

FOREWORD

To remain as the backbone of the future intermodal transport system, bringing growth, jobs and prosperity, railways will have to be much more autonomous, more capable, flexible, cost-effective and safer. It needs radical change to keep its unique role to the forefront and as the core of the future digital sustainable mobility.

The "Connected Trams" demonstrator showcases several radical innovations in the fields of computing and communications. These technologies will be cornerstone of such future railway system.

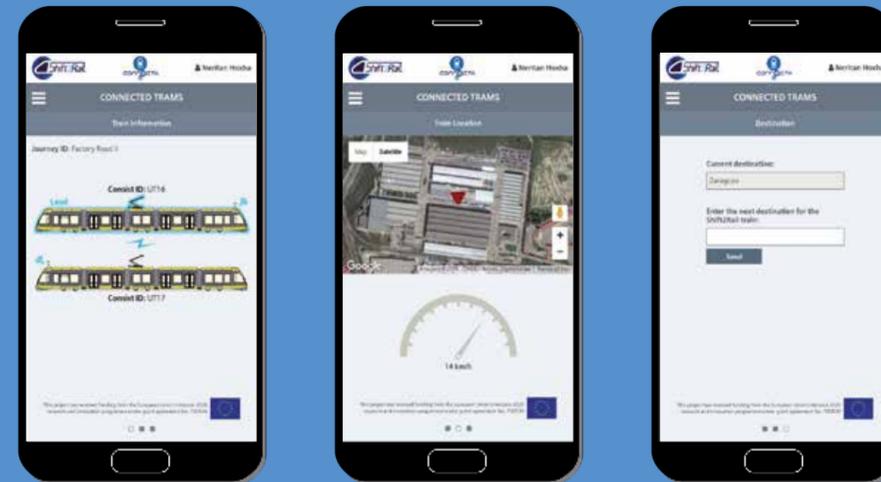
PARTNERS



In that sense, Shift2Rail means a unique set of opportunities to the railway sector to radically transform and re-affirm its key role. The Shift2Rail members Bombardier Transportation, CAF and Siemens Mobility, sharing this vision, proudly present their "Connected Trams" demonstrator, as part of the CONNECTA project.

WEB APPLICATIONS

FRONT END - MOBILE VIEW



WITH THE COLLABORATION OF:



PROVINCIE **UTRECHT** | OPENBAAR VERVOER



HUAWEI

ACKNOWLEDGMENTS

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To find more, please visit the video of "Connected Trams" by scanning the code



THE CONNECTED TRAMS DEMONSTRATOR

Showcase of the next generation
of the Train Control and
Monitoring System



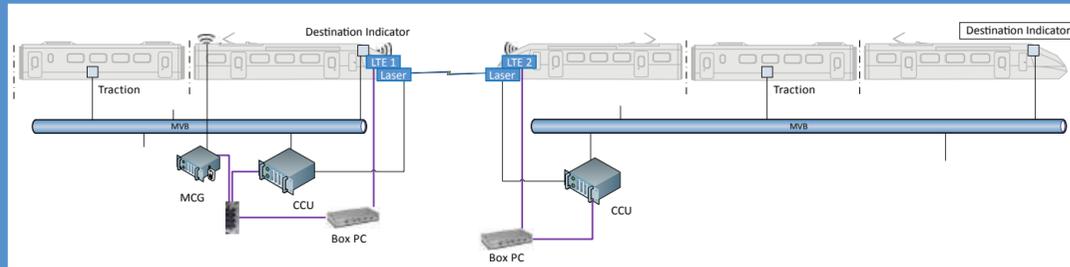
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No: 730539



WIRELESS TRAIN BACKBONE

The Wireless Train Backbone (WLTB) is an evolution of the Ethernet Train Backbone (ETB) which allows the use of wireless technology for consist-to-consist communications. The WLTB is based on LTE technology due to its maturity and its efficient radio access management. Due to the radio resource scheduling capabilities of LTE, a reliable and scalable communication can be established between the coupled trams. Compared to 802.11-based wireless networks, the LTE technology deploys a radio access scheduling, avoiding possible collisions between different users in the wireless network. In "Connected Trams" CAF has replaced the trams' ETB

by a fully operational WLTB. As the current LTE release does not provide native multicast support in its uplink, needed for the TRDP Process Data traffic, two BoxPCs have been used to create a L2 tunnel, which makes the wireless backbone transparent to both trams equipment, forwarding all traffic from one unit to another. The "Connected Trams" demonstrator evidences that the adoption of the WLTB, besides the reduction of costs associated to wiring and physical connectors, allows new disruptive applications for the railway operation.



VIRTUAL COUPLING

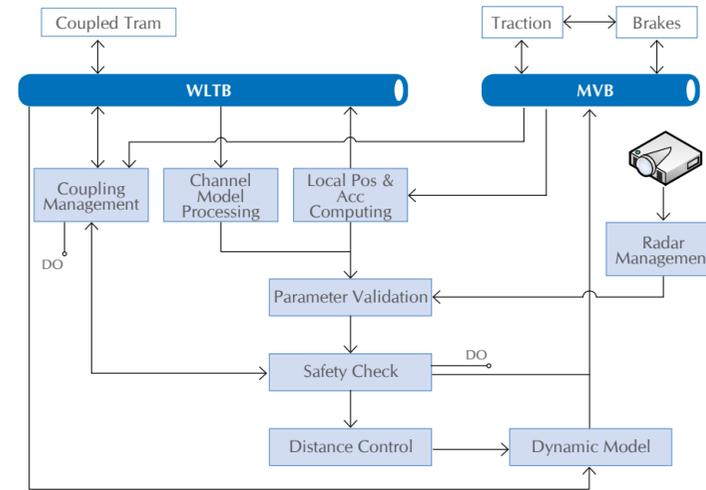
Virtual Coupling of trains is said to be a new paradigm in railway operation, proving much higher flexibility, full interoperability, reduced costs and travel times, and maximizing the capacity of lines and stations. This technology allows trains run closer together without any physical connection, building platoons of trains, where the headway between them is reduced to some meters and is far below the absolute braking distance. Coupling and uncoupling can eventually be done on the move, enabling new operational concepts and optimum use of the infrastructure.

Splitting convoys when arriving at stations and re-joining when leaving them will allow shorter platforms and shorter walking distance for passengers, while reducing stopping times.

An additional benefit of the virtual coupling relies on the complexity (and cost) reduction by shifting most of the traffic control from the infrastructure to the vehicles (vehicle centric approach). Indeed, trains will talk to each other and, potentially, to infrastructure artifacts, while minimising the required signalling equipment.



For the first time, a prototype of the virtual coupling has been developed and tested on two tramways. Based on the new wireless train backbone defined within Shift2Rail, CAF designed the virtual coupling solution as a two-layer architecture with multiple sensors and data fusion, which uses an embedded vehicle model to get smoother control and better stability.

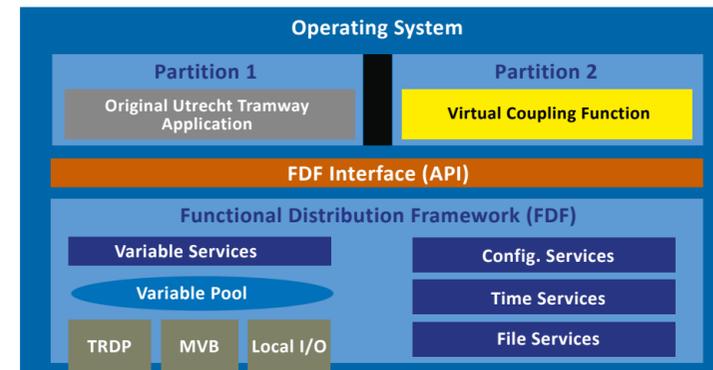


The virtually coupled vehicles behave like normal mechanically coupled consists, as the ETB is replaced by a fully operational WLTB and the train lines are managed locally by I/Os. The virtually coupled tramways safely reduce the headway to few metres, far below the absolute braking distance. As a consequence both tramways move in a coordinated manner, keeping the established headway (approx. 1-2 seconds), and are always protected by the implemented safety measures.

The amount of collected data and gained experience will pave the way for further research activities and the implementation of more complex prototypes, involving more than 2 trains, and manoeuvres like joining or leaving the convoy on the move. The proposed solution and its prototype here presented pioneer the development of the virtual coupling technology, which will mean one of the cornerstones of the future railway system.

FUNCTIONAL DISTRIBUTION FRAMEWORK (fdf)

Another innovation introduced by CAF in the demonstrator is the functional architecture as a new onboard computing approach. The partitioning mechanism of the developed middleware allows the integration of the virtual coupling function through a common interface without altering the original application of the tramways and preventing the new function to misuse communication networks and other hardware resources.



NEW STANDARDISED TRAIN-TO-GROUND (T2G) COMMUNICATION

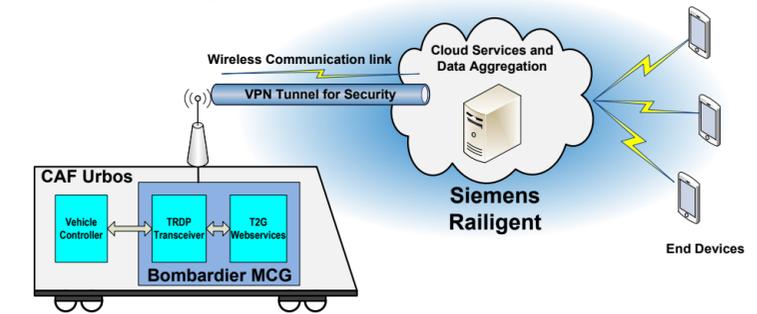
Today proprietary vehicle manufacturer solutions enable railway vehicles to communicate with the railroad operator, however this lacks interoperability. In the future, standardised train to ground communication mechanisms, will enable great opportunities for railway operators to employ new digitalisation solutions, e.g. for fleet management and passenger information, across their entire fleets.

The new standard IEC 61375-2-6 resolves this problem. It describes a unified train-to-ground communication solution for railway vehicles utilising standard web protocols. The included service primitives will get offered by future railway vehicles conforming to this communication standard.

A Mobile Communication Gateway (MCG) is the core train to ground communication component installed in railway vehicles. The IEC 61375-2-6 standard defines the communication services to be offered by the MCG.

Accordingly, Bombardier applied the new IEC 61375-2-6 standard within the "Connected Trams" demonstrator to develop an MCG which is using a standardised network protocol (TRDP) to connect to the vehicle network installed in the tram. Using the standardised train to ground services, the MCG uses a protected communication link to connect to a cloud service provided by Siemens on the ground side.

Seamless Digitalization via Webservice Protocols



By specifically defining an interactive service for this demonstrator, deployed to run between the tramway (vehicle control unit by CAF and the MCG by Bombardier) and the cloud solution by Siemens, it is possible to demonstrate the inherent advantages of interoperability and tangible digitalisation as a one of the key innovation drivers. The next phases of Shift2Rail will continue to define advanced and streamlined infrastructure solutions for railway operators, fostering the digitalisation and guaranteed interoperability of rolling stock.

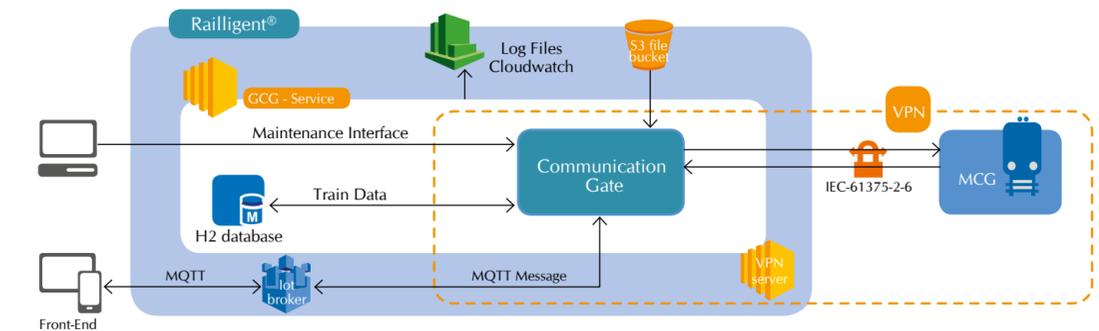
MOBILITY AS A SERVICE (MaaS)

Talking about the digitalization in the railways, innovations and future transportation, we mean first of all a robust connectivity, access and data collection in a secure way, generating more value from the data and provide added value to the customers in a form of reliable solutions and services. At the end we are about providing Mobility as a Service (MaaS) and the connectivity is a first key (point) to all subtopics of it; be it communication train-to-ground or consist-to-consist, virtual coupling, autonomous driving or generating intelligent services.

Pushing the standardisation and introducing the innovative state-of-the-art IT technologies in the railways sector, Siemens Mobility contributes to the "Connected Trams" demonstrator by:

- Implementation of new train-to-ground communication standard IEC-61375-2-6, which is one of deliverables of previous Shift2Rail activities;
- Architecture development for the Ground Communication Gateway (GCG), and;
- Mobile / Web Application as an Interface (UI) to real-time train data, interaction with trains as well as an example of easy handled customer services.

GCG-Service as well as Mobile Apps is based on proven state-of-the-art IT technologies like HTTP/s, JSON, MQTT, VPN, OKTA, OAuth 2.0 etc. Avoiding a proprietary protocols and using the standard IT mechanisms and solutions allows an interoperability and easy coupling of trains and units made even by different manufacturers.



Both services are developed and allocated in the run-time environment on the Railligent® - cloud-based mobility-platform for digital services. Being based on the approved technologies from the digitalization world, Industry 4.0 and Internet of Things (IoT), the platform-based approach forces reusability, saves resources and enables fast prototyping and generation of innovative intelligent solutions and services. At the same time it ensures 100-percent availability, high security and sustainability of the mobility, for today and the future.