Drive-by-Data & Integrated Modular Platform

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CONNECTA has received funding from the European Union’s Horizon 2020 research and innovation programme under agreement No: 730539. Safe4RAIL has received funding from the Shift2Rail Joint Undertaking under grant agreement No: 730830. This Joint Undertaking receives support from the European Union’s Horizon 2020 research and innovation programme.
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?

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<th>Today</th>
<th>With Drive-by-Data</th>
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| **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)

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

Middleware with data distribution support

Upper communication layers & network services

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

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

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)
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)
Next station is... (2/2)

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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