The Value of COVESA VSS for SDVs –

A Member's Perspective (and our partners)

Fall AMM 2024 – Novi, MI U.S.A.

26 September 2024

COVESA
Accelerating the future of connected vehicles

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Agenda

- NXP Semiconductors – SDV and Data Management
- COVESA VSS Usage and Value (NXP + partners)
- Future collaboration opportunities
- VSS feedback and improvements
- Key takeaways

NXP Semiconductors

SDV and Data Management

SDV INTRODUCTION

VEHICLES ARE EVOLVING RAPIDLY

SOFTWARE-DEFINED

Defines features through software
(Software instead of hardware ECUs)

CLOUD-CONNECTED

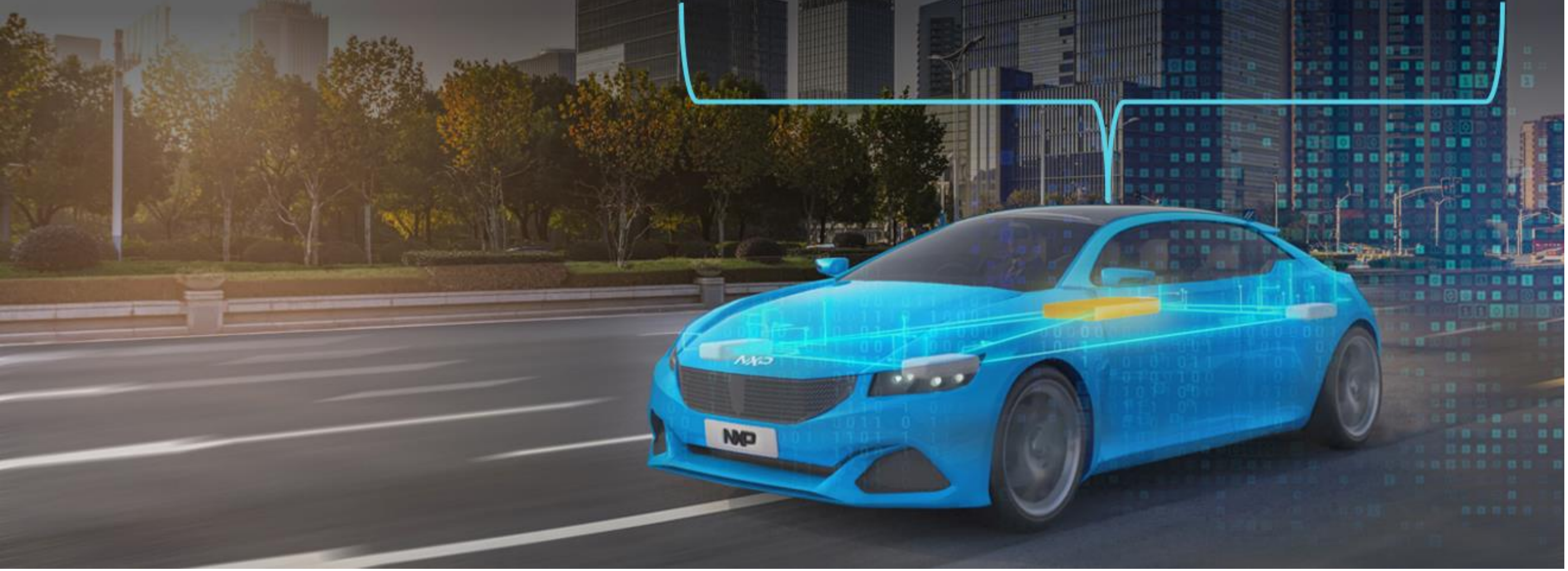
Leveraged throughout vehicle lifecycle
(Development, Testing, Production, Post-Sale)

VEHICLE DATA-DRIVEN

Provides new vehicle data intelligence
Drives continual vehicle improvements

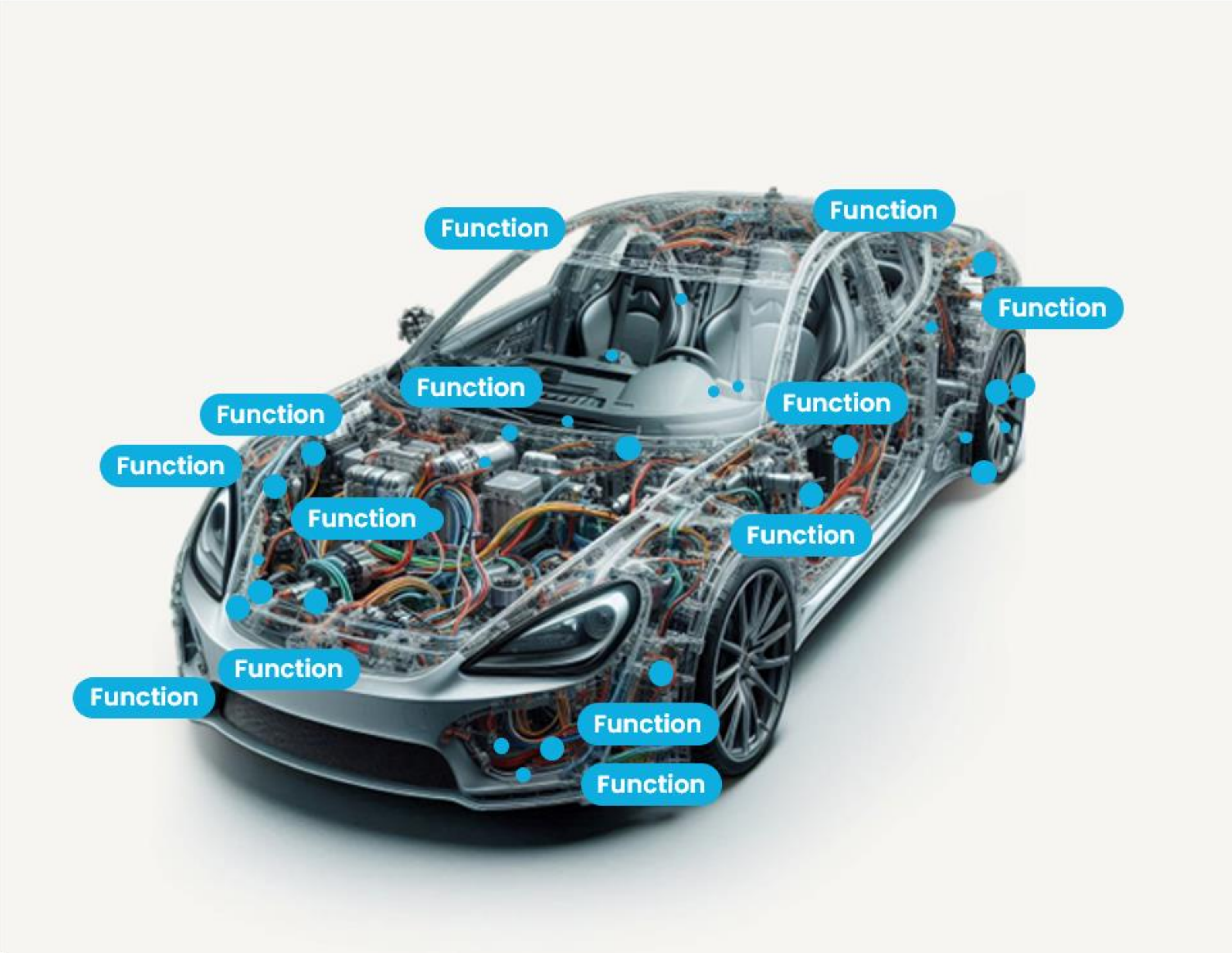
SERVICE-ORIENTED

Decouples hardware and software
Deploys new services through lifecycle

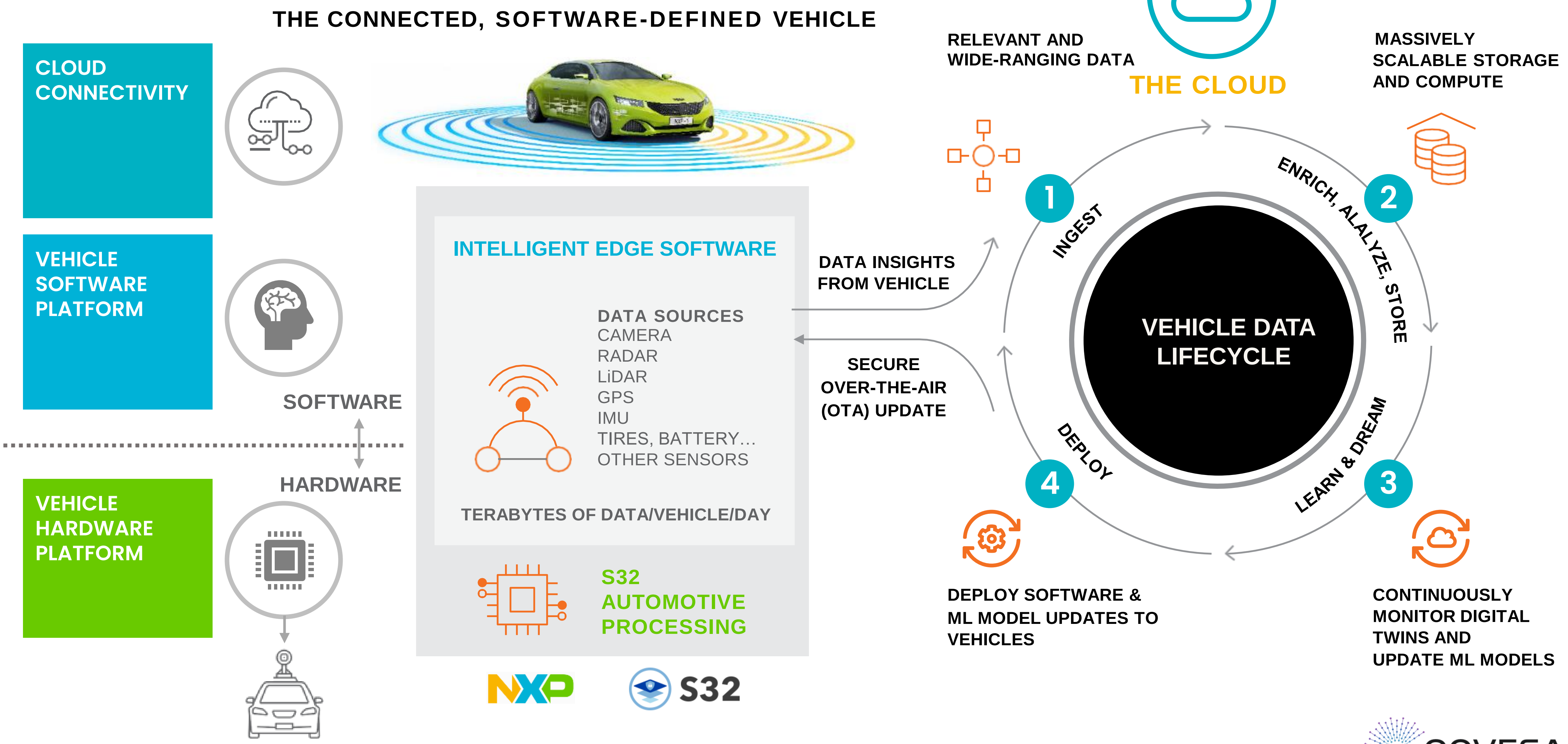


When you see the data, you realize the possibilities

Data is locked inside ECUs scattered throughout vehicle



Software-defined vehicle data lifecycle



Software-defined vehicle data can create new experiences

MOBILE APPLICATIONS

CLOUD APPLICATIONS

IN-VEHICLE APPLICATIONS

Data Intelligence

Virtual Sensors

Sensors and ECU raw data → Zone or End Node → Central Vehicle Computer

NXP S32 · NXP S32

Real-time vehicle data acquisition and processing

(ingestion, storage, processing, services, transmission)

- Improving the driving experience
- Enhance vehicle performance and efficiency
- Monitoring and maintaining vehicle health
- and much more!

In-vehicle data management functions

Vehicle Data
(Feeders)

In-vehicle Data Management

Vehicle Services

Vehicle Insights

Subscribers

- In-vehicle
- Cloud
- Mobile
- Home
- Others

Ingestion

- CAN
- Ethernet
- PCIe / others

Storage

- Database
- Datalogging
- Statistics

Processing

- AI/ML
- Contextual
- Statistics

Services

- Data-centric
- Microservices
- Virtual sensors

Transmission

- Data conversion
- Protocols
- Onboard/offboard

NXP is building the foundation for SDVs

Vehicle Computer

Low-Latency Gateway

High-Performance Cross-Domain Zonal Control

Hard Real-Time Domain/Zone Control

End Nodes

End Nodes

End Nodes

Vehicle E/E Architecture

Centralize / Cross-Domain / Zonal

- High-performance compute
- Service-oriented, soft real-time
- Low direct I/O control

Scalable / Flexible Processing Solutions

- High-performance control
- Signal-oriented, Hard real-time
- High direct I/O control

Arm cores / Common Peripherals

ASIL D FuSa / Beyond EVITA Full Security / Hardware-based Isolation

NXP S32N

NXP S32G

NXP S32E

NXP S32Z

NXP S32K3

NXP S32M2

NXP S32K1

MCUs and Processors

S32G GOLDBOX 3
(Central Vehicle Computer/ Gateway)

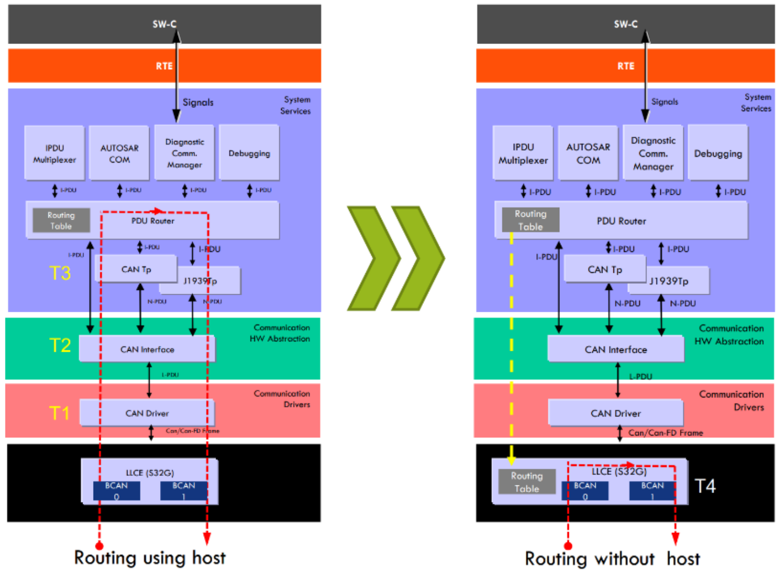
S32Z/E GREENBOX 3
(Real-time, zones, electrification)

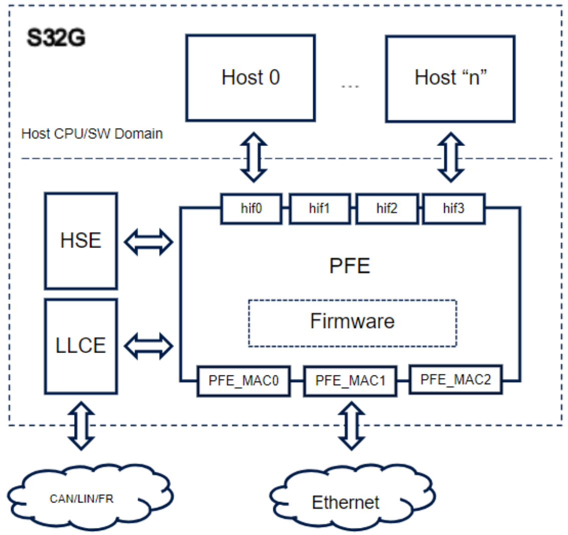
S32K DEV BOARDS
(End Nodes, Zones)

Platforms

Hardware acceleration can streamline data ingestion
Example: S32G

- Fast path routing for CAN (LLCE) and Ethernet (PFE/NETC)
  - Reduced interrupt load on the host core
  - Including mirroring and protocol conversion
  - Time sync and global timestamping
  - Direct hardware security module (HSE) data path
- Low Latency Communications Engine (LLCE)
  - Filtering (bitwise, range etc) and prioritisation
  - ID remap
- Packet Forwarding Engine (PFE)
  - Standard switch, router capabilities, MAC filtering, VLANs
  - QoS, shapers
  - L3/L4 checksum offload, modify headers





COVESA VSS Usage and Value

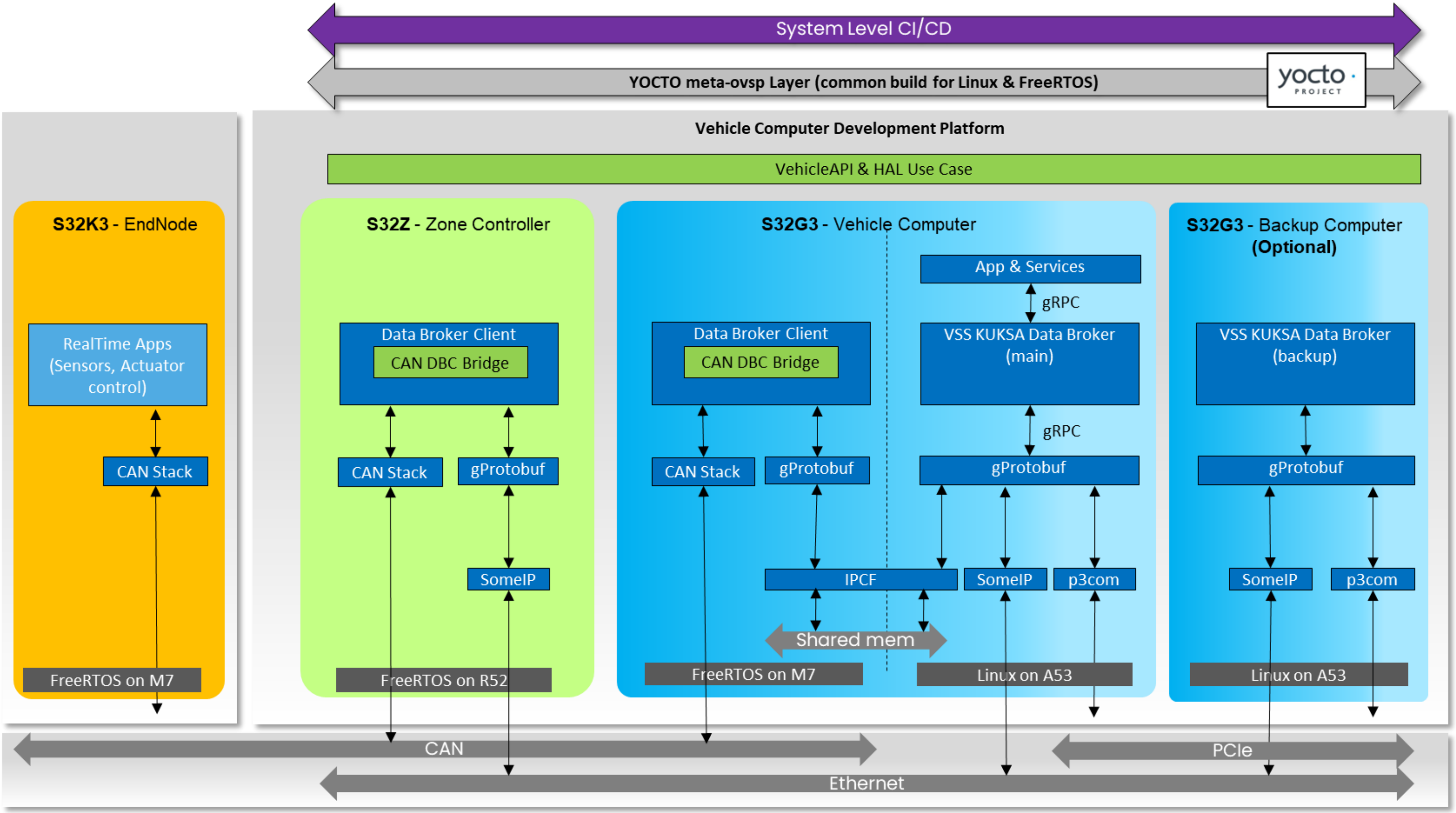
NXP and our Partners

Motivation

- Vehicles are generating huge amount of data
- There is a need to collect and make data available **systematically & centrally** for
  - Analysis
  - Monitoring
  - Refinement
  - Creating value added applications
- Technology is needed to easily map the framework to arbitrary E/E architectures and is extensible for different use case domains
- NXP started PoC on COVESA VSS to assess suitability for above requirements

NXP Vehicle Level Integration PoC

- Based on open source and NXP software components
- Using Yocto multi-config project as a common build environment
- Focused on development of communication middleware based on VSS technology
- Transparently supporting arbitrary physical transports (Ethernet, PCIe, CAN, inter-core cluster shared memory) and transport protocols



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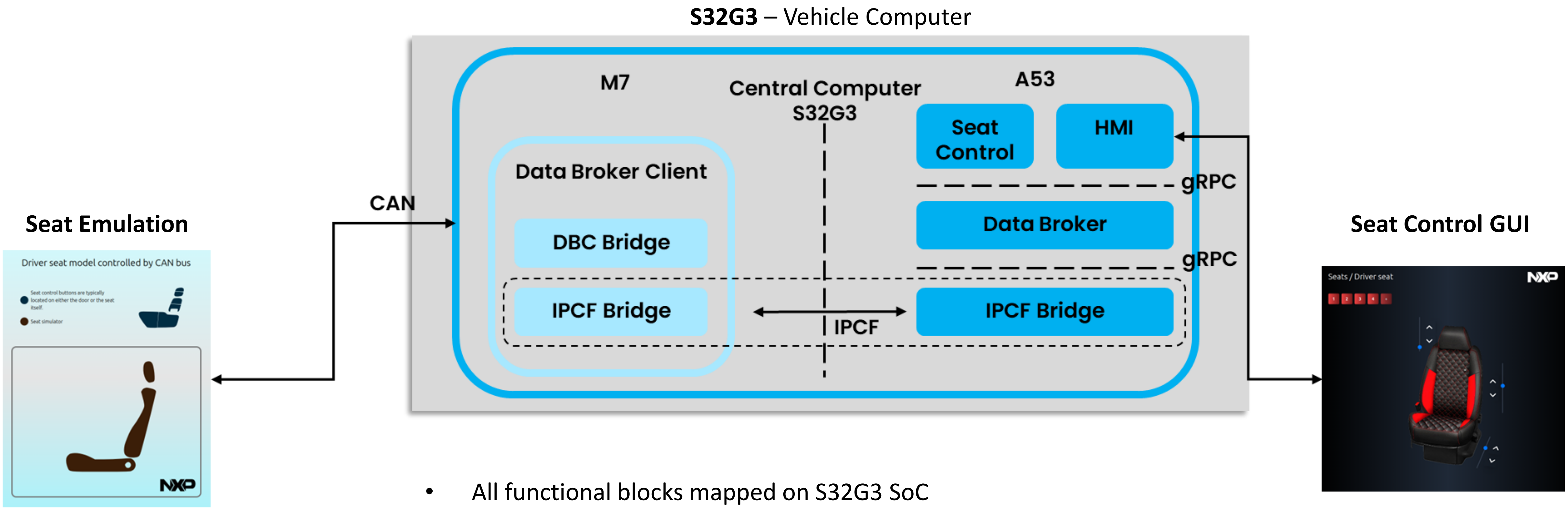
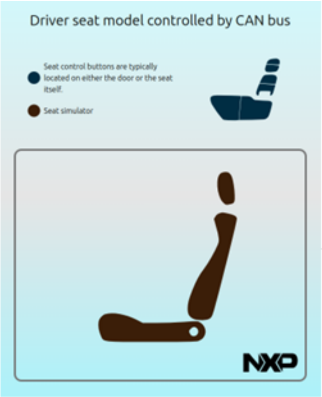
Seat Control Demo – Single device Setup



- All functional blocks mapped on S32G3 SoC
- Cortex-M7 (real-time core cluster) runs Data Broker Client (DBC bridge)
- Data Broker hosted on Cortex-A53 core cluster (Linux)
- Communication through IPCF (passing gProtobuf)

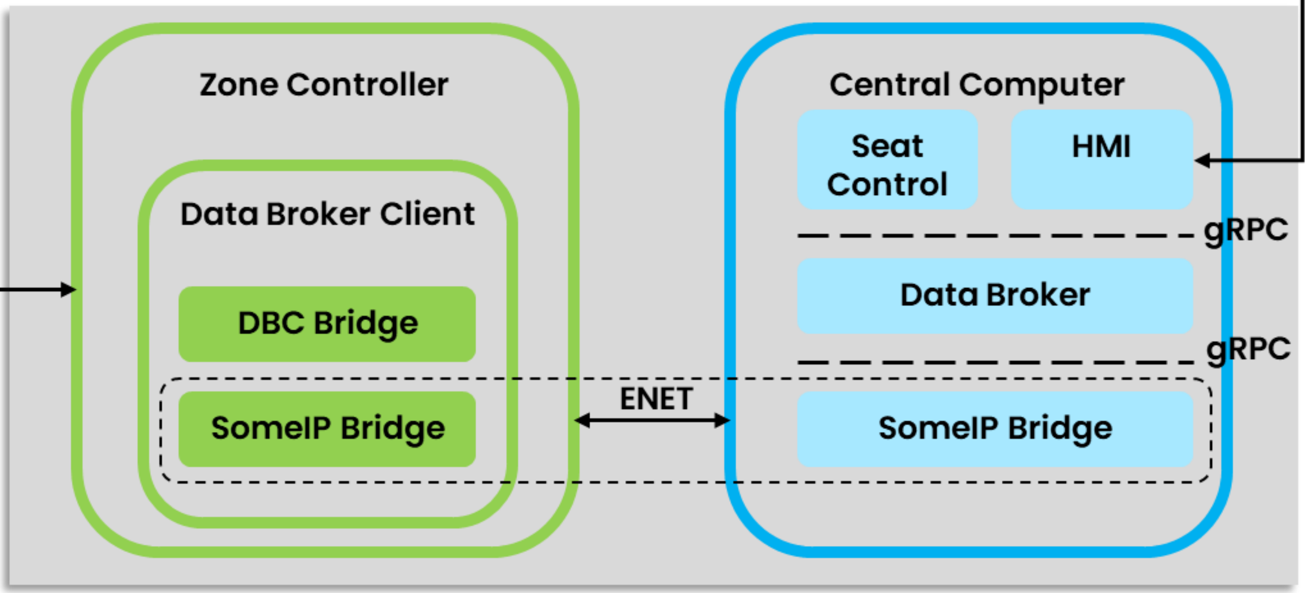
Seat Control Demo – Two device Setup

Seat Emulation



- S32Z Zone Controller (Cortex-R52 RT core cluster) runs Data Broker Client (DBC bridge)
- Data Broker hosted on Cortex-A53 core cluster (Linux)
- Communication through SOME/IP over Ethernet

Seat Control GUI



S32Z - Zone Controller

S32G3 - Vehicle Computer

NOTE

Single and two device setup can be combined

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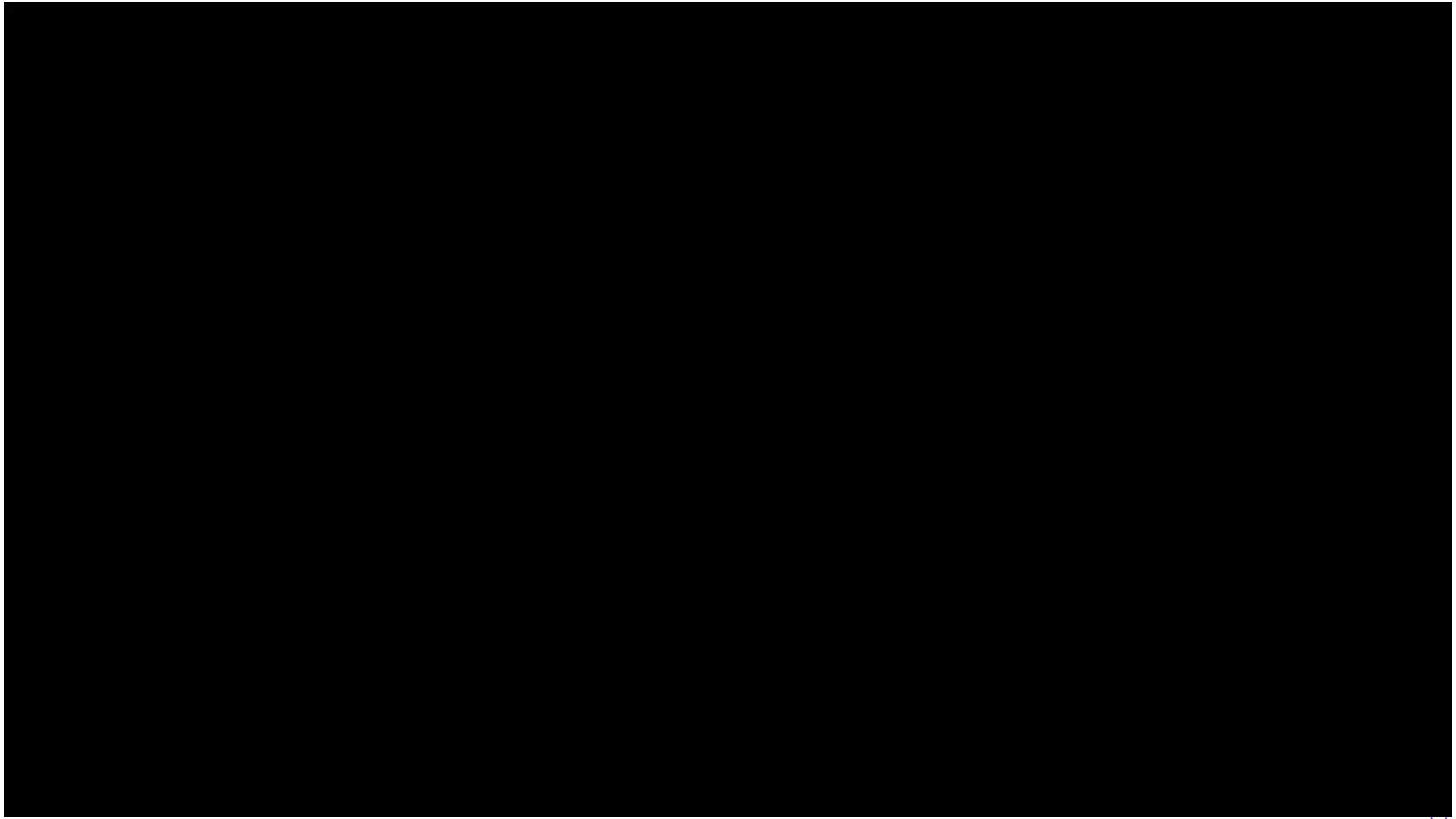
Seat Control Demo Video



Results & Next Steps

Results

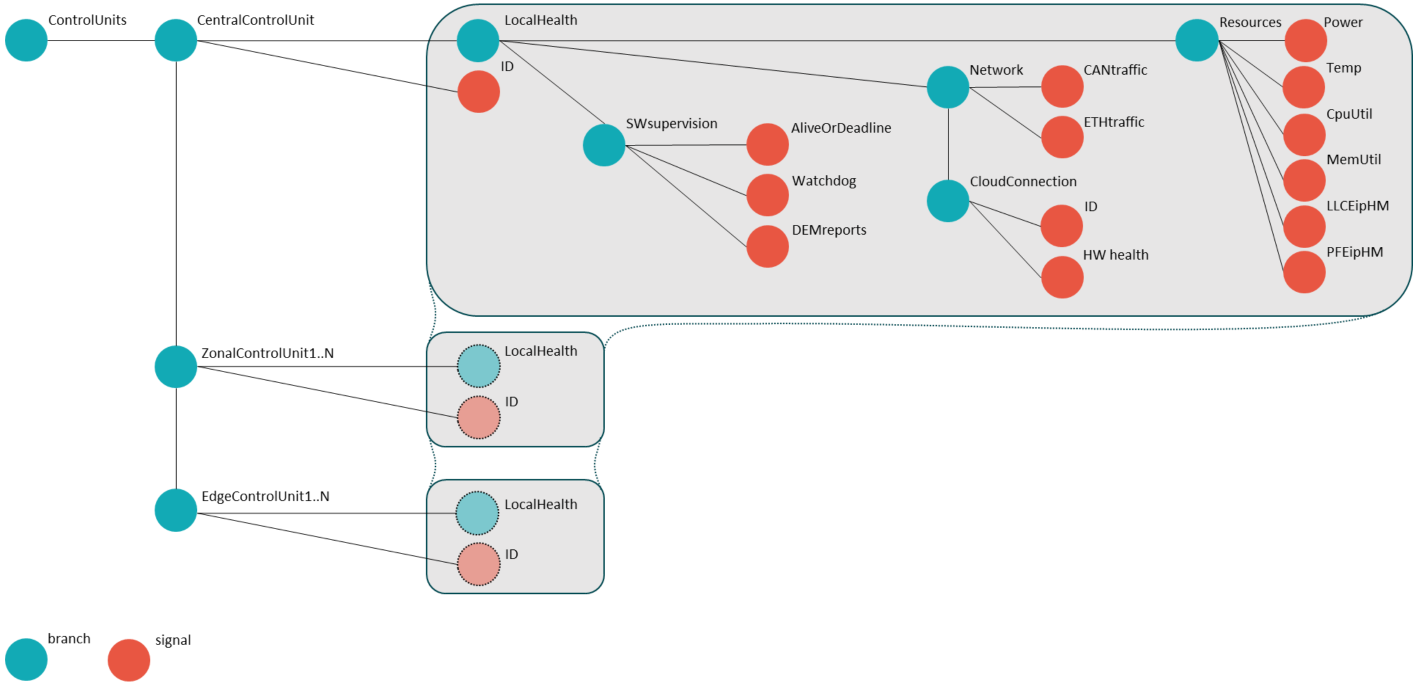
- Successfully used KUKSA data broker on S32G3 for Seat Control Demo
- Developed KUKSA client library including DBC, SOME/IP and IPCF bridges, mapping it to RT devices (S32G3-M7, S32Z-R52)
- The solution proofs to be highly flexible in terms of supporting arbitrary E/E architectures

Next Steps

- Assess performance and capability to cope with large number of signals @ high data rates
- Assess real time behavior and potential acceleration through dedicated accelerators (LLCE, PFE, …)
- Adoption of VSS methodology for other application domains (for instance Vehicle Health Monitoring)
- Real time data broker for RT critical communication & applications
- Investigate integration with Central Data Service Playground

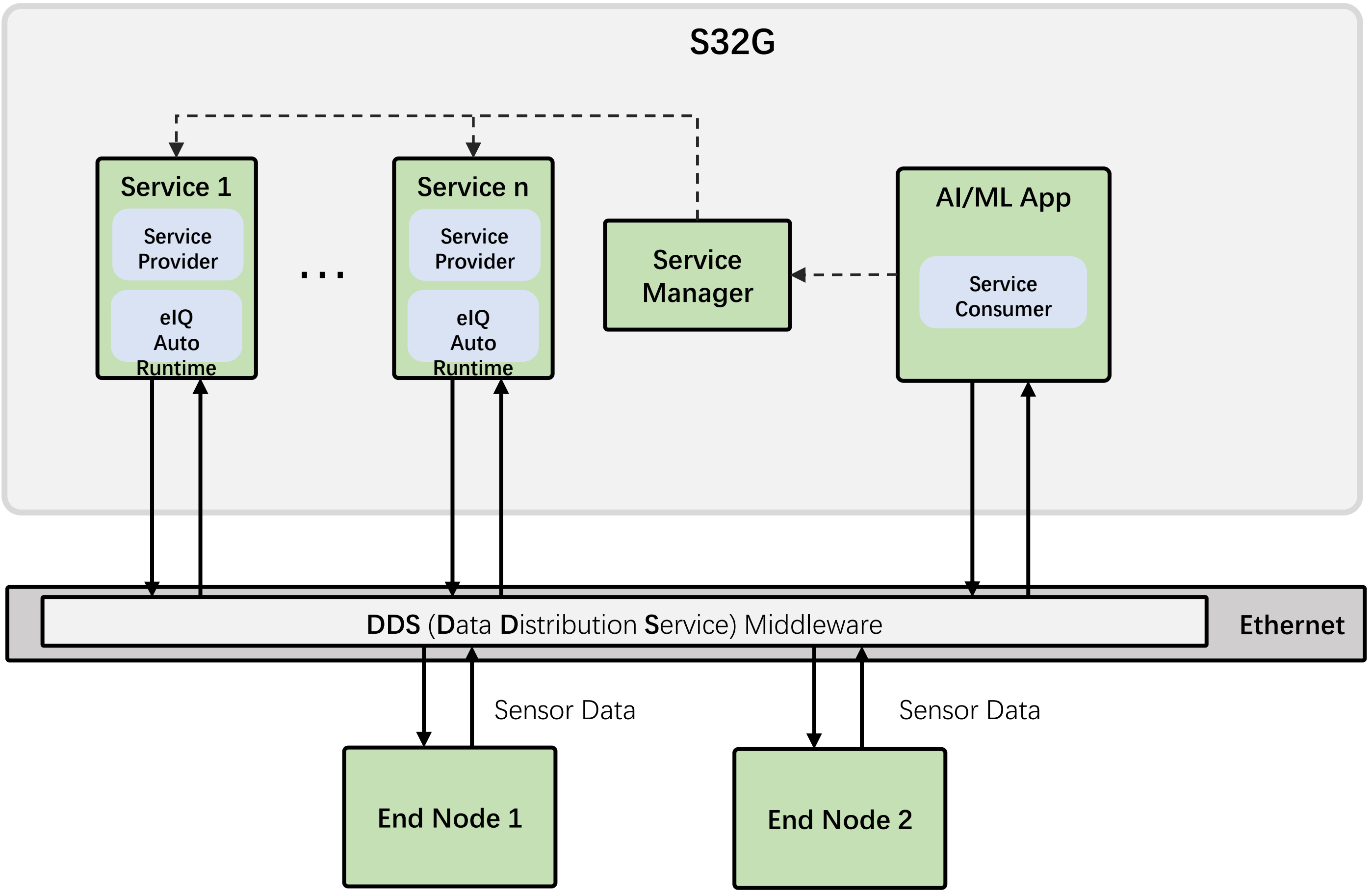
VSS for Vehicle Health Monitoring

- Assessing use of VSS framework for VHM domain
- Separate domain taxonomy or overlay to standard VSS catalogue
- Hierarchical structure for control units CCU->ZCU->End Node
- Major part of the tree is repetitive



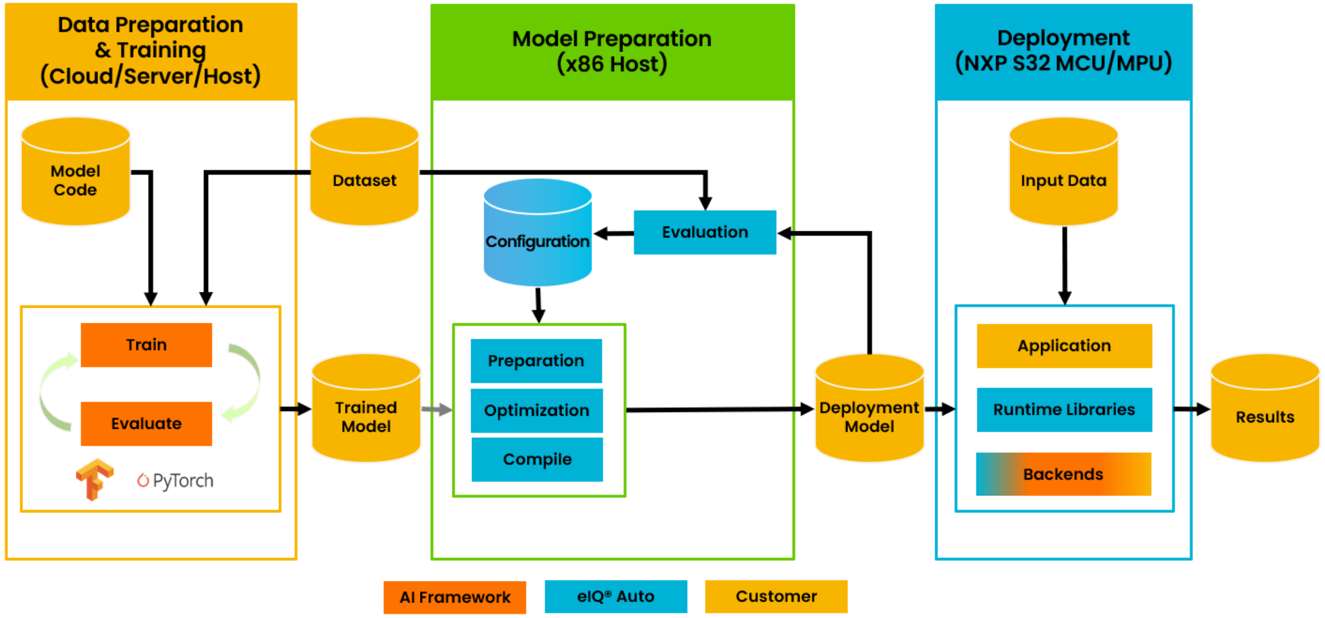
AI as a Service

- Edge AI deployment challenges:
  - Limited compute, limited model size, optimization required, supported NN operators limited.
  - If the neural network model is large, and latency is not critical, deploying it on HPC and CCU is a better option
- Efficient data collection and model runtime management



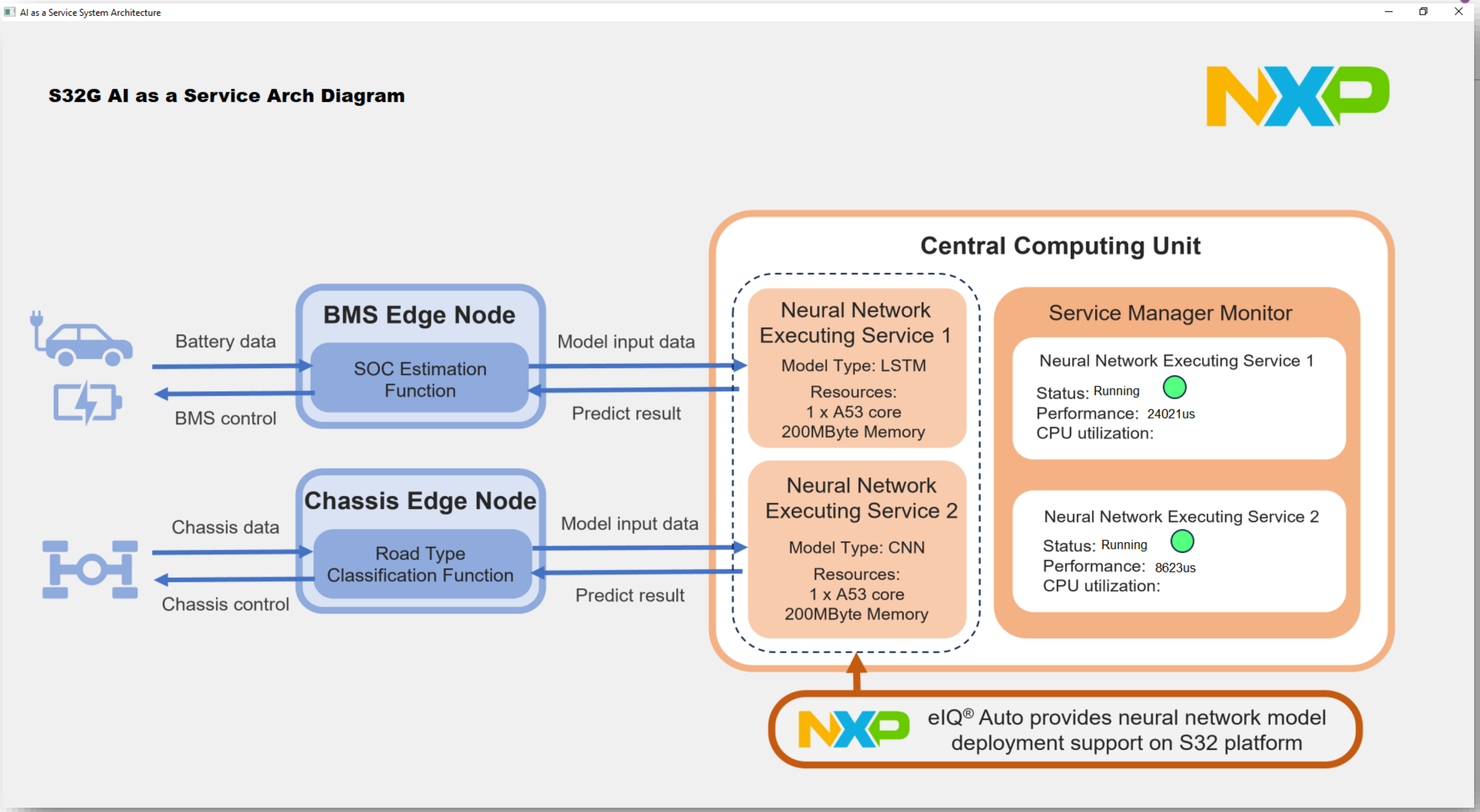
eIQ® Auto ML Software Development Environment

- Unified APIs - across hardware backends, model types and inferencing frameworks
- Performance advantage
  - 1.5x to 2.0x better than off-the-shelf open-source offering (on Arm cores)
  - Performance via toolkit/enablement which can translate to customers' models as well
- Automotive quality (ASPICE) runtime
- Ease of use
  - Debugger, Profiling; MATLAB and NXP S32 Design Studio integration; libraries and APIs to support customers easy porting of both Deep Learning and Machine Learning algorithms
- Reference use cases
  - Data analytics, virtual sensor and IDPS, audio processing

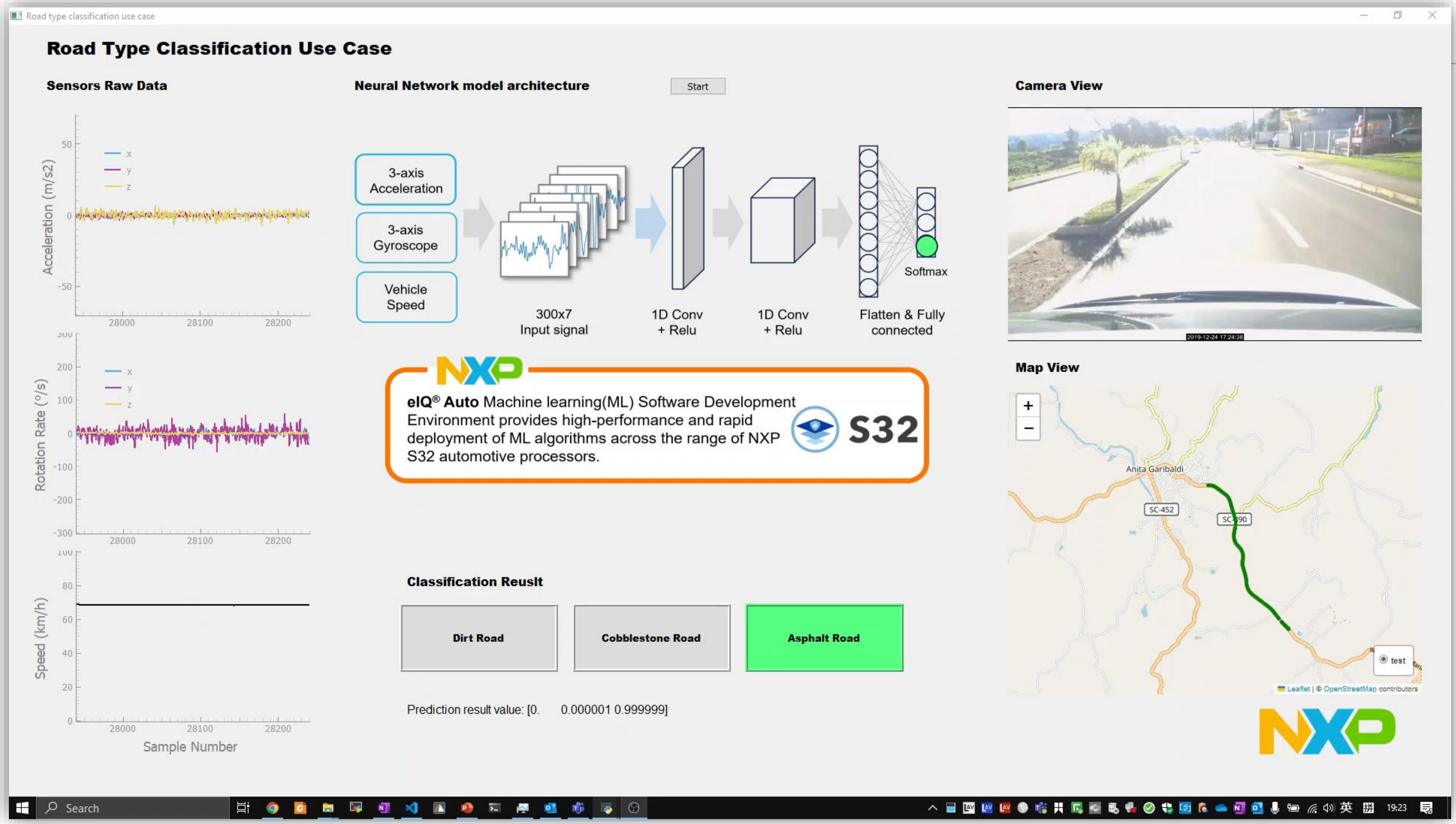


S32	Reference Use cases/Applications	ARM/ACCL Core	Backend
S32G	Prediction Maintenance – Vehicle Health IDPS - Driver Monitoring Edge to Cloud*	CPU (A53)	Glow
		CPU (A53)	ONNX RT/TFLite
		Hailo	Hailo RT
S32Z2/E2	Prediction Maintenance – BMS Anomaly detection – Power Train Applications Audio Classification - Emergency Vehicle Detection	DSP-Accelerator	Glow
		CPU (R52)	Glow
S32K	Predictive Maintenance - BMS, Sensor Data Analysis	CPU (M7)	Glow

AI as a Service – Demo



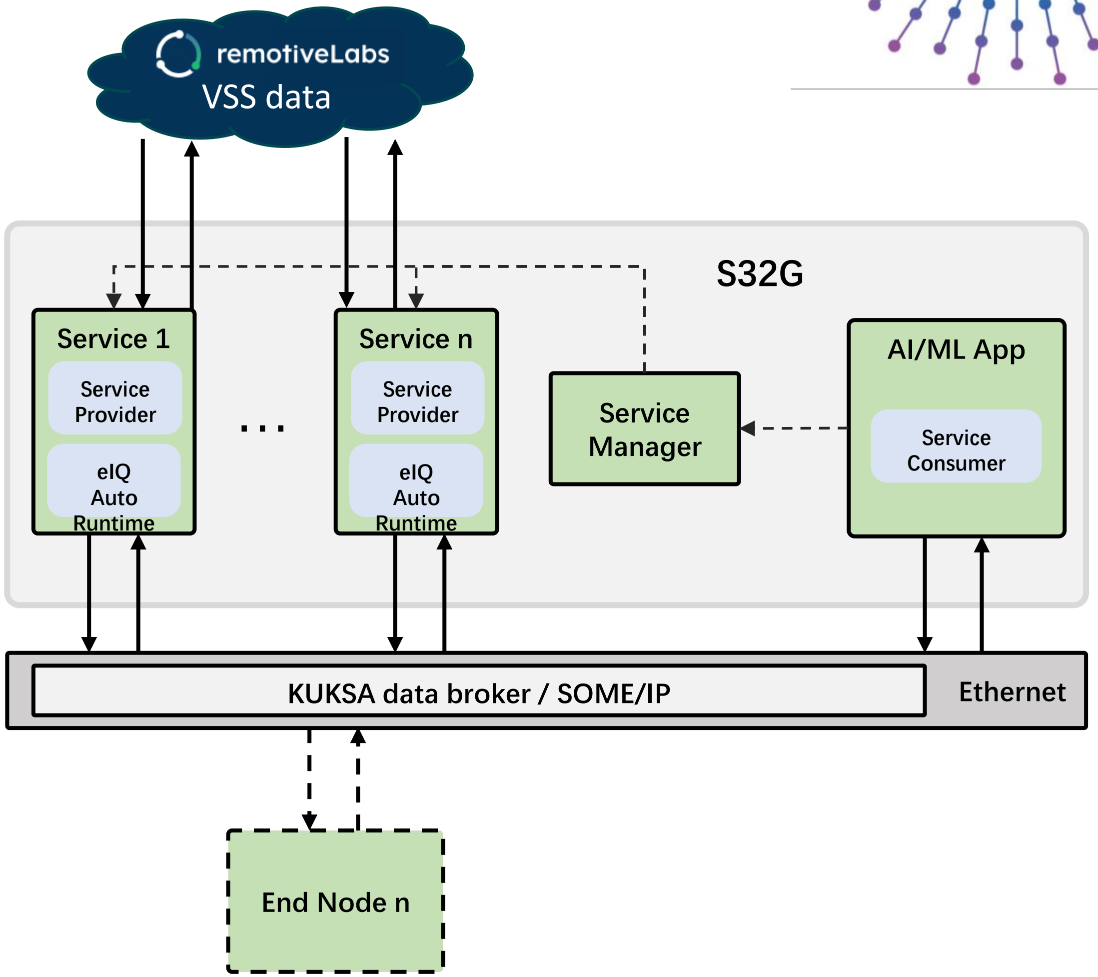
AI Deployment as a Service – Demo video



https://www.kaggle.com/datasets/jefmenegazzo/pvs-passive-vehicular-sensors-datasets?resource=download

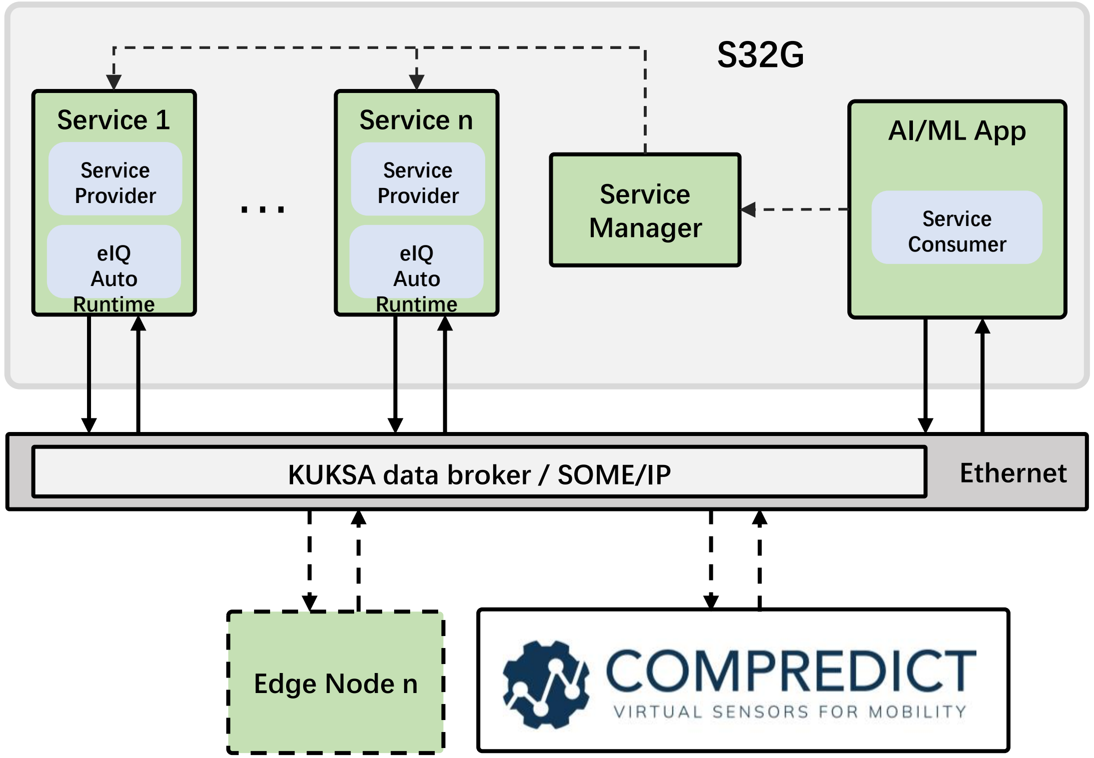
AI as a Service – future steps

- Integration with RemotiveLabs
  - Data playback without the need of an end node – simplified development flow
  - Optional VSS signal conversion in RemotiveLabs
- Integration with KUKSA data broker
  - Leveraging VSS signals further
  - Reuse NXP software components already developed (DBC bridge etc.)
- Interfacing with virtual sensors using VSS signal names for input/output, thus offering newly synthesized signals



Virtual sensors

- Virtual sensors: methods and algorithms to replace physical sensors to
  - Reduce BoM cost (hardware sensor replacement, e.g. tire pressure, headlight levelling)
  - Offer additional measurement capabilities (e.g. vehicle weight, wheel forces, equipment wear)
  - Deploy to physically inaccessible locations (e.g. electric motor rotor temperature, battery temperature)
  - Create synthesized quantities, sensor fusion, e.g. driver profile, child presence detection
- Uses VSS signals; creates (potentially new) VSS signals
- Optionally use the AI server to request inferencing of ML models



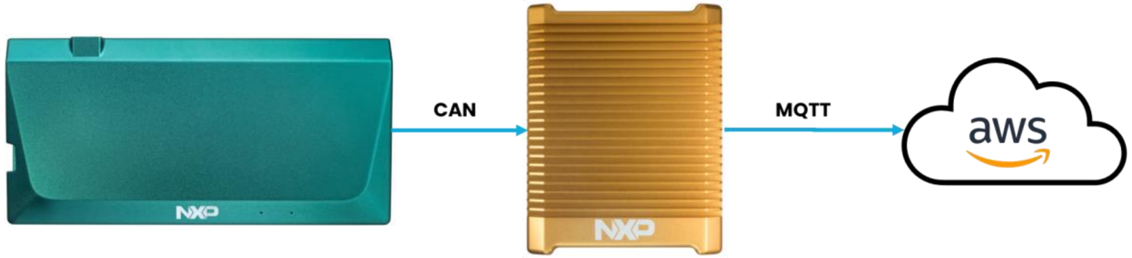
Intelligent CAN to COVESA VSS Data Management

Standardized Data Formats

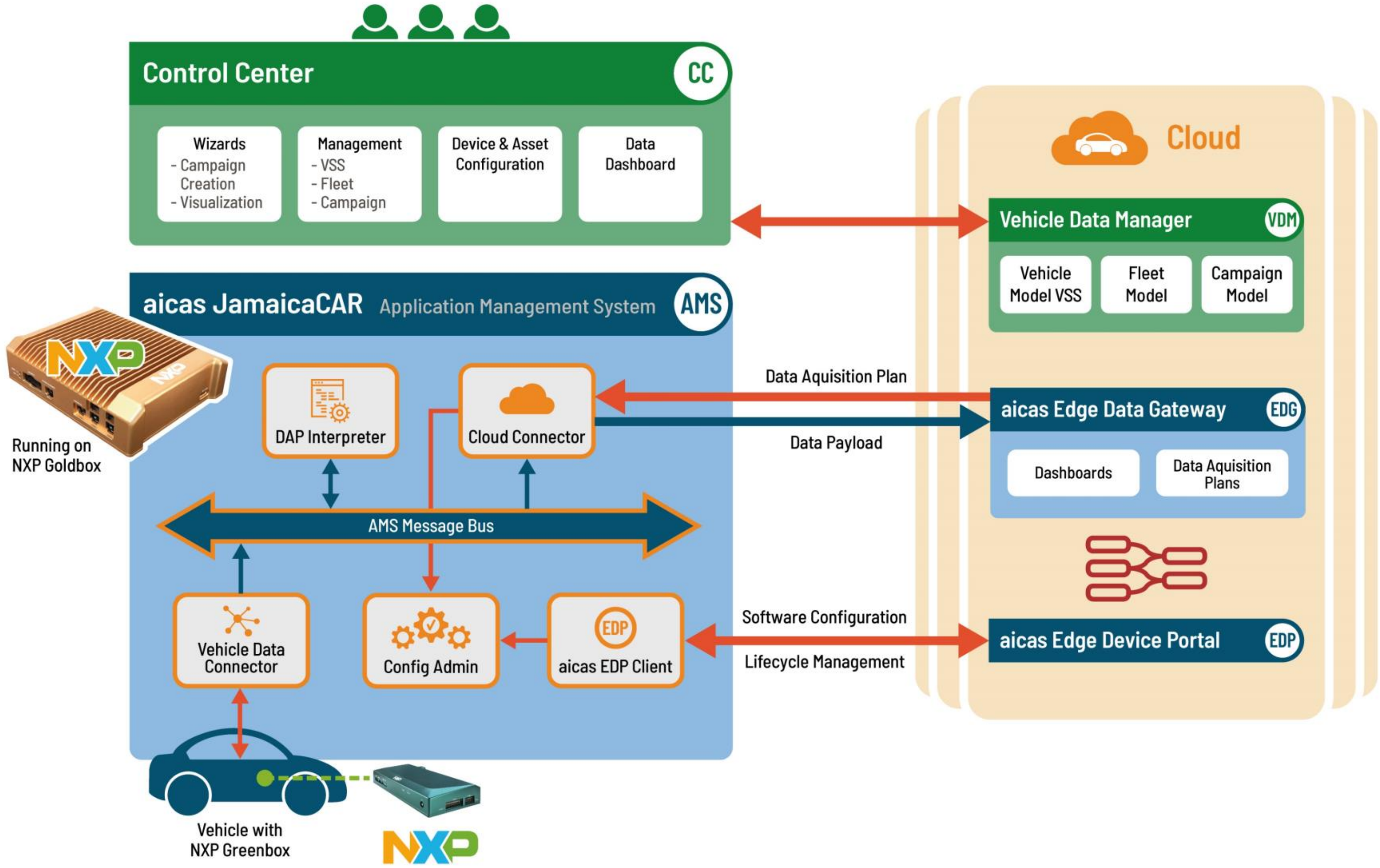
Efficient data management via edge processing, filtering, and optimized data to cloud

Real World Application

Automotive grade hardware and software: aicas JamaicaAMS application running on NXP S32G3 GoldBox



Data Collection and Processing for Vehicle on the Road



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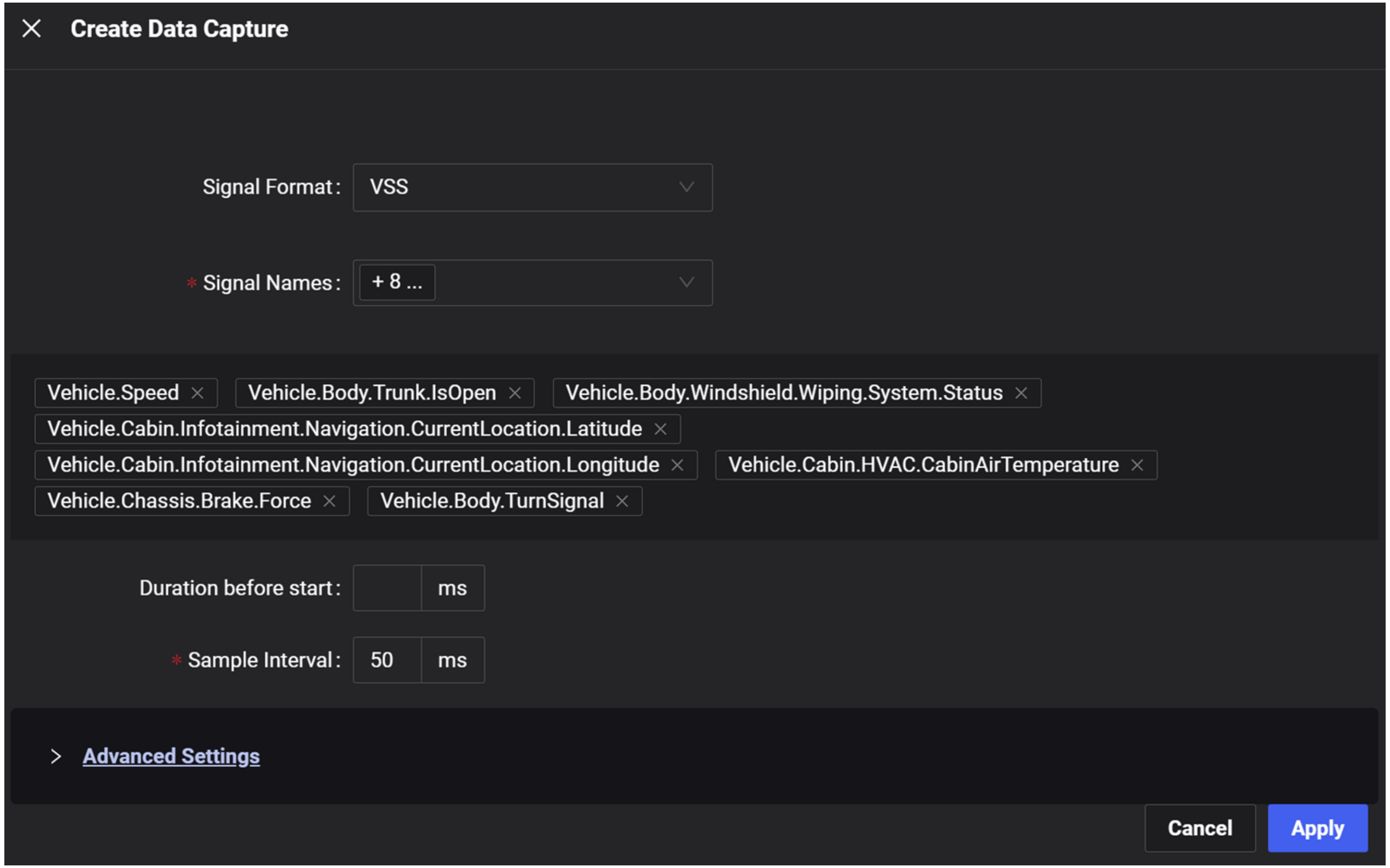
Sonatus Vehicle Platform benefits from VSS

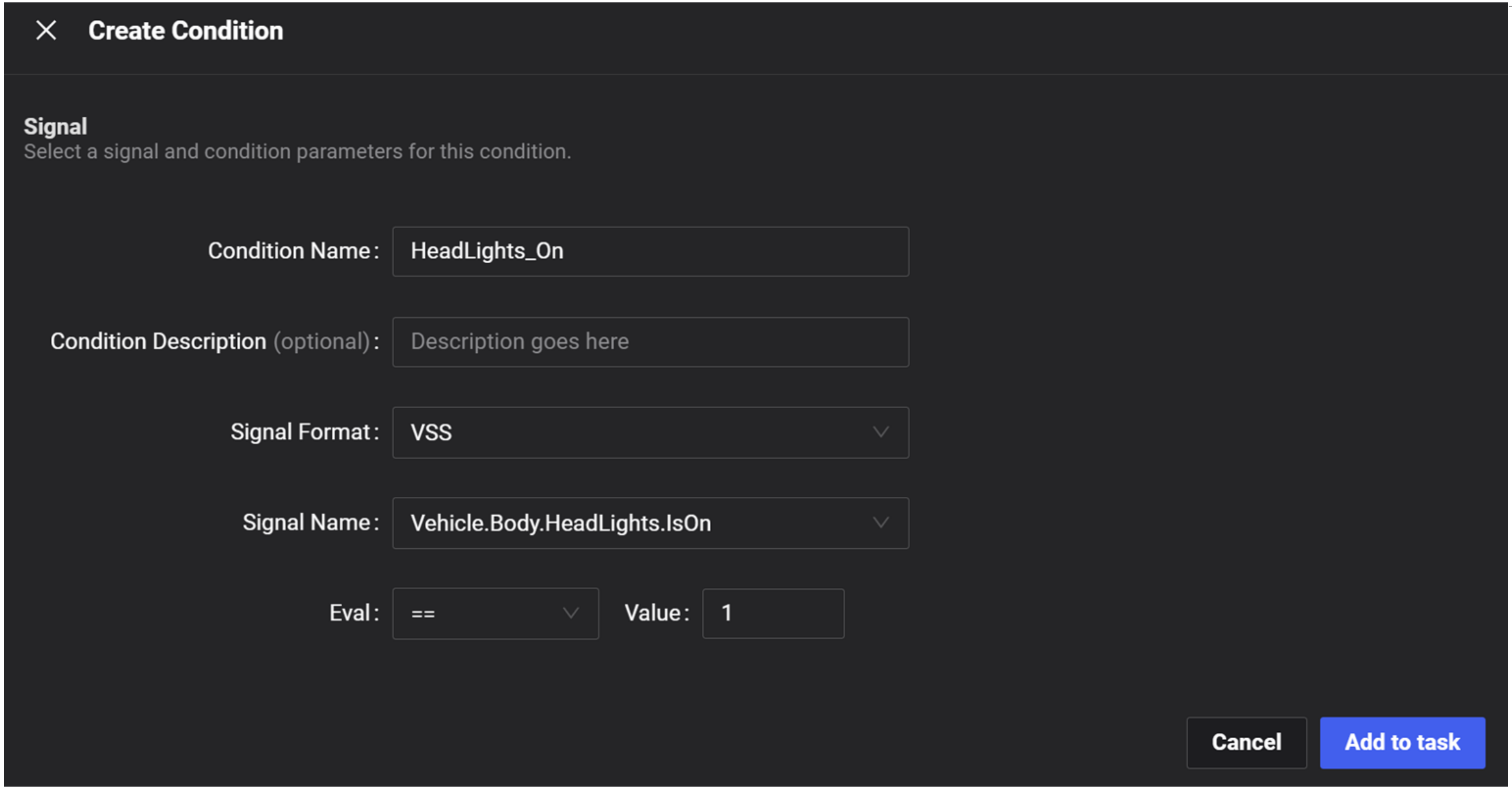
- VSS provides a useful abstraction layer along with standardized names
  - Reduces development costs and improves overall understanding
- Sonatus Collector and Automator can map VSS to vehicle-specific CAN signals
  - Provides better clarity on policy generation
  - Enables better portability across vehicles

VSS	**Vehicle 1**	**Vehicle 2**	**Vehicle 3**
Vehicle.Speed	VehSpd	Eng_VehicleSpeed	Veh_Speed_2
Vehicle.Cabin.Door.Row1.Pos2.IsOpen	PassengerDoor_Open	Pass_Door_Open	AssistDoorOpen

Example: Using VSS in Sonatus Collector

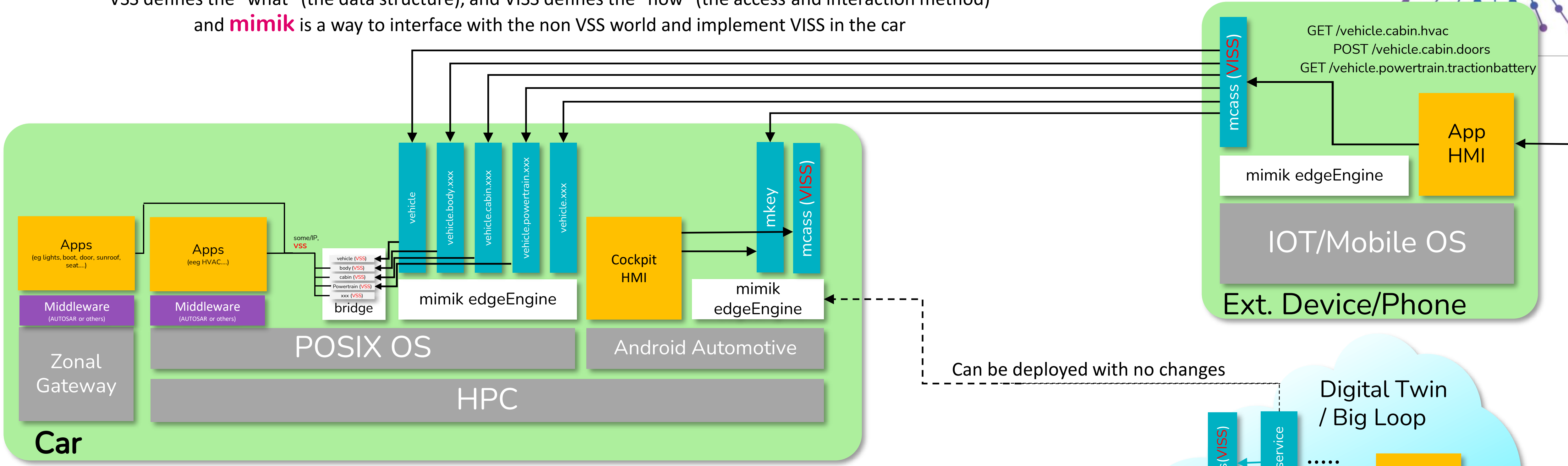


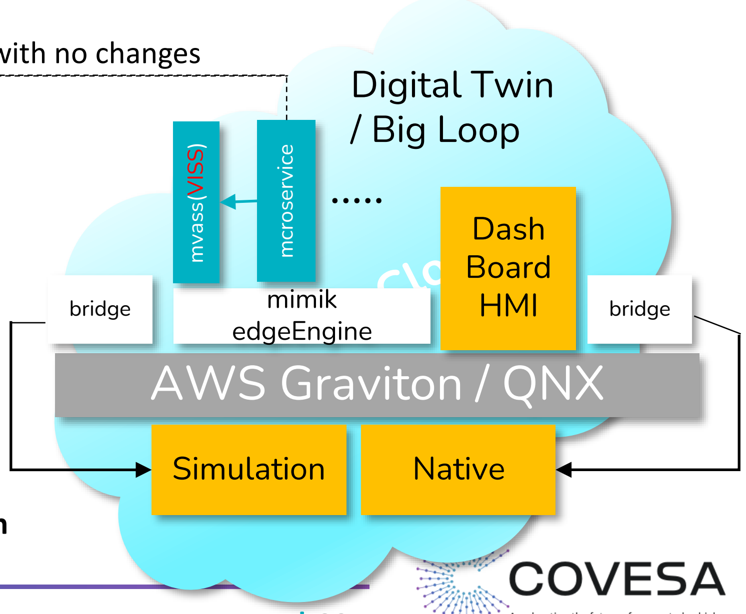
Example: Using VSS in Sonatus Collector



mimik and COVESA VSS and VISS

VSS defines the "what" (the data structure), and VISS defines the "how" (the access and interaction method) and **mimik** is a way to interface with the non VSS world and implement VISS in the car





- **mimik bridges are used to translate or interpret a VSS or non VSS event. The result is an event corresponding to the VSS specification**
- **Edge microservices are used to implement a specific function and expose API using the VISS specification**
- **mcass edge microservice discovers the specific functions that are implemented by the car and expose a subset of the VISS tree corresponding to that specific car**

mimik solution is well suited to implement COVESA VSS/VISS specification directly in the car and yet enable ad-hoc service mesh with other domains

Future Collaboration Opportunities

Collaboration opportunities

- Provide access to our KUKSA layer (on top of standard BSP), either Ubuntu (available today) or GoldVIP (future work).
  - GoldVIP integrates other tools and data management solutions as well
- Leverage NXP platforms for collaboration and experimentation:
  - Data feeder optimization
  - Data management
  - AI workload deployment and services
  - Sensor-to-cloud
  - Virtual sensors
  - Microservices
- Standard hardware modules available to create flexible vehicle architectures

VSS Feedback and Improvements

Upcoming Advancements and Proposals

VSS Overlays
support for on-the-fly extension of base VSS models

Similar Taxonomies for ECU and SoC data
for diagnostics, health monitoring, performance management, etc.

Sparkplug Integration
adapt new transport models

Diverse VSS Deployments
implementation in trucks, buses, and trailers

VSS Outside the Vehicle
Integration with smart home and city standards

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Key Takeaways

Key Takeaways

- SDVs are creating new opportunities for new, data-driven services
- NXP offers a wide range of SDV platforms and software to enable rapid development and prototyping
    - Platforms, software, AI/ML, cross-vehicle solutions
    - Leveraged today by many SDV and data-focused customers and partners
- NXP is working internally with COVESA VSS, KUKSA, AI/ML and other technologies to show how they provide the value for SDVs and data-driven use cases
- NXP is ready to collaborate – together we can better promote the value of COVESA

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