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 to the Next Generation Train Control and Monitoring System (NG-TCMS)

Shift2Rail TD1.2

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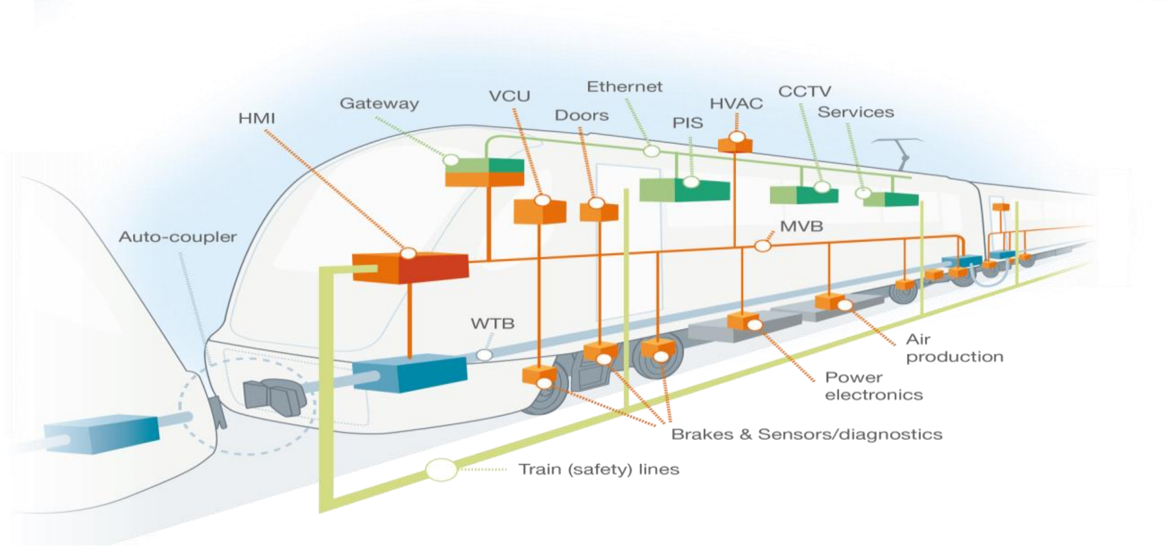
Outline

- Current TCMS: Problems and limitations
- Key Performance Indicator defined within Shift2Rail
- Architecture and underlying technologies proposed for Next Generation TCMS
- Strategy for the quick adoption of technologies
- Adoption of networking technologies from manufacturing, aeronautics and automotive industries
- Adoption of development framework concepts from automotive industry
- Adoption of subsystem supplier knowledge
- Adoption wireless technologies from research initiatives

Current TCMS: Problems and limitations



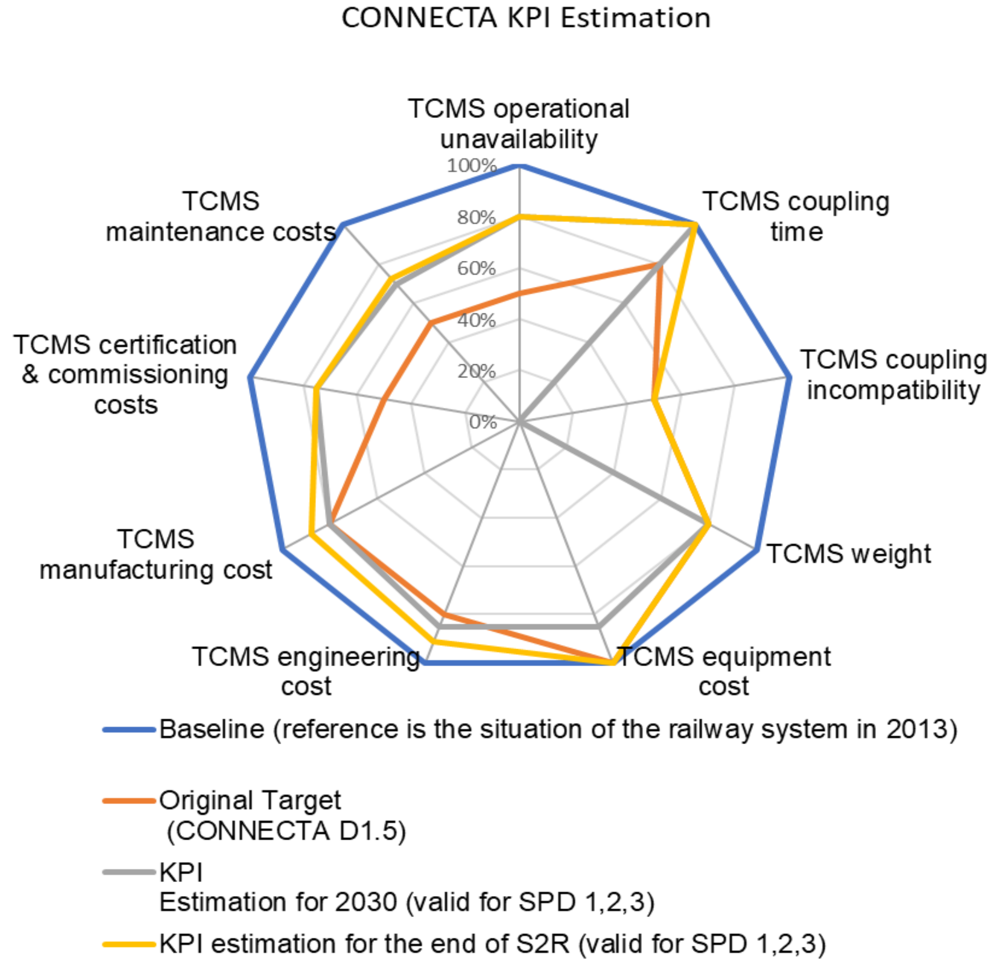
Main stakeholders joined to define the Next Generation TCMS aiming to overcome these problems.

CAF ALSTOM⟺BOMBARDIER SIEMENS SNCF DB

- Multiple buses with different technologies coexist in the same vehicle.
  - Increases the complexity
  - Increases the maintenance cost
  - Reduces the replacement of subsystems
- Each subsystem has its own control unit.
  - Difficults the obsolescence management.
- Many safety functions relay on train lines.
  - Increases the costs and complexity
- There are no standard interfaces between TCMS and subsystems.
  - The interfaces must be agreed with each supplier → Higher engineering costs.

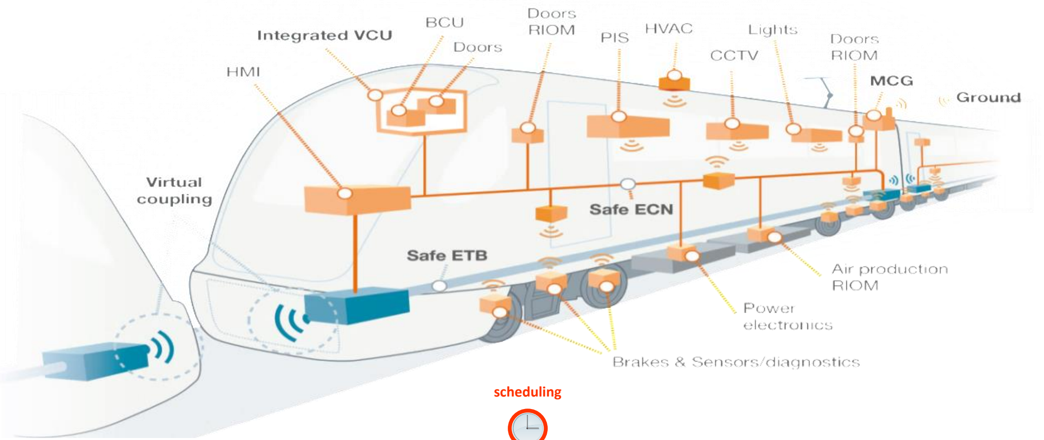
Key Performance Indicator defined within Shift2Rail

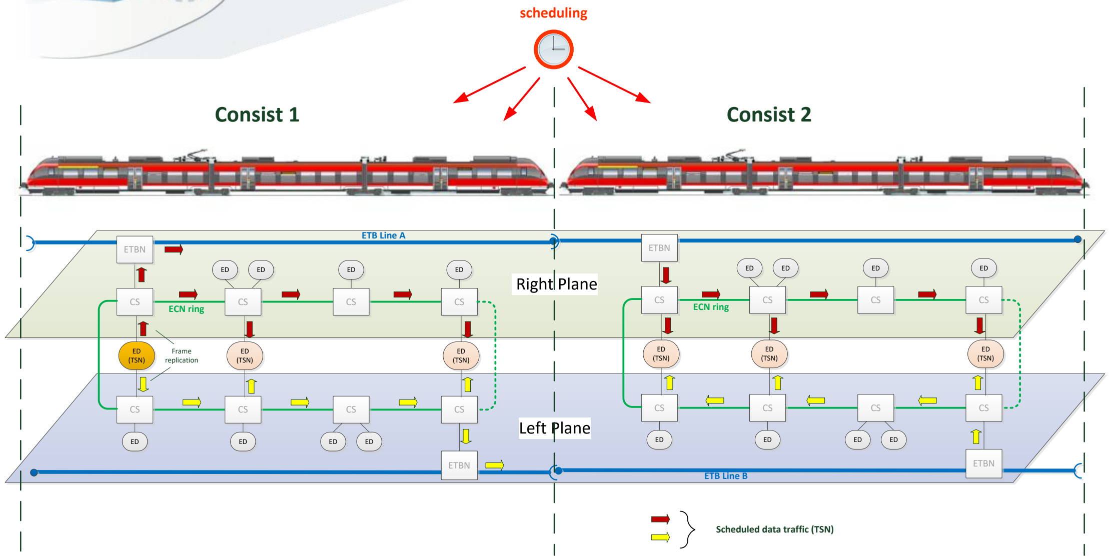
	Target CTA-1	Estimation for 2023	Estimation for 2030
TCMS operational unavailability	50%	80%	80%
TCMS coupling time	80%	100%	100%
TCMS coupling incompatibility	50%	50%	0%
TCMS weight	n/a	80%	80%
TCMS equipment cost	100%	100%	85%
TCMS engineering cost	80%	91%	85%
TCMS manufacturing cost	80%	88%	80%
TCMS certification & commissioning costs	50%	75%	75%
TCMS maintenance costs	50%	73%	70%



Architecture and underlying technologies proposed for Next Generation TCMS

- Single bus technology based on Ethernet with TSN features.
  - Common standard (IEEE) to other industries
  - Broader market, not railway specific
  - Combines deterministic delivery and high thoughput
- Functional Distributed Framework. Centralized Control Unit running different SIL level apps.
  - Common HW platform, less control unit distributed, easier redundancy management.
- Safe Train Inauguration and Safe Data Transmission (SDTv4) protocol up to SIL4
  - Possibility to remove most of train lines.
- Application Profiles and Functional Open Coupling as standardized interfaces
  - Based on well known, de-facto industry standard, SySML models.
- Adoption of wireless technology in consist-level and train-level networks



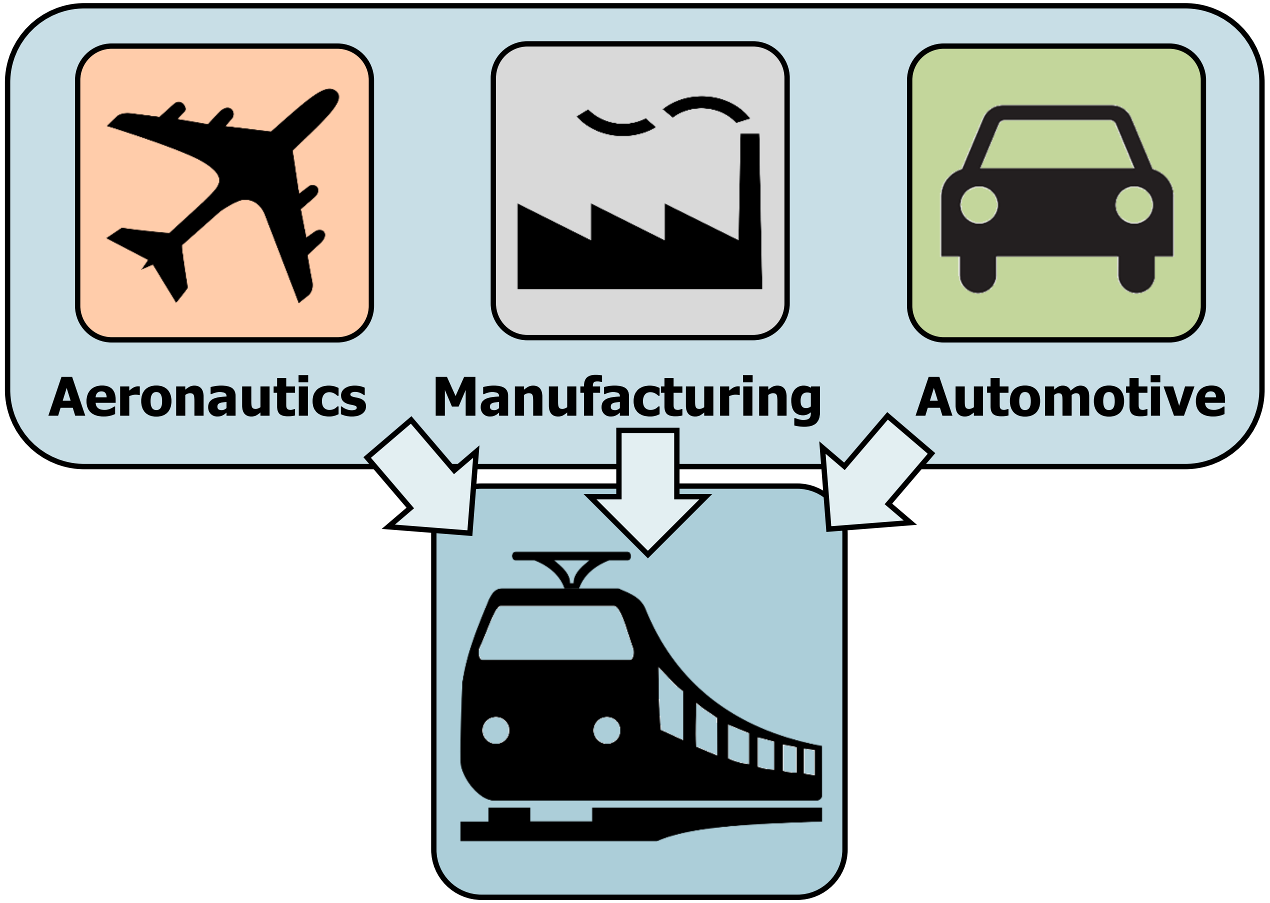


Strategy for the quick adoption of technologies

1. Do not start from scratch, learn from other critical industries tackling with similar problems
2. Common Bus →Inspired in approaches from automotive, aeronautics and automation. All of them working on IEEE TSN.
3. FDF → Inspired on Aeronautics (ARINC) and Automotive (AUTOSAR Adaptive Platform) concepts.
4. Application Profiles → Involving subsystem providers inside and outside Shift2Rail CFMs.
5. Close collaboration with complementary project Safe4Rail-2 bringing all this experience from other vertical industries to Shift2Rail.

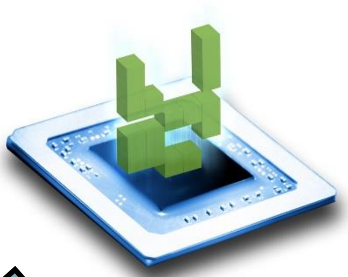
Cross-Domain Approach in CONNECTA-2/Safe4RAIL-2

Proven technologies from other sectors



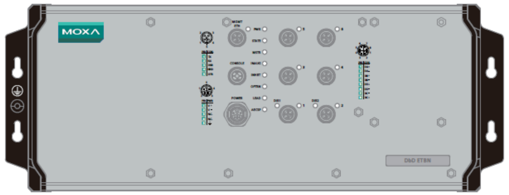
Adoption of Networking Technologies

- Time Sensitive Networking (TSN):
  - Deterministic communications
  - Safe train inauguration
- Interoperability between vendors



TSN IP
TTTech

MOXA
Reliable Networks ▲ Sincere Service



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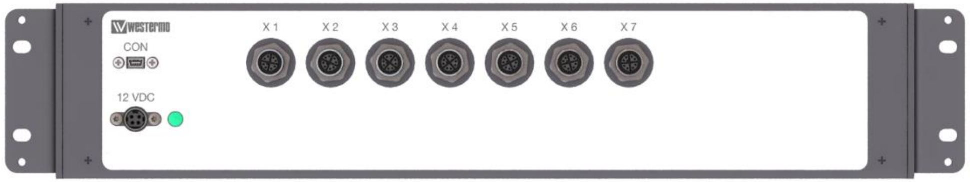
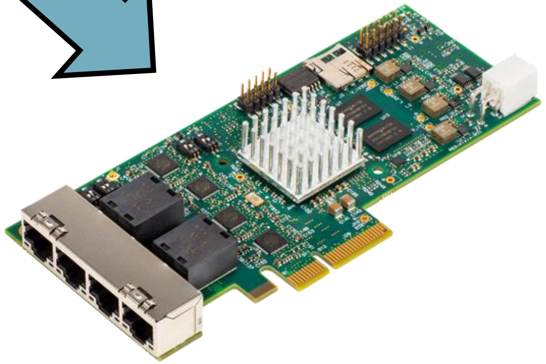




Ethernet Train Backbone Nodes (ETBNs) and Consist Switches (CS)

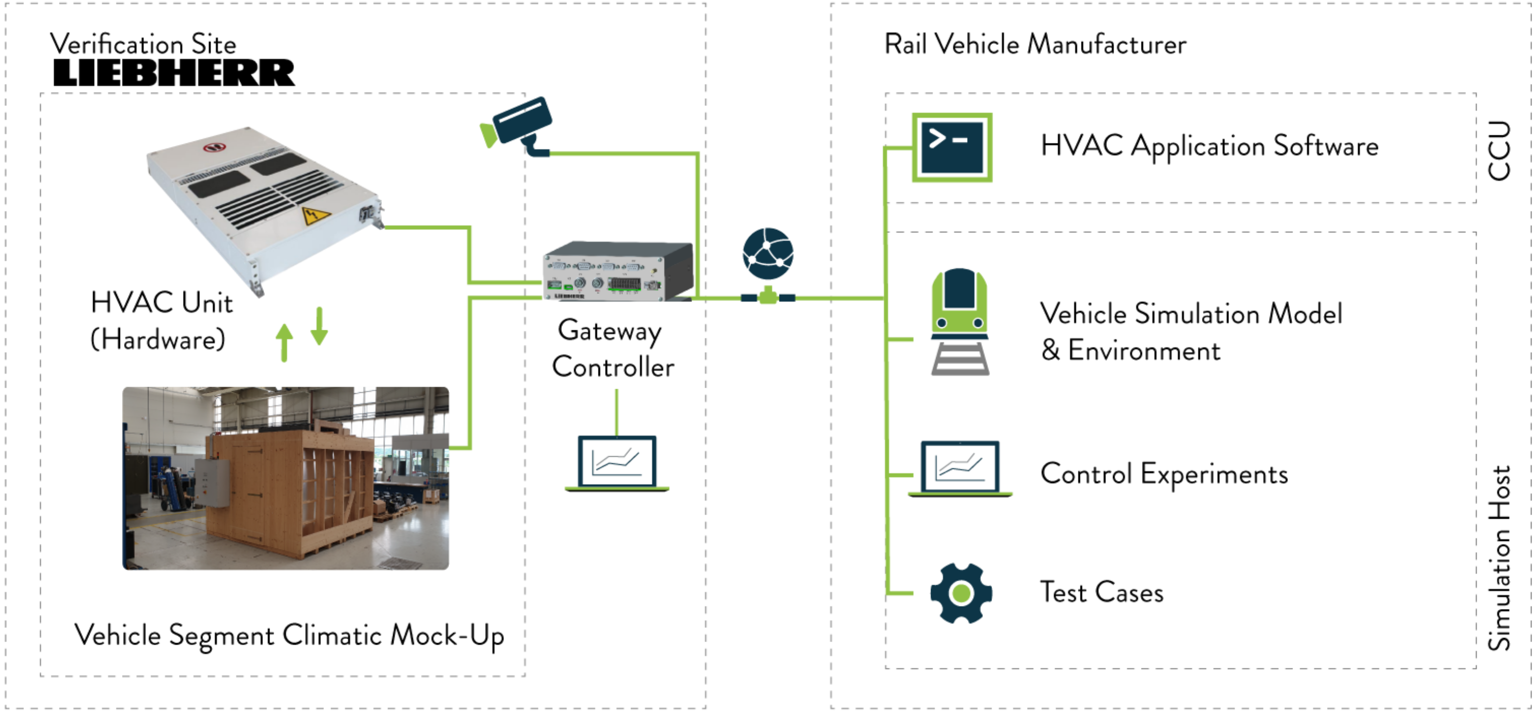
End Devices
TTTech

Adoption of Development Framework Concepts from Automotive Industry

- AUTOSAR Adaptive Platform (Regional Demonstrator)
- FDF Integration with Application Profiles → **same HVAC code** in both demonstrators

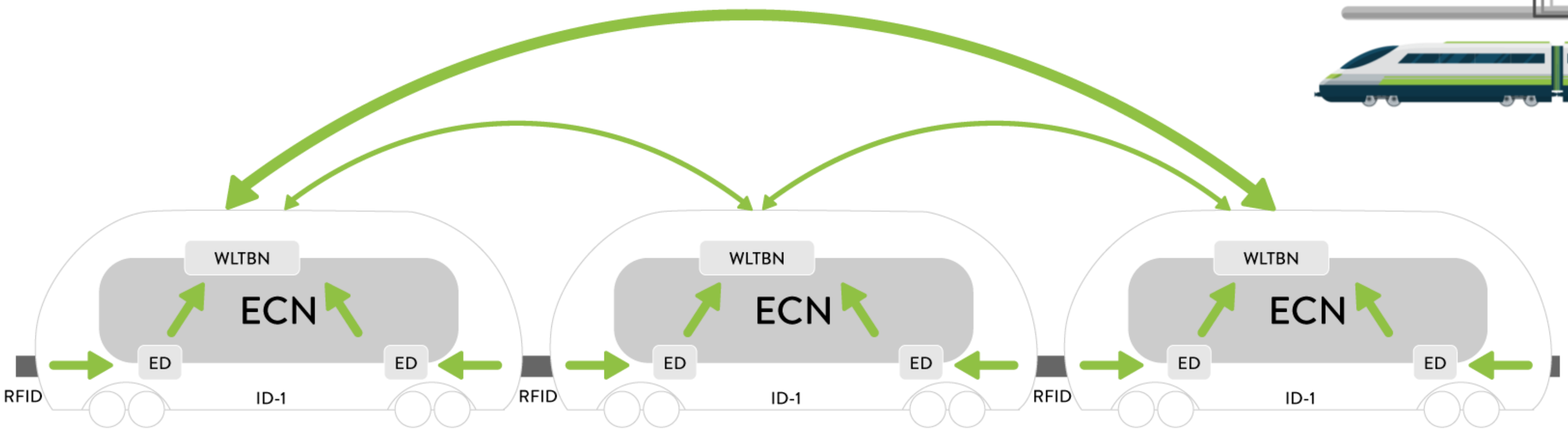
Adoption of Subsystem Supplier Knowledge

- HVAC simulation environments
- Remote HVAC integration
- Subsystem testing and validation



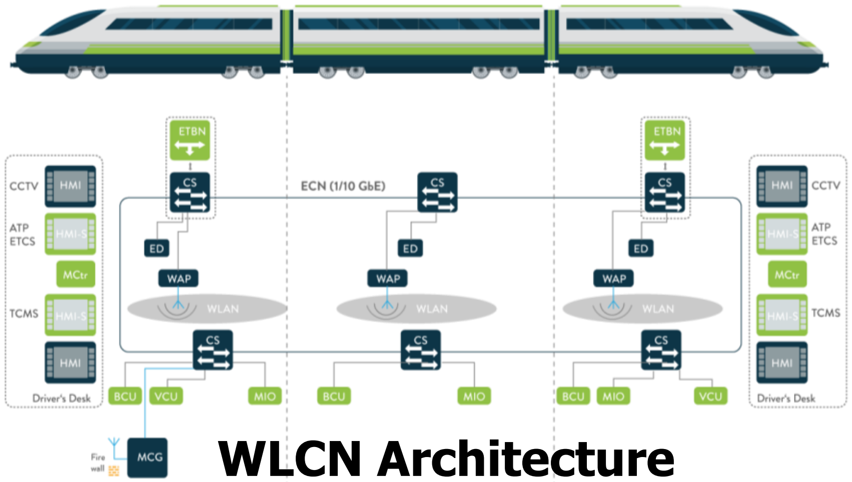
Adoption of Wireless Technologies from Research Initiatives

- **Wireless Train Backbone (WLTB)**
- TCMS radio devices based on vehicular technology (LTE-V2X)
  - Direct UE-to-UE communications in train backbone
  - Implemented with *OpenAirInterface*™ open-source technology

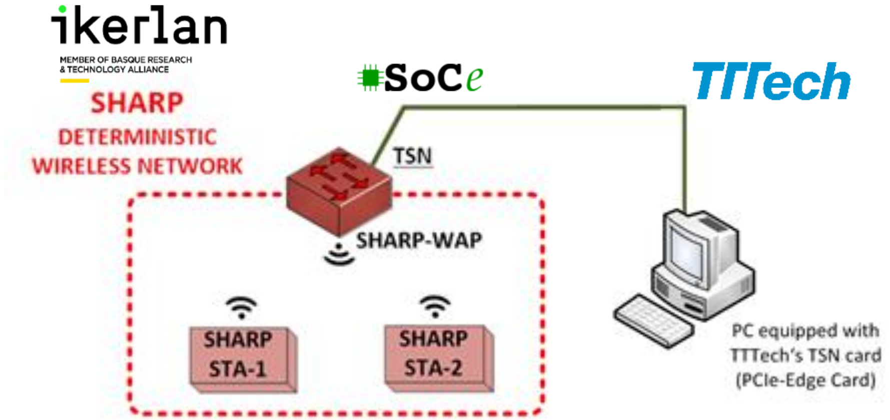


Adoption of Wireless Technologies from Research Initiatives

- **Wireless Consist Network (WLCN)**
- Two solutions:
  - Railway-certified WiFi
  - Wireless TSN → Interoperability between TSN providers

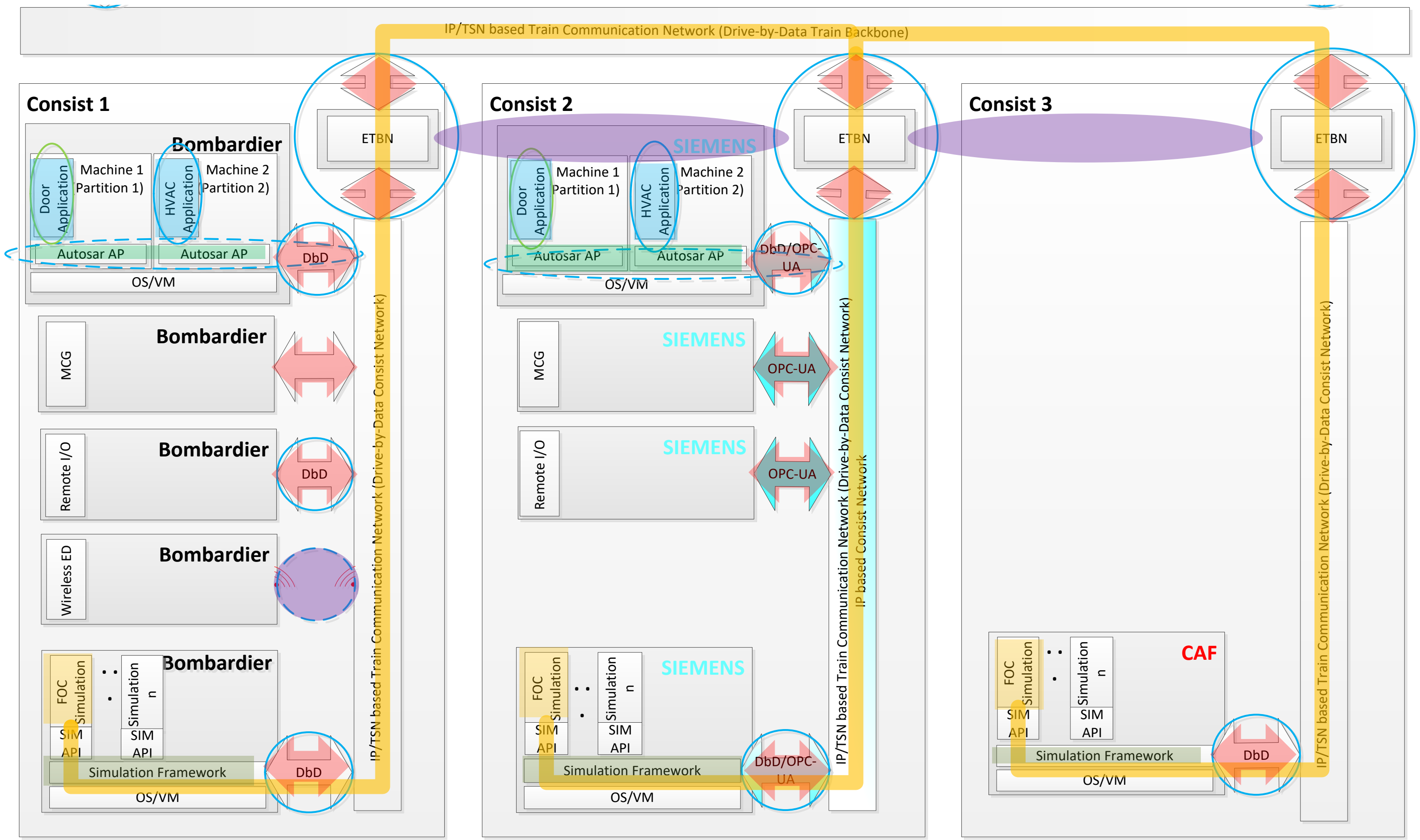


WLCN Architecture



Wireless TSN

Integration of Technologies in CONNECTA-2 Architecture



Functional Open Coupling (FOC)
Drive-by-Data (TSN)
Functional Distribution Framework
Train Subsystems
Simulation Framework
Wireless TCMS