MIH Recommended Standard Software Defined Vehicle Classification Ver 1.0

MIH Consortium

2024/08

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Document information

- Document Version: Ver 1.0
- Editor: Ted Lien ted.lien@mih-ev.org

1. Revision history

Ver.	Date	Edited	Company	Changes
0.1	4/09/24	Ted Lien	MIH	Initial draft of SDV term definition
0.2	4/12/24	Ted Lien	MIH	Add viewpoints from key players
0.3	4/23/24	Ted Lien	MIH	Some URLs modification per WG input
0.4	5/6/24	Chris Yang Jun-Dong Chang Huei-Ru Tseng Stephen Liu Luffy Lu Kevin Su	Foxconn III ITRI Sonatus TrendMicro Yuntech	Some key wording changes reviewed by domain experts
0.5	8/7/24	Ted Lien	MIH	5-level definition
0.6	8/15/24	Justin Moon Ted Lien	QNX MIH	Add notice of SW foundational platform across all the levels by QNX.
0.7	8/22/24	Zhang Yang Michael Kung Ted Lien	Autocore Foxconn MIH	Why/What revision with input from Autocore and Foxconn
0.8	8/28/24	Ted Lien	MIH	3-level definition Smartphone vs Vehicle

2. Acronym list

ACC	Adaptive Cruise Control
AEB	Automatic Emergency Braking
AVP	Automated Valet Parking
BSD	Blind Spot Detection
DOW	Door Opening Warning
FCW	Forward Collision Warning
FSR-ACC	Full Speed Range - ACC
Full ADS	Full Automated Driving System
LCA	Lane Change Assist
LDW	Lane Departure Warning
LKA	Lane Keeping Assist
NOA	Navigation On Autopilot
RA	Reverse Assist
RCW	Backward Collision Warning
TJA	Traffic Jam Assist

3. Summary

This Software Defined Vehicle (SDV) Classification Standard document was developed and confirmed by MIH and partners. This standard defines **3 levels** of software control and update capabilities from end user perspective, enabling the automotive industry to quickly understand and grasp the convenience and advantages that software can bring to vehicles.

4. Introduction

With the trend of CASE (Connected, Autonomous, Shared & Services, and Electric), the competition in the new generation of vehicles, which leverages software and networks to create value, is intensifying, affecting various countries, regions, and enterprises. More and more OEMs in the automotive industry are pursuing the technology to define vehicle through software. The actual essence of SDV is the mindset of breaking hardware boundaries, allowing vehicle functions and user experiences to evolve with the times. Although the trend is emerging, there is still no clear agreement that represents SDV.

The Smartphone Revolution: A Blueprint for the Future of EVs

The modern smartphone is arguably the most successful software-defined product in history. It's not just a device for making calls; it's a powerful computer in your pocket, constantly evolving through software updates. This software-centric approach has transformed the smartphone industry, enabling rapid innovation, personalization, and a vast ecosystem of apps. The comparison between smartphone and vehicle is as Figure 1.

	Yearly Volume (M)	Performance APPs	Safety
	1400	millions	Not related
	75	hundreds	Directly related

Figure 1 : Smartphone vs Vehicle

Now, we are on the cusp of a similar revolution in the automotive industry, with electric vehicles (EVs) leading the charge. The vision is clear: to build EVs with the same software-centric approach as smartphones. This means moving beyond the traditional hardware-

focused model and embracing a future where software defines the vehicle's capabilities and user experience.

The benefits of this approach are numerous. Just as smartphones receive regular updates with new features and improvements, software-defined EVs can evolve over time, staying ahead of the curve. This also opens the door for personalization, allowing owners to tailor their vehicles to their preferences. Imagine customizing your car's performance, interior ambiance, or even its driving style with a simple software update.

Moreover, a software-centric approach fosters a thriving ecosystem of apps and services, like the app stores we have on our phones. This could revolutionize the in-car experience, with new entertainment, productivity, and safety features constantly being developed and deployed.

Of course, building software-defined EVs comes with its own set of challenges. It requires a fundamental shift in the way cars are designed, manufactured, and serviced. It also demands robust cybersecurity measures to protect against potential threats.

However, the potential rewards are immense. By embracing the software-defined model, we can unlock a new era of innovation and user-centricity in the automotive industry. Now, it's time to bring that same spirit of innovation to the world of EVs. The difference between traditional and software defined vehicles is as Figure 2.

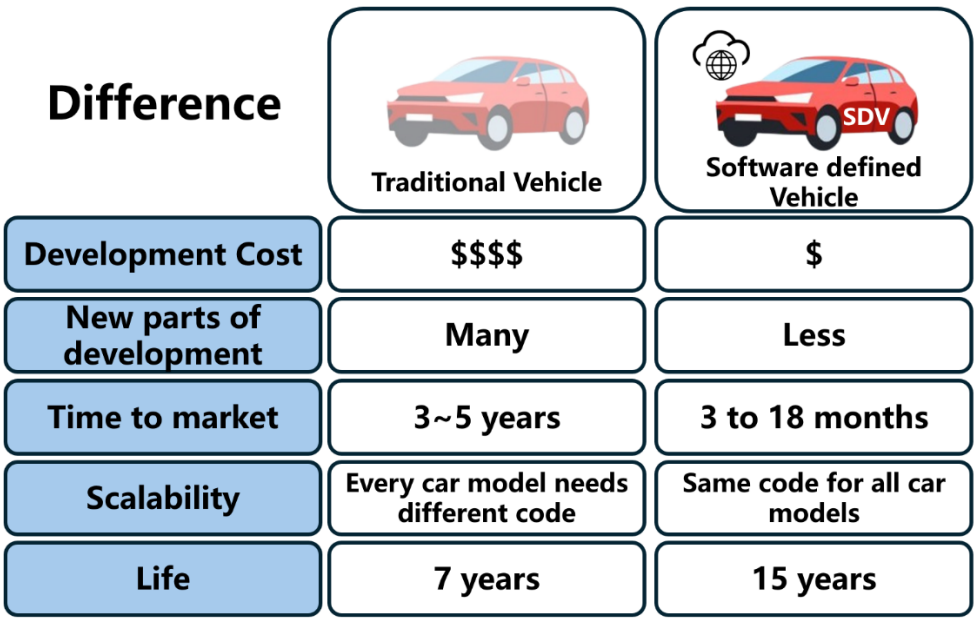

Figure 2 : SDV Difference

The Need for Personalized experiences and Upgradable Vehicles

SDV are revolutionizing the automotive industry, offering a win-win scenario for all involved. End-users gain personalized experiences and the ability to keep their vehicles up to date, extending their lifespan. OEMs enhance product value, reduce development costs and time, and unlock new revenue streams through innovative business models like software subscriptions. Suppliers benefit from a shift towards software development, fostering flexibility and agility to meet the evolving needs of diverse vehicles and markets. The SDV revolution is here, ushering in a future of smarter, more adaptable, and customer-centric vehicles.

5. SDV SCOPE

This document outlines the standardization requirements for the SDV of electric vehicles. It can cover many items, like Smart Cabin, Autonomous Driving, Security & OTA, Middleware & Runtime, Energy Management, Powertrain, Thermal Management, E/E Architecture (EEA), UX, Could Service, Connectivity, Vehicle Dynamics. The priorities are the smart cabin which interacting with the drivers and occupants frequently. This can be classified with 3 levels as Figure 3.

Level	Description	Examples
1	**E**ssential features that interact directly with the driver and passengers, frequently used to ensure basic driving experience and safety.	➢ Smart Cabin ➢ Audio Video Voice ➢ Phone ➢ Navigation
2	**F**eatures that improve driver and passenger comfort, convenience or entertainment, providing a better driving experience in certain situations. These features may require periodic updates to maintain optimal performance.	➢ Autonomous Driving ➢ Could Service ➢ Security ➢ Connectivity ➢ Middleware
3	**F**eatures that users rarely interact with directly, mainly responsible for the vehicle's underlying operation and safety. These are typically updated less frequently after the vehicle leaves the factory.	➢ EEA ➢ Energy mgmt. ➢ Powertrain ➢ Thermal mgmt. ➢ Vehicle Dynamics

Figure 3 : SDV Scope

Value and cost proposition of the 3 levels

Now, Level 1 offers appropriate value because the cost is reasonable. Levels 2 and 3 provide limited additional value at significantly higher costs. In the future, Levels 2 and 3 increase more values with less cost. This is illustrated in Figure 4.

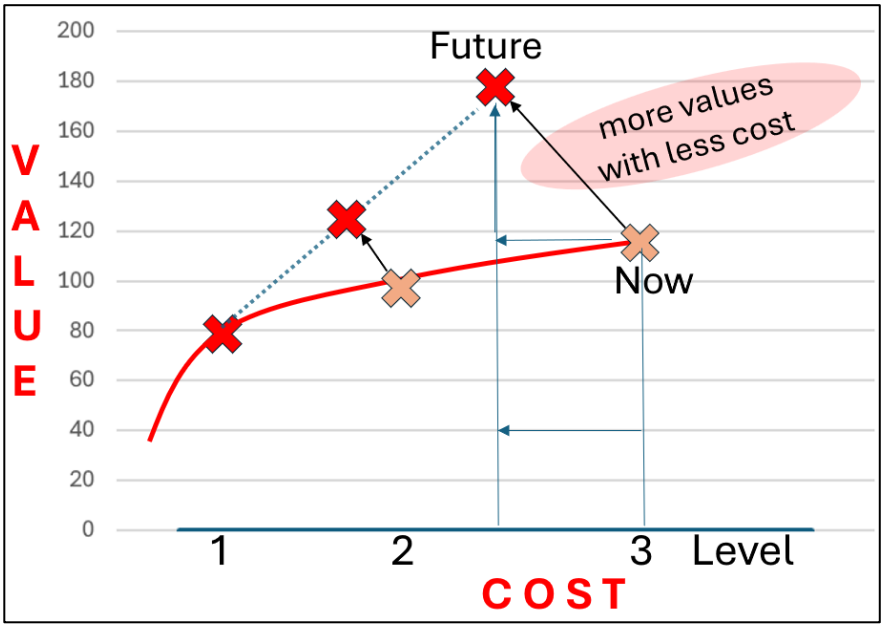

Figure 4 : Value-Cost Proposition

6. Functions Break Down

The functions can be broken down as Figure 5.

OTA capabilities	MIH SDV LEVEL 1	MIH SDV LEVEL 2	MIH SDV LEVEL 3
Audio Video	V	-	-
Phone	V	-	-
Voice	V	-	-
Navigation / Map	V	-	-
ACC	V	-	-
TJA	V	-	-
HUD	V	-	-
DMS	V	-	-
LDW	V	-	-
LKA	V	-	-
NOA		V	-
RoboTaxi		V	-
Could Service		V	-
Middleware & Runtime		V	-
EEA		V	-
Connectivity		V	-
Energy Management			V
Thermal Management			V
Powertrain			V
Vehicle Dynamics			V

Figure 5 : SDV Functions Break Down

Level 1: Enhanced Comfort & Convenience

Infotainment and Communication: Audio, video, phone, and voice control systems provide entertainment and seamless communication on the go, making every journey enjoyable.
Navigation and Assistance: Navigation, ACC, TJA, HUD, DMS, LDW, and LKA features reduce driver stress by providing guidance, maintaining safe distances, and alerting to potential hazards, resulting in a more relaxed and confident drive.

Level 2: Advanced Assistance & Connectivity

Enhanced Autonomy: NOA enables hands-free driving in certain conditions, providing a taste of autonomous capabilities and reducing driver workload on long highway trips.
Emerging Services: RoboTaxi and Cloud services showcase the potential of future mobility solutions, offering convenient transportation options and remote vehicle management.

Advanced Technology: Middleware & Runtime, EEA, and Connectivity form the technological backbone, enabling seamless integration and communication between various SDV components, paving the way for future advancements.

Level 3: Optimized Performance & Efficiency

Efficient Operation: Energy and Thermal Management systems work together to maximize vehicle range and efficiency, reducing environmental impact and operating costs.
Enhanced Driving Dynamics: Powertrain and Vehicle Dynamics systems optimize power delivery and handling, resulting in a smoother, more responsive, and enjoyable driving experience.

7. Sanity Check

To ensure the 3 levels SDV standard can cover most of the value and capabilities, the sanity check of the market is necessary. The investigation shows that most of the hot selling vehicles are level 1 as Figure 6.

Oem	Brand	Seg	MSRP (k) USD	MIH SDV LEVEL 1	MIH SDV LEVEL 2	MIH SDV LEVEL 3
BYD	Seagull	A	29.0	V	-	-
Wuling	MiniEV	A	4.3	-	-	-
Fiat	Fiat 500	A	27.5	V	-	-
Chevrolet	Bolt	B	27.5	V	-	-
VW	ID.3	C	36.0	V	-	-
Toyota	bZ3	C	54.5	V	-	-
Nissan	Leaf	C	29.3	V	-	-
GAC	AionS	D	13.9	V	-	-
Buick	Velite 6	D	23.1	V	-	-
Luxgen	N7	D	30.6	V	-	-
Tesla	Model 3	D	51.3	-	V	-
Hyundai	Ioniq 6	D	48.9	-	V	-
Audi	e-tron GT	E	161.5	V	-	-
BMW	i4	E	76.1	V	-	-
Benz	EQS	F	139.7	V	-	-

Figure 6 : Sanity Check

Based on SDV's 3-level classification, sanity check reveals that most popular models, regardless of price, fall within Level 1, indicating that Level 1 capabilities already satisfy most consumers. These models span various segments, including the entry models BYD Seagull, Fiat 500, Chevrolet Bolt, Nissan Leaf, GAC AionS, mid models like the VW ID.3 and Toyota Z3, and even premium models such as the Audi e-tron GT, BMW i4, and Benx EQS.

Only a few models, like the Tesla Model 3 and Hyundai Ioniq 6, manage to achieve Level 2. This suggests that while Level 1 capabilities are sufficient for the mass market, there's still room for improvement and innovation to reach higher levels of capabilities.

8. Conclusion

The 3-level SDV standard offers a clear roadmap for end users to understand and experience the benefits of software-defined vehicles. From a development perspective, traditional EE architecture is highly complex due to the number of ECUs and single-function controllers. Software Definition enables consolidation, reducing hardware complexity. However, it significantly increases software development complexity. To address this, we should seek to standardize the foundational software and leverage it across all SDV levels. Once we identify the components of this foundational platform, it will be easier to achieve economies of scale by leveraging common software elements across all levels.

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