TTTechAuto

# TTTech Auto Offering Introduction

Pre-Sales
Systems Engineering

TTTech Auto

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# Agenda

01 TTTech Auto Introduction

02 MotionWise Core Solution Capabilities

03 MotionWise with 3rd party stacks including AP

04 MotionWise Cyclone DDS

05 Discussion

06

# TTTech Group - Truly Global

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**Global Reach:**
**2300+ employees**
**20 locations/sites**
**in 14 countries**
**headquartered in Austria**

NVIDIA, RENESAS, SAMSUNG, VW, Audi, SAIC, BMW, Continental, APTIV, HYDAC, rosenbauer, Infineon technologies, WINTERSTEIGER, MASCHIO GASPARDO, ROPA, POTTINGER, NXP, JLG, B&R, ST, IMMER GROUP, HYUNDAI, LIEBHERR, KAISER, FERRUZ, FARID INDUSTRIE, Prinoth, LoadPro®, casagrande, TESMEC, Vestas, eASIC, MOXA, intel, ABB, FILL, FELSS, TAILYN, THALES, GE Aviation, EMBRAER, LOCKHEED MARTIN, BOEING, Collins Aerospace, Honeywell, NORD-MICRO, Parker, LEONARDO, esa, RUAG, AIRBUS, MAXAR TECHNOLOGIES, Jacobs, BOMBARDIER, BAE SYSTEMS, NAI, LADOG, DDC-I, SYSGO, NASA, MERCURY, GENERAL DYNAMICS, ROHDE&SCHWARZ, ZÖLLNER, amu, XILINX, SIKORSKY, SAFRAN, WIND

# TTTech Auto
# The global Auto-Tech leader

**1.200+** Highly-skilled software engineers

**20+** Years of cross-industry experience in development of safety-critical systems

**60+** Network of OEMs, Tier 1s and technology partners

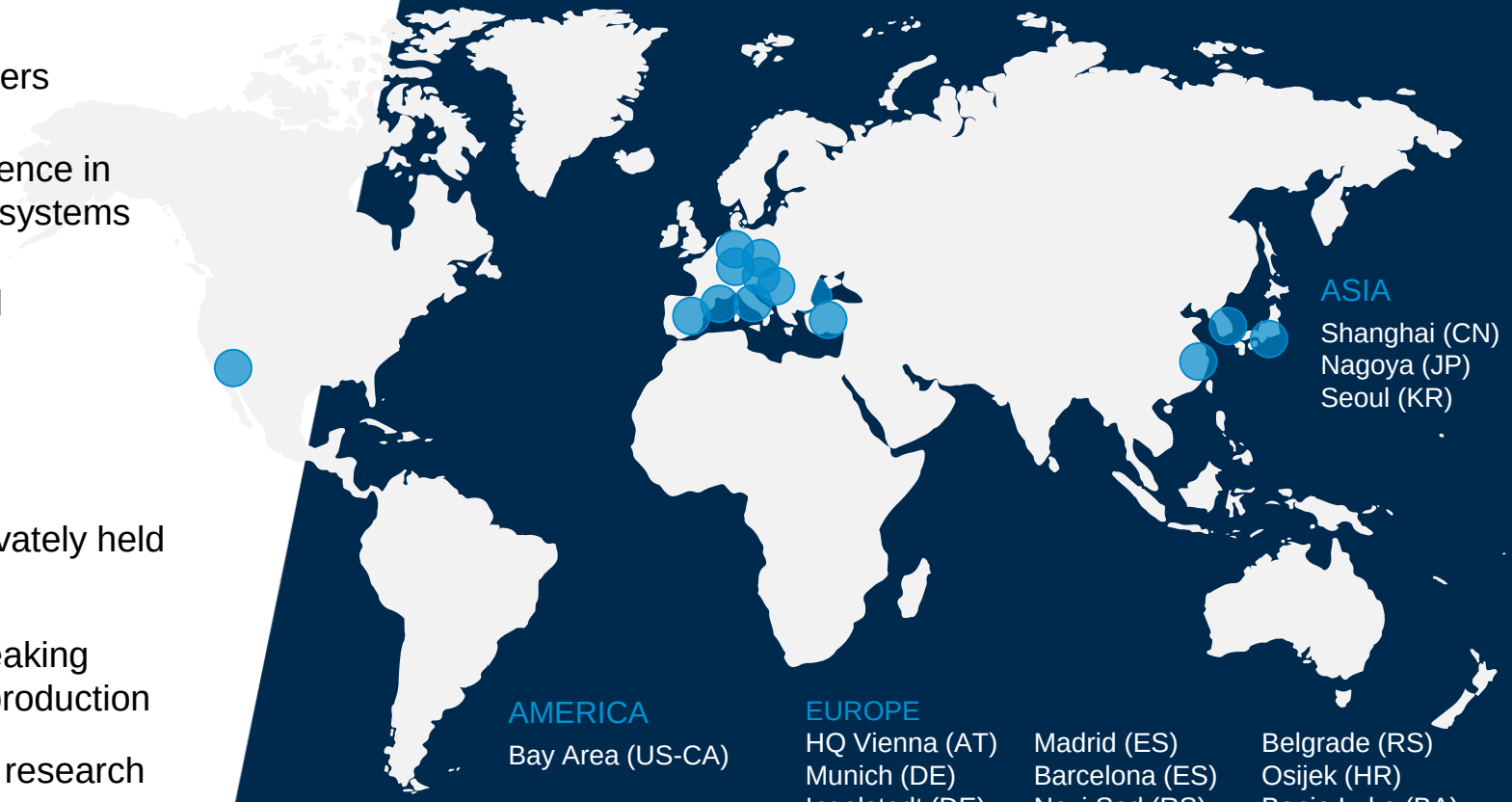
**24** Patents for system safety

Member of TTTech Group, privately held Austrian high-tech company

Innovation leader – groundbreaking academic research to series production

Ecosystem leading industry & research partners

International footprint with **14** locations



**ASIA**
Shanghai (CN)
Nagoya (JP)
Seoul (KR)

**AMERICA**
Bay Area (US-CA)

**EUROPE**
HQ Vienna (AT)
Munich (DE)
Ingolstadt (DE)
Madrid (ES)
Barcelona (ES)
Novi Sad (RS)
Belgrade (RS)
Osijek (HR)
Banja Luka (BA)
Izmir (TR)

July 2022

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# TTTech's DNA:
# Safe System Design

Development and deployment of safety-critical avionics networks, for e.g., Boeing 787, Airbus A220 (fly by wire), NASA Orion spacecraft, ESA Ariane 6

**>1 billion** flight hours

**23** different aircraft types

**700 million** passengers

First series-proven ASIL D safety software platform for ADAS Domain ECUs in the market

MotionWise

**>2 million** vehicles

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Transforming leading research into market-shaping, safety-critical aviation products and advanced driver assistance system (ADAS) platforms.

TTTech Auto MotionWise – the safe software vehicle platform for automated driving, based on experience in the development and deployment of safe and reliable critical avionics systems/networks.


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# TTTech Auto
# Product and Solution Offering

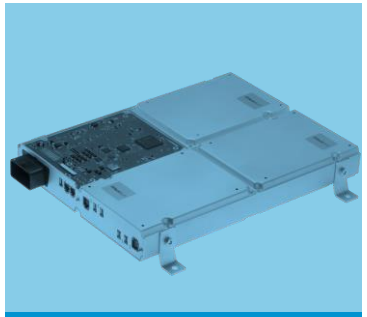
## MotionWise – Safe Vehicle Software Platform (VSP)

Vehicle Software Platform

Platform Integration Services

## System Design Services (SDS)

System, Safety & L4 Architecture Consulting



Electronic Controls Design House

## Other Automotive Services and Solutions

Automotive Engineering Services

ECUs, Displays & TSN IP

Software Components | Professional Services | Hardware Components

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# MotionWise

## The Safe Vehicle Software Platform Overview

# Transition from a traditional auto supply chain to …

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## … an open platform-based auto-tech ecosystem

**OEM**

- Innovation cycles not fast enough
- Threat of vendor lock-in
- Uncertain system-level results (integration complexity)

**Tier-1**

- Engineering process
- Tailor-made software - high efforts and little re-use

**Tier-2**

- Service / Component specific to individual project – business model not lucrative

- Fast innovation cycles
- Guaranteed system-level results

**OEM**

**Open innovation platform**

- Technology-driven assembly of standardized components
- Multisource approach

**Software platform / Component / Applications companies**

- Modular, interoperable software components
- Win-win business model

**System / Hardware parts companies**

- Tier-1s
- Hardware suppliers
- System architects
- Component suppliers: sensors, actuators

**Service providers**

- Additional engineering services as know-how and scaling partners

November 2021

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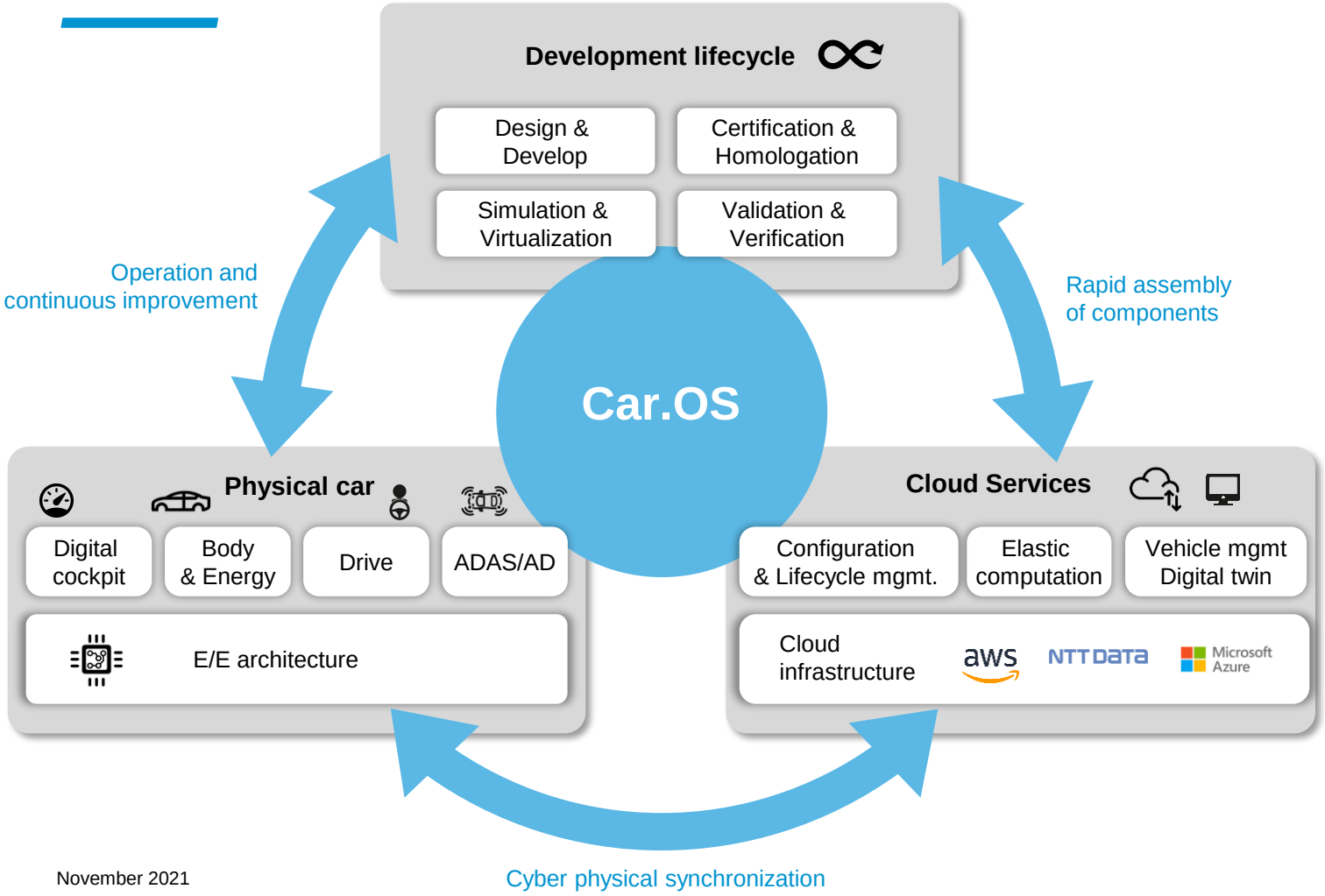
# Deliver robust car software at quality and scale “Guarantee of Integration and Service”




The characteristics of the delivered car operating system:

- **Safe & Secure**
- **Hard real-time performant (µsec)**
- **Upgradeable**
- **Cloud enabled**



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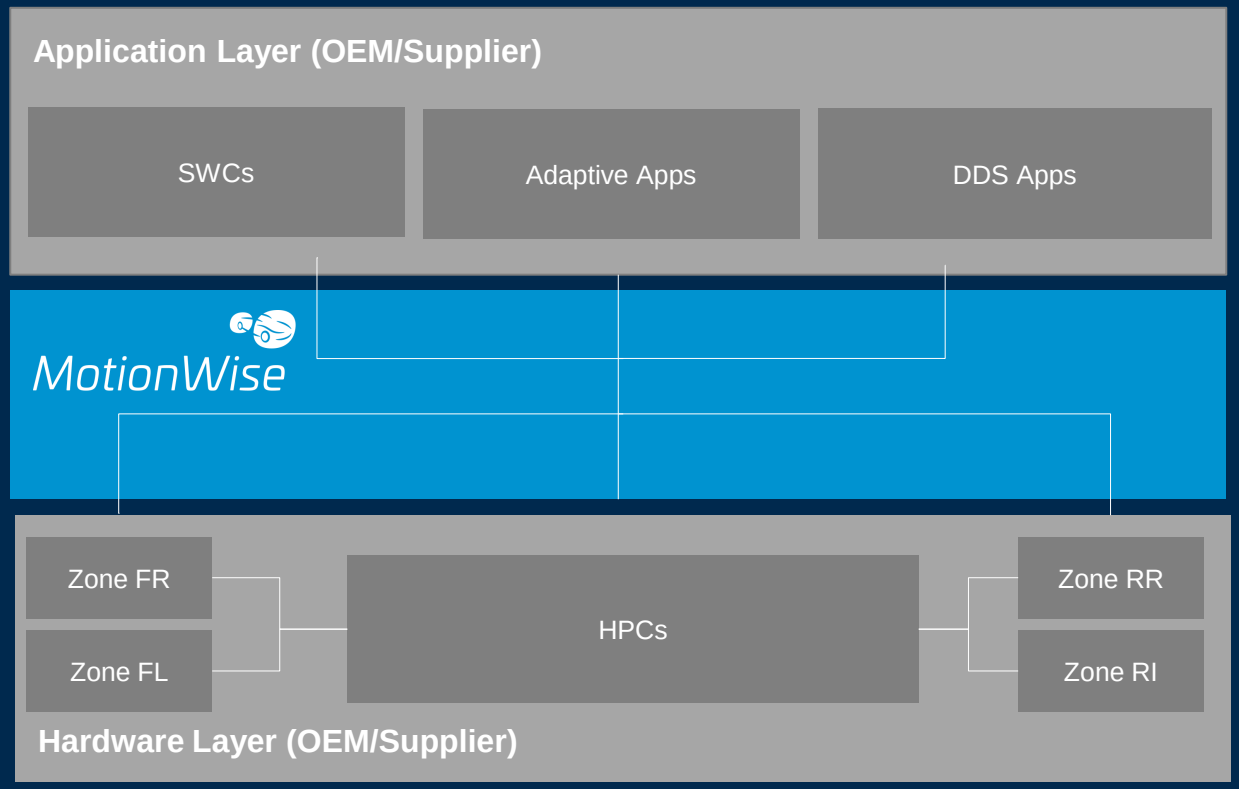
# Enabling Safe workload orchestration at vehicle level




**Resource Management** enables the abstraction of computational & communication resources in multiple SoCs and multiple ECUs

**Safe Execution and Communication Platform** providing global scheduling capabilities and global time synchronization, enabling end-to-end timing guarantees at the ms level at vehicle level

**System-wide platform** across the vehicle, enabling scalability and portability of application across E/E architectures

**One stop shop** integration of third-party software stacks

**ASIL-D Ready** paving the way towards Fail-Operational

Based in **Open Standards**: DDS, TSN, AUTOSAR, ROS2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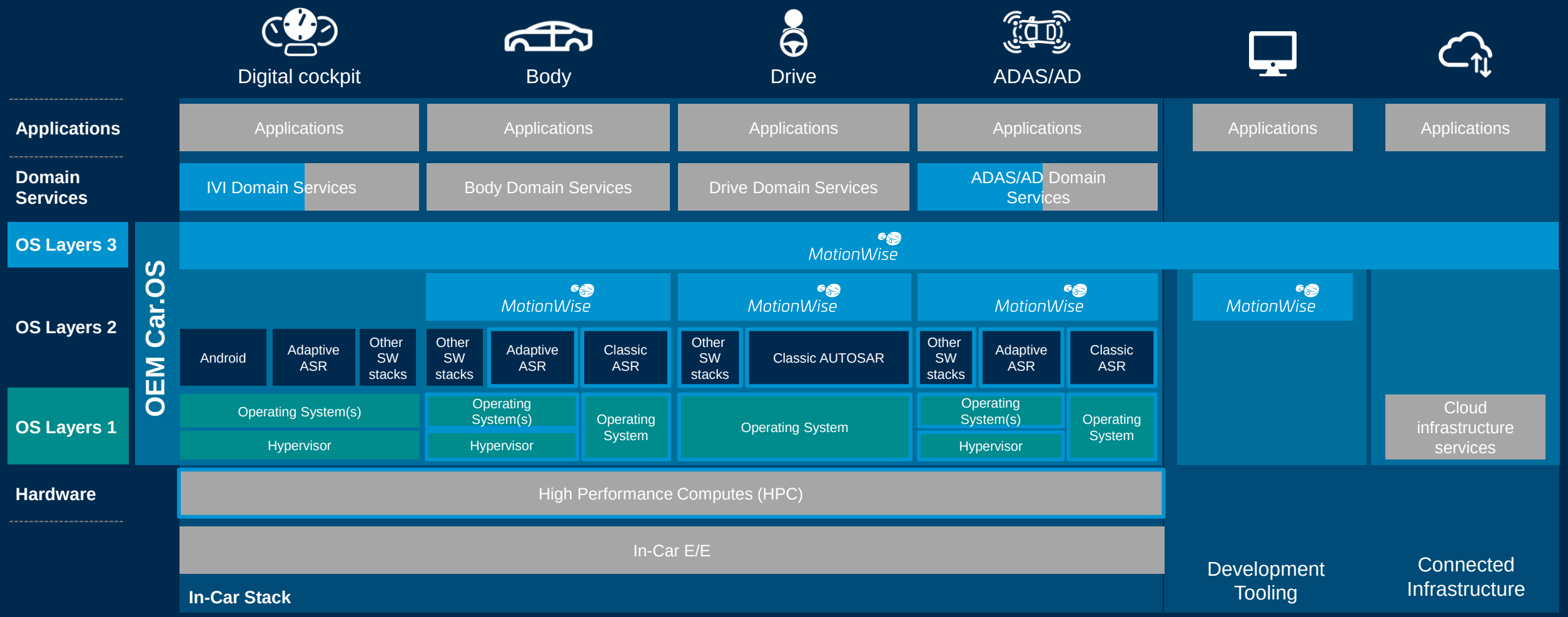
# MotionWise VSP Footprint
# Example of Usage within an OEM Car.OS




MW Service

Hardened 3rd Party Service / Resource



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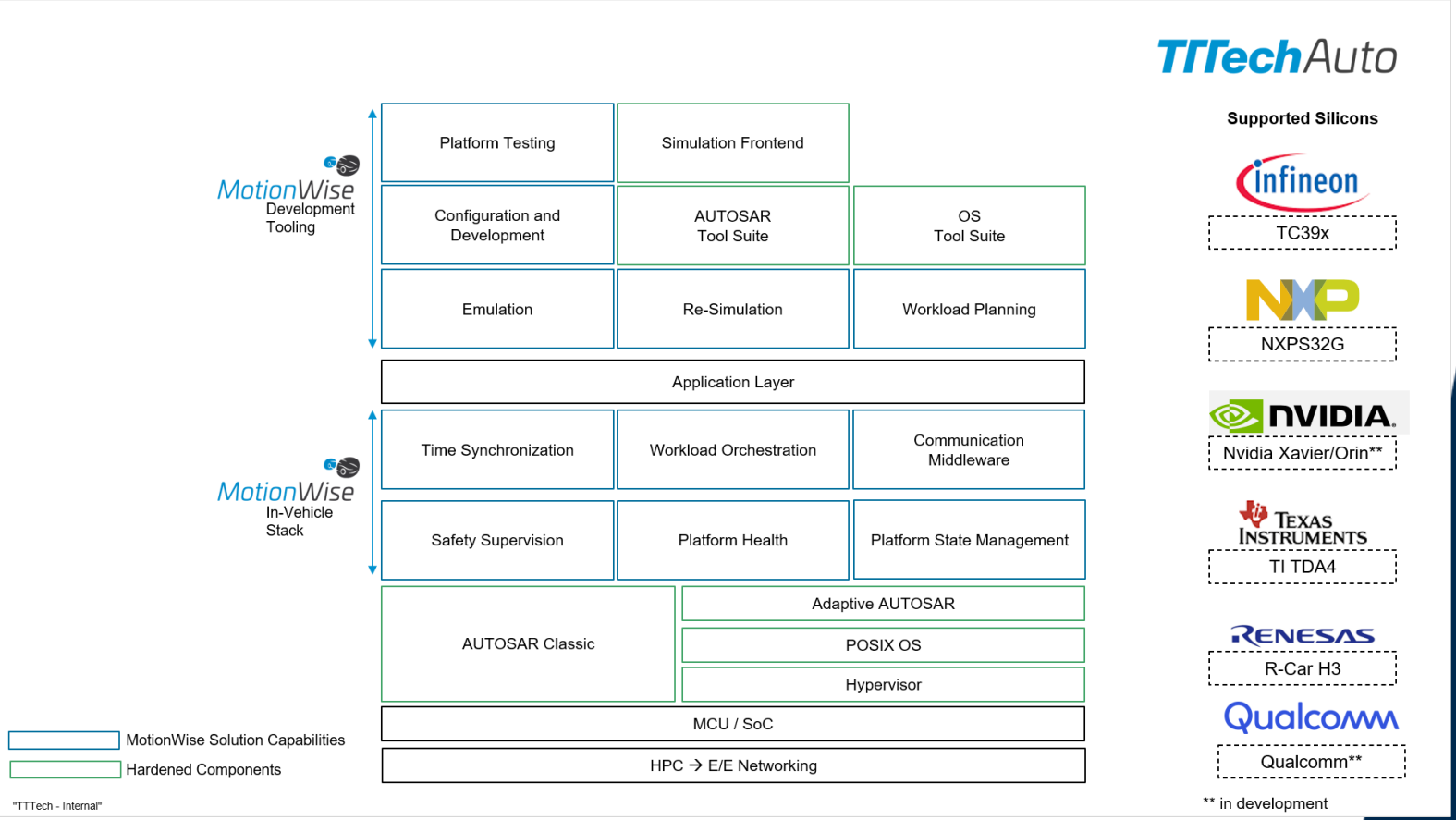
# MotionWise Solution Capabilities




## MotionWise Classic

- Solution targeting MCUs / Safety Islands
- Compatible with Classic AUTOSAR architecture & paradigm

## MotionWise SOA

- Solution targeting Micro Processors Units (MPUs)
- Compatible with Adaptive AUTOSAR

## MotionWise

- MotionWise Classic + SOA
- Targeting HPCs with a multi-SoC landscape
- TSN and PCIe communication backbones
- System Properties
- Integrated Platform Safety Case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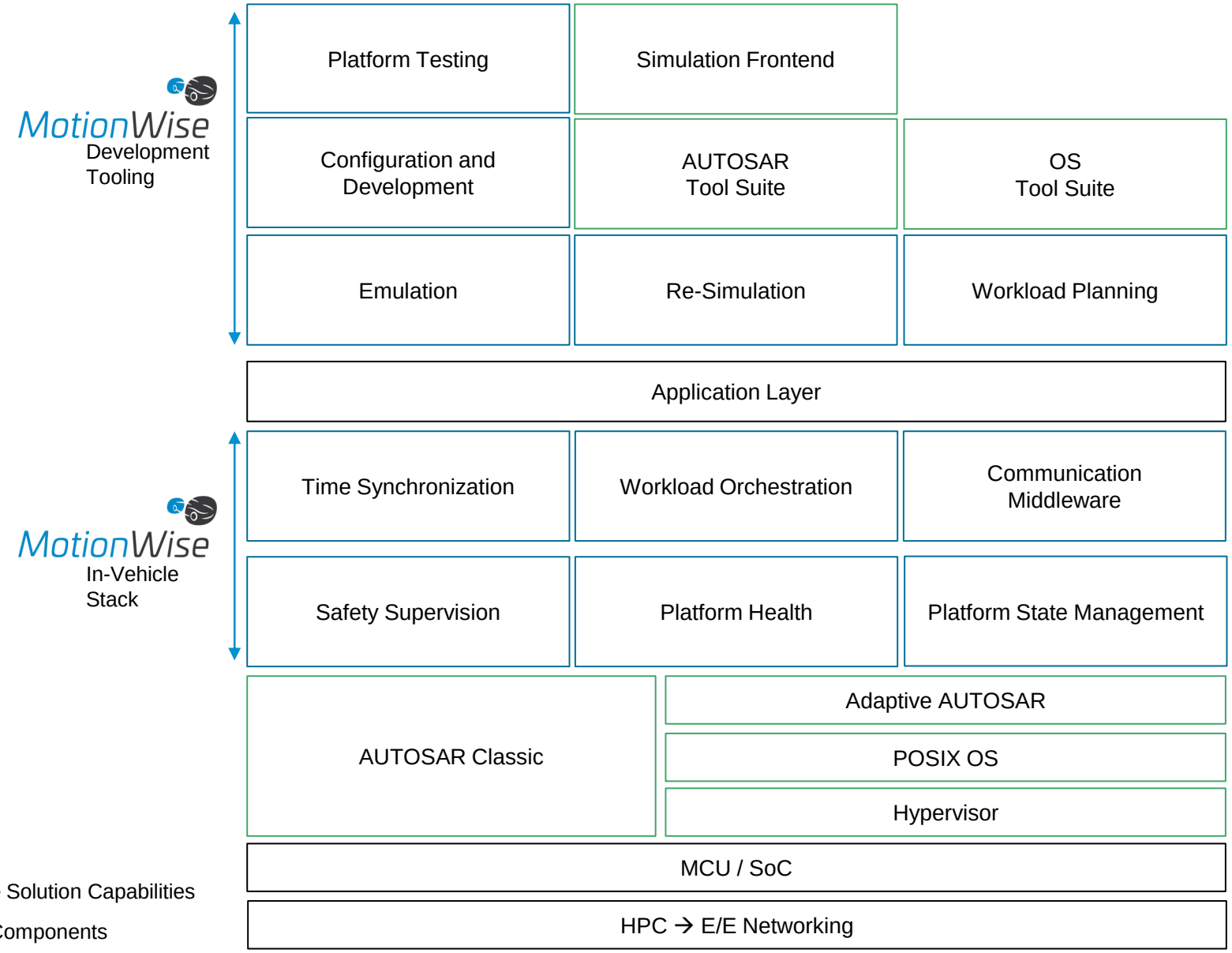


MotionWise Solution Capabilities

Hardened Components

**Supported Silicons**

Infineon
TC39x

NXP
NXPS32G

NVIDIA
Nvidia Xavier/Orin**

Texas Instruments
TI TDA4

Renesas
R-Car H3

Qualcomm
Qualcomm**

** in development

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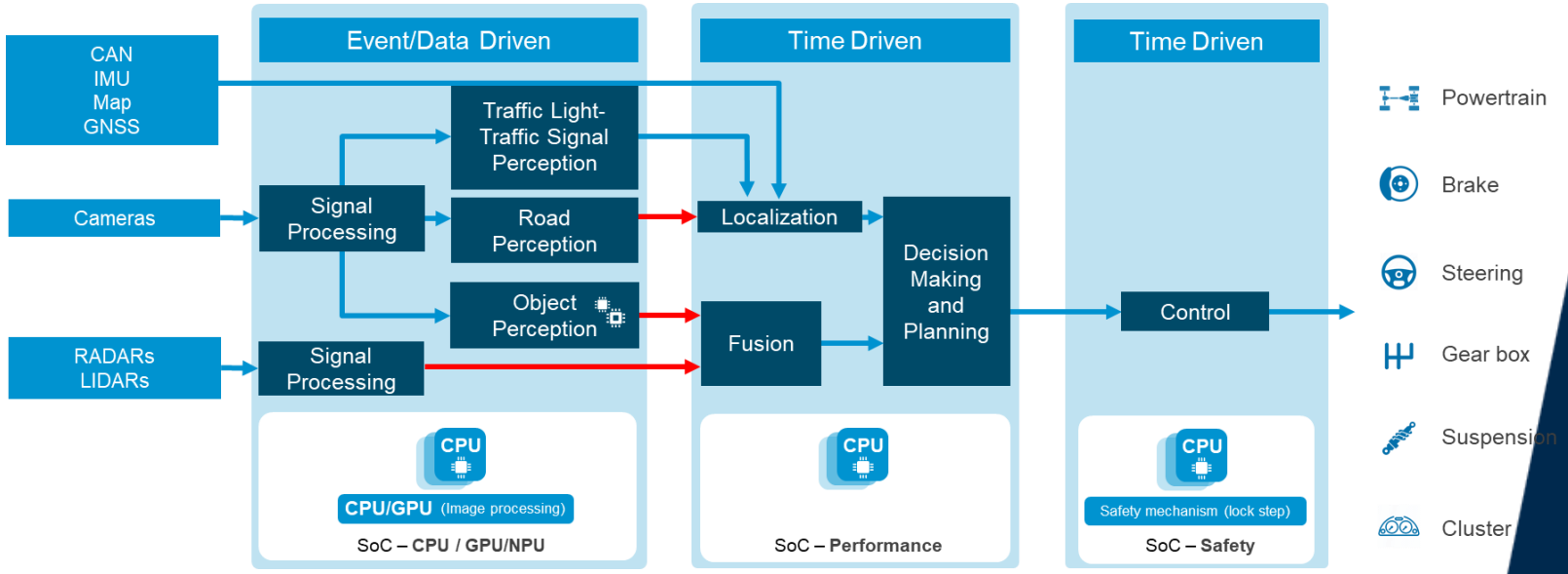
# Global Scheduling

# Complexity brought by multi-ECU, multi-SoC, multi-core environment



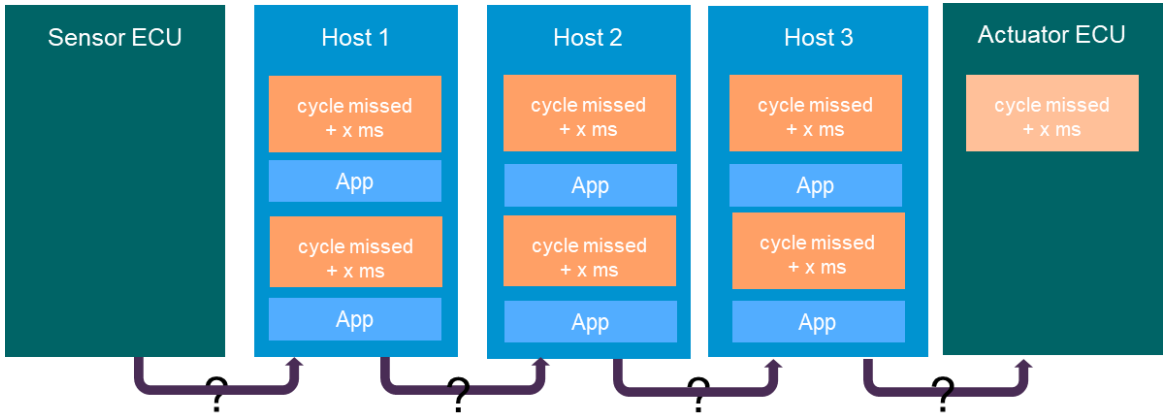

Need for satisfying FFI and timing guarantees in a heterogenous, safety-critical distributed system in the presence of:

- Increasing number of complex applications sharing the same resource
- Mixed-critical applications hosted on diverse SoCs with different properties and criteria to be satisfied
- Multiple operating modes with different sensors and applications
- Inter-SoC communications

***Disclaimer: Diagram is a reference use case, without claim of completeness.*

# Use case study: Adaptive AUTOSAR in existing multi-SoC ECU Program

1. Lack of multi-SoC synchronization
2. Unknown of communication delay for intra and inter-SoC
3. Lead to integration and debugging problems




- **Problem 1: No synchronization of execution and communication between hosts or applications**
  - > 20% overprovisioning because of unsynchronized computation and communication
  - E2E Latency budget not meetable even with extreme App Timing Optimization

- **Problem 2: COTS Adaptive Autosar Stacks have no real-time capable IPC**
  - Data transfer (even on host) has huge overhead
  - No temporal FFI because sending leads to context switch to receiver even if not yet ready for cycle

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# MotionWise Global Scheduling vs Adaptive AP Execution Management: Local Scheduling Policies

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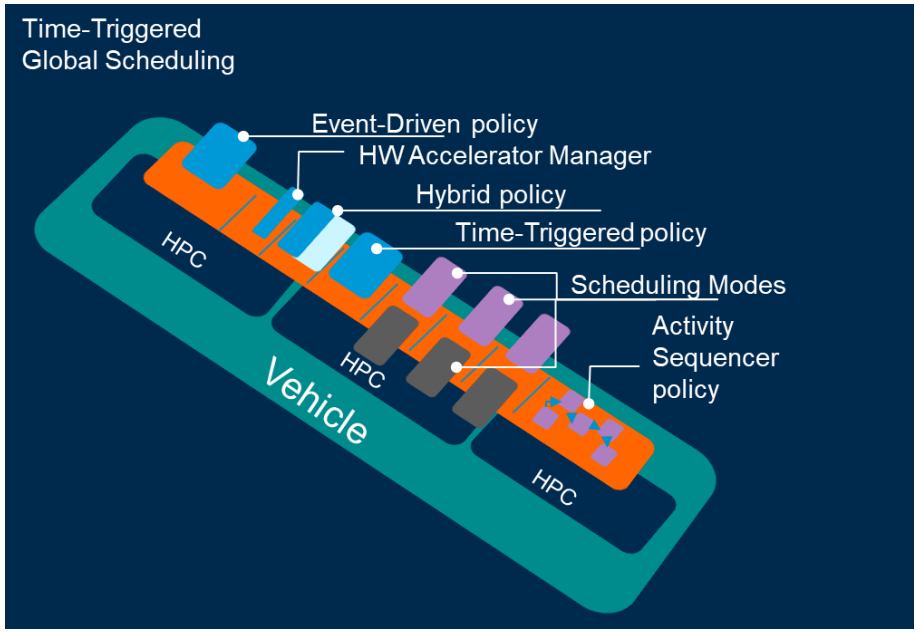
MotionWise

MotionWise Local scheduling policies provide a harmonized scheduling scheme across all POSIX based systems. The configuration of each of them are completely done via the MotionWise Scheduling suite, without any intervention from the user on the OS level.




AUTOSAR Adaptive Platform

AUTOSAR

Specification of Execution Management
AUTOSAR AP R21-11

Requirement [SWS_EM_02104] permits the initial thread (the "main" thread of the process) to be bound to certain cores [SWS_OSI_01012]. Depending on the capabilities of the `Operating System` the sub-set could be a single core. If the `Operating System` does not support binding to specific cores then the only supported sub-set is the entire set of cores.

**7.7.3.3 Scheduling**

Currently available POSIX-compliant `Operating Systems` offer the scheduling policies required by POSIX, and in most cases additional, but different and incompatible scheduling strategies. This means for now, the required scheduling properties need to be configured individually, depending on the chosen OS.

Moreover, scheduling strategy is defined per thread and the POSIX standard allows for modifying the scheduling policy at runtime for a given thread, using `pthread_setschedparam()`. It is therefore not currently possible for the `AUTOSAR Adaptive Platform` to enforce a particular scheduling strategy for an entire process, but only for its first thread.

**7.6.3.5 Real-Time Resources**

To ensure Time Determinism (see 7.6.1.1), i.e. to make sure that a cyclic deterministic execution within a `process` (see 7.6.3.1) is finished at a given deadline we need:

- `Execution Management` supports deterministic multithreading to meet high performance demand, see 7.6.3.2
- The integrator needs to assign appropriate resources to the `process`.
- The integrator needs to assign appropriate scheduling policies. Details and options other than standard POSIX scheduling policies (see [SWS_EM_01014]) heavily depend on the used Operating System, are vendor specific, and are for now out of scope of the Adaptive Platform specification.

Source: https://www.autosar.org/fileadmin/user_upload/standards/adaptive/21-11/AUTOSAR_SWS_ExecutionManagement.pdf#page=89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# MotionWise VSP aligns the functional and design perspective

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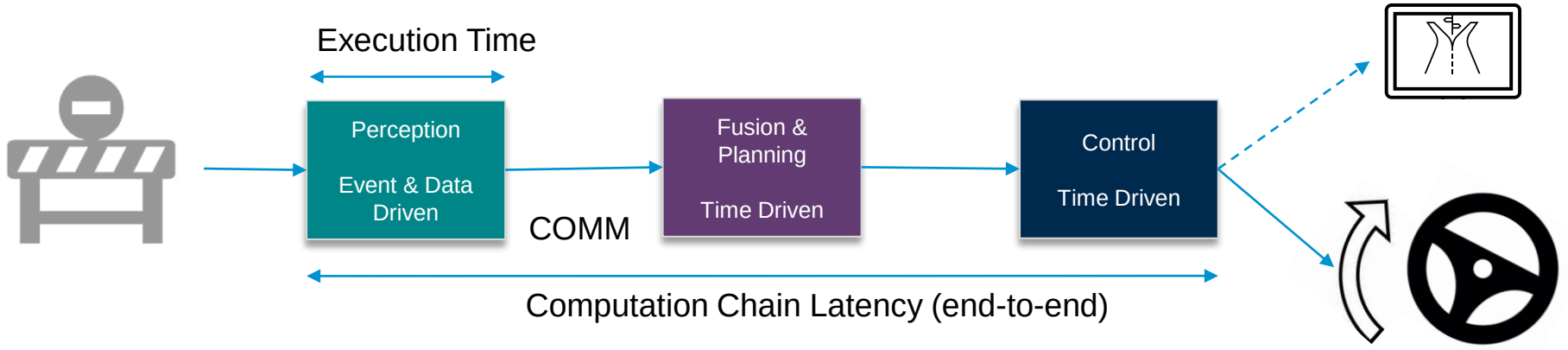
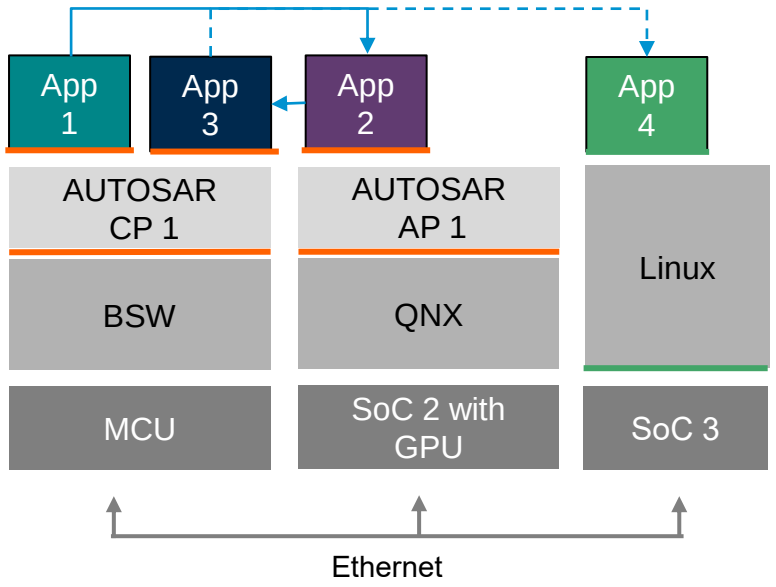
**Functional Perspective**




**System Design Perspective**

**AUTOSAR Adaptive Architecture**

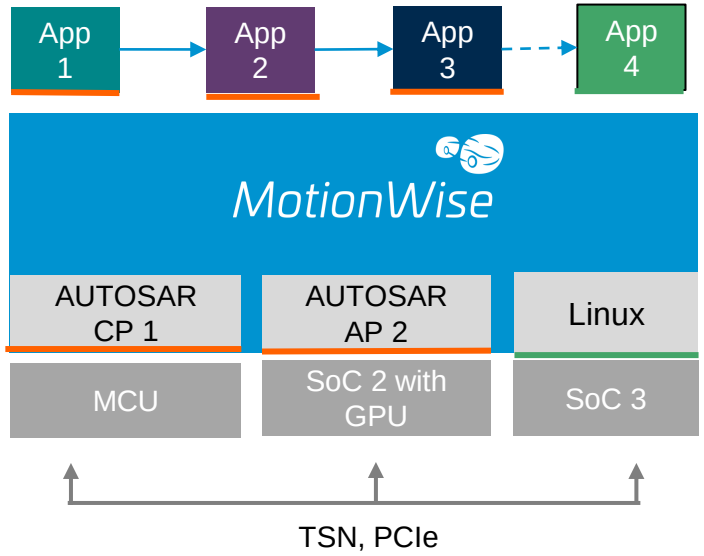



✕ Only SoC based task planning supported

✕ Limited to AUTOSAR ecosystem

✕ Missing deterministic COMM

**MotionWise VSP Architecture**




✓ Supports planning of computation chains

✓ Broad ecosystem support

✓ Deterministic COMM guarantees



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# MotionWise enables scalability to multiple computation chains on same resources

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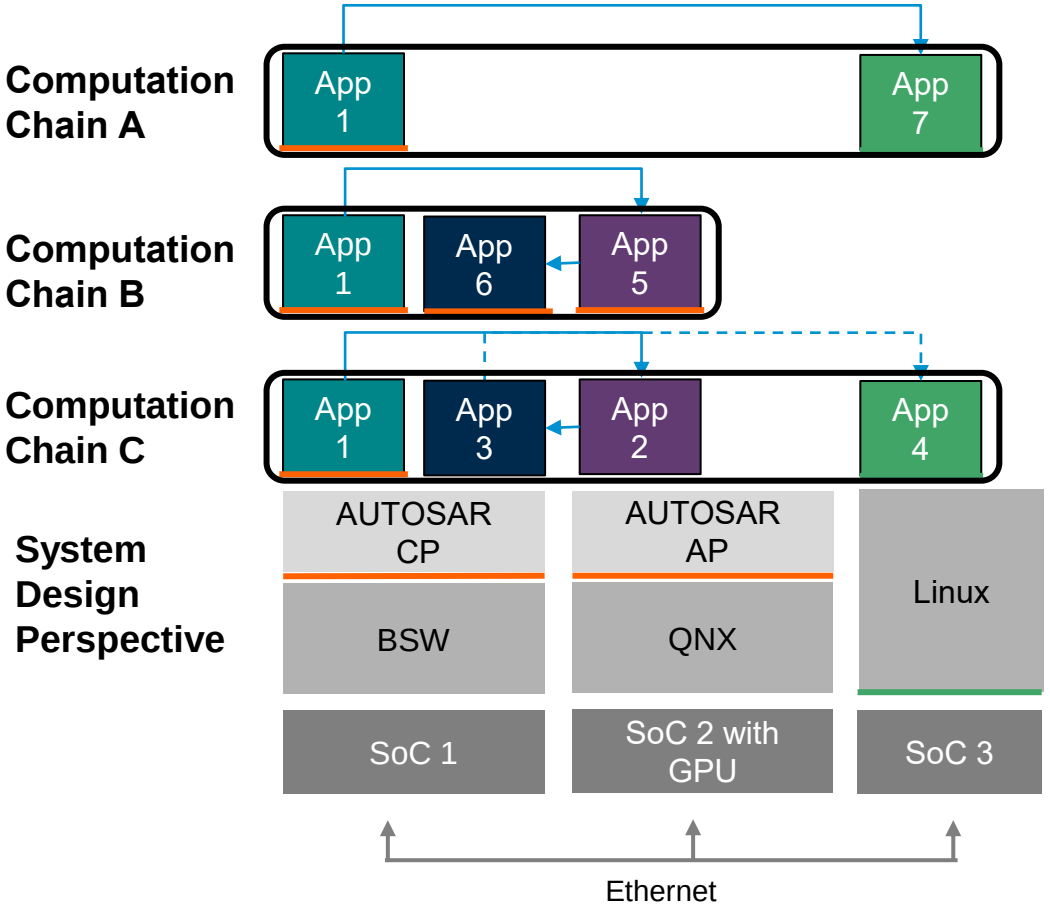


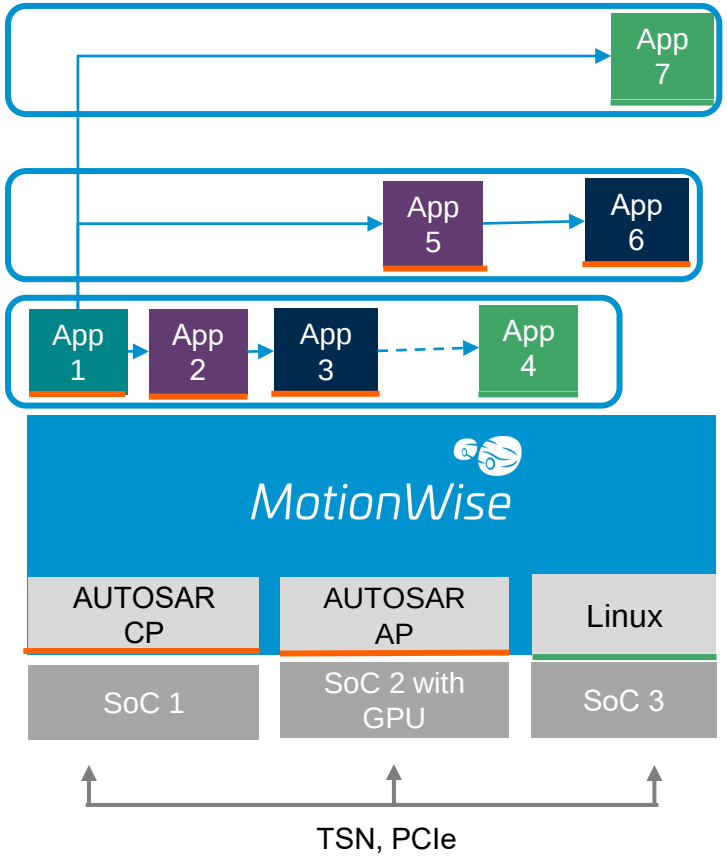


✔ L3 OS Supports planning of chains

✔ Broad ecosystem support

✔ Deterministic COMM guarantees



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# Scheduling Complexity in Numbers

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## Software figures

**100** Applications

**400** Tasks

## Computation unit figures

**46** CPU Cores

**6** HW Accelerators

**2** Ethernet switches

**1024** Time sensitive links

**2048** “Network tasks”

## System Constraints

**100+** Time, precedence constraints etc.

## Solution space

**Theoretical** vs **Valid** configurations

$10^{5000}$

$10^{5}$

Atoms in the universe

$10^{80}$

How do we efficiently search this enormous solution space to find only valid configurations?


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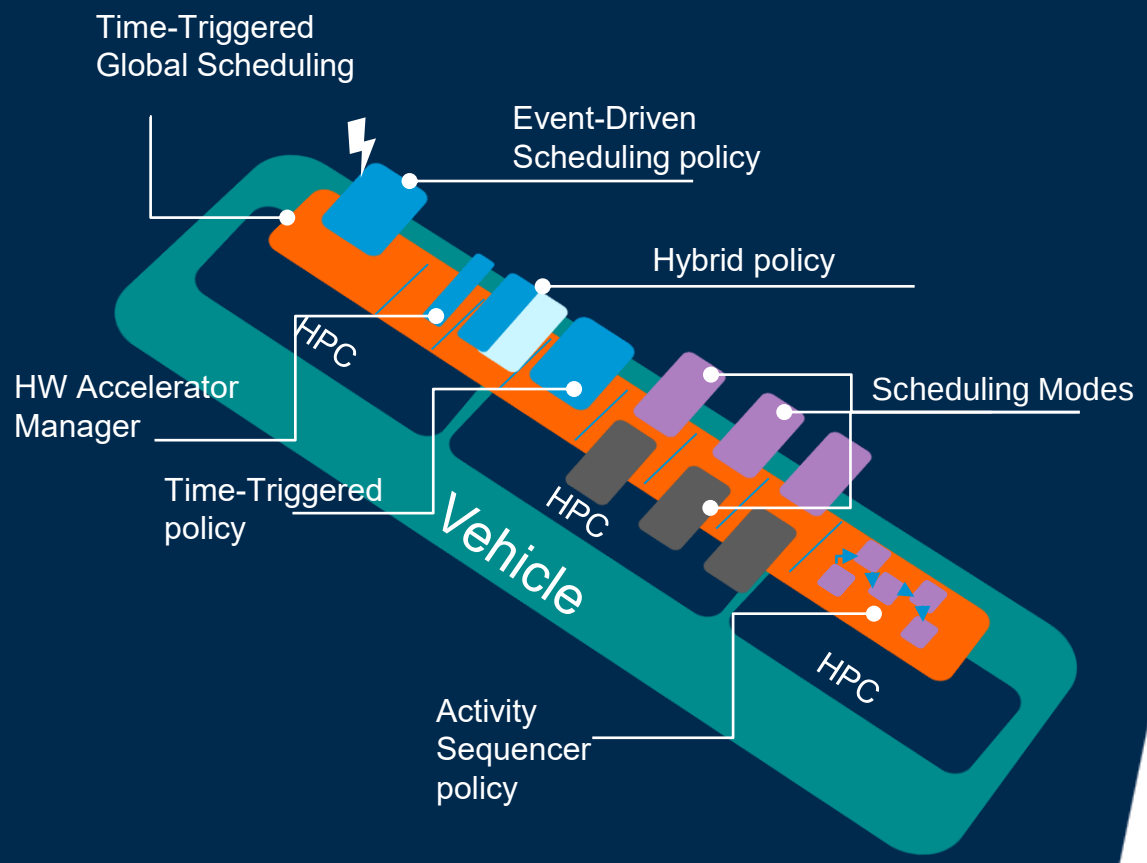
# Global Scheduling

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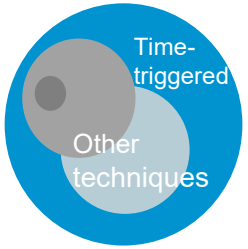
## Feature Overview




1. TTTech scheduling algorithms approach the solution space smartly
2. Workload Planning tool suite enables workload planning and allocation (APPs and Communication) with the given system constraints
3. Time-sync and system-wide end-to-end properties
4. Auto-generation of third-party SW stacks such: RTOS, POSIX OSs, networking devices
5. Scheduling policies provide flexibility for application developers (e.g. “Activity Sequencer”)
6. Fulfilling System Integrator and Software Developers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# Generating Vehicle wide Schedule configurations

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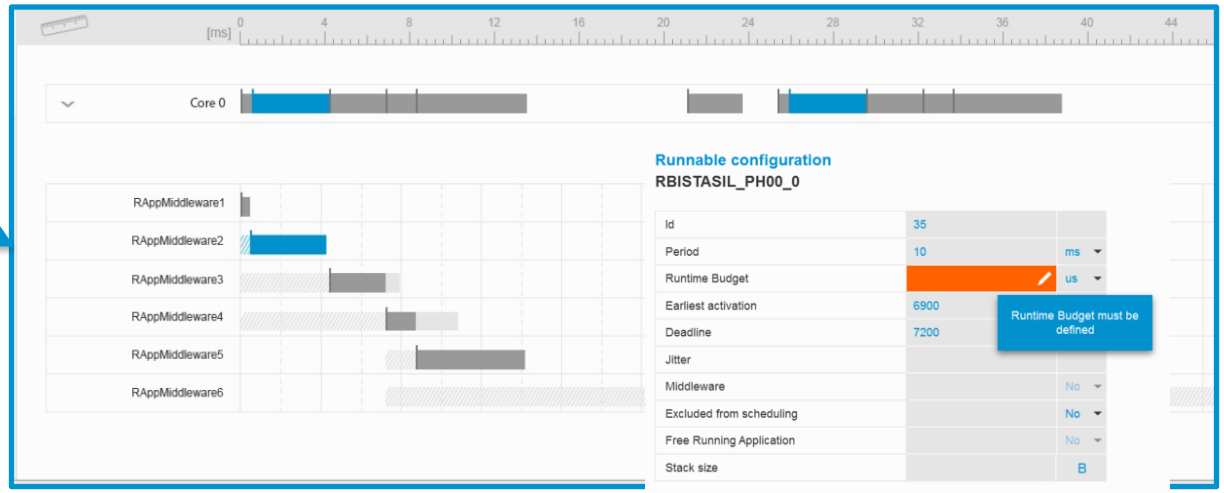
**System Definition** 1

.arxml
.arxml
…
.arxml

- Number of Tasks
- Periods
- Host Affinity
- Resources

**Scheduling Suite Configuration** 2

- *Computation Chains*
- *Timing Budgets*
- *Jitter*
- *Category (Time/Event/Data Driven)*
- *Free Running App*




3

**Task Mapping & Comp. Chain Scheduling Tool**

4

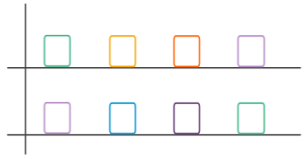
**Network Scheduling Tool**

Scheduling Core Configuration } - AUTOSAR - RTOS - Linux

Network Schedule Configuration

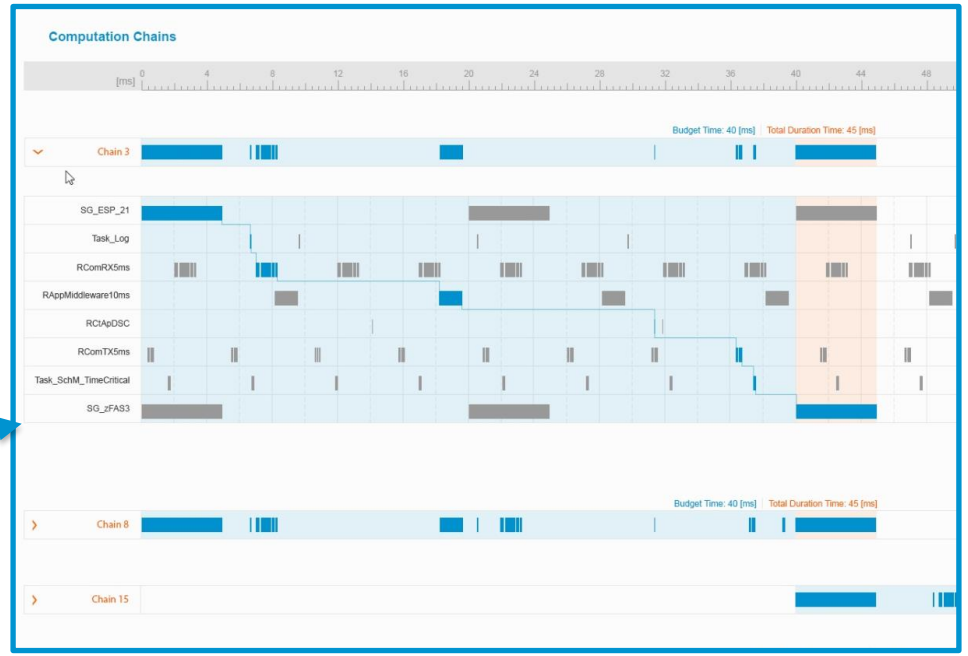
5

**Task Schedule Visualization**



ECUs

Network Switch



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# Communication Middleware

# Communication Middleware Overview

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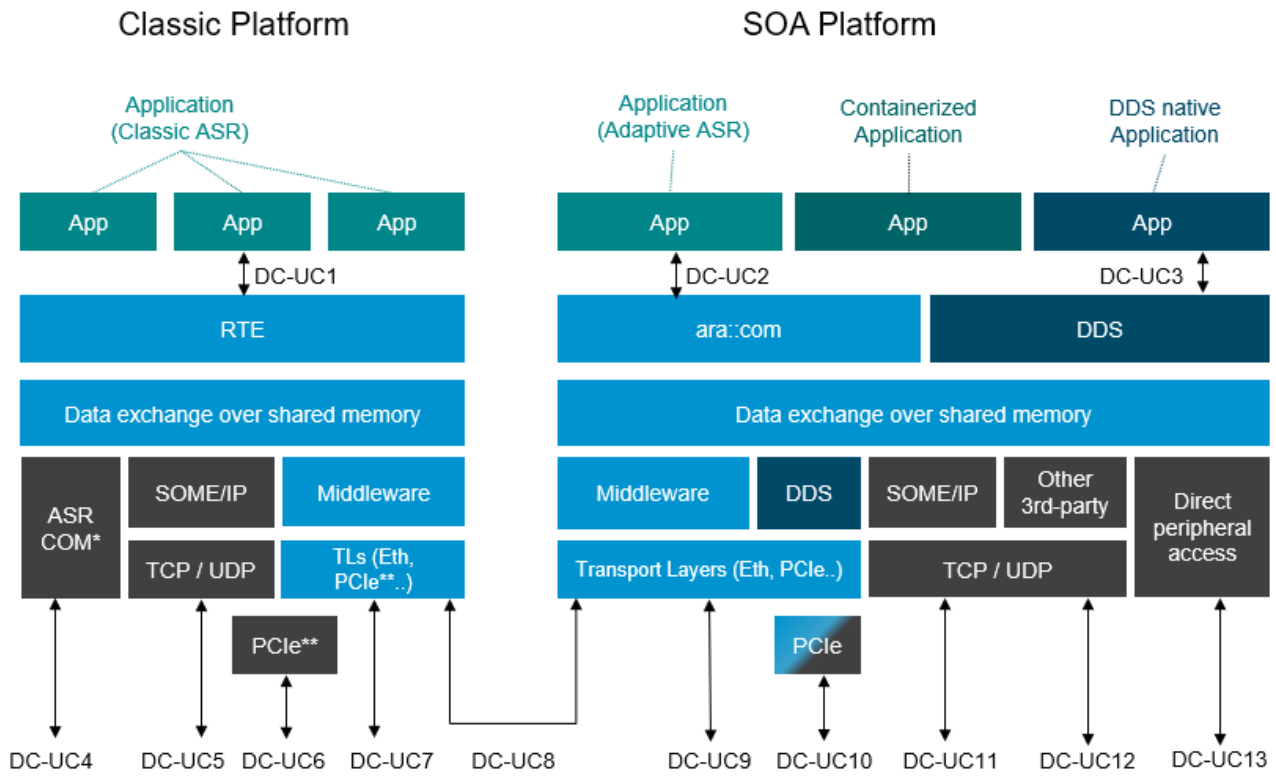


MotionWise Components

3rd-Party – Harden w/ MotionWise

## Feature overview

1. Communication API based on Adaptive AUTOSAR specification and DDS abstracting underneath mechanism
2. Zero-copy ASIL-D IPC mechanism (data exchange) on shared memory.
   - Shared memory communication between Classic and SOA.
3. MotionWise Communication based on DDS
4. Harden SOME/IP stack for communication with non-MotionWise entities
5. TSN and PCIe TL
6. Connecting other protocols and peripherals via shared memory API


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# MotionWise Communication Middleware

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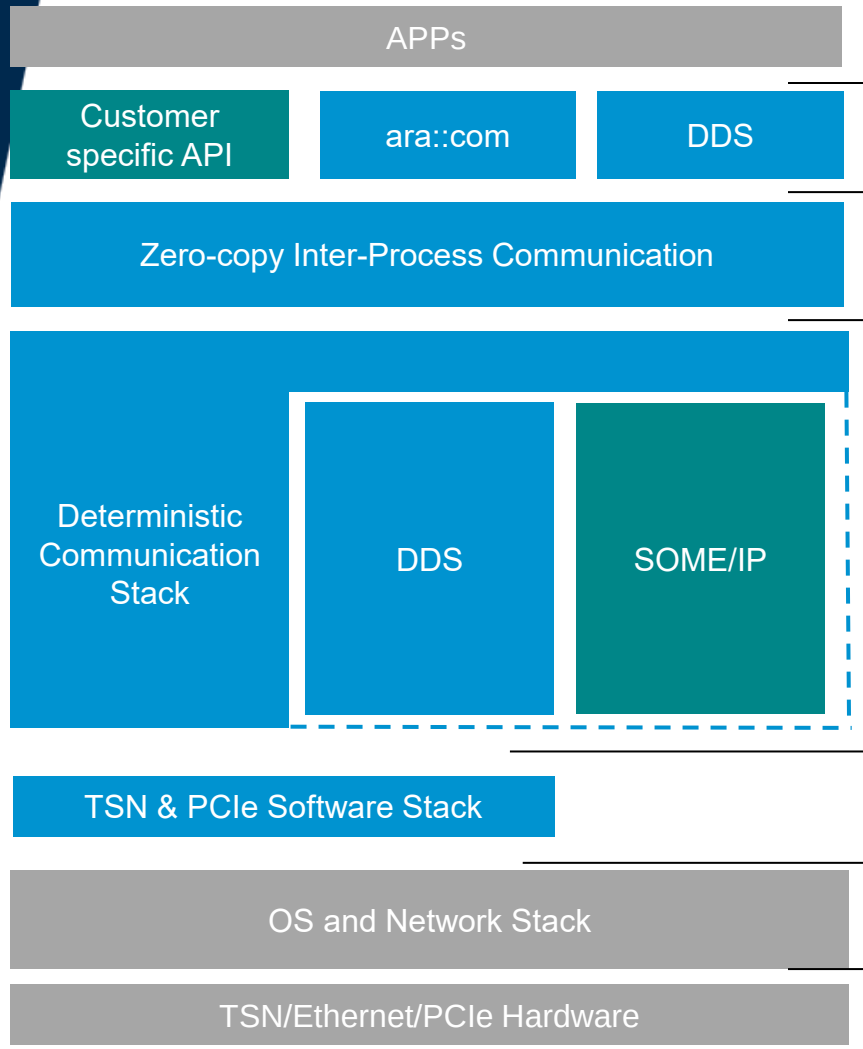


Solutions:

- Build upon standardized ara::com and DDS APIs
- Zero-copy Inter-Process Communication (ASIL-D) for optimal performance
- Hardened Communication stack (ASIL-D) ensures behavioral guarantees across communication paradigms (incl. Integration of 3rd party SOME/IP stacks)
- DDS stack (ASIL-D) for safe and flexible communication, leveraging TSN QoS mechanisms
- TSN & PCIe TL to abstract underlying hardware, configurable via Toolsuite
- Hardening of Operating System, e.g., network stack bypass via XDP

MotionWise

Exchangable Stack

## Key Challenges we see

**Avoiding Vendor lock-in**

**Mixed-Criticality Communication**

**Flexible deployment with end-to-end guarantees**

**Stack hardening for safety and performance**

# MotionWise
# Communication Middleware

## What‘s in the box?

### Communication Management

- CAN & Ethernet Communication
- Time Triggered Ethernet Comm.
- Time Sensitive Networking Comm.
- Inter-Process Comm.
- Service Oriented Communication – SOME/IP
- PCIe Communication
- Data Distribution Service (DDS) Communication

### Communication Planning

- Time Triggered Communication Planning
- Time Sensitive Networking (TSN) Communication Planning

MotionWise SOA only

## Key Benefits

- Enables mixed criticality and ensures reliable communication in vehicle and to cloud
- Seamless abstraction of data source and routing for development of safety-critical applications and non-safety-critical applications
- Supports various communication paradigms (service-oriented, signal-based, time-triggered) for safety-critical and non-safety-critical applications

# MotionWise can use complete In-Vehicle Network with TSN

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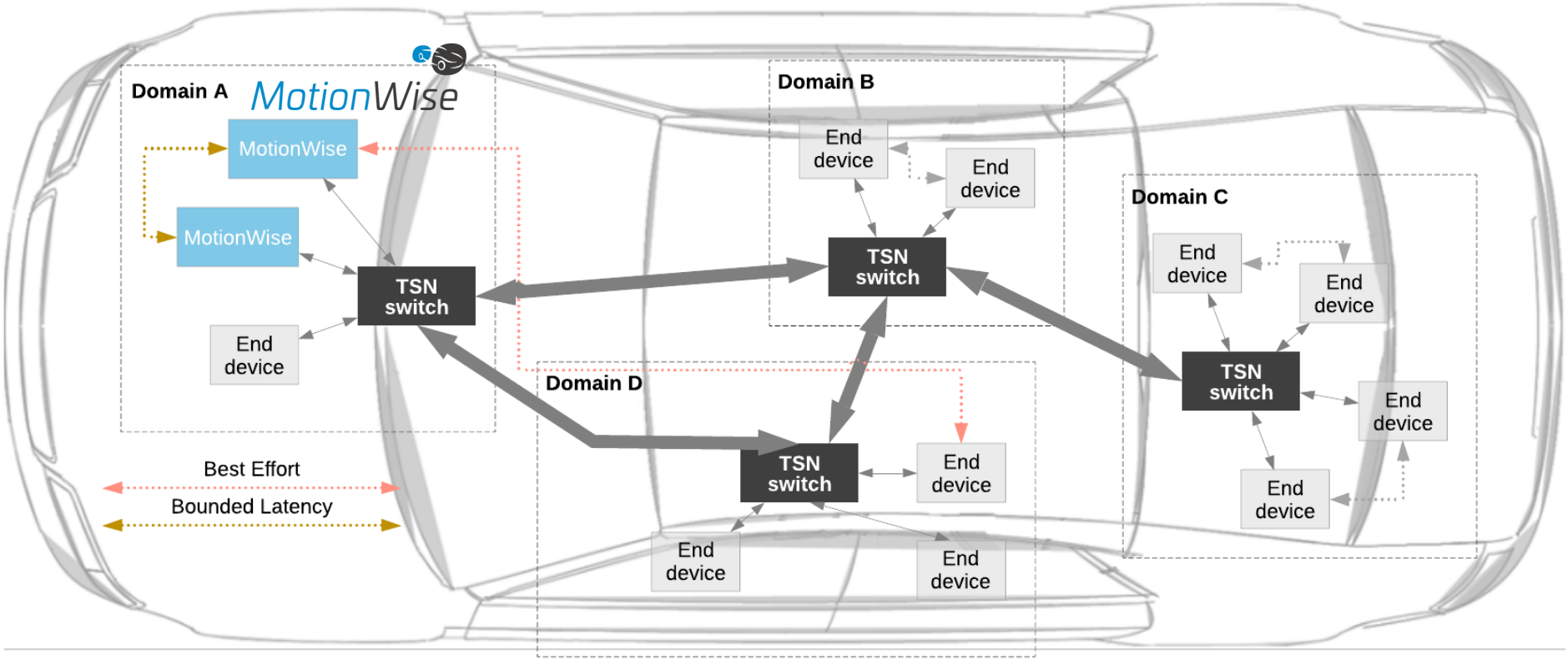
**Switches Observed**
Realtek RTL9072
TDA4 CPSW 9G/2G**
NXP SJ1105/1110

** TSN Switch on the SoC

## E.g.: TSN backbone between different vehicle domains.



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# TSN Mechanisms Supported in MotionWise

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## IEEE 802.1 AS-REV
## Timing and Synchronization for Time-Sensitive Applications

### What is it?

- Time synchronization protocol of TSN Standards and the most recent revision
- Profile of the IEEE 1588 (gPTP) standard
- Defines two active clock-masters for redundancy
- Enables recognition of multiple time domains in each node

### User Need Addressed

- Provides a network-wide notion of time
- Eliminates single point of failure for synchronization enabling high-availability TSN networks

### TTTech Auto View

- Time Sync is a key part of TSN in MotionWise
- Used for timestamping of events, traffic shaping, filtering, etc
- Essential to enable the benefits of TT Architecture

## IEEE 802.1 Qbv
## Enhancements for Scheduled Traffic

### What is it?

- Defines up to 8 queues per port for forwarding traffic at scheduled points in time
- Frames are assigned to queues by QoS priority
- Time-aware shaper mechanism blocks transmission of other queues during scheduled time windows to ensure traffic cannot be delayed in the network

### User Need Addressed

- Guarantee path for time-critical traffic over Ethernet
- Enables convergence of dedicated controls networks with wider infrastructure

### TTTech Auto View

- Scheduled Traffic is a key part of TSN in MotionWise
- Creates deterministic traffic patterns with very low latencies
- Essential to enable the benefits of TT Architecture



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# IEEE 802.1Qbv: Scheduled Traffic

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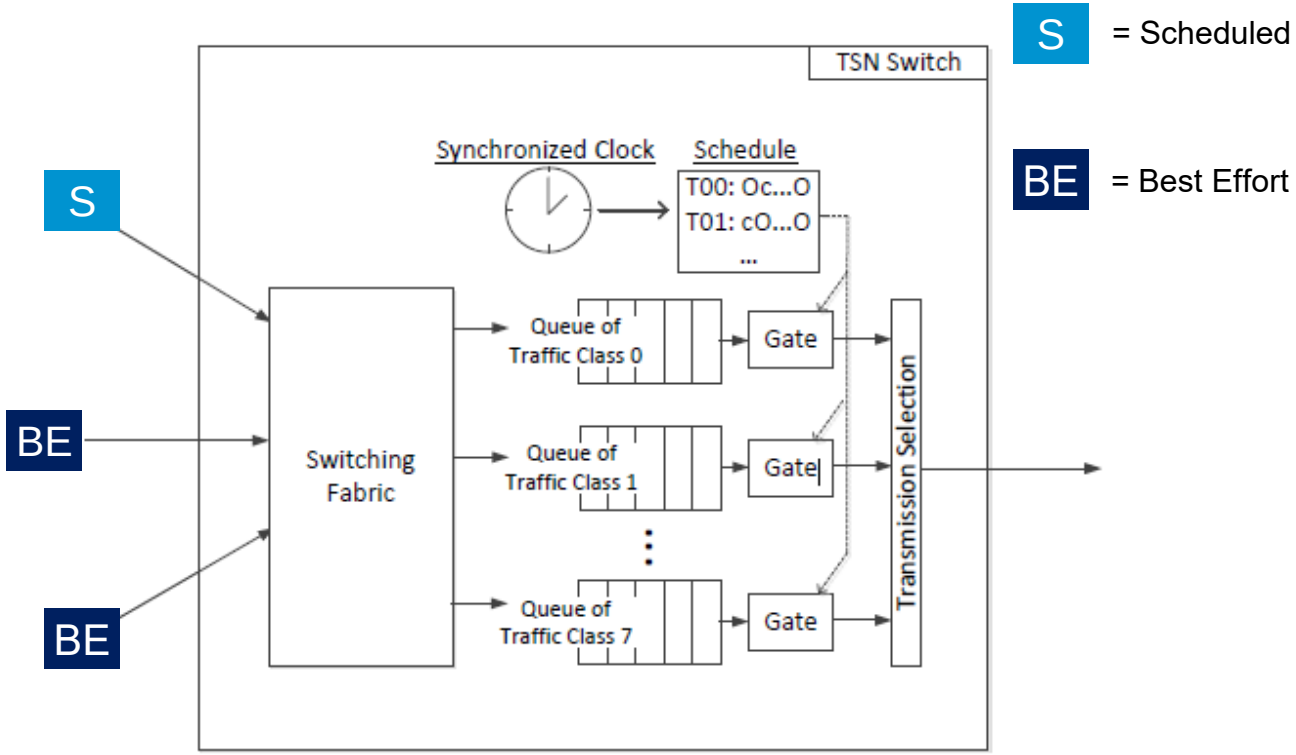
**Gate control list (GCL)**

- A schedule determines which traffic queue will be forwarded from the switch at any given point in time.
- Qbv specifies the so called “gate open” and “gate close” events for each queue.



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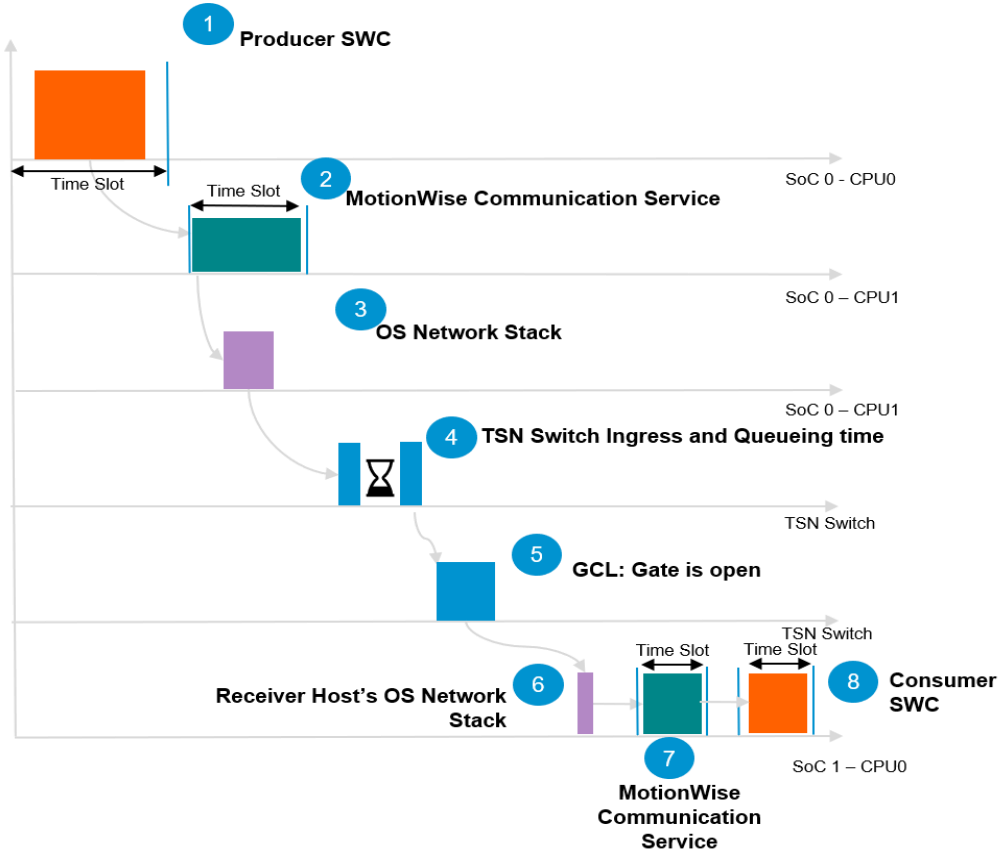
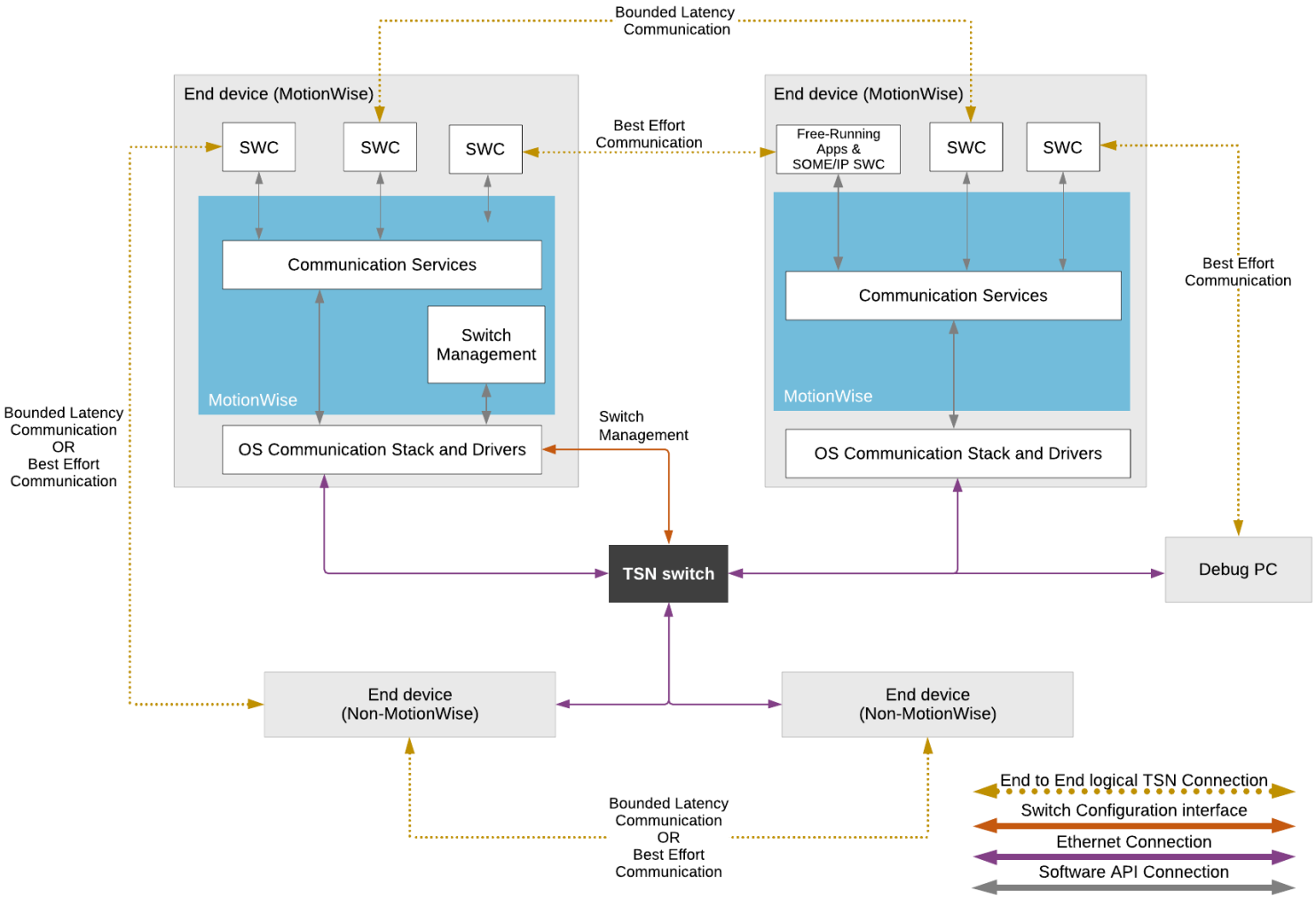
# MotionWise enables Deterministic Communication between Applications using TSN

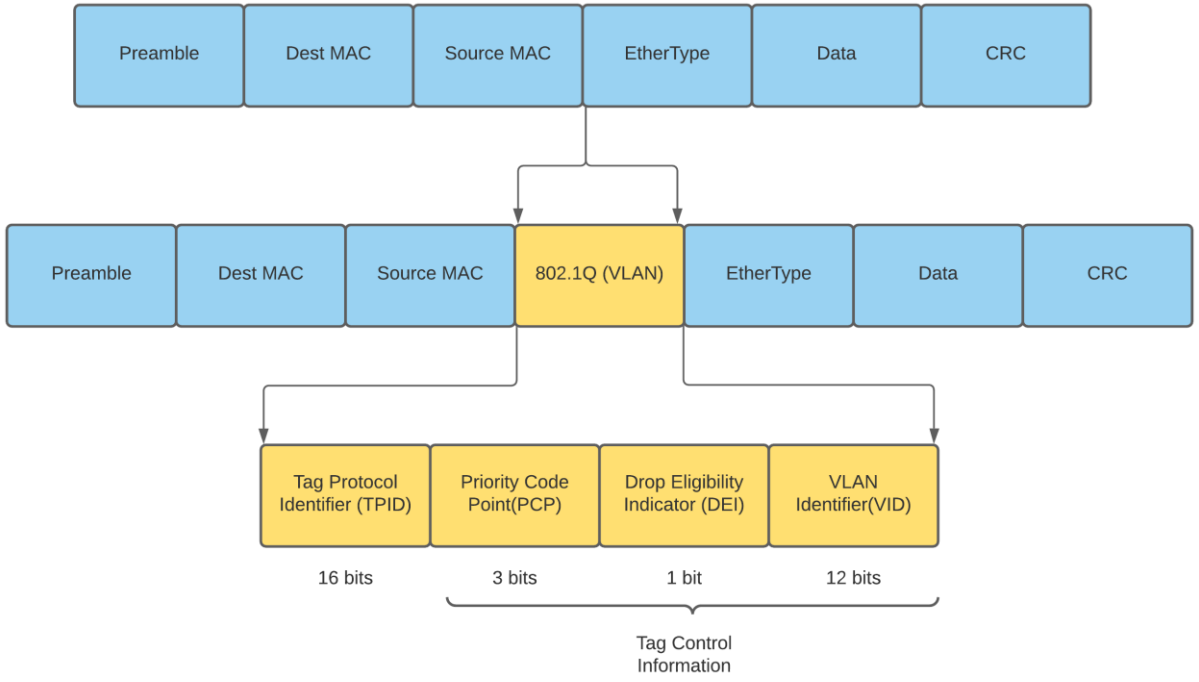



***MotionWise Global Scheduling Combines Task Scheduling with Network Scheduling to enable end to end guarantees***

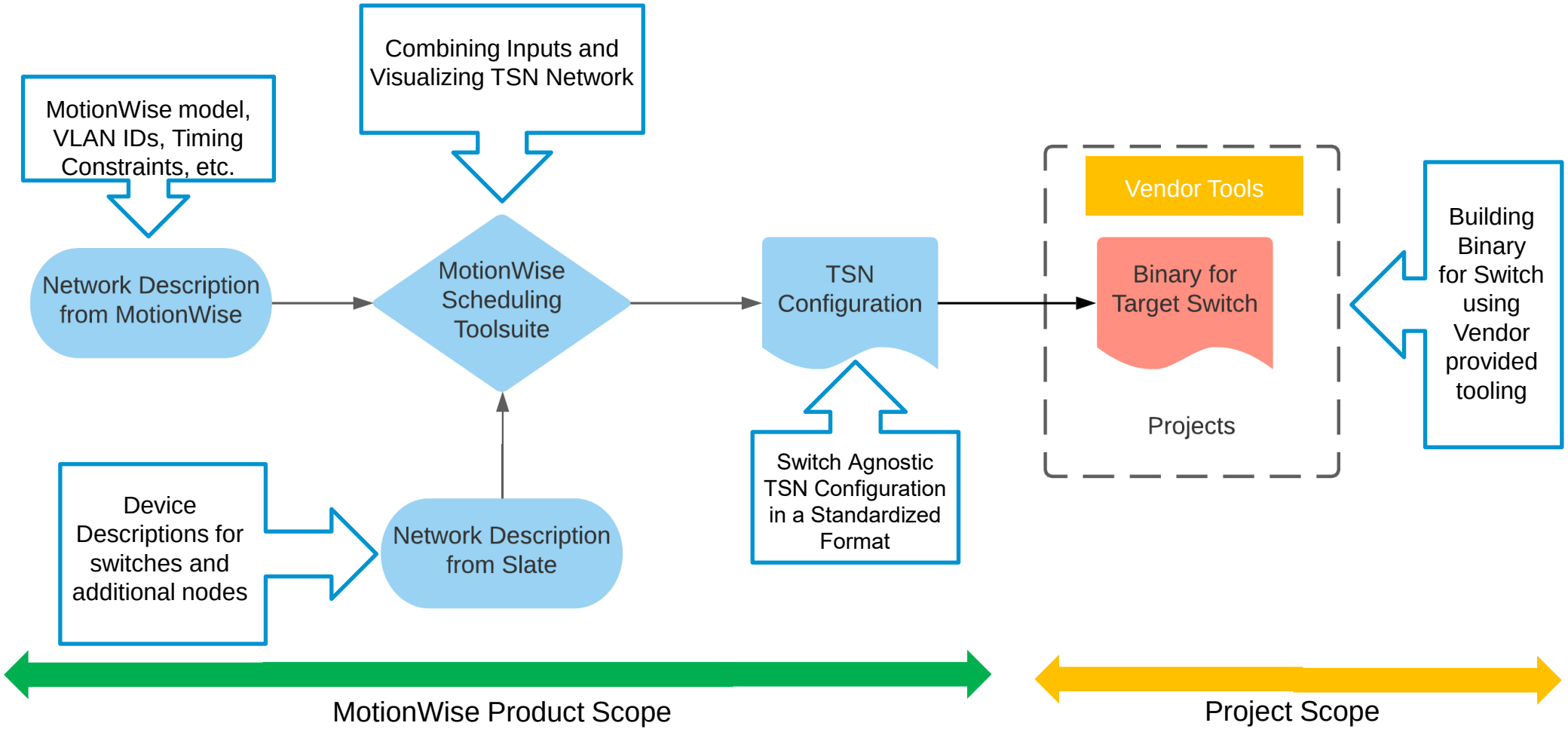
# In-Vehicle Stack for TSN

- MotionWise provides a TSN Transport Layer within the Communication Middleware as part of In-vehicle Stack
- Transport Layer is responsible for tagging each frame with right information required for TSN
- VLAN ID is enabled using the system model
- Priority for each frame is tagged during runtime using a Lookup table
  - Lookup table is generated with help of MotionWise Scheduling ToolSuite



# Development Tooling for TSN

TTTechAuto



# Generating Vehicle wide Schedule configurations

TTTechAuto

**System Definition**

.arxml
.arxml
…
.arxml

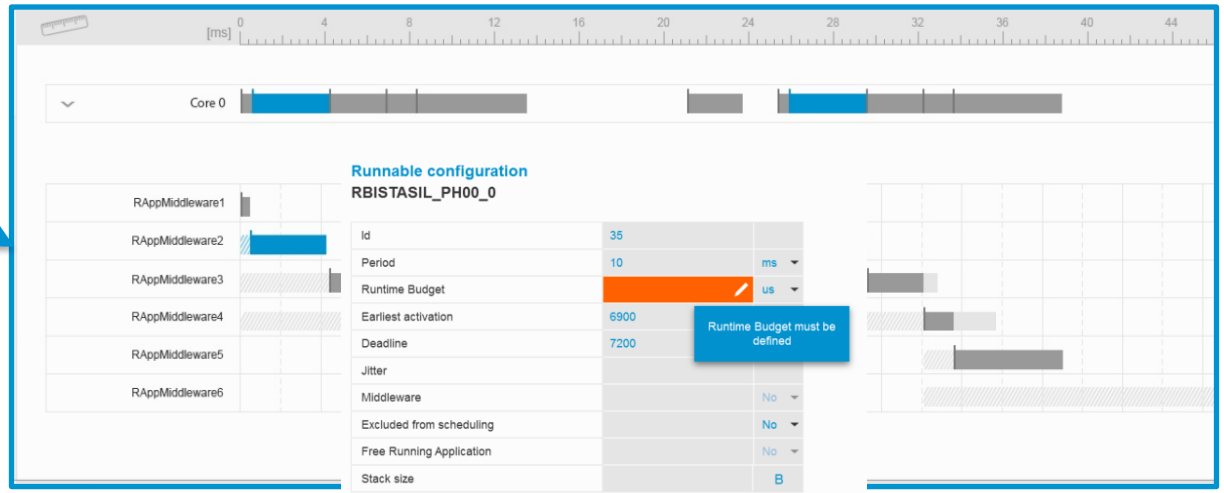
- Number of Tasks
- Periods
- Host Affinity
- Resources

1

**Scheduling Suite Configuration**

2

- *Computation Chains*
- *Timing Budgets*
- *Jitter*
- *Category (Time/Event/Data Driven)*
- *Free Running App*




3

**Task Mapping & Comp. Chain Scheduling Tool**

4

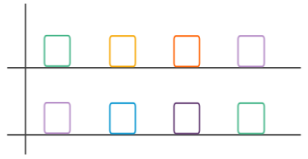
**Network Scheduling Tool**

Scheduling Core Configuration
- AUTOSAR
- RTOS
- Linux

Network Schedule Configuration

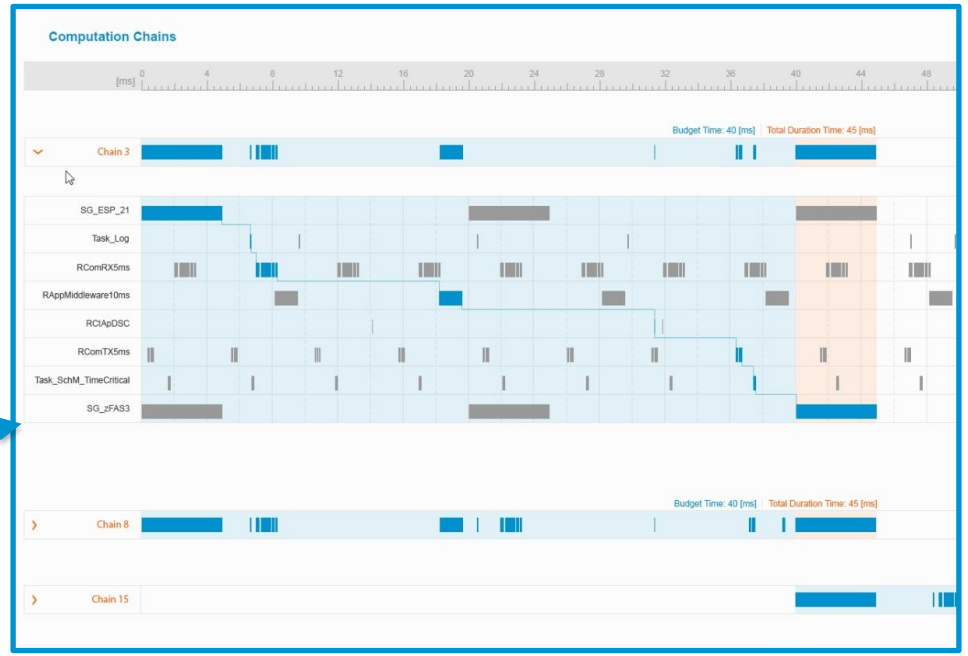
5

**Task Schedule Visualization**



Network Switch

ECUs



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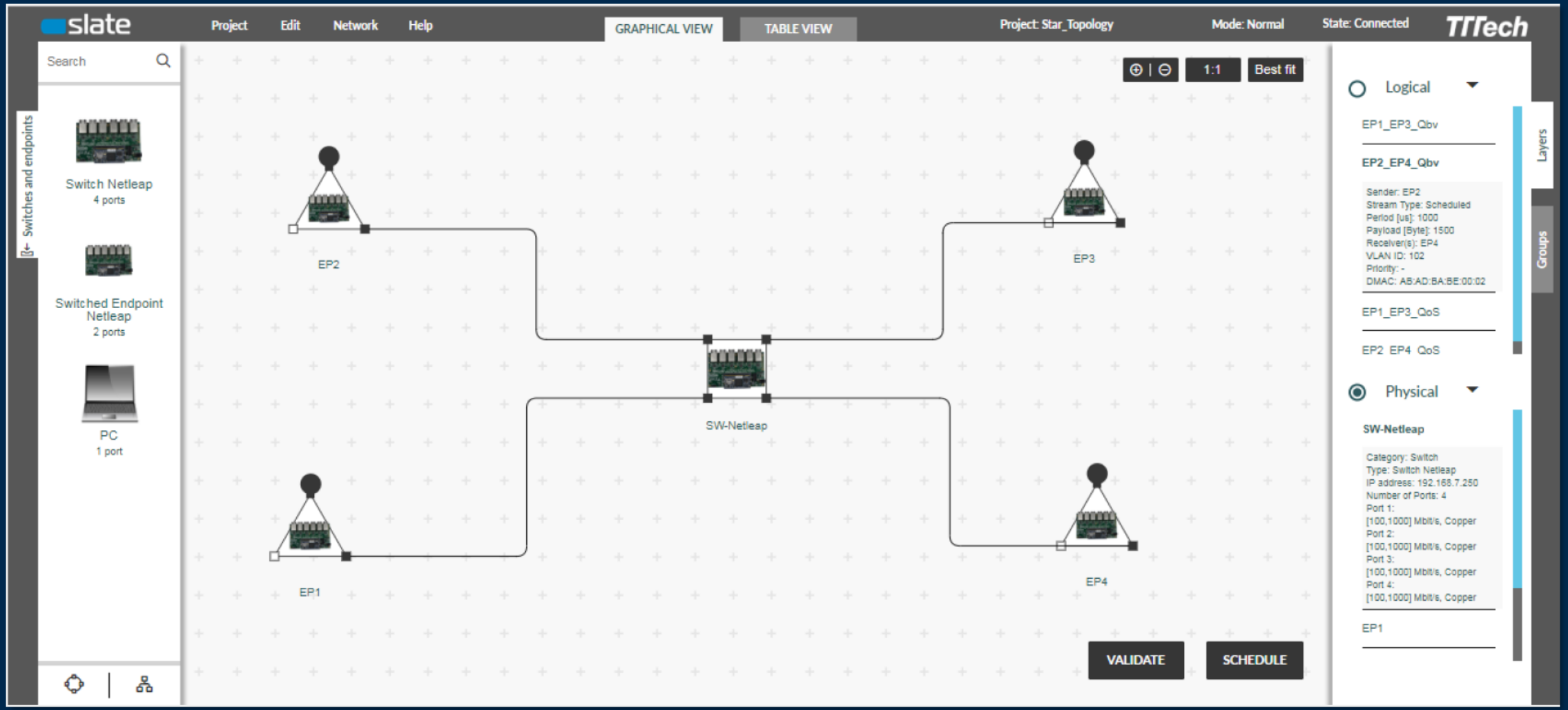
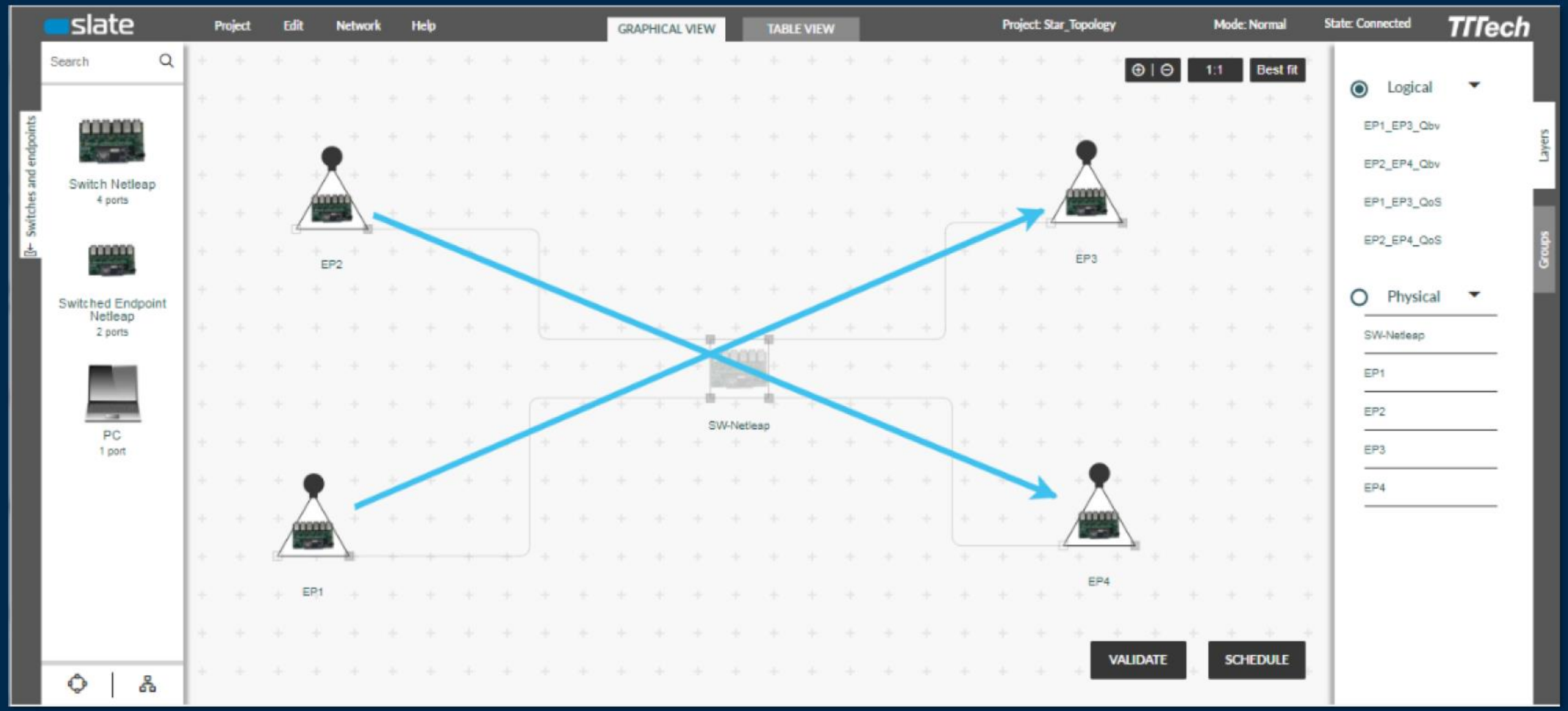
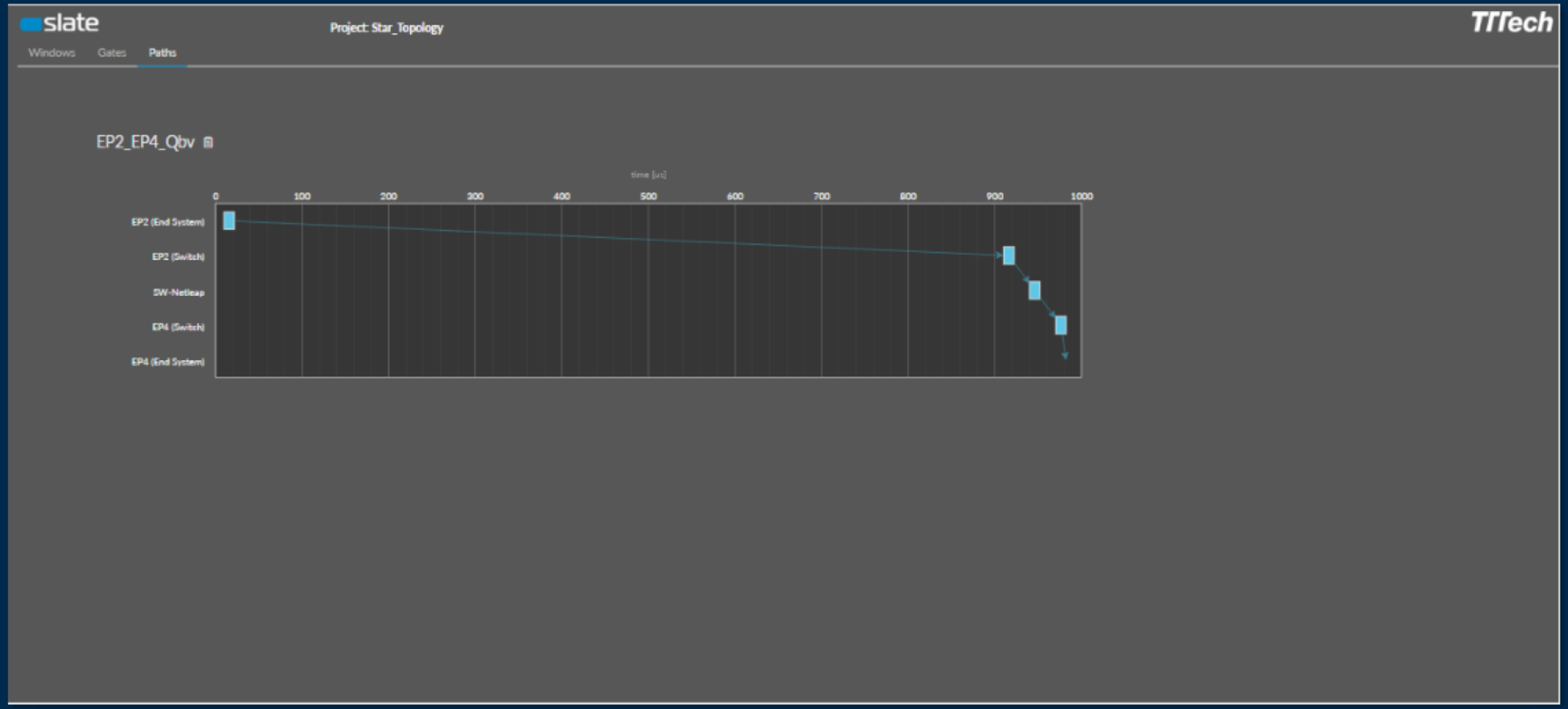
# Physical Topology View



# Physical Topology View



# Scheduled Path Visualization



# A unified, abstracted, **safe** & **secure** communication backbone for new E/E architectures

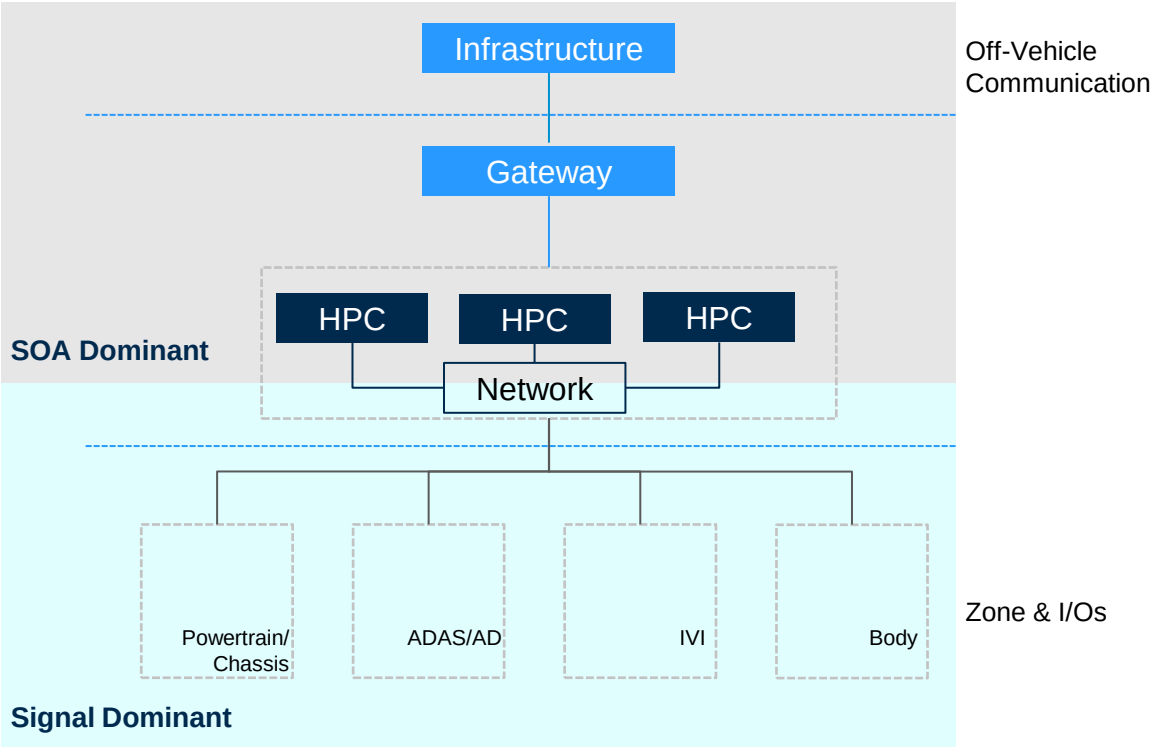
Service Oriented Architectures (SOA) enabling flexibility and platform abstraction to SW development teams, while keeping the system integrable

Communication fully abstracted by standardized APIs: Adaptive AUTOSAR & DDS and configuration generated by tooling support

Service oriented communication with Quality of Service (QoS) at vehicle level exploiting Time Sensitive Networking (TSN) capabilities

Compatible with other standards (e.g, SOME/IP) and network bindings: Ethernet, TSN, PCIe

Standard compliance: DDS OMG Object Management Group. AUTOSAR ROS




Note: Simplified architectural view

# ZettaScale Technologies spins out from ADLINK and raises strategic investment from TTTech Auto

NEWS PROVIDED BY
**ZettaScale →**
May 31, 2022, 10:00 ET

SHARE THIS ARTICLE

*ZettaScale and TTTech Auto will collaborate to develop a safety-certified platform to accelerate the development of software-defined vehicles*

**Summary**

- Zettascale is securing a strategic investment and partnership from TTTech Auto to grow its product offerings tailored to the automotive market.
- The fruit of the partnership will be the joint product Motionwise Cyclone DDS, a safety-certified software platform that ensures safe and quality-guaranteed real-time communication in vehicles.
- Zettascale's expansion to automotive software complements its product portfolio covering mission critical, vehicle-to-everything (V2X) and robotics middleware.

Source: https://www.prnewswire.com/news-releases/zettascale-technologies-spins-out-from-adlink-and-raises-strategic-investment-from-tttech-auto-301557457.html

TTTech Auto

zetta scale

MotionWise

Cyclone DDS

MotionWise
Cyclone DDS

# Product Offering Overview

MotionWise Cyclone DDS ***Pro Edition***

OMG DDS conformant specification

Focus in performance

Tool Suite

TSN extensions

Compatible with MotionWise

Compatible with standardized frameworks: ROS2 and Adaptive AUTOSAR

MotionWise Cyclone DDS ***Certified Edition***

Automotive profile subset

Safety, Security, Real Time and performance focus

Tool Suite

TSN extensions

Compatible with MotionWise

Compatible with Adaptive AUTOSAR frameworks

ISO26262 ASIL-D Certification

MotionWise

MotionWise Cyclone DDS integration within MotionWise

Abstraction with Adaptive AUTOSAR communication API (ara::com)

Extended with Global Scheduling capabilities



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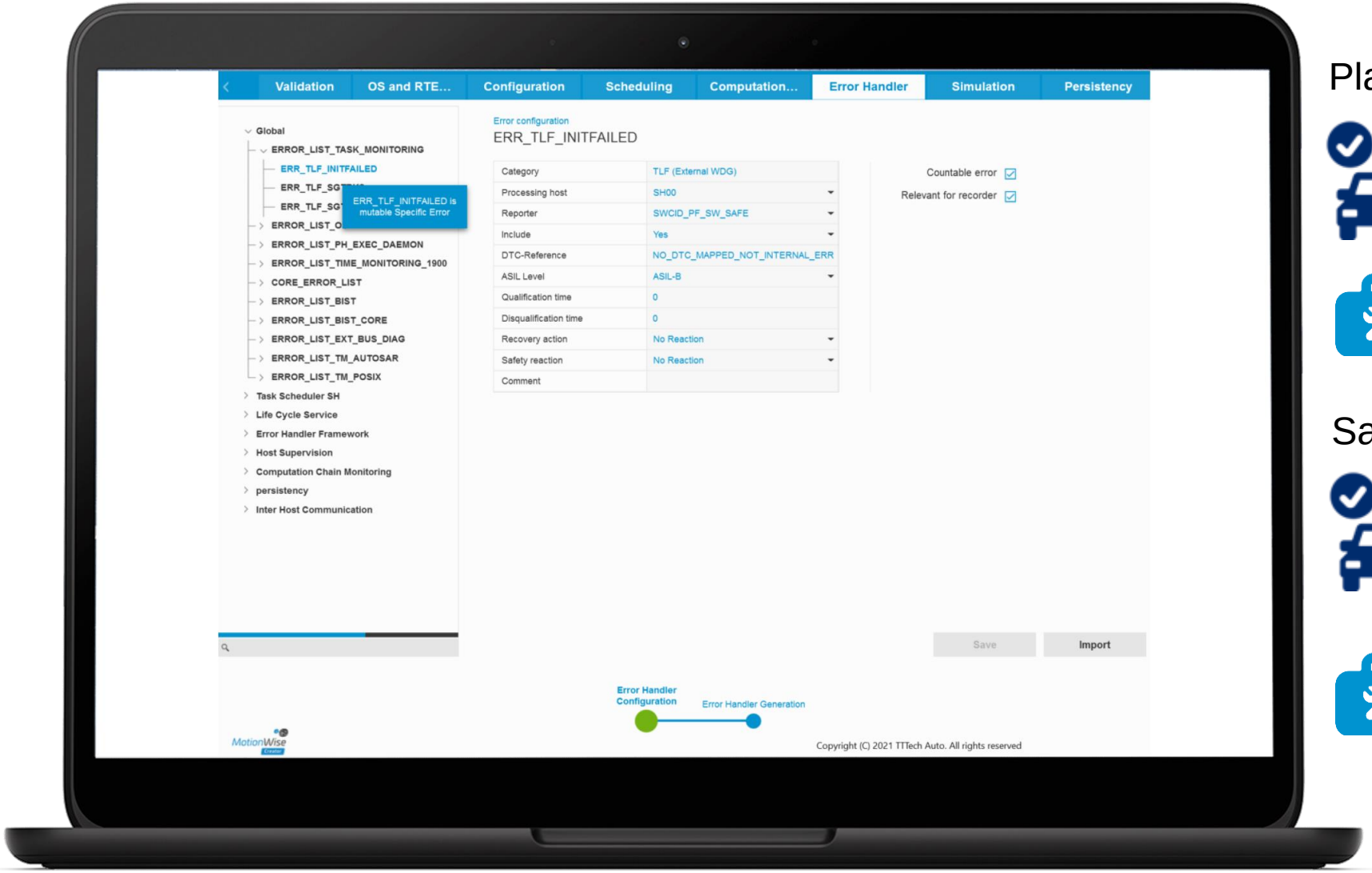
TTTechAuto

# Platform Health Management & Safety Supervision

# A clear path to end-to-end system behaviour ready to configure & deploy in your system

TTTechAuto




## Platform Health Management

- Supports fail-operational execution modes
- Provides a global health status of the entire system and recovery mechanisms

## Safety Supervision

- Ensuring freedom from interference for all computational resources and applications
- Seamless integration of safety mechanisms



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# MotionWise Safety Supervision & Platform Health Management bring safety & robustness during operation

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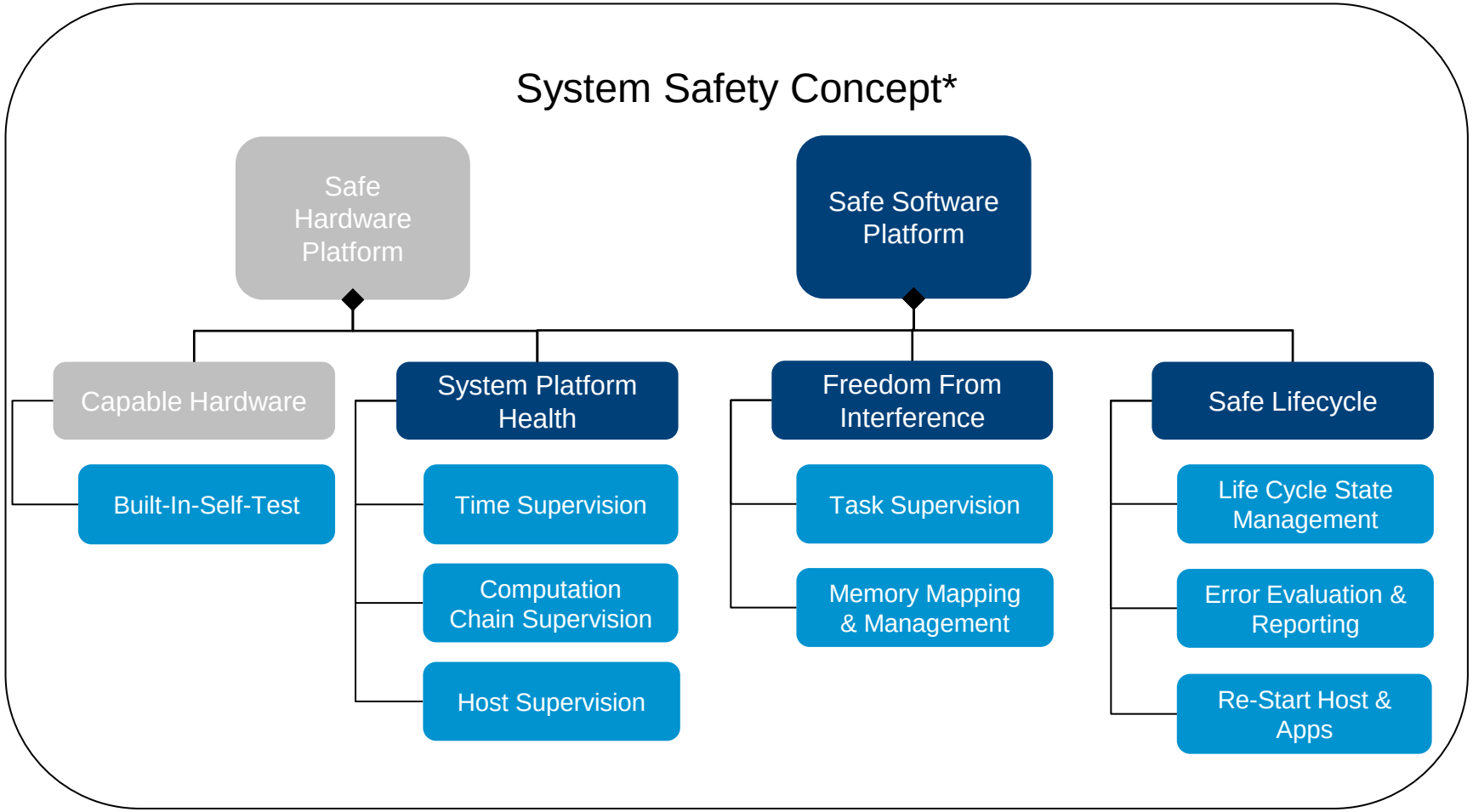
- Provides temporal & spatial Freedom from interference
- Ensures safe communication (prerequisite: safe execution) or fails silent
- Realized by MotionWise Platform Health Management & Safety Supervision up to ASIL-D
- Configurable to reach required fault tolerant time interval
- Foundation for fail-op extensions (redundancy, diverseness)




*simplified



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# MotionWise

## Platform Health Management and Safety Supervision

## What‘s in the box?

### Platform Health Management

- Error Evaluation & Reporting
- Memory Mapping & Management
- Built-In-Self-Test
- Function Inhibition

### Safety Supervision

- Task Supervision
- Time Supervision
- Host Supervision
- Computation Chain Supervision

MotionWise SOA only

## Key Benefits

### Platform Health Management

- Supports fail-operational execution modes
- Provides a global health status of the entire system and recovery mechanisms

### Safety Supervision

- Ensuring freedom from interference for all computational resources and applications
- Seamless integration of safety mechanisms

# Platform Safety Supervision & Health Management seamlessly integrate with your system

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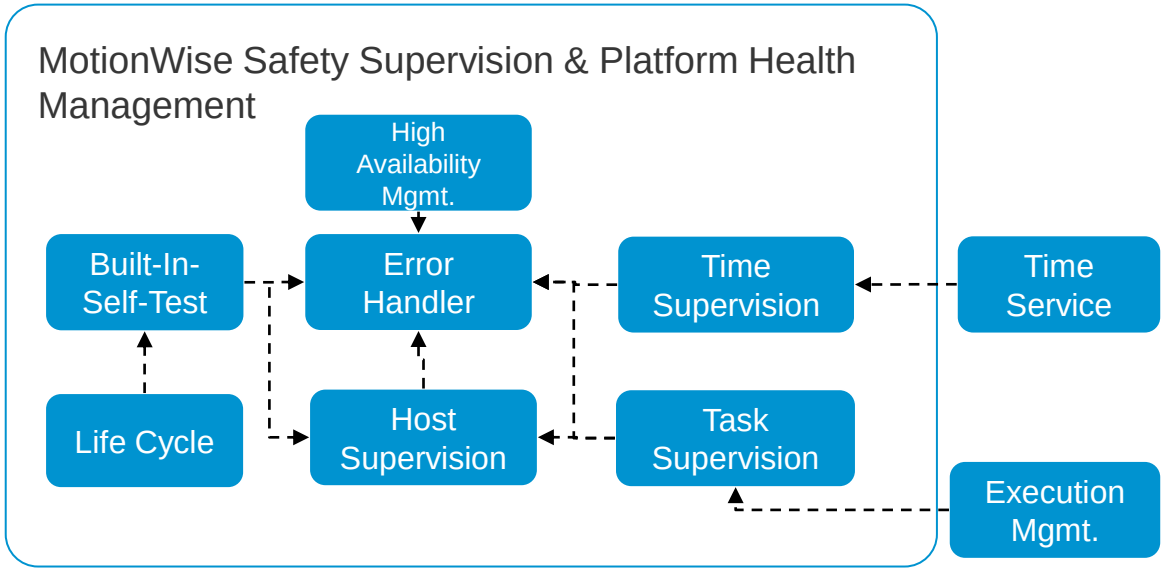


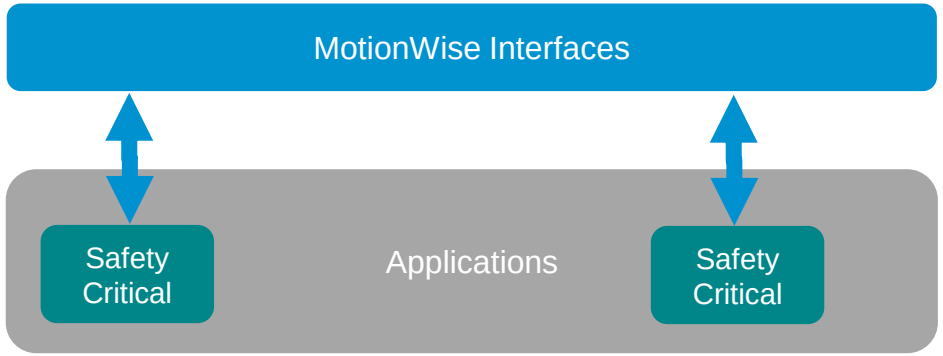


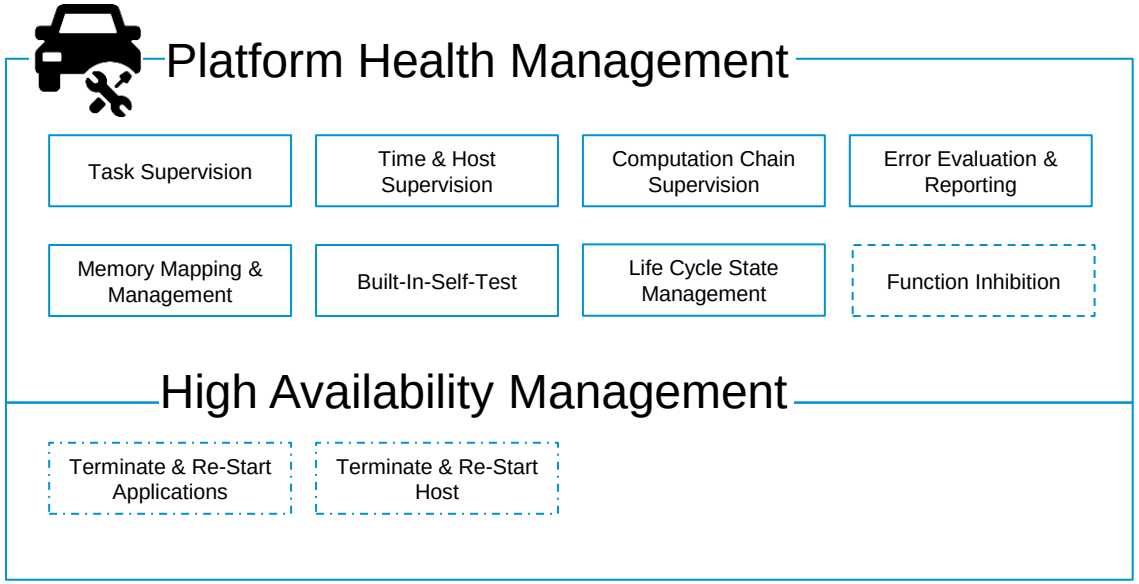


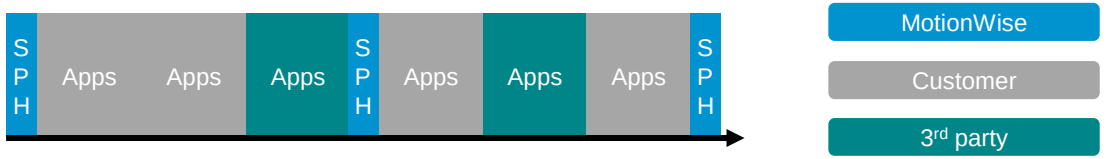


Example: Schedule Table

SPH = Safety Supervision & Platform Health Management

Software provider



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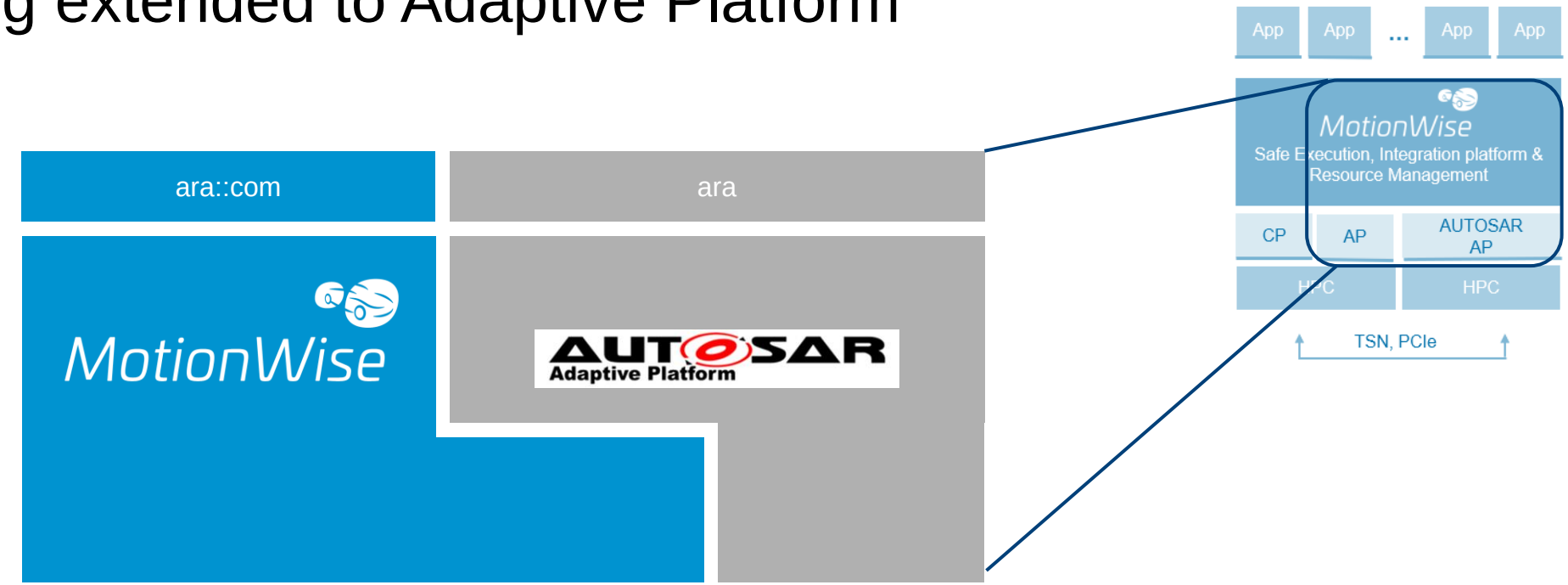
TTTechAuto

# MotionWise with 3rd party stacks including AUTOSAR Adaptive

# MotionWise and AUTOSAR:
# A proven pairing extended to Adaptive Platform




## Benefits

| Following a successful pattern | Beyond the Adaptive standard | Exchangeability |
|---|---|---|
| MotionWise integrated with ASR Classic on MCUs in many series programs | Improve dependability of application interaction<br>Integrate in mutli-SoC system | Integration with arbitrary AP stack on project basis |



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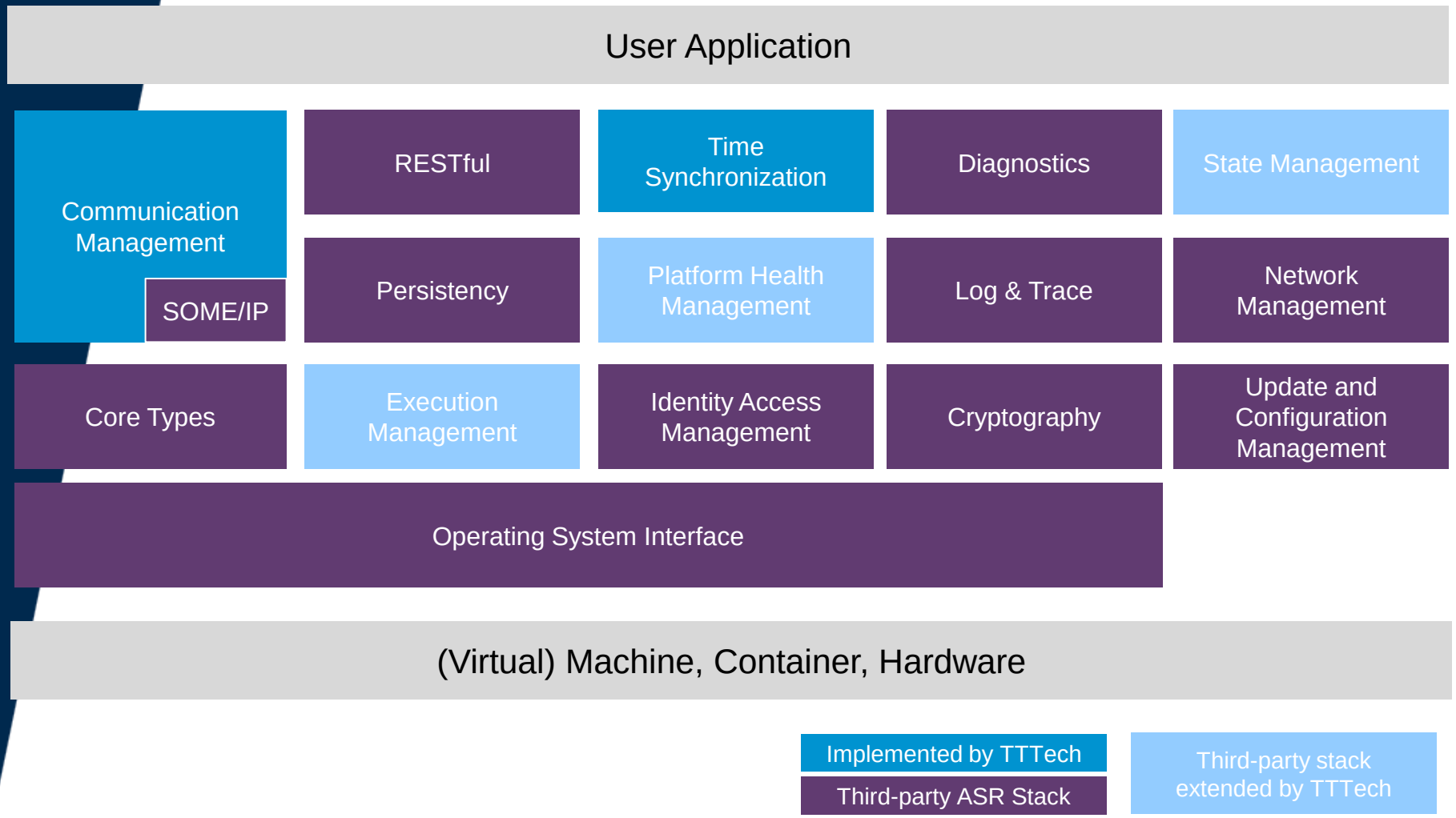
# Autosar Adaptive Functional Clusters

Integration distinguishes per Functional Cluster:

**MotionWise implements** functions that are related to safe and r-t execution: Communication Management (except Some/IP) and Time Synchronization.

**MotionWise extends** related services such as Execution Management, State Management and Platform Health Management

**MotionWise uses** (as is) all other functional clusters of the third-party stack (e.g. Diagnostics)



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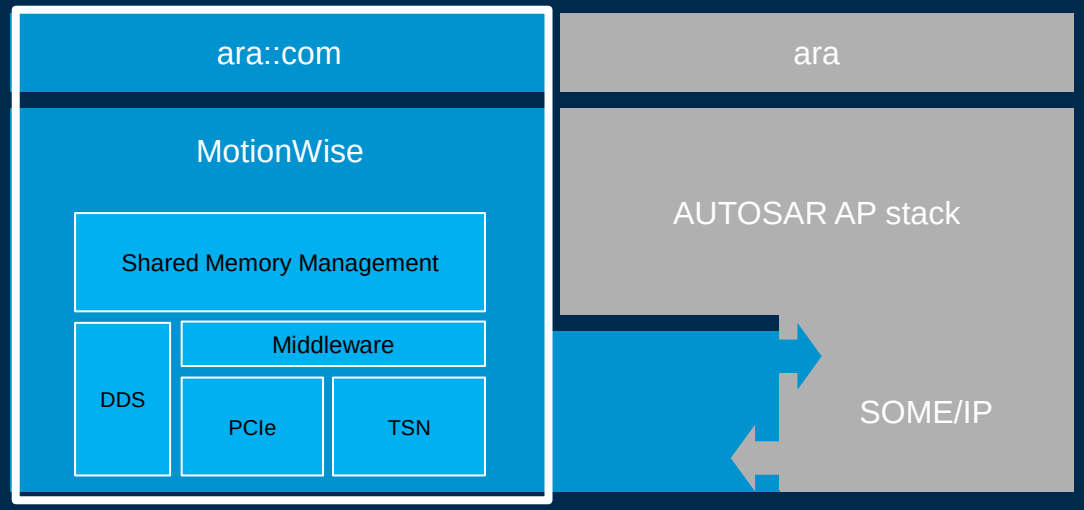
# MotionWise brings Deterministic Communication to Adaptive Applications

ASR standard specifies the communication methods.

But TTTech provides via its own implementation of communication stack..

- Optimized ara::com and IPC implementation through efficient data exchange (e.g. zero-copy shared mem.)
- Automatic generation of deterministic communication via network scheduling (like TSN)
- Service-Oriented Architecture including 3rd party communication stacks e.g., SOME/IP and DDS
- Selectable transport layers via configuration: Ethernet (TSN), PCIe




Deterministic data exchange is essential for safe operation in driving scenarios with increaded system load!



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on this slide

In-Vehicle stack | Dev. Tooling

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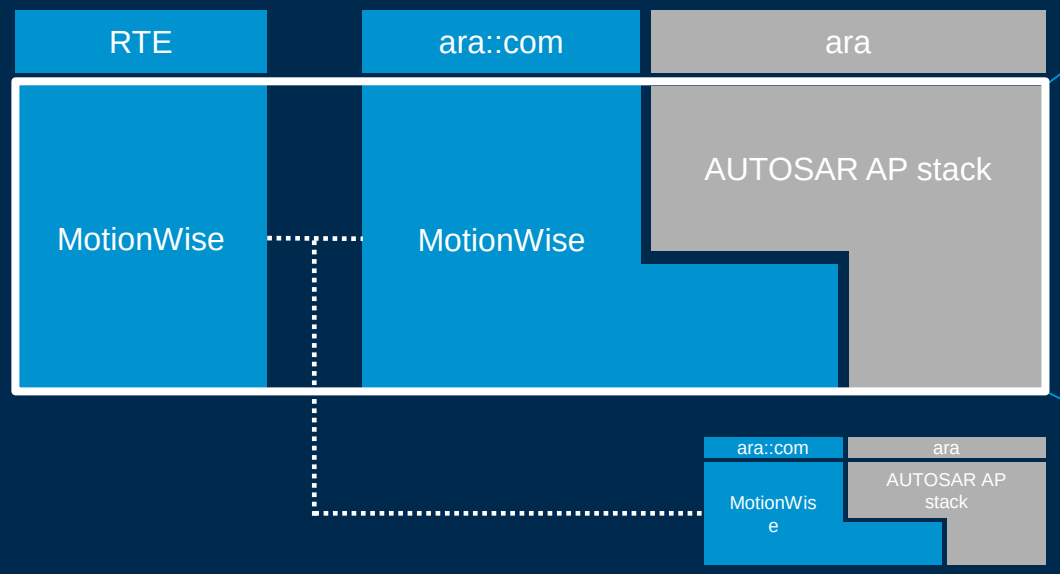
# Embedding Adaptive ASR in a safe multi-SoC environment




| MotionWise Solution Capability | Adaptive Platform Functional Cluster |
| --- | --- |
| Global Scheduling | AP Execution Management |
| Global Time Synchronization | AP Time Synchronization |
| Global Health Management & Safety Supervision | AP Platform Health Management |
| Global State Management | AP State Management |

# Benefits brought by MotionWise Global Solution Capabilities

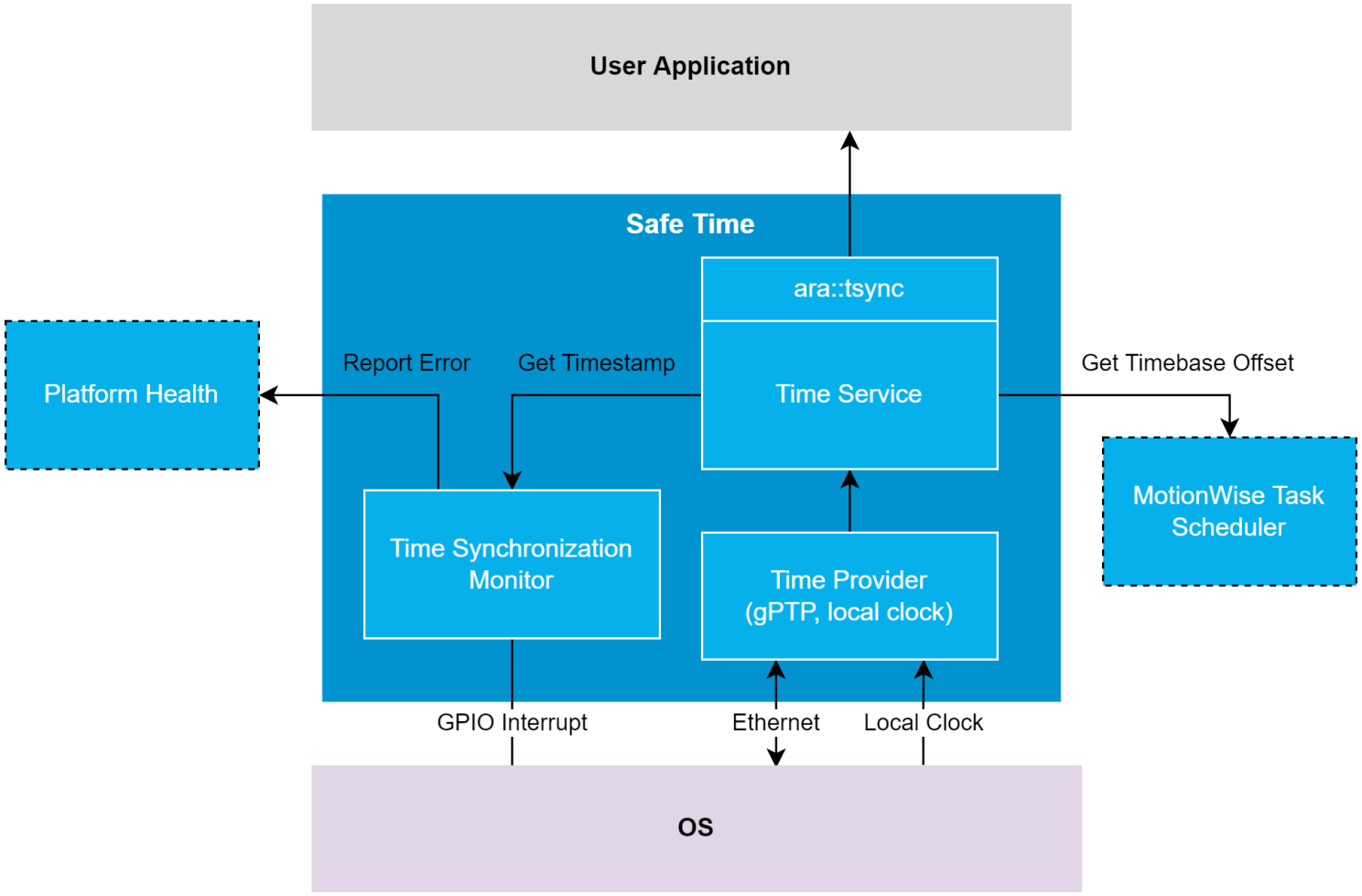
| MotionWise Solution Capability | Adaptive Platform Functional Cluster (FC) | Benefits |
|---|---|---|
| Global Scheduling | Execution Management | • Advanced and broad scheduling policies also for AP<br>• Automated single-step scheduling for multi-SoC & multi-ECU |
| Global Time Synchronization | Time Synchronization | • Synchronized global time bases up to ASIL-D<br>• Enables ASIL-D computation chains among the full system |
| Global Health Management & Safety Supervision | Platform Health Management | • Health Management on multi-SoC / multi-ECU level<br>• MotionWise supervises the 3rd-party adaptive stack |
| Global State Management | State Management | • Synchronized ECU life cycle (startup, runtime, shutdown)<br>• Consistent Operation Modes (e.g., parking, highway mode) |

* Global: spanning across multi-SoC and -ECU

# Time Synchronization

MotionWise SOA Platform provides ara::tsync

- Provide time bases up to ASIL-D quality
  - For applications as well as platform level functions like Logging
- Safe time synchronization via Time Sync Monitoring
- Required for global schedule synchronization
- Replaces ara::tsync from 3rd-party stack



# Execution Management

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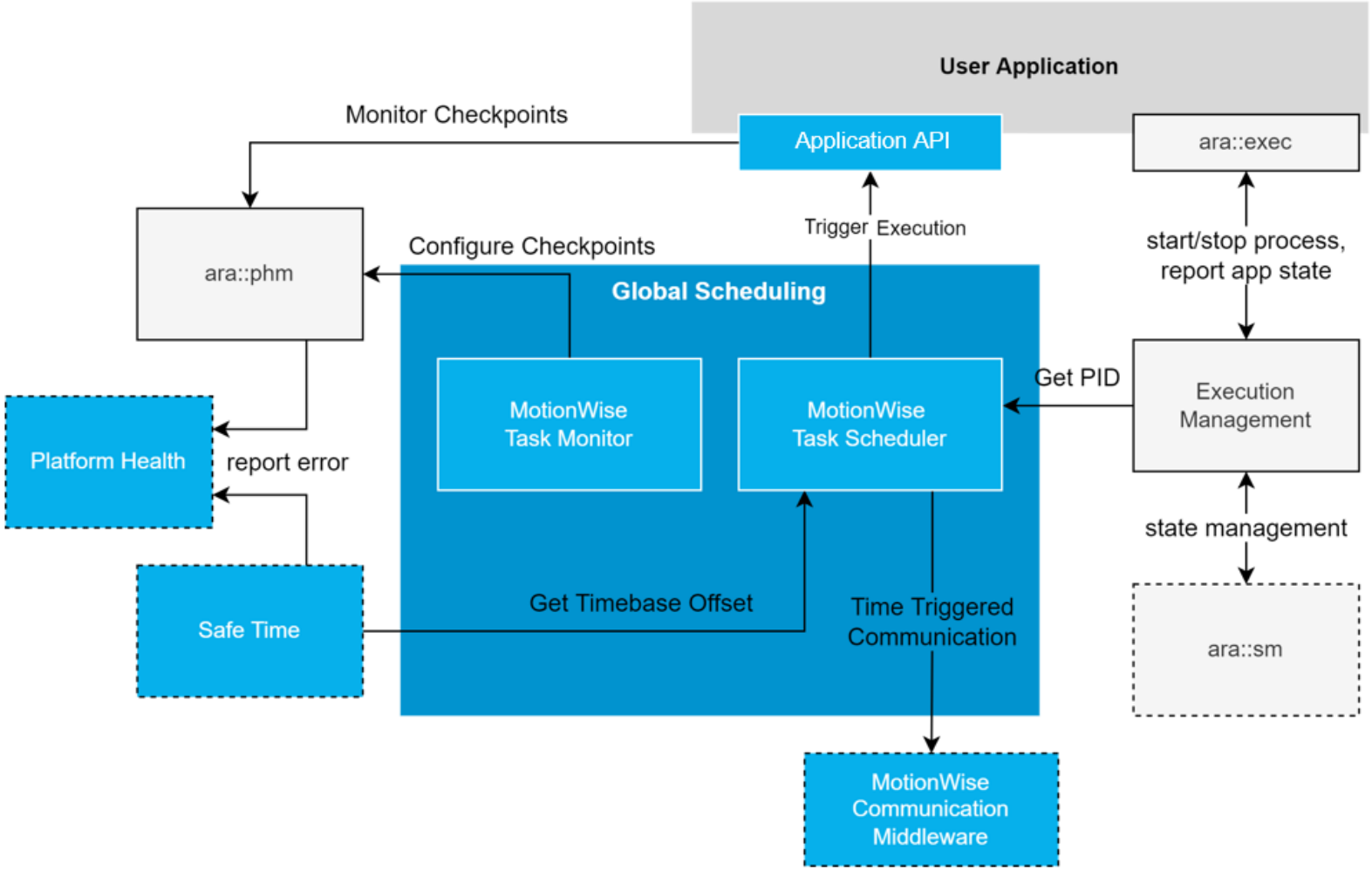
Adaptive Execution Management

- To start/stop application process

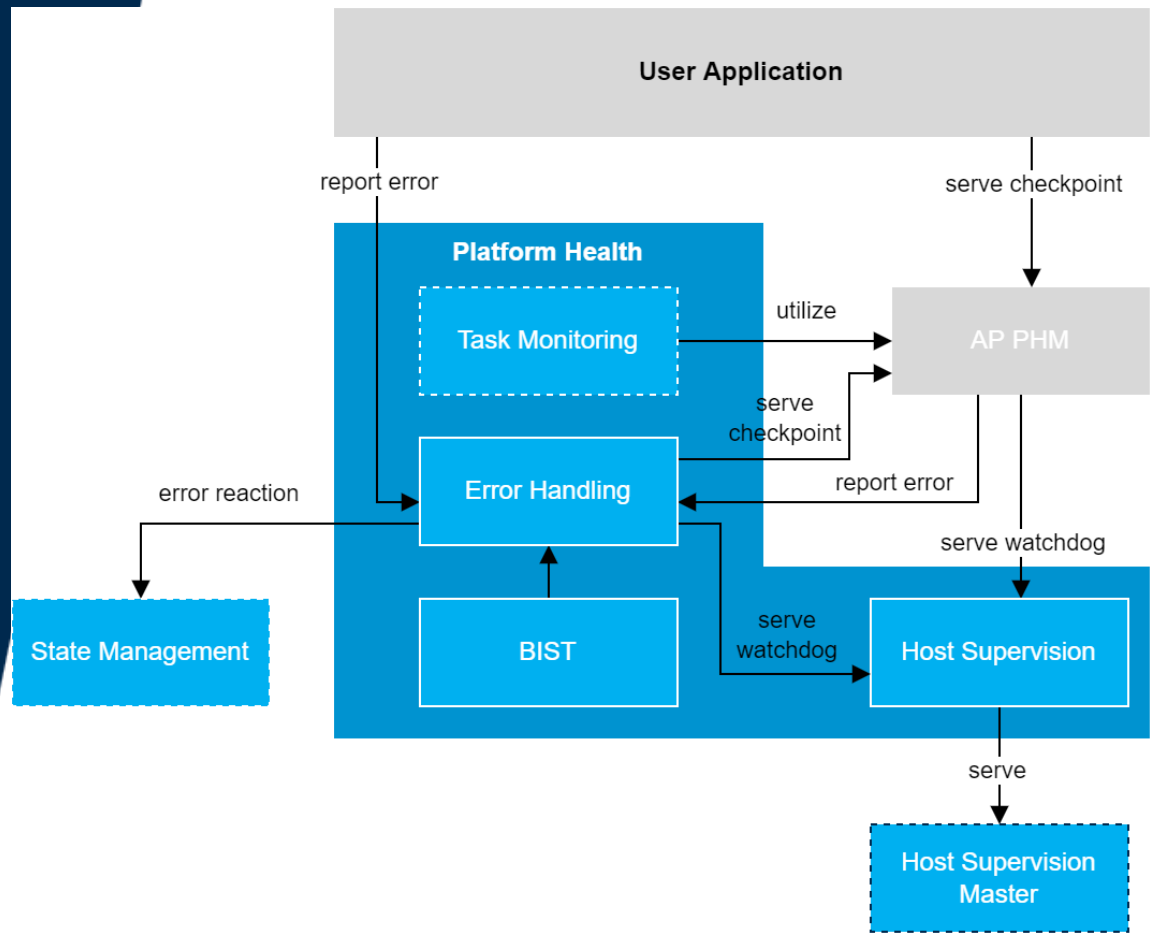
MotionWise Task Scheduler

- Requires ara::exec interface for identifying process IDs
- Triggers application execution
  - Except „free running apps”
- ECU-wide scheduling via time synchronization
- Uses ara::phm for monitoring



# Platform Health Management

- MotionWise Capabilities
  - Applications send checkpoints to AP PHM
  - Task Monitoring utilizes AP PHM for application deadline, aliveness, program flow monitoring
  - Applications can report error directly to Error Handling. AP PHM reports to it as well
  - Host Supervision acts as a watchdog for the AP PHM



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# MotionWise

## Cyclone DDS

Data Distribution Service (DDS) Solution Bundle Description

# ZettaScale - a strong TTTech Auto partner

- Strategic investment and partnership to grow product offerings tailored to the automotive market
- Joint product MotionWise Cyclone DDS: a safety-certified software platform that ensures safe and quality-guaranteed real-time communication in vehicles
- Mission critical, vehicle-to-everything (V2X) and robotics middleware

TTTechAuto → MotionWise

zetta scale → Cyclone DDS

MotionWise Cyclone DDS

Source: https://www.prnewswire.com/news-releases/zettascale-technologies-spins-out-from-adlink-and-raises-strategic-investment-from-tttech-auto-301557457.html

# ZettaScale
# Key Technologies

DDS, the OMG standard for data-centric connectivity was literally born in our team!

Cyclone DDS

Zenoh

We are also the inventor of Zenoh - the most powerful and efficient communication Protocol Yet!

More information https://zenoh.io/

# ZettaScale DDS History

**1987**
Inventor of DDS technology, with SPLICE Patent (Subscription Paradigm for the Logical Interconnection of Concurrent Engines)

**2004**
One of the main contributors to the OMG Data Distribution Service Specification

**2006**
Spin-off from Thales-NL and first compliant implementation of OpenSPLICE DDS as COTS

Co-author of additional 15 others OMG specifications

**2017**
Launch of the Cyclone DDS Eclipse Project

**2019**
Cyclone DDS, the default implementation in Galactic Geochelone ROS2 & Autoware

**2022**
Strategic partnership with TTTech-Auto

*Our DDS products are deployed in thousands of Hard Real-time Mission Critical to large scale secure System of System*



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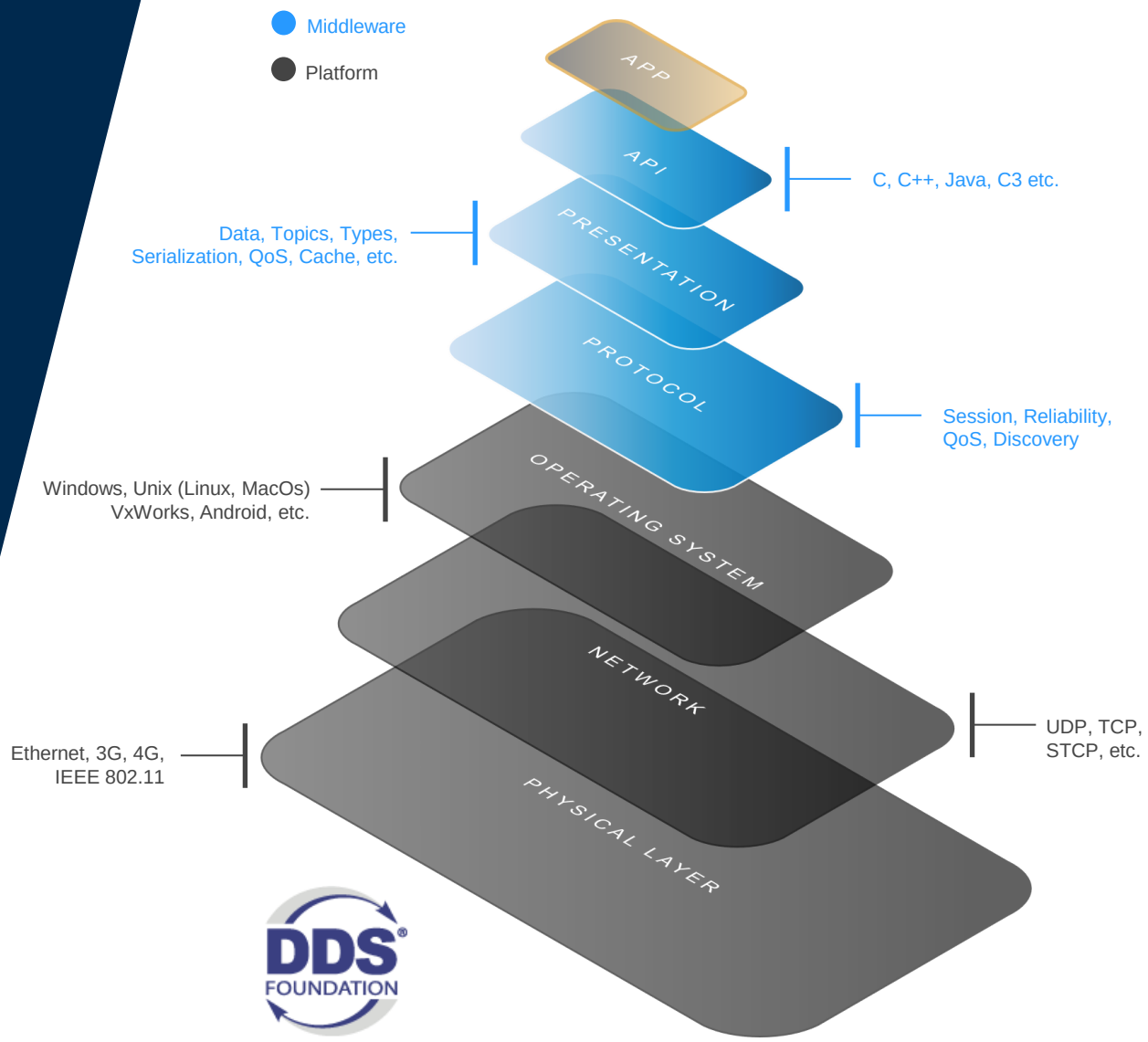
# General introduction to DDS

DDS Middleware is a software layer that abstracts the application layer from the details of the operating system, network transport, and low-level data formats.

The same concepts and APIs are provided in different programming languages allowing applications to exchange information across operating systems, languages, and processor architectures.

Low-level details such as data wire format, discovery, connections, reliability, protocols, transport selection, QoS, security, etc. are managed by the middleware.



# Product offering overview

MotionWise Cyclone DDS ***Pro Edition***

- OMG DDS conformant specification
- Focus in performance
- Tool Suite
- TSN extensions
- Compatible with MotionWise
- Compatible with standardized frameworks: ROS2 and Adaptive AUTOSAR

Available within 2022

MotionWise Cyclone DDS ***Certified Edition***

- Automotive profile subset
- Safety, security, real-time and performance focus
- Tool suite
- TSN extensions
- Compatible with MotionWise
- Compatible with Adaptive AUTOSAR frameworks
- ISO26262 ASIL-D certification

Available eo 2023



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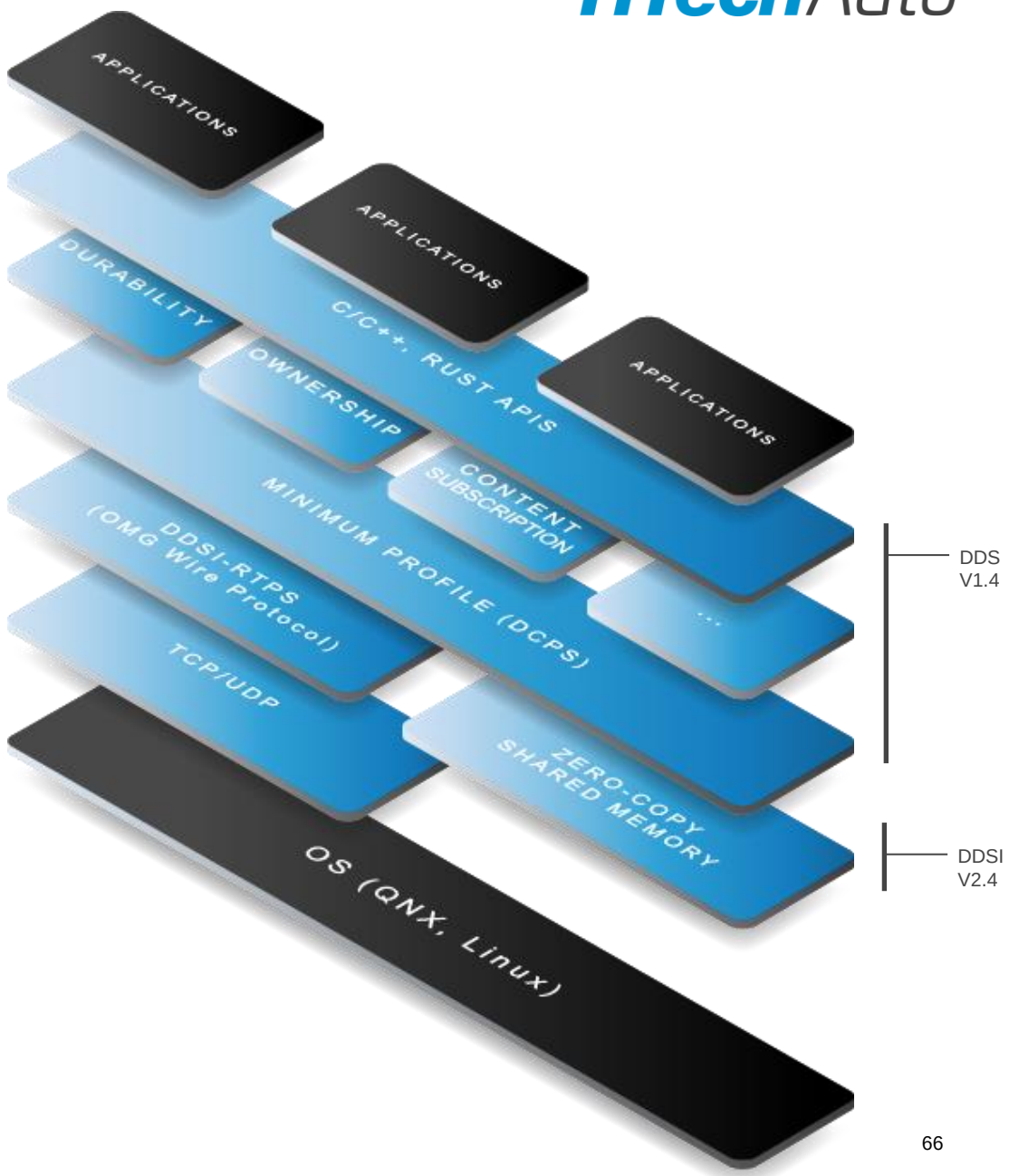
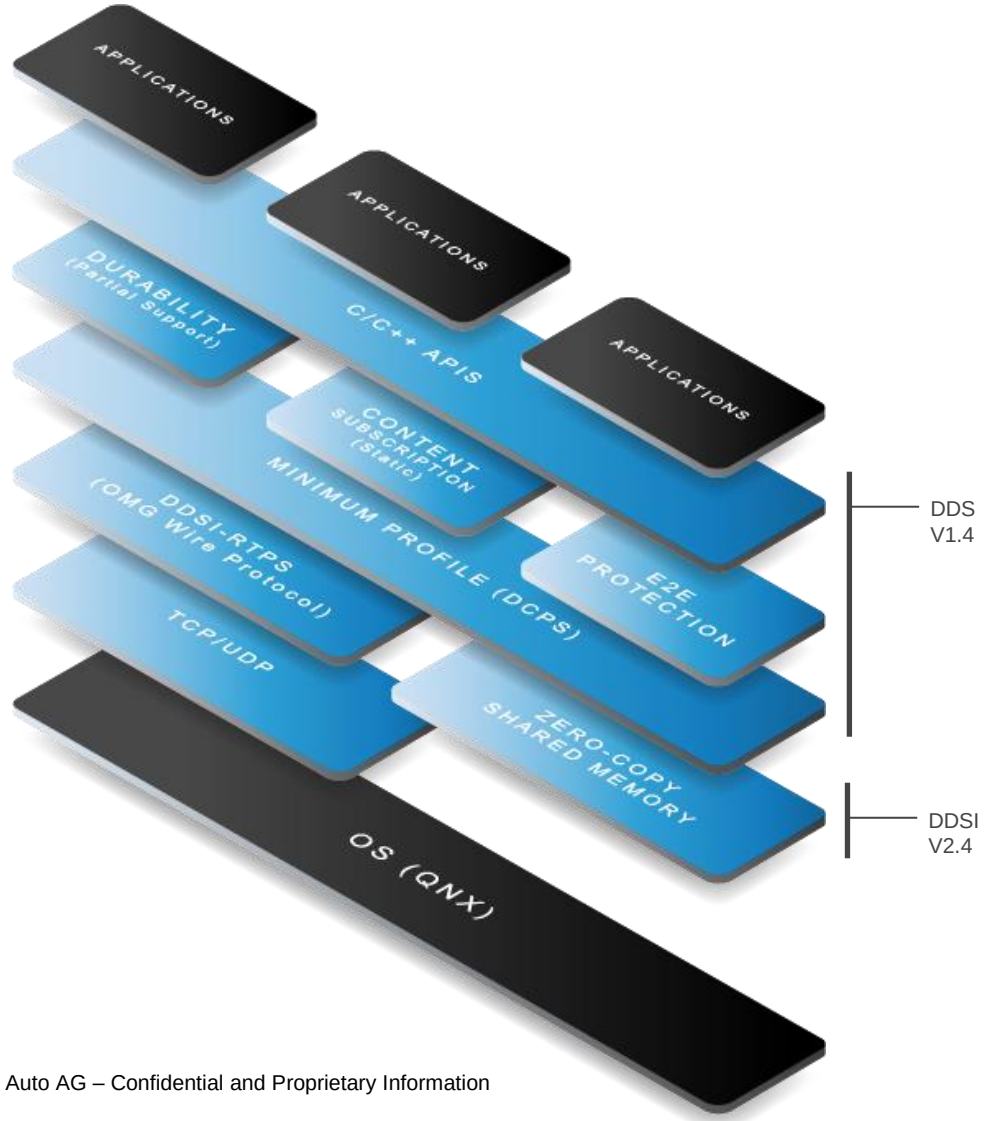
# MotionWise Cyclone DDS Pro Edition stack overview - for Micro Processing Units (MPUs)

## Stack Overview

- C/C++ and RUST (Roadmap) bindings
- Linux and QNX OS support
- DDS API compliance with DDS1.4
- DDS security support
- Compliance with DDSiV2.4
- Zero-copy shared memory
- TSN extensions
- Wide connectivity, through Zenoh technology
- Interoperability with other DDS implementations



# MotionWise Cyclone DDS Certified Edition stack overview - for Micro Processing Units (MPUs)




## Stack Overview

- C/C++ bindings
- ISO26262 certification up to ASIL-D
- Safety Element out of Context (SEooC) including QNX integration
- DDS API compliance with DDS1.4
- DDS security support
- Compliance with DDSiV2.4
- Zero-copy shared memory
- TSN extensions
- Wide connectivity, through Zenoh technology
- Interoperability with other DDS implementations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| Feature | Implementation Coverage Pro edition | Implementation Coverage Cert edition | Description |
|---|---|---|---|
| **API**<br>• C<br>• C++<br>• RUST | <br>Yes<br>Yes<br>Yes | <br>Yes<br>Yes<br>No | DDS APIs in C / C++ or RUST |
| **Large Data Support**<br>• Fragmentation<br>• Async Publication | <br>Yes<br>Yes | <br>Yes<br>Yes | • Large data samples are split in configurable fragements to meet the network capacity .<br>• The Application Writing thread is decoupled from the CycloneDDS sending thread |
| **Safety**<br>• End-to-End Protection mechanism<br>• Safety Certification Package | <br>No<br>No | <br>Yes<br>Yes | • Data integrity preservation<br>• Certificable against ISO262622 up to ASIL-D |
| **Security**<br>• Access control<br>• Message encryption<br>• Message authentication<br>• Digital signature<br>• Secure logging | <br>Yes<br>Yes<br>Yes<br>Yes<br>Yes | <br>Yes<br>Yes<br>Yes<br>Yes<br>Yes | • Ability to protect data topics, dds partitions , dds domains with Read/Write access controls<br>• Cryptography uses AES-GCM and AES-GMAC for message authentication<br>• The ability to check application identity and/or that invokes operations on DDS<br>• Digital signature is used for non-repudiation, authentication and data integrity,<br>• Logging of security events ( denied permissions , integrity errors) in trace files |
| **Static Memory Allocation** | Yes | Yes | • pre-allocation of data buffers in advance ( in the initialzation phases) |
| **DDS XTypes 1.3** | Yes | Yes | • Ability to evolve data type definition while maintaining backward compatibility with old versions |
| **Dynamic discovery** | Yes | No | • Ability to automatically discover new DDS entities in the system at runtime |
| **Time Sensitive Network**<br>• Qbv (scheduled traffic)<br>• 1AS (Timing and Synchronization) | <br>Yes<br>Yes | <br>Yes<br>Yes | • Abitity to synchronise Cyclone writing and reading thread with the overall end to end scheduling |
| **ASIL Zero-Copy shared memory IPC** | Yes | Yes | • Ability to share data by exchanging pointers instead of content |



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| Quality of Service (QoS) | Implementation Coverage Pro Edition | Implementation Coverage Certified Edition | Restrictions Certified Edition |
|---|---|---|---|
| **User data** | Yes | Partially | Limited to max N characters |
| **Topic data** | Yes | No | |
| **Group data** | Yes | No | |
| **Durability** | Yes | Partially | Volatile (V) and transient local (T-L) |
| **Durability service** | | | |
| • cleanup delay | Yes | No | Irrelevant for V, T-L; only 0s allowed; Transient and Persistent (T/P) out of scope |
| • history | Yes | Partially | V: must be keep-last 1; T-L: same as History; T/P out of scope |
| • resource limits | Yes | Partially | V: must be inf/inf/inf; T-L: must match Resource limits; Transient Persistent (T/P) out of scope |
| **Presentation** | Partial (per instance) | No | |
| **Deadline** | Yes | Yes | |
| **Latency budget** | Yes (default value) | Yes | |
| **Ownership** | Yes | No | |
| **Ownership strength** | Yes | No | |
| **Liveliness** | Yes | Yes | |
| **Time based filter** | (Roadmap) | Partially | Simplest version to be implemented (filter by timestamp) |
| **Partition** | Yes | Partially | 1 partition (0 spec'd by user = default of ""), no wildcards, max name length N |
| **Reliability** | Yes | Yes | |
| **Transport priority** | Yes (default) | Yes | |
| **Lifespan** | Yes | No | |
| **Destination order** | Yes | Yes | |
| **History** | Yes | Partially | Keep last N |
| **Resource limits** | Yes | Yes | Bounds the data volume injected in the Global data space |
| **Writer data lifecycle** | Yes | No | |
| **Reader data lifecycle** | Yes | No | |



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# Connectivity with Microcontrollers (MCUs) and Classic AUTOSAR environments

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Needs:

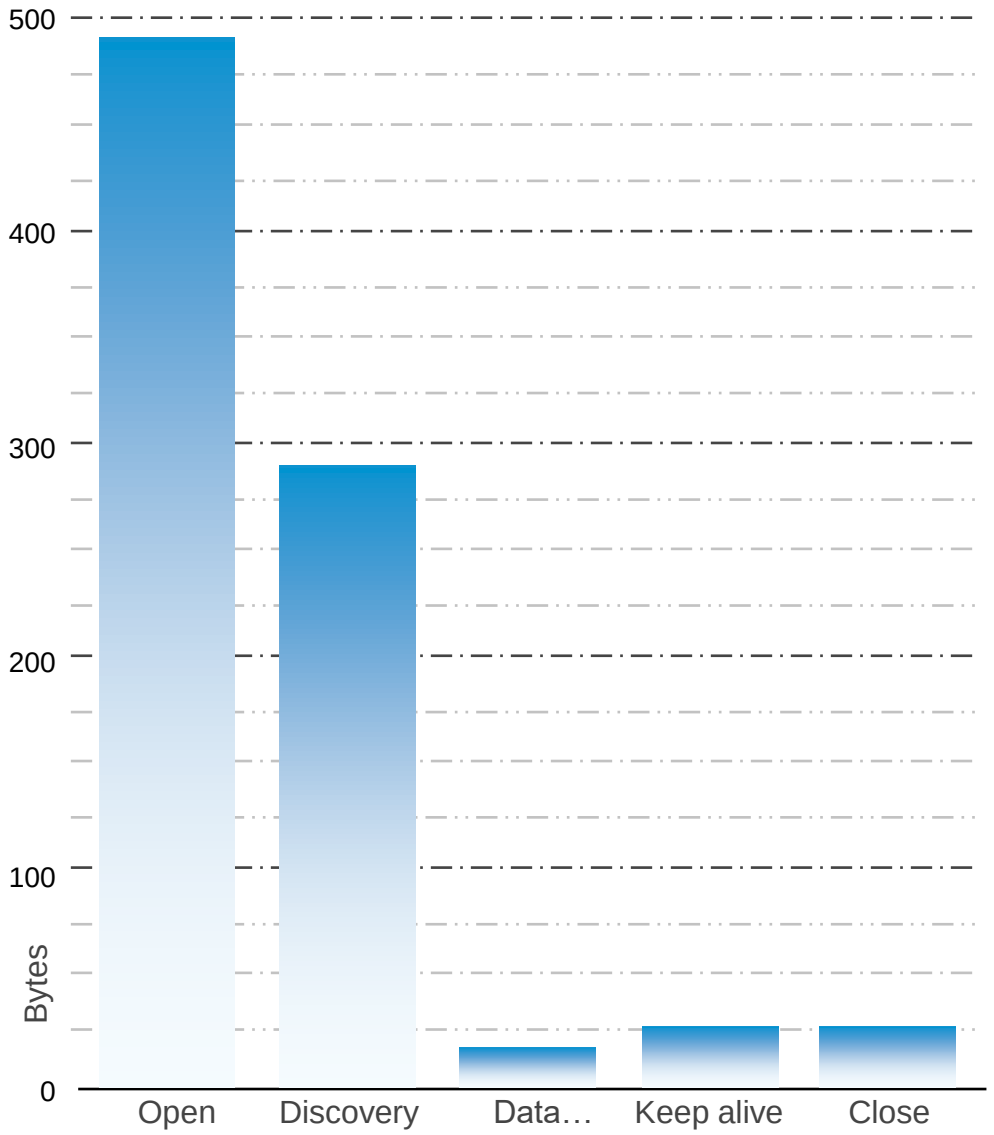
- Enable Classic AUTOSAR SWC to communicate with DDS APPs in MPUs
- Wire-compatible protocol
- Enable exploit of DDS QoS
- High performance and small footprint

Industry solutions

- DDS suppliers provide DDS-XRCE (Extremely Resource Constrained Environments) as a performant solution for MCUs
- DDS-XRCE is a new (2020) OMG specification

# Limitations DDS-XRCE

- DDS-XRCE was introduced to deal with the inability of DDS to effectively address MCU
- DDS-XRCE is not interoperable with DDS, and it requires a bridge
- The protocol is not extremely parsimonious in resource usage, footprint and presents an extremely cumbersome API

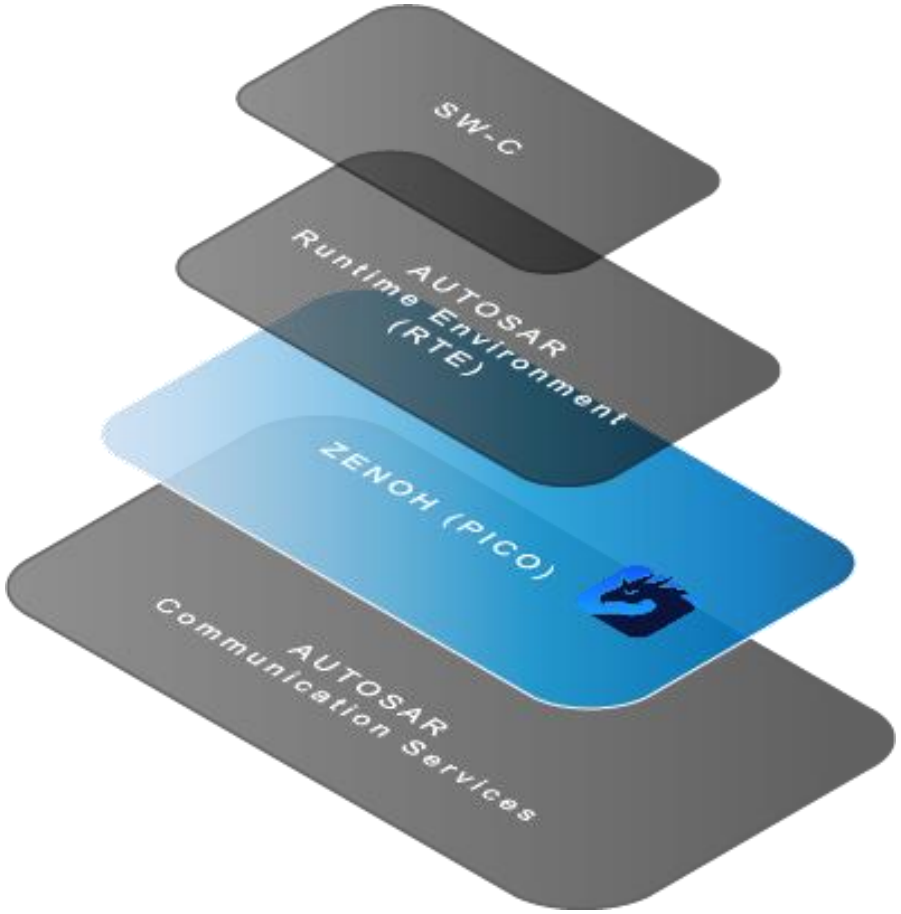


# Introduction of Zenoh

Zenoh

- Pub/Sub/Query protocol that unifies data in motion, data at rest and computations from embedded microcontrollers up the data centre
- Provides location-transparent abstractions for high performance pub/sub and distributed queries across heterogeneous systems
- Delivers higher performance then competing protocols, has built-in support for zero-copy, and an extremely clean and user-friendly API

# Connectivity with Microcontrollers (MCUs) and Classic AUTOSAR environments

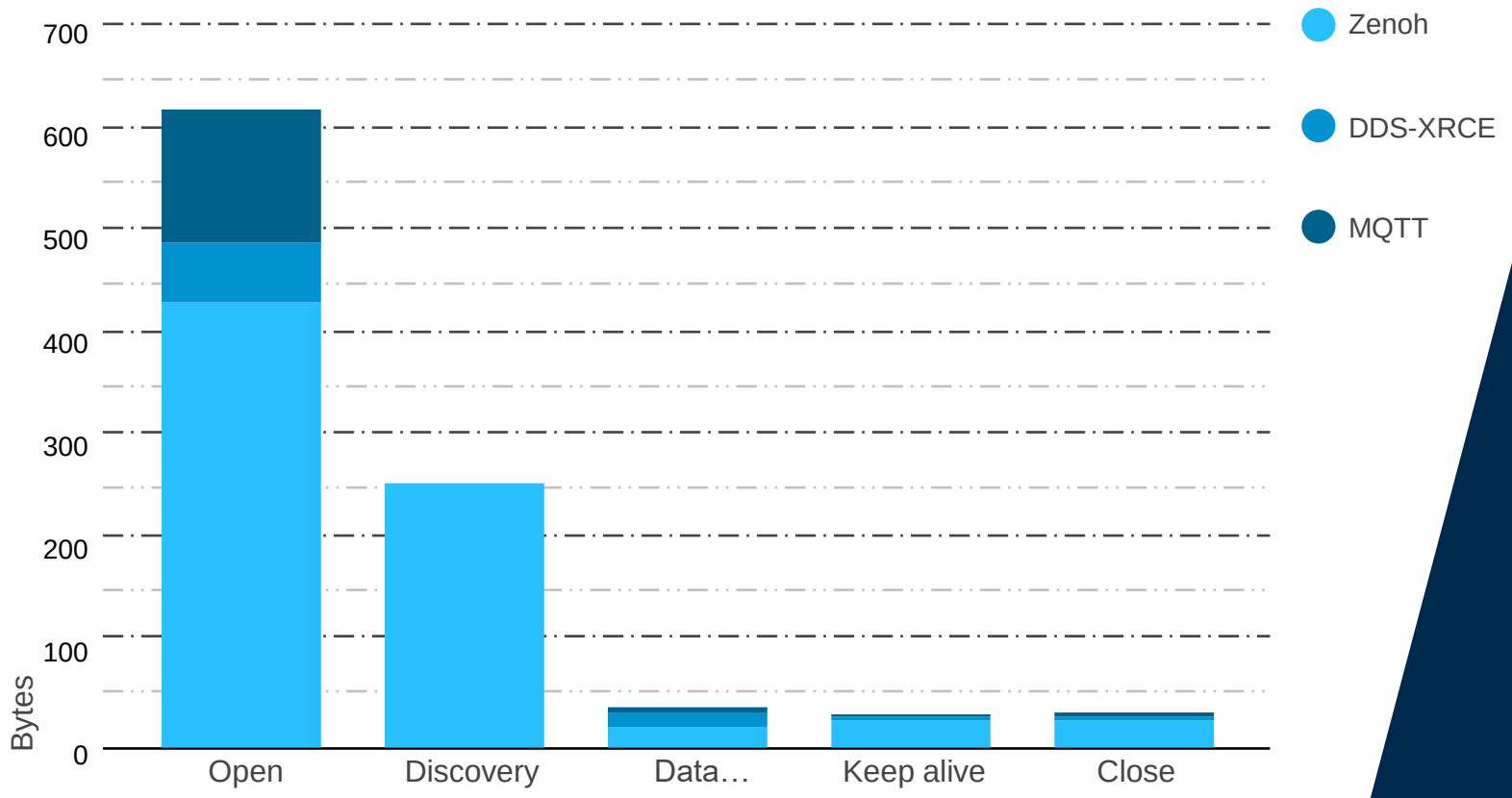



- Usage of Zenoh (Pico) as a communication protocol
- Wire compatibility with DDS
- Fully abstracted by AUTOSAR RTE API
- Integration tool enabling arxml to code generation
- Higher performance in comparision with DDS-XRCE (see following slides)
- Lower footprint in comparision with DDS-XRCE

Discover Zenoh!

More information https://zenoh.io/

# Zenoh vs DDS-XRCE & MQTT




- Zenoh is far more efficient than DDS-XRCE both in terms of wire-efficiency and footprint
- Zenoh is easier to use (See this blog)

# MotionWise Cyclone DDS Tool-Suite

- **Netlens**

- DDS Entity Viewing, System topology and QoS & Datatype Conflict detection : **Monitoring phase**
- Configuration Validator tool, to check Cyclone DDS deployment descriptor correctness: **Configuration phase**
- Record And Replay Tool , to selectively record data and replay it for a post-mortem analysis : **Recording and Replaying phase**

- **Slate**

- End-to-end tool for the configuration of TSN networks. Topology design, traffic scheduling and deployment of the result.
- Headless operation for network scheduling based on TSN standards: **Slate CNS**
- GUI to define the network topology and visualization of the schedule: **Slate XNS**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# Slate

1. Headless and GUI to design the network topology
   - Drag & drop network devices
   - Planning result visualization
   - Windows and Linux support
2. Schedule your network traffic based on supported TSN profiles: 802.1AS, 802.1Qbv, 802.1Qbu, 802.1Qci and 802.1CB
3. Deploy schedule in supported TSN switches through a standard configuration process

## slate CNS

- Integrating TSN network planning library into 3rd party tool
- Planning networks with standard compliant TSN devices
- Using standardized models on library interface
- Headless operation

## slate XNS

- Planning TSN networks (using CNS)
- Deploying configurations to standard compliant TSN devices
- Configuring complex TSN Networks w/o specialist knowledge
- Using Graphical User Interface and visualizing planning result

# Delivery package

MotionWise Cyclone DDS *Pro Edition*

- DDS stack delivered as a library
- NetLens monitoring tool
- Slate tool
- User Manual
- Integration Manual

MotionWise Cyclone DDS *Certified Edition*

- DDS stack as a library as a SEooC for QNX OS
- NetLens monitoring tool
- Slate tool
- User Manual
- Integration Manual
- Safety Manual and Assumptions of Use
- ISO26262 work products



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# Roadmap

MotionWise Cyclone DDS

## 2022

### Q3

MotionWise Cyclone DDS Pro - product launch based on open-source feature scope

Suitable for prototype and pre-series programs

### Q4

MotionWise Cyclone DDS Pro edition – initial release:

- TSN support
- Linux OS support
- QNX OS support
- Slate Tool

## 2023

### Q1

MotionWise Cyclone DDS Pro edition

- MCU integration
- NetLens Tool

### Q2

MotionWise Cyclone DDS Pro edition final launch

- Zero-copy shared memory IPC

### Q4

MotionWise Cyclone DDS Certified edition available

- Certified Zero-copy shared memory IPC

MotionWise Cyclone DDS Pro edition final launch

- Certified Zero-copy shared memory IPC

## 2024

### Q1

MotionWise Cyclone DDS Certified edition final launch

**Timeline subject to change**



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# Mastering OMG DDS through MotionWise Cyclone DDS Pro

| | |
|---|---|
| Objectives | Define the key concepts of the Data Distribution Service<br>Learn the key DDS architectural patterns<br>Learn how to build an information model with DDS<br>Master the Cyclone DDS APIs and QoSs<br>Develop optimized MotionWise Cyclone DDS based applications using the well-established DDS patters.<br>Tune the middleware behaviors and troubleshoot a MotionWise Cyclone DDS based system. |
| Audience | Decision makers, architects, analysts, developers and testers involved in a DDS based system. |
| Prerequisites | Intermediate knowledge of C++/Python or C languages |
| Training approach | Interactive lecture (60%)<br>Hands-on programming (40%) |
| Courseware Provided | Handouts and exercise |
| Maximum Attendees | 10 |
| Duration | 3 days |



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# Detailed content

- **Laying the foundation**
  - Data centricity approach
  - Publish/Subscribe concept
- **Information Modelling**
  - Modelling Data Types in IDL
  - Topic Creation with Datatypes
  - IDL-language mappings
- **OMG DDS standard and its DCPS (Data-centric Pub/Sub ) modules**
  - The Minimum, Ownership, Content Subscription, Durability Service Profiles
  - The Infrastructure Module
  - The Domain Module
  - The Topic Module
  - The Publication and Subscription Modules
- **API and QoS Overview**
  - Overview of the all-important entities and QoS settings for each DCPS (data-centric Pub/Sub) modules
  - Using the ishapes demo to define illustrate some DDS QoSs and concepts
  - Design and implement the several DDS based applications to illustrate the concepts
- **Deployment**
  - Configure and tune the Cyclone DDS middleware deployment and behaviour for maximum performance and manage security
- **Prerequisites**
  - Intermediate knowledge of C/C++ or Python languages
- **Courseware Provided**
  - Handouts
  - Exercises
- **Training Approach**
  - Interactive lecture
  - Hands-on programming


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