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“Software Defined“

- Its Essential Nature and Key Technologies

December 11, 2025
Panasonic Automotive Systems Co., Ltd.
EVP, CTO

Masashige Mizuyama

Emerging Trends of SDV Transformation

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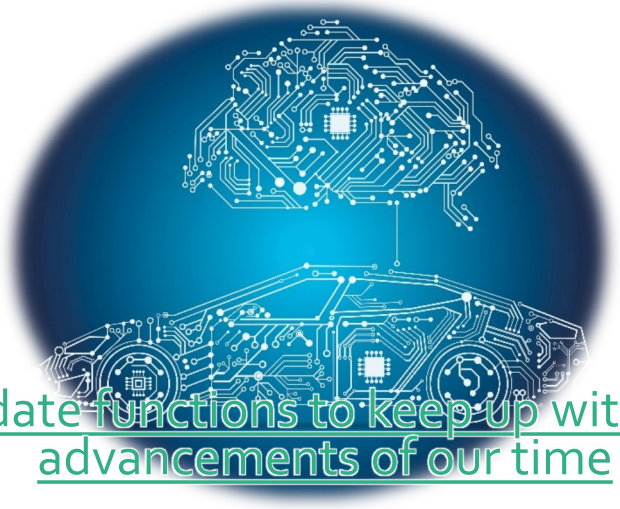
Comfortable cabin UX, advanced safety, evolving vehicles…
Toward the era of Software Defined Vehicles, in which much of the value is created by software

Comfortable cabin spaces/UX



Update functions to keep up with the advancements of our time

Advanced safety technology

Those who can advance their software more rapidly will gain crucial competitive advantages.

: SDV is a "Game Changer"

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The Speed of Product Discovery Matters

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Product Develop-ment

Measures for software that expands exponentially due to shifting to SDVs

Time To Market, resource limit, explosion of development cost

Product Discovery

Competition to "discover the right products to develop"

How fast can you reach the right product through repeated try-fail-improve?

Competitiveness in product discovery will significantly influence the advantage.

Conventional-type hardware company

IT industry

Copy machine, car navigation, automotive parts
Development period: 1-3 years
(surveyed by iTiD Consulting)

Release in approximately two-week cycles with agile development on the cloud
Amazon: Frequency of once every 11.6 seconds on average

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From “Hardware First” to “Software First”

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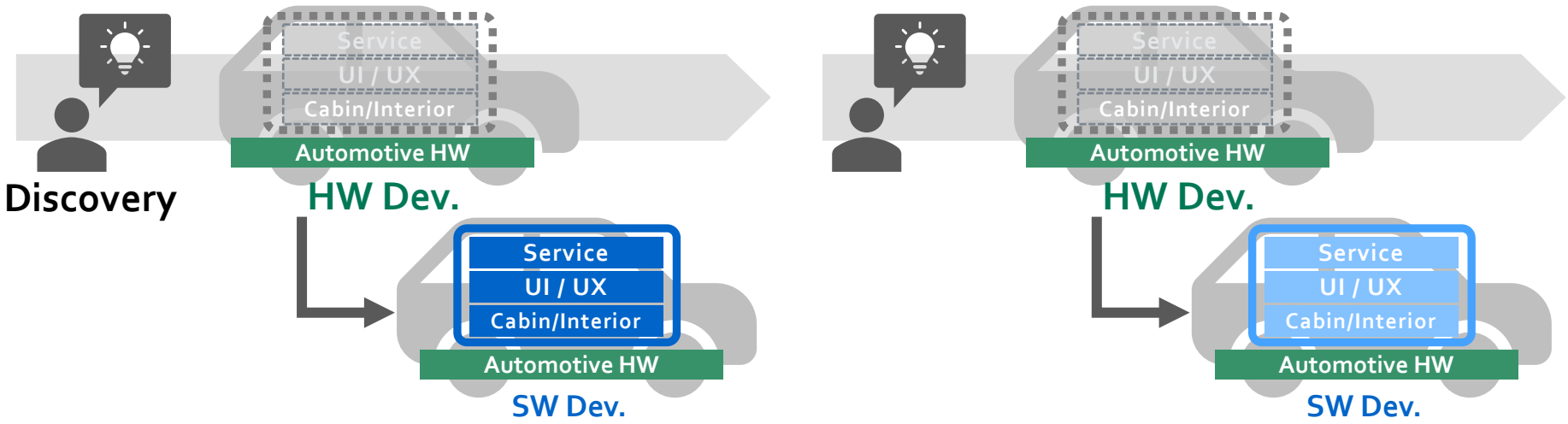
Evolve Software Continuously to Increase *Value*, Develop Optimal Hardware to Run it.

Legacy

Hardware First

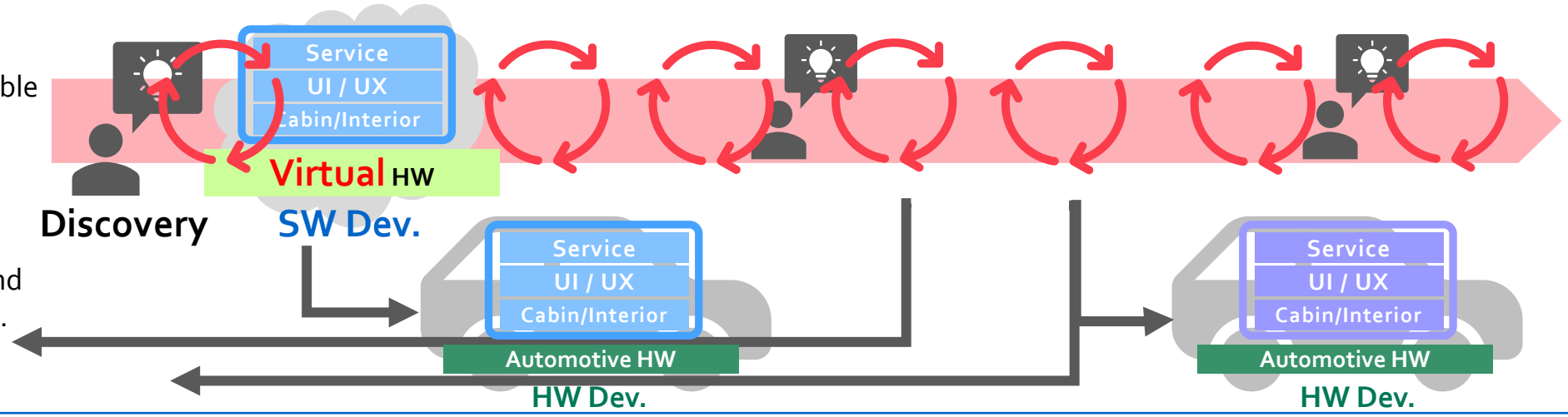
- Realizing limited value within hardware constraints.
- Long lead time to realize new value.



To Be

Software First

- Selecting the most suitable and latest hardware for realizing value through software.
- Faster value discovery and introduction into market.



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Key to "Software-First" : VirtIO, the Hardware Virtualization Architecture Standard

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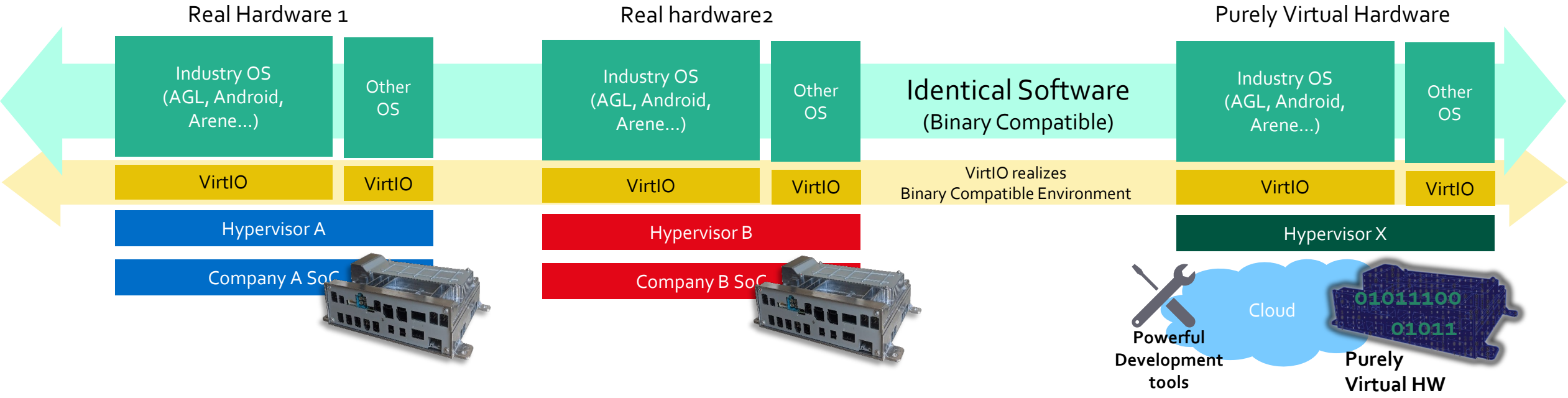
Panasonic Automotive strategically open sources and engages key players to lead industry standardization

Since 2018~

With VirtIO
① Eliminate dependency on specific hardware including SoC, evolve software first and select hardware later
② Fast development and continuous evolution of software on virtual hardware built in the cloud independent of hardware development



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Cloud Native Development w/Purely Virtual Hardware in the Cloud

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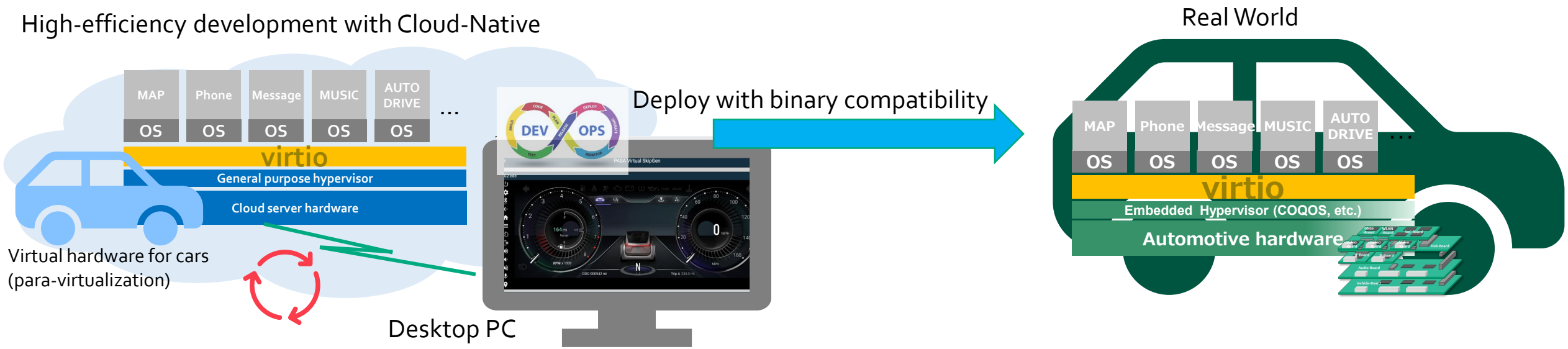
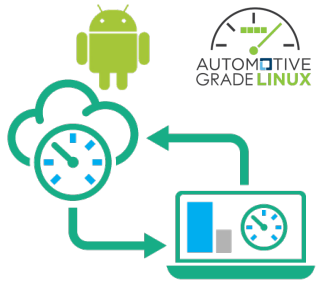
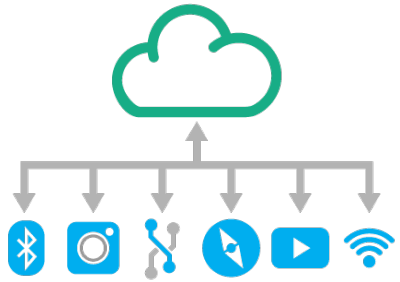
➔ Achieving binary compatibility in cloud-automotive hardware through VirtIO

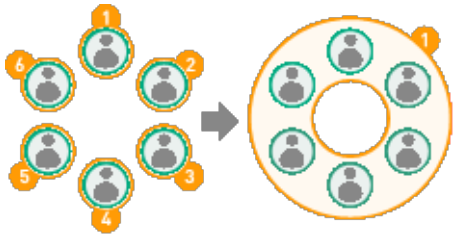




Fully VirtIO Compliant Virtual CDC Reference Platform



Various Virtual Peripheral Devices supported



Multiple vSkipGens on the same cloud server

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AGL in the frontier of Automotive VirtIO since 2018

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- Healthy Eco-system Concept w/VirtIO @2018
- Peripheral Device Coverage for Automotive
- AGL UCB on VirtIO since 2020
- VirtIO-compatible Virtual Hardware in the Cloud @2021
- Unified Virtual Display System (UnifiedHMI)　@2022
- System Diversity Support, Performance
- Led to “SoDeV” @2025

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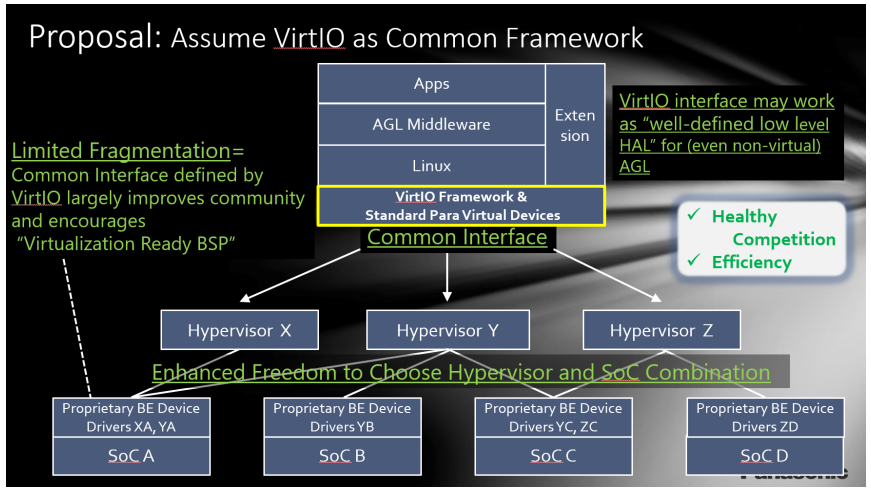
The Vision is getting Reality!!

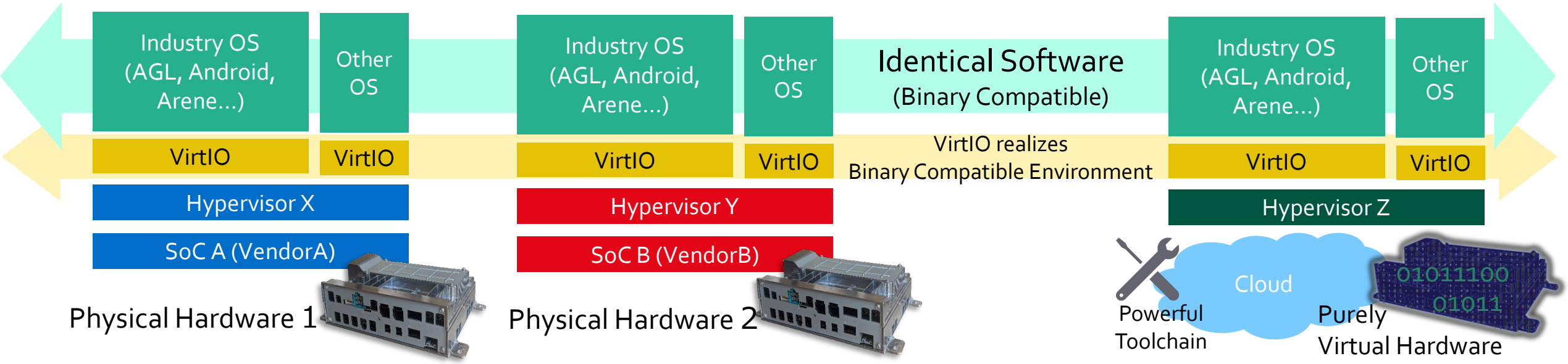
- 1st Proposal: Keynote @2018 Spring AMM
- Included in AGL UCB since 2020
- Virtual HW in the cloud available since 2023 (vSkipGen)

Now, we are making a steady progress toward:

- Software First! w/Freedom of Choice of Hardware
- Explosive Development Speed! w/Cloud Native Development



excerpts from keynote @2019 fall AMM



Strong Supports and Endorsements for VirtIO

has expanded over the Semiconductor Industry.

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SoCs

AMD

intel.

MEDIATEK

Qualcomm

RENESAS

SAMSUNG

Telechips

Core IPs

arm

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Moreover, more vehicles cockpit becoming fully VirtIO'ed

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- Some, already very close to be SOP
- Others, platform under development

VirtIO

VirtIO

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Not only API but also VirtIO is critical for healthy ecosystem

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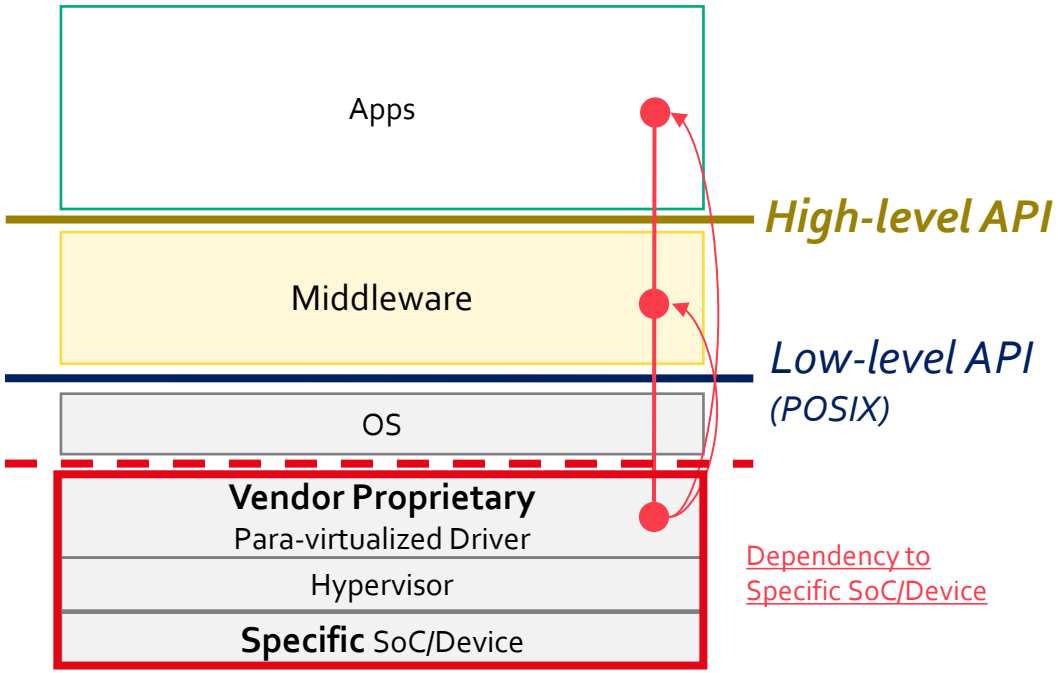
Issue: Dependency on vender specific hardware can remain even in compliance with Standard API



- **Syntax** Level Compatibility: assured by POSIX
- **Semantic** Level Compatibility
  for Peripheral Devices needs additional scheme
- We need ***BOTH*** for healthy ecosystem

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Not only API but also VirtIO is critical for healthy ecosystem

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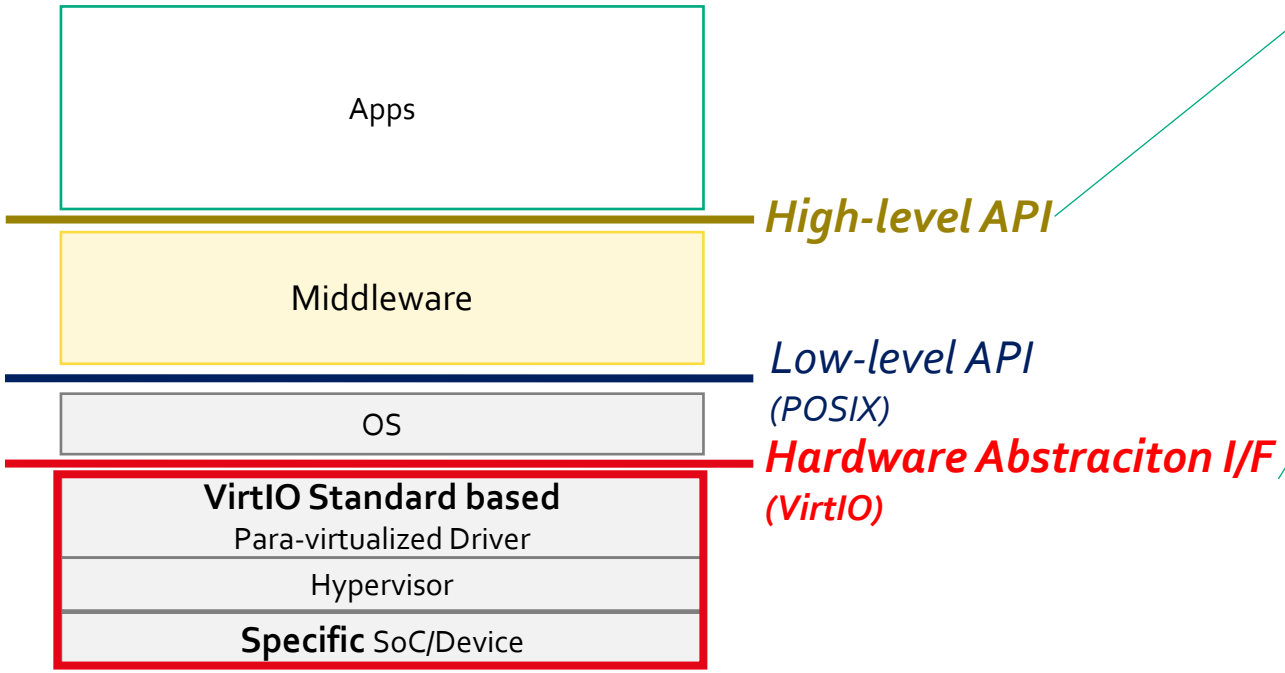
Introduce VirtIO to Bring Semantic Level Compatibility for Peripheral Devices



For healthy **Apps Ecosystem** supported by rich domain functionality of middleware

For healthy **Hardware Ecosystem** and ***Software First*** *w/***Purely Virtual Hardware**

- semantic compatibility by VirtIO HAL and standard I/F
- VirtIO front-end reference standard implementation is open sourced for each device type
- VirtIO back-end is hardware dependent

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VirtIO and S-Core: Key Complementary Pieces

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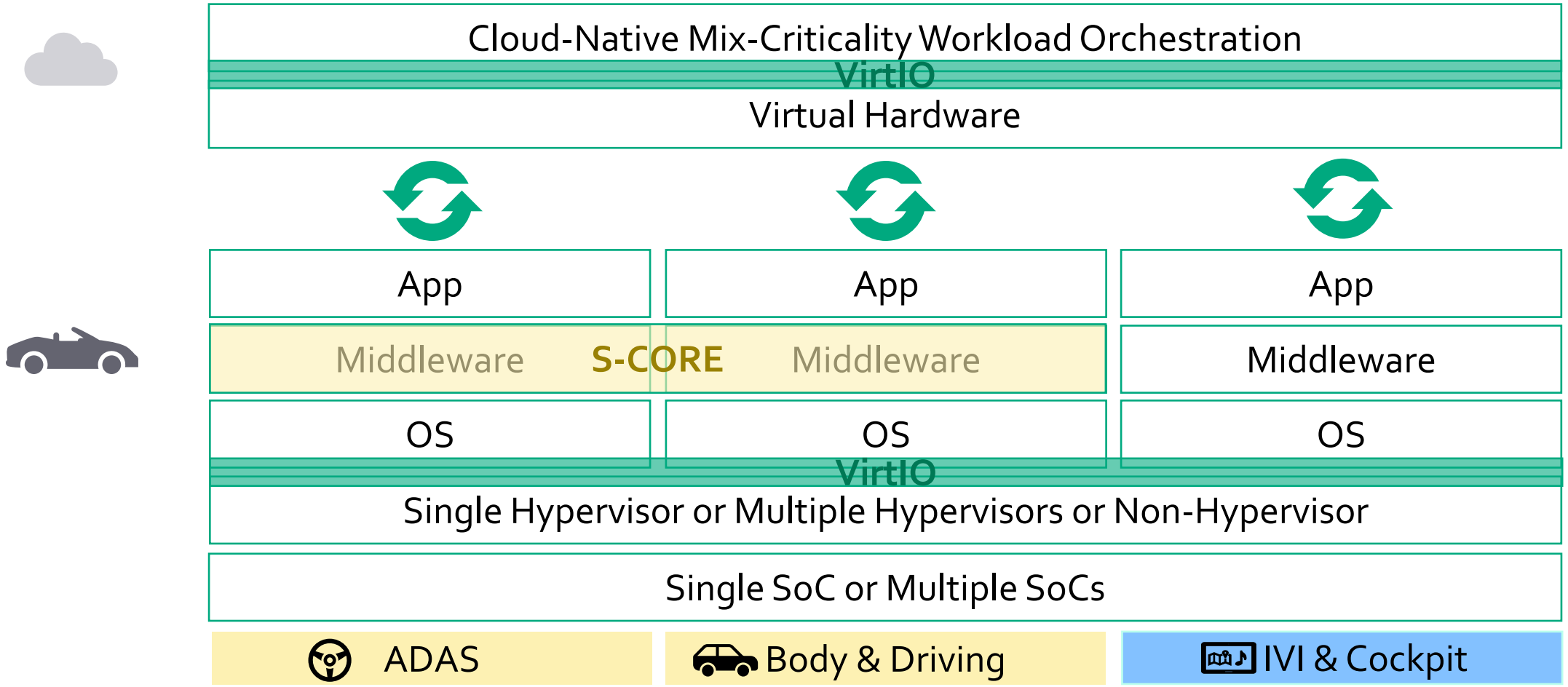
VirtIO to provide common & standard low-level HAL implementation, enabling SW/HW decoupling.
S-CORE to provide common & standard high level API with rich functionality to vehicle applications.



UX Design ... All you need is *Agility.*

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Display Virtualization Technology “Unified HMI”

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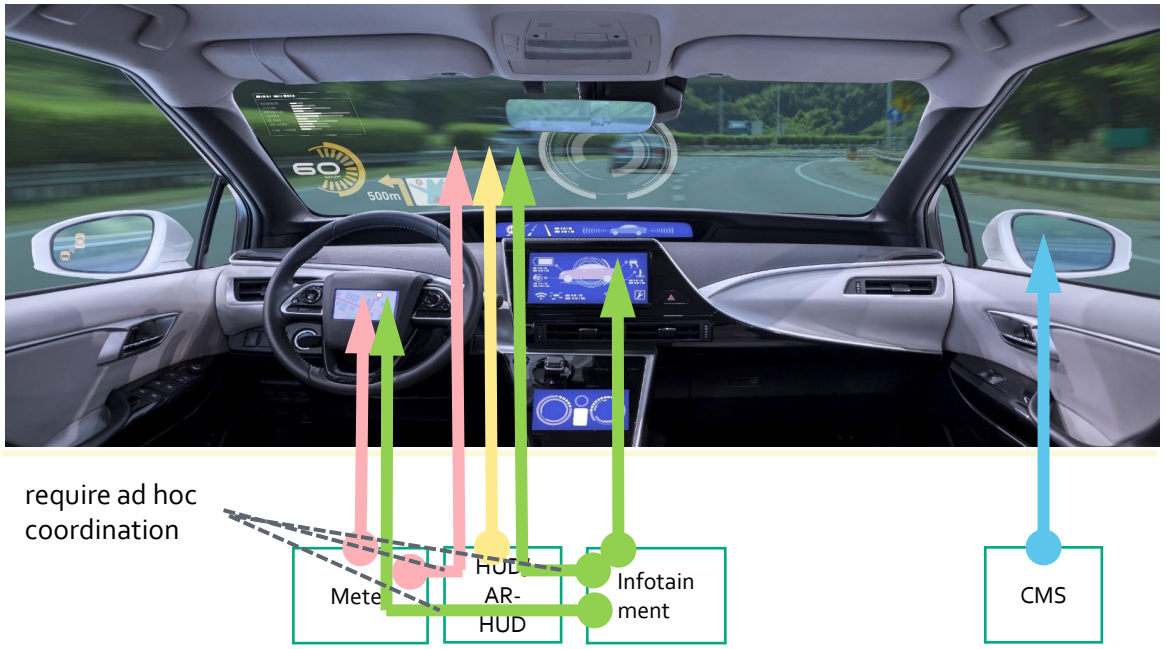
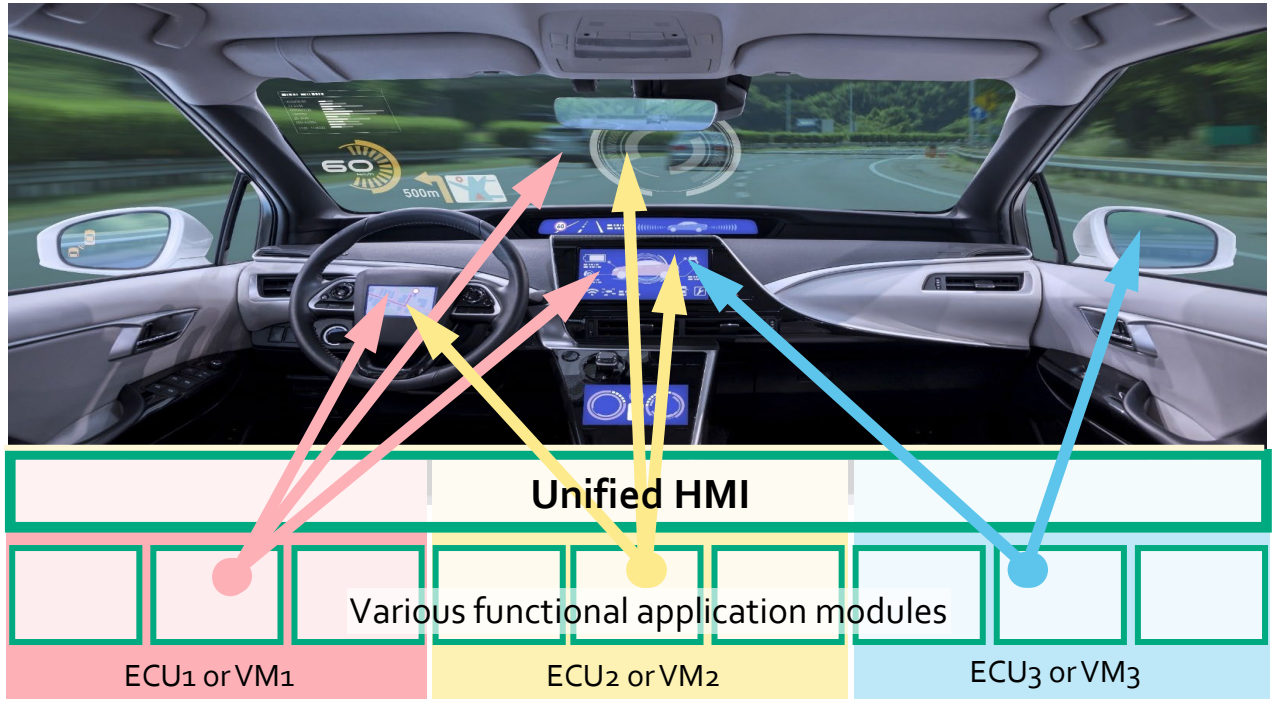
Developing virtual display technology “Unified HMI” to accelerate the evolution of cockpit UX

-Promotion of adoption within industry through open-source’ing :

Strict Restriction on ECU & Function-Display Relationship causing harmful Impediment for Cockpit UX



Full Flexibility on ECU & Function-Display Relationship for Cockpit UX Innovation



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Further Challenges with Virtualization Technologies

Coupling and *De*coupling for Extended Values

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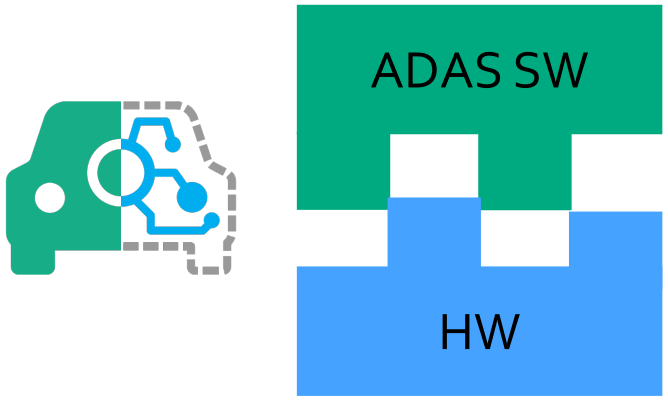
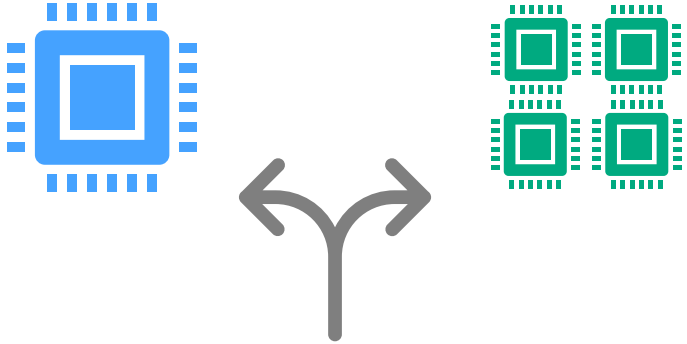
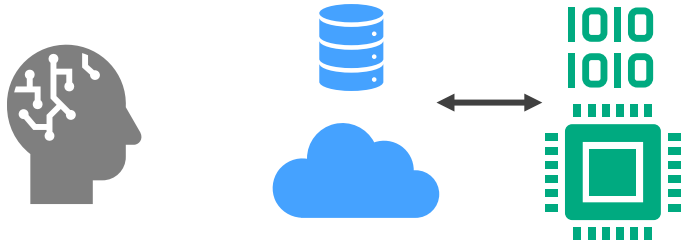
*DE*coupling of ADAS/HW.



*DE*coupling from Sys. Arch.



*DE*coupling of AI/HW



Coupling of Cloud-native/Models

Coupling of Cloud-native with MBD Models or Other Simulated External Systems

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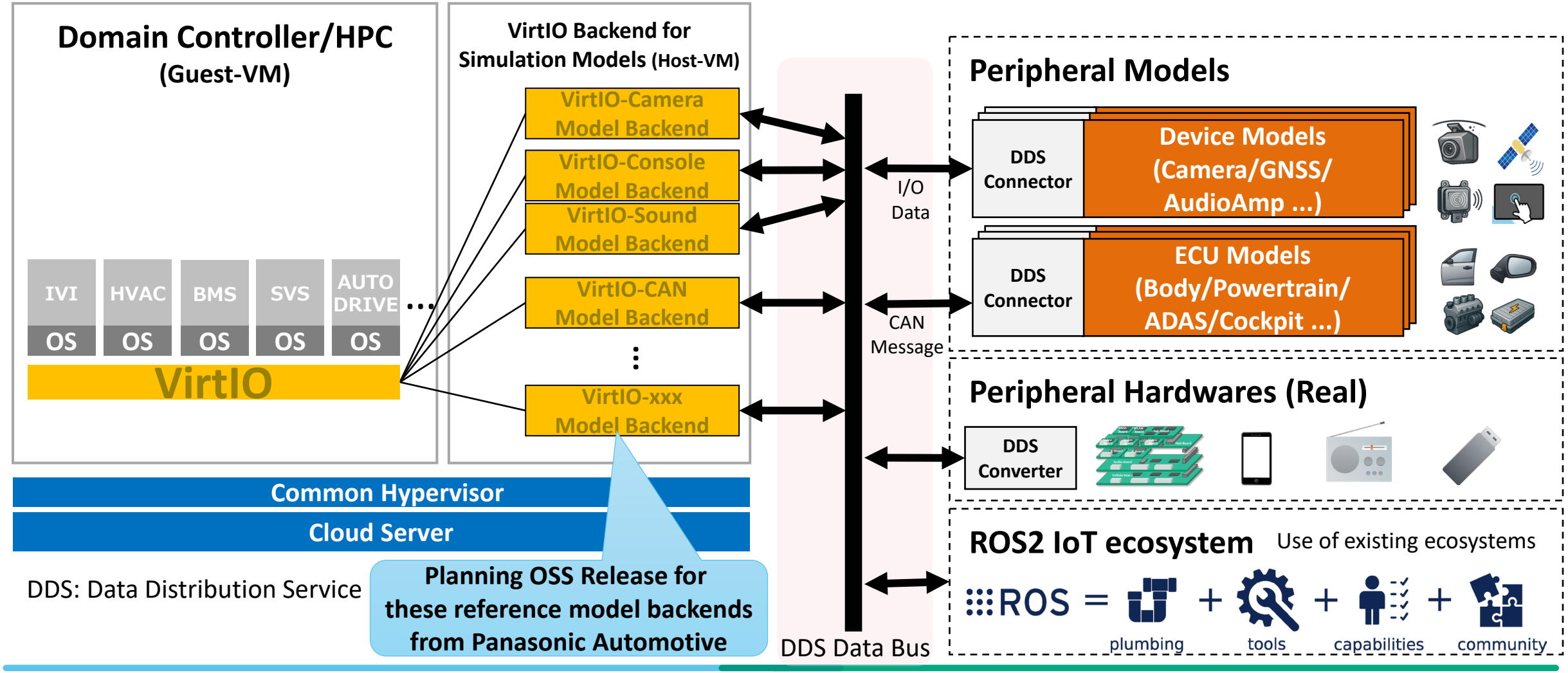
Accelerate model standardization and reuse through a VirtIO-compliant Model interface backend



source: https://www.ros.org/blog/ecosystem/

AGL has been continuously working on SDV

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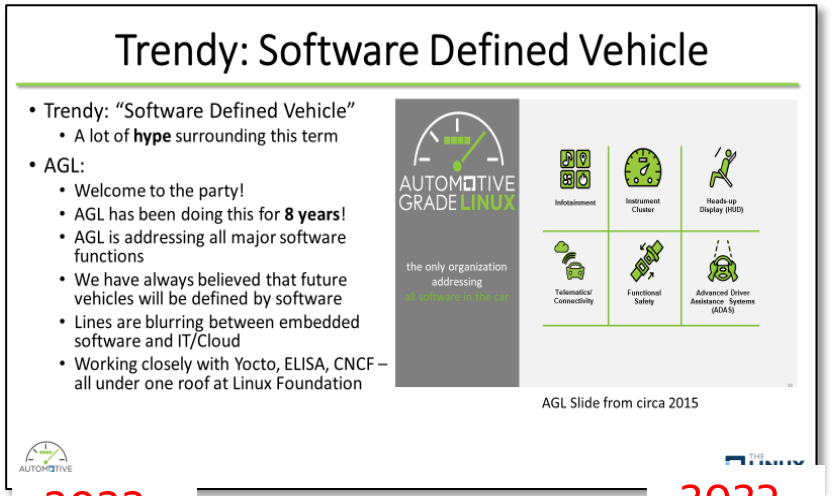
Since the foundation of AGL, the community has been taking the concept of "Software-Defined" into practice and continuously incubated or evolved **technology enablers** for SDV in terms of "Application Framework" and "Hardware Virtualization Framework".

The key characteristics of AGL is "**Code First**".



Applications

Application Framework

Operating Systems

Hardware Virtualization Framework

Hardware

2022
Flutter
Cross-platform OSS UI software development kit

2022
gRPC
Global IPC framework enabling various use cases like remote desktop/workload orchestration

2023
KUKSA.val
Common I/F for CAN signals easy to customize and extend by overlaying JSON files

2020
VirtIO
Standard device virtualization framework to abstract devices in various hardware architectures

2023
Unified HMI
Virtual display technology to abstract displays cross-VM and cross-ECU

2024
Cloud AGL
AGL UCB running at Public Cloud (e.g AWS Graviton)

2025 **New!**
SoDeV
AGL Reference Platform for SDV, integrating all existing AGL key virtualization components above while incubating new innovation with other key SDV pieces born in Linux Foundation, such as "Xen" and "Zephyr".

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AGL SDV Reference Platform – Action in AGL as Integrator & Incubator

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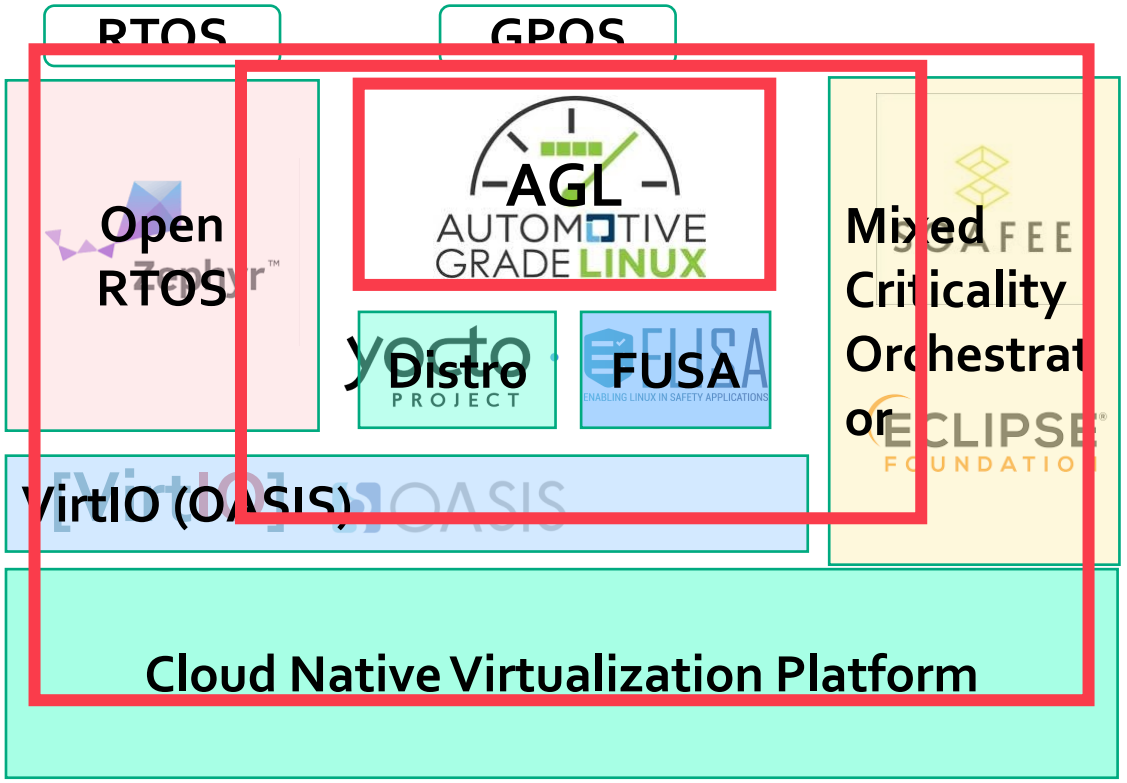
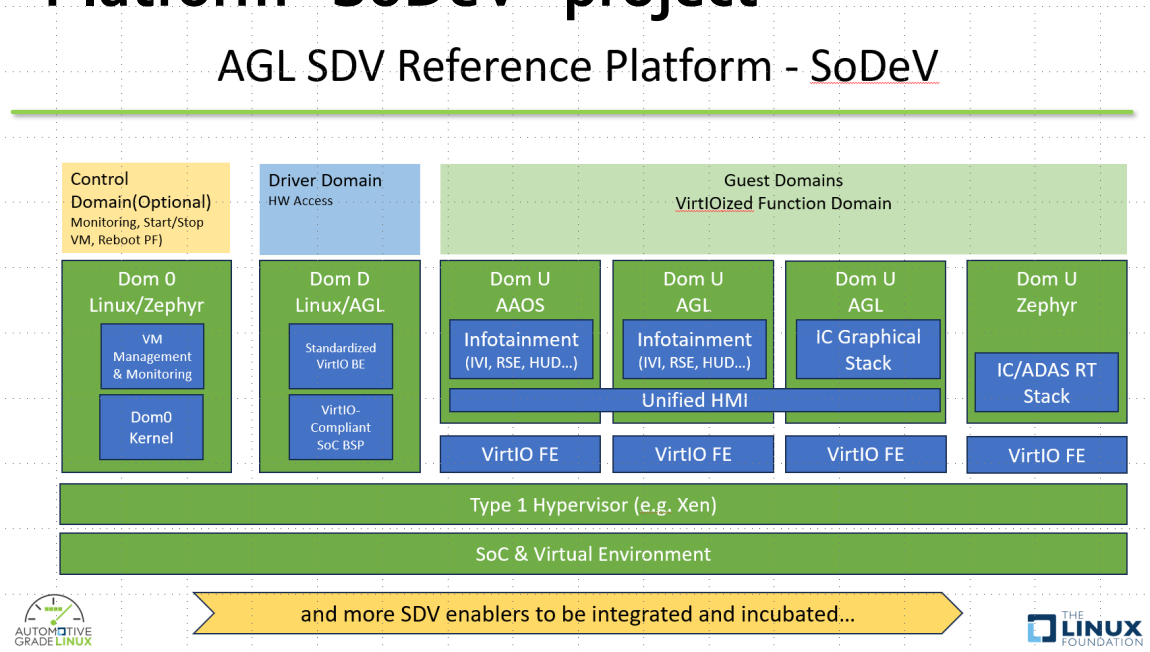
- As a code-first community, AGL is a Great Integrator & Incubator of key technologies enabling SDV from Linux Foundation and other communities (SOAFEE, Eclipse, COVESA and etc.)

2024/7 Berlin AMM Panasonic Keynote



2025: Launch of AGL SDV Reference Platform "SoDeV" project



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Expanding SDV Horizons: Complementary Strengths of S-CORE, AGL & SOAFEE

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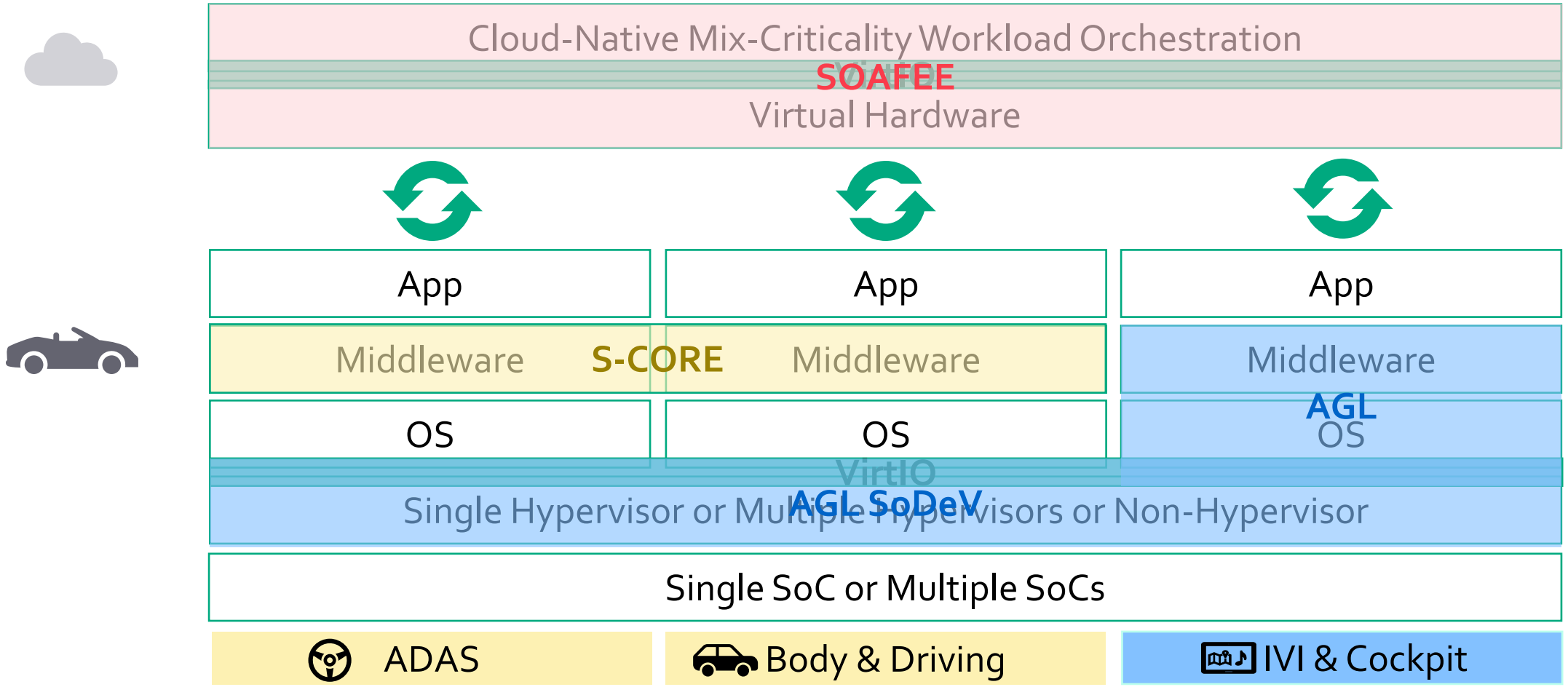
The combination of S-CORE, AGL, and SOAFEE covers broader SDV domains and contributes to a more standardized ecosystem. Our strengths are complementary, not competitive.



Increasing Panasonic Automotive's Engagement in Community Activities

- ✓ **PAS individually joined Linux Foundation as a Gold Member**

Panasonic Automotive Systems Joins the Linux Foundation as a Gold Member

THE LINUX FOUNDATION | 15 APRIL 2025

ANNOUNCEMENT

Linux Foundation Welcomes Panasonic Automotive as a Gold Member

Panasonic AUTOMOTIVE

THE LINUX FOUNDATION

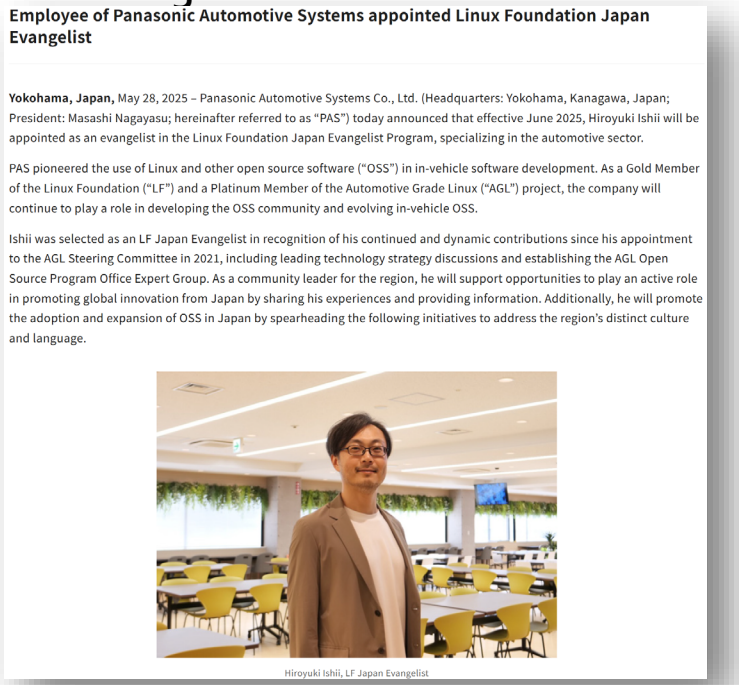
Panasonic Automotive Systems Aims to Expand Open Source Engagement and Initiatives in Japan and Around the World.

SAN FRANCISCO – April 15, 2025 – The Linux Foundation, the nonprofit organization enabling mass innovation through open source, welcomes Panasonic Automotive Systems Co., Ltd (PAS) as a Gold Member of the foundation. PAS was established in April of 2022 as an operating company responsible for the automotive systems business of the Panasonic Group's operating company system, and is helping to create comfortable, safe, and secure automobiles.

"We're pleased to welcome Panasonic Automotive Systems as a Gold Member of the Linux Foundation," said Jim Zemlin, Executive Director of the Linux Foundation. "Their leadership in automotive innovation and ongoing contributions to open source reflect the growing importance of collaborative software development in the mobility sector. We look forward to working with PAS as they help shape the future of software-defined vehicles in Japan and globally."

Source: https://www.linuxfoundation.jp/press-release/2025/04/panasonic-automotive-systems-joins-the-linux-foundation-as-a-gold-member/

- ✓ **Hiroyuki Ishii became the 5th Linux Foundation Japan Evangelist**



Employee of Panasonic Automotive Systems appointed Linux Foundation Japan Evangelist

Yokohama, Japan, May 28, 2025 – Panasonic Automotive Systems Co., Ltd. (Headquarters: Yokohama, Kanagawa, Japan; President: Masashi Nagayasu; hereinafter referred to as "PAS") today announced that effective June 2025, Hiroyuki Ishii will be appointed as an evangelist in the Linux Foundation Japan Evangelist Program, specializing in the automotive sector.

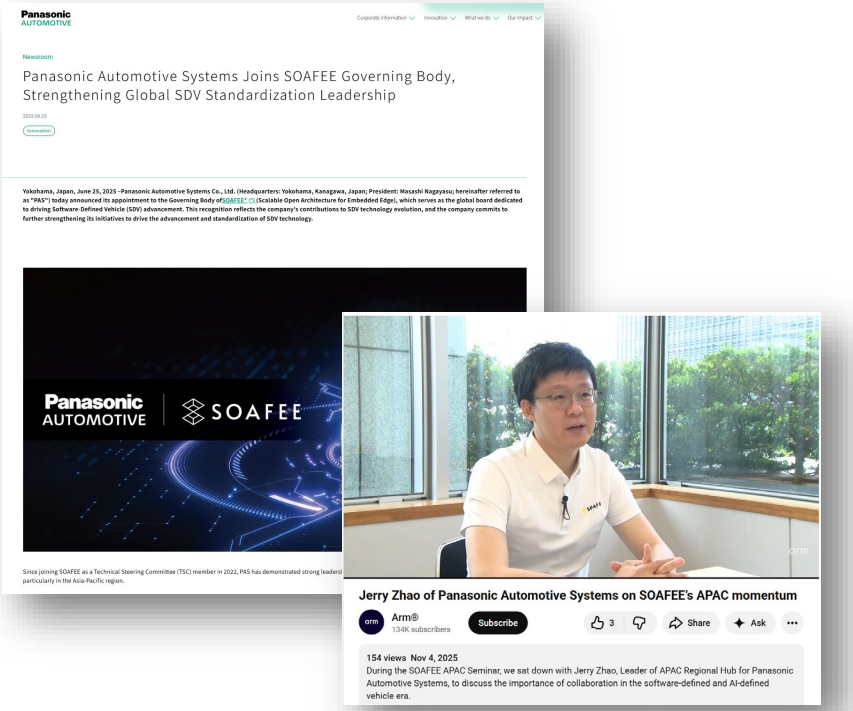
PAS pioneered the use of Linux and other open source software ("OSS") in in-vehicle software development. As a Gold Member of the Linux Foundation ("LF") and a Platinum Member of the Automotive Grade Linux ("AGL") project, the company will continue to play a role in developing the OSS community and evolving in-vehicle OSS.

Ishii was selected as an LF Japan Evangelist in recognition of his continued and dynamic contributions since his appointment to the AGL Steering Committee in 2021, including leading technology strategy discussions and establishing the AGL Open Source Program Office Expert Group. As a community leader for the region, he will support opportunities to play an active role in promoting global innovation from Japan by sharing his experiences and providing information. Additionally, he will promote the adoption and expansion of OSS in Japan by spearheading the following initiatives to address the region's distinct culture and language.

Hiroyuki Ishii, LF Japan Evangelist

Source: https://news.panasonic.com/global/press/en250528-3

- ✓ **PAS joins SOAFEE Governing Body and Jerry Zhao leads APAC Regional Hub**
- ✓ **Enable future "code-first" collaboration**



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Newsroom

Panasonic Automotive Systems Joins SOAFEE Governing Body, Strengthening Global SDV Standardization Leadership

Panasonic AUTOMOTIVE | SOAFEE

Jerry Zhao of Panasonic Automotive Systems on SOAFEE's APAC momentum

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154 views Nov 4, 2025

During the SOAFEE APAC Seminar, we sat down with Jerry Zhao, Leader of APAC Regional Hub for Panasonic Automotive Systems, to discuss the importance of collaboration in the software-defined and AI-defined vehicle era.

Source: https://automotive.panasonic.com/en/newsroom/soafee

Four-Level Model for Utilizing Open Source (in my opinion)

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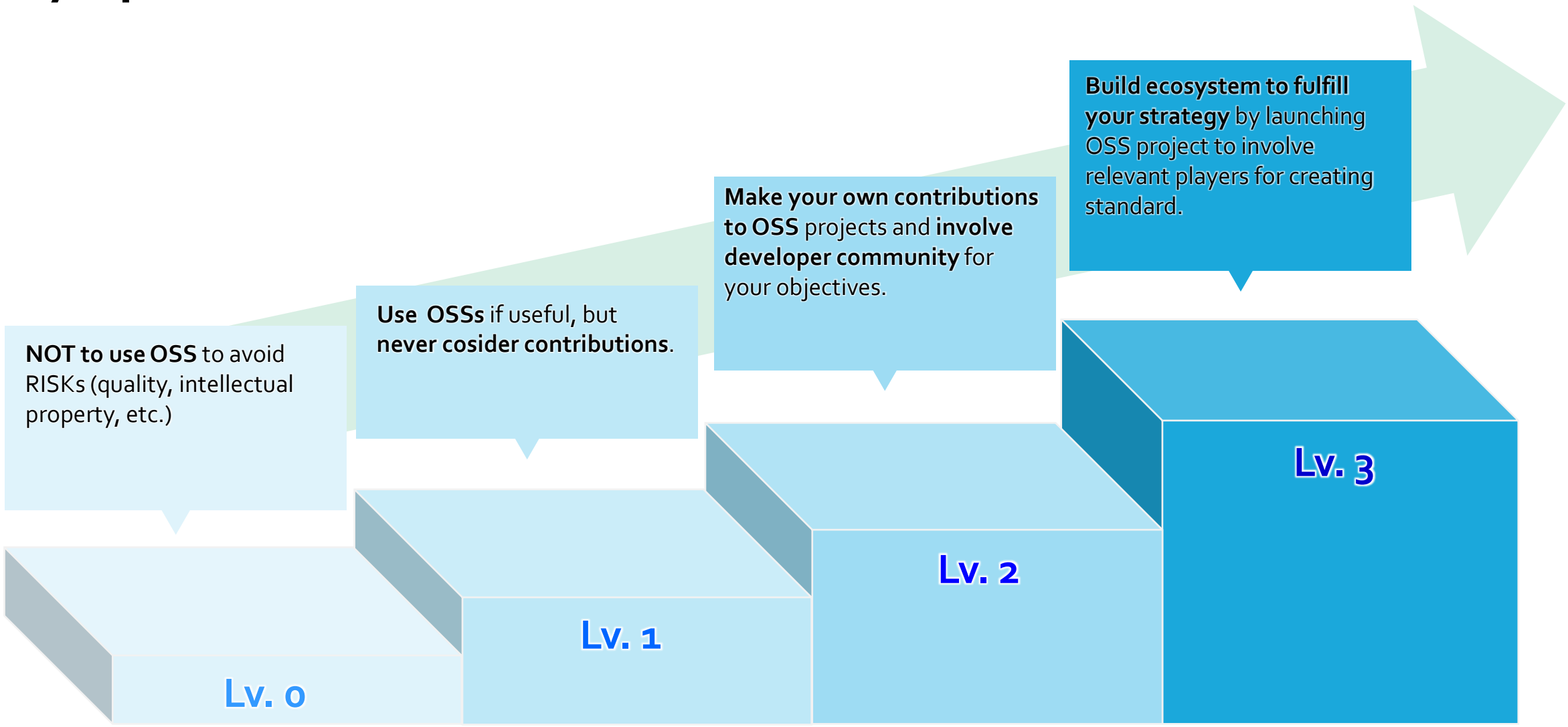

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Heartmotive

Connecting our hearts to the Journey