자유와 활력이 넘치는
파워풀 대구

FIX All on AI

Future Innovation tech eXpo Conference 2025

Architecting the Future: Service Oriented Architecture as a Foundation for Software-Defined Vehicles

Mr. Piyush Burangi

Architect, SDV & GenAI

Agenda

FEV Introduction

SDV Introduction and FEV offerings

Whitepaper Overview

Proposed solution & Case Study

Summary

Contacts

Your engineering and consulting partner – strong, competent and reliable

GLOBAL REACH –
ONE FACE TO THE CUSTOMER

7,000
Employees globally

~740 M€
Total output (2024)

>250
Test cells for batteries & fuel cells, e-drives, T/M and engines

200
Patent applications per year

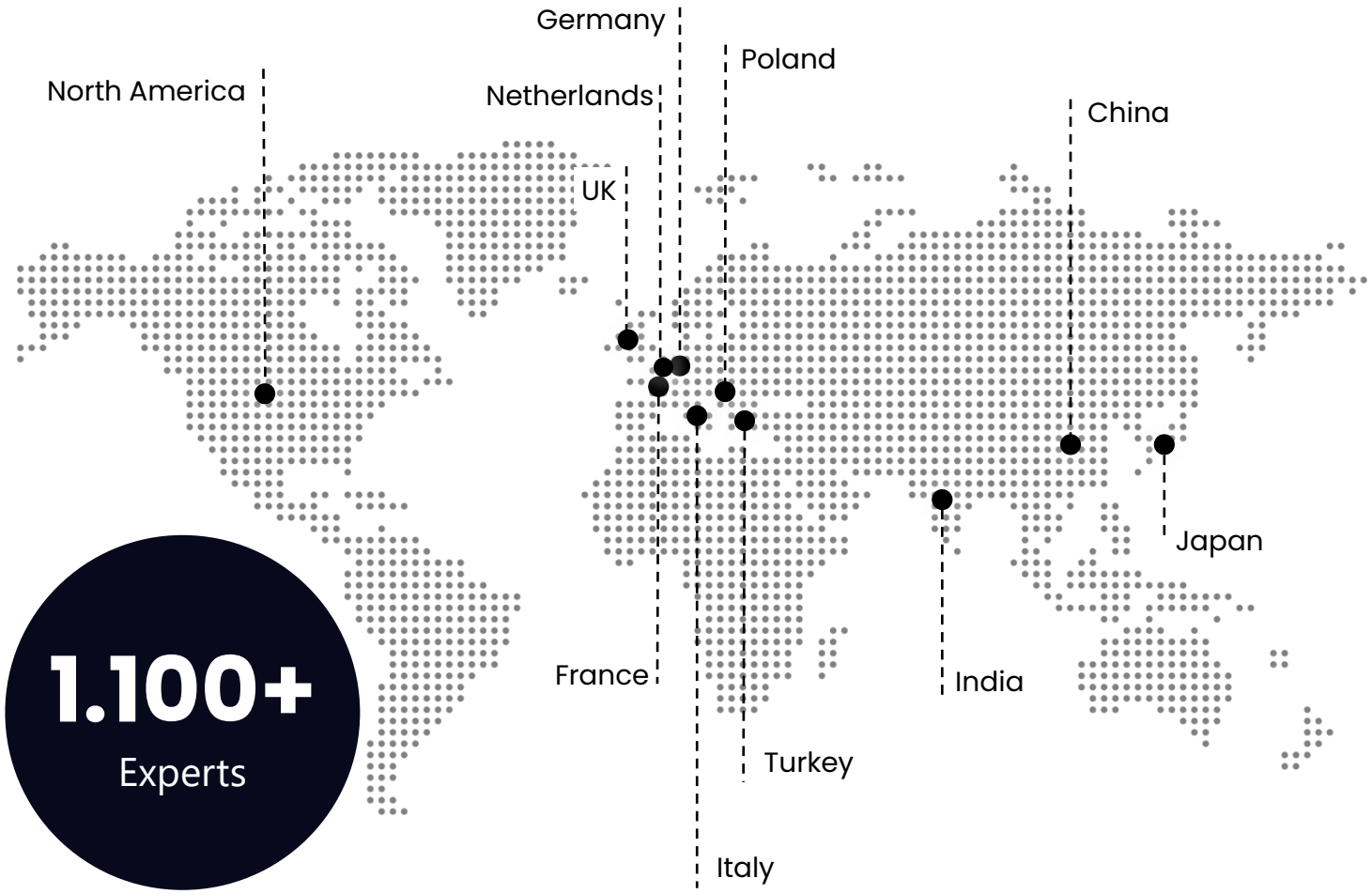
70%
Academics

>45
Years of experience

>45
Subsidiaries on five continents

>50
Different nations

We combine proximity with global delivery power for scaling, efficient and aligned technology delivered at high quality and best expertise



Customer proximity

- Local development experts
- Local contacts & project mgr.
- Enables: Fast & easy communication
- Enables: Joint understanding of expectations & requirements
- Enables: Co-creation

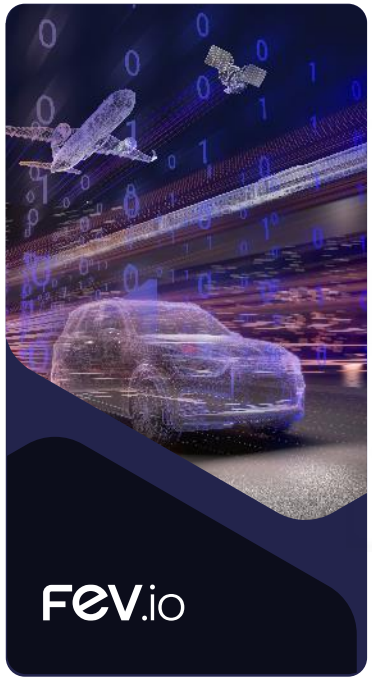
Global delivery power

- Common development framework
- Access to global competencies
- Enables: high quality & cost sensitive delivery
- Enables: best expertise fit

We are the innovation powerhouse for mobility, energy and software that fosters sustainability and a greater quality of life for all

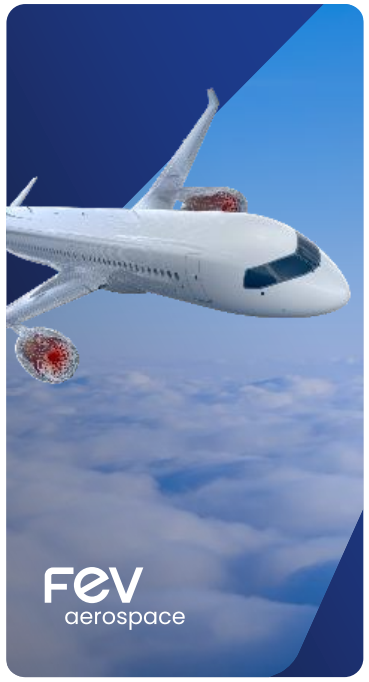
BUSINESS AREAS

- Chassis
- Cab
  - Body in White
  - Ext. & Interior
  - Lighting
- Architecture
- Performance
- NVH
- Integration



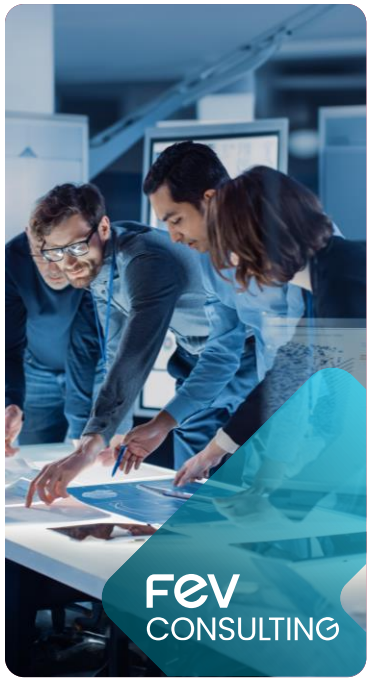
- System Eng
- FUSA
- Cyber Security
- ADAS / AD
- Connected Mob.
- Infotainment
- SW & E/E platform.

- ICE
  - Gasoline
  - Diesel
  - Gas
  - H2
- Gearbox & Axles
- Battery
- EDU & e-Axle
- Inverter
- Fuel Cell



- Fuel Cell / H2 (direct burn)
- Battery (dev. & testing)
- SAF
- HV systems
- SW Solutions
- Cyber Security
- MBSE

- Energy plants
  - Wind
  - Solar
  - H2
- Energy storage

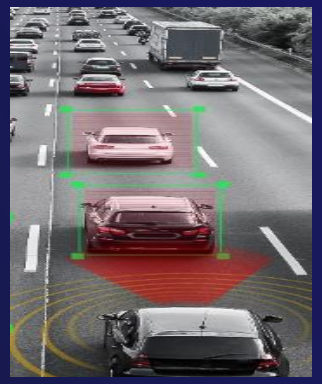


- Market studies
- Benchmarks
- Roadmaps
- Concept studies
- Modularization
- Sourcing strategy
- Cost reductions
- Value chain opt.

Systems Engineering

Cyber Security

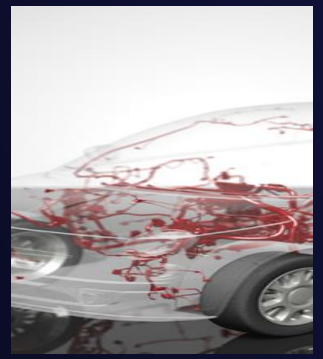
Functional Safety



Assisted & Automated Driving

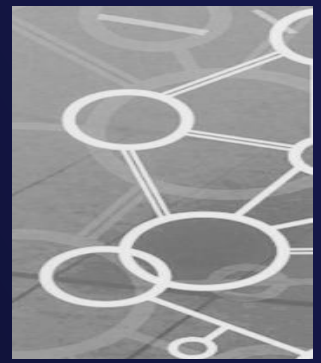
eCockpit & Driver Information Systems

Connected Mobility



EE SW & Integration

Software & SDV



Data Science & Engineering

SOVD, Functional Diagnostics, OTX, EOL

E2E Validation – Bench level → LabCar → Field Testing

Generative AI – from Systems Engineering to Validation

FEV.IO PORTFOLIO

Agenda

FEV Introduction

SDV Introduction and FEV offerings

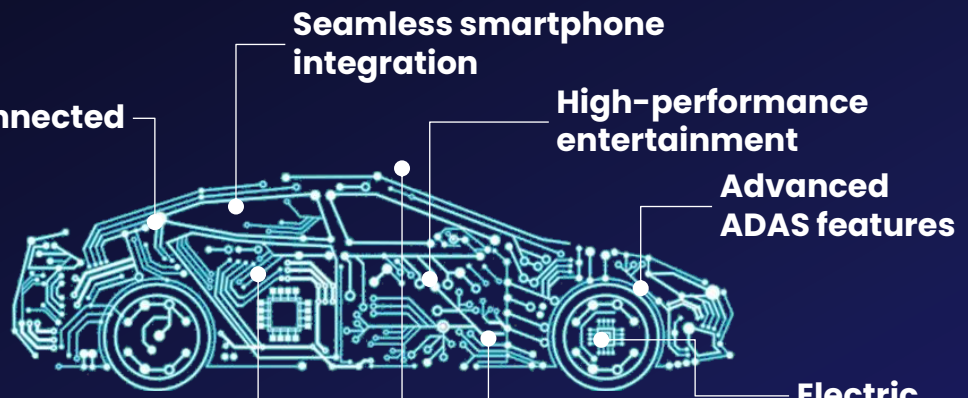
Whitepaper Overview

Proposed solution & Case Study

Summary

Contacts

The industry is transforming towards software-centric products



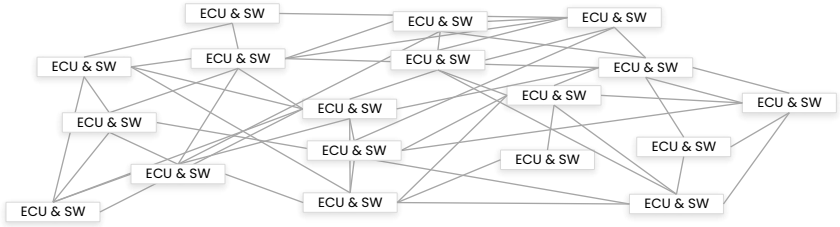
Market Demand
- Advanced Features
- Updateability
- Upgradeability

Cost Reduction
- Simplified, modular hardware
- Cost efficient SW platforms

Competition
- Development efficiency by DevOps, automation, virtualization
- Reduced time-to-market and; new way of working
- Reduced recalls (by OTA and data analytics)

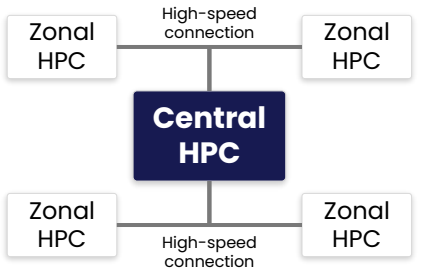
...BUT TECHNICAL BACKBONE IS NOT READY

Traditional E/E & SW Architecture:
Decentralized & signal-oriented (monolithic)

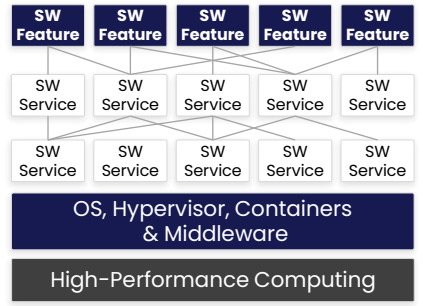


VISION
(IN-VEHICLE)

Centralized E/E Architecture w/ **high-performance** computing cluster



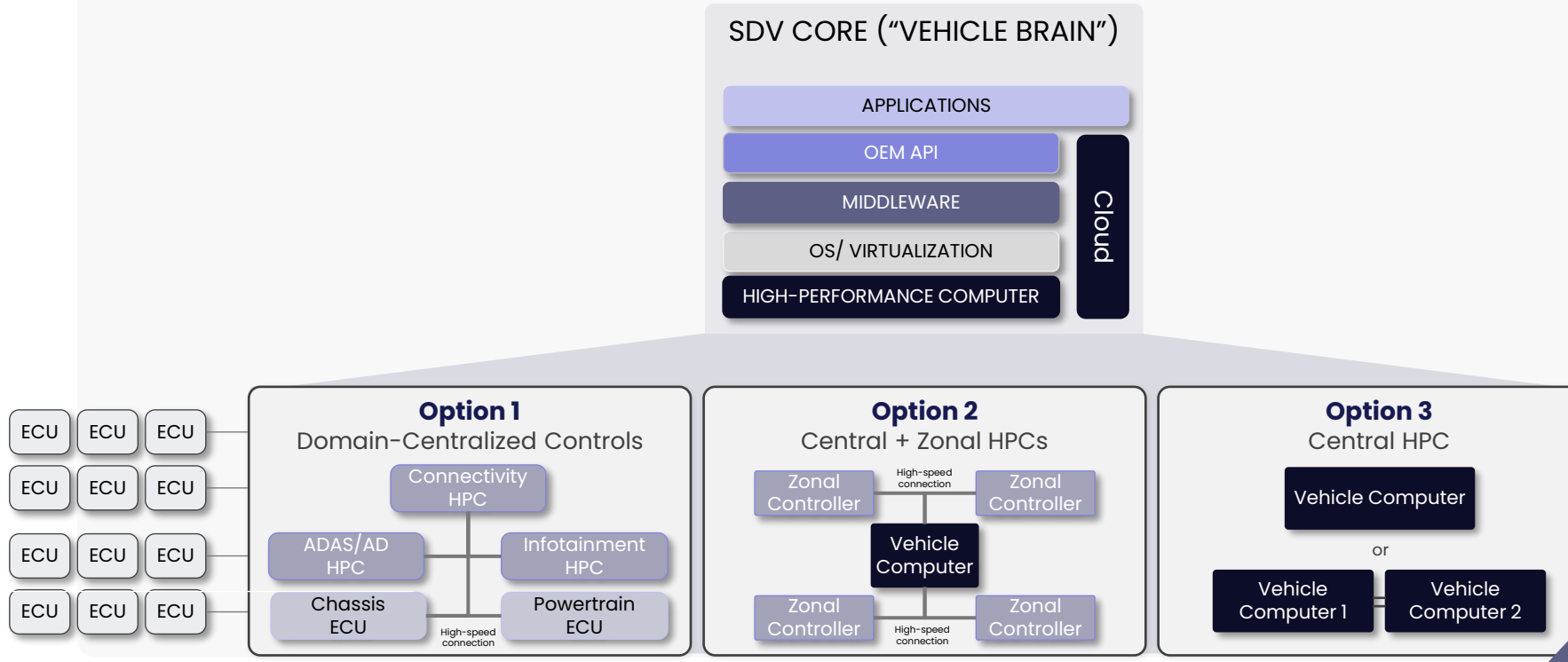
Mainly **service-oriented** software architecture



A high-performing E/E architecture builds the backbone for future product and development excellence – different levels of centralization are possible

E/E ARCHITECTURE STRATEGY

› Illustrative



Consideration of legacy through **stepwise evolution towards desired centralization level**

CENTRALIZATION APPROACH

- Top-level control through "Vehicle brain"
- High performance and classical controllers
- Zonal controllers to minimize wiring

What is the right software architecture for my use-cases?
Software architecture classification (simplified for illustration)

FEV.io

I VIRTUAL MACHINE ARCHITECTURE

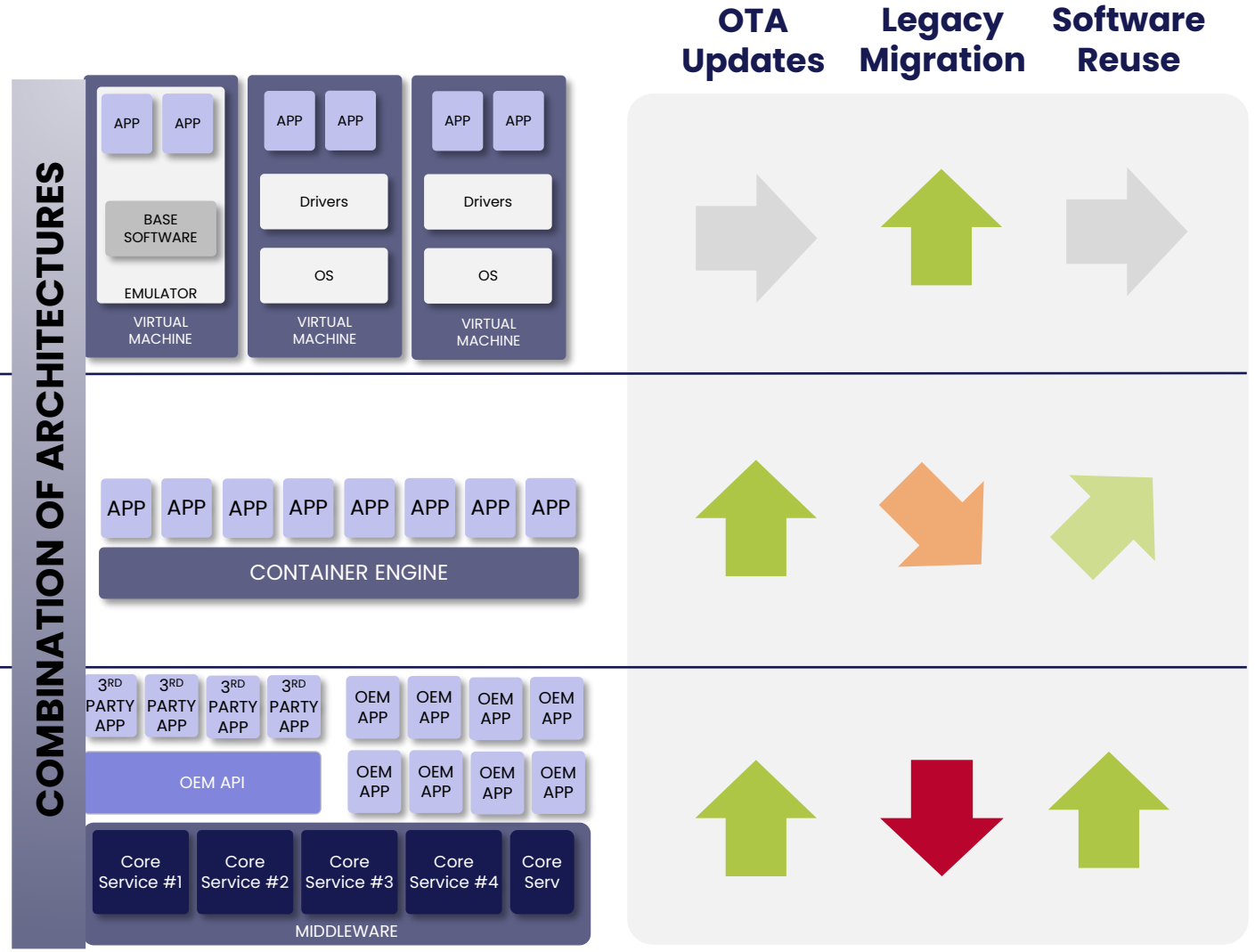
- Execute virtual machines on HPC
- Emulate legacy software “as is”
- Best for legacy migration and safety

II CONTAINERIZED ARCHITECTURE

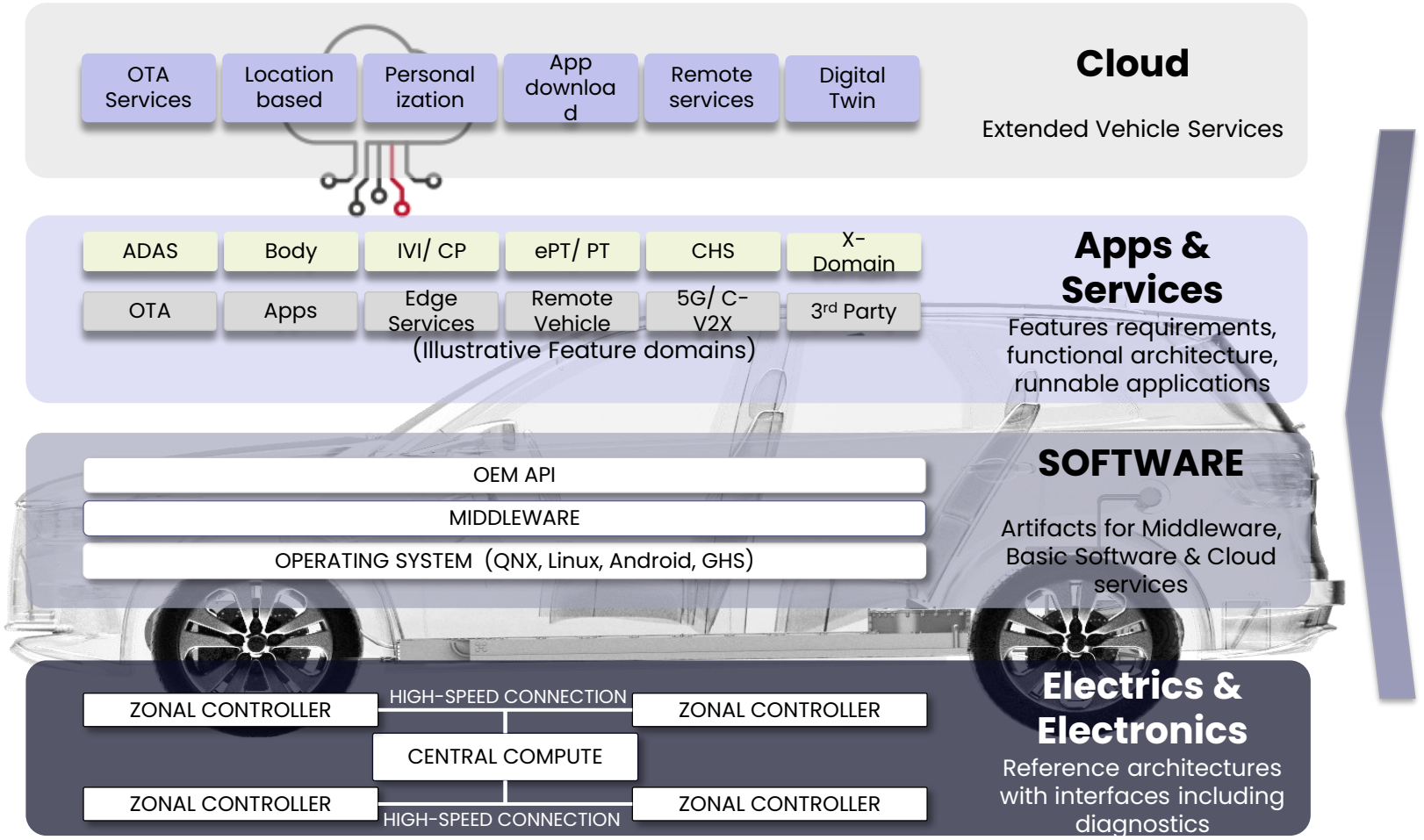
- Facilitate over-the-air updates better
- Supports up-date of single features
- Leaner admin approach

III SERVICE-ORIENTED ARCHITECTURE

- Approach maximize Software re-use
- Supports best 3rd party app ecosystem



SDV Building Blocks
FEV Experience & Offerings



FEV.io

SOFTWARE FACTORY

Platform

- HPC's – NXP, Infineon, Renesas, TI, NVIDIA,
- AUTOSAR & Adaptive AUTOSAR
- QNX, Linux , Android, GHS
- AWS, Azure, GCP
- Micro services, Dockers & virtualization

Process

- AGILE & DevOps – CI/ CD/ CT
- SUMS (Software update mgmt. system)
- CSMS (Cyber Security management system)
- ASPICE & TISAX

Tools

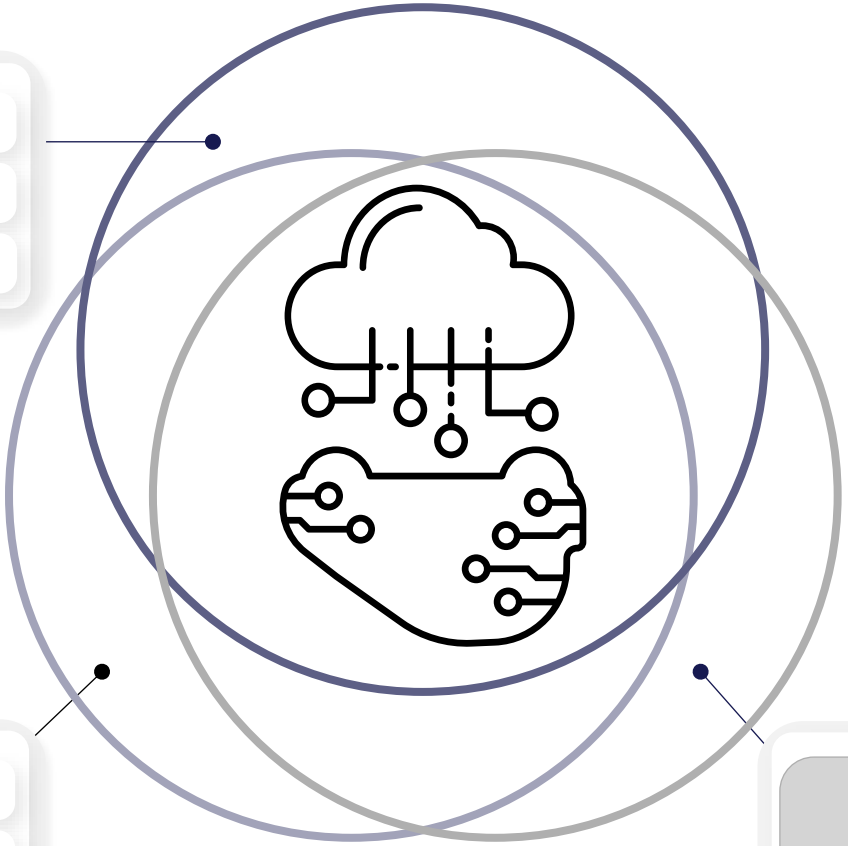
- MATLAB, C, C++
- EA, VECTOR, PREEvision, ETAS, EB
- dSPACE, NI, Polyspace, Tessy
- PLM/ ALM

We provide series development excellence by deep understanding of SW&EE combined with detailed domain know how

FEV.io

SYSTEM

- DOMAIN SPECIFIC DEVELOPMENT
- STRUCTURED SYSTEMS ENGINEERING
- FUNCTIONAL SAFETY & CYBER SECURITY



SW

- FEATURE DEVELOPMENT (EMBEDDED & WEB APPLICATIONS)
- SW INTEGRATION, CALIBRATION & MAINTENANCE
- AGILE WORKFLOW & INFRASTRUCTURE IMPLEMENTATION

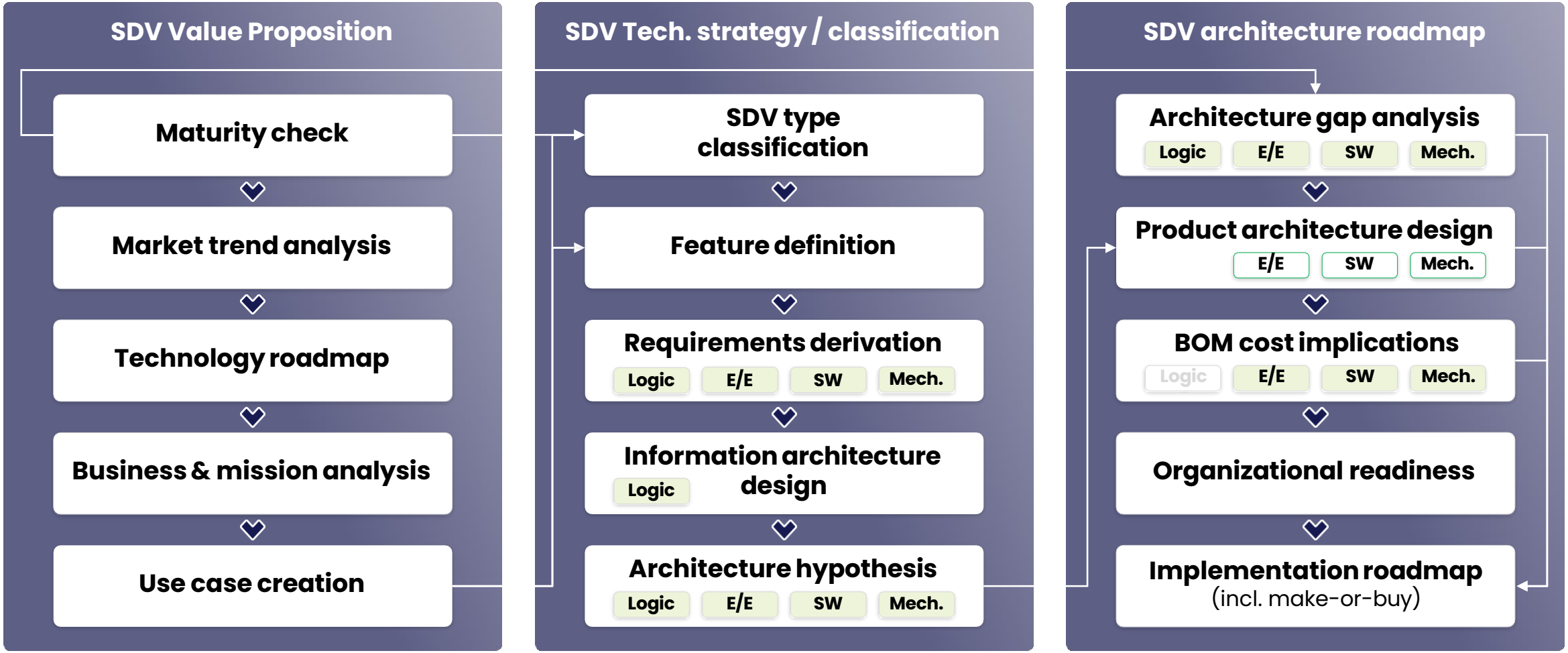
EE

- EE ARCHITECTURE DESIGN & INTEGRATION
- VEHICLE NETWORK & DIAGNOSTICS
- VALIDATION & TESTING

Series Development excellence

We can support in a comprehensive SDV strategy definition with a streamlined approach focusing on business, product and organization

SDV PROJECT APPROACH



FEV leverages its partnerships, consortiums memberships & in-house technology roadmaps

CONSORTIUMS

FEDERATE

SDV Eclipse Software Defined Vehicle

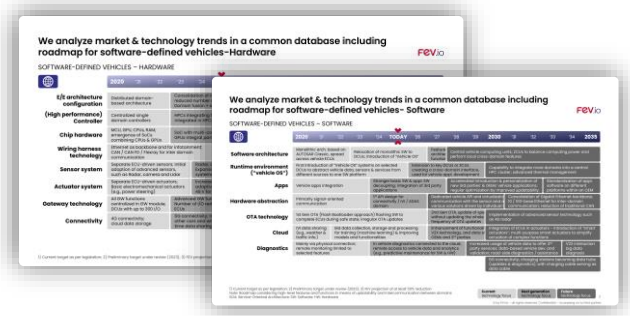
Eclipse S-CORE

AUTOSAR

SOAFEE

SDVERSE VEHICLE SOFTWARE MARKETPLACE

FEV SDV Technology Roadmaps



- Forecast of major SDV technologies and markets
- Database of standards and regulations
- Benchmark report of vendor solutions

PARTNERSHIPS

wipro

excelfore

Green Hills SOFTWARE

SIBROS

MathWorks®

cerence®

NVIDIA

Microsoft

BOSCH

Red Hat

Agenda

FEV Introduction

SDV Introduction and FEV offerings

Whitepaper Overview

Proposed solution & Case Study

Summary

Contacts

Overcoming Legacy Challenges Through SOA Principles

Challenges faced with current architecture

- Tight Coupling of Components
- Limited Scalability and upgradability
- Poor Flexibility and Reusability
- Slow Deployment Cycles
- Integration Bottlenecks
- Maintenance Overhead
- Limited Fault Isolation
- Technology Lock-In
- Security Challenges
- Data Management Complexity

SOA as solution to overcome these challenges by

- Loosely coupled
- Reusable
- Reliable and consistent communication

Middleware Available in Market to Achieve SOA

Vector MICROSAR Adaptive

Robot Operating System

TTTech Auto (MotionWise)

Real-Time Innovations

Elektrobit

Apex.ai

Zenoh by Zetta Scale

Red Hat

Critical Dimensions Impacting SOA Adoption

Methodology	Introduce a phased migration strategy addressing two distinct pathways: 1. Transforming existing legacy systems into SOA-based architectures 2. Designing new systems with SOA principles from the ground up
Tooling	Leverage modern tools and frameworks 1. Streamline service wrapping, orchestration 2. Real-time monitoring for seamless SOA integration
Best Practices	Share guidelines for service design, testing, and governance.

Modernizing with SOA: A Phased Approach to Migration and Value Realization

Decision Matrix

- Define template for the decision matrix to identify services for SOA

Approach Selection

- Bottom up approach for legacy migration to SOA
- Top Down – Create SOA application from Scratch

Workflow Definition

- Workflow definition
- Parameter identification

Agenda

FEV Introduction

SDV Introduction and FEV offerings

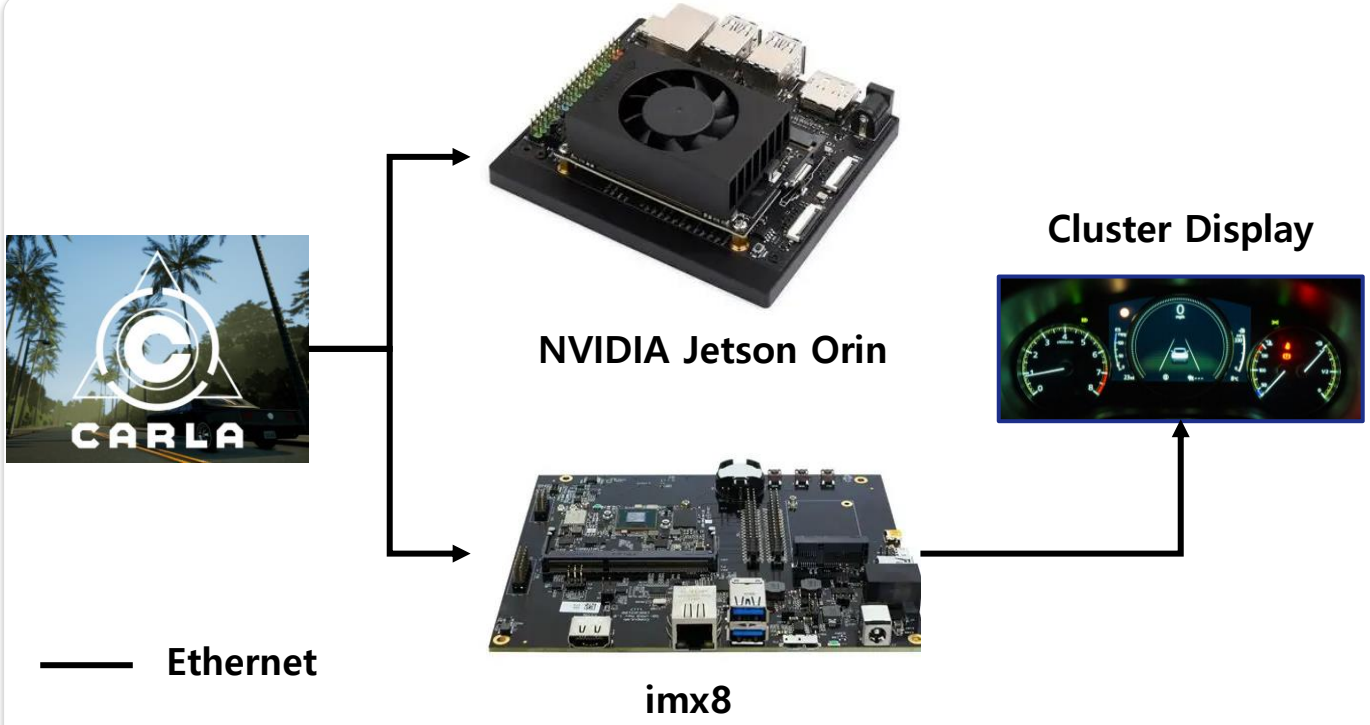
Whitepaper Overview

Proposed solution & Case Study

Summary

Contacts

Traffic Sign Recognition - Case Study for Legacy Migration



Case Study Details

Traffic sign recognition is selected as the use case to demonstrate legacy migration to SOA.

Hardware Details:
NVIDIA Jetson Orin
Imx8

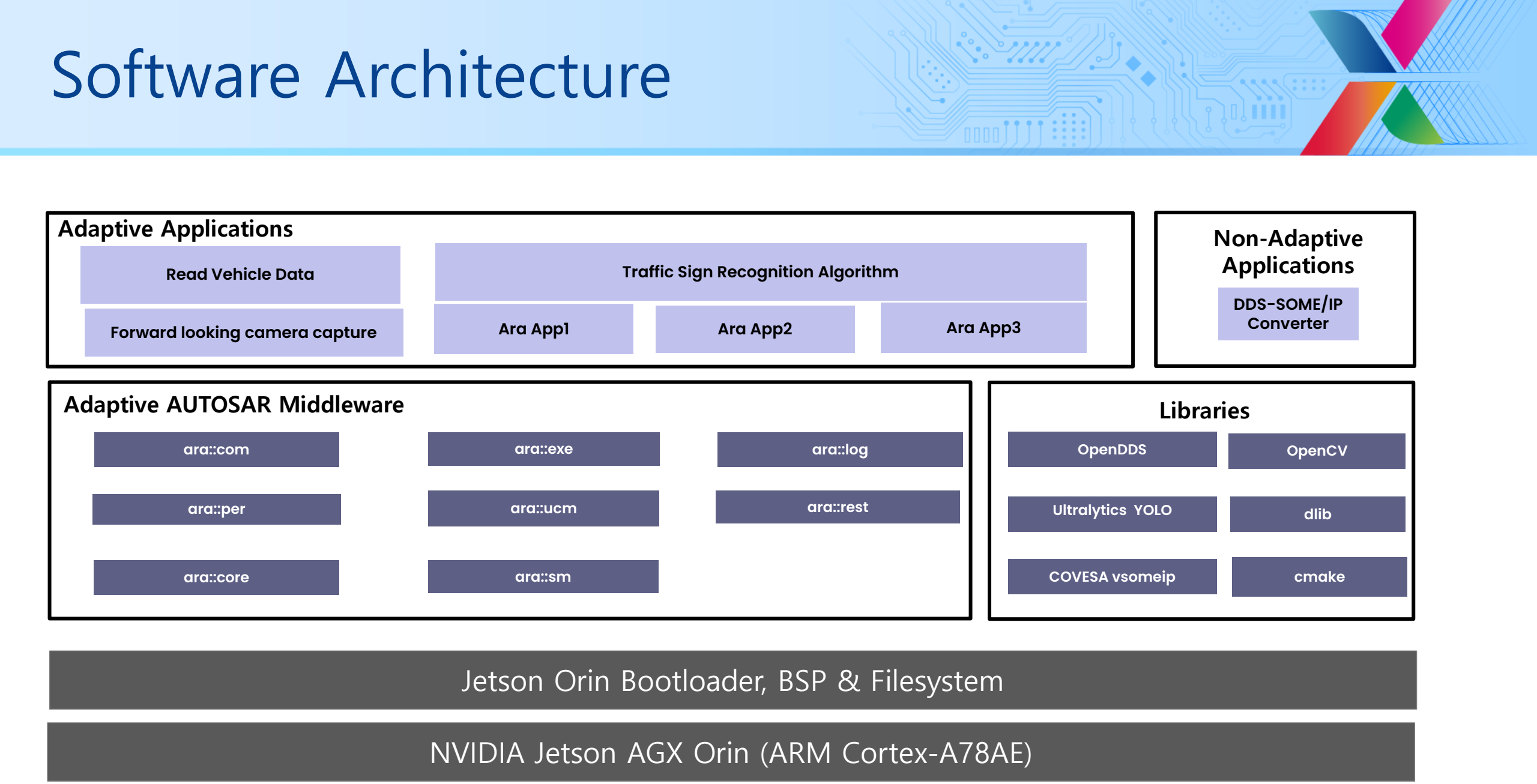
Use cases/features:
Traffic sign recognition

Software details
QT for HMI
QEMU for virtual validation

Middleware
Vector Adaptive ASR

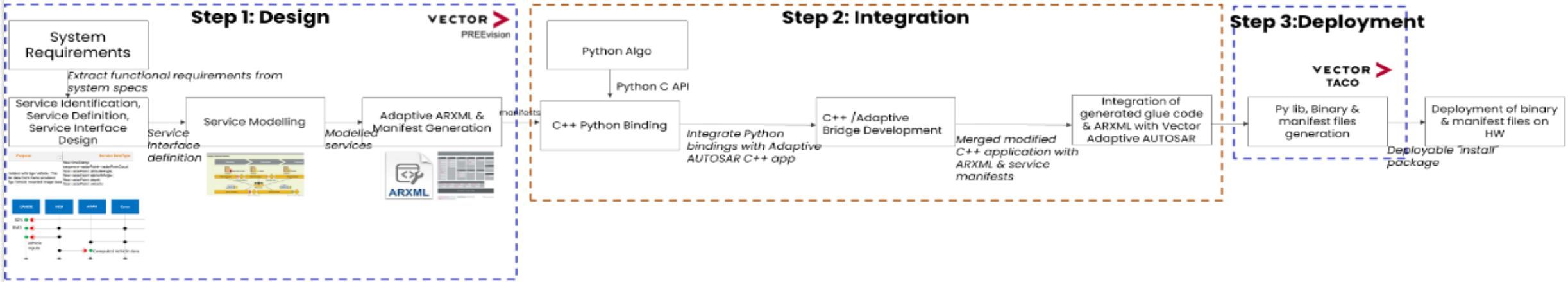
Simulators
CARLA

Software Architecture



Migration Approach

Bottom-Up Workflow Applied:



1. **Input:** Camera frames from CARLA simulator via **DDS**
2. **Processing:** TSR service on **NVIDIA Orin platform**
3. **Output:**
   - Detected signs distributed via **SOME/IP** to ADAS consumers
   - Parallel output to **cluster display service** demonstrates **multi-consumer capability**

Output – Decision Matrix & ARXML

SOA Decision	Parameters	Description		Selection Categories		Weightag
System	Fuction Reusability across cross domain	modularity and reuse across domains by multiple clients		4:Mostly compatible with SOA 3:Needs careful integration 2:Requires significant adaptation 1:Contradicts SOA principles		5
	Multiple Activations	Ways to activate system/start		5:concurrent, secure activation from more than four sources with conflict resolution & state synchronization. 4:Supports at least 3 activation modes cleanly,minimal race issues. 3:Supports 2 sources, some manual sync required. Limited activation paths with middleware dependency. 2:Supports only 1 source natively (IVI, CCSD, T-Box, C-App,MFS), others via workarounds	
	Scalability	OTA	SW Update (Function)	If a service, an application, underlying middleware could be updated Over The Air	4:OTA supported with system-wide scheduling constraints. 3:Updates possible but require manual intervention or ECU reboot. 2:No modular update; whole system reflash required. 1:Static firmware only; no software update capability.	5
	Boot Time Demand		SW Upgrade (Function)	Beyond updates, ability to change service versions or scale to better performance is essential.	4:Upgrades possible with controlled rollout. 3:Upgrade process requires system-wide testing or scheduling. 2:Only minor patches allowed; no functional change. 1:No upgrade mechanism without reflashing entire stack.	4
	Real Time Demand		Subscription (Feature)	If an application could subscribe for OTA updates so that it could be updated OTA or at garage	5:Robust pub-sub system with dynamic discovery, QoS, OTA notifications. 4:Efficient and scalable subscription model for multiple clients 3:Subscription exists but lacks dynamic features or is hardcoded. 2:Manual polling or static configuration needed 1:No subscription support; push model unsupported.	3
	Ethernet Interface Connectivity	Cloud Interface	Interaction with Cloud/Edge	SOA facilitates offboard computation and connectivity	5:Cloud-native communication with secure data exchange and service mirroring. 4:Reliable connection to backend with remote diagnostics and control. 3:Cloud integration exists but limited to telemetry or batch upload. 2:Cloud access requires intermediate gateways or offline sync.	
	SOA middleware availability on HW (microcontroller or HPC)		Cloud Native			
			Digital Twin			
		FuSa	ASIL Rating	Safety level impacts ability to use SOA (especially dynamic service invocation, inter-process comm). ASIL-D systems need strong	5:Service meets ASIL-D constraints using proven isolation and safety layers. 4:ASIL-B or C achievable with qualified SOA framework. 3:Limited ASIL scope; depends on context and partitioning. 2:Not certifiable beyond QM/ASIL-A. 1:Fails safety requirements; no compliance path.	5
			FTTI	SOA overhead can affect initial perception latency in ADAS systems. High weight is time-critical apps.	5:More than ISO 26262 allows; designing FTTI for mission operational use—non-safety-critical tasks may exceed. 1:e.Maintenance/diagnostics, ISO 26262 tolerates seconds-level FTTI 4:100ms to 1s:User-interactive systems where human perception tolerates slight delays.Features like object detection or driver alerts can tolerate slightly longer latency—multiple hundreds of ms. 3:100ms to 500ms:(5 Hz to 10 Hz) HVAC/UI alerts; acceptable fault handling 2:30ms to 100 ms:ISO 26262 and SAE ADAS research often cite 100 ms as a critical threshold for high-level safety maneuvers.Critical ADAS/SAE L4 FTTI, perception-action latency 1time:<10ms:Must meet deterministic timing; delay could cause failure of safety system(hard real time)	5

INPUT #1: SERVICE DECISION MATRIX

FUNCTION ID	FUNCTION NAME
ADB03.01	TSI Activation/ Deactivation
ADB03.02	Detect traffic sign information
ADB03.03	TSI warning
ADB03.04	TSI Configure setting
ADB03.05	TSI HMI Request
ADB03.06	TSI HMI Status
ADB03.07	TSI HMI Error & Warning
ADB03.08	Traffic Sign Information

INPUT #2: FUNCTION LIST & SYSTEM REQUIREMENTS

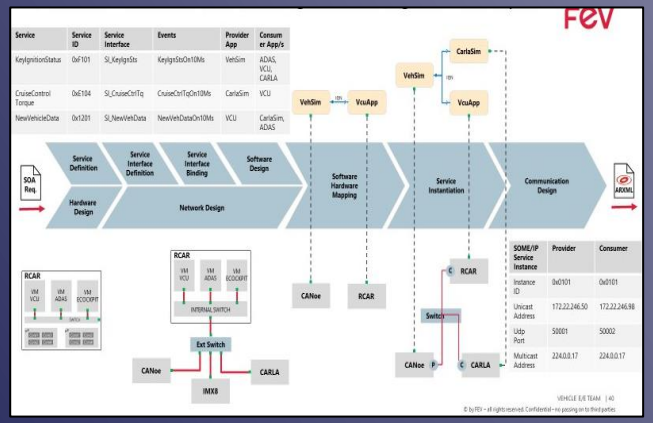
L2 Req ID	Function Name	Requirement Area	Requirement title	Involved components	Requirement Text
ADAS.ADB03.L20039	Switch On/Off	Results	Feature status - unavailability	TSR system	The TSR system shall send 'TSR unavailability status' signal to IVI when geographical region is apart from GCC and KSA.
ADAS.ADB03.L20040	Switch On/Off	HMI/User Feedback/Warnings	Feature status - unavailability - HMI	IVI	The IVI system shall display TSR unavailability status when TSR feature is unavailable.
ADAS.ADB03.L20041	Switch On/Off	Results	Feature status - activation	TSR system	The TSR system shall send TSR activation status signal to IVI/HMI when TSR feature is activated.
ADAS.ADB03.L20042	Switch On/Off	HMI/User Feedback/Warnings	Feature status - activation - HMI	IVI	The IVI system shall display TSR activation status when TSR feature is activated.
ADAS.ADB03.L20043	Switch On/Off	Results	Feature status - temporarily deactivation	TSR system	The TSR system shall send TSR temporarily deactivation status signal to IVI/HMI when TSR feature is temporarily deactivated.
ADAS.ADB03.L20044	Switch On/Off	HMI/User Feedback/Warnings	Feature status - temporarily deactivation - HMI	IVI	The IVI system shall display TSR temporarily deactivation status when TSR is temporarily deactivated.
ADAS.ADB03.L20045	Switch On/Off	Results	Feature status - deactivation	TSR system	The TSR system shall send TSR deactivation status signal to IVI/HMI when TSR feature is deactivated.
ADAS.ADB03.L20046	Switch On/Off	HMI/User Feedback/Warnings	Feature status - deactivation - HMI	IVI	The IVI system shall display TSR deactivation status when TSR feature is deactivated.
ADAS.ADB03.L20047	Switch On/Off	Results	Feature status - Temporary deactivation/Deactivation/Unavailable reason	TSR system	The TSR system shall send possible reason to IVI/HMI when TSR feature is temporarily deactivated/Deactivated/Unavailable.
ADAS.ADB03.L20048	Switch On/Off	HMI/User Feedback/Warnings	Feature status - Temporary deactivation/Deactivation/Unavailable reason - HMI	IVI	The IVI system shall display 'possible reason' when TSR feature is temporarily deactivated/Deactivated /Unavailable.
ADAS.ADB03.L20049	Switch On/Off	HMI/User Feedback/Warnings	Feature status - standardized symbols - HMI	IVI	The IVI system shall display the current state of the TSR feature using standardized symbols in accordance with ISO 2575.
ADAS.ADB03.L20050	Malfunction warning	Tasks/Actions	Health monitoring of TSR system	TSR system	The TSR system shall continuously perform TSR feature health monitoring to ensure proper end-to-end working of the system and shall check/detect for malfunctions if any.
ADAS.ADB03.L20051	Malfunction warning	Tasks/Actions	Malfunction and severity levels	TSR system	The TSR system shall associate a severity level (TBD) and category (TBD) for every malfunction (TBD) detected in TSR system.

Output

Output 1: Service Decision Matrix for TSR

Domain	Feature ID	Feature Name	Feature SOA Applicability	Function ID	Function Name	System Decision Drivers: Reusability over cross domain	Cross Functions Impact	Multiple Activations	Scalability	Boot Time Demand	Real Time Demand	Ethernet Interface Connectivity	Middleware availability on HW (microcontroller or HPC)	SW Update / Upgrade	Subscription	Cloud Interface: Data on Cloud	Cloud Native	Digital Twin	FuSa: ASIL Rating	FTTI	FTTI Range	Security	Function SOA Applicability
ADAS	ADAS01	Traffic Sign Recognition	yes	ADAS01.01	Activation/Deactition	4	4	3	5	5	4	5	5	5	5	3	5	3	4	3	100ms-500ms	4	
ADAS	ADAS01	Traffic Sign Recognition	yes	ADAS01.02	Detect Traffic Signs Information	2	4	3	5	5	4	5	5	5	5	3	5	3	4	3	100ms-500ms	4	Yes
ADAS	ADAS01	Traffic Sign Recognition	yes	ADAS01.03	TSR warnings	2	4	3	5	5	4	5	5	5	5	3	5	3	4	3	100ms-500ms	4	Yes
ADAS	ADAS01	Traffic Sign Recognition	yes	ADAS01.04	Configure settings	4	4	3	5	5	4	5	5	5	5	3	5	3	4	4	>1s	4	Yes
ADAS	ADAS02	Adaptive Cruise Control	yes	ADAS02.01	Activation/Deactition	Yes	Yes	NA	Yes	Low	Mid	Yes	Yes	Yes	Yes	Not-Applicable	Not-Applicable	Not-Applicable	4	Mid	100–1000 ms	medium	yes

Output 2: Service Modelling Exports for TSR



Agenda

FEV Introduction

SDV Introduction and FEV offerings

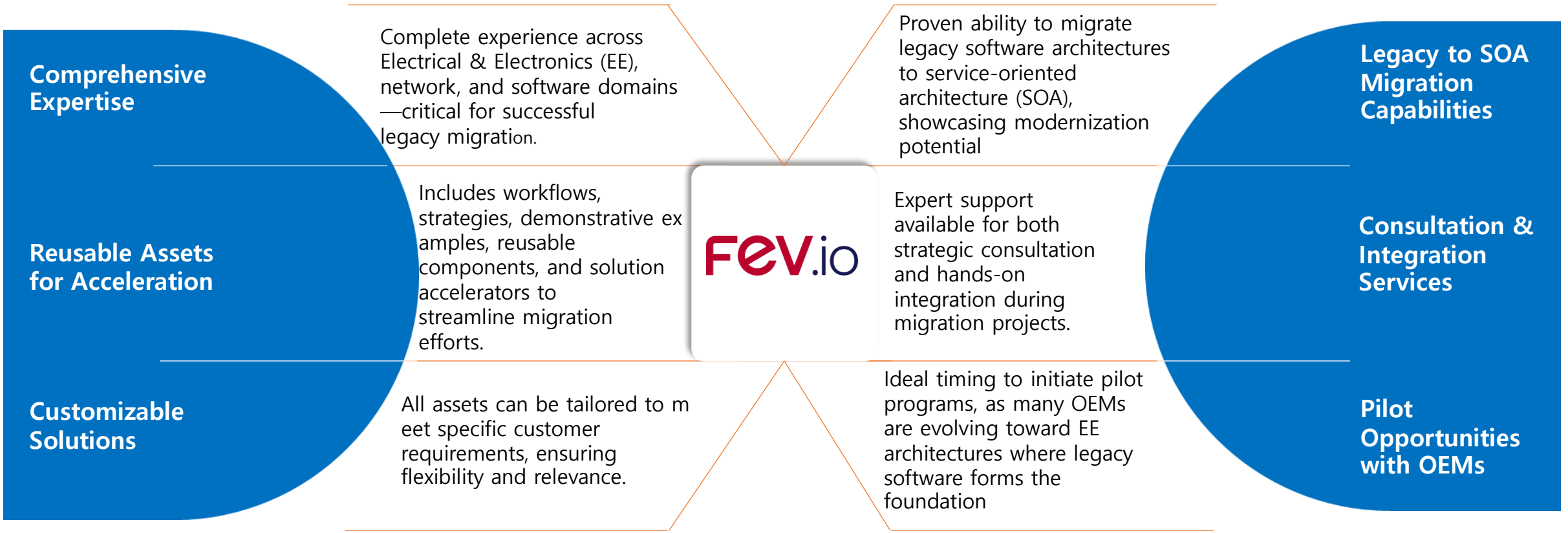
Whitepaper Overview

Proposed solution & Case Study

Summary

Contacts

Project Offerings



Agenda

FEV Introduction

SDV Introduction and FEV offerings

Whitepaper Overview

Proposed solution & Case Study

Summary

Contacts

Contacts

Piyush Burangi

Architect, SDV & GenAI
FEV.io

Intelligent Mobility, India

+91 92847 37486
burangi@fev.com

Jyotsana Singh

Architect, SDV
FEV.io

Intelligent Mobility, India

+91 96111 22182
singh_jy@fev.com

Rital Surana

Specialist Engineer, SDV
FEV io

Intelligent Mobility, India

+91 8989614900
surana@fev.con

Arshiya Shaikh

Expert Engineer, SDV
FEV.io

Intelligent Mobility, India

+91 8928063387
shaikh_ar@fev.com

References

1. **AUTOSAR Adaptive Platform** – "AUTOSAR Adaptive – Technical Overview." [Online]. Available: https://www.autosar.org/
2. **DDS Standard** – Object Management Group (OMG), *Data Distribution Service for Real-Time Systems*, Version 1.4, 2015
3. **SOME/IP Standard** – AUTOSAR, *Scalable Service-Oriented Middleware over IP (SOME/IP)*, Release 19-11, 2019
4. **ISO 26262:2018** – *Road Vehicles – Functional Safety*, International Organization for Standardization, 2018
5. **ISO/SAE 21434:2021** – *Road Vehicles – Cybersecurity Engineering*, International Organization for Standardization, 2021
6. **CARLA Simulator** – Dosovitskiy, A., Ros, G., Codevilla, F., Lopez, A., & Koltun, V., *CARLA: An Open Urban Driving Simulator*, Proc. 1st Annual Conference on Robot Learning, 2017
7. Li, X., et al., *Service-Oriented Architecture for Automotive Systems: Challenges and Opportunities*, IEEE Transactions on Intelligent Vehicles, vol. 4, no. 2, pp. 123–134, 2019
8. Puschner, P., *Middleware for Automotive Software: DDS and SOME/IP in Practice*, SAE Technical Paper 2020-01-1234, 2020