Software-Defined Vehicle Support and Coordination Project

D4.5 Strategic Roadmap – Second Version
M24

Authors: Bugar Andreas (CONTI), Cuenot Philippe (CONTI), Khalaf Ahmed (CONTI), Niklas-Hoeret Michael (CONTI)

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WP Leader	Jan Kubovy | BMW
Deliverable Leader	Andreas Bugar, Philippe Cuenot | CAG, CAF
Contact Person	Andreas Bugar
Email	Andreas.Bugar@aumovio.com

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Table of Contents

1 Executive Summary

This deliverable document the objectives, guiding principles and expected results of the SDVoF initiative, with related contributions of the SDV Associations and European projects involved in the vision of future for SDV. It details the contribution of those projects in the coordination action of the FEDERATE project, and draft recommendation for the related and follow up general action.

An initial version of the strategic roadmap was published in February 2025. This updated edition highlights the key changes and developments since the first release and provide insights on new projects. An overview of key updates regarding the previous edition of this document is provided in 2.2.

2 Introduction

2.1 Introduction – Purpose of This Document

In late 2022, the European Directorate-General for Communications Networks, Content, and Technology launched a consultation process that led to the creation of the "Software Defined Vehicle of the Future (SDVoF) initiative." As part of this effort, the FEDERATE team developed a vision and roadmap document to support the initiative's foundation.

This deliverable presents a strategic roadmap designed to realize the vision of a robust SDV ecosystem. It outlines the optimal combination of publicly funded collaborative projects, consortia, and foundations necessary to address the challenges ahead. The roadmap is based on valuable input from various consortia and projects, whose contributions we gratefully acknowledge.

An initial version of the strategic roadmap was published in February 2025. This updated edition highlights the key changes and developments since the first release.

2.2 Summary of Strategic Roadmap Updates Since D4.4

This chapter provides a consolidated overview of the key updates, additions, and changes made in this updated version of the Strategic Roadmap (D4.5), compared to the previous version (D4.4, published in 2024). It highlights the evolution of the SDVoF ecosystem, new project contributions, and enhanced collaboration mechanisms.

2.2.1 Structural Enhancements

The scope of project coverage has been expanded

New projects added in Chapter 5.2:

- Shift2SDV (5.2.2)
- RIGOLETTO (5.2.3)
- Code4SDV (5.2.4)
- TwinLoop (5.2.5)
- UP2DATE4SDV (5.2.6)
- EEA4CCAM (5.2.7)
- S-CORE (5.2.8)
- AUTOSAR CAPI (6.2.9)

Several new sections have been introduced to improve clarity and traceability:

- Chapter 6.2: Key information of OEMs and Tier1s on SDVoF roadmap
- Chapter 7: Overview of OEM and Tier1 participation

2.2.2 Content Updates

Contributions from existing projects have been revised and expanded

- HAL4SDV (5.2.1): Now in its second year, with proposal high level roadmap and deliverables.
- 2ZERO (5.1.1), CCAM (5.1.2): Revised based on updated Horizon Europe calls, new selected project and concrete synchronisation actions.
- Eclipse SDV (5.3.1): Expanded to include new projects like S-CORE and OpenSOVD.
- COVESA (5.3.2) reviewed with roadmap alignment and governance contributions.

- AUTOSAR (5.3.3) reviewed and updated considering discussion of Common AUTOSAR Adaptive Platform Implementation (CAPI) more documented in 6.2.9.

New roadmap tables have been added to enhance visibility

- HAL4SDV deliverables timeline (5.2.1.5)
- OEM participation across projects and associations (Chapter 7)
- Discussion on European Connected and Autonomous Vehicle Alliance (ECAVA) related to mission in relation to SDVoF future (Chap 7.2.2)

2.2.3 Collaboration and Governance

Synchronization efforts have intensified across projects:

- Monthly meetings between HAL4SDV, Shift2SDV, and FEDERATE (5.2.2, 5.2.1)
- Joint publications and events (e.g., TRA'26, ADTC, SDV Ecosystem Summit) mentioned across 5.2.4, 5.2.5

Governance mechanisms have been strengthened

- Introduction of the External Experts Advisory Board (EEAB) (5.2.1.5)
- Use of Eclipse Foundation Specification Process (EFSP) for open specifications (5.2.1.5)
- Participation of FEDERATE members in the ECAVA discussion (7 & 8)

2.3 Definitions

Table 1: Definitions, Acronyms, Abbreviations

Definitions, Acronyms, Abbreviations	Meaning
AUTOSAR	Automotive Open System Architecture
COVESA	Connected Vehicle Systems Alliance
ECAVA	European Connected and Autonomous Vehicle Alliance
E/E	Electrical and Electronic
HMI	Human Machine Interface
HW	Hardware
HPC	High Performance Computer
ODD	Operational Design Domain
SOAFEE	Scalable Open Architecture for Embedded Edge
SDV	Software Defined Vehicle
SDVoF	Software Defined Vehicle of the Future
SRIA	Strategic Research and Innovation Agenda
SW	Software
R&I	Research and Innovation

3 Document Structure

The document is structured in three sections:

- Section 1: Chapter 5 provides an overview of the objectives, guiding principles and expected results of the SDVoF initiative. This lays the foundations for further contributions of SDV Associations and European projects that pursue the vision of the initiative.
- Section 2: Chapter 6 lists not only different SDV Associations and European projects which will contribute to the vision, but it describes as well how they are planning to contribute to the objectives and guiding principles of the SDVoF initiative.
- Section 3: Chapter 7 and 8 will conclude with recommendations how the vision can be achieved by the different SDV Associations and European Projects. Emphasis will be on the collaboration between these different bodies.

4 SDVoF Initiative

The SDVoF initiative emphasizes collaboration among European OEMs and suppliers, focusing on non-differentiating elements of the vehicle software stack. By adopting a system-level approach, it aims to foster coordination among existing alliances and to establish strong connections with EU initiatives related to open automotive hardware, connected, and automated vehicles, and zero-emission mobility. This collaboration is intended to create a robust ecosystem. Additionally, the initiative will integrate open-source software where appropriate, enhancing innovation and development efficiency across the automotive industry.

This chapter describes the objectives, guiding principles and expected results of the SDVoF initiative. It concludes with the proposed development phases of the SDVoF initiative.

4.1 Objectives and Goals of the SDFoF Initiative

The SDVoF initiative has jointly identified objectives which should serve as a foundation for other SDV initiatives.

4.1.1 Objective 1: Improving Agility and Automotive Grade Quality in (Hardware and) Software Development

Automotive software, both onboard and increasingly offboard, has always demanded exceptionally high quality, reliability, and dependability due to its safety-critical nature. Vehicles must adhere to stringent safety and security standards, emphasizing rigorous development methods, processes, verification, and validation. The primary goal of this initiative is to enhance development agility while maintaining automotive-grade quality.

Open source plays a vital role in the global software industry. The success of the Linux operating system and many cloud software systems demonstrates how open-source approaches can enhance agility and development speed. Therefore, the SDVoF initiative embraces open-source wherever beneficial. Open-source software (OSS) projects offer global access, attracting top talent and creating expert ecosystems essential for the industry. Additionally, the "code-first" approach ensures that standardization and industrialization efforts are focused on successfully implemented, integrated, and tested software components.

The initiative aims to avoid unnecessary, costly developments by utilizing available components and concepts. Collaboration with relevant initiatives such as COVESA, SOAFEE, AUTOSAR, and ECLIPSE-SDV is essential.

4.1.2 Objective 2: Reduce Time-to-Market and Development Costs by Collaboration

Collaboration in non-differentiating areas, combined with automation where useful, across the entire software lifecycle—from inception via development to maintenance and field monitoring—will enhance development agility, reduce costs, and accelerate time-to-market across OEM and Tier boundaries.

4.1.3 Objective 3: Support New Business Models in the Automotive Industry enabled by the Open SDVoF Platform

As software-defined vehicles receive over-the-air updates and functional extensions throughout their operational lifetime, new service-oriented business models emerge in the automotive industry. The SDVoF software structure and components will support these new business models.

4.1.4 Objective 4: Fostering Open Communities for Collaborative Creation of Open SDV Source SW Components

Collaborating with existing open-source initiatives and creating new communities will build a vibrant open-source ecosystem for SDVoF software components. Aligning closely with the "High-Performance Automotive RISC-V Reference Platform" initiative will accelerate the adoption of new European SDV-HW platforms.

4.1.5 Objective 5: European Strategic Autonomy in SDV-HW and SDV-SW

Creating a European SDV software ecosystem with a common structure and open-source components will ensure European strategic autonomy in SDV software. Similarly, the "High-Performance Automotive RISC-V Reference Platform" initiative will ensure autonomy in SDV hardware.

4.1.6 Objective 6: Joined Effort of Industry and Public Authorities for the Design and Implementation of an Open SDV Platform

Public-private cooperation in funded projects under the SDVoF initiative will create a level playing field for the European SDV industry in global competition. Using common building blocks, a standard SDV software structure, and agreed interfaces will enhance interoperability and reduce vendor lock-in, fostering fair competition. Relying on open source and ensuring transparency will allow broader participation in the ecosystem.

4.2 Guiding Principles SDVoF

The following guiding principles are defined in SDVoF Vision paper [1] For detailed description of the guiding principles please see the SDVoF document:

- Collaborative development of open non-differentiating building blocks
- Open-source and Code-first
- Agility and speed through rapid demonstration in representative use cases
- HW/SW abstraction and virtualization
- Working in a common structure of the SDV SW stack
- Tools and tool chains designed for the SDV of the Future
- Support of the collaborative development of high-performance (open) SOCs designed for SDVoF
- Close collaboration with existing initiatives to avoid “reinventing the wheel”
- Defined governance of the SDVoF initiative
- Participation in the SDVoF ecosystem

4.2.1 Structured SDV SW stack

The initiative has agreed on a three-layer structure for SDVoF HW/SW stacks as depicted in Figure 1.

Layer 1 (SDV-Hardware):

This layer includes all hardware components such as HPCs and domain controllers, and the software abstraction of their resources required for AI-based software across various automotive domains, meeting requirements like non-safety critical, safety critical, security, and energy efficiency.

Layer 2 (SDV-middleware & hardware abstraction & OS):

This layer, the main focus of the SDVoF initiative, consists of primarily open-source software building blocks that connect the hardware layer to the applications layer, allowing separate development cycles for hardware and software. It ensures the safe execution of layer 3 applications and can integrate with existing OEM software stacks. As applications often have both on-board and cloud components, a service-oriented interface layer will exist in the cloud. Layer 2 includes two sub-layers: 2a) hardware abstraction, virtualization, and OS, and 2b) SDV middleware and API framework.

Layer 3 (SDV-Applications):

This layer includes differentiating applications for automotive domains like infotainment, automated driving, advanced driver assistance, chassis and powertrain control, user interfaces, e-charging, routing, and comfort functions. Many applications have components both onboard the vehicle and in the cloud.

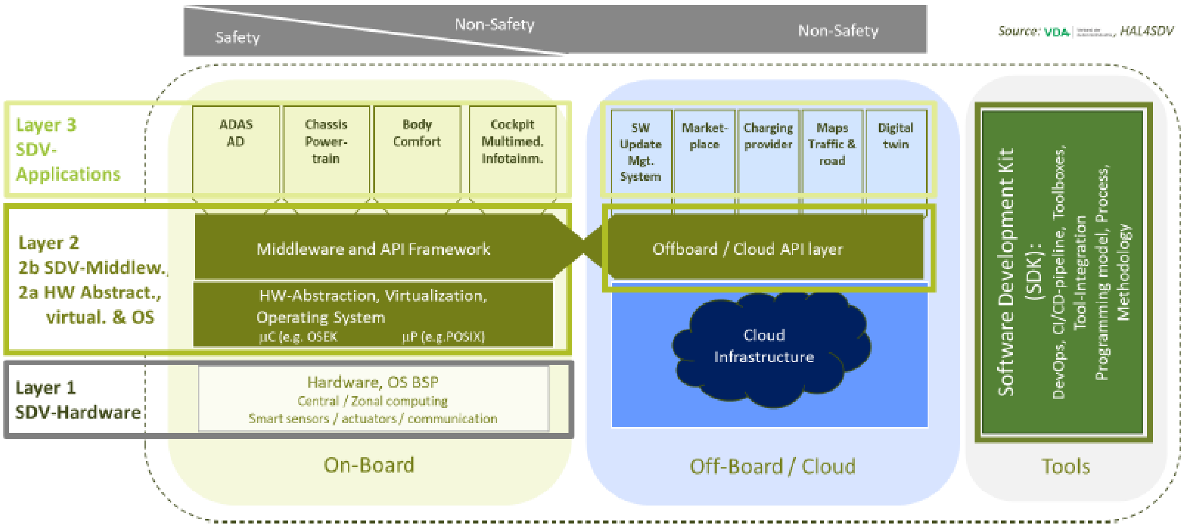

Figure 1: Basic structure of SDVoF HW/SW stack

4.3 Expected Results SDVoF

The following results are requested by the SDVoF initiative:

- Large positive impact on the open SDV communities and SDV tool ecosystem
- Pool of open automotive grade building blocks for SDV SW stacks (bottom-up approach)
- Reference SW stack composed of SDVoF building blocks (top-down approach)
- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF

4.4 Proposed Development Phases within the SDVoF Initiative

The SDVoF initiative outlines a comprehensive development process divided into three distinct phases:

4.4.1 HW/SW Abstraction

This initial phase focuses on creating a clear separation between hardware and software components. By abstracting hardware functionalities, the initiative aims to enhance interoperability and flexibility. This abstraction layer ensures efficient integration of various hardware platforms while maintaining compatibility with the evolving software stack.

The SDVoF initiative aims to provide a modular and scalable software architecture for OEMs and Tier 1 suppliers to build SDV systems. By decoupling software functions from hardware, the initiative reduces dependencies and vendor lock-in. However, being hardware agnostic does not mean ignoring hardware; requirements must be defined from the SDV application perspective, utilizing emerging hardware features for performance, functionality, safety and security. While hardware requirements should be fixed early, SDV software application requirements will evolve over the vehicle's lifetime.

4.4.2 Middleware and API Framework

The second phase involves building a robust middleware layer that bridges the hardware/OS and application layers. This standardized middleware stack provides essential services such as communication protocols, security mechanisms, and data management. Additionally, an API framework ensures seamless interaction between different software modules, facilitating efficient development and integration.

4.4.3 DevOps Tool Chain

The final phase emphasizes automation throughout the software development lifecycle. An integrated DevOps toolchain simplifies the adoption and use of new software layers, streamlining processes such as continuous integration, testing, deployment, and monitoring. By automating these steps, the SDVoF initiative accelerates development cycles, enhances quality, and ensures timely updates.

5 Relationship and Contribution of SDV Associations and European Projects

This chapter focuses on how the SDV Associations and European projects contribute to the Guiding principles and expected results of the SDVoF Vision. Additionally, it elaborates the aspect how the collaboration and relationship between FEDERATE and the SDV Associations/European projects is implemented so far and what could be further improved.

The guiding principles of the SDVoF Vision document are summarized in chapter 5.2, the expected results are summarized in Chapter 5.3.

The SDV ecosystem operates through multiple phased projects, each addressing different layers (see 5.2.1) to develop the non-differentiating building blocks, reference implementations defined by the SDVoF initiative, and building blocks for SDV DevOps tool chains.

Figure 2 illustrates the sequence of already started or planned projects and partnerships in the scope of the SDVoF initiative.

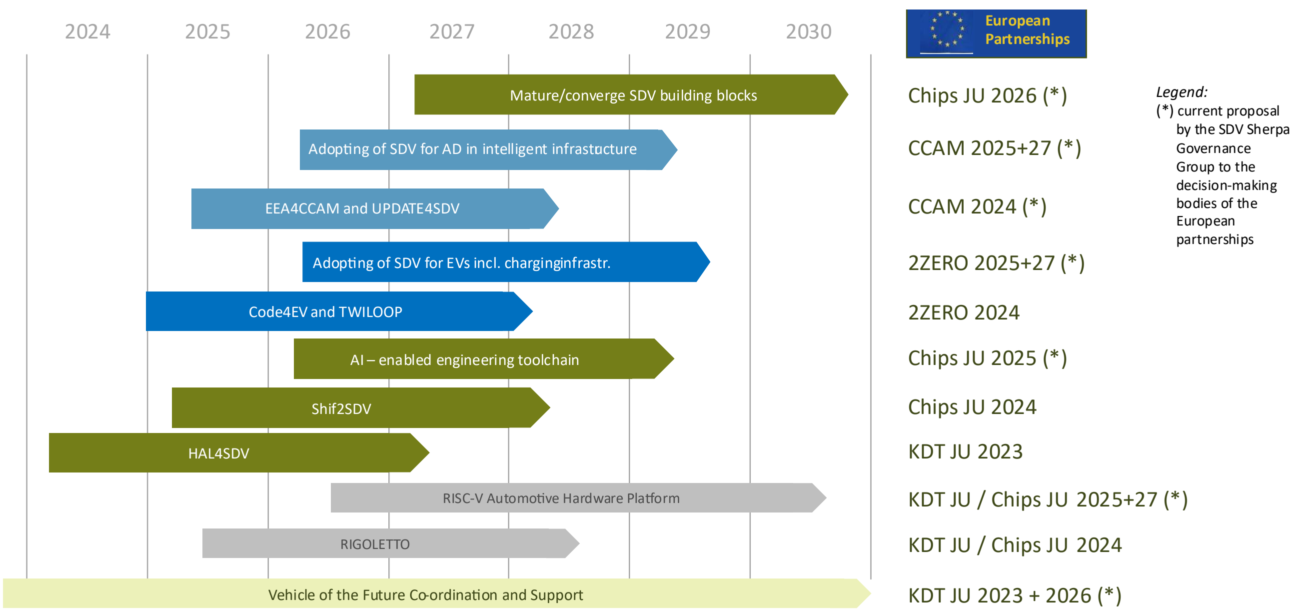

Figure 2: Overview of the SDVoF initiative

5.1 European Partnerships

5.1.1 2ZERO

5.1.1.1 Updates in 2025

Following discussion with 2ZERO association member the collaboration and relationship to SDVoF chapter was revised according to updated Horizon Europe calls, and with concrete actions for 2ZERO labelled project.

5.1.1.2 General Introduction

The 2Zero (Towards zero emission road transport) is a partnership [2] aiming at accelerating the transition towards zero tailpipe emission road mobility across Europe. The 2Zero partnership promotes and facilitates pre-competitive research and innovation on road transport mobility within the European Research Area with the supports of European Technology Platforms (ERTRAC, EPoSS, ETIP-SNET, ALICE and Batteries Europe) related to smart mobility services, vehicle technologies, propulsion solutions, energy systems, battery technologies, sustainability focus, and circular economy for zero emission vehicles.

The 2ZERO partnership publishes a Strategic Research and Innovation Agenda as a reference document with regular update, considering the roadmap of the overarching technology platform, that allows to submit innovation topics to the European Commission as co-program for the Horizon Europe funding Framework. It also coordinates the partnership ecosystem and supports the promotion and dissemination of 2Zero labelled funded projects and actions.

The 2Zero activities are organized in four pillars translated in the SRIA agenda as:

- Vehicle technologies and vehicle propulsion solutions for BEV and FCEV,
- Integration of the battery electric vehicle into the energy system and related charging infrastructure,
- Innovative concepts, solutions and services for the zero-emission mobility and goods transportation,
- LCA and circular economy approaches for sustainable and innovative road mobility solutions.

5.1.1.3 Contribution to the SDVoF Guiding Principles and Expected Results

The contribution of 2Zero to the SDVoF vision is based on the identification of potential contributions of Horizon Europe funded projects from the destination 5 “Efficient, sustainable and inclusive energy use” of the Cluster 5 “Climate, Energy and Mobility” work-program. 2Zero is setup in different programs as shown in the SDVoF Roadmap (Figure 2). The focus is to evaluate the impact of the SDV on typical (E-)powertrain controllers, systems, and infrastructure to be considered in the strategic roadmap build in the FEDERATE project.

One of the main challenges is to identify how the E/E architecture moves towards a HPC/Zonal architecture and how it can impact the 2Zero related topics, to enable the identification of the contribution/alignment with FEDERATE building blocks for the strategic roadmap.

The basis of the project guiding principles and results includes the following focus:

- Collaborative development of open non-differentiating building blocks, whereas project calls promote identification and analysis of potential regulatory aspects and barriers for relevant standardisation activities via common, interoperable, and open standards, protocols, and digital services.
- Agility and speed through rapid demonstration in representative use cases.
- Working in a common structure of the SDV SW stack.
- Tools and tool chains designed for the SDV of the future by developing advanced digital tools can enable the mobility industry to efficiently develop and operate software-defined electric vehicles that

are key for achieving sustainable mobility solution. It also covers methods and tools for reliable modelling and simulation of total vehicle systems including its environment.
- Close collaboration with existing initiatives to avoid "reinventing the wheel" by outlining in the proposal close collaboration between selected projects under this architecture and modalities.

5.1.1.4 Collaboration and Relationship to SDVoF

The high-level analysis of SDV relevant topics were identified with the following perspective:

- Short-term with 2Zero topics mostly fixed for 2024 and 2025 calls:
    - Advanced digital development tools to accelerate the development of software defined vehicles in CL5-2024-D5-01-05 call,
    - bi-directional stationary charging for vehicles, where synergies can be exploited with SDV,
    - Cybersecure & resilient EV ecosystem, highly relevant for SDV,
    - Post-Crash management as potentially SDV relevant,
    - Lifetime extension of BEV components (circular economy) where the digital twin is SDV relevant,
    - Energy efficient vehicle designs including (predictive) energy management as SDV relevant,
    - BEV trucks operations (including digital twins) as potentially SDV relevant,
    - CODE4EV and TWINLOOP project selected in 2024 call were identified with potential link related to SDVoF
- Mid-term for the upcoming 2Zero calls 2026 and 2027 with:
    - Identification on focus call related to Vehicle, Charging, Freight, Public transport.
- Proposal to mandate synergies with SDVoF actions in the call text Long-term for new FP10 Framework is documented in section 6.1.3

The collaboration with 2ZERO was defined based the following concepts:

- Present SDVoF visions and FEDERATE activities to 2ZERO members
- Identify selected R&D project under the 2ZERO umbrella related to SDVoF
- Contact project to present FEDERATE GitHub repository federating SDVoF BBs
- Interact with project to identify reused BBs, potential contribution and clarify roadmap and milestone related to SDVoF BBs

5.1.2 CCAM

5.1.2.1 Updates in 2025

Following discussion with CCAM association member, the collaboration and relationship to SDVoF chapter was revised according to updated Horizon Europe calls, and with concrete actions for 2ZERO labelled project.

5.1.2.2 General Introduction

The CCAM (Connected Cooperative and Automated Mobility) partnership [3] aiming at exploiting the full systemic benefits of new mobility solutions enabled by CCAM to increase road safety while reducing congestion and environmental footprint. Its objective is also to help removing societal and administrative barriers to contribute to the acceptance and inclusiveness of transport while ensuring an efficient rollout of technologies and services and demonstrating automated mobility to be ready for deployment. Like 2Zero, related pre-competitive research and innovation on road transport mobility are connected to relevant European Technology Platforms (ETRAC, EPoSS, etc..) and other associations.

The Partnership develops and implements a shared, coherent, and long-term Strategy Research and Innovation Agenda, which defines the process for identifying and prioritizing the research and innovation activities needed to achieve these objectives. This SRIA is the basis for the CCAM Partnership under the Horizon Europe funding framework, co-programmed with the European Commission. Through coordination of the eco-system, it accelerates the development or technology and services and supports the promotion and dissemination of CCAM labelled funded projects and actions.

The CCAM activities are structured in seven Cluster organising the necessary R&I actions:

- “Large scale demonstration” to support the implementation of other cluster results into pilots and living labs experience,
- “Vehicle technology” to deliver safe and reliable future technical solutions,
- “Validation” to provide tools, methods and processes needed by the technologies,
- “Integrating CCAM in the transport system” to develop the infrastructure required for CCAM systems,
- “Key enabling technology” to enable cross-cutting technologies like Artificial Intelligence, Big Data, Cybersecurity,
- “Societal aspect and people need” to consider citizen and societal aspects of such technologies,
- “Coordination” to facilitate knowledge exchange and enables lessons learns.

5.1.2.3 Contribution to the SDVoF Guiding Principles and Expected Results

The contribution of CCAM to the SDVoF vision is based on identification of potential contribution of Horizon Europe funded project from the destination 6 “Safe and Resilient Transport and Smart Mobility services for passengers and goods” of the Cluster 5 “Climate, Energy and Mobility” work-program. CCAM is setup in different programs as shown in the SDVoF Roadmap (Figure 2).

The focus of the alignment shall be to evaluate the identification of FEDERATE planned building block used or generated out of CCAM project results to support the new HPC/Zonal architecture and related infrastructure.

The basis of the project guiding principles and results includes the following focus:

- Collaborative development of open non-differentiating building blocks, whereas projects call promotes international cooperation and coordination between EUs activities and especially other partnerships and harmonization and development of technical standards to promote standardization.
- Agility and speed through rapid demonstration in representative use cases.
- HW/SW abstraction and virtualization in the background of developed technology enabling co-design of hardware, software, and big smart data flow to an emerging framework of the open European software defined platform.
- Working in a common structure of the SDV SW stack as developed vehicle technologies and solutions aim to optimize on board and off-board experience and data access solutions. Projects to strengthen cooperation of OEMs and suppliers to co-design a standard cybersecure electronic architecture with harmonized interfaces.
- Tools and tool chains designed for the SDV of the Future by developing technology to perform verification, validation, and development of proposed solutions.
- Close collaboration with existing initiatives to avoid “reinventing the wheel”.

5.1.2.4 Collaboration and Relationship to SDVoF

The following perspective was identified and shall be confirmed during discussion with cluster leader:

- Short term with CCAM topics mostly fixed for 2024 and 2025 calls:
  - Development vehicle technology identified in CL5-2024-D6-01-01,
  - Key enabling technology mostly centred on IA (not only) for ODD extension visible in CL5-2024-D6-01-04 and for HMI in CL5-2024-D6-01-02, and ITS communication in CL5-2024-D5-01-3,
  - Extension of 2024 and 2025 calls to be revisited as topics are today not visible.
  - EEA4CCAM and UP2DATE4SDV selected in 2025 where identified with potential link related to SDVoF
- Mid-term upcoming call in 2026 and 2027 calls
  - Identification of environment perception, edge AI, EEA topics and deployment on large-scale demonstration,
  - Proposal to mandate synergies with SDVoF actions in the call text
- Long-term for new FP10 Framework is documented in section 6.1.3.

Like for 2ZERO, the collaboration with CCAM was defined based the following concepts:

- Present SDVoF visions and FEDERATE activities to CCAM members
- Identify selected R&D project under the CCAM umbrella related to SDVoF
- Contact project to present FEDERATE GitHub repository federating SDVoF BBs
- Interact with project to identify reused BBs, potential contribution and clarify roadmap and milestone related to SDVoF BBs

5.2 SDV Projects

The following paragraphs will provide an overview on Chip-JU related projects with focus on SDV based on information which is publicly available as of today. This section will be updated frequently as soon as new information becomes available.

5.2.1 HAL4SDV

5.2.1.1 Updates in 2025

The HAL4SDV has successfully entered the second project year. All milestones have been achieved successfully on time.

As HAL4SDV progresses into its next phase, several strategic priorities have emerged in response to evolving requirements within the SDVoF ecosystem. These updates reflect the project's commitment to robust governance, open collaboration, and sustainable innovation.

Key Challenges are seen in the area Lifecycle Management of Specifications and implementation topics of building blocks.

Details can be found in the Roadmap section 6.2.1.5.

5.2.1.2 General Introduction

The HAL4SDV project is an EU-funded Research and Innovation Action (RIA) project on a mission to advance European solutions in software-defined vehicles and next-generation vehicles. HAL4SDV will enable software configuration that abstracts from vehicle hardware, paving the way for a "software-defined vehicle" approach for both safety-critical and non-safety-critical applications in future vehicles. It aims to pioneer methods, technologies, and processes for series vehicle development beyond 2030, driven by anticipated advancements in microelectronics, communication technology, software engineering, and AI.

5.2.1.3 Contribution to the SDVoF Guiding Principles and Expected Results

- Collaborative development of open non-differentiating building blocks

The HAL4SDV platform foresees a domain-oriented approach for the implementation of the non-differentiating, non-safety-relevant- as well the differentiating, safety-relevant- platform design. It is to be investigated within the project, whether it is favourable to separate the connection to the cloud for up-load and up-stream services between the non-safety-related domain like the infotainment domain from the safety-relevant domains like ADAS/autonomous driving, Chassis or the potentially partly mixed safety-relevant domain of battery management & charging.[1]

- Open-source and Code-first

HAL4SDV is relying on an open-source strategy to facilitate participation in the ecosystem. HAL4SDV has defined as an objective the definition of standards for non-differentiating elements of the SDV platform and implementation of these standards in open-source software and reference implementations. Along the way, a thorough analysis of the needs expressed by the OEMs of this consortium, proposals for (the extension of) standards through Eclipse, etc. could be made available. However, this will require the active participation of the major European market players and the EU[2].

- Agility and speed through rapid demonstration in representative use cases

To ensure the automotive community takes the results of Project A seriously, the developed sub-systems and components must be validated at each step as appropriate. In HAL4SDV, all partners will contribute to creating and presenting demonstrators, specifying and executing functional tests, and evaluating results. This will involve real test benches, software test suites, and simulations from all participants. Initial demonstrations will occur in the partners' laboratories.

- Working in parallel on the open-source domains enabling fast results plus IP related contributions for safety-related contributions potentially requiring certification

The approach supports both “lines”, the open-source activities on the one hand, mainly intended for non-safety-relevant, non-differentiating contributions to the SDV topics and, on the other hand, safety-related, differentiating IP based contributions. The later considered needed in order to enable applications like ADAS/autonomy, chassis control or similar to in the long run be added to the means of SDV approach with OtA updates and automated installation and initialization for such critical functionality.

- HW/SW abstraction and virtualization

HAL4SDV has defined different building block activities which are required for the platform. The building block “HW/SW Abstraction”. The activity will focus on decoupling the OS layer from underlying hardware, enabling mixed criticality systems on multicore HPC processors, and enhancing safety and security to meet regulations like ISO 26262 and the Cyber-Security Resilience Act. It aims to produce the necessary software environment and interfaces for the HW abstraction layer. This includes defining and specifying its structure and required software modules and components, making it a central part of the HAL4SDV project. Integration of

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[1] HAL4SDV Proposal Paper, 1.2.1.4 Secure and domain structured approach.

[2] HAL4SDV Proposal Paper, 1.2.2 Expected results.

isolation/container technology for open-source Linux, proof of concept for application isolation, and Data Distribution Services (DDS) benchmarking will be included.[3]

- Working in a common structure of the SDV SW stack

HAL4SDV has defined three different kind of overarching activities: (a) the so called “Building Block” (BB) activities, calling specific research and development topics forming the core of the R&D project, (b) so called “Enabler” (EN) activities, in support of the BB activities and so called “Definition” (DEF) activities discussing and denoting definitions that need to be put in place for precise annotation of used technical notations and terms complete the work proposed. All activities are allocated on a standardized SDV SW stack (Figure 3).

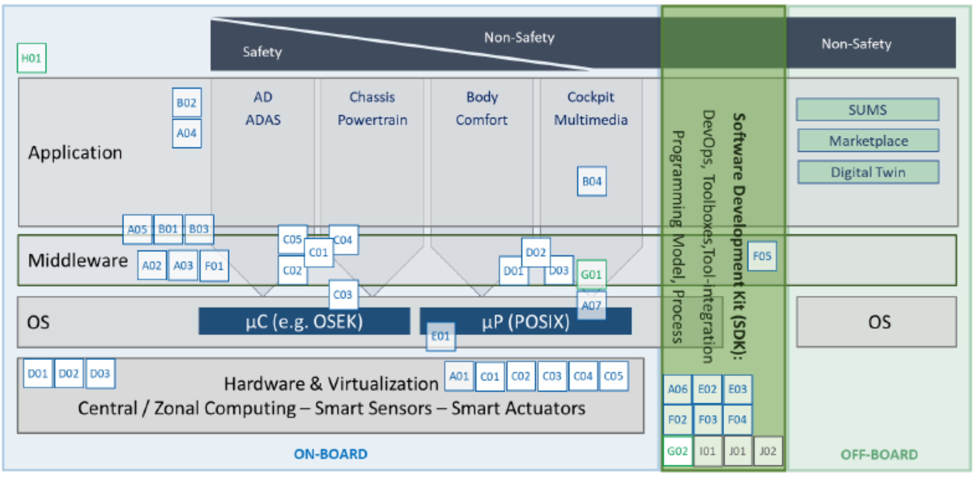

Figure 3: Allocation of the HAL4SDV activities in SDV SW stack

- Tools and tool chains designed for the SDV of the Future

The HAL4SDV Transversal Activity “Development Process Tools” will address secure code writing guidelines, design tool aspects, and required configuration tools for platform development and operation. It will support the RUST ecosystem to avoid vendor lock-in and investigate using open-source components to meet automotive grade standards and ISO/IEEE compliance. The project will explore using Linux for safety-critical applications targeting high-integration platforms like autonomous driving. It will also focus on integrating services and providing a platform for application software abstraction, virtualization, and integration into the on-board HAL4SDV platform. Safety and security aspects related to the tooling will be examined, as well as alternatives to C++ for ASIL-B/ASIL-D (RUST SDK for POSIX). Analysis and potential development of architecture modelling tools are also planned.[4]

- Support of the collaborative development of high-performance (open) SOCs designed for SDVoF

As the HAL4SDV focuses vehicle abstraction topics, the collaborative development of SOCs is not part of this program.

- Close collaboration with existing initiatives to avoid “reinventing the wheel”

[3] HAL4SDV Proposal Paper, 3.1.1 Overall Structure of the work plan

[4] HAL4SDV Proposal Paper, 3.1.1 Overall Structure of the work plan

The reuse and integration of already available results and technologies supporting the upcoming requirements out-lined above will be applied as a strategic approach.[5] Many initiatives in Software-Defined Vehicles and adjacent areas share similar goals, making it crucial to avoid fragmentation and encourage consolidation. The aim is to unify leading automotive OSS initiatives, including COVESA, AGL, ELISA, SOAFEE, Eclipse SDV, Eclispe S-CORE, Linux Foundation Europe, Eclipse Foundation, and Linaro. Initial steps involve advancing standardization activities like the vehicle signal specification (VSS) within COVESA and its use in Linux Foundation's AGL and Eclipse SDV projects. This effort will promote a unified vehicle abstraction layer in Europe, with formal methods and criteria proposed to ensure interoperability among OSS initiatives.[6]

- Defined governance of the SDVoF initiative

The SDV-Sherpa governance group (SDV-SGG) oversees and governs the work of the coordination and support action FEDERATE and the funded projects initiated by the SDVoF initiative.

Many contributors of the HAL4SDV are also represented in the CSA FEDERATE project and even in the SDV-SGG.

- Participation in the SDVoF ecosystem

HAL4SDV is a chips JU program and so a considered project of the SDVoF initiate which aims for an Eco-System.

Additionally, the HAL4SDV project will pay attention to

- Reference SW stack composed of SDVoF building blocks (top-down approach)
- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF

as proposed by the SDVoF vision.

5.2.1.4 Collaboration and Relationship to SDVoF and FEDERATE

The current proposal for HAL4SDV collaboration is:

- Current Collaboration and relationship

HAL4SDV is seeking to establish a European Eco System within the European automotive industrial domain. For that purpose, HAL4SDV has installed a dedicated Work Package (WP 1, "Governance, Vision and derived Strategic Goals") lead by OEM BMW to transfer information and recommendation provided and generated by the FEDERATE CSA project. The SDVoF Eco System is closely cooperating with FEDERATE as many of the HAL4SDV Partners are participating in FEDERATE and/or the SDVoF Eco System directly.

The goal is to enable the best possible adaptation of R&D work and HAL4SDV results according to first-hand information on trends and new or changed/updated requirements coming from the large-scale payers, the OEMs in first instance as well as the large Tier organizations.

The communication with other projects in the industry dealing with similar innovation like SOAFEE/COVESA etc. are also part of the FEDERATE part of the FEDERATE communication to avoid potential "reinvention of the wheel" and use available results to drive innovation beyond existing solutions and results.

- Improvement proposal on collaboration and relationship

The approach building as wide as possible relations and foster communication about targeted results, research

[5] HAL4SDV Proposal Paper, 1.1.2 HALSDV Vision

[6] HAL4SDV Proposal Paper, 1.1.3 Objectives and KPIs, Objective 7

and innovation work listening to potential proposals for improvement and/or enhancement will sustainably increase the value of the initiatives and the HAL4SDV project results. HAL4SDV will always investigate about adopting recommendations or at least endeavour to enable later implementation /integration/connection of such recommendations at a later time or possibly also after the HAL4SDV project. Thus, the cooperation in particular with FEDERATE is of highest importance for the success of the HAL4SDV project.

5.2.1.5 HAL4SDV Project Roadmap on SDVoF topics

The HAL4SDV project follows a roadmap for deliverables as shown in Table 2 below. Completed deliverables are highlighted in green.

Table 2: HAL4SDV Deliverables (green indicates completed and released status)

Del. Nr.	Deliverable Name	Due Date
D8.2	Initial dissemination and exploitation plan	30.09.24
D2.2a	Requirements for the non-safety-relevant, non-differentiating open-source HAL4SDV Platform part (draft)	30.11.24
D1.1	Report on the cooperation with the CSA „FEDERATE“	31.03.25
D2.2b	Requirements for the non-safety-relevant, non-differentiating open-source HAL4SDV Platform part	31.03.25
D2.4	Requirements for the HAL4SDV platform Tools	31.03.25
D2.5	Requirements for the demonstrators and the test-, and V&V-campaign	31.03.25
D8.3	Project Newsletter 1	31.03.25
D8.8	Dissemination and communication report 1	31.03.25
D3.1	Modelling and simulation conducted for open-source implementations	30.09.25
D8.6	Initial project exploitation report	30.09.25
D8.7	Initial Report on Standardization	30.09.25
D1.2	Report on the cooperation with the CSA „FEDERATE“ update 1	31.03.26
D3.2	Modelling and simulation activities for the RISC-V integration	31.03.26
D3.4	Modelling and simulation activities for the HAL4SDV tools	31.03.26
D5.6	Driver behavioural analyses report; e.g. the ability of the driver to take longit. and lateral control over time	31.03.26
D8.4	Project Newsletter 2	31.03.26
D8.9	Dissemination and communication report 2	31.03.26
D3.5	Virtual HAL4SDV laboratory platform for simulation on vehicle level	30.09.26
D4.5	Design of the demonstrators	30.09.26
D5.1	HAL4SDV platform integration for the non-safety-relevant, open-source-based platform part	30.09.26
D1.3	Report on the cooperation with the CSA „FEDERATE“ update 2	31.03.27
D5.4	HAL4SDV platform demonstrator report	31.03.27

Del. Nr.	Deliverable Name	Due Date
D5.5	Provisioning of Virtual Demonstrator	31.03.27
D5.7	Experimental & demonstration vehicle with partial elements of HAL4SDV platform for CCAM tasks	31.03.27
D8.10	Dissemination and communication report 3	31.03.27
D8.11	Open-source working model report	31.03.27
D8.12	Study materials for professional courses & trainings for selected elements of the HAL4SDV	31.03.27
D8.5	Project Newsletter 3	31.03.27

Besides the project deliverables there is ongoing alignment between the project steering board and stakeholders including funding authorities. The following key topics were addressed in the project steering board meetings and have a direct link on the collaboration with partners in the SDVoF ecosystem.

Open standardization

A well-documented outcome of the HAL4SDV project represents a key asset for its overall success. For instance, a specification document can serve as one such outcome.

A) Handling open specification

Key Challenges related to open specification

- Lifecycle Management of Specifications: Ensuring a structured and transparent process for specification development, committee oversight, and release cycles.
- Support for Implementations: Addressing critical aspects such as:
    - Technical compatibility certification
    - Trademark and intellectual property (IP) licensing

Possible Solutions: Use Eclipse Foundation for managing specification activities

To address these challenges, HAL4SDV discussed the adoption of the Eclipse Foundation Specification Process (EFSP[7]). This well-established framework provides:

- A governance model led by a dedicated specification committee to oversee development and lifecycle management.
- A structured release cycle that includes:
    - Publicly available certification kits
    - Licensing frameworks
    - Reference implementations

[7] https://www.eclipse.org/projects/efsp/

B) Enhancing Open-Source Contribution Visibility

Key Challenge

A lot of partners are contributing building blocks that are already hosted within the Eclipse S-CORE as well as in other running projects. Transparency and traceability are required in order to trace this back to HAL4SDV activities.

Envisaged Solution

In the meanwhile, a mutual understanding within the HAL4SDV consortium as well as the Chips-JU including the HAL4SDV Project Officer has been established: HAL4SDV developments like open-source building blocks can also be provided to such other running projects like Eclipse S-CORE using the HAL4SDV funds. To doubtlessly identify the HAL4SDV origin, a label will be attached (such as “HAL4SDV inside”) identifying that the specific open-source contribution was generated under the workplan of HAL4SDV. This will solve several issues in one action:

- **a.** No problems in following technical and legal requirements of the target project like Eclipse S-CORE
- **b.** No redundant developments
- **c.** Perfect fit to the other workplan with a lean approach concerning managerial and organizational matters – simply no extra effort needed, fits on itself per definition since the subject partners submitting such building blocks are tied into the target project’s processes anyway
- **d.** Creating a seamless SDV software environment that efficiently makes use of various developments currently done in the eco system with a high probability of later implementation in series production
- **e.** By entering the specific building blocks into the “inventory list of FEDERATE” in the subject GitHub the marking with reference to the target project provides maximum transparency
- **f.** HAL4SDV will also keep a list of these building blocks to document the origin of such developments.

External Experts Advisory Group (EEAB)

HAL4SDV plans to establish an External Experts Advisory Group (EEAB). This group will consist of specific experts as representatives from key initiatives such as SOAFEE, Shift2SDV, and others. The EEAB will provide strategic insights, foster alignment, and ensure that HAL4SDV remains responsive to cross-initiative developments.

A General Assembly is scheduled for mid-September 2025, to be held at one of the pre-identified venues. This event will serve as a platform to review progress, align on strategic directions, and engage with stakeholders across the SDVoF ecosystem.

5.2.2 Shift2SDV

5.2.2.1 Updates in 2025

Shift2SDV officially commenced in July 2025. The subsequent sub-chapters have been updated to provide a more precise description, and an initial roadmap has been outlined.

5.2.2.2 General Introduction

Shift2SDV (A common Software development framework and hardware independent microservice-oriented middleware architecture for the stepwise migration to the Software Defined Vehicle of the Future) is an EU-funded (Chips JU) Innovation Action (IA) project on a mission to advance European solutions in software-defined vehicles and next-generation vehicles.

Focusing on SDV Middleware Layer: The Car OS is further extended by a Middleware and Application Programming Interfaces (API) Framework, which is service -oriented and data-centric. By including building blocks for x-domain and platform integration, high-level system functionalities, virtual resource management, and by using general concepts like encapsulation and modular service-oriented approaches, this framework abstracts the low-level technical details of the entire SDV SW stack up and facilitating vehicle services deployment, configuration and maintenance. The Middleware and corresponding APIs is the second level of decoupling between hardware and software and is intended to expose the hardware functionalities directly as services, in an OS independent, standard & interoperable, safe, secure and efficient way, thereby building the connection to the SDV Application Layer including services for off-board interaction, vehicle diagnostics.

5.2.2.3 Contribution to the SDVoF Guiding Principles and Expected Results

The scope of the contribution of Shift2SDV is the definition of modular (open source) building blocks and open architectures of the SDV middleware and API framework for the vehicle of the future.

The planned contribution to SDVoF guiding principles are as follows:

- Collaborative development of open non-differentiating building blocks

Close collaboration with existing initiatives to avoid “reinventing the wheel” and support of the collaborative development of high-performance (open) SOCs designed for SDVoF.

Modular platforms based on the concept of standardised, interoperable and non-differentiating “building blocks”, based on open source components as far as appropriate, enabling in-vehicle and cloud-based applications and ensuring the integration and support of existing frameworks such as ECPLISE SDV, AUTOSAR Adaptive, COVESA, SOAFEE, digital.auto, etc. Modularity is fundamental to promote the evolution of a European platform for the SDV Vehicle of the Future.

- Open-source and Code-first

Building blocks are encouraged to be open-source wherever adequate.

- Agility and speed through rapid demonstration in representative use cases

Demonstrate the benefits in several of the engineering challenges: engineering costs, time-to-market, development costs, development agility, quality, inclusion of hardware and software legacy technology and solutions, resource optimization, service interoperability, availability, modularity, diversity, data/knowledge management.

Shift2SDV’s visionary use case include the following domains: (1) chassis and powertrain, (2) body and comfort, (3) ADAS and AD, and (4) cockpit and multimedia.

- HW/SW abstraction and virtualization and Working in a common structure of the SDV SW stack

Building on the SDV Virtualization, OS and Hardware Abstraction Layer building blocks developed in related projects, development of reference implementations of the SDV Middleware and API framework for the SDV Vehicle of the Future in different scenarios of OEMs and TIERs. Reference implementations will allow the concrete evaluation of the SDV platform with demonstrators.

- Tools and tool chains designed for the SDV of the future

Highly automated engineering methods, tools and tool-chains using existing or developing missing engineering building blocks for toolsets, supporting the DEV/OPs continuous approach and virtual engineering, including design, development, test, validation solutions to improve the efficiency, productivity, quality and trustability of the engineering process and engineering process support should rely on existing solutions wherever possible, extended and/or complemented by newly developed methods, toolchains, and tools, when required (e.g. phases of the engineering process not covered, missing tools, improvement of existing tools, etc.).

- Defined governance of the SDVoF initiative

The SDV-Sherpa governance group (SDV-SGG) oversees and governs the work of the coordination and support action FEDERATE and the funded projects (like Shift2SDV) initiated by the SDVoF initiative.

- Participation in the SDVoF ecosystem

Shift2SDV is part of Chips JU program and so a project of the SDVoF initiate which aims for an Eco-System.

Work in Shift2SDV will be aligned with the results from the project focusing on building blocks around the HAL from the call HORIZON-KDT-JU2023-2-RIA Topic 2 (HAL4SDV) to allow for reuse and to maximize efficiency.

- Large positive impact on the open SDV communities and SDV tool ecosystem

Shift2SDV is aware of FEDERATE Github and will ensure to be synchronized with future requirements and technical objectives.

Additionally, Shift2SDV will pay attention to

- Pool of open automotive grade building blocks for SDV SW stacks (bottom-up approach)
- Reference SW stack composed of SDVoF building blocks (top-down approach)
- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF

as proposed by the SDVoF vision.

5.2.2.4 Collaboration and Relationship to SDVoF

The current proposal for collaboration is:

- Current Collaboration and relationship

Shift2SDV is based on content which has been partially defined by the FEDERATE und HAL4SDV project team. Numerous members of Shift2SDV are already member of FEDERATE and HAL4SDV. This ensures a consistent information flow between these projects.

- Improvement proposal on collaboration and relationship

Regular synchronization and alignment between the different project bodies (HAL4SDV, FEDERATE and others) is required. This needs to be formalized and monitored. A monthly meeting has been scheduled to support the collaboration between the different project bodies.

5.2.2.5 Project Roadmap on SDVoF topics

The project has started in July 2025. Right now, the open source roadmap is being developed by the building blocks. So far, the following building blocks have already identified possible open-source contributions during the workshops held in preparation for and during the kick-off meeting:

- C1: Plug and Charge
- E1: In-vehicle Communication Middleware
- E2: V2X Communication Middleware
- F1: Intrusion Detection
- F3: Security and Safety API
- G1: Digital Twin for vECU
- H1: SOVD

- I1: Microservice Management

All 14 Shift2SDV building blocks are currently developing their open source roadmap, including specific contributions, selected open-source projects, and timeline.

5.2.3 RIGOLETTO

5.2.3.1 Updates in 2025

In the 2024 version we announced about a potential project which is supposed to be selected in the call Chips JU 2024-1-IA-T2 (High Performance RISC-V Automotive Processors supporting the vehicle of the future).

The RIGOLETTO was selected and is documented below.

5.2.3.2 General Introduction

RIGOLETTO is an EU-funded RIA with the main objective to prepare the way for further exploiting the full potential of open-source RISC-V ISA (instruction set architecture) as a key technology to address the demands in the context of future Software Defined Vehicles (SDV) with software running on more powerful in-car computers and the need for adequate real-time processor architectures. The project aligns with the high-level goal of EU Chips Joint Undertaking and of the industry-led Vehicle of the Future initiative: namely, the creation of a RISC-V based automotive hardware platform strongly linked with the formation of an open, software-defined vehicle ecosystem led by European automotive manufacturers and suppliers.

RIGOLETTO contributes to the collaborative industrial research challenges defined in the "Roadmap for Future Automotive-driven RISC-V Developments in Europe". [8]

The main goal is to expand, mature and industrialise a novel European RISC-V automotive ecosystem that allows for the next generation high-performance European automotive processors. Enabling safe, secure and real-time automotive functionalities in the RISC-V world, RIGOLETTO will establish the foundation for a next-generation Automotive Computing Platform based on the open RISC-V ISA. The project intends to develop a dedicated Automotive Processor Family together with several accelerators - focusing on open-source solutions and EDA tools in the domains of processor and chip design.

5.2.3.3 Contribution to the SDVoF Guiding Principles and Expected Results

RIGOLETTO aims at developing RISC-V intellectual property (IP) components, including processor reference architectures, accelerators, interconnects, memory hierarchy and peripheral subsystems. RIGOLETTO will operate in five focus streams targeting a multitude of highly innovative results:

1. Scalable RISC-V automotive control processors: Processor reference architectures & demonstrators of a novel RISC-V based automotive control processor family in 32 and 64bit, with an emphasis on safety, security and real-time execution.
2. High-Performance RISC-V-based Application Processors: Reference architectures including 4 wide OoO processor core, hypervisor support, scalable memory encryption, integrity protection, post-quantum cryptography accelerators and ISA Extensions.
3. AI/ML Accelerator: A wide range of diverse accelerators with suitable ISA extensions, including novel solutions, heterogeneous architectures, multi-purpose ML accelerator as well as neuromorphic, and

[8] https://ecssria.eu/Roadmap_RISC-V_v240216_Final.pdf

systolic array-based accelerators.

4. Automotive Computing Platform: The overall integration of the developed processors, accelerators, and peripherals into a singular automotive computing platform.
5. Tooling: Encompassing a wide variety of tools and infrastructure regarding EDA, compilers, deployment, AI/ML code generation, architecture exploration, benchmarking, safety and security evaluation, modelling, and performance estimation and optimization, etc.

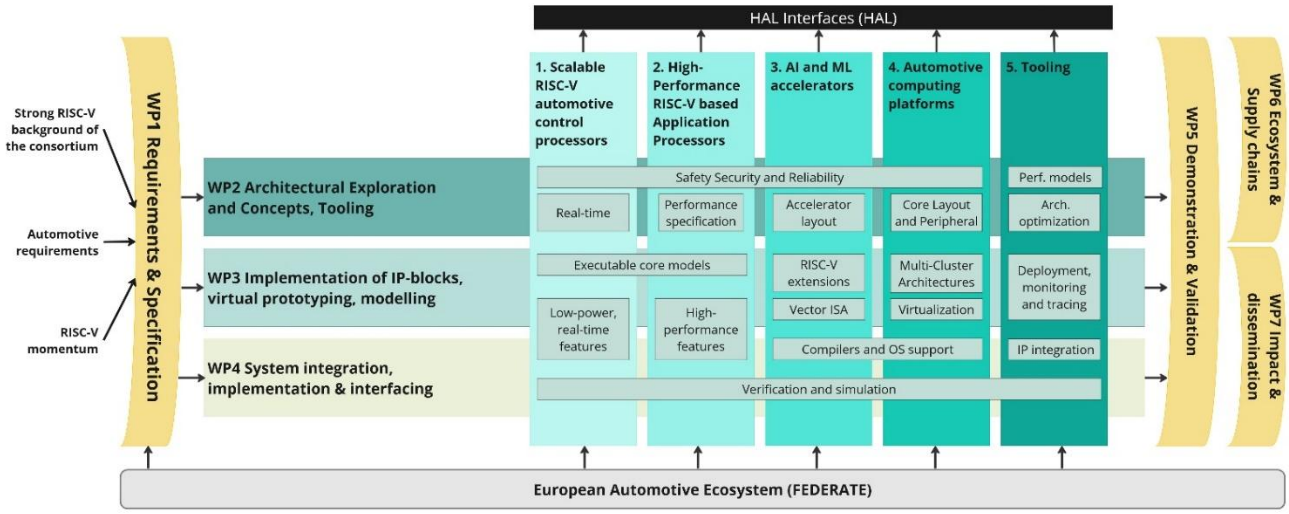

Figure 4: RIGOLETTO Project Architecture

RIGOLETTO is an industrial statement and clear commitment of key European automotive stakeholders to RISC-V technology. The large consortium with leading European Integrated Device Manufacturers (IDM), Tier 1s, Academia and Research Institutes builds upon the flexibility and momentum of an open source ISA, and will establish strong standardization and collaboration efforts. The project is an important cornerstone on the road to Digital Sovereignty for the European semiconductor industry

5.2.3.4 Collaboration and Relationship to SDVoF

The current proposal for collaboration is:

- RIGOLETTO will foster relations and provide inputs for other leading EU-funded RISC-V initiatives (e.g., TRISTAN, ISOLDE), important SDV- initiatives (mainly HAL4SDV), and strategic projects like FEDERATE-CSA. Networking activities will also contribution to workshops, input for Strategic Research Agendas, White Papers, etc., with EPoSS, AENEAS, and/or INSIDE. RIGOLETTO also aims to align with relevant standardization activities. Partners will participate in technical committees in standardization groups and submit modifications to existing standards when needed. RIGOLETTO seeks to identify areas where standardization of RISC-V extensions may be required and take European leadership in technical committees.
- RIGOLETTO will foster industrial feedback and guidance from an Industry Advisory Board (IAB). The IAB will comprise representatives of leading European OEMs and automotive companies, will act as industrial sounding board, and gives advice on RIGOLETTO's strategic developments and decisions.

- RIGOLETTO will also closely collaborate with the consortium, currently preparing a proposal for the Chips JU call “HORIZON-JU-CHIPS-2025-IA-two-stage”. The overall ambition of this call is to develop RISC-V based, automotive demonstrators taped-out on leading-edge processes. Proposals are expected to significantly bolster the development of a high-performance automotive RISC-V reference hardware platform.

5.2.3.5 *Project Roadmap on SDVoF topics*

The RIGOLETTO project has started July 3rd. 2025. A detailed roadmap planning will be developed during next months.

5.2.4 Code4SDV

5.2.4.1 *General Introduction*

The CODE4EV project aims to accelerate the development of electric software-defined vehicles (SDVs) by establishing a collaborative development framework. This framework will support the design, production and operational phases of electric vehicles (EVs) by demonstrating its application through selected Use Cases relevant to emerging and future SDV architectures.

The project key objectives include the elaboration of digital design tools and a trustworthy development methodology for electric SDVs, improving the efficiency and reliability of SDV architecture component sharing, and accelerating validation processes.

The project Use Cases will demonstrate the implementation of the collaborative development framework, such as data-driven EV optimisation, health monitoring and predictive maintenance, and smart motion control. These Use Cases aim to demonstrate improvements in energy consumption, component life extension and overall vehicle performance.

CODE4EV plans to develop virtual, hybrid and full-scale demonstrators of electric SDVs for different vehicle categories, focusing on efficient verification procedures and the evaluation of the scalability of the CODE4EV approach. These efforts aim to ensure compatibility and efficiency for a range of vehicle types, including heavy-duty trucks and L-class EVs, thereby making an important contribution to the promotion of zero-emission mobility solutions.

5.2.4.2 *Contribution to the SDVoF Guiding Principles and Expected Results*

The planned contribution of EEA4CCAM to the SDVoF guiding principles are as follows:

- Collaborative development of open non-differentiating building blocks

CODE4EV is organized around 5 assets

- Asset 1: collaborative development framework
- Asset 2: Tailored electric SDV architecture
- Asset 3: Optimal powertrain design & control
- Asset 4: EV health monitoring & predictive maintenance
- Asset 5: Smart motion control

These assets are refined in “project results” (as of the terminology from Horizon Europe), which can be seen as building block. The mapping between CODE4EV’s project results and FEDERATE BBs is currently subject of alignments between the two projects.

- Open-source and Code-first

CODE4EV approach is relying on the development of technology demonstrators, which are deployed and evaluate in relevant use cases. While each partner (and IP owner) is directly interested to increase the outreach of their solution, the decision about the distribution and licensing model is up to each partner according to their respective exploitation strategy. A detailed overview will be provided in the context of the public deliverables D8.2 (Intermediate dissemination and communication report, M18) and D8.3 (Final dissemination and communication Report, M36).

- Agility and speed through rapid demonstration in representative use cases

CODE4EV approach is relying on the rapid demonstration in representative use cases for 2-wheelers, passenger cars and heavy-duty vehicles. The use cases are the following:

1. Use Case I on data-driven EV optimization has two targets: from the side of EV engineering, the focus is on new methods of the powertrain control with enabled optimisation using AI components based on the analysis of the actual on-board data and collected historic data about the EV operation; from the side of the SDV architecture, the goal is to demonstrate the implementation of the vehicle-to-cloud (V2C) services for improving EV efficiency. The project will use an original V2C service that will be adopted to the *CODE4EV* SDV architecture.
2. The second Use Case on EV health monitoring and predictive maintenance has focus on chassis and powertrain health monitoring with mixed on-board and cloud-based diagnosis. The component level introduces a set of sensor fusions for the vehicle systems. Both common vehicle sensors and additional soft sensors are being used for the monitoring. The strategy of the health monitoring in CODE4EV is targeting continuous analysis of operational states of brake, chassis, battery, and powertrain systems as especially relevant for EV.
3. The third use case on Smart motion control deals with safety-critical functions and should demonstrate benefits of SDV concepts and AI-based control approaches for vehicle dynamics control realised by systems as ESP, torque vectoring et al. At that the vehicle should not only demonstrate required driving safety but also increase of energy efficiency through integrated operation of powertrain and chassis systems with smart redistribution of control efforts.

- HW/SW abstraction and virtualization
- Working in a common structure of the SDV SW stack
- Tools and tool chains designed for the SDV of the Future
- Support of the collaborative development of high-performance (open) SOCs designed for SDVoF
- Close collaboration with existing initiatives to avoid “reinventing the wheel”
- Defined governance of the SDVoF initiative
- Participation in the SDVoF ecosystem
- Reference SW stack composed of SDVoF building blocks (top-down approach)
- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF

Those sections require more intensive alignment with FEDERATE and will be updated for the next iteration of the deliverable.

5.2.4.3 Collaboration and Relationship to SDVoF

The current proposal for collaboration is:

- Current Collaboration and relationship

The collaboration with the SDVoF community is considered as essential by CODE4EV – at the same time is it a central aspect to not violate the confidentiality established through the respective consortium agreement from each of the projects. For this purpose, the collaboration is relying on the following pillars

1. Information about the public deliverables, providing relevant insights about the projects and relying on content which has been already released for general public
2. Information from publications (e.g., peer-reviewed conferences or journal, industrial conferences and fairs, white papers) – again relying on content released for general public
3. Participation to relevant events, where the expert can meet and align on different aspects
4. Creation of common publication, respectively designing follow-up research programs, thereby acting as "melting pot" inside the SDVoF community

Regarding 1) and 2), CODE4EV is relying on the ZENODO community to publish their results, see https://zenodo.org/communities/code4ev. Additionally, CODE4EV foresee the following public deliverables to accelerate exchange of information (due date subject to change):

- D1.4 Specification of Use Cases (M12)
- D2.1 SDV design methodology (M06)
- D3.1 Integrated CODE4EV environment (M15)
- D4.3 Evaluation of Use Case I (M33)
- D5.3 Evaluation of Use Case II (M33)
- D6.3 Evaluation of Use Case III (M33)
- D8.1 Dissemination, communication and exploitation plan (M03)
- D8.2 Intermediate dissemination and communication report (M18)
- D8.3 Final dissemination and communication report (M36)

Regarding 3) and 4), CODE4EV has participated to the ADTC conference in 2025 (https://adtc-conference.eu) and to the European SDV ecosystem summit 2025 (https://federate-sdv.eu/event/european-sdv-ecosystem-summit-2025/). Beside this, a joint publication between the projects CODE4EV, TWIN-LOOP, FEDERATE, HAL4SDV and Shift2SDV for the TRA'26 conference (https://traconference.eu) is being coordinated by CODE4EV. This joint publication targets to present the projects and their synergies to advance the SDVoF community.

- Improvement Proposal on collaboration and relationship

The upper points 3) and 4) from the previous section are addressing especially this topic.

5.2.4.4 Project Roadmap on SDVoF topics

This section requires more intensive alignment with FEDERATE and will be updated for the next iteration of the deliverable.

5.2.5 TwinLoop

5.2.5.1 General Introduction

Twin-Loop aims to enhance software-defined electric vehicles (EVs) through a novel TwinOps approach, combining Digital Twins, Model-Based Engineering, and DevOps. The goal is to enable continuous, intelligent updates of vehicle functions based on real-world data across the entire lifecycle.

At the heart of the project is the MyEV Digital Twin, a hybrid in-vehicle/cloud system that reflects the unique state and usage of each EV. These twins support energy optimization, thermal and battery management, and improved driver experience through AI-powered applications.

Twin-Loop also develops a dedicated framework for agile software deployment, including formal verification and runtime monitoring. Security is addressed through AI-driven Security Chaos Engineering, ensuring resilience against cyber threats. This integrated approach supports safer, smarter, and more efficient EVs for the future of European mobility.

5.2.5.2 Contribution to the SDVoF Guiding Principles and Expected Results

The planned contribution of TwinLoop to the SDVoF guiding principles are as follows:

- Collaborative development of open non-differentiating building blocks

Twin-Loop contributes to the SDVoF vision by developing an open and modular TwinOps framework and a suite of proprietary reusable digital twin components that are non-differentiating yet critical for enabling lifecycle-wide vehicle intelligence. These building blocks, including runtime monitoring tools, physics-based battery models, AI-based power range forecasting modules, and formal verification engines, are designed for broad applicability across EV platforms and OEMs. The project actively engages with open ecosystems such as Eclipse SDV and COVESA to ensure alignment, interoperability, and collaborative reuse of its assets.

- Open-source and Code-first

Twin-Loop adopts a code-first and open-source approach, prioritizing the delivery of functional, modular software components from the early stages of development. At the heart of this strategy is the Open Framework for TwinOps, which is being implemented as a working software platform with clear architectural layers, APIs, and data models to support interoperability and reusability across SDV applications. The project actively integrates digital twin orchestration, DevSecOps lifecycle support, and containerized microservices, enabling cloud-native, scalable deployments. Twin-Loop also builds on and contributes to open ecosystems such as OpenTwins and Eclipse Ditto, ensuring compatibility with existing standards and fostering cross-project collaboration within the European SDV community.

- Agility and speed through rapid demonstration in representative use cases

Twin-Loop is designed to enable rapid prototyping, integration, and validation of software-defined vehicle functionalities through representative and realistic use cases. By coupling in-vehicle and cloud-based digital twins with real-time and historical data flows, the project supports continuous iteration and improvement, accelerates validation and impact in three concrete, complementary use cases that reflect key SDV challenges: i) Integrated and Holistic EV Digital Twin, demonstrates the Open Framework's ability to support continuous data-driven optimization across the full vehicle lifecycle; ii) Enhanced Power Range Forecasting, showcases how AI-based applications can improve accuracy by combining battery health data, driver profiling, and environmental inputs; iii) Cybersecure and Resilient Software-Defined EVs, puts the TwinOps architecture to the test in dynamic threat scenarios using secure OTA updates, runtime monitoring, and chaos engineering.

- HW/SW abstraction and virtualization

Through the TwinOps framework, real-time and historical data from EV subsystems, such as batteries, thermal systems, and powertrains, are abstracted into modular, interoperable software components. This abstraction enables the virtualization of key functions (e.g., diagnostics, energy optimization, forecasting) across both in-vehicle and off-board environments. The architecture supports containerized deployment and dynamic orchestration of services, making it adaptable to different hardware platforms and scalable across EV categories.

- Working in a common structure of the SDV SW stack

Twin-Loop contributes to a harmonized SDV SW stack by aligning its Open Framework with emerging European initiatives such as Eclipse SDV, AUTOSAR, and COVESA. Its architecture is modular by design, with clearly defined layers for digital twin orchestration, data exchange, and DevSecOps integration. This structure enables seamless integration of Twin-Loop applications such as battery diagnostics or range forecasting into broader SDV environments.

- Tools and tool chains designed for the SDV of the Future

Twin-Loop delivers a comprehensive suite of tools tailored for the next generation of SDVs. These include a modular TwinOps framework, advanced digital twin orchestration tools, and DevSecOps-aligned CI/CD pipelines for continuous deployment and validation. The project also integrates proprietary AI-based applications for energy optimization and diagnostics, model-based V&V tools for architecture assessment, and a Security Chaos Engineering environment for robust cybersecurity testing. All components are designed to be interoperable, cloud-native, and easily integrable into existing SDV toolchains.

- Support of the collaborative development of high-performance (open) SOCs designed for SDVoF

While not directly focused on hardware design, Twin-Loop supports the collaborative development of high-performance SoC platforms by providing an open, modular software framework that is hardware-agnostic and optimized for embedded deployment. Its lightweight AI models and digital twin components are designed to run efficiently on constrained computing platforms, including automotive-grade microcontrollers and future open SoCs.

- Close collaboration with existing initiatives to avoid "reinventing the wheel"

Twin-Loop actively collaborates with leading SDV communities such as Eclipse SDV, COVESA, and AUTOSAR, ensuring its framework, tools, and APIs align with shared standards and open architectures. It builds on outcomes from projects like HAL4SDV, Shift2SDV, and Code4SDV, focusing on integration rather than duplication. Defined governance of the SDVoF initiative.

- Defined governance of the SDVoF initiative

The Twin-Loop governance is under definition, however specifically referring to the Open Framework, given the Open-Source nature, it has been initiated a dialogue with ECLIPSE-SDV in order to evaluate different suitable models

- Participation in the SDVoF ecosystem

The reuse of some results from ECLIPSE-SDV projects and from the FEDERATE Building Blocks is envisioned at lower level, for the implementation of the in-vehicle and of-vehicle Digital Twins.

- Reference SW stack composed of SDVoF building blocks (top-down approach)

Twin-Loop contributes to the SDVoF reference stack by delivering modular, interoperable components, such as the TwinOps orchestrator, digital twin modules, and runtime tools, designed from a top-down architectural perspective. These building blocks fit within standardized SDV layers, supporting integration and reuse.

- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF

Twin-Loop delivers an automotive-grade software engineering environment that supports the full lifecycle of SDV development—from design and implementation to deployment and continuous operation. The project integrates model-based engineering, DevSecOps pipelines, and runtime validation tools into a unified TwinOps framework enabling continuous updates, formal verification, and secure OTA delivery, ensuring safety, performance, and cybersecurity.

5.2.5.3 Collaboration and Relationship to SDVoF

The current proposal for collaboration is:

- Current Collaboration and relationship

The project coordination team is in constant contact with Federate, organizing and/or participating to common dissemination activities and workshops related to SDVoF. Few members of TWIN-LOOP are also involved in ECLIPSE-SDV projects.

- Improvement Proposal on collaboration and relationship

Regular synchronization and alignment between the different project bodies (HAL4SDV, FEDERATE and others) is required. This needs to be formalized and monitored. A contact with the new CCAM project on SDV will be established. TWIN-LOOP will explore possibilities of future collaboration addressing coming project opportunities.

5.2.5.4 Project Roadmap on SDVoF topics

TWIN-LOOP is working on a Roadmap towards the use and production of Building Blocks of the SDVoF, aiming to be as open source as possible. A more detailed roadmap planning should be developed during next months that will be documented in the next release of the deliverable.

5.2.6 UP2DATE4SDV

5.2.6.1 General Introduction

The UP2DATE4SDV project brings together automotive hardware manufacturers, the automotive software industry and SMEs, and researchers in the field to jointly create a comprehensive ecosystem for updatable, upgradable, and reconfigurable software-defined connected and automated vehicles. The project is a kind of successor project of the H2020 UP2DATE (https://h2020up2date.eu/) project.

To this end, a middleware solution is to be created and integrated into the current automotive open source standards, which allows complete abstraction not only of the software running in the vehicle, but also of the installed hardware. As a result, not only can the software be continuously updated over the air over the lifetime of the vehicle and thus kept safe, secure, and up to date, but hardware components can also be easily replaced or supplemented to meet future requirements. To achieve this, the project will additionally develop a new hardware component based on established automotive systems, which will be expanded in such a way that the unavoidable overhead resulting from the update capability of the systems is minimized thanks to explicit hardware support.

The overall solution is suitable for the upcoming zonal E/E architectures that have a permanent connection to the cloud. The project therefore aims to develop and integrate methods that ensure the safety of the systems during an update by strictly separating all individual automotive applications in containers. In addition, a security layer will be introduced to prevent attacks via the cloud link or among the application modules.

Finally, we want to make it easier for automotive software developers to use our middleware by establishing a reference layer based on a hypervisor that prevents the real-time requirements of different application modules from influencing each other. Communication to the vehicle components and to the cloud is abstracted and standardized. In addition, methods are provided to automate the V&V process for each further update, upgrade or reconfiguration and to ensure security at every step.

5.2.6.2 Contribution to the SDVoF Guiding Principles and Expected Results

The planned contribution of UP2DATE4SDV to the SDVoF guiding principles are as follows:

- Collaborative development of open non-differentiating building blocks

UP2DATE4SDV aims to develop a comprehensive ecosystem for seamless and efficient software-updates, hardware-upgrades, and situation-dependent reconfigurations of software-defined CCAM vehicles (SD-CCAM-V). For that, the project focuses on the definition and development of two abstraction layers – the Hardware Abstraction Layer (HAL), and the OS/MW abstraction layer (OAL) for the operating-system (OS) and middleware (MW) – as well as on researching and prototyping a safe-and-secure orchestration and reconfiguration plane (ORP) between vehicle and cloud. This will improve CCAM system reliability and performance, extend vehicle life-cycles, and reduce electronic waste. Additionally, the project's new modularity concepts will speed up the transition towards a safer, more sustainable automated driving, enabling incremental steps towards level 4+ automation and longer vehicle life-cycles.

The project supports two main streams:

1) Open-source research demonstrator: The project will build up a blue print consisting of a modular and upgradable hardware platform and a software stack that allows SW update, dynamic mode switching and dynamic reallocation of workloads.
2) Industrial demonstrator: This demonstrator will be a branch of the open-source demonstrator including closed-source /commercial software components

- Open-source and Code-first

Even though the UP2DATE4SDV project is not mainly a SW development project, we aim at using open-source SDV software wherever possible. Specific open-source software the project will contribute to are:

- L4Re Hypervisor and Operating System Framework
- Eclipse Ankaios framework
- Eclipse Zenoh

The contributions to another Open-Source software will be decided during the course of the project. Developed architecture blueprints, including the defined abstraction layers for monitoring, control and modular updates will be made publicly available.

- Agility and speed through rapid demonstration in representative use cases

To develop, review and disseminate its HAL, OAL and ORP as well the UP2DATE4SDV CI/CD- and DevOps-Framework, UP2DATE4SDV will extensively exchange knowledge with partners of the SDV-Alliance as well as the CCAM-partnership. To this end the project will establish an expert-network, an industrial advisory-board and a dissemination-board together with a communication plan to synchronize its starting point, intermediate results, and possible open-source contributions, as well as its final outcomes with related projects (e.g. HAL4SDV, FEDERATE, Eclipse4SDV) and the SDV- and CCAM-community. For that, six use-cases (UC1-UC6) are defined to explain and demonstrate the results by the means of demonstrators which will be incrementally developed and integrated in three phases: In the end of phase One, UC1 (“Updating and upgrading HW/SW in the perception chain”) is going to show different basic reconfiguration scenarios: in-place update/upgrade of SW components; replacement of a HW unit; and adding/activating an additional HW unit. After phase Two, first, UC2 (“Maintaining reliability”) will exemplarily show that the system maintains reliability in case of changing (e.g. erroneous) system conditions, e.g. by stopping erroneous functions or functions with low criticality to ensure continuous operation of critical functions, addressing reliability requirements. Second, UC3 (“Considering hardware resource constraints”) will demonstrate the proper handling of resource constraints, confirming that the system is able to understand if resources are sufficient for the deployment of new/additional functions. Third, UC4 (“Considering Cyber-Security”) will show how the security of update packages and update-processes are ensured before, during and after deployment using model-based V&V and DevOps methods. Finally, in the end of phase Three, UC5(“Perception stack upgrade and mode switching”) demonstrates how a perception stack can be switched on different levels in dependency to different CCAM scenarios, and UC6 (“Connected Automated Driving (CAD)”) how a vehicle controller of an autonomous vehicle’s software stack utilizes cloud provided environmental information in fusion with the in-vehicle perception system to derive a more comprehensive CCAM scenario perception.

- HW/SW abstraction and virtualization

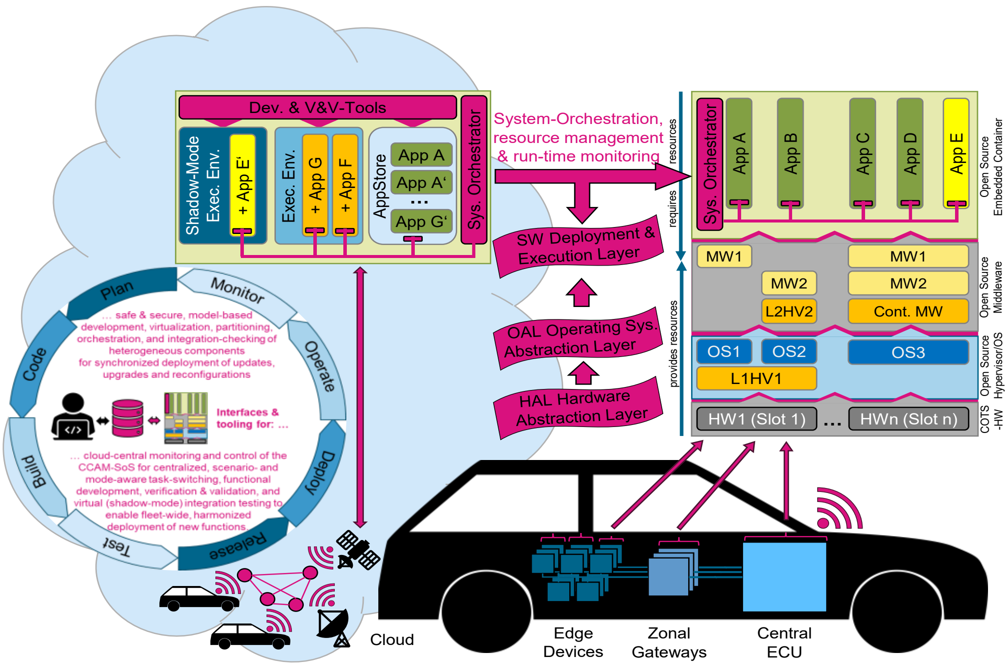

Figure 5: UP2DATE4SDV project scope

The above figure summarizes the overall vision behind the UP2DATE4SDV overall approach, connecting the safe and securely updateable, upgradable and reconfigurable centralized in-vehicle architecture (right) with the cloud-based frameworks for DevOps-services (e.g., MBSE, shadow-mode execution, runtime-monitoring, etc.), V&V (e.g., virtual-integration testing, simulation-based virtual verification, etc.), and CI/CD (left) are connected through the system-orchestration and reconfiguration plane. Based on the previously mentioned concepts of MBSE, UP2DATE4SDV will establish a layer-based architecture for the rigorous modularization, monitoring and control of HW- and SW-resources by the means of containers, container-runtimes and a cloud-centric orchestration- and reconfiguration plane to coordinate interactions and dependencies, especially in the case of updates, upgrades and reconfigurations. For that, three main layers will be defined: the hardware abstraction layer (HAL), the operating system and hypervisor abstraction layer (OAL) and finally the software deployment and execution layer (DEL), which will finally build the interface to the system orchestration and reconfiguration plane (ORP). To ensure strict, interference-free modularization, each layer is required to provide a well-defined interface for the monitoring and control of its resources and to the services it offers. Components and compositions that do not fulfil this need, cannot be integrated in this stack, i.e. such HW/SW would be rejected during upgrade/update. For that, the ORP will integrate services to monitor and control HW upgrades, SW updates and system reconfigurations (e.g. task-reallocations between car and cloud), enabling for different, scenario-dependent operation modes between full-operational with and without cloud-connection to degraded mode or safe-state in the case of malicious HW modifications. Based on that, the ORP also controls the isolated execution containers for the individual application software as well as the communication between them. Additionally, to allow for synchronized and coordinated, scenario-aware updates and reconfigurations, the ORP will be distributed across vehicles (CCAM-participants) and the cloud. On the one hand, this allows for a fleet-wide, coordinated overview and control of each car’s situation, on the other hand, this provides access to cloud-based App-Stores (for the download of applications and updates) and execution containers (for additional driving-assistance or shadow-mode execution), as well as to the CI/CD and DevOps-framework for the development, integration, validation and verification of new software and software-updates.

The proposed structure and abstraction point across the HW/SW stack have a similar structure to the proposed SDVoF layers. During the UP2DATE4SDV project we aim at harmonizing abstraction layers interfaces and naming conventions with the SDVoF community.

- Working in a common structure of the SDV SW stack

As described in the previous answer we aim at harmonizing the structure of the UP2DATE4SDV SDV SW stack with the proposed structure in SDVoF.

- Tools and tool chains designed for the SDV of the Future

The main new contribution of the UP2DATE for SDV project will be an orchestration software for SDV software components that is target hardware platform resource aware (computational, communication and memory capacities) and allows a dynamic orchestration of software components for software updates also in combination with hardware upgrades.

- Support of the collaborative development of high-performance (open) SOCs designed for SDVoF

The project will focus on the integration of mainly existing hardware on System on Modules (SoM), which are connected though a high-speed (Gbit) TSN network. A base-board will be provided that allows the update/upgrade of SoMs in such an architecture.

- Close collaboration with existing initiatives to avoid “reinventing the wheel”

UP2DATE4SDV is open to collaborate with all relevant initiatives around the SDV. This includes the SDVoF initiative and the Eclipse SDV community. Further relevant communities will be elaborated during the project.

- Defined governance of the SDVoF initiative

The UP2DATE4SDV project will analyze the proposed SDVoF governance and provide feedback where necessary.

- Participation in the SDVoF ecosystem

The UP2DATE4SDV project aims at actively participating in the SDVoF ecosystem wherever possible. The further details have to be decided by the UP2DATE4SDV consortium.

- Reference SW stack composed of SDVoF building blocks (top-down approach)

Same as above, since the UP2DATE4SDV project does not aim to define entirely new building blocks, our project will analyze where contributions are possible and lead to accepted extensions. These extensions will most probably be in the area or composable monitoring, re-configuration and update of SDV building blocks.

- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF

To ensure safety- and security of the overall UP2DATE4SDV methodology for updates, upgrades and reconfigurations, UP2DATE4SDV implements a safety- and security-process, starting with a safety- and security-analysis to provide safety- and security-requirements for the planned processes, architectures and tools, followed by regular safety- and security-reviews of the intermediate results, as well as by a final safety- and security-assessment together with standardization and certification bodies. To ensure reliability during realization MBE methodology will be used. The concepts and tools of model-based system engineering will be used to specify, develop and verify intermediate results, UP2DATE4SDV plans to provide modularly structured, verifiable and re-usable models and formalisms to describe architectures, properties, interfaces and processes.

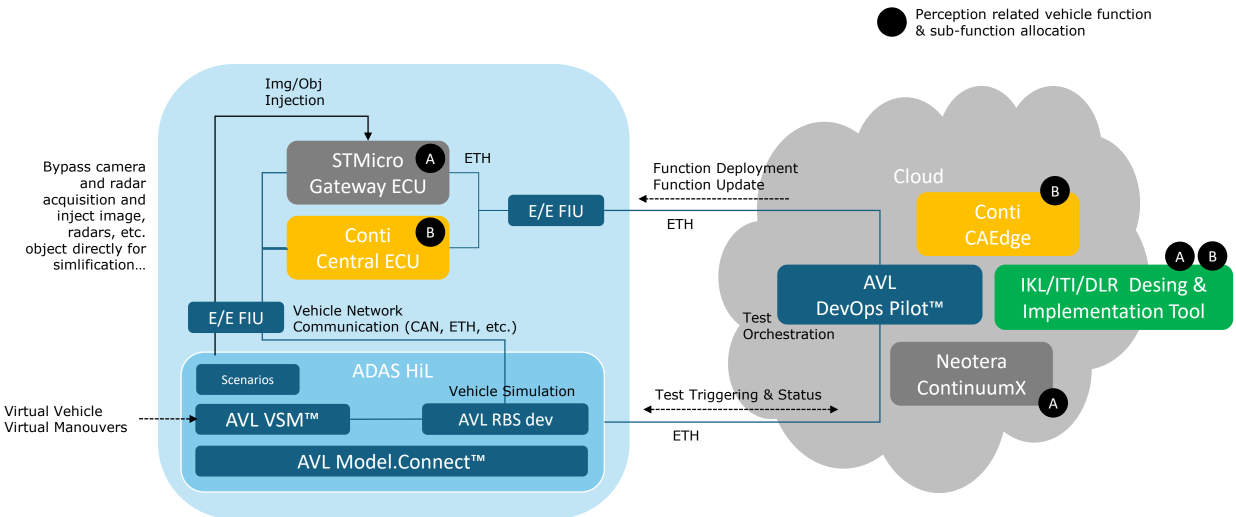

Figure 6: Demonstration environments and MBE toolchains

In the above figure the planned demonstration environments and MBE toolchains are shown. As a central part for developing the technology and as first testing platform for developers the TuringPI[9] cluster board will be used. The board provides a multi-System-on-a-module (SOM) environment which depicts the in-vehicle situation of having a cluster of different heterogenous compute units that are running our modular and resource aware update stack, while allowing dynamic adaptations, as described in the previous section. Project partner will provide their modelling, design and V&V tools and extensions to provide a single toolchain that supports the design and implementation phase by modelling the system architecture and functionality and

[9] https://turingpi.com/

generating code. Continental will provide its AWS based CAEdge[10] platform to enable cloud-based testing of updates on a network of different virtual ECUs before linking to physical ECUs in a Hardware-in-the-Loop setup. Different STM SoMs of the new Stella family with varying capabilities and performance will be used to demonstrate the upgrade of hardware. AVL will use its CI/CD pipeline, the AVL DevOps Pilot to execute cyber security testing using a model-based approach. It will also be used to run the off-vehicle orchestrator service. Further, AVL will support different use-cases in simulation using AVL software tools like Model.CONNECT[11], VSM[12] and AVL Scenius[13]. For E/E Architecture validation and testing the re-location of functions as reaction on issues with computer modules or network connection we will add fault injection units.

5.2.6.3 Collaboration and Relationship to SDVoF

The current proposal for collaboration is:

- Current Collaboration and relationship

Some partners of the UP2DATE4SDV project are involved in HAL4SDV and FEDERATE. Furthermore, some partners are actively contributing to the Eclipse SDV open-source ecosystem. Since UP2DATE4SDV recently started (07.2025), we aim at actively collaborating to SDVoF. Detail on the collaboration have to be established in cooperation with the EEA4CCAM project (funded in the same CCAM call as UP2DATE4SDV).

- Improvement Proposal on collaboration and relationship

The UP2DATE4SDV project has been started on 07.2025, this will be documented in the next release if relevant.

5.2.6.4 Project Roadmap on SDVoF topics

The initial roadmap of UP2DATE4SDV roadmap if defined as following:

M12 (06.2026) - UP2DATE4SDV early version solution:

- Definition and initial implementation of Hardware Abstraction Layer (HAL) and modular HW platform available
- Definition and initial implementation of OS/MW Abstraction Layer (OAL) available
- Orchestrator and Realization Framework [D3.3]), and
- SASE (SAfety- and SEcurity) Update Cycle &Architecture Definition available
- SASE (SAfety- and SEcurity) mechanism available

M15 (09.2026) - UP2DATE4SDV early version solution evaluation:

- Initial version of the open-source research demonstrator available
- UC1 (“Updating and upgrading HW/SW in the perception chain”) is going to show different basic reconfiguration scenarios: in-place update/upgrade of SW components; replacement of a HW unit; and adding/activating an additional HW unit.

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[10] https://www.continental-automotive.com/en/software/software-enablers/continental-automotive-edge-framework.html

[11] https://www.avl.com/en/simulation-solutions/software-offering/simulation-tools-a-z/modelconnect

[12] https://www.avl.com/en/simulation-solutions/software-offering/simulation-tools-a-z/avl-vsm

[13] https://www.avl.com/en/testing-solutions/automated-and-connected-mobility-testing/avl-scenius

M30 (12.2027) - UP2DATE4SDV final version solution and feasibility analysis

- Final version of the results mentioned in M12
- Final version of the open-source research demonstrator available
- UC2 (“Maintaining reliability”) will exemplarily show that the system maintains reliability in case of changing (e.g. erroneous) system conditions, e.g. by stopping erroneous functions or functions with low criticality to ensure continuous operation of critical functions, addressing reliability requirements.
- UC3 (“Considering hardware resource constraints”) will demonstrate the proper handling of resource constraints, confirming that the system is able to understand if resources are sufficient for the deployment of new/additional functions.
- UC4 (“Considering Cyber-Security”) will show how the security of update packages and update-processes are ensured before, during and after deployment using model-based V&V and DevOps *methods. Finally, in the end of phase*

M36 (06.2028) – UP2DATE4SDV final CCAM use-cases

- *UC5(“Perception stack upgrade and mode switching”) demonstrates how a perception stack can be switched on different levels in dependency to different CCAM scenarios,*
- *UC6 (“Connected Automated Driving (CAD)”) how a vehicle controller of an autonomous vehicle’s software stack utilizes cloud provided environmental information in fusion with the in-vehicle perception system to derive a more comprehensive CCAM scenario perception.*

5.2.7 EEA4CCAM

5.2.7.1 General Introduction

The EEA4CCAM project is an EU-funded Research and Innovation Action (RIA) targeting the design and development of a novel electronic control architecture (ECA) for vehicles. The project aims to enable the safe and cyber-secure deployment and operation of CCAM solutions across a wide range of operating conditions (ODDs) by developing a novel, centralized, reliable and cyber-secure in-vehicle ECA that can be upgraded. The project will facilitate a paradigm shift in the design of in-vehicle ECAs by developing a centralized, upgradable design that integrates hardware and software co-design, enables smart data flows and ensures safe, cyber-secure operation.

5.2.7.2 Contribution to the SDVoF Guiding Principles and Expected Results

The planned contribution of EEA4CCAM to the SDVoF guiding principles are as follows:

- Collaborative development of open non-differentiating building blocks

The EEA4CCAM project aims to facilitate a paradigm shift towards integrated, resource-efficient and reliable in-vehicle electronic control architectures based on open-source layouts, which will make it easier to develop and integrate connected and automated driving functions. Furthermore, a key objective of the project is to establish international cooperation between European OEMs and suppliers to jointly design a harmonized ECA layout with standardized interfaces. In this regard, a harmonized E/E architecture proposal is one of EEA4CCAM's key impact results. The supplier-driven EEA4CCAM consortium comprises the majority of the entire CCAM value chain, complemented by project collaborations, international cooperation, and related networks and initiatives.

- Open-source and Code-first

The non-differentiating parts of the harmonized E/E architecture layout (a key impact result of EEA4CCAM) driven by standardized interfaces will be represented as open-source layouts. The exact parts to be addressed will be determined during the project, which is expected to last 36 months.

- Agility and speed through rapid demonstration in representative use cases

The EEA4CCAM projects will deliver seven use cases at different levels (subsystem, system and overarching), including four demonstrator vehicles showcasing the results achieved at three proving grounds and one public road-testing area, one software demonstrator, one lab demonstrator and one overarching demonstrator related to harmonized validation methods. The use case landscape is completed by two impact results driven by international cooperation and harmonization.

- HW/SW abstraction and virtualization

Several use cases make use of hardware/software abstraction and virtualization to a certain degree. The use case linked to the four demonstrator vehicles utilizes the virtualization of the implemented E/E architecture during the design and development phases, which is then justified via real-world demonstrations on the related proving grounds and public road-testing areas. Additionally, a software-driven use case focusing on middleware targets hardware/software abstraction in many details.

- Tools and tool chains designed for the SDV of the Future

The software demonstrator related to the middleware is based on the tool RTMaps™.

- Close collaboration with existing initiatives to avoid “reinventing the wheel”

EEA4CCAM will collaborate with several related CCAM projects, such as UP2DATE4SDV (the sister project to EEA4CCAM), SUNRISE, SYNERGIES and CERTAIN, on validation-related aspects, and with AITHENA and AIGGREGATE on AI-related topics. In the field of Chips-JU, the aim is to establish collaborations with FEDERATE, HAL4SDV and SHIFT2SDV, which address the SdV project landscape, and with EdgeAI-Trust, which accounts for Edge AI-relevant inputs. Further exchanges are planned with 2ZERO and BATT4EU projects, but these have not yet been finalized.

- Defined governance of the SDVoF initiative

In cooperation with the two CCAM-related coordination and support actions, FAME and CCAMbassador, EEA4CCAM will address this topic.

- Participation in the SDVoF ecosystem

As a CCAM project, EEA4CCAM is considered a relevant project of the SDVoF initiative, which aims to create an SDVoF ecosystem.

Additionally, the EEA4CCAM project will focus on:

- combining a top-down software-oriented approach with a bottom-up hardware-oriented approach;
- considering the entire lifecycle perspective,

as proposed by the SDVoF vision.

5.2.7.3 Collaboration and Relationship to SDVoF

The current proposal for collaboration is:

- Current Collaboration and relationship

EEA4CCAM will collaborate with the relevant CCAM, Chips-JU, 2ZERO and BATT4EU projects. Additionally, EEA4CCAM aims to establish links with the CLEPA supplier network, the SAE standardization community, and relevant EEA initiatives in Japan, the US, and the UK through planned international cooperation activities. A couple of workshops are planned during the project to establish efficient and effective collaboration across the aforementioned communities, focusing on harmonization and standardization.

- Improvement Proposal on collaboration and relationship

At the start of the project, EEA4CCAM wants to highlight three areas for improvement:

- More open exchange of lessons learned along the relevant initiatives, with Europe, Japan, the UK and the US as key partners, to build sustainable international cooperation.
- Agreement on harmonized EEA interfaces and non-differentiating EEA elements, driven by open-source layouts, is expected to enable in-depth long-term collaboration.
- Finally, more focus should be placed on harmonized validation methods to support effective and efficient collaboration and relationships within the entire community.

5.2.7.4 Project Roadmap on SDVoF topics

The EEA4CCAM project has started July 8th. 2025. The project develops its BBs in an iterative manner, consisting of two main cycles. The first cycle involves early prototyping and testing, with a milestone at month 18 (26 November 2026). The second cycle builds on the learnings from the first cycle to extend individual functionalities at month 36 (May 2028).

Following these two stages, the harmonized EEA, harmonized validation methods and standardized interfaces will also be available. A more detailed roadmap planning should be developed during next months.

5.2.8 S-CORE

5.2.8.1 General Introduction

The scope of this project is the development of an open source core stack for Software Defined Vehicles (SDVs), specifically targeting embedded high-performance Electronic Control Units (ECUs).

Safe Open Vehicle Core is targeting to be the non-differentiating core of a software stack running on HPC ECUs of a software-defined vehicle. Consequently, this project's scope are the "inner layers" of such a stack between a hardware abstraction as its 'lower bound', 'southbound interface' and a platform API towards vehicle function applications as its 'upper bound', 'northbound interface'.

Out of scope are said applications running on this stack (those carry the differentiating aspects covered by adopters of the stack). As well out of scope are any aspects related to a concrete hardware target, which will be freely chosen by each adopter individually, as per the needs of and as they see fit with their vehicle architecture — except support for a potential reference hardware. Furthermore, any off-board functionality (e.g. cloud services) is considered out of scope. Looking beyond mere implementations in code, the project very well considers establishing concepts and implementations of processes, or a "way of doing things", or best practices to be in scope — but only as long as it pertains to making code fit for automotive grade.

5.2.8.2 Contribution to the SDVoF Guiding Principles and Expected Results

The planned contribution of S-CORE to the SDVoF guiding principles are as follows:

- Collaborative development of open non-differentiating building blocks

The Safe Open Vehicle Core project aims to create a common full stack solution of a software runtime that serves as the best possible solution for shared industry problems. By achieving efficiencies through a single, joint solution instead of multiple specific ones, the project addresses non-differentiating scopes and ensures that the scope is significant for multiple parties, rather than catering to singular interests.

- Open-source and Code-first

The S-Core project is built in Open Source with the clear aim of a Core-First Approach.

- Agility and speed through rapid demonstration in representative use cases

The project accelerates development by working in open source, focusing on code-centric and iterative methods rather than primarily on textual specifications HW/SW abstraction and virtualization

- HW/SW abstraction and virtualization

The project emphasizes the decoupling of hardware (HW) and software (SW), ensuring that applications do not depend on specific hardware characteristics. It establishes predetermined breaking points to enable the exchange of implementations of individual layers, aspects, and components, such as ECU communication protocols. Additionally, it focuses on enabling project-specific extensions of the stack, providing a flexible framework that can be customized and extended to meet the specific requirements of different projects.

- Working in a common structure of the SDV SW stack
- Reference SW stack composed of SDVoF building blocks (top-down approach)

The structure is organized in Building Block (BB) architecture as displayed in the figure below, giving also some preliminary information on BBs priorities and roadmap.

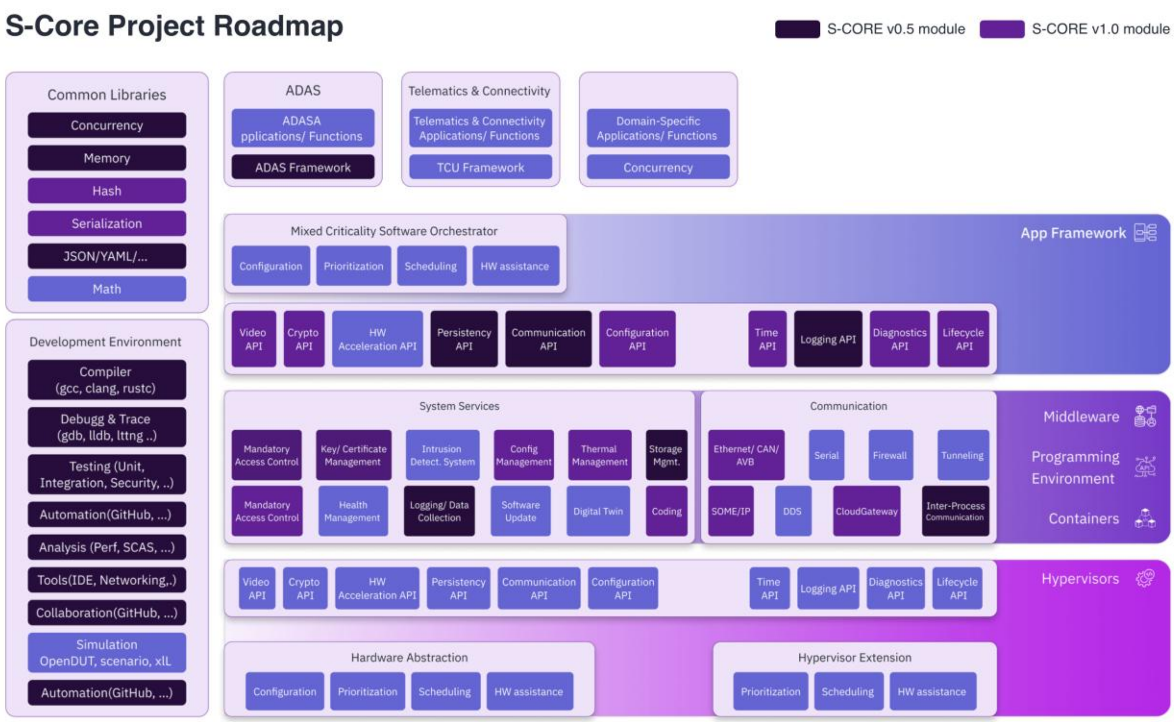

Figure 7: SDV SW stack architecture of Eclipse S-CORE project

- Tools and tool chains designed for the SDV of the Future

The build system uses Bazel to automate workflows like repository cloning, software builds, documentation generation, testing, and more. Documentation is managed with Sphinx and sphinx-needs, while diagrams are created using PlantUML and draw.io. Supported languages include C++ and Rust, with testing handled by gtest/gmock.

- Support of the collaborative development of high-performance (open) SOCs designed for SDVoF

S-CORE is targeting to be the non-differentiating core of a software stack running on HPC ECUs of a software-defined vehicle. It strives for impactful, efficient contributions that evolve the project without redundancy while connected to the "Development Workflow”. The stack works from core systems to application support.

- Close collaboration with existing initiatives to avoid “reinventing the wheel”

The vision/mission is depicted in the figure below extracted from the project website14.

Figure 8: Vision Mission of Eclipse S-CORE project

- Defined governance of the SDVoF initiative

S-CORE brings together members, technical leads, and specialized teams to define and manage modules, propose requirements, and ensure the platform evolves with clarity and purpose. The picture below, extracted from the project website, depicts the governance of S-CORE with a complementary role between Committee governing the project and Operations contributing to it.

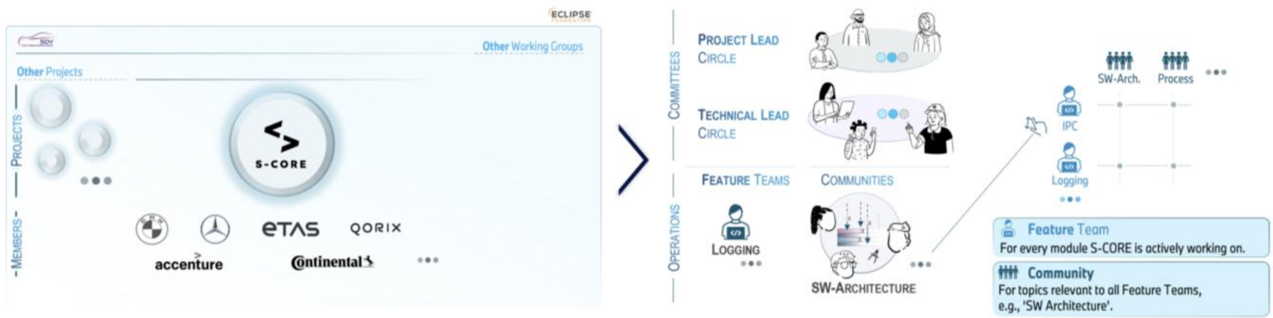

Figure 9: Community Structure of Eclipse S-CORE project

14 https://eclipse.dev/score/about-us.html

Every core member can name a project lead. Project leads are representatives of their entities, and jointly they´re steering the project. Because of the project´s size, an additional role “technical leads” was introduced in S-Core. Each project lead can nominate one technical lead to support in operational topics like project planning. To run the project, there are two major committees Technical Lead and Project Lead as depicted below:

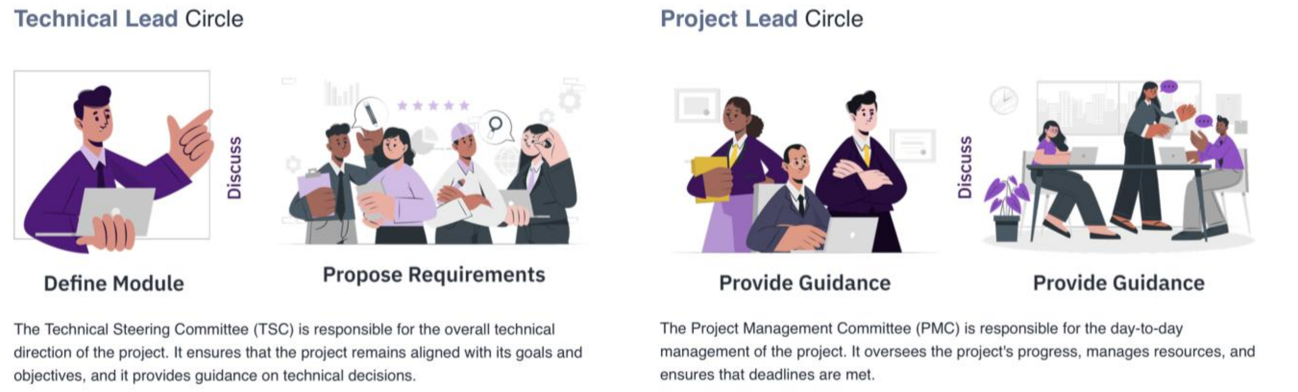

Figure 10: Communities Eclipse S-CORE project

- Participation in the SDVoF ecosystem

S-CORE plays a central role in the SDVoF ecosystem as it provides a certifiable, modular software stack for SDV platforms, with contributions from OEMs, Tier1s, and software vendors.

- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF

S-CORE project is currently defining a process compatible to automotive quality level as document in the process reference document[15]. This process defined 4 Maturity level as displayed in the figure below.

Maturity Level

ML 0	**Plan** - Process definition planned Documents not available or most empty
ML 1	**Initial** - Process definition in place, but not yet compliant, consistency across S-CORE platform, modules and repeatability of processes may not be possible. Documents are mostly available, main parts done, principles clear, all top level questions addressed, well structured.
ML 2	**Managed** - Process definition in place but not yet deployed in S-CORE, but execution would allow consitency across S-CORE platform and modules, repeatability of processes possible Documents are complete, documented on a comprehensible systematic approach, verified, only minor questions open, Process requirements enforced by implemented Tool Requirements.
ML 3	**Defined/Practiced** - Deployed (at least once) in S-CORE platform or one Module, The processes have been practiced, and evidence exists to demonstrate that this has occurred. Document are complete, verified and released, Initial Safety Audit passed.
ML 4	Improving - Deployed on S-CORE platform and various S-CORE Modules and constantly improving, using suitable process metrics, S-CORE commiter control the effectiveness and performance of the platform and modules and demonstrate continuous improvement in these areas.

Figure 11: Maturity level of Eclipse S-CORE artefacts

[15] Process — Process Description documentation

5.2.8.3 Collaboration and Relationship to SDVoF

The current proposal for collaboration is:

- Current Collaboration and relationship

S-CORE acts as an industry wide integration project and with defines Architecture, Processes, Methods and Tools to be compatible with S-CORE. This is essential to have in future a pre-integrated stack up and running incl. all relevant safety documentation.

- Improvement Proposal on collaboration and relationship

The next step is to align the technical BB which are needed and will be developed by other projects.

5.2.8.4 Project Roadmap on SDVoF topics

In complement to S-CORE BB architecture defined above, the initial roadmap of S-CORE roadmap is depicted as following:

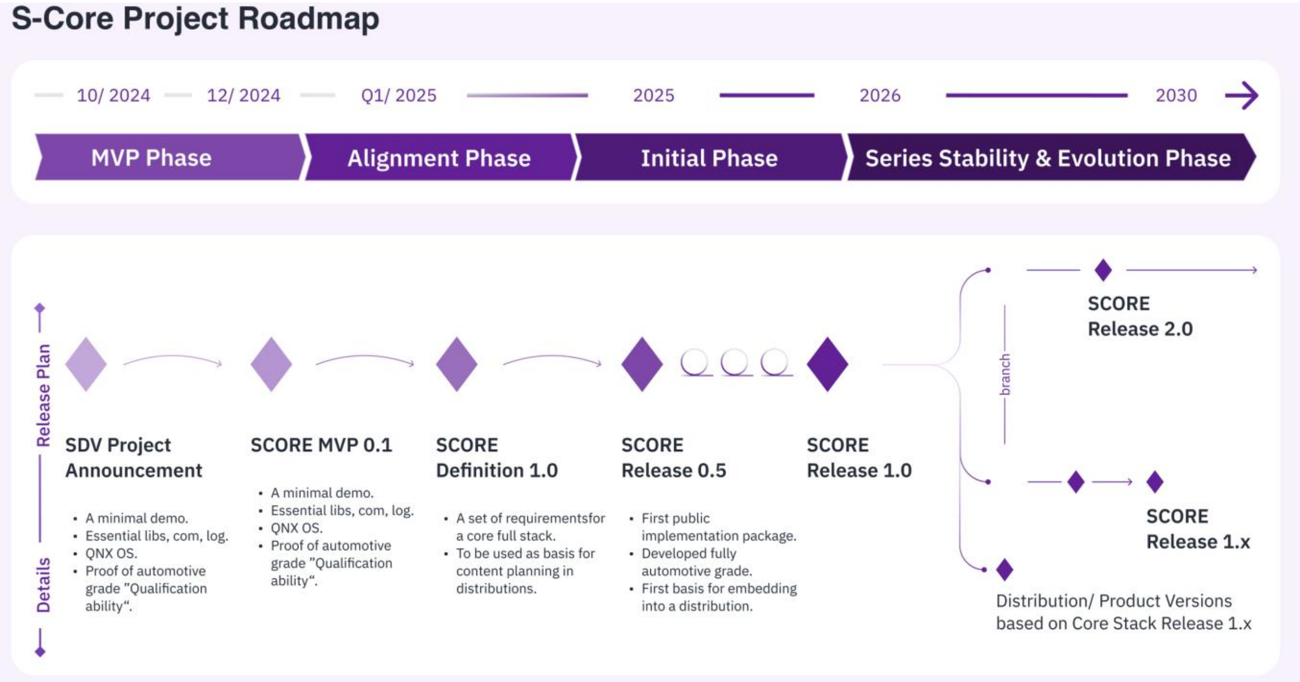

Figure 12: Roadmap of Eclipse S-CORE project

5.2.9 AUTOSAR CAPI

5.2.9.1 General Introduction

The AUTOSAR Common Adaptive Platform Implementation (CAPI) is a strategic, code-first project launched by the global AUTOSAR partnership. Its mission is to provide a standardized, automotive-grade, and safety-qualifiable source code implementation of the AUTOSAR Adaptive Platform standard. CAPI is designed to serve as the foundational middleware for the Software-Defined Vehicle (SDV), eliminating redundant development of non-differentiating software across the industry.

By extending AUTOSAR's 20+ years of specification-based standardization into a collaborative code development model, CAPI aims to deliver a common implementation that OEMs and suppliers can use as a basis for their production systems. CAPI is distinguished by its unique global scope and governance, being developed by and for a partnership of over 300 international industry leaders. This ensures the implementation is backed by a diverse, worldwide ecosystem, making it a de facto global standard rather than a region-specific solution. It embodies a code-first approach, where development happens iteratively and in parallel, ensuring that specifications are validated and refined through a tangible, high-quality codebase. CAPI is permanently open to contributing AUTOSAR partners and, following a release, to the public. It is designed for synergistic collaboration with the broader ecosystem, including initiatives such as Eclipse SDV, S-CORE, COVESA, and SOAFEE.

5.2.9.2 Contribution to the SDVoF Guiding Principles and Expected Results

The planned contribution of AUTOSAR CAPI to the SDVoF guiding principles are as follows:

- Collaborative development of open non-differentiating building blocks

CAPI is the embodiment of open, pre-competitive collaboration for non-differentiating building blocks, a principle that has been the cornerstone of the AUTOSAR partnership since its inception. This effort is fueled by a unique global alliance comprising all major European OEMs and Tier 1s, alongside leading international automotive and software companies.

The strength of this collaboration is amplified by the active participation of these partners in other key consortia and open-source projects (e.g., COVESA, Eclipse, SOAFEE). This cross-pollination ensures that the identification of relevant non-differentiating components within CAPI's scope is continuously validated against the broader ecosystem's needs, preventing duplication and ensuring strategic alignment. By pooling resources and expertise to develop a common implementation, this model guarantees that complex core middleware components are developed "only once" to the highest automotive grade. This allows every participating organization to redirect its valuable R&D capacity toward innovating unique, brand-differentiating features and applications.

- Open-source and Code-first

While the CAPI source code and AUTOSAR specifications are released quarterly in sync and are publicly available free of charge, akin to open source, the project operates according to AUTOSAR's proven IP pooling model. This model grants partners automatic access to a managed IP pool, eliminating the costly legal reviews often required for pure open-source code and providing greater legal certainty for commercial use. The development process is code-first, meaning that contributions, prototyping, and validation happen directly in the codebase, accelerating the standardization process by quick proof of concept and ensuring specifications are pragmatic and implementable. This translates to faster, safer, and more cost-effective implementation, while the permanent public availability ensures the same accessibility and treatment under export control regimes as typical open-source projects.

- Agility and speed through rapid demonstration in representative use cases

CAPI enables a significant increase in development agility. The project is structured for quarterly releases, a substantial leap from traditional cycles. This rapid cadence is supported by continuous integration, validation cycles, and a prototyping environment. This allows for quick prototyping and feedback, ensuring that the implementation meets real-world automotive needs and can be demonstrated in representative scenarios, such as those described in the AUTOSAR deployment patterns (e.g., Automotive API, ADAS data feeds, Cybersecurity).

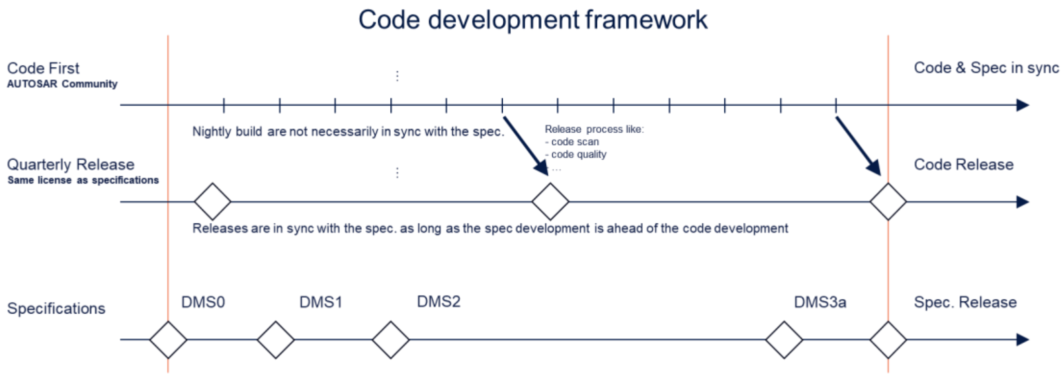

Figure 13: AUTOSAR CAPI code development framework

- HW/SW abstraction and virtualization

Hardware abstraction is a core tenet of AUTOSAR's philosophy since its inception. CAPI, as an implementation of the AUTOSAR Adaptive Platform, provides a standardized safe and secure abstraction layer that decouples software applications from the underlying hardware and operating system (POSIX-based). This enables software portability and reuse across different hardware platforms and supports virtualization paradigms essential for mixed-criticality systems on high-performance compute (HPC) architectures.

- Working in a common structure of the SDV SW stack

CAPI provides the definitive middleware foundation within the common SDV SW stack structure. It implements the comprehensive AUTOSAR Runtime for Adaptive Applications (ARA) APIs, which deliver a standardized, automotive-grade interface for the entire vehicle software ecosystem. This includes critical services such as ARA::COM for service-oriented communication (exemplified by the DDS, or the SOME/IP protocol, which is maintained as an AUTOSAR Standard since 2016), execution management, persistence, and diagnostics, including support for Service-Oriented Vehicle Diagnostics (SOVD).

This robust runtime environment is designed to be the stable, safety- and cybersecurity-qualifiable base upon which other initiatives like Eclipse S-CORE or application-level standards from COVESA can reliably build. By providing this unified foundation, CAPI ensures that all building blocks fit into a coherent, interoperable whole. Furthermore, as the AUTOSAR community continues to extend this runtime to encompass new safety-critical and cybersecurity challenges, it ensures the entire SDV stack evolves with a consistent, reliable, and standardized architectural core.

- Tools and tool chains designed for the SDV of the Future

CAPI is developed using harmonized toolchains and state-of-the-art infrastructure technologies (e.g., Git-hub, CI/CD) to ensure seamless integration into modern software engineering environments, including those of OSS projects. The AUTOSAR standard also defines a methodology and exchange formats (e.g., ARXML) that enable a toolchain ecosystem for design, configuration, and integration, supporting the entire SDV software lifecycle.

- Support of the collaborative development of high-performance (open) SOCs designed for SDVoF

While not developing hardware, CAPI is designed to be hardware-agnostic and is a key enabler for high-performance SoCs. By providing a standardized, optimized software interface, it reduces the software burden on SoC vendors and allows them to focus on hardware innovation. The implementation will support and leverage the capabilities of modern SoCs, including those based on open architectures like RISC-V.

- Close collaboration with existing initiatives to avoid “reinventing the wheel”

Collaboration is fundamental to CAPI's strategy, building upon AUTOSAR's pioneering role in standardizing SDV middleware. The development of the AUTOSAR Adaptive Platform began in 2016, with its first release delivered in March 2017, making it the first standardized middleware solution for high-performance computers in vehicles. This platform has been continuously refined and extended by the global AUTOSAR community for years, resulting in a mature and field-proven set of assets.

Recognizing the need for broader ecosystem alignment to create a holistic SDV stack, AUTOSAR became a founding member of the SDV Alliance, working closely with COVESA, SOAFEE, and Eclipse SDV to ensure technical alignment and avoid duplication. For instance, the AUTOSAR Automotive API standard leverages the COVESA Vehicle Signal Specification (VSS) to enable seamless vehicle-to-cloud data access.

Looking forward, AUTOSAR is open to further consolidation of collaborative efforts. This includes a potential merger of the SDV Alliance with the European Commission's "Connected and Autonomous Vehicle Alliance," provided a common platform for coordination is established. The goal of such a "collaboration of collaborations" must be to ensure compatibility between all initiatives and to build upon existing, proven foundations like the AUTOSAR Adaptive Platform, thus truly avoiding the reinvention of the wheel.

- Defined governance of the SDVoF initiative

AUTOSAR fully supports the need for a defined governance structure for the SDVoF initiative, as exemplified by the SDV-Sherpa Governance Group (SDV-SGG). The AUTOSAR partnership itself operates under a proven, well-defined governance model with over 20 years of experience, featuring clear steering bodies, technical working groups, and transparent processes for contributions. This internal governance ensures that CAPI is developed efficiently and aligns with industry needs.

Crucially, AUTOSAR is committed to integrating into the broader SDVoF governance framework. As a founding member of the SDV Alliance and an associate member of the FEDERATE project, AUTOSAR actively participates in these overarching bodies. The goal of this participation is to ensure that CAPI's development is coordinated with other initiatives, thereby supporting the SDV-SGG's mission to create a cohesive, non-fragmented ecosystem and a unified SDV stack.

- Participation in the SDVoF ecosystem

AUTOSAR and its CAPI project are not just participants but are a proven cornerstone of the emerging SDVoF ecosystem. Recognizing the strategic urgency for industry-wide collaboration, AUTOSAR was a founding member of the SDV Alliance, anticipating the need for a global "collaboration of collaborations" to build a unified SDV stack.

The ecosystem benefits immensely from this participation. CAPI provides a mature, field-proven codebase for safety-critical middleware components, de-risking the SDVoF initiative by offering a stable, automotive-grade foundation instead of a theoretical starting point. This active and open participation ensures that the broader SDVoF goals are built upon a foundation of interoperability, proven technology, and the collective wisdom of AUTOSAR's 20+ years of standardizing non-differentiating software. Many AUTOSAR partners are also key contributors to FEDERATE, HAL4SDV, and other SDVoF initiatives. By integrating CAPI, the ecosystem avoids reinventing core components and can instead focus its energy on higher-layer innovation and integration.

- Reference SW stack composed of SDVoF building blocks (top-down approach)

CAPI is intentionally designed to be the automotive-grade reference implementation for non-differentiating middleware components in a top-down defined SDV software stack. It provides the certifiable core services (communication, execution, persistence, health management, etc.) that form the stable foundation upon which higher-level initiatives can reliably build.

This role is clearly recognized within the evolving SDV ecosystem. As illustrated in the FEDERATE vision, the

Eclipse S-CORE project is the designated integrator for the open-source SDV reference stack. AUTOSAR is actively collaborating to ensure CAPI's components are seamlessly integrable into S-CORE, for instance through a shared plugin concept for protocols. This synergy means that CAPI is not just a standalone component but is positioned to become the de facto core of the S-CORE reference stack, providing the automotive-grade robustness, functional safety, and security that the ecosystem requires. By providing these validated, pre-integrated building blocks, CAPI de-risks the S-CORE integration effort and allows the entire ecosystem to focus on innovation rather than re-developing foundational middleware.

- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF

CAPI is not just code; it is developed with the full rigor of automotive-grade engineering. This includes established processes for requirements management, coding guidelines, testing, validation, and traceability that are adequate for functional safety (ISO 26262) and cybersecurity (ISO/SAE 21434) standards. This makes CAPI a unique offering in the landscape, bridging the gap between open-source agility and the stringent quality demands of series production.

Furthermore, CAPI is designed to facilitate harmonized engineering environments and toolchains. By aligning with modern, state-of-the-art development infrastructure and advocating for compatible processes, CAPI ensures a seamless user experience for developers working across different consortia and projects. This commitment to toolchain alignment significantly reduces integration overhead, accelerates development cycles, and mitigates the risk of errors when combining building blocks from various sources (e.g., Eclipse S-CORE or AUTOSAR-specific components). The result is a powerful, cohesive engineering environment that supports the entire SDV software lifecycle, from initial development to final validation, fostering efficiency and reliability across the entire SDVoF ecosystem.

5.2.9.3 Collaboration and Relationship to SDVoF

The current proposal for collaboration is:

- Current Collaboration and relationship

AUTOSAR is an associate member of the FEDERATE project, ensuring a direct channel for collaboration and alignment. The CAPI project is deeply aligned with the SDVoF initiative's goals, as it directly addresses the problem that ~70% of OEMs' software development effort is spent on non-differentiating elements. Numerous partners within the AUTOSAR and FEDERATE initiative are identical (e.g., BMW, Bosch, Continental, VW), ensuring a natural flow of information and a shared commitment to the SDVoF vision. Furthermore, AUTOSAR's central role in the SDV Alliance creates a formal framework for technical collaboration with COVESA, SOAFEE, Eclipse SDV and S-CORE.

- Improvement Proposal on collaboration and relationship

To further strengthen collaboration and realize the full potential of a unified SDV stack, we propose moving beyond ad-hoc alignment to a more institutionalized, technical collaboration framework. A key enabler for this could be the implementation of the "OSS Collaboration Working Model" presented by AUTOSAR, which is based on two pillars:

1. A "Compatible Process and Tooling Framework" to ensure seamless development and integration experiences across consortium boundaries.
2. A dedicated "Compatibility Layer" between the AUTOSAR and OSS repositories to manage interfaces and dependencies effectively.

To make this model effective, we propose the establishment of a standing cross-initiative technical synchronization group. The mandate of this group would be to proactively define and maintain the requirements for this compatibility layer, ensuring interoperability between building blocks from AUTOSAR, Eclipse S-CORE, and other key projects. This includes establishing clear protocols for the cases where full compatibility is not achieved at a given point in time, ensuring mitigation strategies are defined and transparently communicated to all developers in the ecosystem to prevent integration failures.

Furthermore, this synchronization group should foster joint demonstrator projects that combine CAPI with building blocks from other SDVoF projects (e.g., S-CORE, HAL4SDV, Shift2SDV). These practical implementations would serve as the ultimate proof of concept for the collaboration model and provide tangible value by validating interoperability for the entire ecosystem.

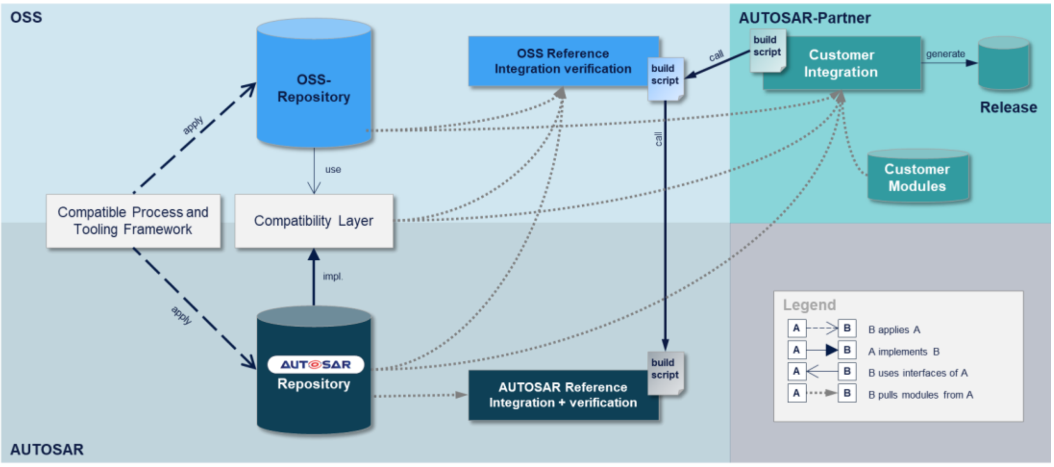

Figure 14 AUTOSAR Proposal for an OSS Collaboration Working Model

5.2.9.4 Project Roadmap on SDVoF topics

The CAPI project follows an ambitious and transparent roadmap with quarterly releases. The following key milestones are planned regarding the availability of building blocks:

- **Q4 2025 (R25-11 Release):** Initial open-source release of core CAPI modules, focusing on foundational infrastructure and a subset of adaptive platform services (e.g., basic Execution Management, Persistency). This MVP will be available for early evaluation and integration by ecosystem partners.
- **2026:** Quarterly releases will progressively expand functionality to cover full-service sets including Communication Management, Platform Health Management, and Diagnostic capabilities. Key milestones will include integration and validation with other open-source projects like Eclipse S-CORE and public demonstrators of specific deployment patterns.
- **2027:** Releases will focus on achieving production-ready maturity, performance optimization, and enhanced safety and security qualifications. The goal is to provide a complete, stable, and certified implementation of the AUTOSAR Adaptive standard, ready for widespread adoption in series development programs.

This roadmap is designed to provide the ecosystem with early access to building blocks, allowing for parallel development and integration, ultimately accelerating the realization of the SDVoF vision.

5.3 SDV Associations

5.3.1 Eclipse SDV

5.3.1.1 Updates in 2025

In the updated Eclipse section of the document, we highlighted how Eclipse mirrors the goals of SDVoF through key projects such as Eclipse Kuksa, Eclipse Zenoh, Eclipse uProtocol, Eclipse SDV Blueprints, Eclipse OpenDUT and Eclipse S-CORE. We also noted Eclipse SDV's role in organizing hackathons as well as community days for developers and dedicated summits for decision makers (AOSS) to promote interoperability, collaboration and organizational changes. Furthermore, we propose a roadmap approach, which is implemented on project level (Eclipse S-CORE) to demonstrate the alignment with SDVoF objectives. Finally, we provide information on the new raised Eclipse Project OpenSOVD.

5.3.1.2 General Introduction

The Eclipse SDV Working Group (WG) has the scope to provide an open technology platform for the Software Defined Vehicle of the Future, accelerating innovation of automotive software stacks through a vibrant open-source community. The Eclipse SDV WG was founded in March 2022 and counts to date 56 members from across the industry spectrum: from technology providers, to Tier1, consulting organizations and OEMs.

The Eclipse SDV WG is is an industry collaboration under the Eclipse Foundation.

The Eclipse Foundation provides our global community of individuals and organizations with a mature, scalable, and business-friendly environment for open-source software collaboration and innovation. The Foundation is home to over 430 open-source projects, including runtimes, tools, and frameworks for cloud and edge applications, IoT, AI, automotive, systems engineering, distributed ledger technologies, open processor designs, and many others. The Eclipse Foundation is an international non-profit association supported by over 330 members, including industry leaders who value open source as a key enabler for their business strategies.

The Eclipse Foundation is the EU's largest open-source software foundation and has 10 years a long-term involvement in EU research programs.

5.3.1.3 Contribution to the SDVoF Guiding Principles and Expected Results

The Eclipse SDV WG has more than 30 Open-Source projects under its purview, in different key functional areas of the automotive SW stack. The projects follow the well-established Eclipse Foundation Development Process (EDP). The EDP does not prescribe any particular development methodology; it is more concerned with the larger-scale aspects of open-source project life cycle, and it is based on the Open-Source Rules of Engagement principles: Openness, Transparency, Meritocracy.

To augment the EDP, the Eclipse Foundation offers the Eclipse Foundation Specification Process (EFSP), which facilitates the creation of open specifications that ensure compatibility, interoperability, and sustainability for both proprietary and open-source implementations. The EFSP offers a defined, structured, and trusted legal framework and governance process and it supports the development of royalty-free open specifications, building on mature open-source processes. The EFSP complies with the Open Standards Requirement for Software established by the Open Source Initiative.

The Eclipse SDV projects constitutes non-differentiating building blocks that can be organized as follows:

- SDV.Dev focuses on development toolchains and workflows to allow for modern development of in-vehicle (and supporting off-vehicle) applications that integrate with cloud-based deployment and

applications management environments,
- SDV.Ops focuses on enabling management of software stacks in large fleets of vehicles, integrating with existing mobility cloud solutions, and supporting open standards where such integrations are established,
- SDV.Edge focuses on bringing cloud-native technologies to a range of in-vehicle software domains including quality-managed (QM) and safety relevant domains.

The Eclipse SDV community follows a "code-first" approach: it is first and foremost focused on shipping working open-source software intended for adoption by the automotive industry.

This Eclipse SDV WG is designed as:

- a vendor-neutral, member-driven organization,
- a means to foster a vibrant and sustainable ecosystem of components and service providers,
- a means to organize the community of each project or component so that users and developers define the roadmap collaboratively.

The governance of the WG relies on three governing bodies composed of representatives from the WG members.

To showcase agility and speed through demonstration in representative use cases, the WG hosts the Eclipse SDV Blueprints project. The project hosts different blueprints each addressing a clear use case making it possible to highlight the capabilities and features of the Eclipse SDV building blocks and explore potential for collaboration and integration of these technologies.

Started in November 2024, and gathering momentum is the Eclipse Safe Open Vehicle Core (S-CORE) project. Eclipse S-CORE aims at developing a core software stack for SDVs, specifically for embedded high-performance Electronic Control Units (ECUs). It aims to bridge the gap between in-vehicle operating systems and the application layer by providing an interface with essential enabler functions for automotive applications. The project's goal is to establish a non-differentiating, common software core for High Performance Computers (HPCs) in SDVs, fostering industry collaboration and efficiency. Its development prioritizes abstraction, extensibility, quality, and speed.

Another key project, resulting from a EU funded research project is Eclipse Kuksa.

While COVESA hosts the Vehicle Signal Specification, which describes and unify the semantics of vehicle data, Eclipse SDV hosts the implementation of such a standardized data model. In other words, Eclipse Kuksa is one of the Eclipse SDV projects that provides an abstraction layer from vehicle data to VSS.

To foster the collaboration between initiatives and to avoid reinventing the wheel, the Eclipse SDV is part of the SDV Alliance, together with AUTOSAR, COVESA, and SOAFEE. The SDV Alliance's purpose is not to produce technology, but to align necessary technologies and plan for integration of those technologies produced by its participating consortia.

5.3.1.4 Collaboration and Relationship to SDVoF

The Eclipse SDV actively participates in the dissemination effort of FEDERATE. FEDERATE has partnered with the Eclipse SDV WG in the organization of OCA (Open Community for Automotive) conference with two representatives in the Program Committee. To highlight the EU based collaborations, we have a dedicated track: "Automotive, Mobility & SDV" focused on collaboration across consortia.

Eclipse mirrors the goals of SDVoF in projects such as:

- Eclipse Kuksa

- Eclipse Zenoh
- Eclipse uProtocol
- Eclipse SDV Blueprint
- Eclipse Safe Open Vehicle Core (S-CORE)
- Eclipse OpenDUT
- Eclipse OpenSDV

In addition, the Eclipse SDV is organizing hackathons to showcase and promote the interoperability of the Open-Source projects. Other events include Community Days community days for developers and dedicated summits for decision makers (AOSS).

5.3.1.5 Project Roadmap on SDVoF topics

Open-source projects are free to plan their roadmaps and targets, hence the Eclipse SDV WG cannot mandate feature requests and milestones. The Eclipse SDV facilitates and promotes activities to enable cross project collaboration to fulfil the Working Group vision and its annual program plan, however the Eclipse SDV WG does not centrally plan project milestones, and to date a unified roadmap across all SDVoF-relevant projects is not available.

The FEDERATE initiative recognizes the need to provide a clearer picture of progress and alignment. To that end, we propose a roadmap approach that includes:

- Project-Level Analysis: A closer look into key projects such as Eclipse S-CORE and Eclipse SDV Blueprint should be conducted to identify concrete milestones, integration points, and development trajectories. These projects are particularly relevant as they focus on BB integration and system-level orchestration.
- Activity Metrics: Once a set of relevant projects is defined, metrics such as number of commits, contributors, and release cadence will be extracted to illustrate project activity and maturity.
- Integration Milestones: Projects like Eclipse SDV Blueprint and Eclipse S-CORE can be used to highlight system-level progress toward SDVoF goals.

In the context of this document, the S-CORE project is most relevant. Please see details in chapter 6.2.8.

In July 2025 another Eclipse Project was raised, Eclipse OpenSOVD. The Service-Oriented Vehicle Diagnostics (SOVD) standard, defined in ISO 17978, is specifying a service-based architecture for secure and scalable access to diagnostic data and functions. However, the automotive ecosystem lacks open-source implementations that developers, researchers, and OEMs can use to experiment, validate, or integrate SOVD into software-defined vehicles (SDVs).

Eclipse OpenSOVD fills this gap by delivering a freely available, collaboration-driven implementation of ISO 17978, fostering innovation, reducing vendor lock-in, and accelerating industry-wide adoption of standardized diagnostics.

5.3.2 COVESA

5.3.2.1 Updates 2025

The following COVESA materials have been reviewed by the COVESA Directorate and continue to reflect current and accurate information.

5.3.2.2 General Introduction

The Connected Vehicle Systems Alliance (COVESA), is a global, member-driven alliance focused on the development of open standards and technologies that accelerate innovation for connected vehicle systems, resulting in a more diverse, sustainable, and integrated mobility ecosystem.

COVESA is the only alliance focused solely on developing open standards and technologies for connected vehicles, which now form a growing percentage of vehicles on the road. Leveraging vehicle data and vehicle-to-cloud connectivity has become a primary goal of automakers and their suppliers.

5.3.2.3 Contribution to the SDVoF Guiding Principles and Expected Results

- Collaborative development of open non-differentiating building blocks

COVESA was established and has successfully operated for over a decade to enable and support collaborative development of open software for several of the non-differentiating building blocks identified in previous phases of the SDVoF project. Mature open projects exist that address topics in all four categories of building blocks and COVESA's core way of working aligns well with the open-source enabler and open governance model expected by the SDVoF project. Examples of work in progress includes Vehicle Signal Specification (VSS), Vehicle Interface Service Specification (VISS) and the Common Vehicle Interface (CVI) projects, though there are many more activities addressing SDVoF building blocks.

- Open-source and Code-first

All COVESA projects are open source licensed and open to the public.

All specifications written in COVESA must be proven by one or more reference implementations.

- Agility and speed through rapid demonstration in representative use cases

COVESA encourages rapid proofs of concept and protypes and provides the industry a collaborative and antitrust-compliant environment to do so.

A primary goal of COVESA is to learn and rapidly produce useful work products without high administrative or bureaucratic overhead.

- HW/SW abstraction and virtualization

Two of COVESA's prime areas of focus are common vehicle data and common vehicle interfaces that are decoupled from specific hardware. Common data models and interfaces are critical components to hardware abstraction.

COVESA supports a data-centric architecture and has published patterns to support this data-centric approach.

- Working in a common structure of the SDV SW stack

The COVESA Data Expert Group has active workstreams on middleware and API's both on and off the vehicle. COVESA's vsomeip, VISS and VSS projects represent mature and well adopted components in the SDV SW stack. At the application layer, COVESA has a large Automotive AOSP App Framework Standardization Expert Group that endeavours to standardize components that facilitate reuse and minimize fragmentation in AOSP deployments.

- Tools and tool chains designed for the SDV of the Future

COVESA's Central Data Service Playground was envisioned and created to realize and support various data-centric architectures. Additionally, the digital.auto tool effectively provides a highly visual method of ideating and developing automotive services using VSS as its data backbone.

- Close collaboration with existing initiatives to avoid “reinventing the wheel”

A prime directive of COVESA is collaboration amongst its members and across like-minded organizations working in the automotive industry. As such, projects within COVESA are internally harmonized when possible. Externally, COVESA actively collaborates with Eclipse SDV, SOAFEE, AUTOSAR, JasPar, ISO, SAE, and many others. VSS is used by several Eclipse projects including Kuksa.val. VSS and VISS are used by AUTOSAR Automotive API project.

COVESA has a vibrant and growing membership of both automotive and non-automotive (e.g., adjacent industries like FinTech, InsureTech, etc.) stakeholders. Many of the current COVESA members are already participating in SDVoF ensuring already existing alignment with SDVoF goals. All the Automotive OEMs in Figure 3 currently collaborate in COVESA.

- Defined governance of the SDVoF initiative

COVESA also has a balanced top-down/bottom-up governance model that ensures that work products created are relevant to the industry while enabling code first contributions to flow from individual contributors. The COVESA Board and Technical Steering Team ensure that projects and groups function consistently but are not overly burdened with overhead that slows progress. Software and documents produced within COVESA are openly available and licensed so that other stakeholders can adopt them with a clear understanding of how they can be freely used for open or commercial products.

- Participation in the SDVoF ecosystem

COVESA was founded on the belief that technologies, including SDV, require vibrant ecosystems surrounding them. A core value of COVESA is its buyers and sellers’ network, represented in COVESA events and various showcases, during which products and services based on COVESA work products can be openly discussed, resulting in a strengthened product ecosystem.

5.3.2.4 Collaboration and Relationship to SDVoF

The current proposal for COVESA collaboration is:

- Current Collaboration and relationship

COVESA is currently an Associate member of the FEDERATE Project and numerous COVESA’s members (BMW, Bosch, etc.) are actively involved participating in SDVoF. COVESA’s mature projects related to a large number of building blocks are open and available for adoption and improvement by SDVoF stakeholders.

- Improvement Proposal on collaboration and relationship

COVESA’s open approach aligns well with SDVoF’s vision for open collaboration and governance. Thus, engaging existing COVESA project communities will benefit SDVoF members and projects through adoption of existing, community-driven, globally relevant work products.

5.3.3 AUTOSAR

5.3.3.1 Updates in 2025

In 2025 AUTOSAR decided to prioritize a joint automotive grade implementation called AUTOSAR Common Adaptive Platform Implementation (CAPI). A model how open source projects can utilize this implementation was shown in some conferences. The implementation is a Community Source approach combining advantages from Open-Source development and appropriate Software to achieve professional automotive grade Software development. The code-first approach is supported and the implementation will be publicly available, but commercial exploitation requires AUTOSAR partnership.

5.3.3.2 General Introduction

The AUTOSAR (AUTomotive Open System ARchitecture) Partnership is a globally accepted and successful open development cooperation with leading companies in the automotive and software industry to develop and establish the standardized framework enabling reuse, exchangeability, easy integration of software and scalable E/E system architectures for intelligent mobility. Since 2003, they have been working on the development and introduction of several open, standardized software platforms including the joining methodology for the automotive industry. By simplifying replacement and update for software and hardware, the AUTOSAR approach forms the base for reliably mastering the growing complexity of electronic and software systems in todays and future vehicles. As AUTOSAR is open to new features in the Automotive area it continuously adapted in the past and it will further continuously adapt the platforms to the market needs in future, driven by its partners. This is not only true for the features but also for the way of working and the scope of deliverables. Key of de-facto standardization is specifications aligned with all the partners. Since 2016 AUTOSAR also started code development as AUTOSAR Software Implementation (realizing requirements of AUTOSAR Specifications) where the partners drive specifications and code development (of course also “code first”) according to their prioritization. A key recent strategic initiative is the **AUTOSAR Common Adaptive Platform Implementation (CAPI)** project, which aims to provide a standardized, automotive-grade source code implementation of the AUTOSAR Adaptive Platform standard, extending AUTOSAR's specification-based approach into a collaborative code development model.

The founding partners called "Core Partners" of AUTOSAR are the Bayerische Motoren Werke AG, Robert Bosch GmbH, Continental AG, Mercedes-Benz AG, Ford Motor Company, General Motors, Stellantis, Toyota Motor Corporation and the Volkswagen AG. The AUTOSAR partnership of more than 300 partners plays an important role in the success of the automotive industry. The AUTOSAR partnership has an established organizational structure to integrate more than 300 global partners including their contributions in terms of fees and full-time equivalents to the development of the AUTOSAR platforms. Although the platforms are publicly accessible, a partnership is required to ensure the “IP pooling”, which has demonstrated its reliability over many years for all AUTOSAR partners.

5.3.3.3 Contribution to the SDVoF Guiding principles and Expected Results

In this section it is elaborated how AUTOSAR is contributing to the guiding principles of the SDVoF Initiative.

- Collaborative development of open non-differentiating building blocks

The AUTOSAR partnership is standardizing non-differentiating building blocks for microcontrollers and SOC systems as well as methodology and exchange formats for such systems, which are aligned between hundreds of companies from the automotive industry for more than 20 years. Its results are open available on www.autosar.org and exploitation is possible for all AUTOSAR Partners. The AUTOSAR Adaptive Platform, which is tackling the middleware for SoC based systems with microprocessors, is also available as a AUTOSAR Software Implementation.

- Open-source and Code-first

While AUTOSAR's primary focus remains on specification, the partnership has embraced a code-first approach through initiatives like the AUTOSAR demonstrator and, more significantly, the Common Adaptive Platform

Implementation project. CAPI aims to develop a common, automotive-grade implementation through iterative, code-first development, ensuring specifications are pragmatic and implementable. The resulting code is publicly available, offering similar accessibility to open source while operating under AUTOSAR's established and legally certain IP pooling model.

- Agility and speed through rapid coding in demonstrator in representative use cases

The AUTOSAR Adaptive Platform Implementation and its evaluation with the demonstrator enables traceability and a higher level of agility. CAPI with its code-first approach is structured for quarterly releases, a substantial leap from traditional cycles, supported by continuous integration and validation. This approach allows findings from implementation to be quickly fed back, increasing the overall pace of standardization and development.

- HW/SW abstraction and virtualization

The main goal of AUTOSAR since day 1 is the abstraction of the Hardware from the Software, by a layered software architecture for the AUTOSAR Classic Platform and a logical software architecture for the AUTOSAR Adaptive Platform both serving the purpose to make it possible to move HW independent applications between different ECUs and to easily re-use them in other projects. The market also offers several solutions with respect to virtualization based on AUTOSAR technologies. Beyond pure low level HW-abstraction, AUTOSAR always considers the automotive ISO standards for safety (e.g. ISO26262), for cybersecurity (e.g. ISO/SAE 21434 or ISO 24089) and automotive diagnosis functions (e.g. ISO 14229 or ISO 15765-4).

- Working in a common structure of the SDV SW stack

AUTOSAR is working on common middleware components within the SDV ecosystem as the basis for a uniform SDV software stack. In an open collaboration with COVESA with the release R24-11 AUTOSAR has taken another step toward SDVoF specifying and implementing the Automotive API. This interface provides standardized data according to the COVESA Vehicle Signal Specification (VSS) to make vehicle data available also for non-AUTOSAR partners.

- Tools and tool chains designed for the SDV of the future

The AUTOSAR Standard defines a methodology which can be implemented and supported by tool chains. The focus of the AUTOSAR partnership however is not to provide tooling, this is usually up to the partners to tackle. With standardized exchange formats defined in AUTOSAR different tools can interact based on these standardized exchange formats.

- Support of the collaborative development of high-performance (open) SOCs designed for SDVoF

This topic is originally not in the focus of AUTOSAR but the intention is (if necessary) to extent the standard to support what are the market needs. This is one example of the adaptations which can be driven by the AUTOSAR Partners. Such collaborative developed high-performance SOCs will be supported if the market is adopting them.

- Close collaboration with existing initiatives to avoid “reinventing the wheel”

Collaboration is a foundational principle for AUTOSAR, extending beyond its own partnership to active engagement with global standardization bodies and consortia. This ensures alignment, avoids duplication, and leverages complementary expertise. A prime example is the co-founding of the SDV Alliance with COVESA, Eclipse SDV, and SOAFEE, which serves as a strategic "collaboration of collaborations" to coordinate technologies and plan integrations for a unified SDV stack. This has yielded concrete technical outcomes, such as the AUTOSAR Automotive API standard, which directly incorporates and aligns with the COVESA Vehicle Signal Specification (VSS) to enable seamless vehicle-to-cloud data access.

This model of collaboration is well-established. Organizations like ASAM and The Khronos Group have joined the AUTOSAR community as partners to harmonize interfaces and work on joint topics within AUTOSAR's proven organizational and IP framework. This ensures a productive flow of information and technical alignment while respecting each organization's governance. For instance, the implementation of the ASAM SOVD (Service-Oriented Vehicle Diagnostics) standard within AUTOSAR and the ongoing collaboration with Khronos to align high-performance graphics and compute APIs (e.g., SYCL) for automotive use cases demonstrate how AUTOSAR naturally facilitates cross-industry cooperation to solve common mobility challenges efficiently.

- Defined governance of the SDVoF initiative

The AUTOSAR partnership operates under a proven, well-defined governance model with over 20 years of experience. AUTOSAR is willing to support the broader SDVoF governance framework, actively participating as a founding member of the SDV Alliance and an associate member of the FEDERATE project. This ensures AUTOSAR's development, including the CAPI project, is coordinated with other initiatives, supporting the SDV-Sherpa Governance Group's (SDV-SGG) mission to create a cohesive ecosystem.

- Participation in the SDVoF ecosystem

With respect to the three before listed bullet items: AUTOSAR is working together within the SDV Alliance with COVESA, Eclipse and SOAFEE and is also collaborating with other standards bodies like ASAM, JASPAR, ISO, IEEE and Khronos just to name a few. AUTOSAR is also an associated member of the FEDERATE program and willing to act as sparring partner to make the SDVoF initiative a success.

- Large positive impact on the open SDV communities and SDV tool ecosystem

The impact of AUTOSAR with more than 300 partners today in the automotive ecosystem is already quite high. The AUTOSAR standards and the huge global community can be a base for the SDVoF initative and solves already many non-differentiating and organizational aspects. On top of the standard open SDV Communities can build and implement further non-differentiating building blocks of the SDVoF Initiative.

- Pool of open automotive grade building blocks for SDV SW stacks (bottom-up approach)

The AUTOSAR platforms already define many building blocks which are non-differentiating starting from the hardware and reaching towards the software interfaces for applications. Its focus is for sure not extensive to cover all building blocks for SDV SW stacks but the specifications are definitely aimed to build automotive grade building blocks.

- Reference SW stack composed of SDVoF building blocks (top-down approach)

AUTOSAR is willing to provide SDVoF middleware components in the form of the AUTOSAR CAPI to compose the reference SW stack.

- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF

Functional safety and cybersecurity play a pivotal role in the AUTOSAR standards, making AUTOSAR support for automotive grade SW engineering one of the basic requirements. With the appropriate support of its partners, AUTOSAR is willing to provide a corresponding automotive grade SW engineering environment for the building blocks provided by AUTOSAR with the necessary support over the entire SW lifecycle of the SDVoF.

5.3.3.4 Current Collaboration and relationship

AUTOSAR is involved today already with many consortia directly or via the SDV Alliance. The goal is also to further collaborate with FEDERATE and other activities of the SDVoF initiative. The CAPI project is deeply aligned with the SDVoF initiative's goals, directly addressing the development of non-differentiating middleware components.

- Improvement Proposal on collaboration and relationship

AUTOSAR would appreciate more direct involvement and exchange. Furthermore, AUTOSAR proposes the institutionalization of a cross-initiative technical synchronization group, as outlined in chapter 6.2.9, to proactively define and maintain requirements for a compatibility layer between initiatives like AUTOSAR CAPI and Eclipse S-CORE. This would ensure interoperability and prevent integration failures within the SDVoF ecosystem.

5.3.4 SOAFEE

5.3.4.1 Updates in 2025

The following SOAFEE materials have been reviewed by the SOAFEE Directorate and continue to reflect current and accurate information.

5.3.4.2 General Introduction

SOAFEE is an industry-led collaboration with the goal of developing an architecture and platform for the development and deployment of the software-defined vehicles of the future. The platform is designed to maximize environmental compute parity between the cloud and the vehicle and focuses on cloud-native software development for mixed-critical workloads.

5.3.4.3 Contribution to the SDVoF Guiding Principles and Expected Results

The SOAFFE consortium identifies the following relevant principles guided by the SDVoF principles:

- Collaborative development of open, non-differentiating building blocks and practices to deliver End-to-End software solutions for the Automotive domain,
- Open standards based with an open-source reference implementation and commercial offerings emphasizing portable workloads and hardware agnostic interfaces,
- Agility and speed through rapid demonstration in representative use cases,
- HW/SW abstraction through virtualization and containerization,
- Cloud-based virtual prototyping environments for early development of SDV workloads,
- Working in a common architecture for development of the SDV SW stack,
- Tools and tool chains designed for the SDV of the future,
- Support of the collaborative development environment for high-performance (open) SOCs designed for SDVoF,
- Close collaboration with existing initiatives to avoid “reinventing the wheel” – founding member of the SDV Alliance collaboration,
- Defined governance of the SDVoF initiative,
- Participation in the SDVoF ecosystem,
- Reference SW stack composed of SDVoF building blocks (top-down approach) and utilizing example components from other SDV Alliance consortiums,
- Automotive grade SW engineering environments for the whole SW lifecycle for SDVoF.

5.3.4.4 Collaboration and Relationship to SDVoF

The current proposal for SOAFEE collaboration is:

- Collaboration with other SDV consortia through SDV Alliance (including COVESA, AUTOSAR and Eclipse.SDV)
- Associate member in GAIA-X Ageda, FEDERATE and HAL4SDV

A more accurate action plan will be discussed with SOAFEE initiative leader (where his/her company is not currently associate member of FEDERATE).

6 Overall Roadmap on SDV

The following Roadmap aims to show expected results in 2025 and 2026 regarding the SDVoF targets.

Align with WP3 repository BB description, the roadmap will be updated frequently, and the goal is to show when concrete results will be ready for using in the SDV Ecosystem (e.g. in- and off-vehicle, tools).

A second objective is to identify direction and commitment of OEMs (and Tiers 1) on open-source initiative and especially tracking reuse of open-source BB and for vehicle serial production.

6.1 SDVoF roadmap

The current R&D project identified in section 5.2 as main contributors to BB block repository are either

- not in a position to disclose all the BB blocks,
- awaiting a major project milestone to consolidate the preliminary list of BBs relevant to the SDVoF open-source roadmap, or
- too recently launched (with a kick-off in 2025) to have identified any BBs yet
- getting an initial roadmap

As of the date of writing this deliverable in 2025, the HAL2SDV and Shif2SDV project, which started in April 2024, falls into the first and second category. The following projects RIGELETTO, CODE4SDV, TWINLOOP, UP2DATE4SDV, EEACAM and Code4SDV -all kicked off in 2025 and belong to the third category. Finaly, S-CORE and AUTOSAR CAPI belongs to the third category.

However, in Figure 15 we explore the collaborative efforts of various projects aimed at advancing software-defined vehicles (SDVs). It provides an overview of how different initiatives interact and progress over time from 2024 to 2030. Details on the highlighted Building Blocks (e.g. Shift2SDV A1) can be accessed by the corresponding projects and is also documented in FEDERATE deliverable D4.2 (Recommendations for building block realization).

Indeed S-CORE is an integration initiative that reuses BB code developed in other projects. It serves as a pre-integration platform to support future industrial projects. Its roadmap only provides visibility on milestones related to industrial development.

Together, these projects form a dynamic and interconnected ecosystem, demonstrating the strategic alignment and phased coordination necessary to realize the SDVoF vision.

The SDVoF roadmap will be updated in the final version of this deliverable in 2026 .

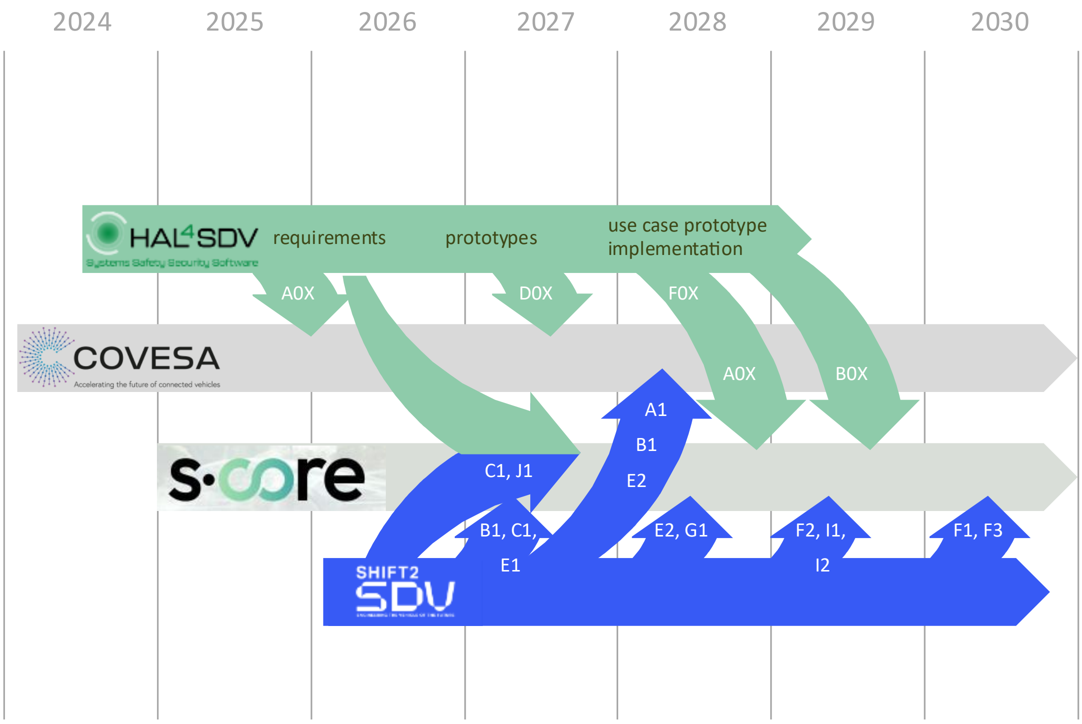

Figure 15: SW Technology integration roadmap of the European driven SDV SW platform initiative

6.2 SDVoF commitments of OEMs

The strategic roadmap of the SDVoF initiative is increasingly shaped by the formal commitments and collaborative actions of European OEMs and suppliers. These are reflected in several key declarations and initiatives that collectively demonstrate industry-wide alignment toward a shared vision for software-defined vehicles.

6.2.1 Commitment through Strategic Declarations

Two foundational documents - the **Manifesto for a European Software-defined Vehicle Ecosystem** (November 2024) and the **Memorandum of Understanding on Automotive Grade Open-Source Software Ecosystem** (May 2025) - serve as public affirmations of OEMs' commitment to open, pre-competitive collaboration.

- The **Manifesto**, signed by leading OEMs and Tier-n suppliers, outlines the need for a transversal framework to overcome fragmentation in vehicle software development. It calls for the creation of a European SDV ecosystem based on standardized building blocks, open interfaces, and modular toolchains. The document emphasizes the importance of reusability, interoperability, and governance to reduce development costs and accelerate innovation.
- The **MoU** reinforces this vision by proposing a shared open-source software ecosystem built on a secure core stack. It promotes a code-first approach, aiming ISO26262 qualification through open source, and collaboration within the Eclipse SDV framework. The roadmap includes milestones such as the public release of key software modules by the end of 2025 and integration into series production by 2030.

6.2.2 ECAVA: A Strategic Coordination Framework

The **European Connected and Autonomous Vehicle Alliance (ECAVA)**, presented at the FEDERATE SDV Summit in May 2025, represents a pivotal step in aligning industrial and institutional efforts. ECAVA is designed to support the competitiveness and strategic autonomy of the European automotive industry, with a focus on software-defined, AI-powered, connected, and autonomous vehicles.

ECAVA's mission is to foster a robust and collaborative ecosystem among European OEMs, Tier suppliers, and open-source initiatives. It promotes the co-development of **shared, non-differentiating software building blocks**, moving away from proprietary silos. This system-level approach supports key EU objectives, including **digital sovereignty**, **zero-emission mobility**, and **industrial competitiveness**.

ECAVA Governance led by OEMs and Tier suppliers, with implementation support from organizations like Eclipse, AUTOSAR, and COVESA.

ECAVA complements the SDVoF roadmap by providing a broader framework for coordination, standardization, and strategic investment, supported by EU and national funding programs. Details on the ECAVA can be found on the document "2025 Technology Roadmap" which was published in September 2025 by FEDERATE[16] and in general context on the European Commission's ECAVA webpage.[17]

6.2.3 Eclipse S-CORE: Operationalizing the Vision

The **Eclipse S-CORE** project (see 5.2.8), launched under the Eclipse SDV Working Group, operationalizes the open-core strategy envisioned in the MoU. It provides a certifiable, modular software stack for SDV platforms, with contributions from OEMs, Tier1s, and software vendors.

Highlights of S-CORE will include:

- A virtual development environment (QEMU), full toolchain support (e.g., Bazel), and integration with CI/CD pipelines.
- A safety-capable development process audited by Exida, covering architecture, verification, and implementation.
- A roadmap leading to **Release v1.0** starting in 2026**, enabling series development.**
- A reference stack that supports integration into diverse vehicle platforms while preserving OEM-specific extensions.

S-CORE exemplifies the shift-left approach, enabling early validation and reuse of non-differentiating components across the industry. It also facilitates harmonized contributions from multiple stakeholders, reducing redundant effort and accelerating time-to-market.

6.2.4 On Disclosure and Adoption

It is important to acknowledge that **OEMs typically do not publicly disclose which specific results or building blocks they reuse from publicly funded projects**. This practice is rooted in competitive and confidentiality considerations. However, their active participation in initiatives such as SDVoF, ECAVA, and Eclipse S-CORE and their signatures on the earlier mentioned documents - serve as strong indicators of alignment and adoption.

[16] https://federate-sdv.eu/wp-content/uploads/2025/09/2025-SDV-TechnologyRoadmap-Whitepaper-ver-1.0-final.pdf

[17] https://digital-strategy.ec.europa.eu/en/policies/vehicle-alliance

6.2.5 Conclusion

The convergence of strategic declarations, coordinated alliances, and operational platforms underscores the growing maturity of the European SDV ecosystem. OEMs are not only endorsing the vision but actively shaping its implementation through structured collaboration, shared governance, and open-source contributions. This collective momentum validates the SDVoF roadmap and reinforces its role as a cornerstone of Europe's automotive digital transformation.

7 Overview of OEM Participation

The objective of this section is to describe the relationship between OEMs (and internal Tiers 1 suppliers), specifically those who are partners or associated members of the FEDERATE project, and the initiatives listed in this document related to SDVoF. This aims to demonstrate their active involvement and commitment to the SDVoF perspective.

These relationships are presented in the tables below, organized according to section 5: European Partnerships, SDV Projects, and SDV Associations.

OEM	CCAM	2ZERO
AMPERE (RENAULT)	X	X
AUDI		X
BMW	X	X
CARIAD (VW)	X	X
DAIMLER TRUCK	X	
FORD OTOSAN	X	X
HYUNDAI EUROPE		
IVECO	X	X
MERCEDES-BENZ		
PMG		
STELLANTIS	X	X
TATA		
VOLVO TRUCK	X	X

Table 3: OEMs involvement in European Partnership

OEM	HAL4SDV	Shift2SDV	RIGOLETTO	Code4SDV	TwinLoop	Up2Date4SDV	EEA4CCAM	S-CORE
AMPERE (RENAULT)	X	X						
AUDI								
BMW	X	X						X
CARIAD (VW)		X						
DAIMLER TRUCK								
FORD OTOSAN	X							
HYUNDAI EUROPE								
ICEVO								
MERCEDES-BENZ	X	X						X
PMG		X						
STELLANTIS								
TATA								
VOLVO TRUCK								

Table 4: OEMs involvement in SDV Project

OEM	Eclipse SDV	COVESA	AUTOSAR	SOAFEE
AMPERE (RENAULT)			X	X
AUDI			X	
BMW	X	X	X	
CARIAD (VW)	X		X	X
DAIMLER TRUCK			X	
FORD OTOSAN				
HYUNDAI EUROPE		X		
IVECO				
MERCEDES-BENZ	X		X	
PMG				
STELLANTIS		X	X	X
TATA			X	X
VOLVO TRUCK		X	X	

Table 5: OEMs involvement in SDV Association

The detailed contribution of OEMs on these initiatives cannot be disclosed, both the association and the project are governed by antitrust behavior and non-disclosure right regarding individual inputs, or by consortium agreements subject to confidentiality provisions.

8 Recommendations and Outlook

The second version of the strategic roadmap to achieve the SDV Ecosystem vision is built upon public available information. Designed to evolve throughout the FEDERATE project, this document will be further refined through operational alignment with other SDVoF initiatives that are still in development.

It aims to build the foreground for the SDV reference implementation and repository maintenance of the future vision of what need to be shared across noncompetitive artefacts related to SDV application development, control, and validation.

To fully realize the objectives of Deliverable D4.5, several recommendations should be taken into account to align with the strategic roadmap of the SDVoF initiative.

Firstly, further structuring is needed to align the various initiatives and operational project executions. This will help clearly define their contributions to the SDV Reference Implementation, which is overseen by FEDERATE. As of the second release of this deliverable, most SDVoF projects have only recently been initiated and are not yet fully operational. Consequently, they are still in the process of consolidating their operational strategies and are not yet in a position to define concrete building blocks or roadmaps. Additionally, the pragmatic, code-first approach encourages a bottom-up consolidation of these building blocks.

Secondly, the FEDERATE repository - along with its data structure and artefact control tooling - is in the early stages of deployment and is currently being tested within the participating SDVoF projects.

Finally, the long-term “governance” of an SDV Reference Implementation remains to be defined beyond the runtime of the FEDERATE project. It is essential to determine who will continue FEDERATE’s efforts and ensure that the guiding principle - “Working within a common structure of the SDV software stack” - is upheld. This includes fostering convergence of the Building Blocks toward a highly reusable SDV reference. The ECAVA initiative, described in section 7 & 8, could serve as the long-term governance framework to maintain the SDVoF roadmap, providing the context for standardization and coordination of the Building Block document initiated in FEDERATE WP3. Ongoing discussions involving FEDERATE members and additional stakeholders will contribute to the definition of the long-term mission.

9 List of Figures

10 References

[1] European Software-Defined Vehicle of the Future (SDVoF) Initiative – Vision and Roadmap https://federate-sdv.eu/wp-content/uploads/2024/04/2024-04-12-SDVoF-Vision-document-ver017-final.pdf

[2] 2Zero European Partnership, https://www.2zeroemission.eu/

[3] CCAM European Partnership, https://www.ccam.eu/

[4] European Connected and Autonomous Vehicle Alliance (ECAVA), https://digital-strategy.ec.europa.eu/en/policies/vehicle-alliance

[5] 2025 Technology Roadmap, 2025-SDV-TechnologyRoadmap-Whitepaper-ver-1.0-final.pdf