Update from the FEDERATE Scientific Board

Daniel Watzenig
May 20, 2025

- Introduction
- SDV roadmaps
- Recent activities
- Takeaways

Scientific board of FEDERATE

- Tasks and responsibilities
  - Continuous analysis of relevant technology trends and other upcoming middleware on the market. This information is essential in the alignment process of the backlog for the building blocks and even more important in the creation of the vision paper for the SDV platform.
  - They play also an essential role in the evaluation of the achieved results in the main projects and give advice how to further improve the building blocks.
- Members
  - Prof. Daniel Watzenig (TU Graz & Virtual Vehicle Research Institute in Austria), Prof. Lutz Eckstein (RWTH Aachen in Germany), Prof. Tero Päivärinta and Prof. Ella Peltonen (University Oulu in Finland), Prof. Alois Knoll (TU Munich in Germany), Prof. Peter Janevik (RISE / ASTAZERO in Sweden), Prof. Alexander Viehl from FZI (FZI Forschungszentrum Informatik)

SDV roadmaps and ecosystems

SDV roadmap

Levels of software-defined vehicles

	Non-connected vehicle	1st gen connected vehicle	2nd gen connected vehicle	Software-defined vehicle	"Immersed" SDV
Customer	• Low cost • No connectivity • Poor user experience	• Connectivity enables map and data updates, such as traffic alerts • Simple remote vehicle access via phone app • No digital services	• Simple OTA updates for functionality and bug-fixes • Simple first-gen. in-vehicle app stores • Limited digital services	• Smartphone like SW releases and updates • Customization to markets • UI/UX personalization	• Vehicle fully immersed into ecosystem of choice
Manufacturer	• Even simple software updates are tedious and often require exchange of hardware	• Hardware limits performance updates	• Tier1-made black-box ECUs prevent access and updates	• Must create an SDV-ready org or will face SOP delays • Must take ownership of end-customer-facing function development • Must master integration challenge	• Integration into a bigger ecosystem enables new business models • Rich sensor set enabling high automation features are a must
	Entry level models	Most mid-level models	BMW iX, i5, i7 Mercedes EQx VW ID3, 4, 5, Buzz …	All Tesla vehicles BMW Neue Klasse (2025+) Mercedes CLx (2025+) …	Xaomi SU7

Jan Becker et al., Apex.AI, 2024

SDV roadmap

IDTechEx Research	Current 'Non-SDV' SDV Level 0	'Basic' SDV Level 1	'Modern' SDV Level 2	'Advanced' SDV Level 3	'Cutting Edge' SDV Level 4	Future 'Futuristic' SDV Level 5
Cockpit						
Connection	None	3G/4G	4G	4G	5G	5G/6G
Display	Non-touch	Small display (non-touch or touch)	Medium-sized Touchscreen	Large Touchscreen	Multiple large touchscreens	Touchscreens for all passengers
Central Compute	No central compute	Central compute with some updates possible over Wi-Fi or connecting a phone	Central Compute with some components connected and updateable via OTA update	Central Compute with key components (engine/electric motor and battery) connected and updateable via OTA update	Central Compute with all components connected and updateable via OTA update	Central Compute with all components connected and updateable via OTA update
In-vehicle payments	None	None	App-based	In-vehicle possible	In-vehicle with biometric identification	In-vehicle with biometric identification for each passenger
Software Apps	None	1st party apps only (e.g. a generic 'Sports' App)	App store with some 3rd party apps (e.g,. Google Maps)	App store with many 3rd party apps (e.g. YouTube, Angry Birds)	App store with many 3rd party apps (e.g. (Google Play Store)	Multiple app stores (e.g., Steam & Google Play store)
Autonomy	Level 0	Level 1	Level 1/ Level 2	Level 2	Level 3	Level 3/4+

IDTechEx, 2024

SDV ecosystem

	SDV level 0 Software-enabled	SDV level 1 Connected	SDV level 2 Updatable	SDV level 3 Software Platform	SDV level 4 Upgradable	SDV level 5 Integration Platform	SDV level 6 Innovation platform	SDV level 7 Artificial identity
Customer experience	Mechanical functions made possible via software	Information and control via connectivity	Vehicle maintenance via OTA updates	Car always feels new via cross-generation software upgrades	New functions via software upgrades	Collaboration with 3rd party ecosystem based on binary exchange/ configuration	Collaboration with 3rd party ecosystem based on source code sharing	Vehicle as identity, interact seamlessly with customers
Scope of adaptability and dynamics	No update and connectivity Hard real-time requirements	Static software in dynamic environment	Static functionality in dynamic software	Dynamic target hardware Singular software platform provider	Dynamic functionality static target hardware	Dynamic software with singular **HPC** hardware provider	New 3rd party function deployed to multi brand fleet	Onboard Machine Learning runs on ASIC (NPU, TPU) Inference and Speech as differentiation

Rinat Asmus, Linkedin, 2024

Li Auto

Li Auto - HaloOS

- Open-sourcing of their vehicle operating system, becoming the world's first automaker to open-source its automotive OS.
- Aim to empower every automaker and supplier to save tens to hundreds of millions in annual OS licensing fees.
- Enabling Chinese innovation to benefit the global community.
- HaloOS repository: https://gitee.com/haloos

https://www.lixiang.com/en/tech/haloos#lian, 2025

Advantages (yet to be proved)

- Enhanced performance and efficiency:
  - Claims to optimize performance, reduce latency, and improve stability compared to e.g., AUTOSAR systems.
  - It claims to reduce perception-decision-execution time, double response speed, and improve stability fivefold.
- Cost reduction
  - Halo OS aims to lower material costs by integrating AI computing power sharing and optimizing hardware resource allocation, potentially saving billions annually.
- Security:
  - It includes built-in security features like data encryption, system integrity checks, and permission management, allowing for wider scrutiny in the open-source model.

https://www.lixiang.com/en/tech/haloos#lian, 2025

Advantages (yet to be proved)

- Adaptability and flexibility:
  - The OS is designed to be adaptable to various automotive-grade chip architectures, including Infineon TriCore, Renesas RH850, and RISC-V.
- Ecosystem development
  - Li Auto's open-source approach aims to attract third-party developers, accelerate adoption of advanced features, and foster a collaborative ecosystem.

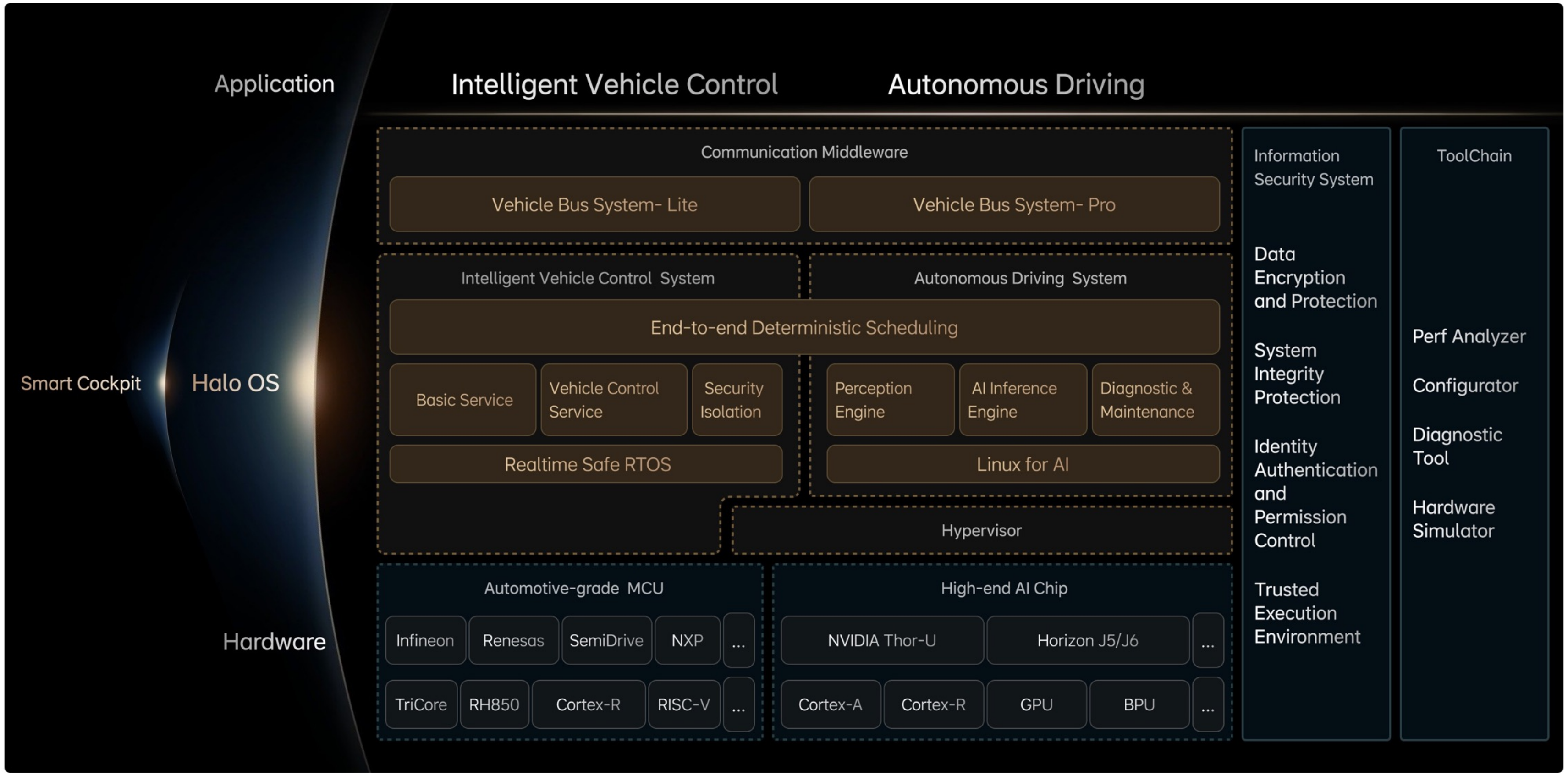
https://www.lixiang.com/en/tech/haloos#lian, 2025

Disadvantages (yet to be proved)

- Dependence on open-source community
  - Rapid innovation through open-source requires widespread adoption by the automotive industry and a strong community of developers to contribute.
- Initial cost overruns
  - Initial development and implementation costs could be high, particularly for other adopters.
- Complexity and learning curve
  - The open-source nature of Halo OS might present a learning curve for developers who are not familiar with its architecture and components.
- Potential for fragmentation
  - If not widely adopted, it could lead to issues with compatibility and interoperability.
- Competition
  - Halo OS will need to prove its value and attract widespread adoption to compete effectively.

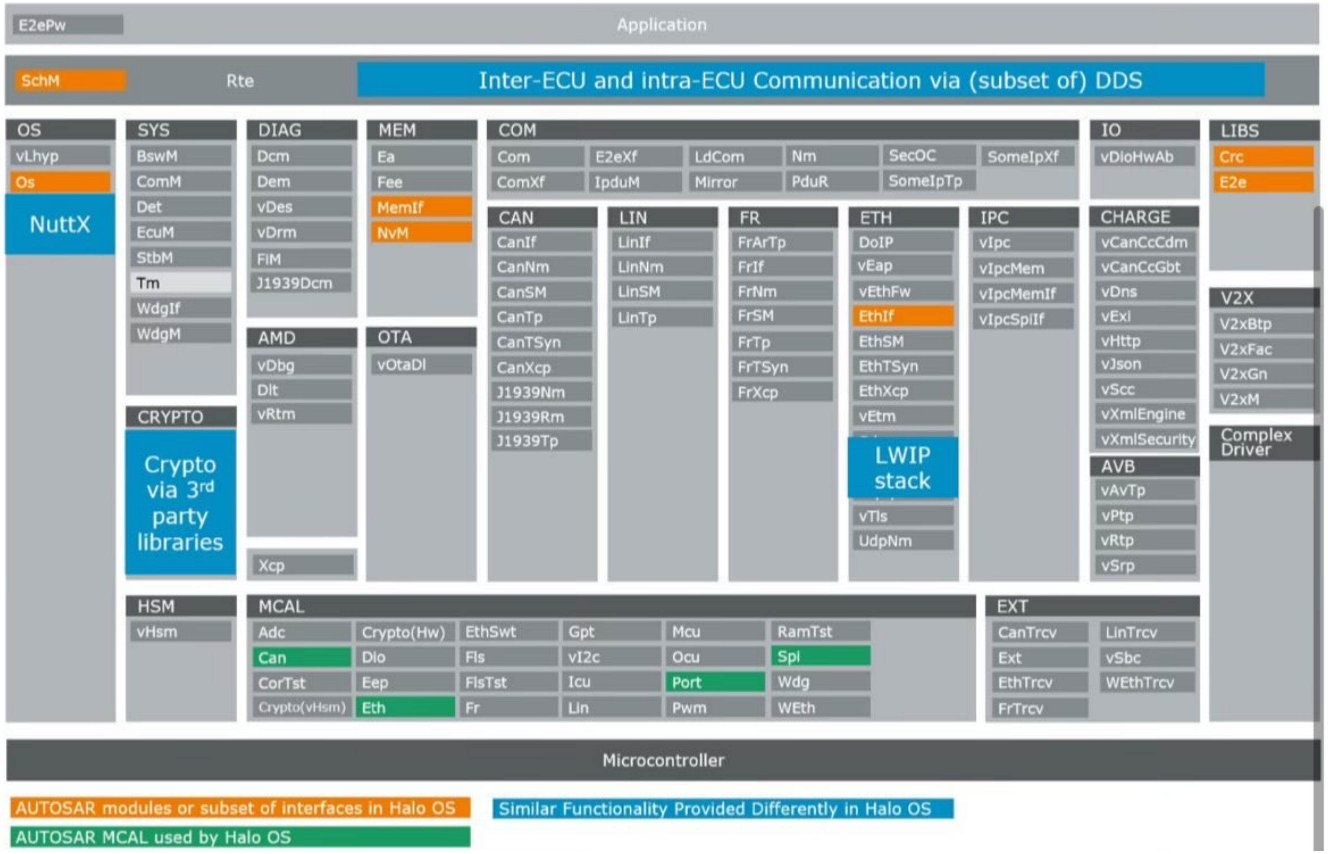
https://www.lixiang.com/en/tech/haloos#lian, 2025

Architecture



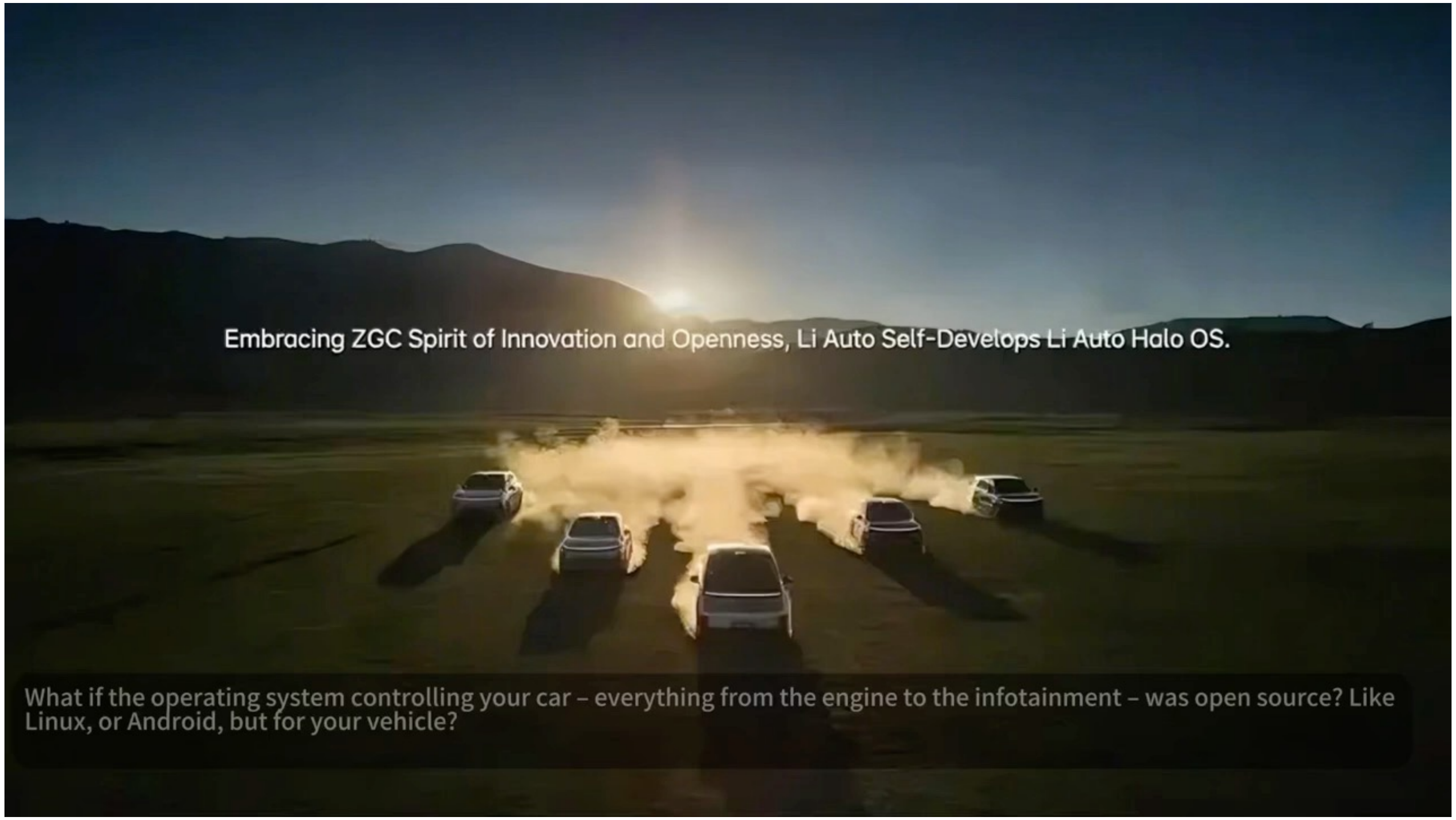
https://www.lixiang.com/en/tech/haloos#lian, 2025

High-level explanation



E. Metzker, 2025

High-level explanation



Youtube, 2025

woven by toyota

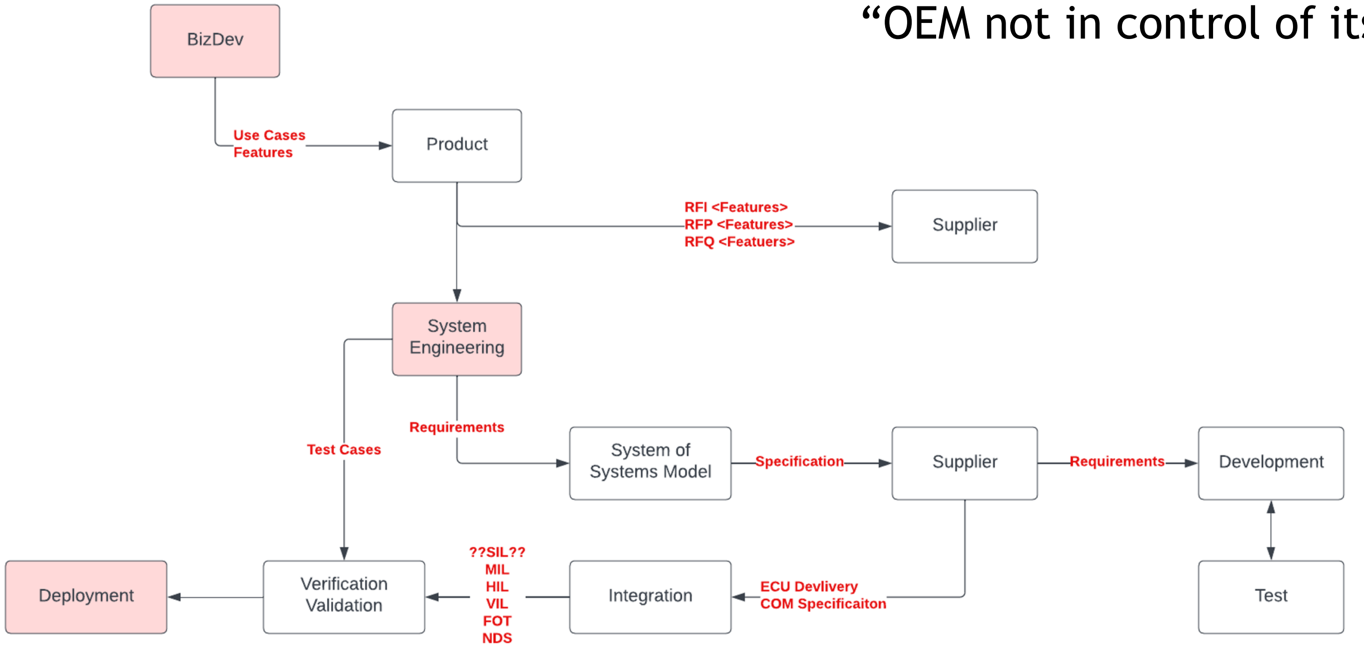
Main challenges as of 2025 (woven by toyota)

- Lack of transparency in SW / HW supply chain management
- Configuration and variant management → CI/CD/CT is needed
- Platform and runtime management including deployment
- The need for standardization across the in-vehicle SW stack
- Maturity models of platforms, AI, etc.
- Open-source project ongoing

Kudos to T. Kuehbeck (Chief Architect) and J.-F. Campeau (Vice President)

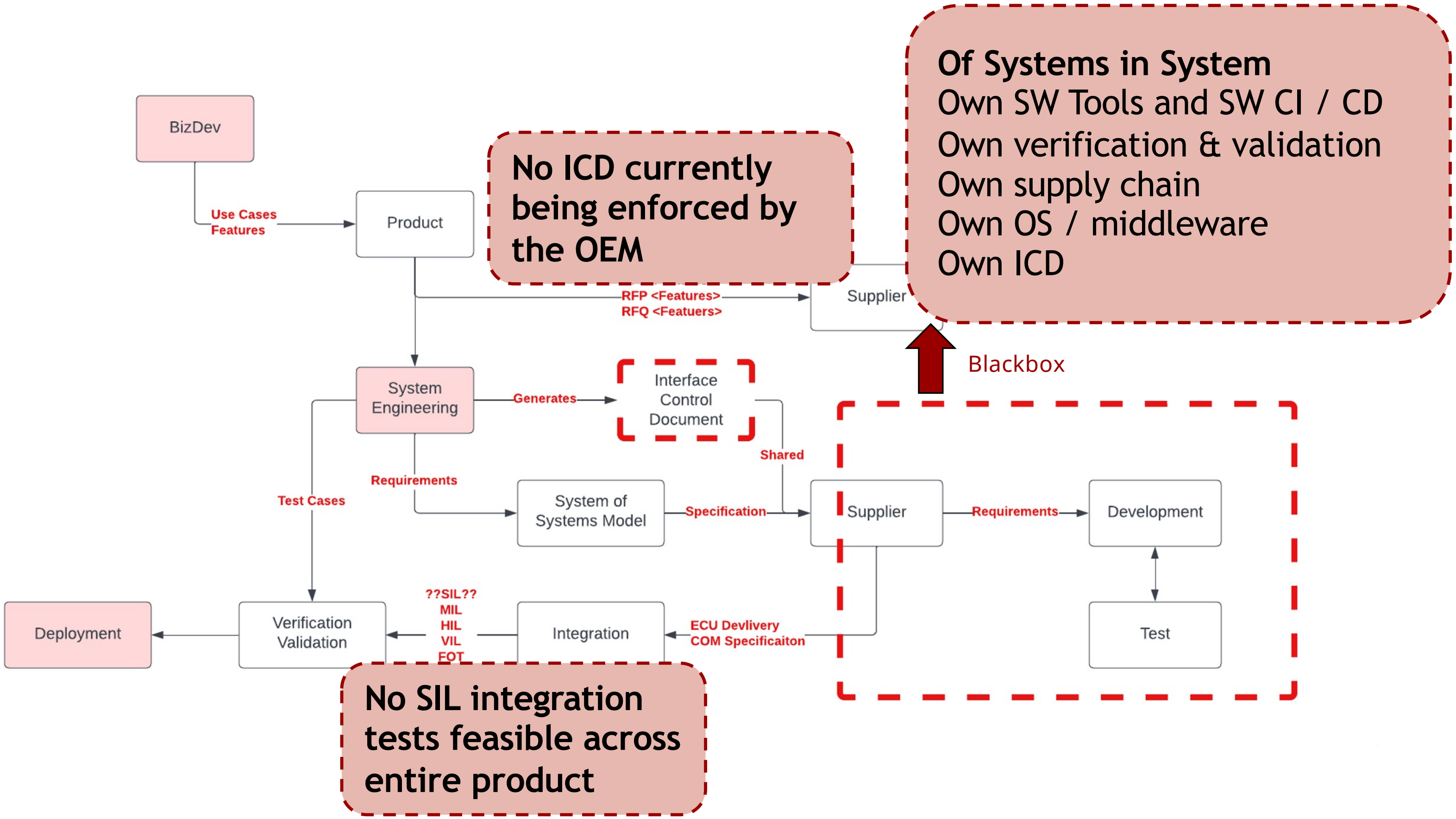
Limited transparency across SW/HW supply chain management

"OEM not in control of its product design"



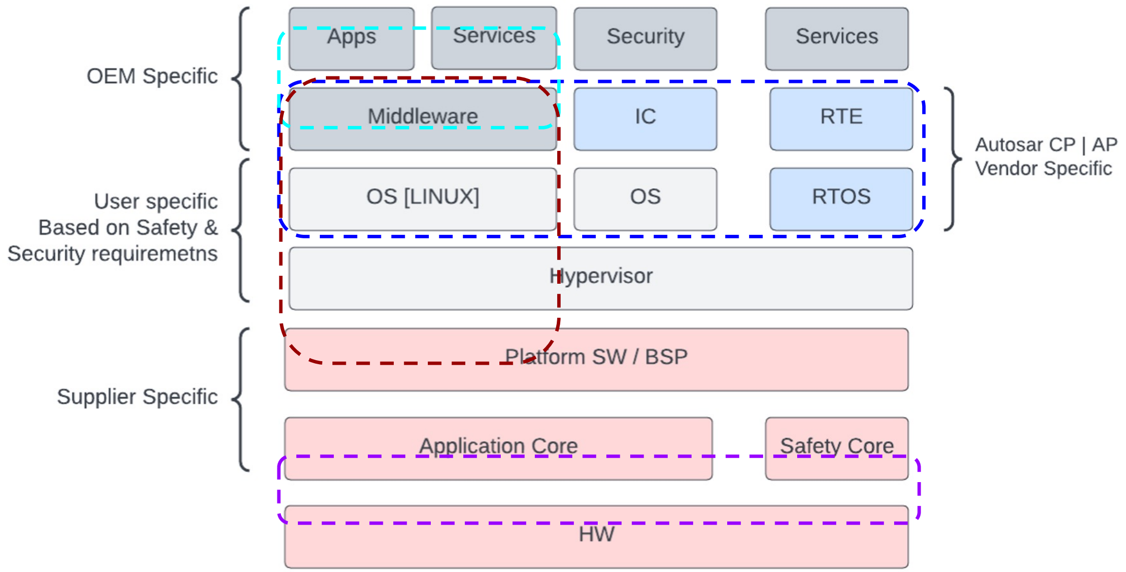
woven by toyota, 2025

Issue in the vertical integration



woven by toyota, 2025

Vehicle deployment and runtime management



Missing application interfaces hinder deep - vertical system integration (No ICD).

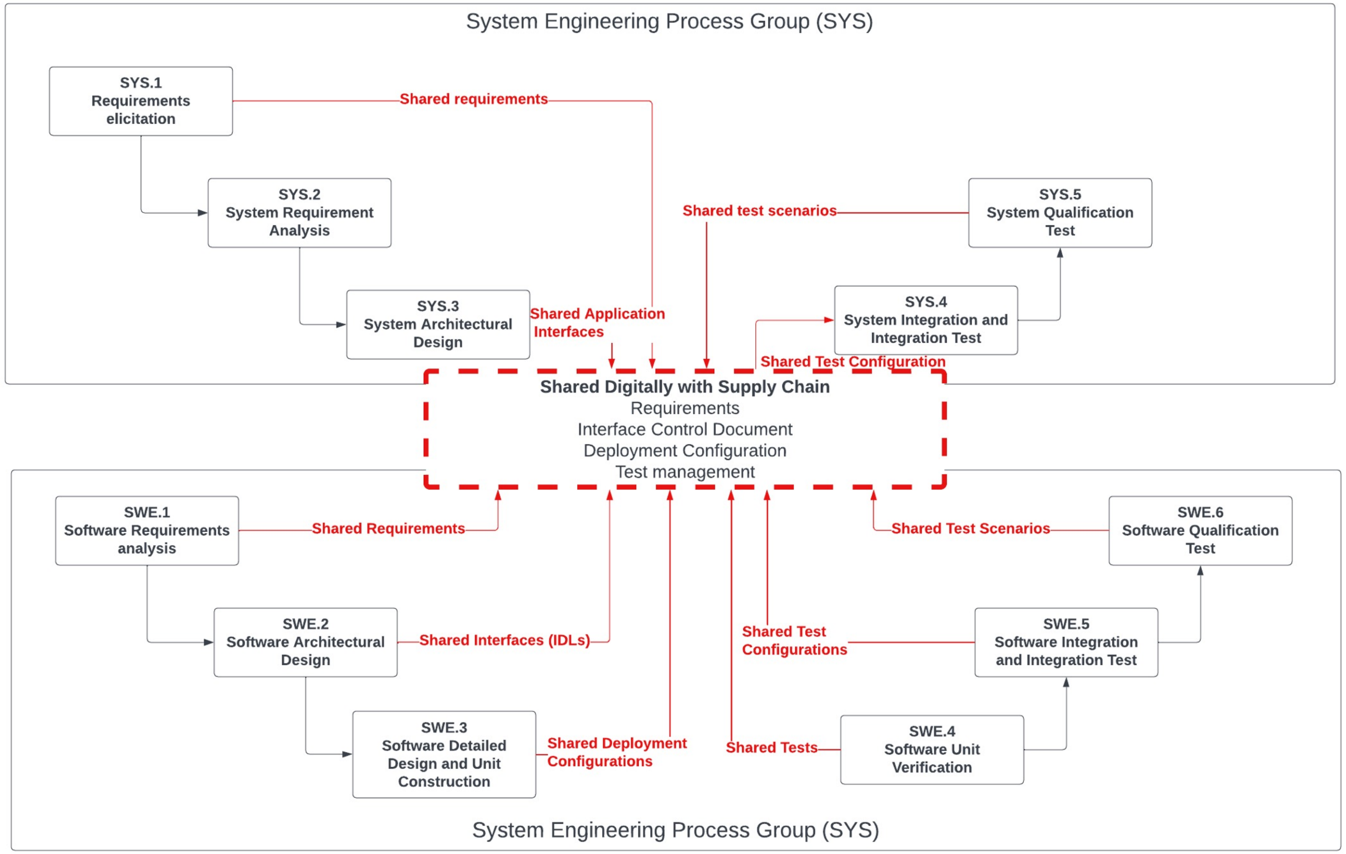
Monolithic implementations in the middleware are heavy and hinder easy integration.

No Single OS solution and no single Runtime configuration suffices requirements across domains

No common standardization for interoperability, virtualization & deployment

woven by toyota, 2025

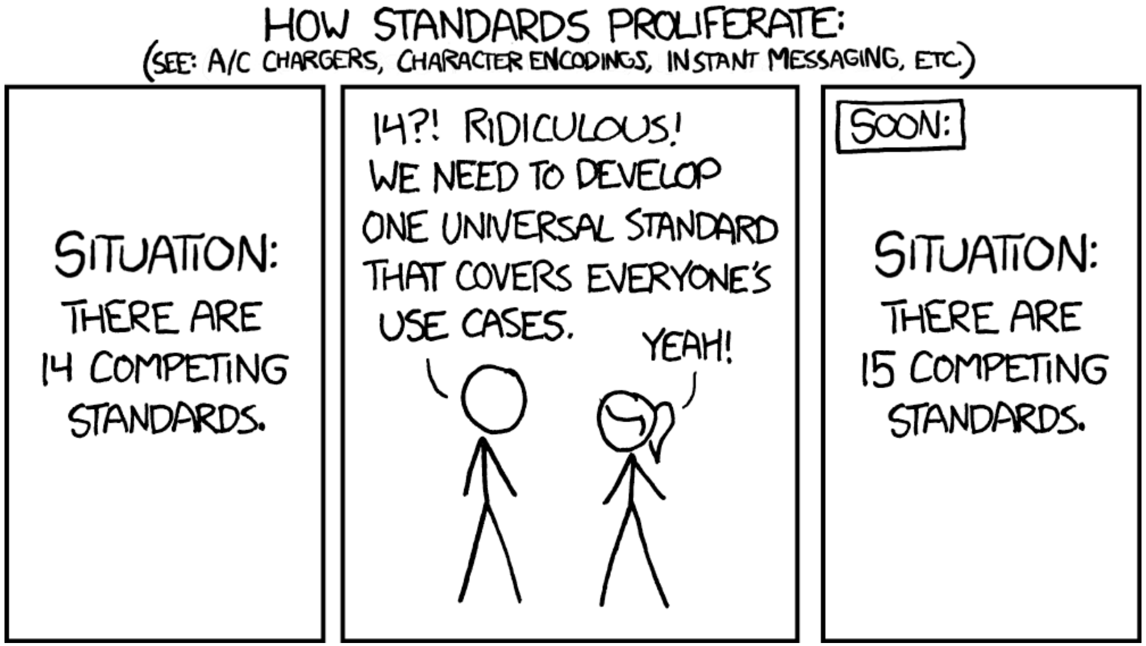
Digitalization and standardization needed to be faster on the market



System architecture across entire product including supply chain is needed

woven by toyota, 2025

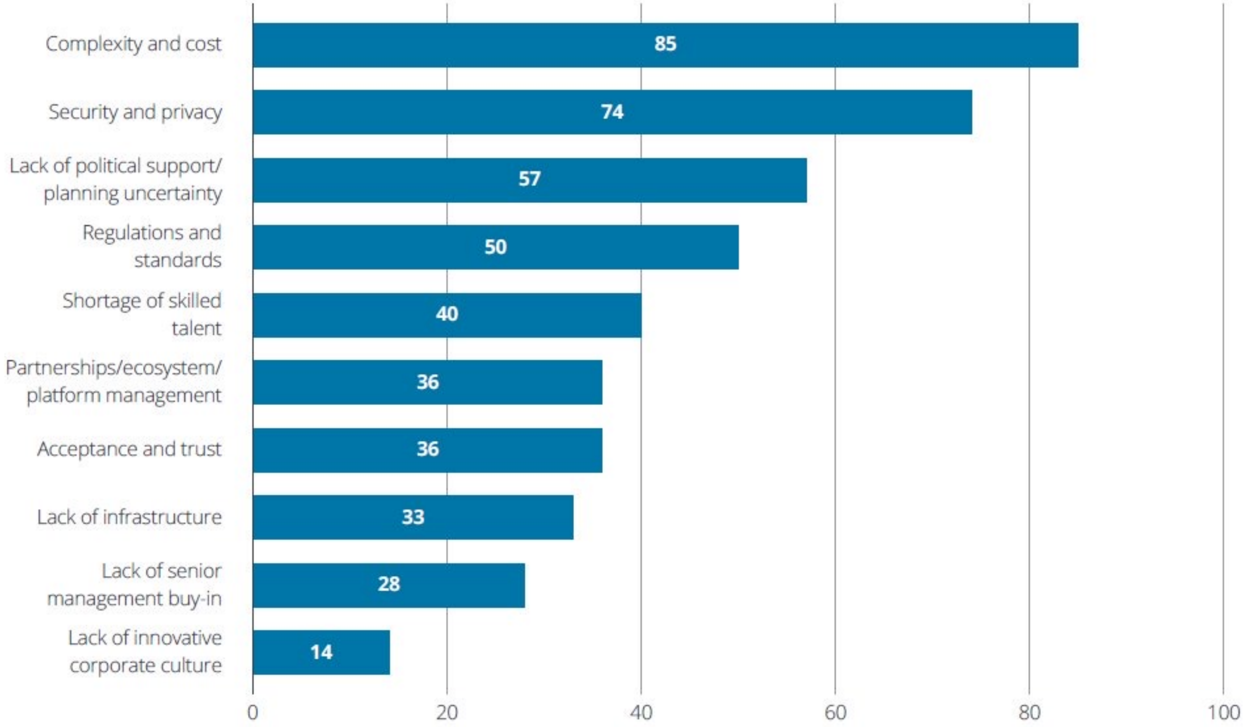
How standards multiple…



Key takeaways

Exploring the transition to SDV

Fig. 10 – Main barriers to the effective use of and the ability to scale SDV
Q22: In your opinion, what are the main barriers to the effective use of and the ability to scale software-defined vehicles? Sample size: n= 141
Participants could select multiple responses. The numbers in the chart represent the total selection for each option.



Surveying the road: Exploring the transition to SDV in the automotive industry, Deloitte, 2025

Exploring the transition to SDV

Fig. 14 – Reducing current complexity as part of the shift to software-defined vehicles
Q24: Which of the following measures are most important when it comes to reducing complexity in the current shift to software-defined vehicles? Sample size: n= 141 Note: For reasons of clarity, the results show only the most important measures ranked number 1 by respondents. Participants gave each option an individual ranking from "1" (highest rank) to "6" (lowest rank).

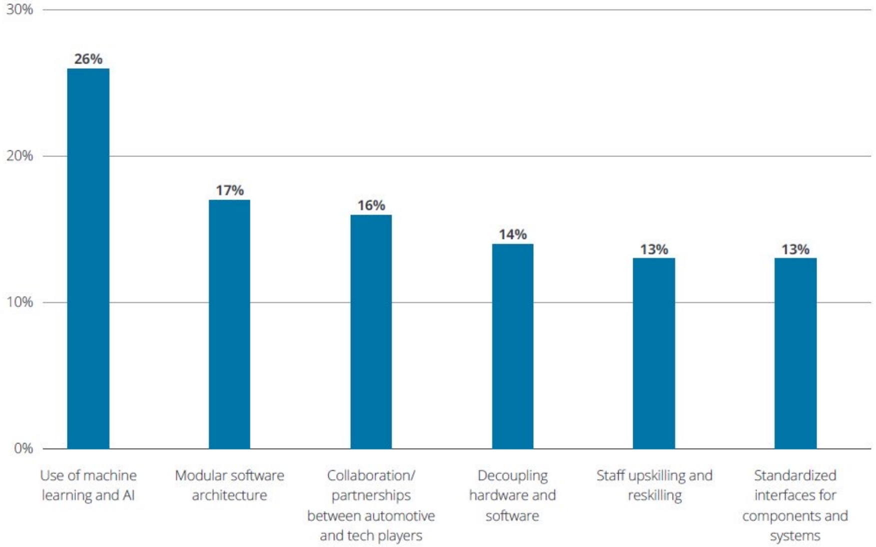
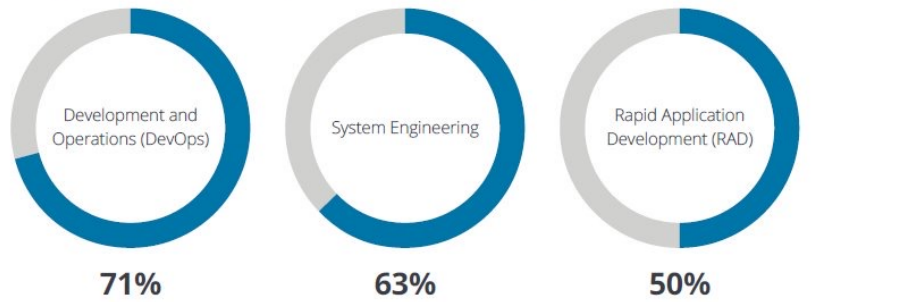
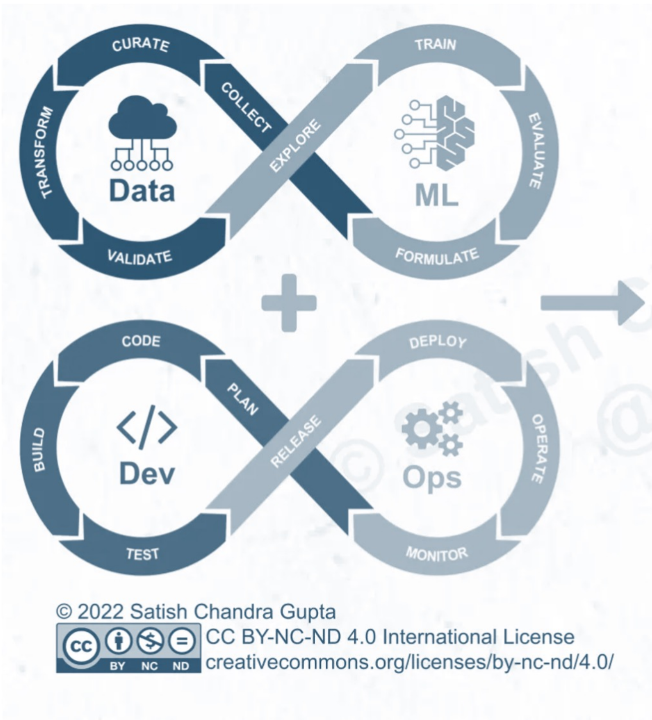


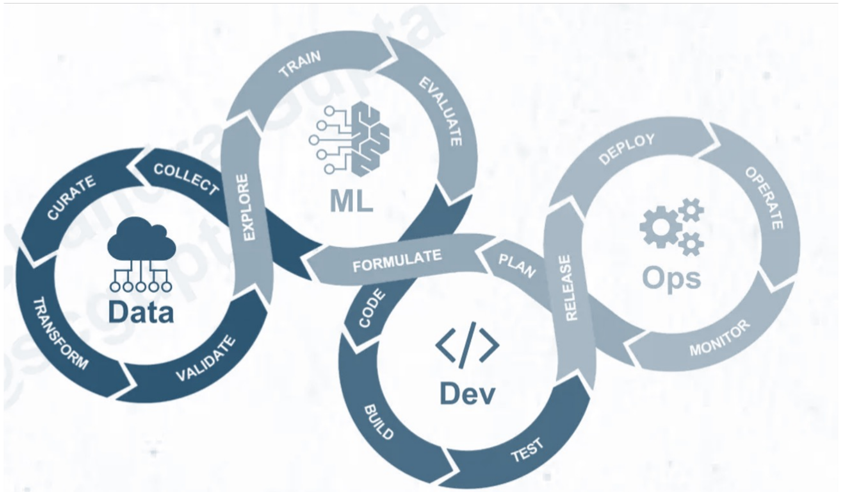
Fig. 7 – Methodologies with the biggest impact on SDV development
Q34: Which methodologies will have the biggest impact on software-defined vehicle development? Sample size: n= 131 Participants could select multiple responses. The numbers in the chart represent the total selection for each option.



Surveying the road: Exploring the transition to SDV in the automotive industry, Deloitte, 2025

DevOps and DataOps leads to MLOps





Takeaways

- Specification & implementation & CI/CD/CT pipeline
- Tools are the key
- Maturity models (platform, AI…)
- HW/SW supply chain management and ecosystem

- SW development is different
  - Small SW teams (6-8 members)
  - "Green field": only a few 100 SW developers are sufficient (Rivian, Tesla, China…)
  - SW manager are missing in Europe

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