Drive-by-Data & Integrated Modular Platform

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Safe4RAIL – SAFE architecture for Robust distributed Application Integration in roLling stock (730830)

CONNECTA – CONtributing to Shift2Rail's NExt generation of high Capable and safe TCMS and brAkes (730539)

What is Drive-by-Data?

- Drive-by-Data investigates and specifies a new generation of train onboard communication network (NG-TCN).

- The NG-TCN shall interconnect all on-board devices including
  - TCMS (with safety function up to SIL4 like doors, brakes, …)
  - CCTV, PIS, … (operator oriented services)
  - ETCS Level 3 onboard equipment, ATO
  - Passenger WiFi (customer oriented services)

- NG-TCN adopts the established Ethernet network topology of a static consist network and a dynamic train backbone

Why Drive-by-Data?

| Today	With Drive-by-Data
Complexity: High networked system complexity High amount of cabling, for e.g. safety lines, signalling, safety and control functions.	Unified networking infrastructure with high part commonality, reduced system complexity and improved reliability,
Lifecycle: Limited network reconfigurability, upgradeability and scalability for new functions	Reduced integration and (re)commissioning effort and costs. Support for simplified verification and modular certification. System integration does not affect the behaviour of already integrated and verified functions.
Performance: Limited determinism and support for "functional distribution" (missing support for fault propagation prevention, QoS/latency/jitter control, system-level time partitioning)	Safe integration of all mixed-criticality safety functions (up to SIL4), time- and mission-critical functions as well as non-critical train functions High performance Deterministic Ethernet

Drive-by-Data in Detail

- NG-TCN Architecture – Topology & Redundancy

- Clock Synchronization (802.1AS-rev & IEEE1588v2)

- Data Transmission & Flow control with TSN (802.1Qbv)

- IMP / FDF Integration

- Safe Data Transmission (SDTv4)

- Safe Train Inauguration

- Safety Certification

NG-TCN Network Architecture (1)
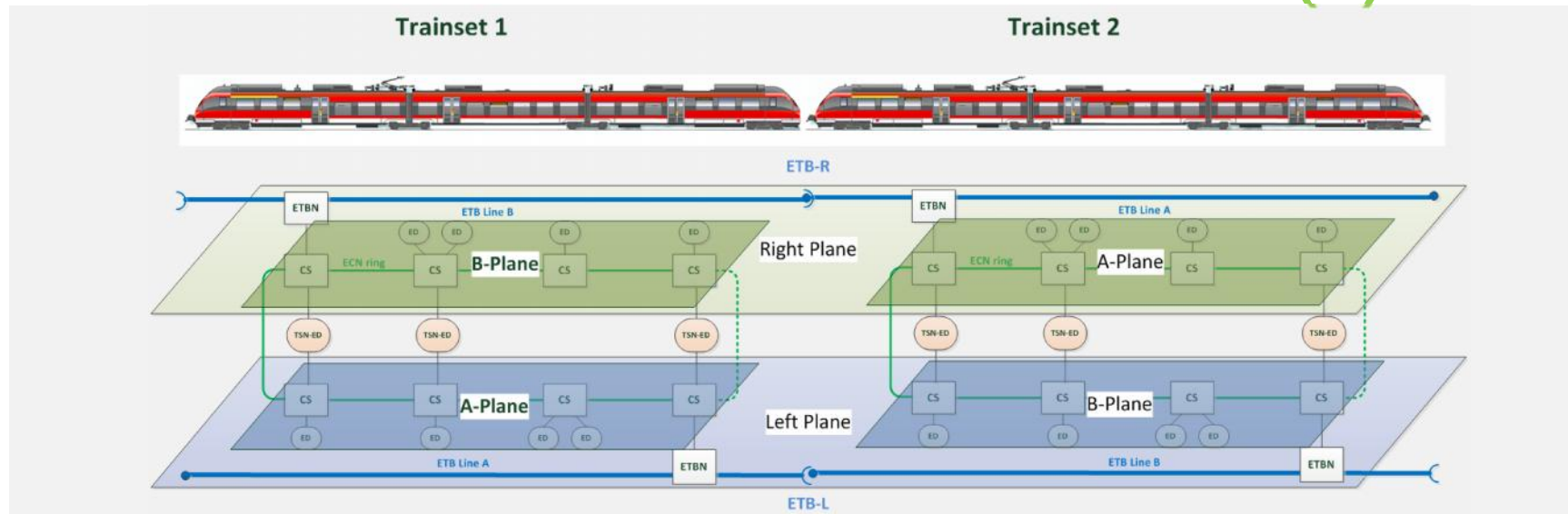
- 2 virtual data planes for reliable scheduled traffic
- Separated GbE ETB Lines along the train (difference to IEC 61375-2-5 !)
- Physical ring topology inside Consist (ECN)

NG-TCN Network Architecture (2)

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

Precise Clock Synchronization

- IEEE802.1AS-rev based train-wide clock synchronization
- 4 redundant grand master clocks in train
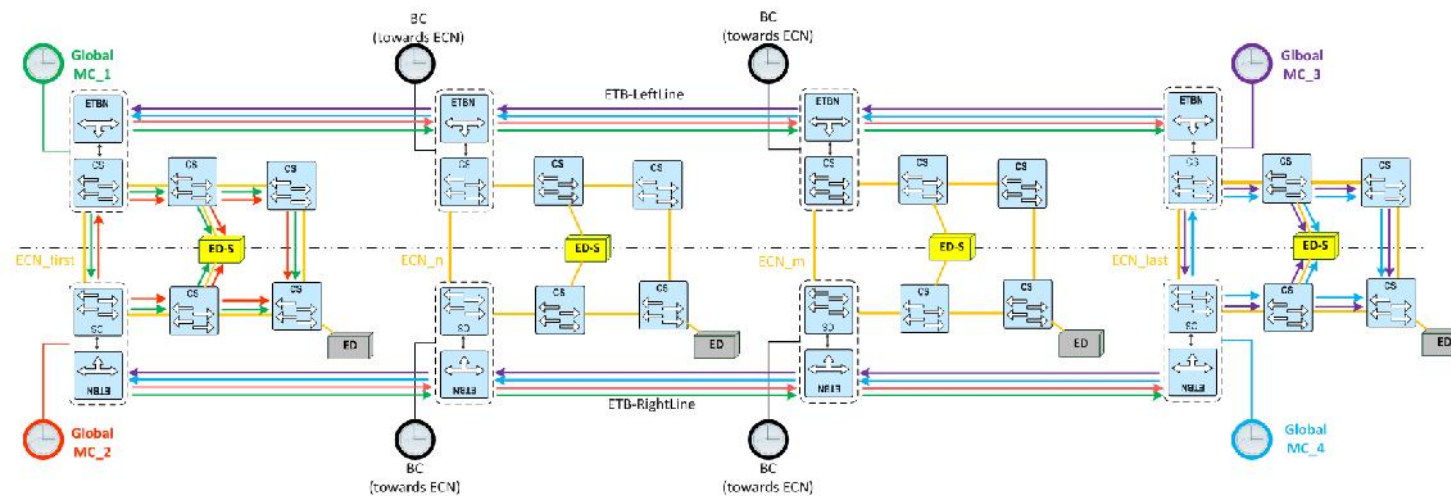
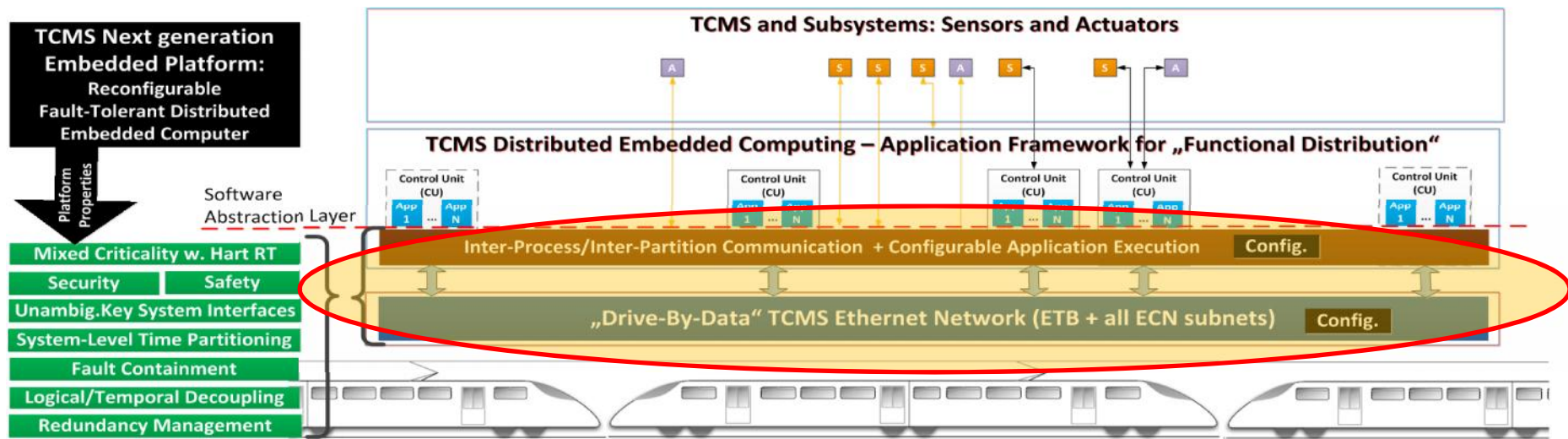# Scheduled Data Transmission (1)
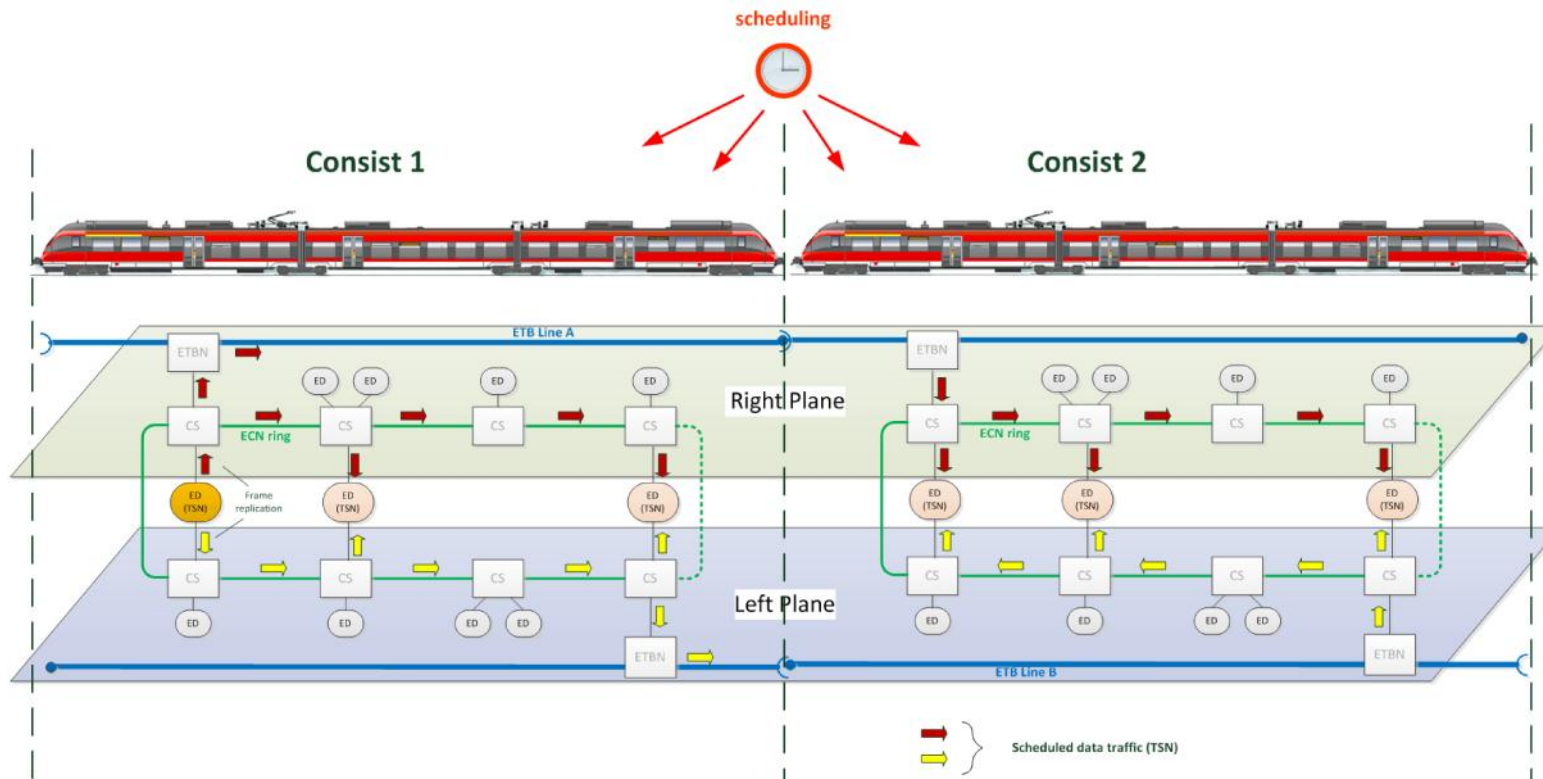
Scheduled Data Transmission (2)

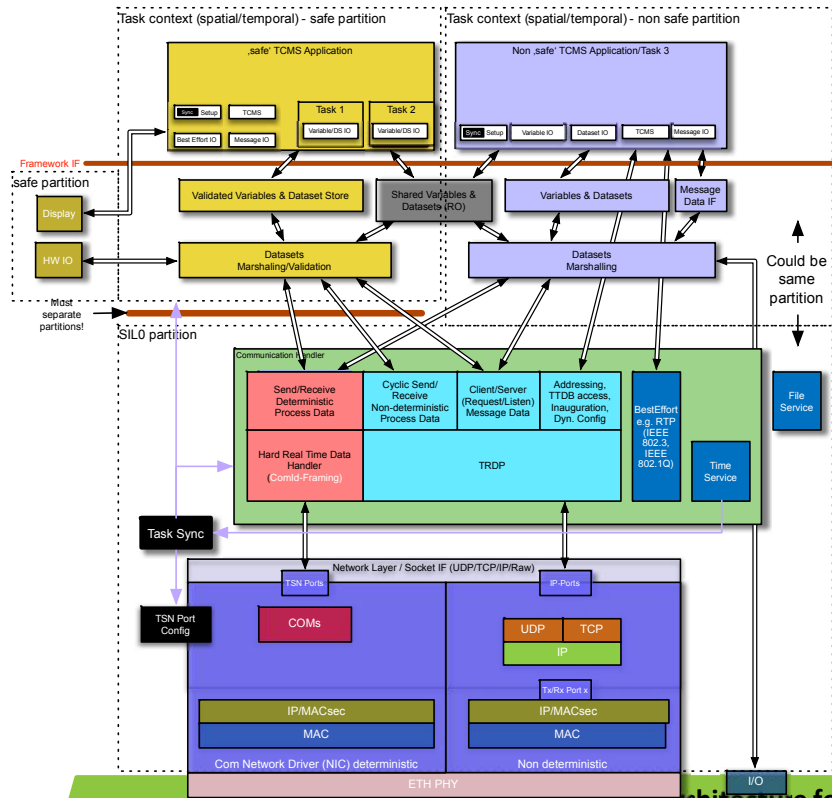Traffic scheduled in each component
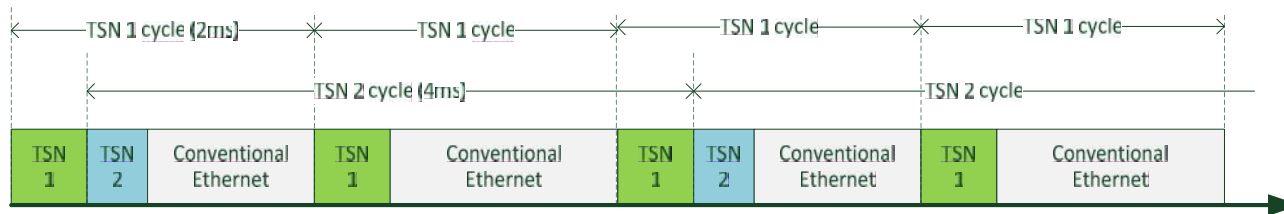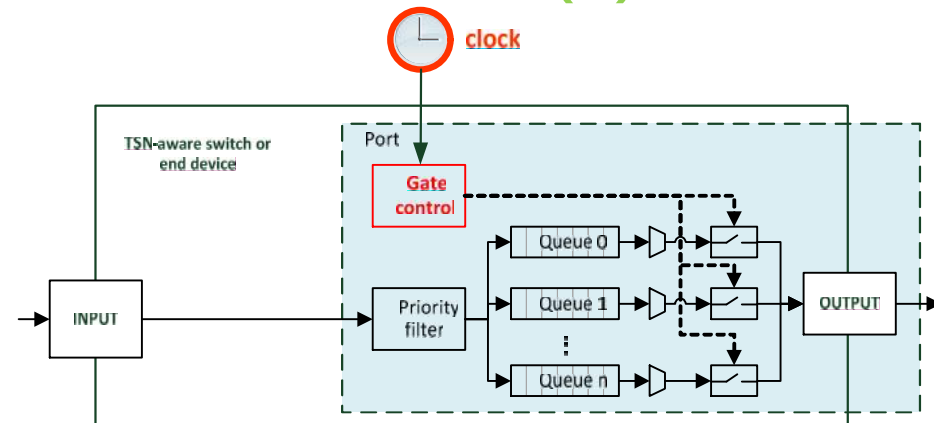
IMP = Integrated Modular Platform

- System Integration Part / Network Communication for „Reconfigurable and Scalable Fault Tolerant Distributed Embedded Computer"

- Viable only with SW platform and network integration as a „standalone" NG TCMS IMP

IMP / FDF / DbD Integration

Applications with function distribution — **FDF**

Middleware with data distribution support

Upper communication layers & network services — **DbD**

Lower communication layers (OSI 1..4) for conventional and scheduled data traffic
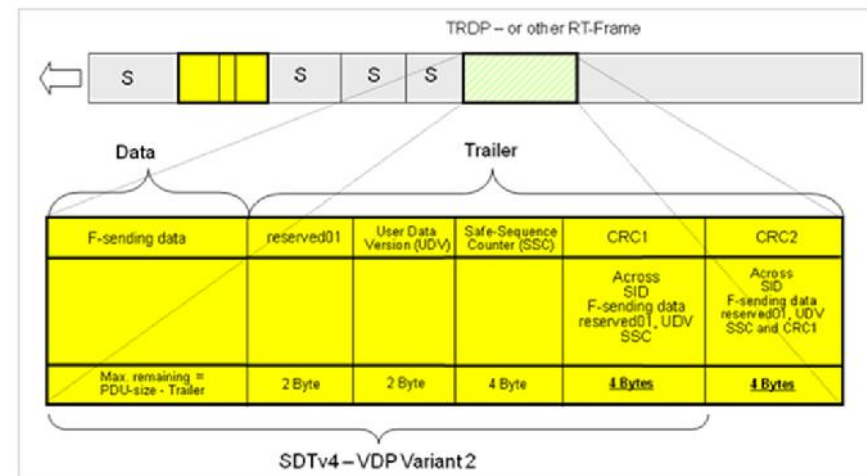
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Safe Data Transmission (SDTv4)

- Trainwide safe data communication
- Enhancement of standardized SDTv2 protocol for supporting functions up to SIL4
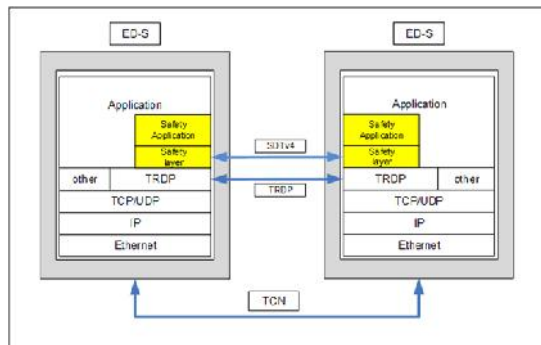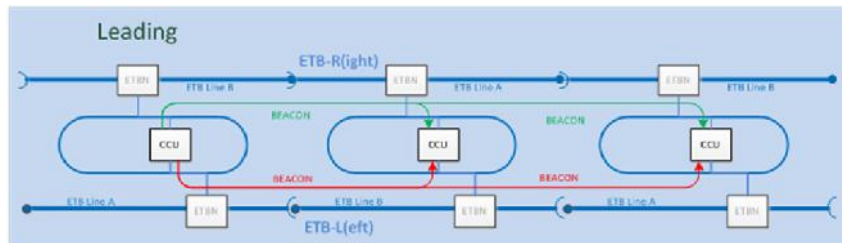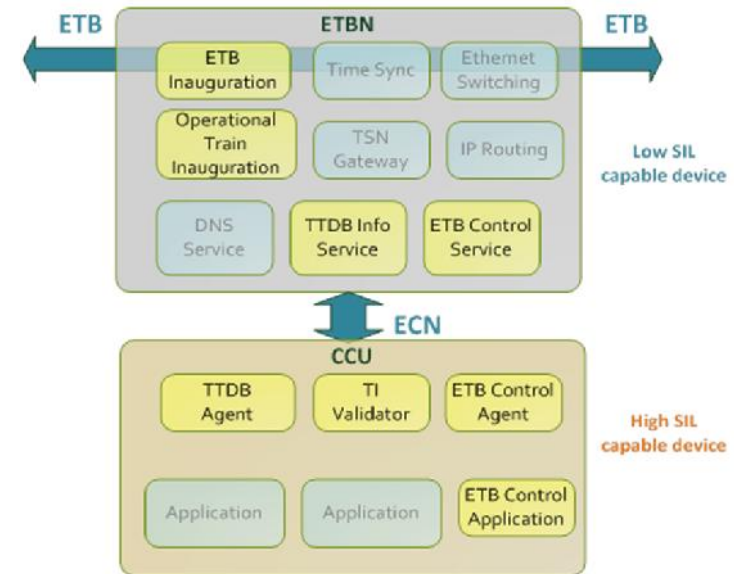

SDTv4 in OSI Model

Safe Train Inauguration

Safe discovery of

- Train directions (driving direction)
- Vehicle sequence
- Vehicle orientation
- Train end

ETB lines as „virtual" train lines

Cooperation of ETBN and CCU

Safety Certification

Study about improved safety approval concept

- generic safety concept for a drive-by-data centric NG-TCMS

- incremental certification through functional separation

- considerations for a generic certification process

- exemplary demonstration of safety case process for two selected train functions, the door function and the brake function
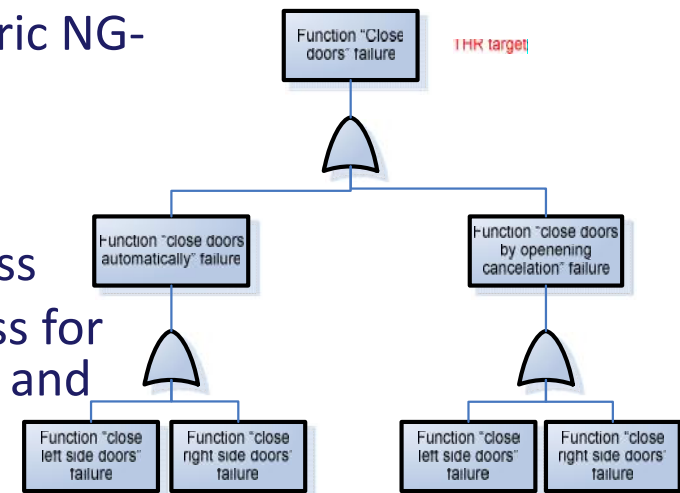
Next station is… (1/2)

- Integrate and test DbD:
  - Definition of test cases and lab setup to test the DbD architecture
  - Development of DbD components
  - DbD in urban demonstrator
  - DbD in regional demonstrator

- Investigate wireless communication:
  - Wireless train backbone (WLTB, using LTE release 14 and 5G technologies)
  - Wireless TCMS (WLCN, using WLAN technologies)

- Launch standardization (IEC WG43, CLC WG15)
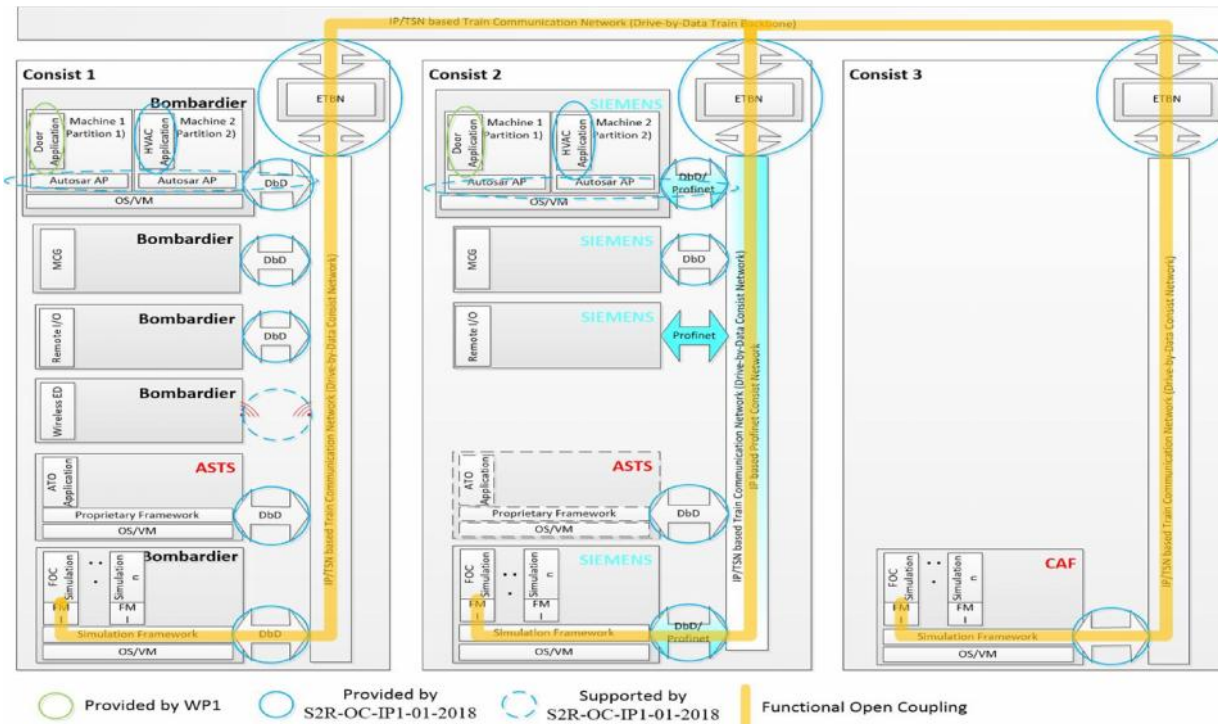
Example:

Regional demonstrator

Conclusions (1)

The main achievements of this work are:

- Introduction of a new **traffic class for scheduled data traffic** based on standard IEEE 802.1Qbv.

- **Clock synchronization concept** based on IEEE 802.1AS-rev and IEEE1588v2 as prerequisite for scheduled traffic.

- Definition of a new network architecture with separated ETB lines and diverse **virtual data communication planes** for scheduled data traffic.

Conclusions (2)

- Supporting **functional distribution framework** and embedding into **integrated modular platform**

- **Safe Data Transmission protocol** and safety layer definition for the transport of safety critical data up to highest safety integrity levels (SIL4).

- **Safe train inauguration concept** for train composition discovery with highest safety integrity levels (SIL4).

- Definition of a **security architecture** and security methods to achieve state-of-the-art cyber security in alignment with actual security standards.

Demo of DbD & Network Simulation
## Short Introduction

DbD Simulation Framework

- Evaluate and validate the applicability of TSN solutions for DbD concepts
  - The V/V processes of train components compliant to TSN protocols are expensive and timely
  - The simulation tools are time and cost efficient alternative for analyzing the temporal and non-temporal attributes of TSN-capable components

- DbD simulation components
  - Configuration Manager
    - Heuristic TT scheduler
    - Network Generator
  - TSN-capable Switches and End-system
    - Time-Aware Shaper (IEEE 802.1Qbv)
    - Ingress Time-based Filtering (IEEE 802.1Qci)
    - Frame Replication and
      Elimination for Reliability (IEEE 802.1CB)
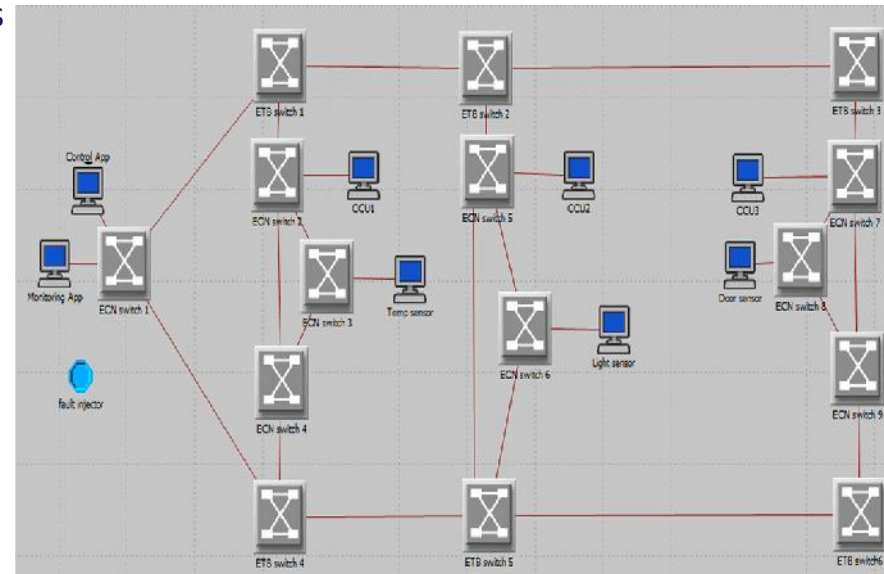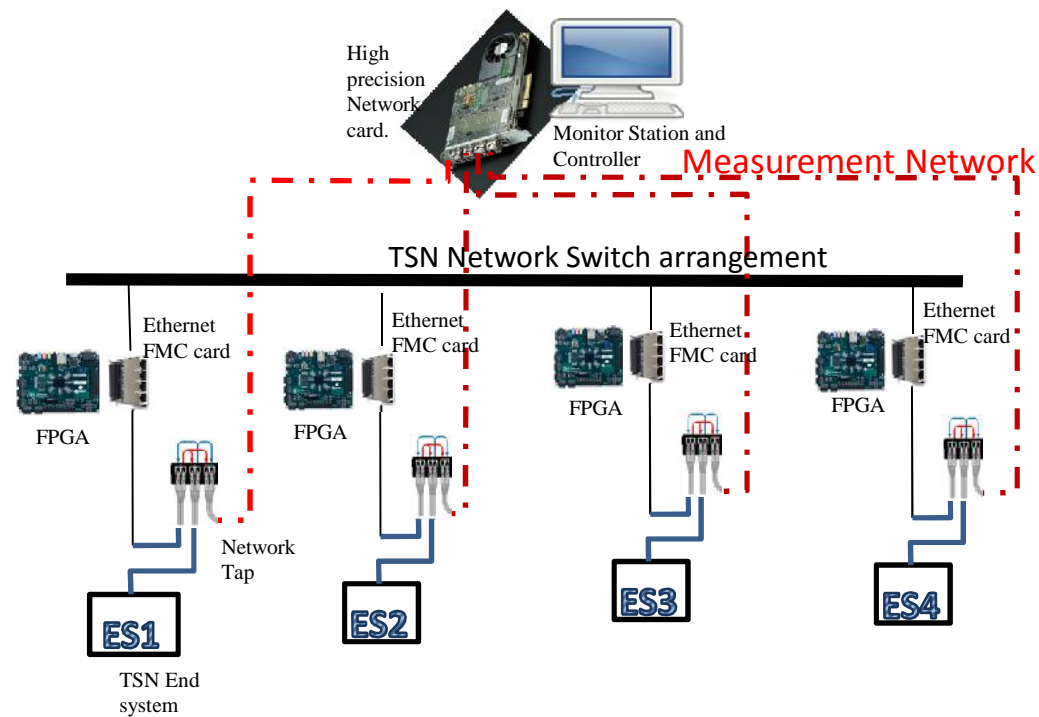
Fault Injection Framework

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