SAFE architecture for Robust distributed Application Integration in roLling Stock 2

CONtributing to Shift2Rail's NExt generation of high Capable and safe TCMS. Phase 2

Introduction of Test Case 2 "TSN Network & OPC UA"

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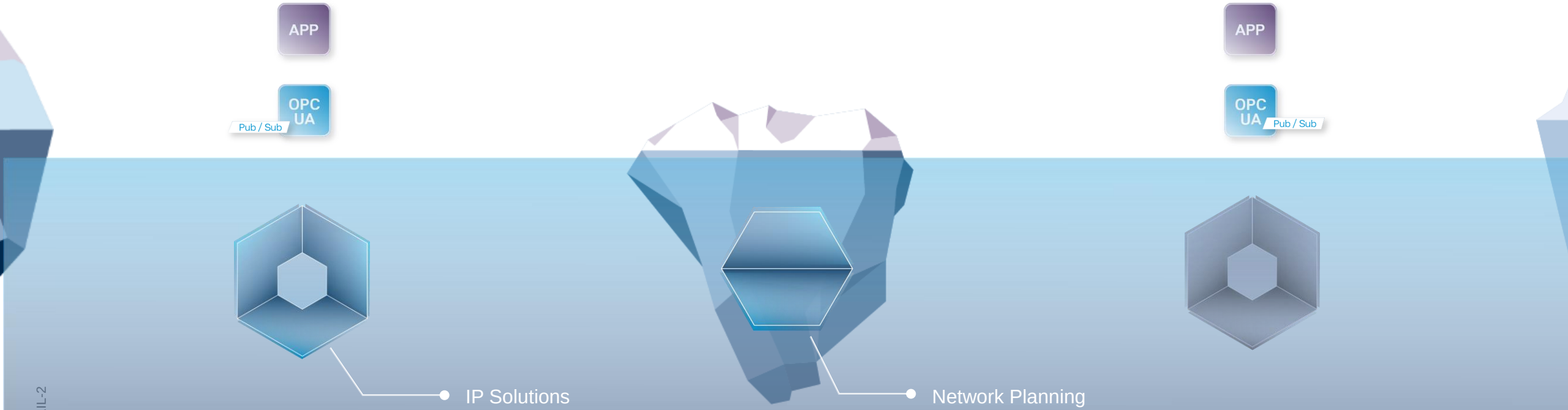
You do the application.



We'll deal with everything below the surface.

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vision

The future train will be full electronic control, without hydraulic, pneumatic or mechanical backup function. Therefore, the Next-Generation TCN (NG-TCN) solution is intended to:

- Provide a robust train network topology and architecture
- Support mixed-criticality data traffic from different user domains (TCMS and Operator/Customer oriented services)
- Handle the coupling and uncoupling of trains robustly and safe (inauguration)
- Support data communication between safety functions up to SIL4

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What is new (in a nutshell)?

- Network topology with **2 independent data transmission planes** for time and mission critical data
- **TSN technology** for time and mission critical data transmission
- **Safe Train Inauguration** (up to SIL4)
- **Safe Data Transmission** (SDTv4, up to SIL4)

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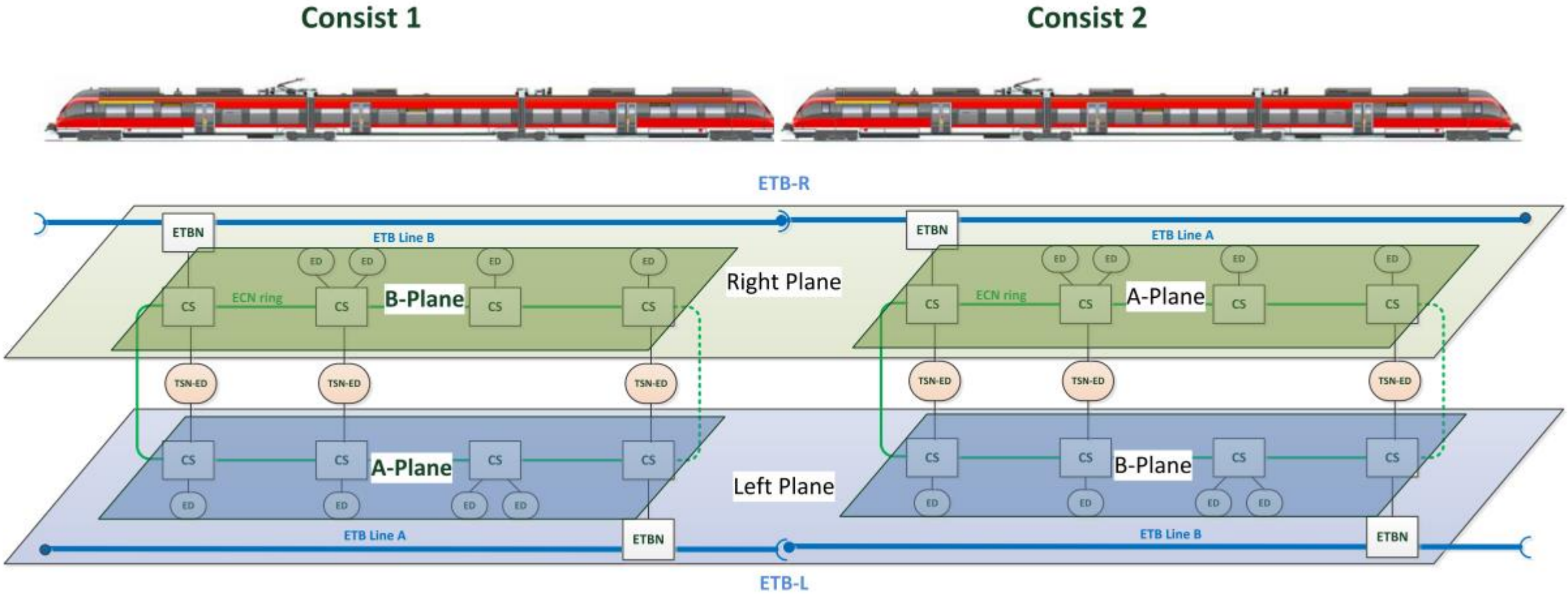
New Train Network Architecture



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New Train Network Architecture

Key benefits	Restrictions
Support of TSN (Time Sensitive Networking) for deterministic data exchange	No communication continuation over powerless consists
Seamless redundancy of time critical data traffic	
Elimination of train lines / reduction of cabling	
High reliability (independency of transmission channels)	
Compliance to existing network architecture	
Intrinsic consist orientation detection (safety)	
No bypass function	
Fire protection support (EN 50553 type 2 fires)	

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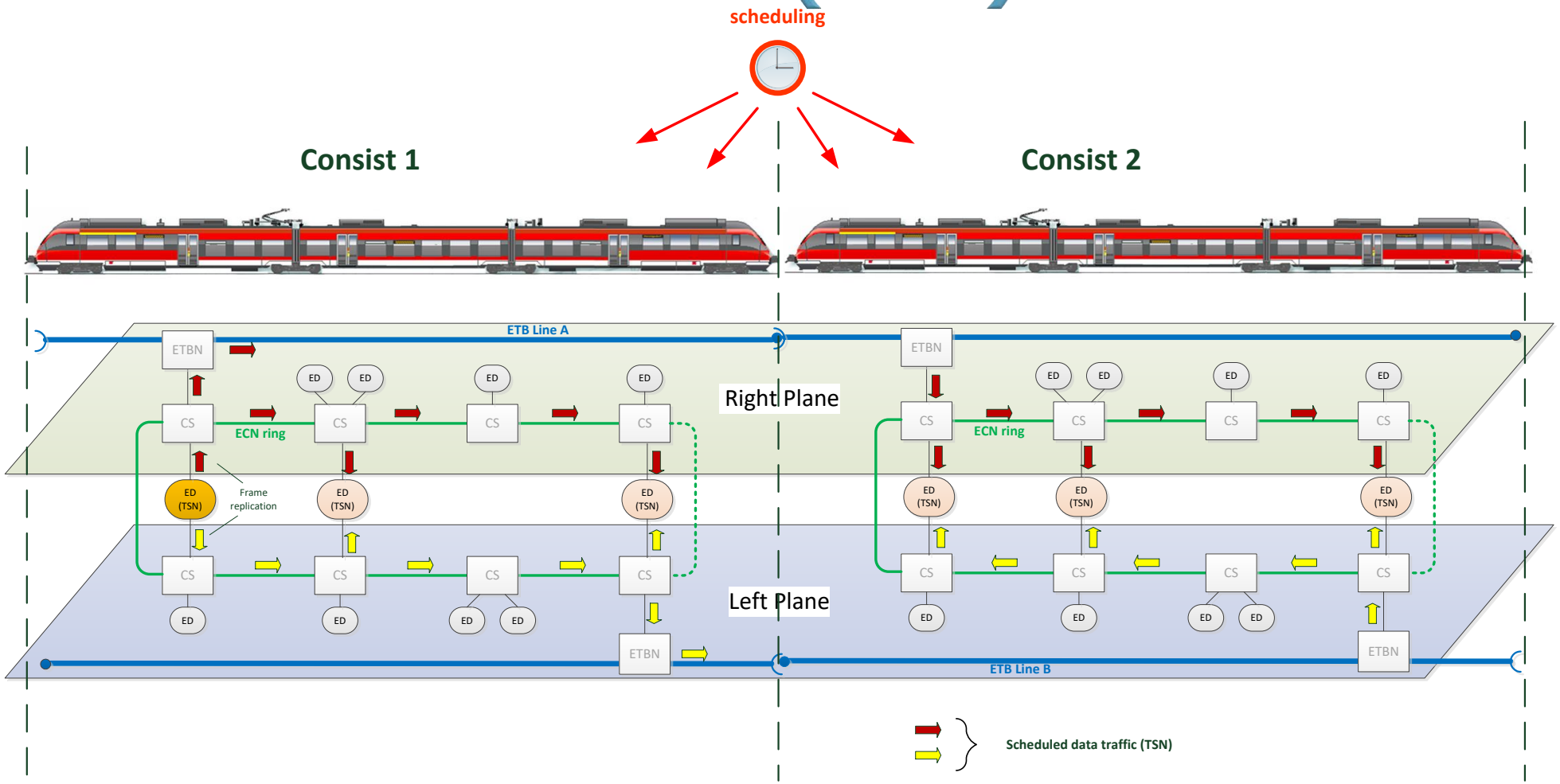
TIME-SENSITIVE NETWORKING

Scheduled Data Traffic (TSN)



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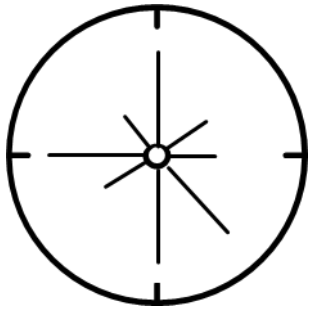
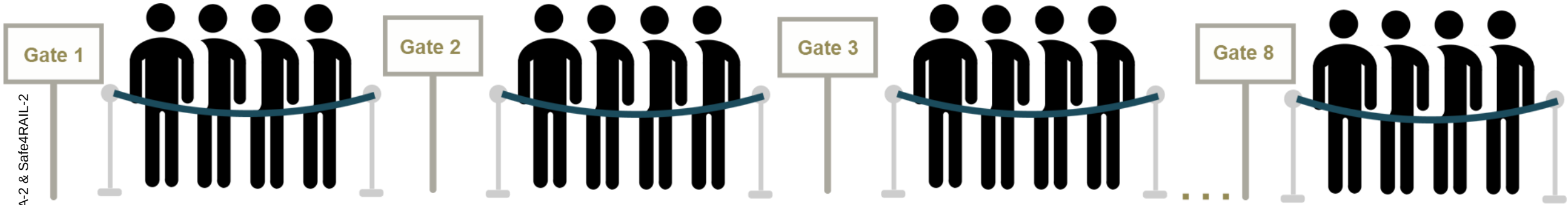
How does TSN work?



- Time Sensitive Networking enables precise control over messages in an Ethernet network.
- Queues are used to shape the flow of messages.
- Then at defined points in time, the messages can be released through gates.



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Selected TSN IEEE Standards

IEEE 802.1Qbv
Time Aware Shaping

Provides guaranteed communication latency for time-critical traffic over standard Ethernet

IEEE 802.1AS-2020
Time Synchronization

Profile of IEEE 1588v2 for synchronization of clocks in the network. Supports timing requirements for scheduled TSN networks.

IEEE 802.1CB
Seamless Redundancy

Allows for optimal bandwidth utilization of non-scheduled background traffic sent in parallel with scheduled traffic.

IEEE 802.1Qcc
SRP Enhancements

Defines the interfaces for configuration (distributed and centralized) of TSN networks. Supports configuration models for dynamic scheduling.

IEEE 802.1Qbu
Frame Preemption

Allows for optimal bandwidth utilization of non-scheduled background traffic sent in parallel with scheduled traffic.

IEEE 802.1Qci
Filtering and Policing

Protects against faulty and/or malicious endpoints and switches. Isolates faults to specific regions in the network.

IEEE 802.1Qcp
YANG Model for Bridging

Enables communication of basic bridging configuration data between bridges in combination with NETCONF

IEEE 802.1Qcw
YANG Model for Qbv, Qbu, Qci

Extends capabilities of 802.1Qcp to communication of scheduling, preemption and policing configuration data between bridges in combination with NETCONF

IEEE 802.1CBcv
YANG Model for CB

Extends capabilities of 802.1Qcp to communication of redundancy configuration date between bridges in combination with NETCONF

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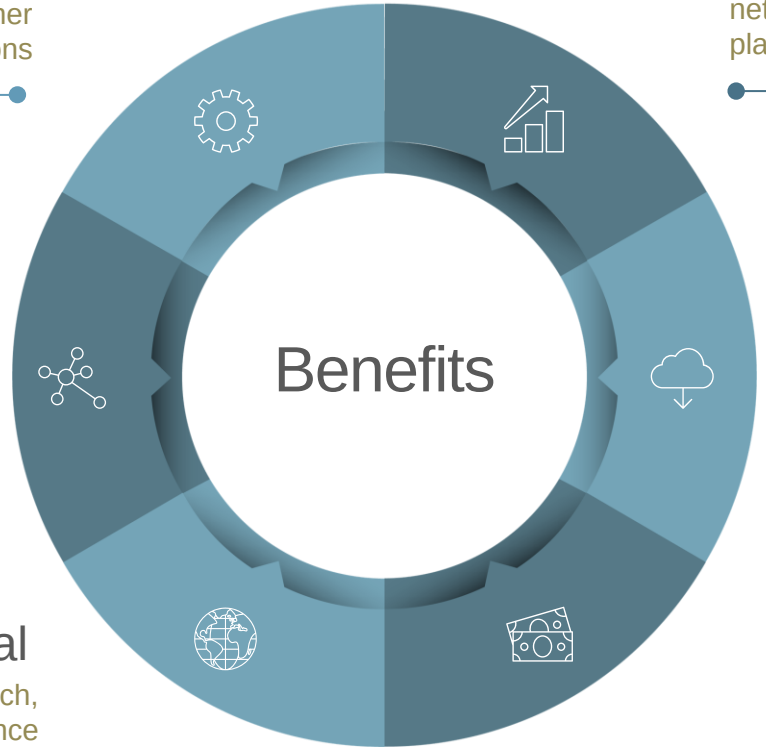
TSN Benefits

Open Standard

Allows the system integrator to focus on one standard technology rather than several propriety solutions

Easy to Use

New nodes can be easily added to the network and start operating in a plug-and-play manner.



Scalable

TSN is not limited in terms of bandwidth, it can scale with Ethernet form 100 Mbps to 10Gb and beyond

Interoperable

Ensures compatibility when connecting devices from different vendors

Universal

Drives down the cost of research, development and maintenance

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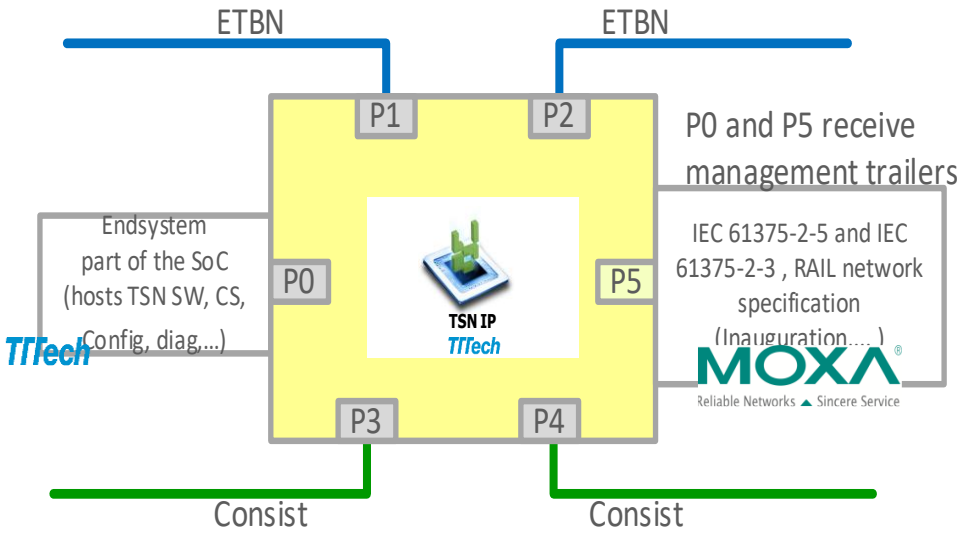
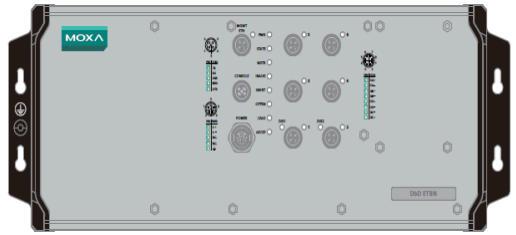
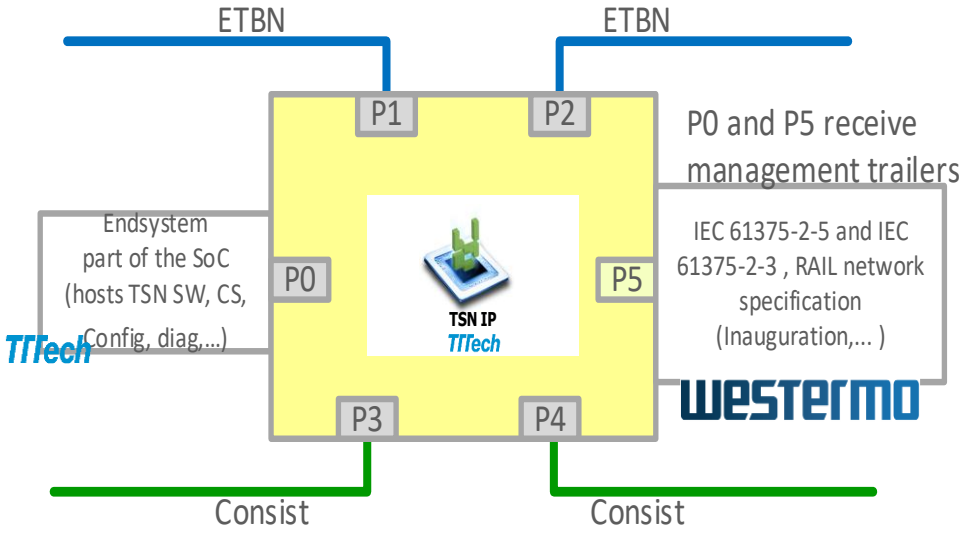
TSN
IP SOLUTIONS





MOXA
Reliable Networks ▲ Sincere Service



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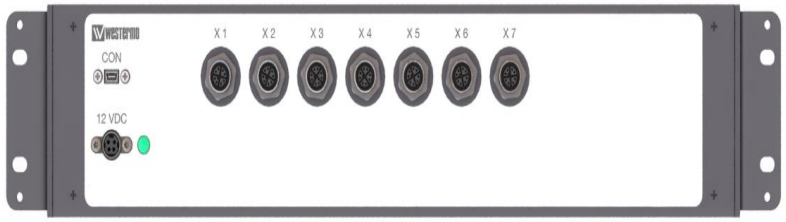

From prototype

Safe4Rail-3

TRL6 / 7

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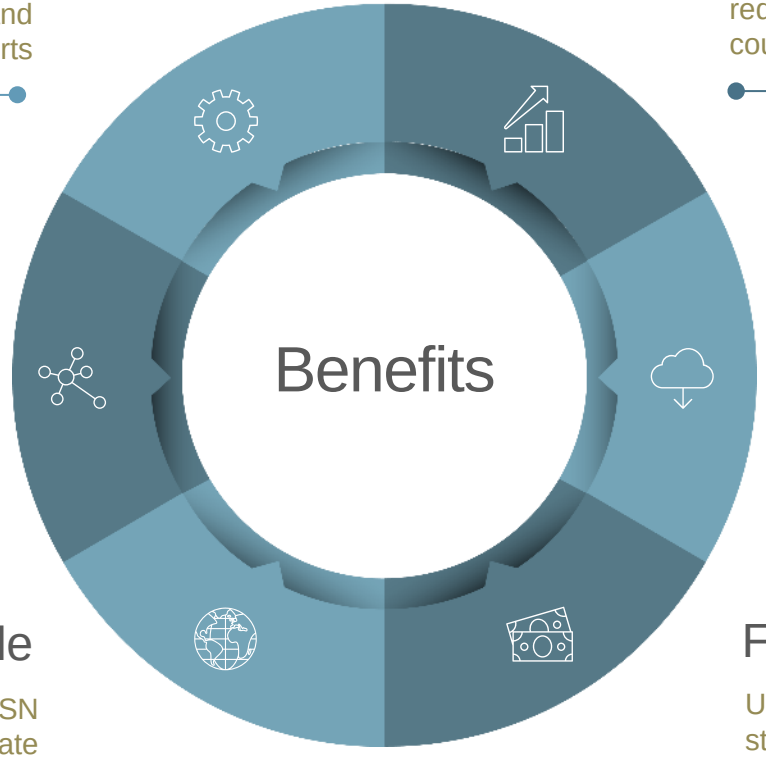
TSN IP Solution Benefits

Easy to Use

Configurable features and supporting software reduce integration and development efforts

Scalable

Scalable to match device and network requirements. Includes a range of port count and TSN options.



Performant

Provides low latency and optimal bandwidth use. Clock synchronization precision below 100ns

Ultra Low Latency Option

Extendable for ultra-low latency, with less than 1µs per-node delay and cycle times of less than 10µs

Compatible

Works with any standard compliant TSN device. Seamless compatibility with Slate network configuration products

Future Proof

Updates for newly implemented TSN standards included in license and maintenance agreement

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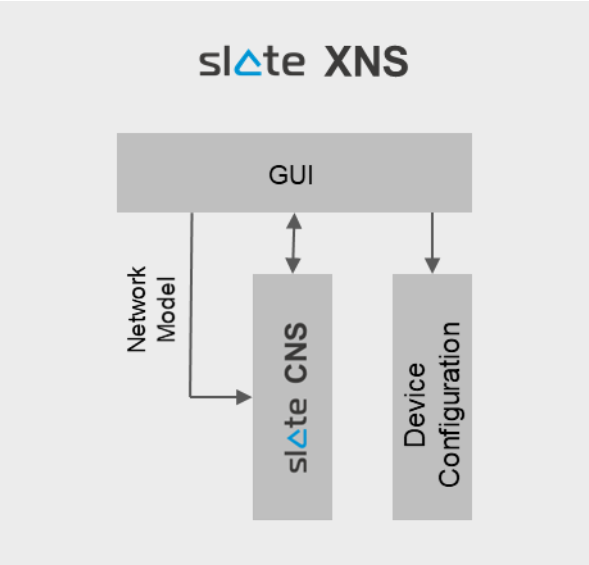
TSN
NETWORK PLANNING

Slate XNS



Browser-based planning software for TSN networks

- Plans TSN networks (using CNS)
- Deploys configurations to standard compliant TSN devices
- Configures complex TSN networks without specialist knowledge
- Uses Graphical User Interface and visualizes planning result
- Runs in Windows or Linux
- Supports derived YANG models for IEEE 802.1Qbv and IEEE 802.1Qcp
- Star, tree, daisy chain, ring and mesh topologies

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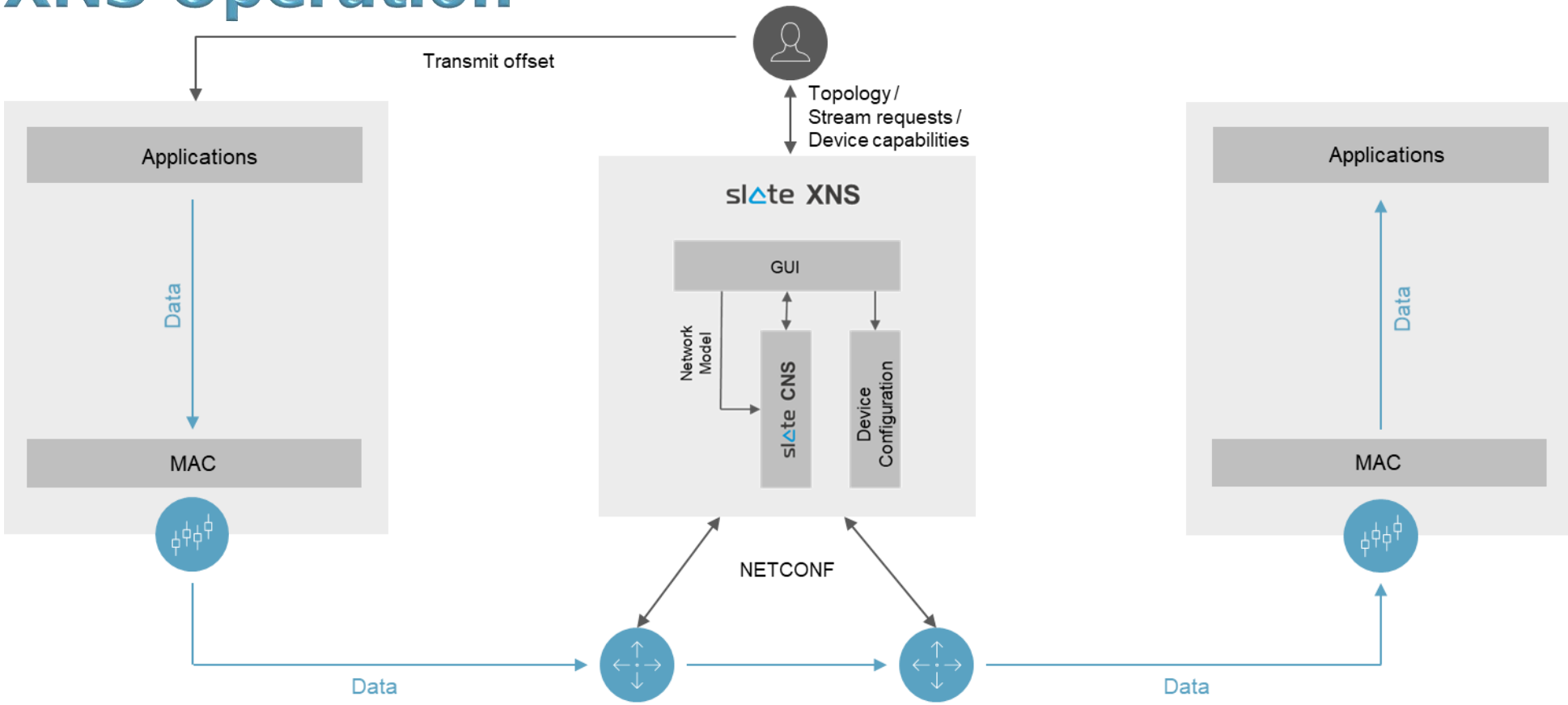
Slate XNS Operation



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Test Case 2 "TSN Network" Session

Rene Smodic

Astrit Ademaj

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OPC UA

Overview

- Introduction: What is OPC UA?
- What makes OPC UA interesting?
- How is OPC UA integrated in the Connecta2 demonstrator?
- What are the results of the evaluation?

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Open Platform Communications Unified Architecture (OPC UA) is vendor independent and widely in use

- Machine-to-machine **communication technology**
- Integration technology in a **wide range of industries** (process automation, factory automation, robotics, CNC, …)
- Specified in **IEC 62541**
- **Specified, tested and certified** by the independent OPC Foundation

Taken from: https://opcfoundation.org/news/press-releases/major-automation-industry-players-join-opc-ua-including-tsn-initiative/

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OPC UA fulfills central requirements of rail industry

Big tool landscape (open source and commercial)

Service-oriented

Platform independence

Interaction of appliances from different vendors

I/O module integration over TSN

Static or dynamic configuration

Central or decentral discovery

- ☑ **Open**
- ☑ **Technological ready**
- ☑ **Comprehensive**
- ☑ **Exchangeable**
- ☑ **Secure**
- ☑ **Safe**

Interoperability through information model

Combined use of wired and wireless communication

Secure transport to wayside over MQTT

Remote Procedure Calls

Cloud capable

Hot research topic

Encrypted and signed traffic

Automated certificate management with Global Discovery Server

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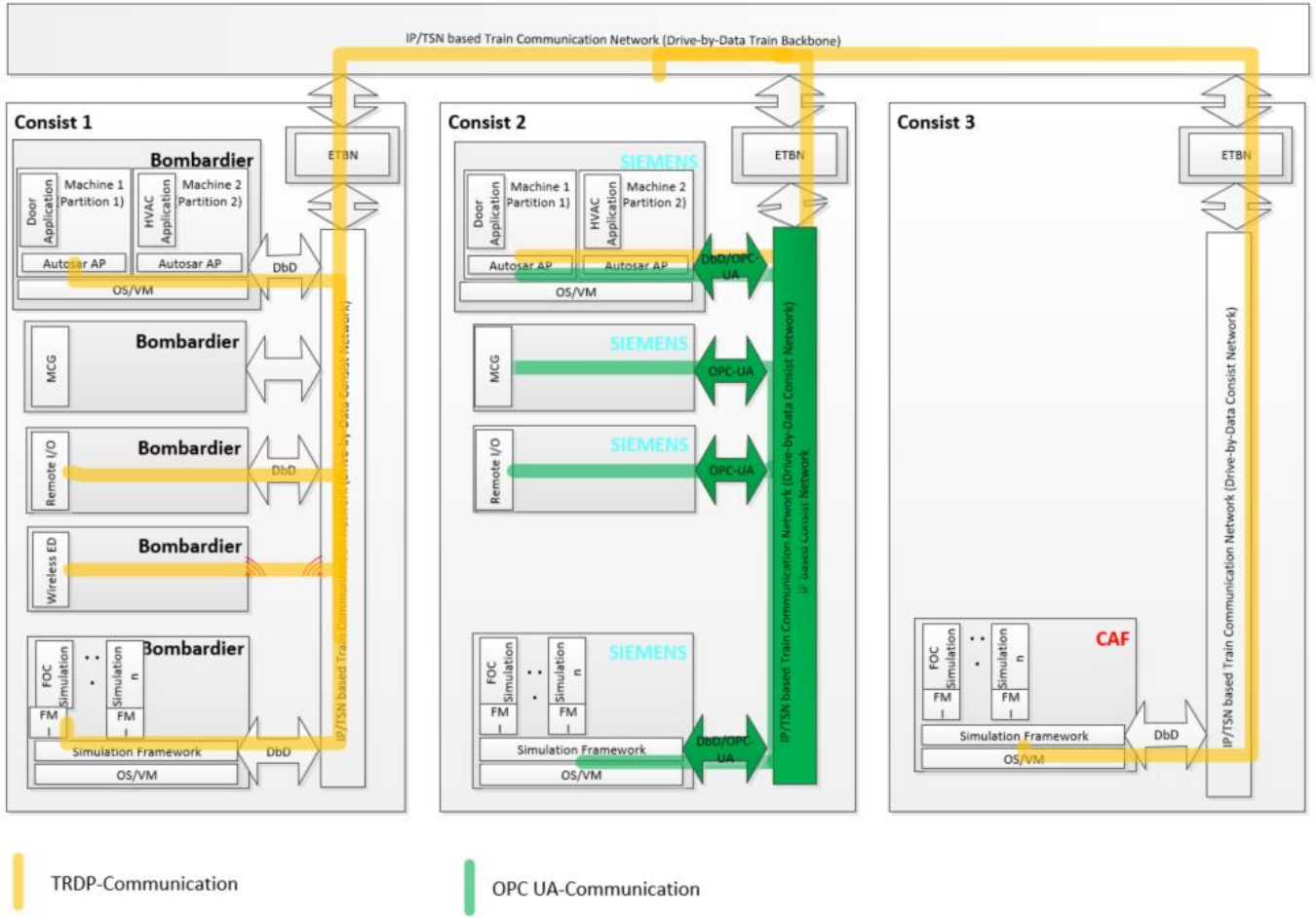
OPC UA successfully evaluated as consist communication technology



Demonstrator integrates:

- Open Source OPC UA Stack open62541 (conformance certified)
- AUTOSAR Adaptive platform
- VeriStand
- I/O device (third party)
- Visualization and test tools based on information model

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OPC UA is ready for rail industry field testing

Making OPC UA a good candidate:

- Vendor independence and widely use
- Fulfills central requirements of rail industry
- Successfully evaluated as consist communication technology
- Assets have proven readiness for field prototypes

Additional benefits clearly foreseeable:

- Master challenges from security requirements
- Digitalization
- Train to ground communication

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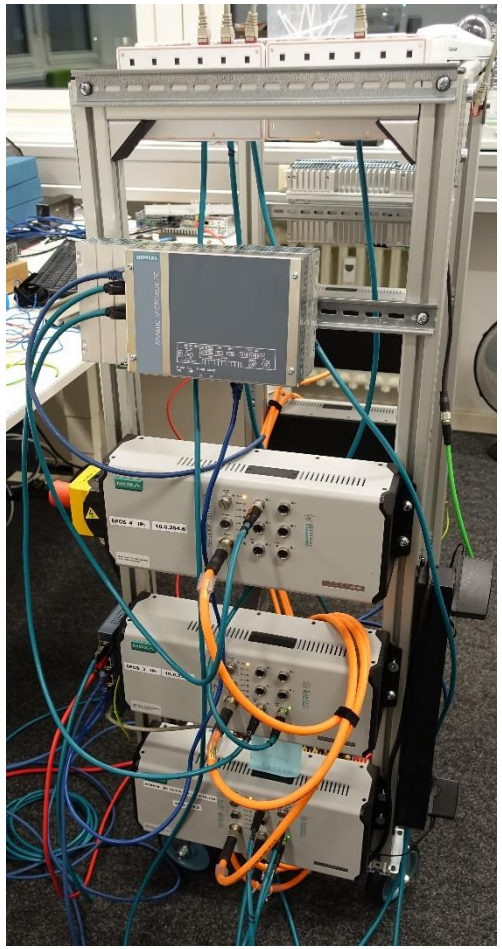
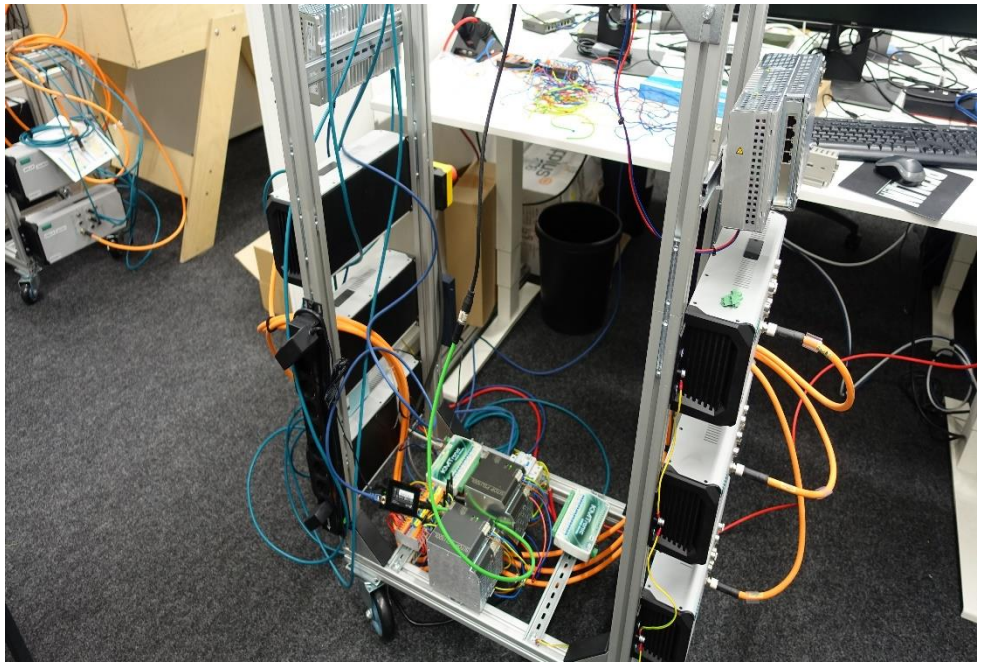
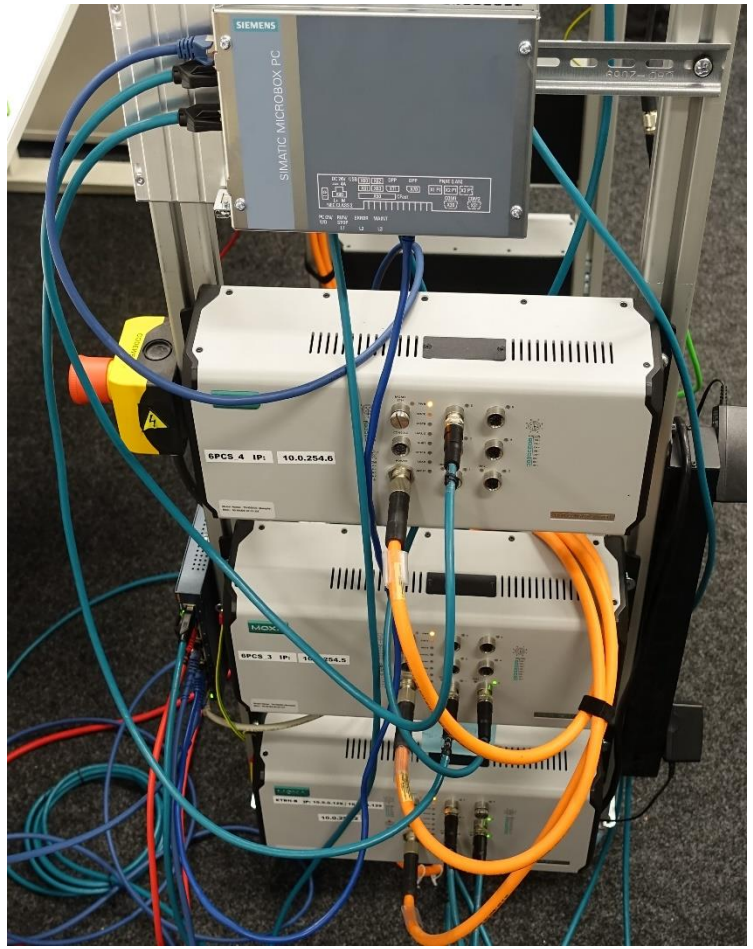
Consist 2 (SIEMENS) Laboratory







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