hardware is tested on component HiL level against their interfaces so the ViL systems can be reduced to a minimum focusing on integration testing in the assumption that all configurations are behaving the same against their interfaces. Only when interface changes are applied the ViL systems need to be multiplied.

Test results are fed back into a Jira based system named XRAY and merged for all test levels over time to generate the big picture. Software packages in the Garage database are getting tagged according their maturity based on test coverage and results, the software developers responsible for the commit(s) in this package get a feedback about the success or failure of the test runs.

Packages tagged with successful test runs on all levels are available on the Garage database for members outside of Software R&D, such as endurance testing as well as to rollout managers to be used in a release. The release process involves all managers responsible for software domains as well as the validation managers, the release program manager and the responsible vice president.

Once a release has obtained the signatures of all managers involved it can be rolled out using the Garage database to define the release target group, rollout velocity and timing, a task performed by the release program manager.

SBD Insight

SBD has found that often it is the maintenance of such diverse testing solutions and issue tracking systems that is overlooked by OEMs. Software configuration and maintenance must be achieved across the suite of rigs and simulators, often requiring separate OTA methodologies to the in-built, due to the nature of which parts of the system are being tested.

Similarly, governance over issue tracking must be prioritized to avoid mis-assuming that issues are resolved by the latest patch, but equally balancing the search for issue root cause on something that has not been seen for some time.

Tesla software team - organizational structure

The Company ▸ Tesla **When** ▸ 2012 onward **The Approach** ▸ Organizational approach to support agile

Overview

Tesla has set up a lean and flat hierarchy to support their fast-paced development and decision making as well as their flexibility and ability to act quickly to unforeseen issues. The average number of levels between engineers and the upper management is smaller than ten with a close connection and communication between all of them. The software team is reporting to the vice president of software, and it is controlled by a committee. The committee is chaired by the program manager of the current release sprint and hosts the managers of all component teams as well as the system integration and validation managers. This committee is responsible for the sprint planning, the long-term planning and the change management process, as such it meets several times per week, with the clear focus on decision making. The leadership committee acts like a congress, a majority vote drives the decision, even if not all members are attending.

Feature teams are in charge for the feature specification, break-down, implementation, integration, validation and support. The feature teams are matrix organized and chaired by the feature integration engineer.

Achievements

- Qualified real time decisions
- Ultra fast process
- End to end responsibility within one feature team

Obstacles

- Risk of hasty decision making
- Overloading team members
- Fluctuation leaves blanks

OEMs

Disruptors	Single brand OEMs	Multi brands OEMs

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX (Software Org)	Engineering
Marketing	Cyber	IT

Layers

Cloud Services	Shared Services	Vehicle Applications
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

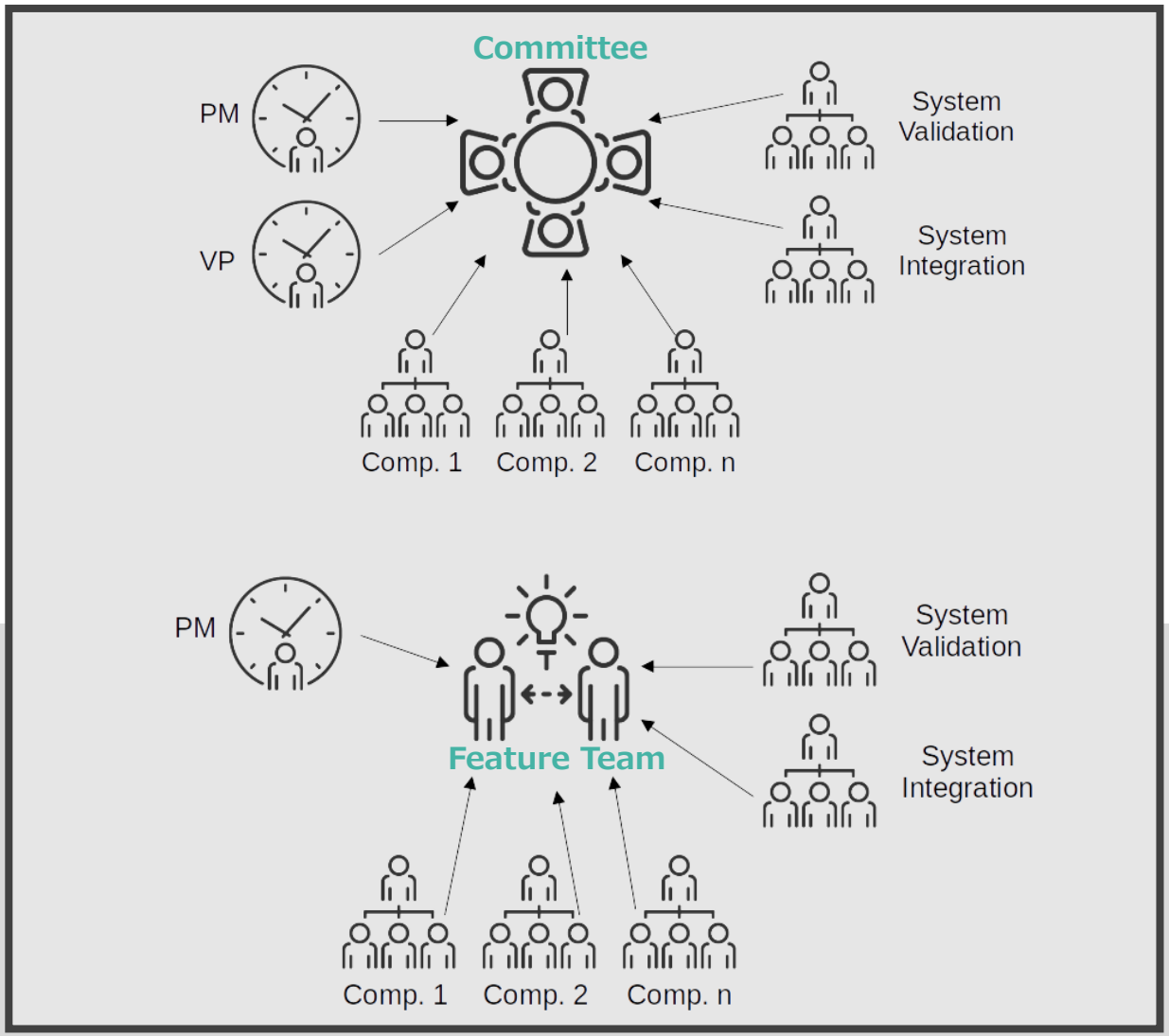
Design	Verify	Launch
Manufacture	Operation	

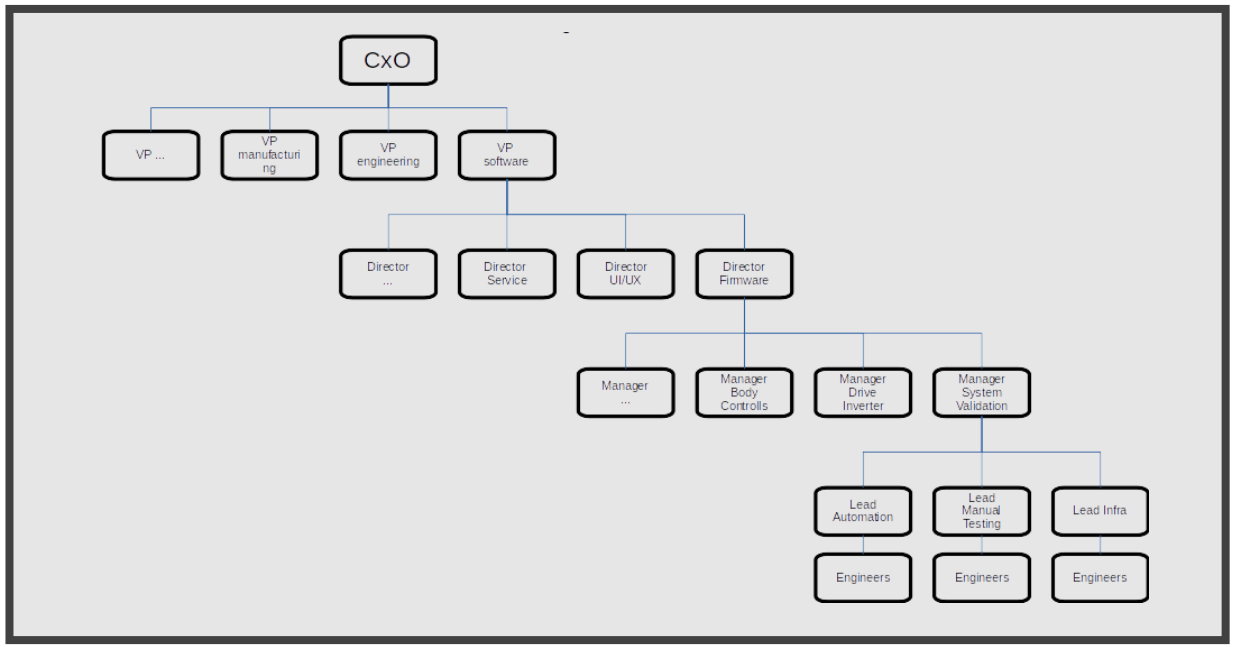
Tesla software team - organizational structure

The Company ▸ Tesla

When ▸ 2012 onward

The Approach ▸ Organizational approach to support agile





SBD Insight

Digging into some case studies within the Tesla organization, there are two types of teams that gather across the organization.

- The top image is that of a committee of team leaders.
- In parallel the feature teams gather together without leadership to collaborate.
- This dual gathering cuts through the organization, which itself in a very flat organization.

Tesla configuration management

The Company ▸ Tesla

When ▸ 2012

The Approach ▸ Allow infinite configurations and master the configuration management

Overview

Tesla does not apply measures to reduce or limit the number of vehicle configurations and their combinations. They also still support all legacy configurations in the fleet (since 2012). Their approach is not limited to pedigrees but mastering their management. Configuration management is built deep into the DNA of all Tesla vehicles (and non-vehicle products, actually). Every car has detailed information about all hardware and software it carries, in a granularity down to components. This information is stored on the central gateway as a manifest and it is continuously checked against the actual hardware and software, synchronized with the mothership server, and from there available to all members of the team in real-time. With this information available Tesla can target their software over-the-air updates very specifically to certain configurations. The vehicle packages are designed so that they contain all possible software versions this package is approved for, and the car can pick the right files from that package. As a result, there is only one package per platform (SX and 3Y), which provides great advantages during the validation phase. Another big benefit of Tesla's approach is that configuration, as long as they are software-driven, can be modified quickly and with low effort during development phases which saves the need for multiple vehicles in the test fleet to test different software.

Achievements

- Real time information about every car in the world
- Very granular information
- Single package for large number of vehicles
- Replacement components in service automatically integrated with OTAs

Obstacles

- Complex initial implementation
- System needs to be architected for this from the beginning
- File multitude can get disorganized

OEMs

Disruptors	Single brand OEMs	Multi brands OEMs

Partners

Silicon providers	Tier-1	SW integration providers

Organization

Product planning	UX	Engineering
Marketing	Cyber	IT

Layers

Cloud Services	Shared Services	Vehicle Applications
Platform & Middleware	OS & Virtualization	Hardware & E/E

Lifecycle

Design	Verify	Launch
Manufacture	Operation	

Analysis

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Chapter Introduction

This chapter introduces the concept of existing Key Automotive Paradigms which can be unlocked by OEMs and partners as part of their journey to Software Defined Vehicles.

Each of today's paradigms is defined and considered in terms of indicative verbatims one might hear in such a culture or arrangement. Each paradigm gives a spectrum of options with benefits and challenges in tension. Case studies from the previous chapter along with additional examples help to demonstrate the state of the art of today's organization and strategies.

OEMs and partners delivering Software Defined Vehicles will continue to have today's options into the future, with the addition of breaking up opportunities in the middle of the spectrum which were previously not possible.

The chapter then attempts to consider the benefits that can be achieved in this 'center space' and to identify the enablers that should be put into place.

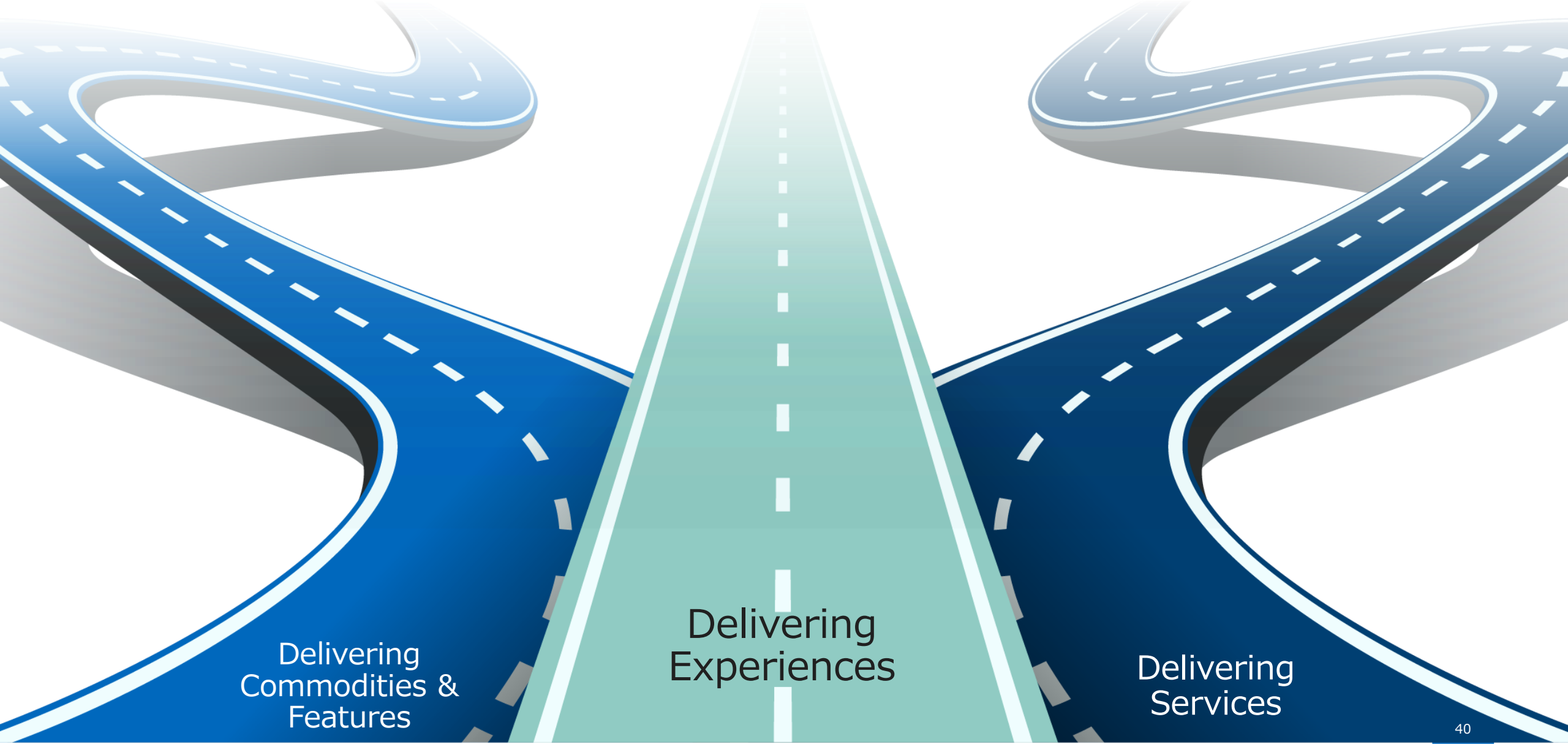
What benefits do the enablers of this chapter deliver?

- Pace & Agility
- New Experiences
- Owning own IP
- Simplifying Complexity
- Revenue Flexibility

Today's Paradigm	
Option A	**Option B**
What to deliver?	
Delivering Commodities & Features	Delivering Services
Commercially Defined Competitive Products	Innovative Features through Technologies
Point of Sale	Aftersales
Who will deliver?	
Product Delivery	Service Operations
Vehicle Line Leadership	Functional Leadership
Third Party Sales & Service	Dealerless Sales & Maintenance
How to deliver?	
Waterfall	Agile
Insource Build	Outsource Buy
On-Vehicle Verification	In-Loop Verification

Paradigms relating to ***What*** *to deliver?*

The Delivery Goal Paradigm



Product Development have been learning to deliver services

Delivering
Commodities & Features
to the customer

Centre Space
Difficult to achieve with today's State of the Art

Delivering
Services
to the customer

A key target of much of an OEM's development is to present customers with a list of content that is included with a vehicle purchase and a list of options. These are usually delivered onto a cross-brand platform with different 'top hats'.

"Start of Production is delayed again as that new feature still isn't ready

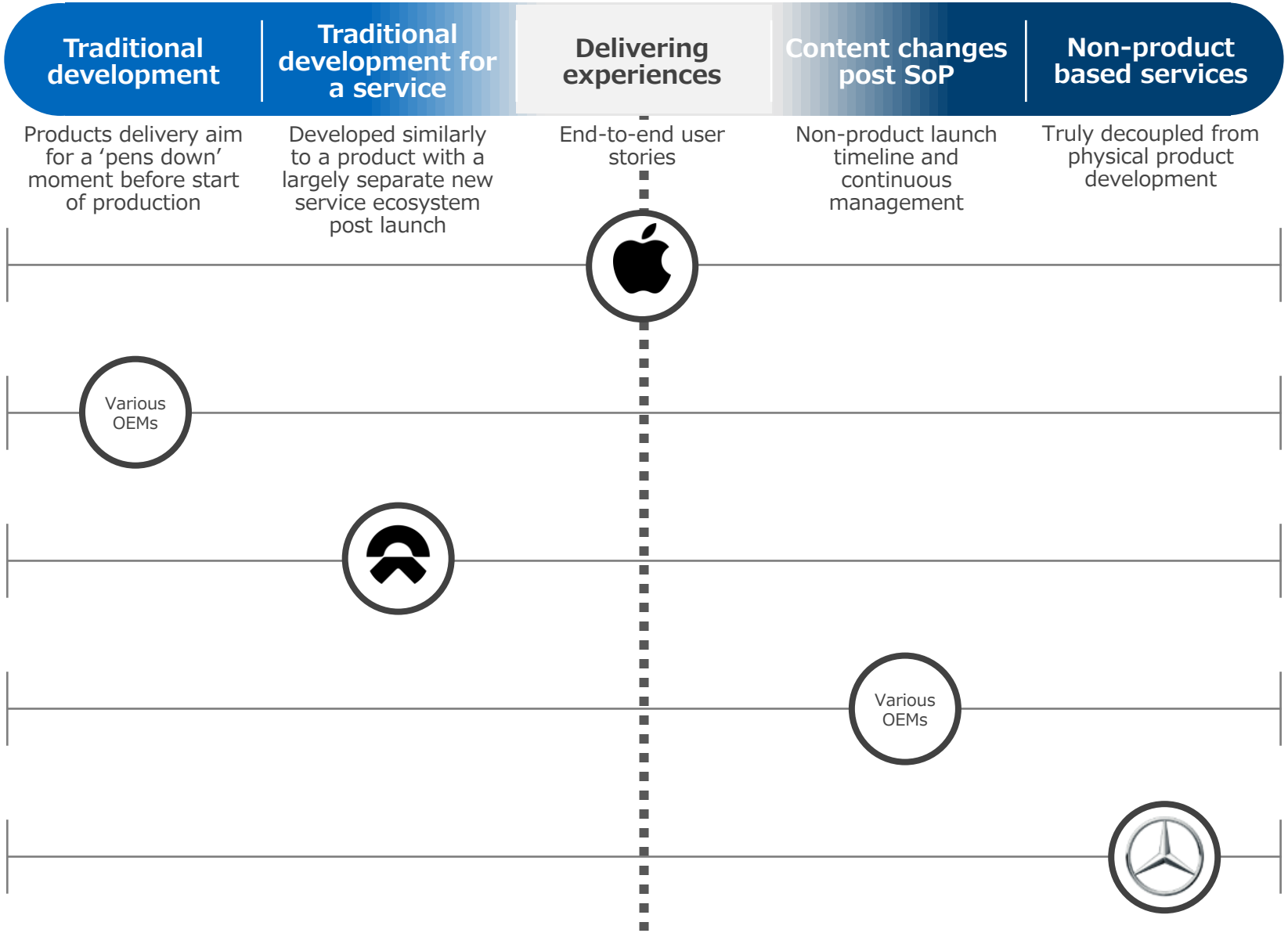
Advantages	Challenges
Discrete work packages	Everything is on the critical path for launch
Low vehicle combination complexity	High system complexity
Direct comparison with competitors	Customers overwhelmed with options
Defined configuration variety	Customer unhappy with combination options
Long term planning	Features outdated when becoming available
Clear validation efforts	Commodities not expected to be paid for

Car makers have traditionally delivered services through their local networks, but with connected cars have been delivering apps and connected services direct from the OEM, but by their nature, services can't be forgotten about after Start of Production.

"Why is it so hard to get Engineering to continue to maintain this service?

Advantages	Challenges
High customer engagement	OEMs need ways of receiving new revenue streams
Opportunity for iteration & improvement	Product Development team culture is focused on SoP
Vehicle agnostic services	Regional variance
Large spectrum of options for the customer	Loss of regulatory approval
Fast product changes when trends change	Loss of warranty
	Potential safety risks

OEMs are optimizing but should shift to be more like Apple iPod



Apple iPod
Although the iPhone is given much credit, iPod launched an end-to-end experience in a single combined product and service. It gave customers a hardware, software, PC/Mac software, and access to a media ecosystem.

Less Features
Various OEMs have launched products with a significantly reduced cockpit feature set, instead focusing on improving the user interactions and delivery of key features.

Battery as a Service
A choice of batteries are offered to choose to be dynamically swapped depending upon the customer's intended usage.

Regional Connected Services Launches
For most Engineering departments, Connected Car launches introduced the need for true service launches to be managed into different regions with different service providers; along with ongoing service management.

Very Niche Apps
Mercedes Ski App is one example of a very specific app developed by an OEM. The app was developed as a true service, un-linked to a specific model launch. Such apps are declining with many OEMs reducing their feature sets.

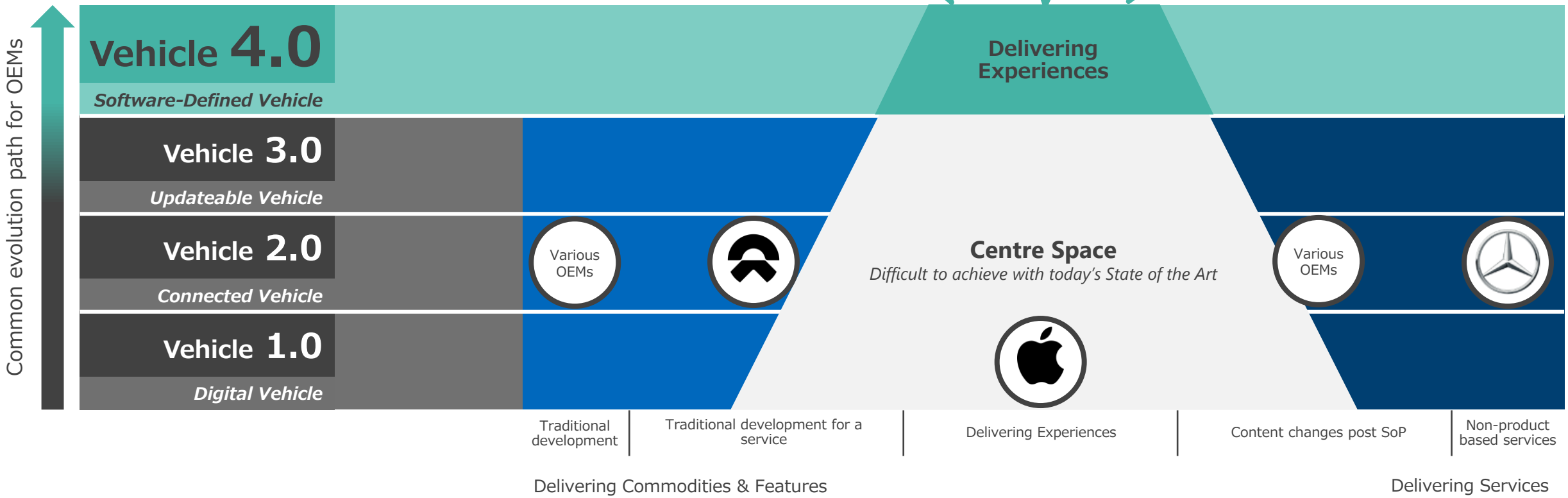
Basic ‘vanilla flavor’ build with decoupled, relational experiences

There is a shift from having a long tick list of features to instead delivering design led user journeys. Customers will start expecting that their vehicle continuously improves and remains fresh.

Pace & Agility
Decoupling experiences from the product launch, wherever possible allow for a basic ‘vanilla flavor’ build which is updated with more broad feature sets’ software during usage.

New Experiences
Data-driven experiences that are hyper-personalized. These might include experiences that previously would not have been possible, but also keeping the user experience fresh for established or hygiene features.

Revenue Flexibility
Revenue models shift to quality of experience pricing rather than quantity of features, with a greater relational emphasis with the customer rather than transactional.



OEMs to add services to their services

Common evolution path for OEMs

		OEMs	Partners
Vehicle 4.0 *Software-Defined Vehicle*	**People**	• Non-automotive skills • Admins • App store • Marketing for launch strategy	• 3rd party app developers
	Finance	• Scaling infrastructure for services • How do you measure the potential value of the flexibility?	• Subscription services
	Process	• Car as a network node • Integration into ecosystems • Functional Safety • Cybersecurity • Decoupled features from electro-mechanical	• Sell to OEM or to customer
Vehicle 2.0 to Vehicle 3.0	**People**	• Add app developers • Add backend developers	• Support app development
	Finance	• Budget for free-to-consumer services as part of the bigger picture	
	Process	• Process for adding services to existing platforms as option, including homologation and validation • OTA rollouts well organized & communicated • Customer release notes	

Share the existing ecosystem info and open up new ones

Description	Enablers	Steps for OEMs	Steps for Partners	Pace & Agility	New Experiences	Owning Own IP	Simplifying Complexity	Revenue Flexibility
R&D member subscription to feature development	Visible system for feature development and progress	Implement ONE toolchain for feature development		●				
3rd party app integrations	Creation of app store	Definition of APIs, rules and validation methods	Creation of apps		●		●	

SBD Insight

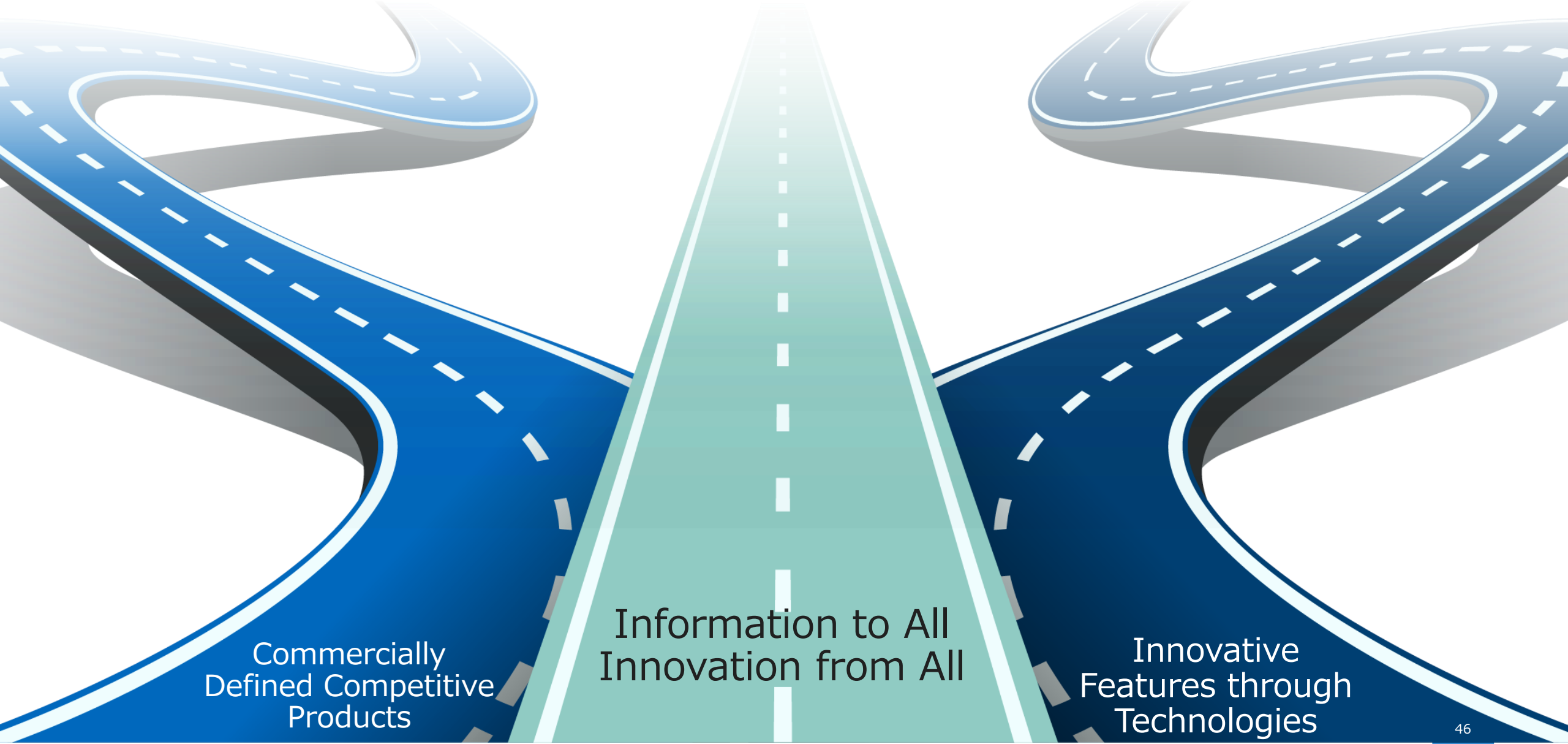
This is likely the paradigm which will be at the top of the list for the largest pool of those in an OEM. Product Delivery teams, by their very nature, focus upon the delivery of products, and these products are delivered by teams who are usually responsible for vehicle lines, commodities, platforms, or systems.

External Perspective

"The society at large is undergoing a transition towards an "experience economy," where consumers increasingly crave personalized experiences. The future vehicle holds the potential to deliver precisely that: an experience that goes beyond being a mere product or service. Through the utilization of software and electronics instead of relying solely on hardware, software defined vehicles (SDVs) have the ability to profoundly alter, impact, or influence the behaviors of the vehicle. This allows for the provision of data-driven experiences tailored to the consumer's desires.

Himanshu Khandelwal - AlixPartners

The Customer Needs Paradigm



Two independent approaches

Customer's needs are defined by
Commercial
teams

Centre Space
Difficult to achieve with today's State of the Art

New customer features are initiated by
Technology & Innovation
from engineering teams

Commercial teams gather voice of the customer data with market insights and competitive benchmarking to define the vehicle's requirements. Similarly, data relating to warranty claims and parts returns feed the next generation/facelift.

"We understand the user's digital journey

Advantages	Challenges
Customer satisfaction	Lifecycle lag to implement following a signal
Regional variance can be well understood	Lifecycle lag to collect the data
Best insight into the customer's digital journey	Struggle to understand second and third owners
Significant dedicated market research resources	Knowing the implications or opportunities of the data
Robust data driven signals	Always one cycle behind
Consistent roadmap start to finish	Risk of missing a trend

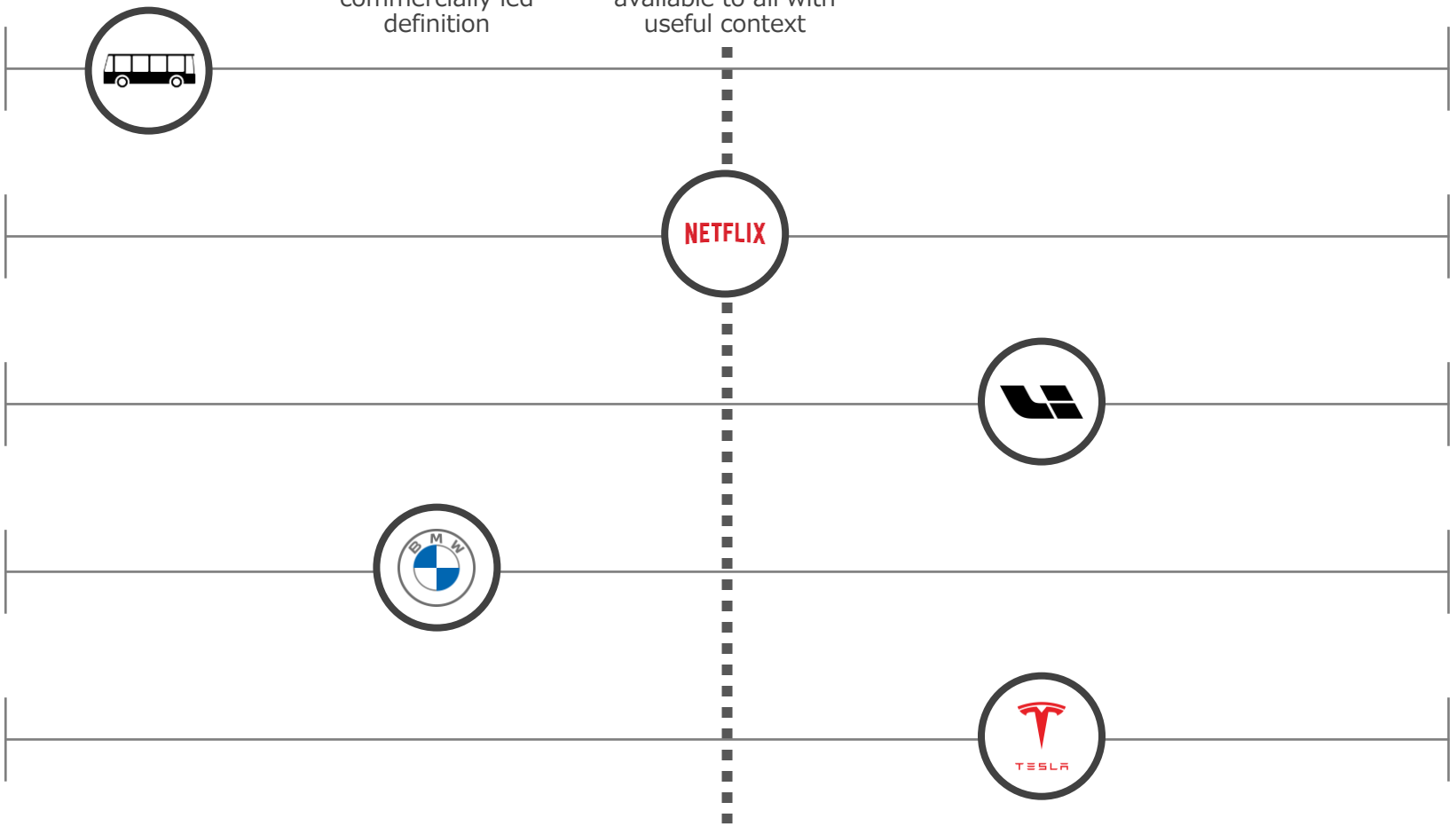
Research and development teams initiate ideas from a new concept or application of a new technology. Commodity or system owners develop a technology roadmap to be rolled onto vehicle lines over time.

"Our research project is complete, which vehicle-line is next that can take it?

Advantages	Challenges
Brand differentiation	Features may not be attractive to customers
Innovation can be timed competitively	Discrete poorly integrated experiences
The experts own the roadmap	Significant overheads with unfulfilled projects
New tech not known to consumers yet	Poorly defined business cases
Vehicle agnostic development	Funding
Not urged by SoPs	Marketing has issues advertising vehicle releases

Continuous data logging releases powerful decision making

Customer expectation-driven	Engineering signal into commercial	Information to All Innovation from All	Production Insight Driven Innovation	Technology-driven
Direct feedback and usage data	Technology roadmaps etc. feed in as inputs to commercially led definition	Commercial data and Engineering data collaboratively available to all with useful context	CAN 'sniffing' or dynamic fleet logging	New technologies or standards drive the roadmap



Buses & Stagecoaches
Coachbuilders sell to service providers and seek their insight on customer needs from the service providers as they are closer to the customer.

Netflix
Constant AB testing drives hugely complex alternative views which different customers are given depending upon their usage. Note this in reference to menu layouts to encourage usage rather than just which media.

Auto temperature setting
Li Auto collects customers' vehicle usage data to optimise their features and vehicle setting. For example, the A/C temperature default setting keeps optimising based on regional customer usage.

i Vision Dee
Technology driven concept shared with the wider community as part of marketing and signal collection

Fleet logging with AI opportunity
The default is to gather data, but this leads to too large a pool of data to navigate through to find trends. With Tesla's AI capabilities, there is an opportunity (/likely strategy) for AI crawling progressively through the data to spot trends

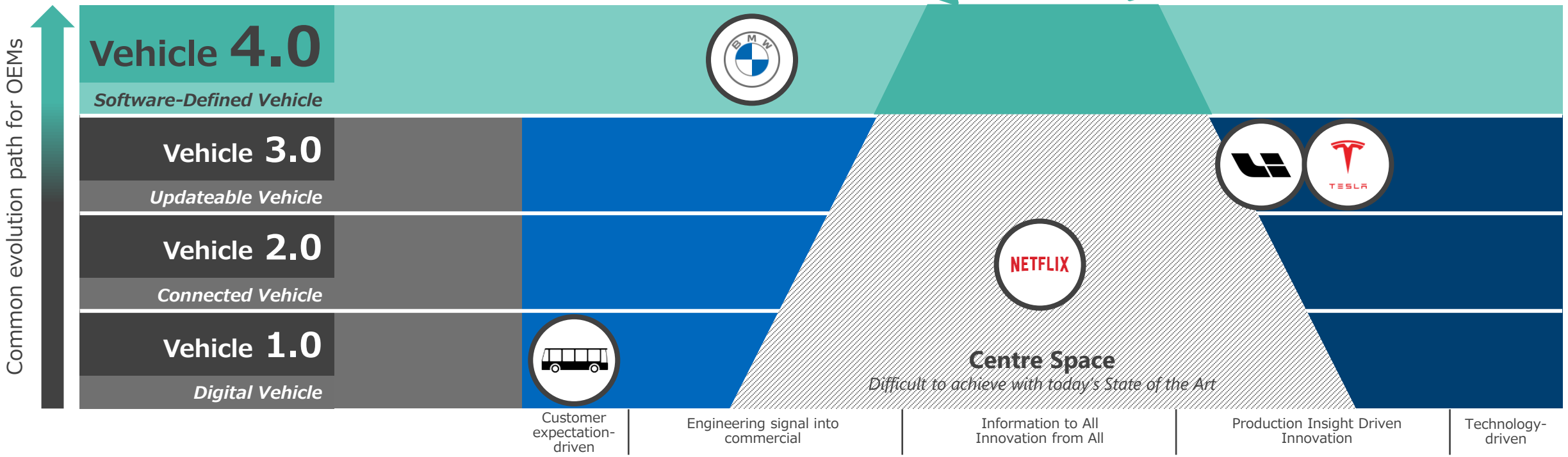
Shorter lifecycle discovery, development, testing and launch

Currently significant data feeds sit within different teams and are not available to the wider business. Even if data is shared, without context colleagues are unlikely to find useful insights. Opening this data and allowing, for example, commercial teams to configure data they'd like collecting, and then to deploy a partial trial to some users to monitor impact, releases all members of the team to collaborate.

Pace & Agility
As well as easier to deploy software changes, dynamic AB testing allows faster feedback within development, and data logging allows shorter lead times for signal collection.

New Experiences
Service providers, initially lease/fleet, and in time shared mobility, encouraged to innovate.

Focus shifts to minor improvements more frequently rather than big monolithic features.



Discover a new world – where data leads the way, lots of data

Common evolution path for OEMs

		OEMs	Partners
Vehicle 4.0 *Software-Defined Vehicle*	**People**	• Self learning data systems with AI • AI Experts • Lifetime Programme Attribute Teams	• Usage profiles
	Finance	• Fast innovation monetarization	• Data monetization • Cross OEM data
	Process	• Who's getting data? Who's responsible? • Phase in process needed different to the classic 3–5-year face lift process • Configuration management process • AB testing	• Tools
Vehicle 2.0 to Vehicle 3.0	**People**	• Data analysts for fleet information • Customer feedback receivers	• Data tools • Server admins
	Finance	• Large database • Data transfer costs	• Data tools as a Service
	Process	• Data logging in the entire fleet • Customer feedback channel	• Getting data to supply base. As a service

The (soon to be) essential ability to get data to and from a car

Description	Enablers	Steps for OEMs	Steps for Partners	Pace & Agility	New Experiences	Owning Own IP	Simplifying Complexity	Revenue Flexibility
Gathering information about real world use of the product in real time	Fleet data logging	Create edge data logging, data transfer and a data lake	Support new tech like Hadoop, AI			●	●	●
Collect customer feedback anytime and anywhere	Direct customer feedback channel	Define channel, assign resources to monitor, analyse and process		●				●
Integrating essential SDV features	Data in and out of the car	Develop vehicle data platform	Sell vehicle data platform as a Service			●		●

SBD Insight

Getting the voice of the customer promptly and their feedback to the right teams is key but there will be increasingly service providers who are closer to the customer than the OEM so will be able to provide expert feedback.

Tesla users can provide feedback via voice command, and NIO users via their app – increasingly direct channels will become more common, along with toolsets and processes to maintain the channels.

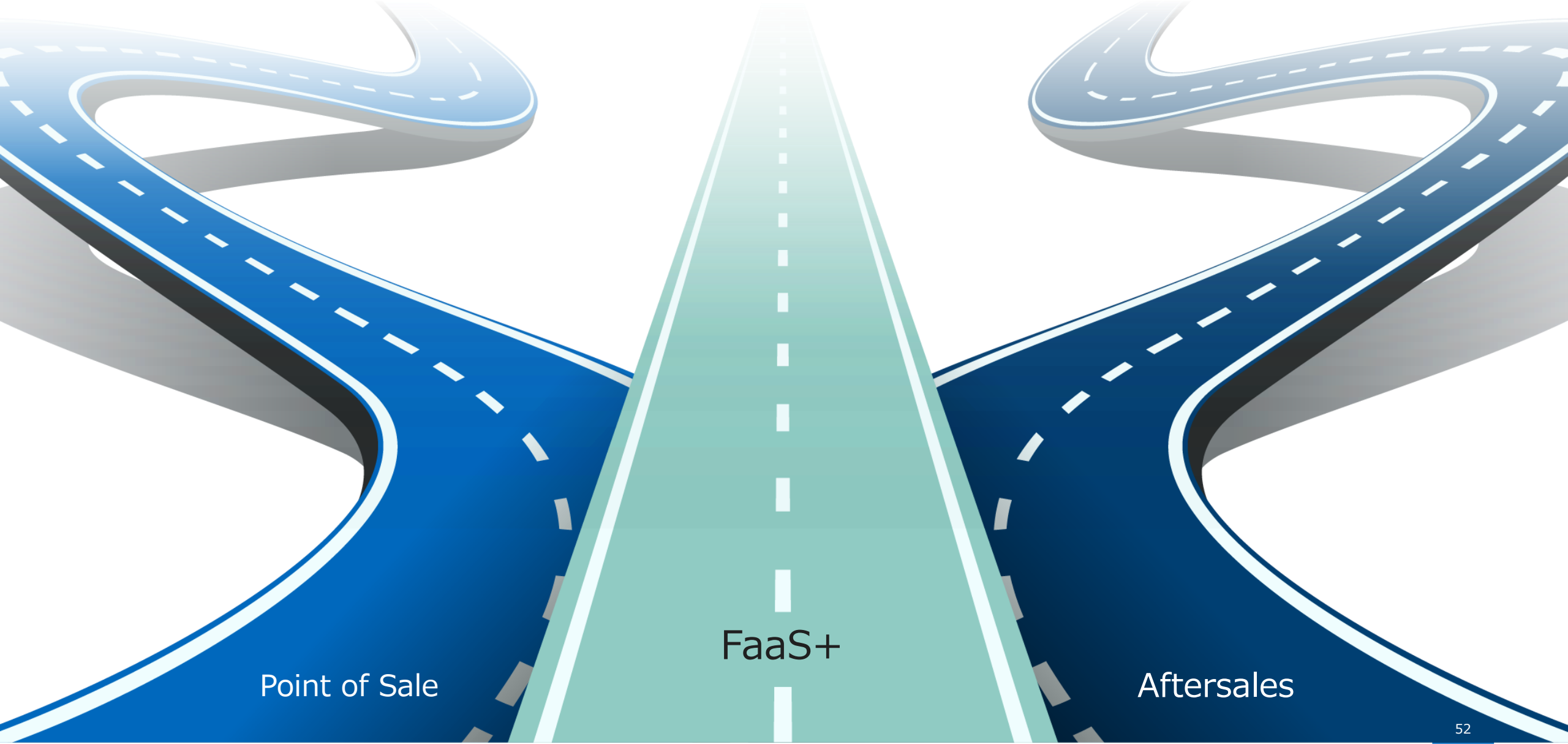
This insight then needs to be available to all in the OEM, and anonymized user data made available so that hypotheses can be backed-up with usage data.

External Perspective

"If we agree that the paradigm shift to delivering experiences and continuous digital twins will be a challenging transition to successfully deliver. Then we have to start to exploring what culture and behaviours will drive success to support these traditional OEM's as they kick start their SDV journey. In my view, ignoring the technical challenges, at the heart of this is to providing an innovation for all mindset where the traditional silos are eroded, and we have a desire to learn from one another.

Jason Craker - ChangeMaker

The Sale Lifecycle Paradigm



Start of Production is not end of a project anymore

Product fully defined as it is delivered at
Point of Sale

Centre Space
Difficult to achieve with today's State of the Art

Features & commodities upgraded by
Aftersales

The car as a product is developed and tested against a product requirement specification catalogue. All features are defined upfront and are available to the end-customer at the time they buy their vehicle, further features are not (or hardly) available to be added after purchase.

> We know what software was on it at build but not today

Advantages

- Defined closure of the PLC
- Clear boundaries between R&D and aftersales
- Plannable availability of resources after SOP
- Long term project planning
- Product homologated and approved by authorities once
- Easy to understand if vehicle line reaches revenue targets

Challenges

- The OEM loses connection to the buyer right after the sale
- No mitigation for security other than recall
- No revenue after initial sale
- Customer expectations towards continuous UX improvement
- Ongoing integration with upcoming technologies

Aftersales activities often focus on enhancing customer satisfaction, maintaining vehicles, and offering upgrades or accessories. Typical features and commodities upgraded by aftersales include accessories, infotainment systems, safety upgrades, performance enhancements and upgrades, maintenance and service packages, warranty extensions, and spare parts.

> Without aftersales, our commitment to customer satisfaction and vehicle longevity would be incomplete.

Advantages

- Independent of OEMs
- Driven by the market
- Not bound to OEM Quality standards
- Large landscape of providers
- Customer is not bound by OEMs strategy of product

Challenges

- No OEM revenue
- Possible loss of warranty / insurance / homologation
- Limited to "high level" changes
- Reverse engineering efforts
- Integration issues
- No complex features at scale

Simple FaaS can be delivered with today's State of the Art

Fixed Product	Cloud Services	FaaS+	Service Ownership	Minimal Integration Feature
Focus is upon what is delivered at the end of the production line	On vehicle delivered with off-vehicle content or configurable FaaS	Post launch additional features available as a service	Ownership & finance options	Vehicle is re-worked
	Various Premium OEMs			
	BMW			
		HARMAN		
		TESLA		
			Renault	

Stolen Vehicle Tracker
Optional SVT feature can be delivered on top of an eCall and connected services offering which is standard fit. From a vehicle perspective a simple configuration is set to enable the feature

Heated Seating as a Service
A fully defined feature is available at the Point of Sale but can be configured at a later date of ownership. The hardware and software are present in all vehicles at the Point of Sale.

Premium Sound through Software
A standard hardware platform is delivered on all vehicles with a later, optional improved audio quality able to be deployed through an OTA update

FSD Trial
New customers are given a one-month trial of FSD, along with relevant software updates, and are given the choice to subscribe to the feature afterwards.
Note: Not currently offered, awaiting iterated software.

Battery Rental and Monitoring
Renault offers a battery as part of the point-of-sale product but the financial risk and maintenance if ring-fenced as part of a battery lease, guaranteeing a range.

So much more than configuring a feature as on or off remotely

FaaS is available with Vehicle 3.0, whereas with FaaS+ features are truly conceived post launch and deployed to existing vehicles.

OTA updates moves from a primarily quality insurance tool, to consider perceived quality and end-to-end experience.

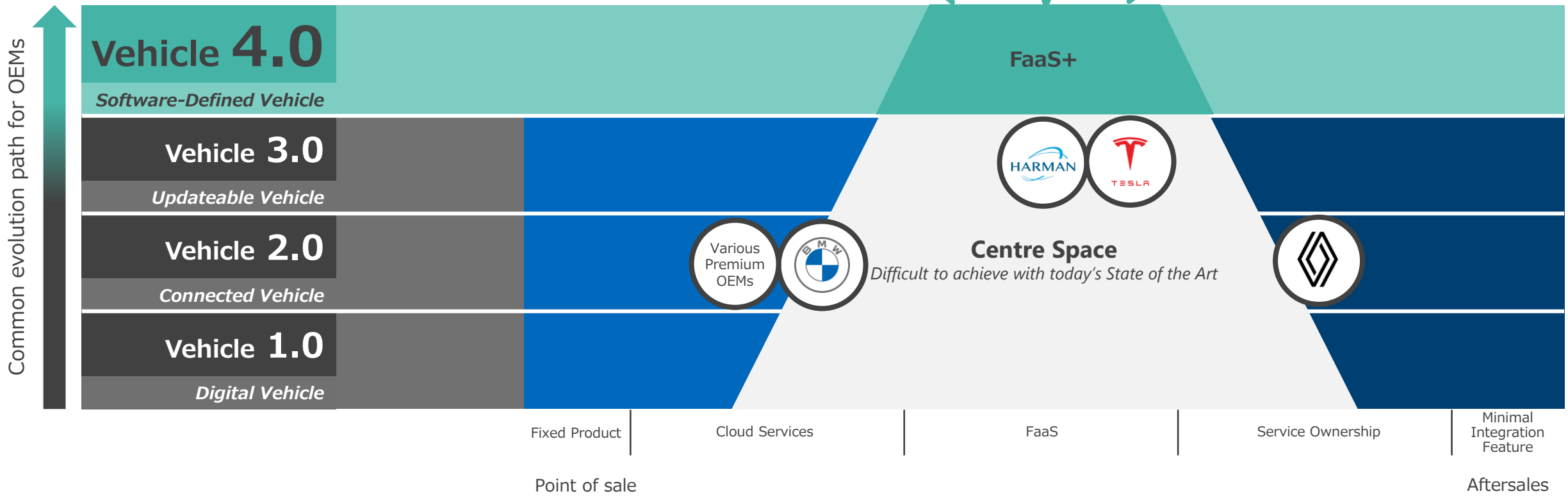
A lifecycle circular economy is developed with vehicles holding their value and needing to exit the market later, with second owners enabling features that the initial purchaser did not.

New Experiences
Rapid deployment of integration with new ecosystems, new software features and continuously fresh interfaces.

Simplifying Complexity
Whereas today's product planners negotiate with component owners on over-specifying components, revenue streams can utilize edge to deliver off-vehicle processing, at a service cost but without uncertain overheads.

Revenue Flexibility
Lifetime revenues become possible, with OEMs shifting from FaaS being a 'second bite of the cherry' to being a forecasted and relied upon business case.

Instances of trials or 'shareware', and usage identification encourage new channels of sale.



FaaS can become a major revenue stream – if set up right

Common evolution path for OEMs

		OEMs	Partners
Vehicle 4.0 *Software-Defined Vehicle*	People	FaaS sales team Dealer training Marketing language change Knowledge about platforms need to be kept active	Data on what want Local sales
	Finance	Complex business strategy - E.g. a big battery not currently covered by complexity saving. Faith in service revenue New revenue calculation methods must be developed	Sharing resources Budgeting resources for feature upgrades
	Process	FaaS in parallel to regular OTA updates Unifying interfaces, languages, OS Plug and play architecture	Config management
Vehicle 2.0 to Vehicle 3.0	People	Feature teams Feature integration PMs and Lead Engineers	Feature collaboration with competition
	Finance	Cover Bill Of Materials in sale price of car and attempt to further commercialize services	Sell features / components in full to the OEM and done or sell per user and get share of later sales?
	Process	Common integration efforts Stable interfaces Inclusive change control	Involvement into vehicle integration

Design the HW and SW architecture with the future in mind

Description	Enablers	Steps for OEMs	Steps for Partners	Pace & Agility	New Experiences	Owning Own IP	Simplifying Complexity	Revenue Flexibility
The vehicle needs to be architected to accept FaaS at scale	Sufficient Resources	Switch accounting from SoP / initial sales model to vehicle lifetime model			●		●	●
The software needs to be architected to handle FaaS	Modular SW Feature switches Stable backbone SW	Appoint and empower software architect Rethink software architecture			●		●	●
Vehicle configurations must be known at all times	Vehicle data base Manifest	Define format Create live database Ensure real time info update Hire data base engineers					●	

SBD Insight

As OEMs build their longer-term growth around lifetime revenues, they will need to become more comfortable with increased risk. The success of a production team will no-longer be around the point of sales value and cost but will have to represent value over lifetime.

Some rules of thumb may become used in OEMs in a similar way to how airlines traditionally sought to pay for the cost of the flight with first class passengers, OEMs in certain segments seek to break even only, to appeal to budget customers or perhaps certain shared mobility models where the user pays for additional experiences. A parallel from the personal computing industry would be discounted printers to claim market share, knowing that consumables will bring the desired revenue.

In time, taxable values of vehicles may come under scrutiny as value is added after Point of Sale. In the US today, software only add-ons are excluded, but such policies may vary regionally.

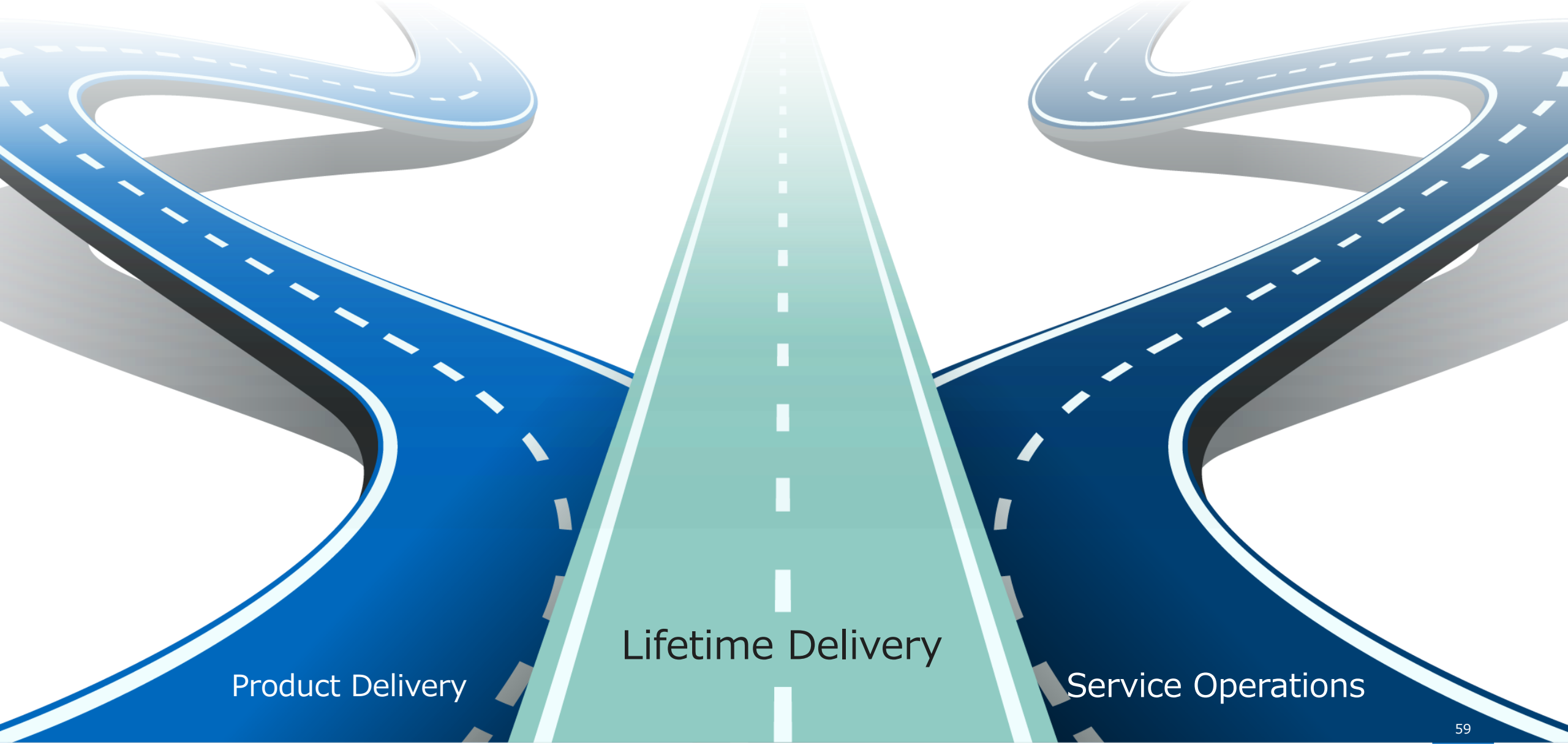
External Perspective

"Though the idea of Feature-as-a-Services is often grouped with the necessity for domain architecture and connected vehicle, the agnostic to architecture and connectivity. FaaS has been around for a while, on both offline cars and distributed architectures. FaaS+ is more complex than just activating a setting somewhere in the configuration file and a dedicated ECU will provide more functionality. On one hand FaaS+ is about the entire vehicle as a whole providing a user experience that is integrating a multitude of controllers, displays, actuators, etc. On the other hand, FaaS+ is about scaling, about flexible feature activations any time anywhere in the world as well as feature maintenance and ordonnance in real time from a centralized management system.

Florian Rohde - iProcess

Paradigms relating to ***Who*** *will deliver?*

The Delivery Phase Paradigm



Two (mostly) independent worlds need to move closer together

Activities conducted through
Product Delivery
up until Engineering signoff

All efforts to get a car from the first concept to the start of production. Requirements engineering, requirements breakdown, Electrical and Software design and implementation as well as integration, verification and validation.

"It is the OEMs job to design a product that can be maintained by service

Advantages

- Focus on innovation and performance
- Streamlined Development Process
- Design Focus
- Cost Optimization

Challenges

- Serviceability Challenges
- Lack of Feedback Loop
- Suboptimal Design for Maintenance
- Missed Opportunities for Improvement
- Customer Dissatisfaction

Centre Space
Difficult to achieve with today's State of the Art

Activities conducted through
Service Operations
after point of sale

All efforts to keep the vehicles on the road safe and comfortable. Maintenance, customer interactions all the way to decommissioning.

"It is the responsibility of service to keep the products running and the customer happy

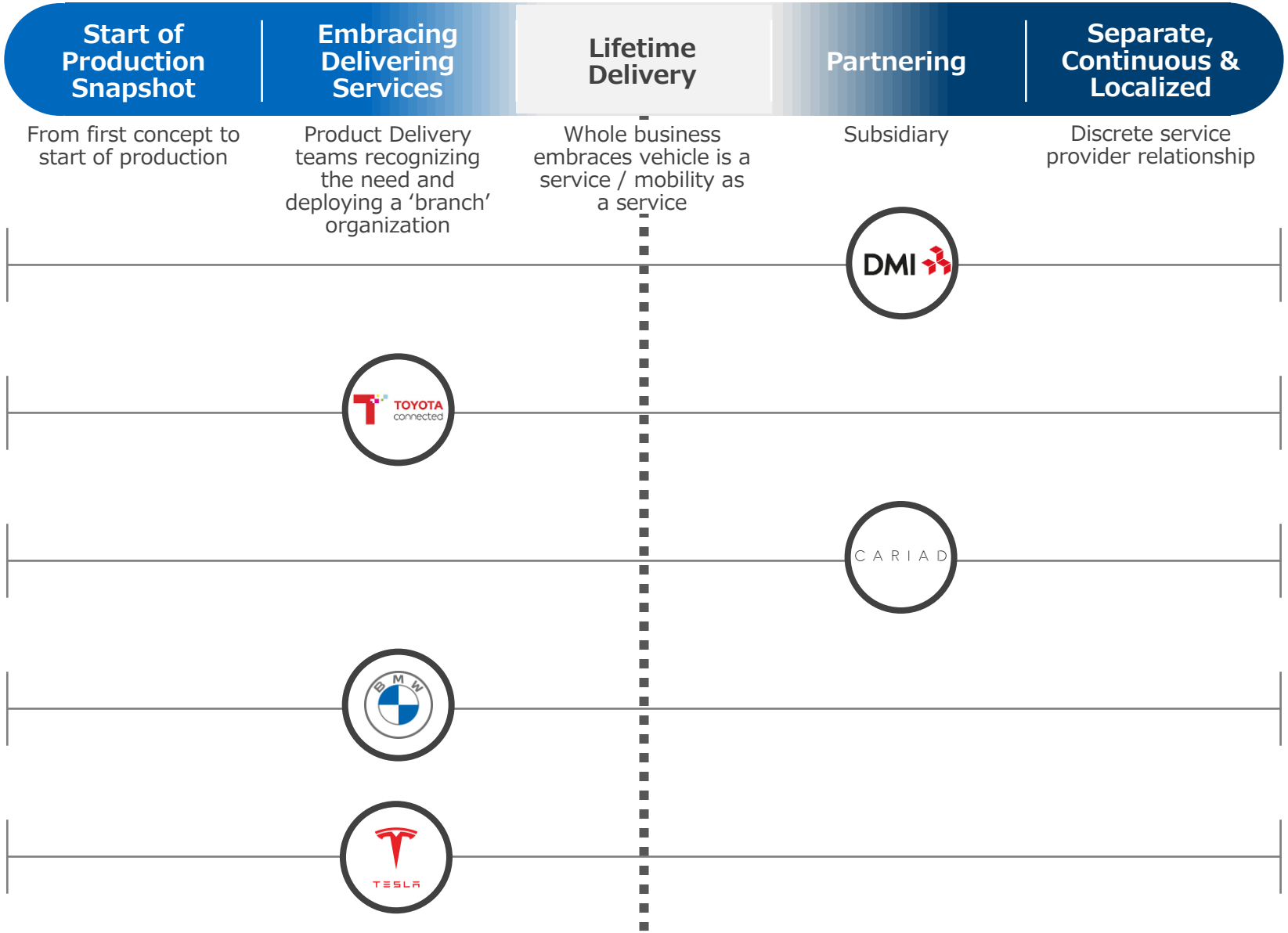
Advantages

- Customer-Centric Approach
- Specialized Industry Expertise
- Flexibility and Agility
- Tailored Service Offerings
- Aftermarket Opportunities
- Collaboration with Third Parties

Challenges

- Higher Service Costs
- Customer Dissatisfaction
- Missed Opportunities for Efficiency Gains
- Reactive Approach to Problem Solving
- Serviceability Challenges

Mobility as a service is (still) new territory for OEMs



OTA Management Provider
OTA configuration and deployment offered to OEMs as a service. ETAS, Carota, Sibros, Exelfore, and Airbiquity are other such providers.

Localized Service Technology Experts
The North American national sales center of Toyota has a department that is truly service-centric managing the localized connected services.

Separate Software Company
CARIAD's software organization serves the brands within VW group but is an independent service-based organization, with its own identity and prioritizing its own tasks. It acts as a partner, despite ownership.

Software Subsidiary
BMW's software subsidiary is a separate organization, with a greater service orientation than the rest of production, but team embers would still consider themselves part of BMW.

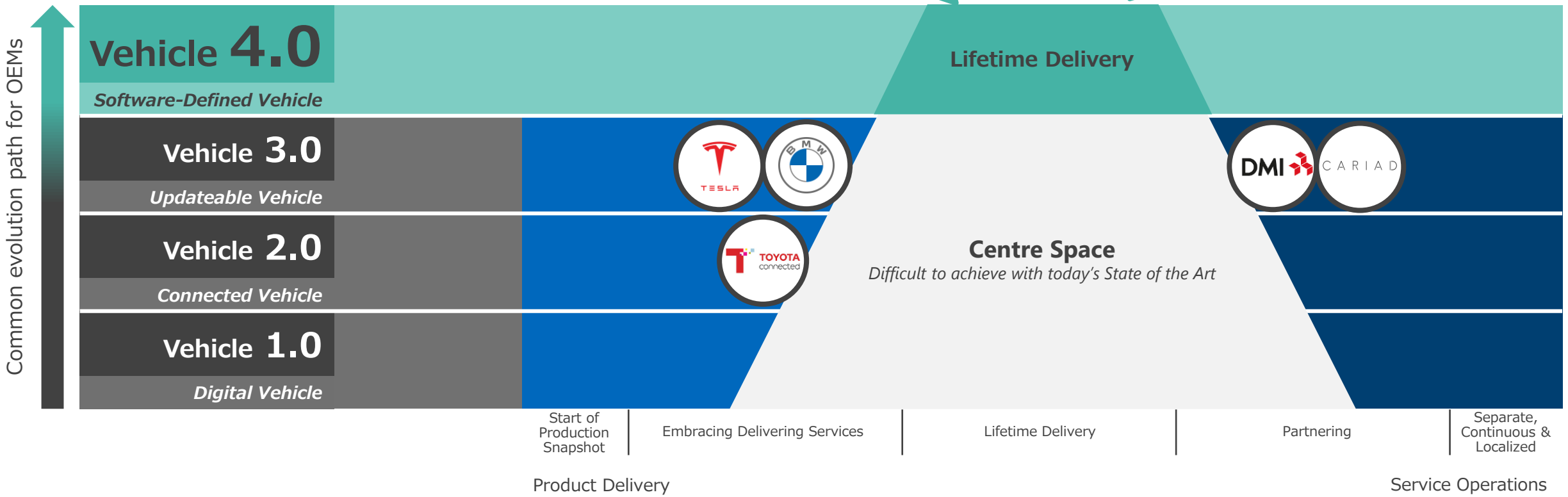
Distinguishing Advanced Users
Service is tuned by factors including which options they've purchased and whether the user has selected 'Advanced User' as an option. This helps to diversify offerings with technology leaders and most users.

A fundamental paradigm shift to delivering life-long services

Product Development Teams are facing a paradigm shift to a service delivery model. This is completely different at every level of the organization, including practical items such as how one measures success of a Chief Engineer. Teams in many OEMs already have an expectation that quality updates will require service support, but this needs to expand past quality topics.

New Experiences
A move away from new monolithic features being deployed on the next appropriate model launch, to a continual improvement in more minor steps that can be trialed and understood, as part of a gradual deployment.

Revenue Flexibility
Business Cases will take on a greater level of risk as OEMs rely upon lifelong revenues. Teams will need clear guidance on how to balance such decisions.



Opportunities through collaboration and communication

Common evolution path for OEMs

		OEMs
Vehicle 4.0 *Software-Defined Vehicle*	People	• Skillset transformation in service org • Cross-disciplinary collaboration -> feature teams • Upskilling and continuous learning • Enhanced customer support • Empowered OTA leaders - currently (in SBD's experience) nearly always in Product Development
	Finance	• Research and Development expenditure • Service revenue and business models • Total cost of ownership
	Process	• Early involvement of service teams • Data-driven service improvement • Data from second and third owners
Vehicle 2.0 to Vehicle 3.0	People	• R&D service engineering organization with direct link to service centers
	Finance	• Allocate R&D budget for service engineering
	Process	• Streamline process of reporting issues between service and R&D (also tools) • Service as a signature on software releases • Selective updates to specific sets of vehicles / configurations / climates etc.

Fill in the moats and merge into a greater whole

Description	Enablers	Steps for OEMs	Steps for Partners	Pace & Agility	New Experiences	Owning Own IP	Simplifying Complexity	Revenue Flexibility
Collaboration and Communication	Defined channels Continuous toolchain	Foster collaboration Keep R&D resources available during service rollouts		●		●		●
Cross-Functional Training and Knowledge Transfer	Availability of information Transparency of deliverables	Streamline information from R&D to Service		●		●	●	
Data and Analytics Integration	Centrally available data from single vehicles and statistics from fleets	Create fleet database, train and enable all employees to gather information			●	●		

SBD Insight

Who should be responsible for lifetime engineering and software. OEMs appear exclusively to have nested OTA management within their production teams, but this can lead to OTA being mainly a quality improvement tool rather than a lifetime service. Some OEMs have some sort of a 'Production Vehicle Engineering Team' who are part of the Product Development Team but are somewhat separate, perhaps based at the factory, managing ongoing quality and updates. These are usually task/team oriented 'firefighters' but in principle such a 'silo' could be a helpful model for lifetime software.

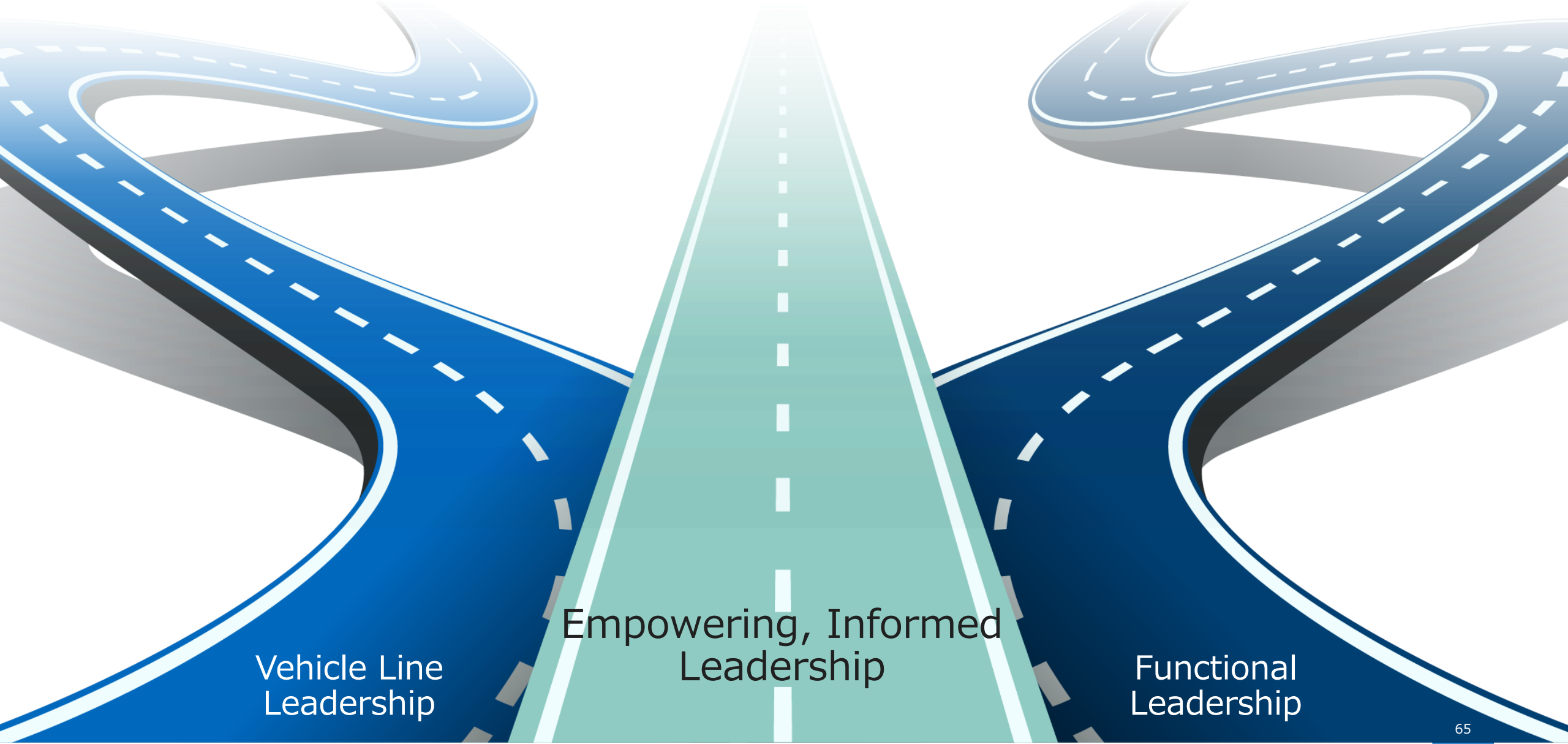
Lifetime service delivery has a risk of infinite complexity. Configuration management and Digital Twins should grow to 'handle' more combinations but a fundamental rebirth with a lower level of complexity is required.

External Perspective

"Besides the obvious proposals of bringing service and R&D closer together, have developers providing instructions and training material, and create a collaboration platform for all involved parties to work in together, one of the most significant enablers for the success when it comes to customer service needs will be the smart handling of data. Single vehicle data for preventive maintenance available to all service centers is equally important as crowd sourced fleet data to support the detection and investigation of systematic issues as well as providing priceless usage information for the next design iterations. This data source, of course under consideration of all privacy and security boundaries, should be available to everyone in the company who can add value with it.

Florian Rohde - iProcess

The ‘Who’s in Control?’ Paradigm



Choosing budget holders within OEM needs care

The leader for the brand or
Vehicle Line
is in control for key decisions

Centre Space
Difficult to achieve with today's State of the Art

The leader for the cross-car-line engineering
Function
is in control for key decisions

Vehicle line-based decision making focuses on developing vehicles within a specific product line or family. It involves designing and engineering vehicles and brands, taking a platform approach when it's advantageous for the vehicle-line.

> "I need a cheaper version of that commodity for my vehicle-line

Advantages

- Efficient Production Planning
- Enhanced Marketing and Promotion
- Class segmentation
- Full priority on single vehicle
- Streamlined Development and Testing

Challenges

- Expensive
- Feature limited
- Held hostage by delayed features
- Slower Innovation Pace
- Complex Supply Chain Management

Function-based decision making emphasizes the development of specific commodities or distributed systems that can be shared across multiple vehicle lines. It involves creating a common set of components or systems that are 'offered' to be integrated into different vehicle platforms.

> "We unlock new levels of innovation and efficiency continuously

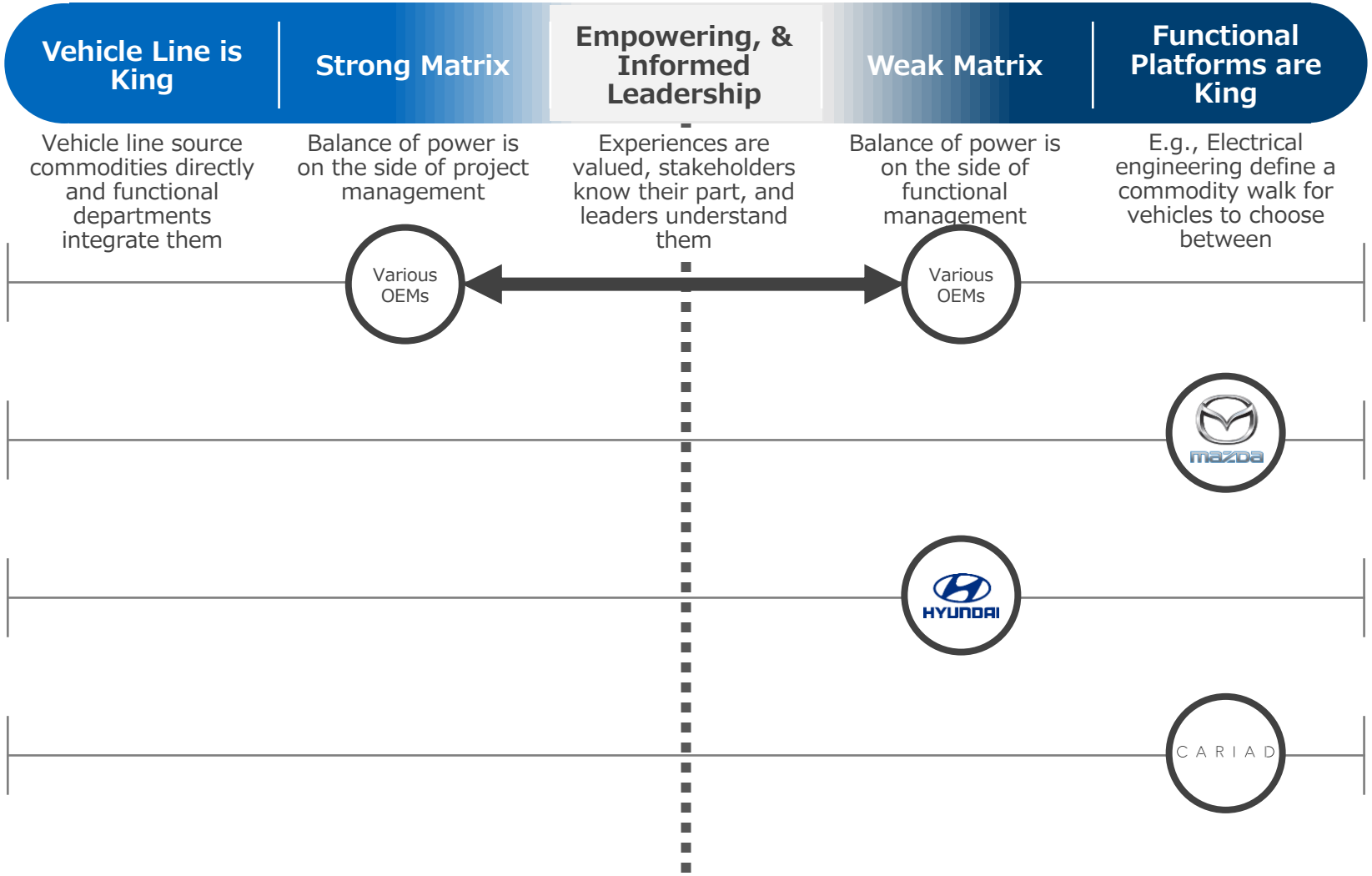
Advantages

- Flexibility and Modularity
- Development and testing until feature ready
- No hostage holding for vehicle programs
- Multiple programs can be served by one team
- Rapid Innovation and Upgrades

Challenges

- Integration Complexity
- Risk of fragmented User Experience
- Developing and integrating standalone features costs
- Could end in a "featureless car" at SoP

Electrical & software complexity driving functional leadership



Iterating strategies
Many OEMs move over time between strong and weak matrix organizations. This is often driven by availability of budget, brand strength, and whether complexity is causing quality issues.

Vehicle Blueprint
Functional teams may not know the vehicle teams well enough but an agreed blueprint is known to all employees for the vehicle line. It distills the key points for the vehicle to help teams make aligned decisions.

E-GMP Modular Platform
The E-GMP provides a standardized platform for electric vehicle, allowing vehicle characteristics defined by software features.

Prioritizing Brand Requests
CARIAD develops software for multiple brands in the VW group and acts as an integrated software tier-1 supplier. Brands are still in the dominant position when it comes to the point of making decisions.

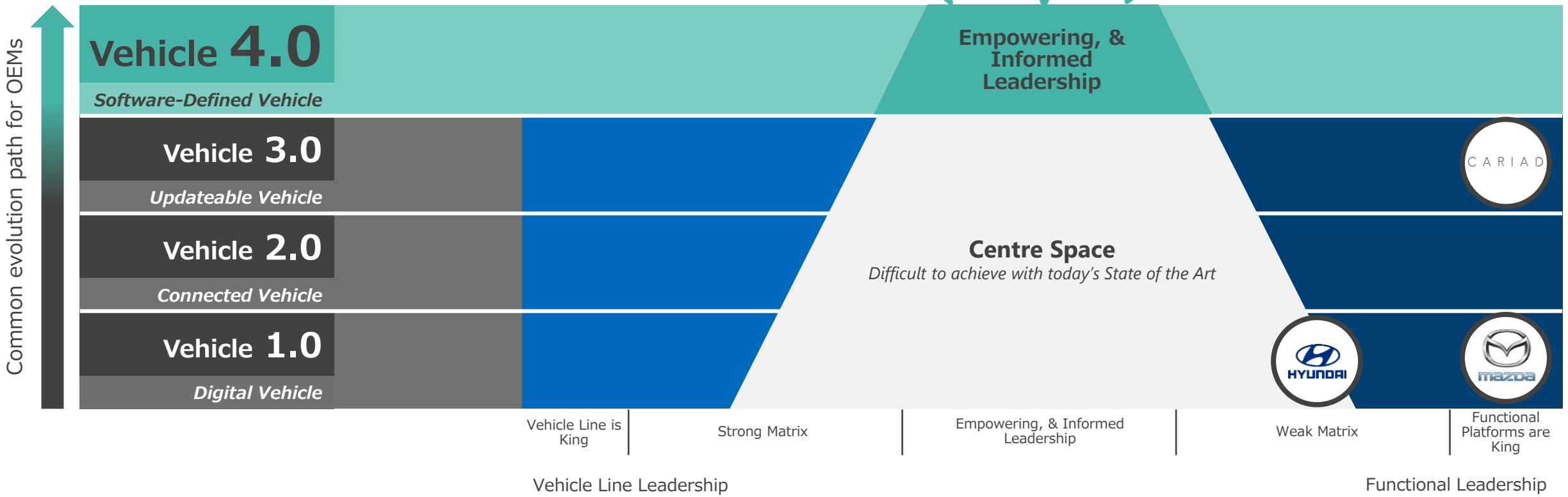
Empowering to reset processes and make silos work

Who owns the purse strings? OEMs yoyo between the vehicle line teams making the decisions in a cross-carline design and vehicle lines owning the budget and decision to allow more specific solutions for models. The future needs to look more flexible for both stakeholders.

Pace & Agility
Empowering leadership allows experts to break open established ways of doing things to improve pace, such as established gateway timings being heavily impacted by the need for two winter tests on two generations of prototypes. Digital twins and other simulations can press reset here.

New Experiences
End-to-end experiences rely upon stakeholders who know and impact the big picture and can work across the elements of the experience. Similarly, leaders understand this big picture and can champion an end-to-end experience rather than certain stakeholders working on their piece independently.

Simplifying Complexity
Silos are not necessarily wrong in a large company if they are empowered to deliver clear interfaces and have a relational interaction with the other Silos. The alternative risk is that increasingly more axes are added to the matrix organization with complex decision-making.



Power to the engineers – allow them to do what they do best

Common evolution path for OEMs

		OEMs
Vehicle 4.0 *Software-Defined Vehicle*	**People**	• Empowered feature leads • Subject matter experts as feature lead • Feature sales team • Clear 'lowest complexity' owners
	Finance	• Move away from the classic "per vehicle sold" • Move towards "per feature sold"
	Process	• Integration centric process • Prioritization methods that can manage both existing products and launching ones • Product Planning must have broader input and alignment.
Vehicle 2.0 to Vehicle 3.0	**People**	• Feature teams • Flat(ter) hierarchy
	Finance	• Account hardware for future features
	Process	• Vehicle and platform agnostic processes • Defined interfaces with strict change control

Rethink the revenue model

Description	Enablers	Steps for OEMs	Steps for Partners	Pace & Agility	New Experiences	Owning Own IP	Simplifying Complexity	Revenue Flexibility
Quick and dynamic feature improvements cannot be going through x levels of approval	Feature leads in power	Allow, empower and motivate feature owners to make the calls		●				
Vehicle platforms architected to grow features over time	Lifetime product vision rather than SoP portfolio	Design new budget and revenue model		●			●	●
Software can serve most / all platforms without modification	Common software base	Define software base with modular add-on concept	Opportunity to deliver add-on modules	●			●	

SBD Insight

Commoditization of electro-mechanical components will allow interchanging between models based on specific needs, and modular software tailoring will allow specific experiences.

Such experiences will require the true balancing of very different aspects of the vehicle through relationship. The choice of charging network and battery size have a direct inter-play on a common experience but in all but the smallest start-ups engineers would not even know the names of the relevant people to talk to.

External Perspective

> In my view, the challenge here is to get our head around the fact that the vehicle is never really finished ! In effect you could argue that with SDVs that vehicles are all only a few hours 'old', with new functionality software being released into production as frequently as the organization can deliver. This is the paradigm shift we have to get our heads around, and does our traditional product launch teams and vehicle platform owners support this level of agility and understanding of how individual customers are engaging with their products across all their markets.

Jason Craker - ChangeMaker

The Sales & Service Paradigm

Huge transformation amongst emerging OEMs

Sales & service are conducted through
Third Parties
established in the market

Centre Space
Difficult to achieve with today's State of the Art

Sales & service are conducted
Without Dealers
being required in the market

A car dealership is a business that specializes in selling new or used vehicles to customers. It serves as a retail location where customers can browse, test drive, and purchase vehicles. Car dealerships often offer additional services such as vehicle financing, trade-ins, maintenance, and repairs.

"The dealer is the trusted connection to the end customer

Advantages	Challenges
Risk-sharing	Costs added
Long-term customer relationship	Real Estate needed
Sales and service bundle	Large inventories parked
Visual presence	Aging cars on the dealer lot
Inventory outsourced	Need to educate dealers about features
Personal interaction	OEM has no quality control of the services provided

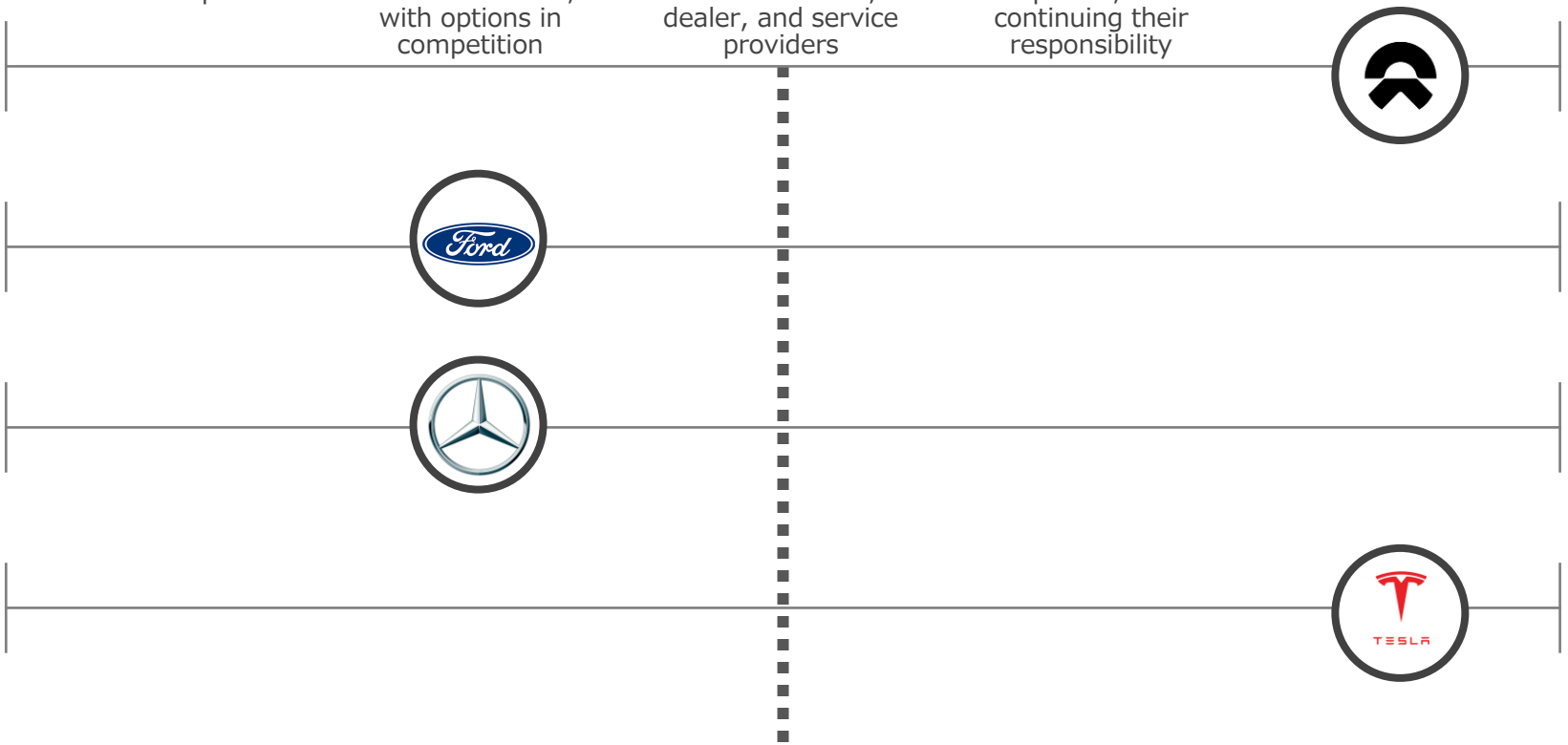
Car sales direct to consumers, also known as direct-to-consumer car sales, involve selling vehicles directly to customers without the traditional involvement of a dealership. In this model, automakers or online platforms act as the sellers, allowing customers to purchase vehicles directly from them.

"Dealers are a relic of a past before the internet

Advantages	Challenges
Lower sales cost	Loosing older target groups
Capture, own, & use data to build customer relationships	US law prohibiting direct-to-consumer in some states
Connection with a younger target group	No personal consultations
Direct customer data from configurators	Hard to upsale
Transparent pricing	No test drives as sales argument
Not bound to opening hours	Financing and trade-in challenges

Customer experience of Sales & Service moving to the OEM

Fixed dealership	Hybrid offering	Transformed service & sales model	Outsourced service	Direct management channel
All the services and sales are through traditional dealerships	Customers choose where to purchase (e.g. online order) and take service, with options in competition	Flexible Customer Relation Management and parts purchases between OEMs, dealer, and service providers	OEMs outsourced some service from its portfolio to 3rd party companies, whilst continuing their responsibility	OEM-operated direct sales and service for customers though in-house channels



Power & Service
Two important value-added services offered and managed directly by NIO. Customers can purchase these service via NIO App directly, including battery swapping, charging van, door-to-door tire service and pick–up etc.

Mobile OEM Units
Ford Explorers are deployed across United States providing local support to customers where Ford own the customer experience and local dealers provide the parts.

Direct Sales Model
The customer can buy new cars from a dealership or online straight from the OEM. No matter where the purchase takes place, there is only one price and negotiations with individual dealers aren't permitted.

Charging Network
Supercharger service is now a significant part of Tesla Energy, but its original launch, and still driving its KPIs, is as a sales incentive to Tesla owners. Customer interactions priorities the car, app and website.

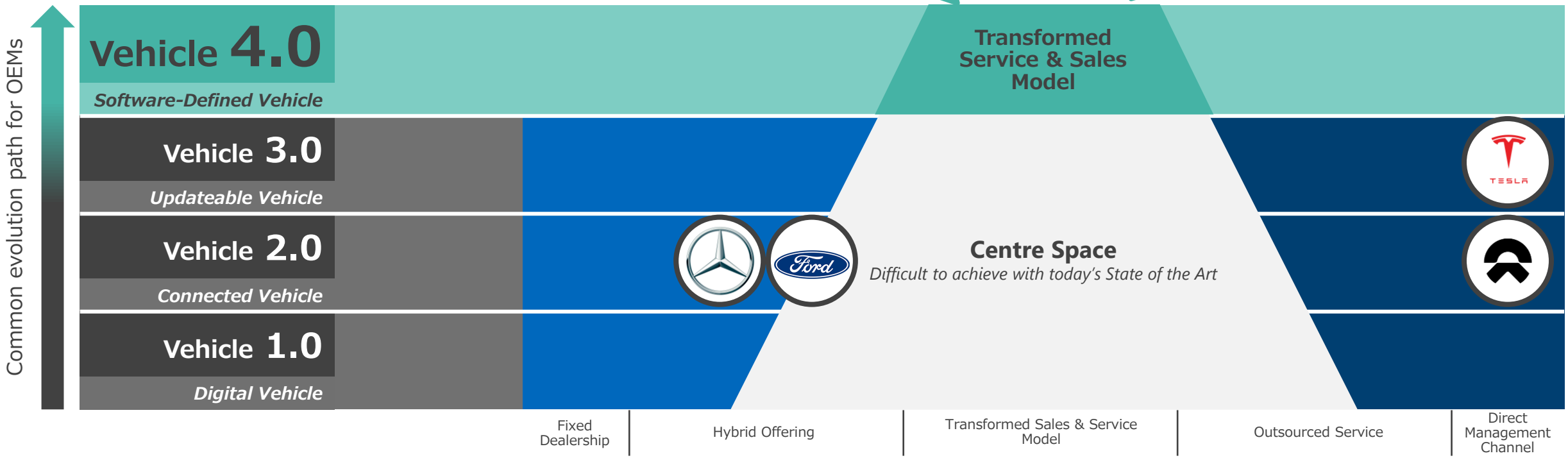
Debate over how dealer service will change, but it will change...

The long terms trajectory of established service and dealership networks seems uncertain but with little doubt of whether it will change significantly. A seamless centralized CRM is required to allow for the flexible revenue streams, and reduced complexity of the ecosystem. This seamless CRM could be hosted and owned in a variety of ways but must serve the customer, the OEM, a local presence and fleet/lease companies.

Legislative drivers are likely to impact this paradigm as some governments try to protect the existing ecosystem.

Simplifying Complexity
With remote diagnostics and through digital twin simulation and prognostics, the primary local task becomes parts and maintenance.

Revenue Flexibility
Lifetime revenue streams require ongoing interaction with the customer that is relational rather than transactional. There will need to be clear ownership of which parts of the ecosystem can engage with the customer, in what ways.



Take advantage of the full integration an SDV can offer

Common evolution path for OEMs

		OEMs	Partners
Vehicle 4.0 *Software-Defined Vehicle*	**People**	• Feature owners delivering instructions, guided troubleshooting, etc. • Online sales interface	• Independent service tools
	Finance	• Just-in-time production	• SDV allows much more ways of vehicle interaction
	Process	• Complete integration of maintenance, service and repair into the SDV ecosystem	• Secure interaction needs to be defined
Vehicle 2.0 to Vehicle 3.0	**People**	• Real-time collaboration between R&D and service	• Service employees need to upgrade skills towards software upgrade features, both in sales techniques as well as in actual technology
	Finance	• Harvest additional revenue from dealer initiated upsales	• Selling after the initial sale
	Process	• Systematic inclusion of the service organization into the R&D organization	• Get involved in the new feature rollout process, be ahead of the game

Take the best of two worlds to create one

Description	Enablers	Steps for OEMs	Steps for Partners	Pace & Agility	New Experiences	Owning Own IP	Simplifying Complexity	Revenue Flexibility
Bring existing dealer network, service and OEMs closer together	Common communication system accessible to all involved parties	Define ONE lightweight communication system	Rollout support and training	●		●		●
Customers need to be educated about upsale options later during ownership	Ongoing dialogue with the customer	Define a channel (mobile app, forum, events, etc.)	Keep dialog going		●			●
Learn from service	Feedback loop from the frontline workers into R&D	Define ONE lightweight communication system	Compile info from customers and communicate to R&D		●			

SBD Insight

There are shifts in the legislative landscape which will drive non-solution neutral results here. Established OEMs have something that would take a long time for start-ups to build, but it comes with significant burdens.

Established OEM sales teams are traditionally trained to sell products, rather than services, and have a bias towards the physical and drivable aspects of a vehicle – both of which are reducing in many purchaser's priorities. It is not unusual to hear an anecdote of someone explaining a technology to a sales team for example.

The Parts and maintenance 'slice of the pie' is the most uncertain, whereas OEMs are fighting to get the user experience / interface into their ownership. Interestingly in a shared mobility world their may be a second transition as fleet providers seek their slide of the user experience.

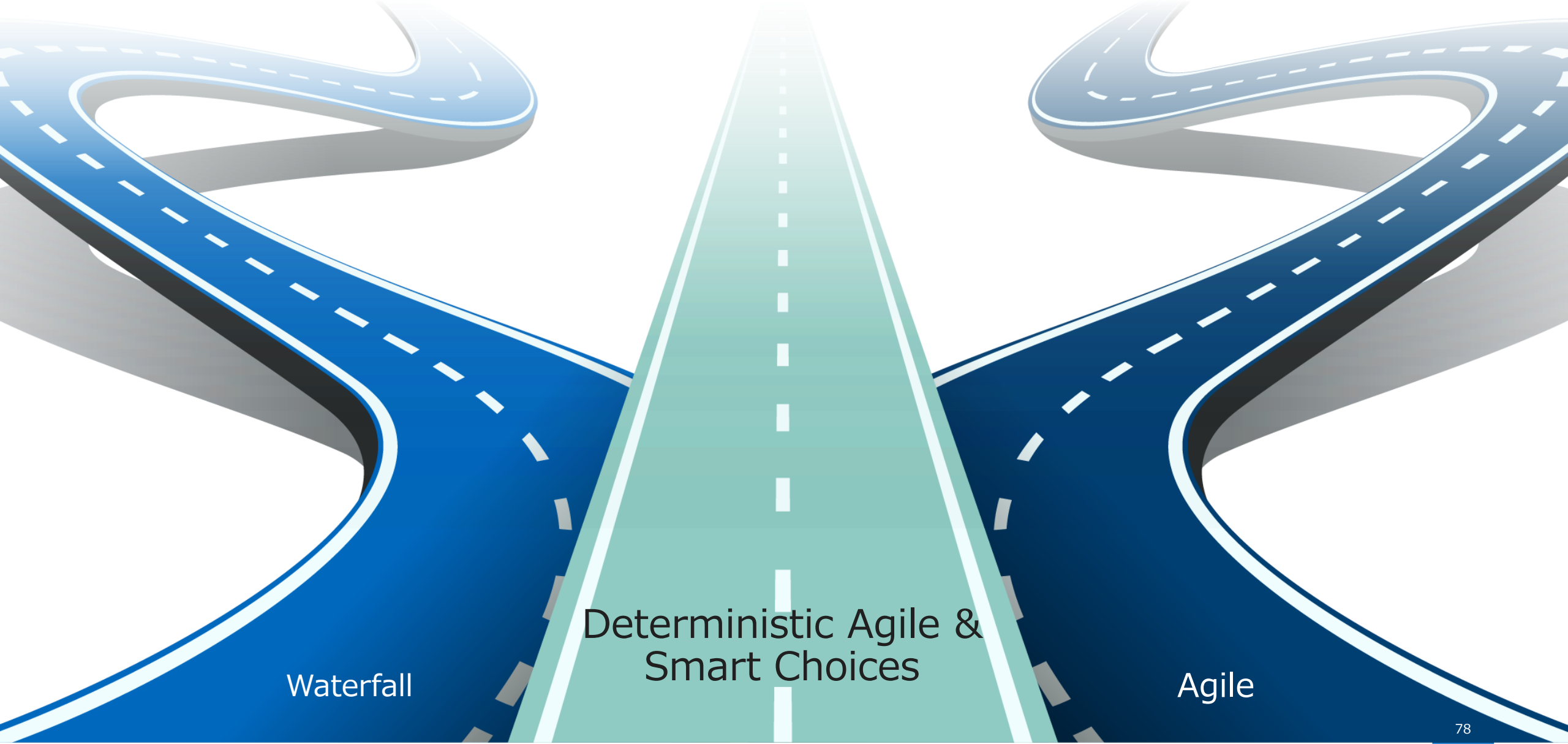
External Perspective

"The digital retail landscape will continue to undergo significant transformation in the next 5-10 years, shaping a new normal. Legacy original equipment manufacturers (OEMs) are poised to establish a "synthetic" direct-to-consumer (D2C) model in North America, while implementing the agency model in Europe. Concurrently, electric vehicle (EV) OEMs are maturing their own D2C models. For legacy OEMs, the creation of new customer journeys becomes a critical focal point as they transition towards a customer-centric approach, which entails establishing numerous touchpoints with customers beyond the initial vehicle sale. A key aspect of this transition involves crafting new and tailored value propositions that enhance revenue flexibility and facilitate revenue and cost sharing among various stakeholders, including OEMs, dealers, technology providers, and other third parties involved in delivering these services to customers. The adoption of the D2C model also necessitates the reskilling of existing resources or the recruitment of new, specialized talent within OEMs, suppliers, and dealerships.

Himanshu Khandelwal - AlixPartners

Paradigms relating to ***How*** *to deliver?*

The Development Mindset Paradigm



Two completely different mindsets from different industries

Systems engineering driven by
Waterfall
requirements, often using the Systems-V

Centre Space
Difficult to achieve with today's State of the Art

Sprints are used as part of an
Agile
delivery process

Waterfall software development is a linear and sequential approach where each phase of the development process (requirements gathering, design, development, testing, deployment) is completed before moving on to the next.

> We don't do Agile, but when we do it's Waterfall!

Advantages

- Clear structure
- Upfront planning
- Strong Documentation
- Ease of management
- Industrial accuracy

Challenges

- Limited flexibility
- Late feedback and testing
- Lack of customer involvement
- Difficulty in managing uncertainties
- Longer time to deliver value
- Limited collaboration

Agile software development is an iterative and flexible approach that emphasizes collaboration, adaptability, and delivering working software in short iterations or sprints. It promotes continuous feedback, allows for changes and adjustments throughout the development process to ensure the final product meets their evolving needs.

> Ready to ship anytime!

Advantages

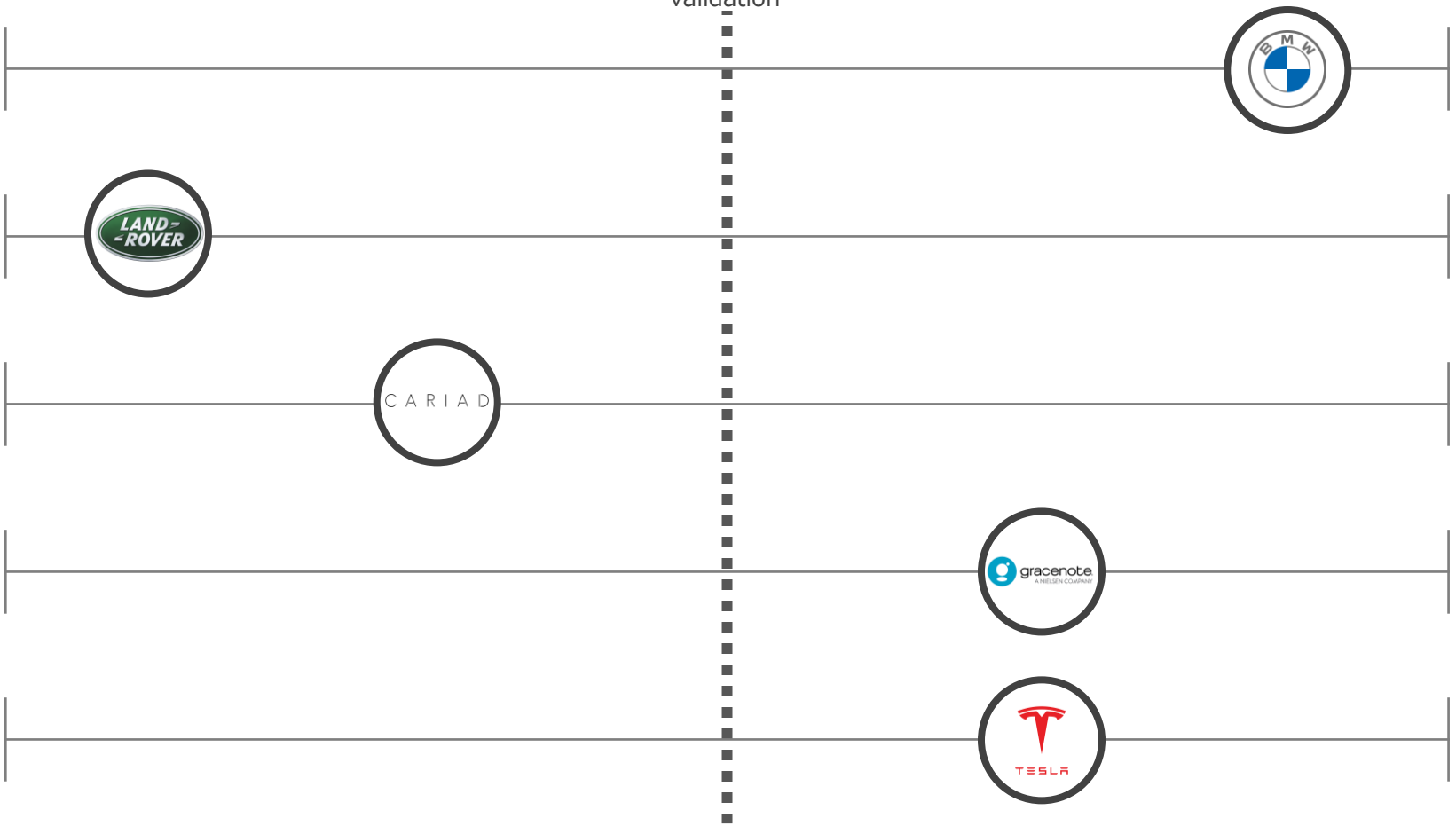
- Flexibility and Adaptability
- Faster Time to Market
- Continuous Feedback and Improvement
- Enhanced Collaboration and Communication
- Risk Mitigation
- Transparency and Visibility

Challenges

- Lack of Predictability
- Managing Scope Creep
- Balancing Priorities
- Technical Debt
- Dependency on Team Collaboration
- Need for Skilled Agile Practitioners

Automotive and IoT methods have to come together

Classic Waterfall	Communicating Waterfall	Deterministic Agile & Smart Choices	Automotive Agile	IoT Agile
Sequential Workflow with limited to no communication loop	Sequential Workflow with iterations and feedback loop	Lean, fast, and safe automotive development and validation	Large org lean, agile and dev-ops techniques	Classic agile as it is used in non-embedded apps



In vehicle infotainment updates
Upgrade Navigation, Streaming services, Display UI and UX, Voice controls, Alexa, etc.

Plug-in Hardware
Pivi infotainment includes a removable hardware with key chipsets delivered with reduced interface complexity with the rest of vehicle. No revenue opportunity hardware update has been announced and feels unlikely.

Vehicle Operating System development
Many stakeholders in the loop, development executed based on initial requirement set, refinement over several iterations

Audio meta data database
Music Recognition, Music Metadata, Video Metadata, Content Recommendation

Vehicle package OTAs
Over the air update of embedded controller firmware and UI software with full vehicle UX modification. Mechanical components initially using prototype manufacturing processes to shorten lifecycle.

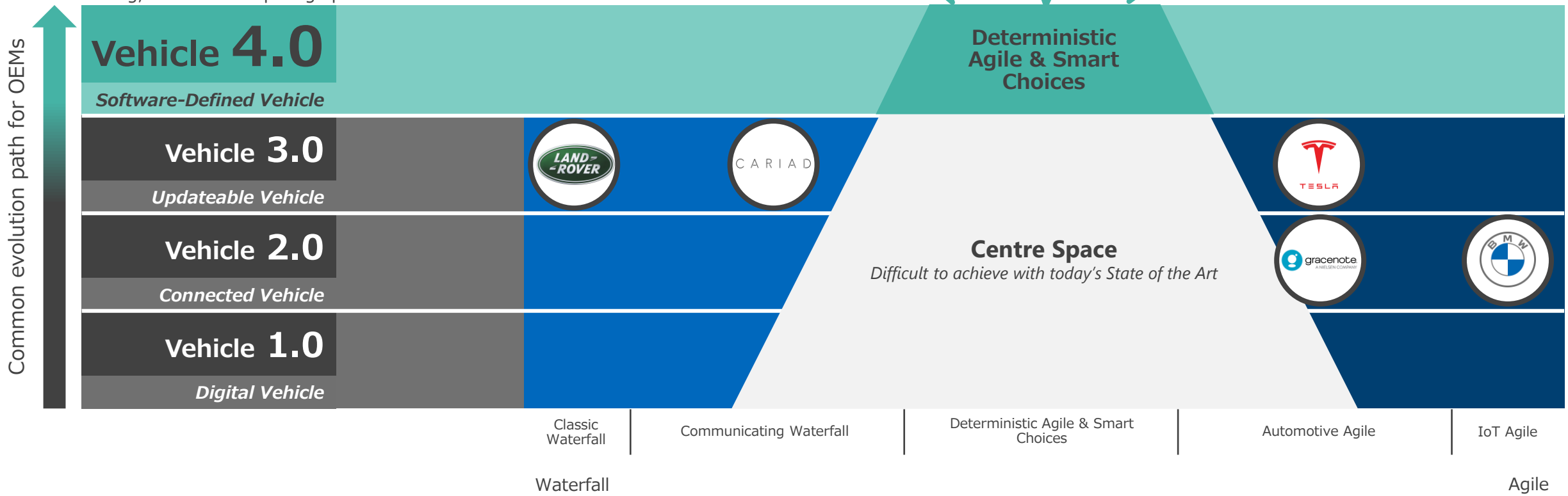
Agile needs evolving to include some key deterministic aspects

Practitioners on either end of the spectrum become frustrated. Mechanical components have long lead times and fewer iterations. The software has short lead times with many iterations. This friction when they collide has the opportunity to merge thanks to the commoditization trends of electro-mechanical components, meaning the hardware and software interfaces can increasingly be decoupled until mechanical and electromechanical development can have more deterministic deliveries with basic or 'vanilla flavor' software builds that are updated later. This is how most smart electronics components are now delivered, with key features working, but others requiring updates.

Pace & Agility
A decoupling of electro-mechanical delivery and software delivery alignment for vehicle launch unless absolutely necessary. This feeds through all departments including marketing choice of messaging at launch. This way longer lead time changes can be optimized and rapid iterative changes don't derail.

Owning Own IP
The modular and flexible nature of the lifetime product releases possibilities for migration of differentiating IP into OEM ownership.

Simplifying Complexity
Significantly reducing physical component complexity, reducing interplays and reliance between features/components, and processes and configuration management which can handle 'infinite' complexity in the real world.



Consider software as an ongoing fix cost item in your budget

Common evolution path for OEMs

		OEMs	Partners
Vehicle 4.0 *Software-Defined Vehicle*	**People**	• Split into backend (integration) and frontend (features)	• App teams
	Finance	• Software development as a fix cost budget item • OTA recall management	• Selling containerized features / apps
	Process	• Modularization of Software as a product • Finance and legal teams etc. feed in at the beginning, not a 'hoop' at the end.	• Containerized software deliveries
Vehicle 2.0 to Vehicle 3.0	**People**	• Feature teams • End to end (req to service) responsibility	• Feature experts rather than customer experts
	Finance	• Software cost spread over all models • Predictive maintenance	• Modular building blocks with re-use for different customers
	Process	• Continuous Integration • Agile • Ticket based development	• Integration into OEM systems

Speeding up software delivery requires new skillsets

Description	Enablers	Steps for OEMs	Steps for Partners	Pace & Agility	New Experiences	Owning Own IP	Simplifying Complexity	Revenue Flexibility
Reaction to unforeseen issues	Modular Software Continuous Integration and Validation	Change SW architecture to modular Integrate validation into CI	Tools, toolchains, APIs, integrations	●			●	
Switch to agile while maintaining deterministic approach	Skills Mindset Tools and Processes	Adjust hiring strategy Train employees Lead by example	Tools Moderators	●			●	
Fast solution Cybersecurity incidents	Cyber security management system + All of the above – CI/CD and OTA	Follow UNECE WP.29 R155 (mandatory)	Follow UNECE WP.29 R155 (mandatory)	●			●	

SBD Insight

It does not go un-noticed that deterministic agile is a contradiction in many ways. It is controversial to say that automotive agile cannot be deployed for whole vehicle development, but to believe agile can provide the benefits of waterfall feels naive. Traditional ways of working must evolve, but we must not 'throw the baby out with the bath water' and loose the robustness and safety of deterministic approaches. With autonomy, majority users will expect an aerospace safety level to relinquish the self responsibility.

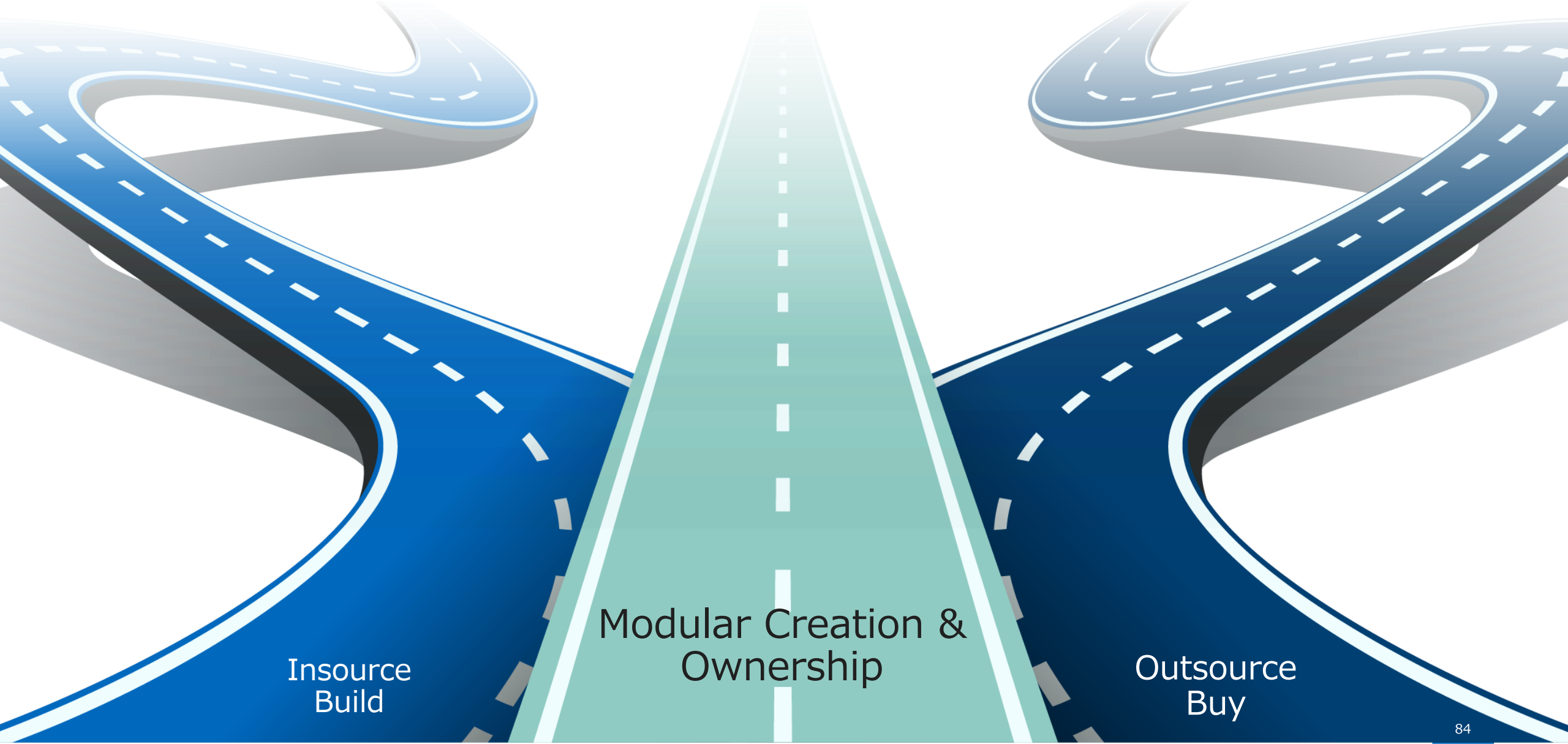
Today steps are being taken to cunningly avoid interfaces, and this can be wise. Removing switch gear for screen content moves functionality into software, but electro-mechanical interfaces will remain. As Digital Twin and commoditization of electro-mechanical parts trends move forwards together a new decoupled process with a sprint nature but specific robust / immovable milestones will emerge.

External Perspective

"The vehicle development processes are poised to undergo significant changes in the coming years as OEMs strive to advance along the SDV maturity curve. Incumbents will be required to shift from the traditional, rigid, and rigorous "V-model" to a more hybrid and adaptable approach as the they integrate the software/cloud-based agile development philosophies into the vehicle development and launch processes. To establish a well-coordinated integrated product development process, the boundaries of the current organizational structure and decision-making will need to be shattered. The product manager will assume ownership of both hardware (HW) and software (SW), with the bill of materials (BOM) encompassing both HW and SW components. Furthermore, OEMs must establish a more robust continuous development and release processes. The SW development factory, particularly for over-the-air (OTA) updates and post SOP features, should drive the transformation of the engineering release process to achieve faster cycle times and expedited delivery.

Shea Burns - AlixPartners

The Build or Buy Paradigm



Modular creation & ownership for both high- and low-level SW

Work is insourced by the OEM and
Build
by an inhouse team

Centre Space
Difficult to achieve with today's State of the Art

Work is outsourced to
Buy
From a Tier One

OEM decides to deliver and own commodities or software, usually (or in particular) relating to areas of discernment from competitors.

> We're aiming to write 50% of our software

Advantages

- Control and flexibility
- Customization and differentiation
- Enhanced quality control
- Efficient communication and collaboration
- Intellectual property protection

Challenges

- High initial investment
- Low know-how and specialization
- Scalability
- Talent acquisition and retention
- Time and Resource constraints
- Cost of validation

Purchasing teams are actively involved in choosing the best price point for something treated more like a commodity (though commonly still developed for the OEM). OEMs balance piece cost vs development/tooling costs. Development may be paid for by a vehicle line or by a functional platform.

> We're switching our supplier again - and to a different one to our other new model.

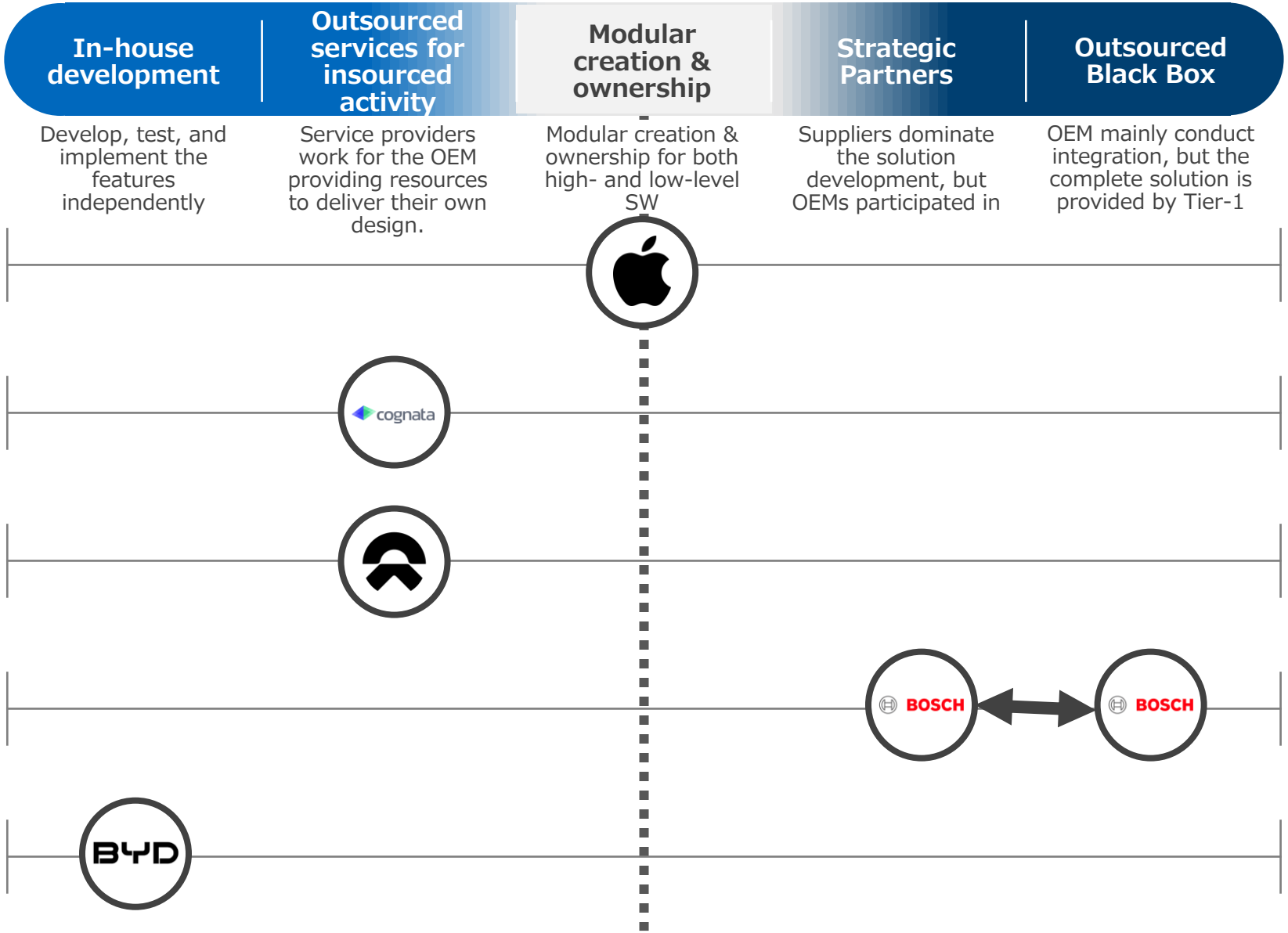
Advantages

- Cost saving
- Accelerated time-to-market
- Scalability and flexibility
- Increased focus on core competencies
- Access to specialized expertise
- Multiple buyers reduce cost

Challenges

- Limited authority
- Low feature differentiation
- Communication and cooperation
- Dependency on external suppliers
- Security and confidentiality Risk
- Integration problems

A wide range of the spectrum is seeing innovation today (1/2)



Third-Party Self-Integration
Apple performs only minimal tests of the key interfaces in the cloud after the apps (or CarPlay functionality within apps) are verified by the third-party developers.

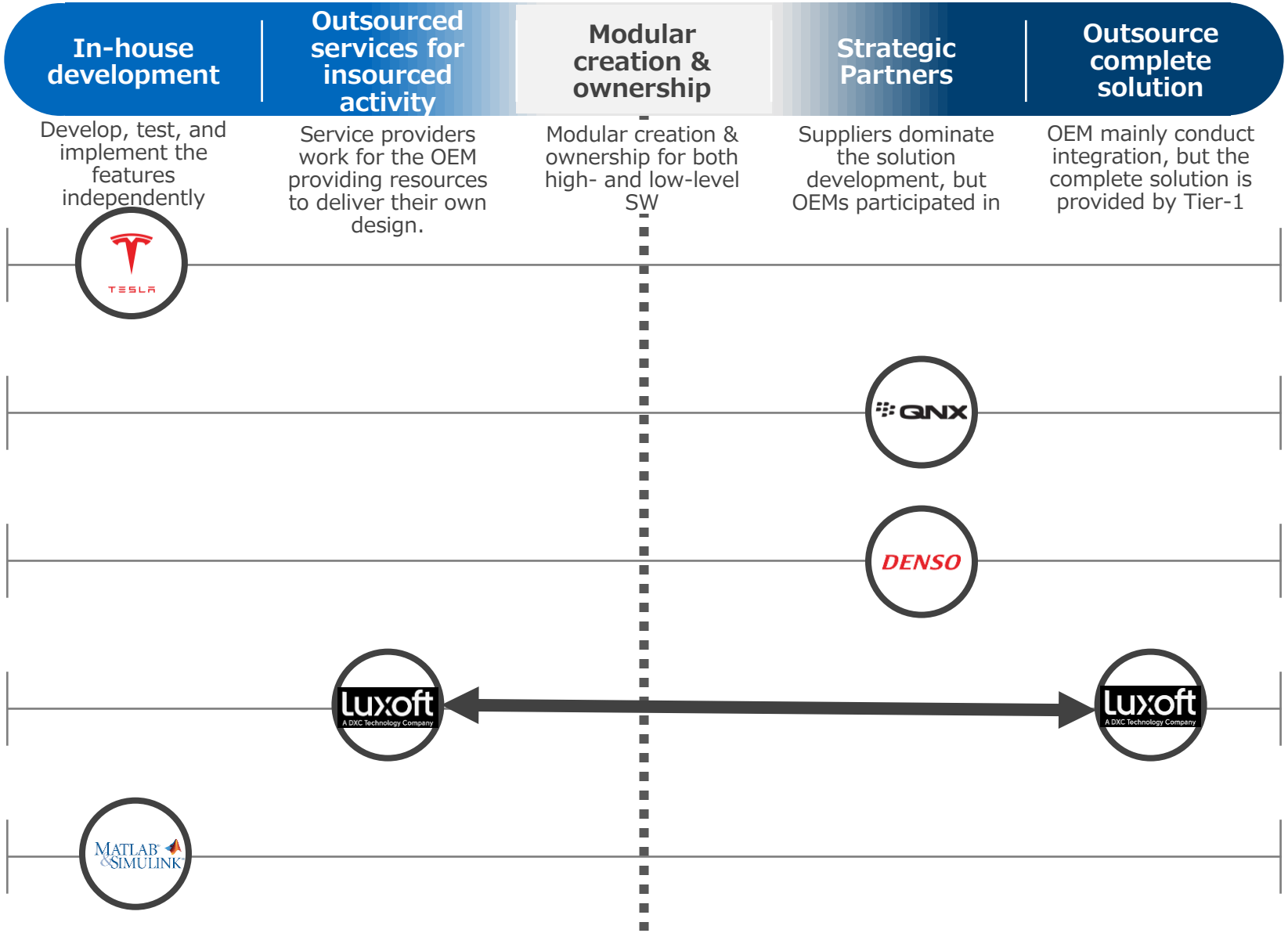
Vehicle Virtual Testing
Audi outsourced its SIL testing to Israel's autonomous vehicle simulation startup Cognata, but the key development is conducted in-house. This is example is also across VW with verification commonly outsourced.

NIO NOP
NIO launched its NOP (Navigate on Pilot), supporting L2+ ADAS features in Highway. Decision-making, route planning, control, and simulation are developed in-house, while a part of perception-related tasks are outsourced.

ADAS / Autonomous Outsourcing
Some OEMs outsourced its ADAS/AD solutions completely to Bosch, where Bosch provide a complete SW+HW solution and sometimes is "black box" to OEMs that OEMs have limited access to customize/tune the feature.

BYD Battery Layout
BYD has established a complete industrial chain layout in the field of batteries, from battery manufacturing, battery material mining, battery recycling to battery management tool.

A wide range of the spectrum is seeing innovation today (2/2)



Own Chipsets & Supply Pivoting
Tesla is developing its own chipsets for the Autopilot commodity on their EE architecture. Tesla was also able to pivot their chip sourcing during the silicon supply disruption thanks to decoupled hardware.

Whole Vehicle Software Licenses
Rather than individually sources commodities, QNX offer OEMs direct sourcing of their middleware OS on a whole vehicle license basis.

Strategic Partnership
Toyota has strategic partnerships with Denso and Nexty to deliver their electrical systems.

Varying Roles
Luxoft acted as a developer tier one for MBUX but a service provider to CARIAD where CARIAD remained owners, with Luxoft providing services. This interesting helps CARIAD in their ambition to license to other OEMs.

In-house through Auto-coding
Although increasing software size, auto-coding from Simulink models allows OEMs to outsource (or centralize) chassis system hosting hardware and generate their own software without traditional software houses.

Plug and Play Modularity

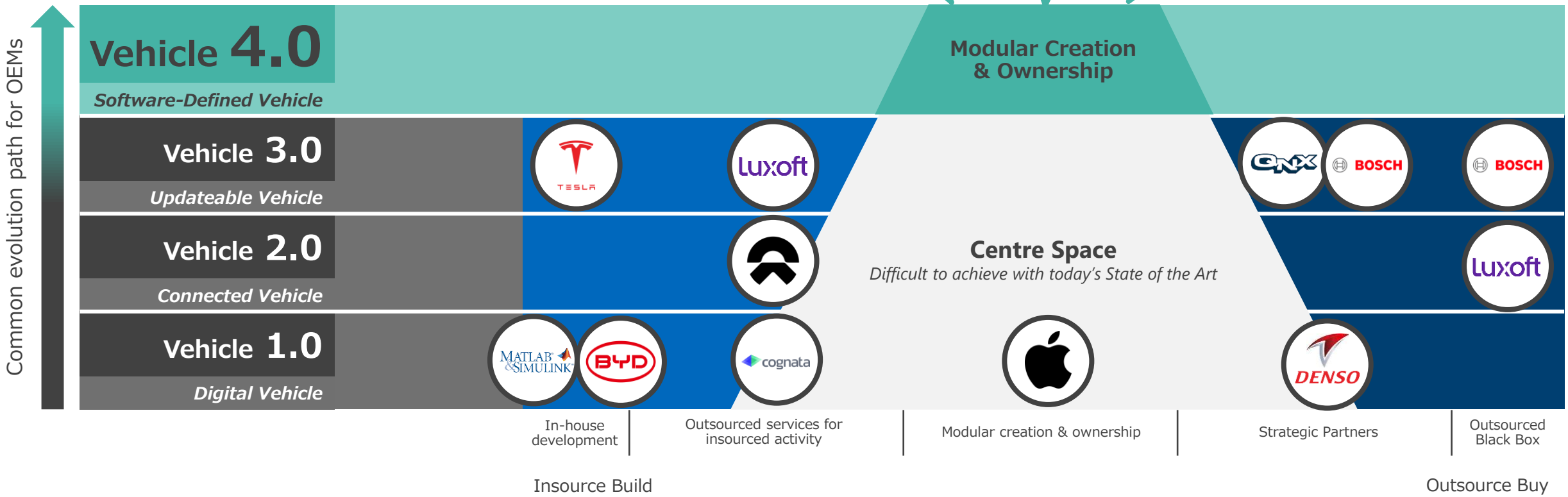
Moving away from the homogenous hardware / software component allows flexibility and pivoting of strategies over time to best offer the value and experiences desired.

Pace & Agility
True plug and play commodities and software allows far faster development times and a longer-term agility - relying on quality history of the wider 'pool' of users.

New Experiences
Defining the interfaces so letting the experts develop the parts of the system that offer the value without bundling into wider commodities.

For example, if a supplier has the best DAB tuner software, then opens sourcing to them rather than being whole cockpit partner.

Owning Own IP
OEMs select the IP they wish to win and rather than amortizing the development costs of outsourcing, move to usage-based licenses, with the ability to migrate over time to in-house.



Find new way to collaborate

Common evolution path for OEMs

		OEMs	Partners
Vehicle 4.0 *Software-Defined Vehicle*	**People**	• Feature owners and base SW architects	• Independent high-level SW development
	Finance	• Subscriptions to the customer • Pay per use services to the customer	• Licensing software to the OEMs
	Process	• Clearly defined interfaces • Strict change control • Automated integration regression testing • Priority rather than unit sales (finances are limited.	• Offering customizable software (similar to Android for Samsung phones for example) aka toolkits / SDK
Vehicle 2.0 to Vehicle 3.0	**People**	• Integration experts	• Toolchain experts
	Finance	• Separate contracts • Platform not series • Core funding • Separate contract for hardware and software even if in a single sourced item, to allow different lifecycles	• Subscriptions to the OEM • Pay per use services to the OEM
	Process	• Platform not series. • Continuous integration testing to avoid big bang	• Continuous delivery and integration into the OEM's CI system

Suppliers do HW and low level, OEMs do high level

Description	Enablers	Steps for OEMs	Steps for Partners	Pace & Agility	New Experiences	Owning Own IP	Simplifying Complexity	Revenue Flexibility
For OEMs to take on high level SW development they need to add skills	Software skills	Hire software engineers	Provide software resources			●		
A new collaboration standard between OEM and suppliers is needed	Collaboration model	Claim high level SW and define collaboration	Claim low level SW and define collaboration	●		●	●	
High level software independent of low-level software	Middleware abstraction layer	Define abstraction layer and communicate interfaces	Develop low level SW against abstraction layer			●	●	

SBD Insight

Luxoft, for example, will support a software house such as CARIAD with CARIAD owning the IP and experience, to brand specifications, but they have also delivered the consumer experience of the MBUX cockpit. There are many options for how software can be made modular and how different organizations can partner to deliver, but it seems unlikely that such an outsourced user experience will remain common-place, with OEMs recognizing this is a key differentiating module.

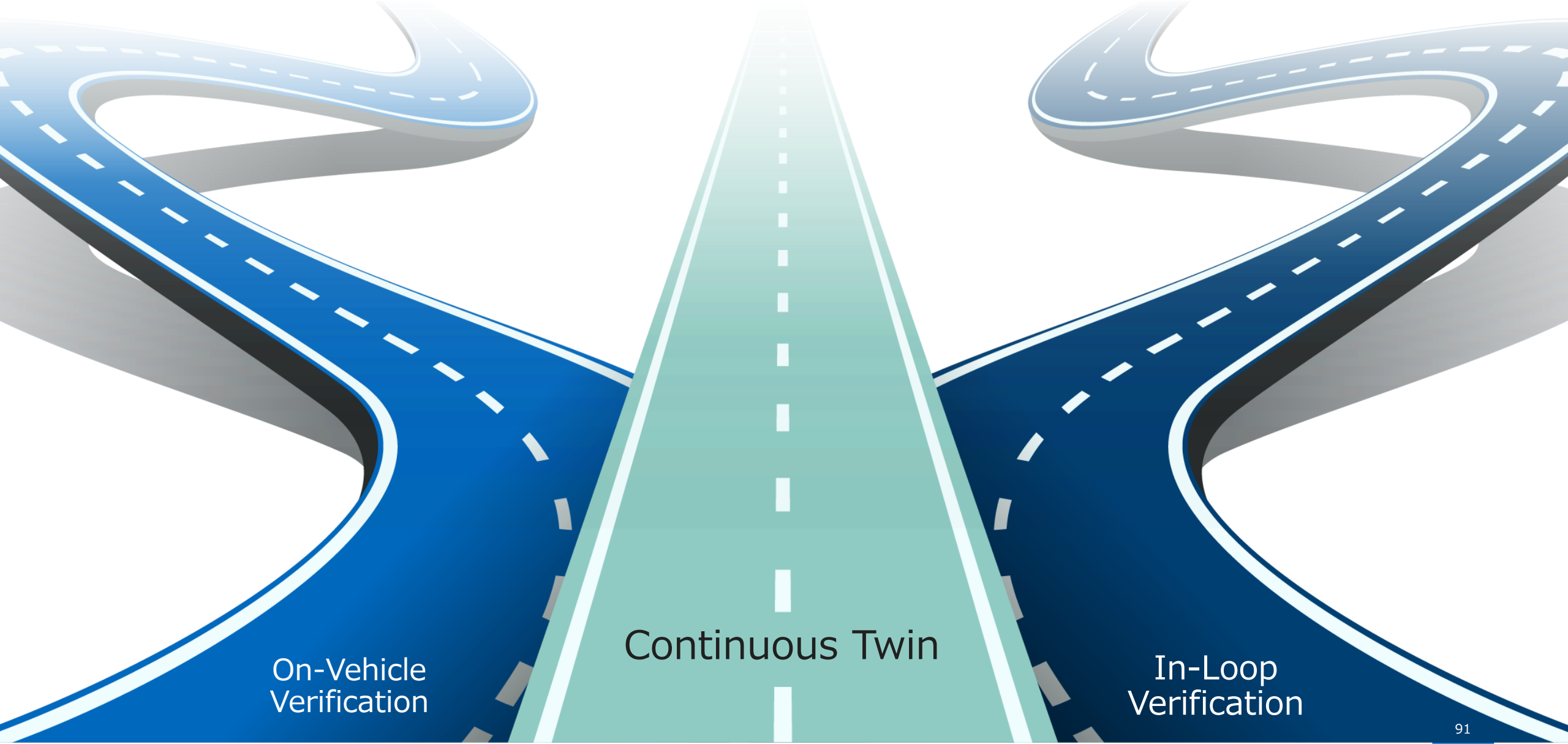
This applies until mobility service providers may start to desire their own user experience at which point such providers may again wish to have service partners for the development.

External Perspective

"We see a positive recent trend from traditional OEM's setting up innovation hubs, venture capitalist investment arms, and forming strong relationships with start-up incubators and accelerators programs, all with a desire to identify key often technology led differentiators to help their brand stand out in the market-place. This trend is a real positive trend, however I do still query, where does the commercial business development capability and capacity sit to help drive these partnerships and relationships without these trying to be commoditised by global purchasing teams.

Jason Craker - ChangeMaker

The Verification Asset Paradigm



Tough to confidently rule out the need for vehicle testing

Verification is conducted through use of
In-Vehicle
testing

Centre Space
Difficult to achieve with today's State of the Art

Verification via
In-the-Loop
testing using simulation and/or a rig

In-vehicle testing involves evaluating the performance, functionality, and safety of automotive systems and components in real-world driving conditions.

"A good test driver cannot be replaced by anything

Advantages

- Real-world environment
- Interaction with the physical vehicle
- Accurate perception of the environment
- Validation of system integration
- Human factors evaluation
- Customer acceptance and feedback

Challenges

- Cost and resource constraints
- Safety considerations
- Limited repeatability and control
- Scale and coverage limitations
- Data collection and analysis
- Test reproducibility and documentation

In-the-loop testing is a method used to evaluate and validate automotive systems and components within controlled and simulated environments. The most common levels are Hardware-in-the-Loop (HIL), Software-in-the-Loop (SIL) and Vehicle-in-the-Loop (VIL).

"xIL coupled with continuous integration

Advantages

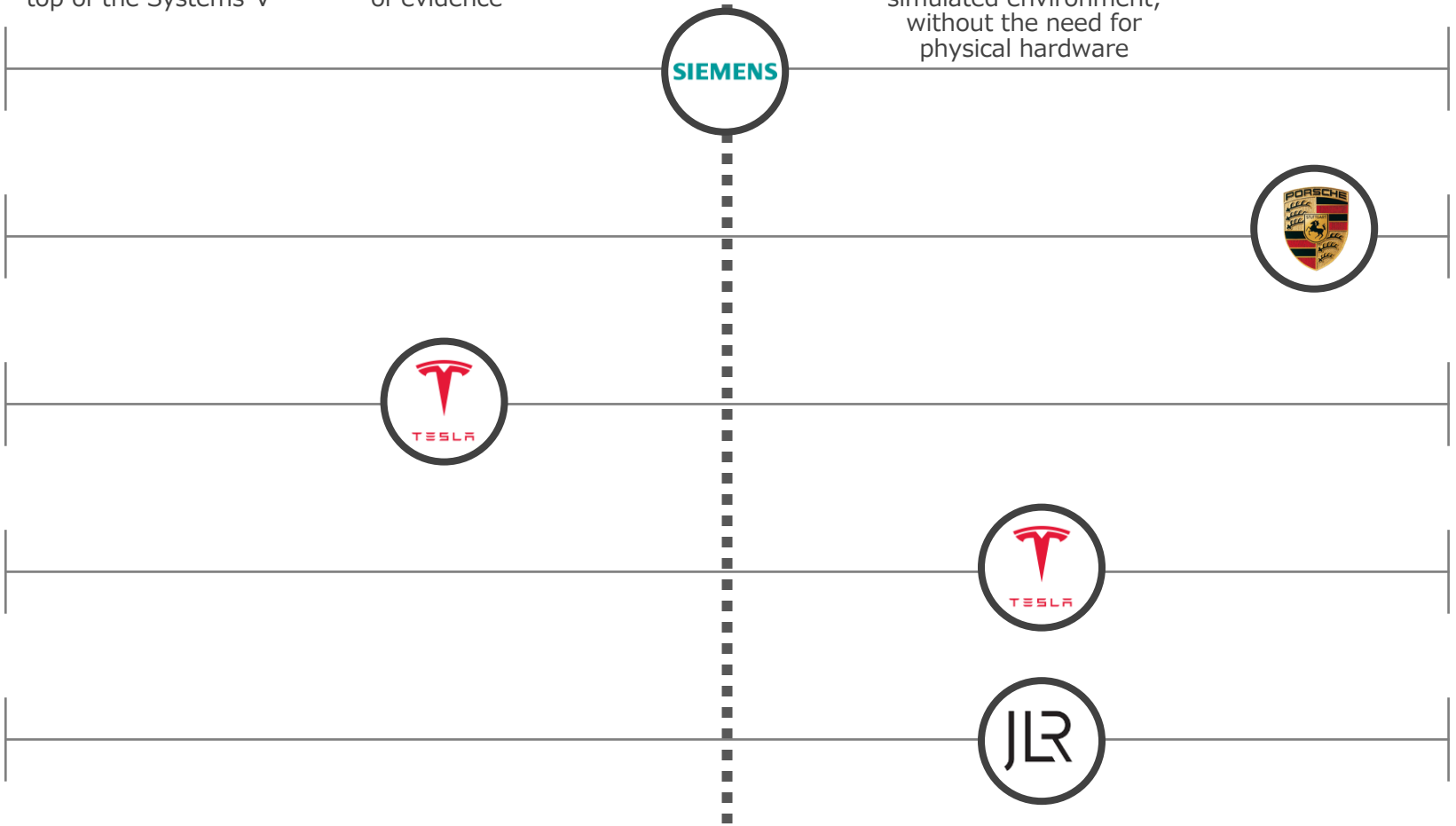
- Cost-effectiveness
- Safety
- Repeatability and reproducibility
- Scalability and coverage
- Accelerated testing cycles
- Controlled evaluation of specific factors

Challenges

- Limited real-world validation
- Sensor and model accuracy
- Validation gaps
- Reduced physical integration testing
- Complexity and setup time
- Validation of human factors

In-the-loop can remove a lot of load from vehicle testing, not all though

Vehicle Test	Data collection-centred vehicle tests	Continuous Twin	Simulation & Software-in-loop	Hardware-in-loop
Testing on vehicles in each configuration is final sign off at the top of the Systems-V	Vehicle's gather data during usage to contribute to a body of evidence	An integrated multi-physics, multi-scale testing method	Running software components or subsystems in a simulated environment, without the need for physical hardware	HIL testing connects real vehicle hardware to a simulated environment



Siemens Digital Twin Vehicle Testing
The digital twin and simulated environment allows CAD modelling, CAE simulation for almost all parts within a vehicle including the vehicle itself. This enables greater reduction of time to market.

Vehicle Dynamics
Simulators have been used for chassis and dynamics systems for well over a decade as part of the development process.

Shadow Mode
Tesla's shadow mode is used to filter those valuable test samples from numerous driving tests data, by contrasting the input difference between algorithms and human driver. It can be also used for perception analysis.

Speeding Up Homologated Lifecycles
The OEM EPA test bench has been certified so that OEM engineers can re-certify latest deliveries 'in-house'.

Separating Homologated/Flexible Lifecycles
JLR's Pivi has an integrated 'always on' modem for infotainment connectivity which is separate and can be changed far more freely that the Telematics and OTA modem which must be eCall homologated.

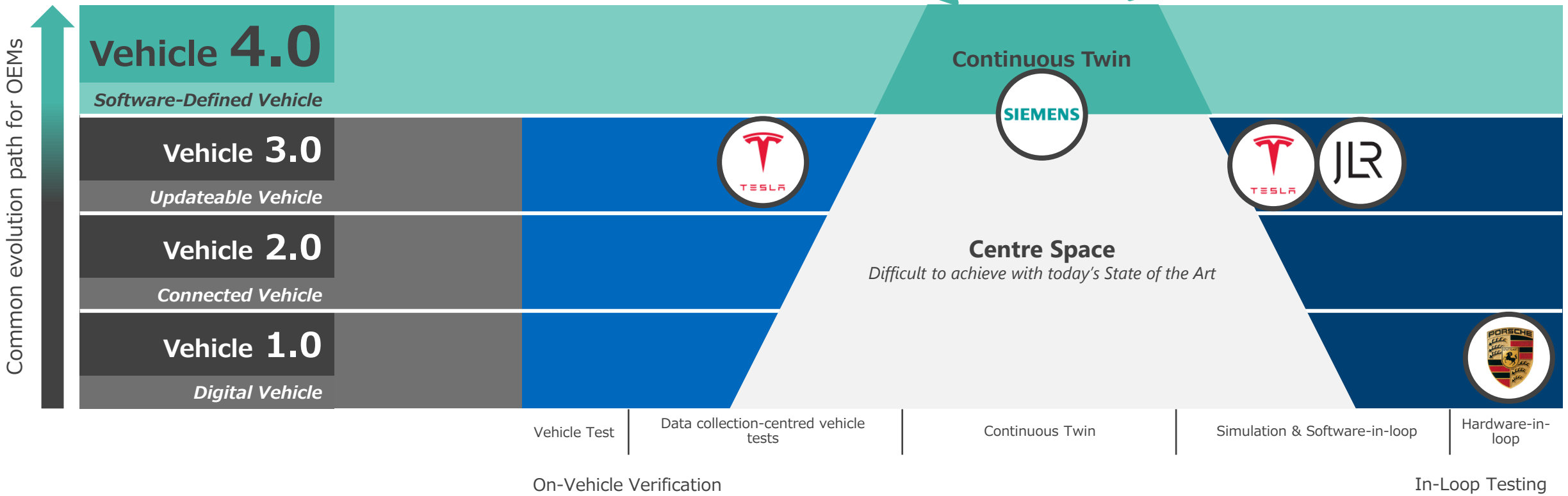
In-the-loop removes significant vehicle testing load, but not all

As hardware and software platforms are increasingly decoupled, testing ad simulation can be compartmentalized with reduced risk, of the rig introducing wrong behaviors.

HIL 'farms' commonly exist today but maintenance of configuration versions rapidly increases as a task, meaning inconsistent versions are tested. Instead of these being used in heavy sprints during sign-off and idling the rest of the time, testing will move to continuous testing, particularly for fully virtualized software able to be simulated in the cloud without hardware.

Pace & Agility
Verification takes around an indicative third of the vehicle program timeline (following Design, and preceding Launch). Decoupling from long mechanical lead times and the need for seasonal testing, combined with continuous statistically based signoff, reduces time to market.

Simplifying Complexity
Interfaces are more deeply understood as decoupling leads to simplification, though care must be taken with increasing configuration management complexity requiring sign off. Off-vehicle, cloud based, continuous verification is really the only long-term way of truly dealing with verifying this complexity.



Full benefit of automation comes with the integration into CI

Common evolution path for OEMs

		OEMs	Partners
Vehicle 4.0 *Software-Defined Vehicle*	**People**	• AI experts	• AI as a service
	Finance	• Options for "infinite" configurations • Homologated test systems rather than homologating product	• Selling data services rather than app SW
	Process	• Immediate test results • Cloud based tests • Realtime feedback • Edge processing	• Test in a simulated OEM environment throughout entire development
Vehicle 2.0 to Vehicle 3.0	**People**	• SW developers in test	• SW developers in test
	Finance	• Budget shift to automation	• XiL as a service
	Process	• Continuous Testing • Data based evaluation • Homologated test systems rather than homologation of product • Organized split between all XiL systems	• Open data communication between OEM and Tiers

Test infrastructure is a product in itself – and must be treated as such

Description	Enablers	Steps for OEMs	Steps for Partners	Pace & Agility	New Experiences	Owning Own IP	Simplifying Complexity	Revenue Flexibility
Automated testing needs to be part of the CI process	Tool integration	Hire tool infrastructure experts	Provide expertise and integrations for CI tools and test systems	●			●	
Organized split between XiL / Integration levels	Open communication between levels	Allow / foster / encourage communication Define single source of truth for test coverage and result reporting	Tool creation and support for coverage and result reporting	●			●	
Push of configuration testing to the lowest possible integration level	Companywide configuration management strategy	Define strategy centrally and make it machine and human readable	CM tools	●			●	●

SBD Insight

Digital twin is a term used to describe many things independently to different people. As software becomes truly decoupled from components then containers can run in the cloud against off-vehicle storage of vehicle configurations (even wheel torque) and real/synthetic data to enable a more robust test.

Edge will allow such software to be deployed to vehicles through, FaaS+ for example, to add significant functionality or deploy an AB test to a small population of vehicles.

This sounds far off, but each of the puzzle pieces offers individual benefit usually justifying their own cost. The issue relates more to ensuring the strategic architecture is in place so that once the enablers are in place the benefits can be realized.

External Perspective

"To adapt to the pace software defined vehicles will require form the R&D teams and to serve customer expectations in quality and quantity of software releases it is essential to grow the testing capabilities in throughput and coverage. In-the-loop test systems are capable to perform a high workload with completely automated preparation, execution and evaluation as part of the software development and release machinery. They must be fully integrated into the CI system and require an end-to-end automation in order to add the maximum value. It is possible to step up and look for ways to have the test systems certified to produce certified software, this is an interesting perspective for the future.

Florian Rohde - iProcess

Risk Appetite is perhaps an over-arching ‘Mega-Paradigm’

We’ve considered nine existing paradigms that will be ‘opened up’ through the shift to Vehicle 4.0. There is perhaps a ‘mega-paradigm’ that cuts across all of the paradigms: Risk Appetite.

Not many people oversee risk appetite in a business, but also, all people are reinforcing a company’s risk appetite in the way they work, meaning it is a very hard thing to change. Many of the steps outlined in this chapter require a shift to be more risk-tolerant. For example, today FaaS strategies are largely an attempt to generate extra revenues. An English expression to say that a vehicle line ‘must wash its own face’ – which means it cannot solely rely on other lines or departments for the company to be profitable. But what about when an OEMs business model begins to rely on lifetime revenues? How should a Point-of-Sale revenue opportunity be compared to a riskier but higher lifetime revenue? Businesses are not new to such problems, but embracing the opportunities will require a greater risk tolerance.

It is possible for an organization to shift its risk tolerance.

- Start-up companies, often begin more risk-tolerant, and then must either work to maintain this or migrate to a more risk-averse company. For example, Netflix is an organization that is very large but began as very risk tolerant compared to Blockbuster Video rental company.
- Some Japanese OEMs have been working to move to a more risk-tolerant profile.
- Volkswagen have embraced the risks in the movement to their software platforms but is seeing an impact on their delivery robustness and quality at this time as a result.
- Volvo was unkeen to risk their brand and hence a ‘spin-off’ company Polestar offers the opportunity to learn lessons with SDVs and then feed learnings back into Volvo.

Option A	Today’s Paradigm	Option B
	Vehicle 4.0 Opportunities	
What to deliver?		
Delivering Commodities & Features	Delivering Experiences	Delivering Services
Commercially Defined Competitive Products	Information to All Innovation from All	Innovative Features through Technologies
Point of Sale	FaaS+	Aftersales
Who will deliver?		
Product Delivery	Lifetime Delivery	Service Operations
Vehicle Line Leadership	Empowering, Informed Leadership	Functional Leadership
Third Party Sales & Service	Transformed Service & Sales Model	Dealerless Sales & Maintenance
How to deliver?		
Waterfall	Deterministic Agile & Smart Choices	Agile
Insource Build	Modular Creation & Ownership	Outsource Buy
On-Vehicle Verification	Continuous Twin	In-Loop Verification

Recommendations

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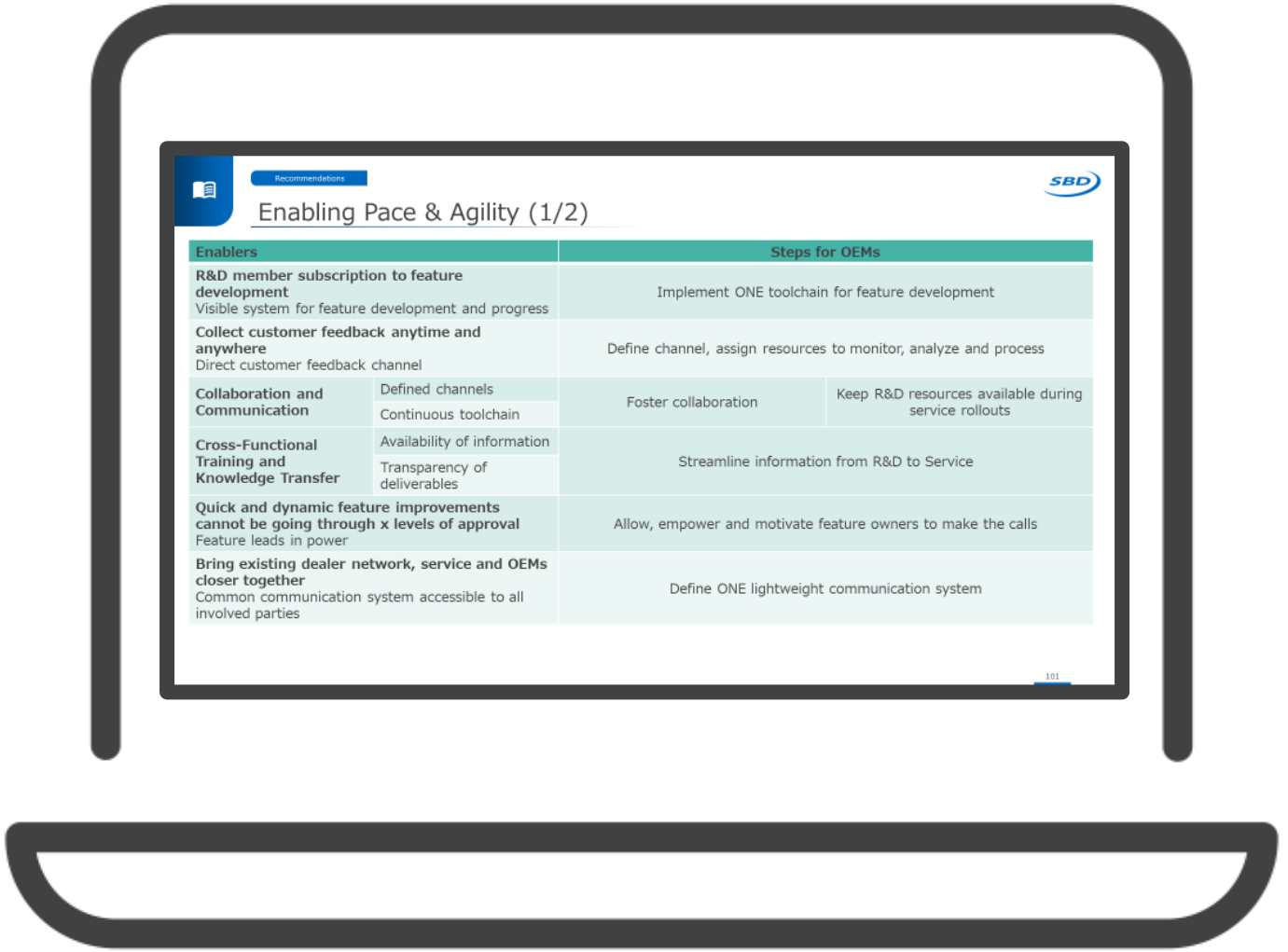
Chapter Introduction

This chapter considers the previously identified enablers and summarizes them against the Software Defined Vehicle Benefit that has the most impact.

Many impact multiple benefits, so the report author has determined a key benefit. Cybersecurity could maybe have been its own benefit, though as cybersecurity is heavily influenced by but not reliant upon SDVs, it has instead been considered as an aspect of simplifying complexity – as reducing, and understanding complexity is a key pillar within cybersecurity.

What benefits do the enablers of this chapter deliver?

- Pace & Agility
- New Experiences
- Owning own IP
- Simplifying Complexity
- Revenue Flexibility



Enabling Pace & Agility (1/2)

Enablers		Steps for OEMs	
R&D member subscription to feature development Visible system for feature development and progress		Implement ONE toolchain for feature development	
Collect customer feedback anytime and anywhere Direct customer feedback channel		Define channel, assign resources to monitor, analyze and process	
Collaboration and Communication	Defined channels	Foster collaboration	Keep R&D resources available during service rollouts
	Continuous toolchain		
Cross-Functional Training and Knowledge Transfer	Availability of information	Streamline information from R&D to Service	
	Transparency of deliverables		
Quick and dynamic feature improvements cannot be going through x levels of approval Feature leads in power		Allow, empower and motivate feature owners to make the calls	
Bring existing dealer network, service and OEMs closer together Common communication system accessible to all involved parties		Define ONE lightweight communication system	

Enabling Pace & Agility (2/2)

<table>
<tr><th colspan="2">Enablers</th><th colspan="3">Steps for OEMs</th><th colspan="2">Steps for Partners</th></tr>
<tr><td rowspan="3">Switch to agile while maintaining deterministic approach</td><td>Skills</td><td rowspan="3">Adjust hiring strategy</td><td rowspan="3">Train employees</td><td rowspan="3">Lead by example</td><td rowspan="3">Tools</td><td rowspan="3">Moderators</td></tr>
<tr><td>Mindset</td></tr>
<tr><td>Tools and Processes</td></tr>
<tr><td colspan="2">Automated testing needs to be part of the CI process
Tool integration</td><td colspan="3">Hire tool infrastructure experts</td><td colspan="2">Provide expertise and integrations for CI tools and test systems</td></tr>
</table>

Enabling New Experiences

Enablers for New Experiences	Steps for OEMs	Steps for Partners
3rd party app integrations Creation of app store	Definition of APIs, rules and validation methods	Creation of apps
Data and Analytics Integration Centrally available data from single vehicles and statistics from fleets	Create fleet database, train and enable all employees to gather information	
Learn from service Feedback loop from the frontline workers into R&D	Define **one** lightweight communication system	Compile info from customers and communicate to R&D

Enabling Owning Own IP

Enablers for Owning Own IP	Steps for OEMs	Steps for Partners
For OEMs to take on high level SW development they need to add skills Software skills	Hire software engineers	Provide software resources
A new collaboration standard between OEM and suppliers is needed Collaboration model	Claim high level SW and define collaboration	Claim low level SW and define collaboration
Gathering information about real world use of the product in real time Fleet data logging	Create edge data logging, data transfer and a data lake	Support new tech like Hadoop, AI
Integrating essential SDV features Data in and out of the car	Develop vehicle data platform	Sell vehicle data platform as a Service

Enabling Simplifying Complexity

Enablers		Steps for OEMs				Steps for Partners
Vehicle configurations must be known at all times	Vehicle data base Manifest	Define format	Create live database	Ensure real time info update	Hire data base engineers	
Software can serve most / all platforms without modification Common software base		Define software base with modular add-on concept				Opportunity to deliver add-on modules
Reaction to unforeseen issues	Modular Software Continuous Integration and Validation	Change SW architecture to modular		Integrate validation into CI		Tools, toolchains, APIs, integrations
Organized split between XiL / Integration levels Open communication between levels		Allow / foster / encourage communication		Define single source of truth for test coverage and result reporting		Tool creation and support for coverage and result reporting
Push of configuration testing to the lowest possible integration level Companywide configuration management strategy		Define strategy centrally and make it machine and human readable				CM tools
Fast solutions to cybersecurity incidents Cyber security management system		Follow UNECE WP.29 R155 (mandatory)				

Enabling Revenue Flexibility

Enablers for Revenue Flexibility		Steps for OEMs	
Vehicle platforms architected to grow features over time Lifetime product vision rather than SoP portfolio		Design new budget and revenue model	
The vehicle needs to be architected to accept FaaS at scale Sufficient Resources		Switch accounting from SoP / initial sales model to vehicle lifetime model	
The software needs to be architected to handle FaaS	Modular SW	Appoint and empower software architect	Rethink software architecture
	Feature switches		
	Stable backbone SW		
Customers need to be educated about upsale options later during ownership Ongoing dialogue with the customer		Define a channel (mobile app, forum, events, etc.)	Keep dialog going

Next Steps

Can SBD help you with any unanswered questions?

Contents Page

About SBD

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Expert Insight

SDV is a cultural shock

As auto-makers chase the target of being tech companies, they are faced with difficult choices on how best to setup their organization and divide up roles & responsibilities. The change initially leads to chaos and inefficiencies. With suppliers bolstering and refining their SDV capabilities, auto-maker decision makers face a tough decision, do I keep investing in my own software development capabilities or do I go with a lower cost solution from a supplier? There is no silver bullet here.

Dr David Abdulmasih, Consulting Manager

Understanding first

There is a lot to do, and it must be done in unison, at the risk of joining the examples of companies who've got part of their offering ready but remain unable to utilize it. This report can be used as a common nomenclature for a team to highlight where empowering needs to occur to allow the opening up of today's way of working. There are plenty of small steps to optimize Vehicle 3.0 but pause and take a breath to understand the big picture of a journey to Vehicle 4.0.

Simon Halford, Author & Reports Manager

Generate value from roadmaps

The industry has been heavily focused on technological disruption over the last 10 years - connecting, digitizing, automating and electrifying cars. The technology roadmaps for most OEMs are now mostly defined, but big questions remain around how best to deliver this change and how to generate value from it. This is the hardest and riskiest stage for OEMs, as success relies on fundamentally transforming of how their organizations think, operate and collaborate. There has never been a more uncertain (and exciting!) time to be working in this space!

Andy Hart, CEO

OTA is only valuable if done correctly

OTA updates are incredibly valuable to both consumers and automotive OEMs, providing improved customer satisfaction, as well as more revenue streams and convenience for manufacturers. However, as beneficial as OTA updating can be, without the correct fundamentals in place, OEMs can, and will struggle to utilize the opportunities that Software defined vehicles present.
Initially, OEMs should focus on organizing their internal divisions so that management and development of OTA updates can be completed efficiently. Following this, implementation can be completed with a significantly higher chance of maximum returns for all parties involved.

Jack Dunkley, SME for SBD's EE Guide

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Securing the SDV

September 2023

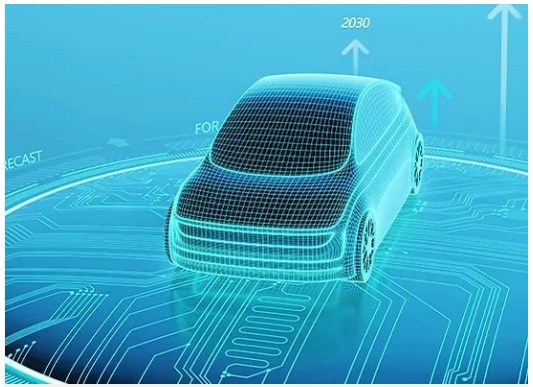
The report provides a high-level threat model of a typical SDV architecture - identifying the best practices for responding to malicious cyber security attacks at each layer of the technology stack.

Learn more

E/E Architecture Guide

Right decisions on E/E architecture leads to increased vehicle safety, security, and system usability

Learn more



SDV Forecast

December 2023

The guide provides a grounded assessment of the growth enabling SDV technologies in different regions and vehicle segments.

Learn more

OTA , FaaS & SW-Delivered Features Guide

The OTA, FaaS & SW-Delivered Features Guide tracks the latest OEM activity around OTA updates to help product planners to assess their strategies against competitors.

Learn more

Contact SBD Automotive

Do you have any questions?

If you have any questions or feedback about this research report or SBD Automotive's consulting services, you can email us at info@sbdautomotive.com or discuss with your local account manager below.

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