SCOTT:
Secure COnnected Trustable Things

Smart Train Composition Coupling Demonstrator

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1 EXECUTIVE SUMMARY

The currently coupling system available at the railway industry is based on a mechanical and physical joint between two or more compositions. The problem of this system is the need of time without operation for the works and the slow manoeuvres, with On Track operator to assist the operation. The consequences of these disadvantages are the inefficiency of the rolling stock services, due to the need of facilities such as station or shunting yard for the movement, and less workers safety.

The virtual coupling developed in the WP19 ensures a safety manoeuvre avoiding the physical joint between the trains but with one of the train assuming the control of both compositions, without the need of the operators between both compositions and the possible risks of the manoeuvres. In addition, the virtual coupling phase can be deployed when both compositions are in movement, using part of the route for the coupling with a normal operating speed. With this system, which uses the wireless communications between trains for the manoeuvres, the need of a specified facility for the joining is suppressed and also the time penalty of the slow manoeuvres.

Figure 1: WP19 – Overall View

Key words: virtual coupling, smart train

2 LIST OF AVAILABLE DEMONSTRATORS

2.1 Demonstrator A

2.1.1 Demonstrator title

Smart Train Composition Coupling.

2.1.2 Demonstrator location

The scenario considered is Havelländische Eisenbahn AG (HVLE), located near Berlin in Germany. For this scenario, it will be used the location known as "Location 1".

The location 1 is placed near to Elstal station and the length is 3 kilometres. The movements will be carried out from Location 1A to Location 1B approximately, which are indicated below.

- Location 1A
    - Location: 52°32'51.83"N, 12°59'14.92"E
- Location 1B
    - Location: 52°32'43.00"N; 13° 1'54.73"E

2.1.3 Demonstrator Partners

Following, the participating partners in this demonstrator are enumerated:

- Indra Sistemas S.A. (INDRA)
- Instituto Técnologico de Informática (ITI)
- Mondragon Unibersitatea (MGEP)
- Universidad Politécnica de Madrid (UPM)

2.1.4 Functional description

2.1.4.1 Key functionalities

The "*Smart Train Composition Coupling*" demonstrator aims to evaluate the properly management and control of multiple compositions via remote control form only one of them. The key functionalities of the demonstrator includes:

- Collect and report positioning information from the wireless sensor network:
    - Speed that represents the current speed reported by the GPS.
    - GPS location that represents the current GPS position of the train.
    - Kilometre Point (KP) that indicates the current KP in which the train is at the moment.
- Collect and report proximity information from the wireless sensor network:
    - Distance
- Secure wireless communications Vehicle-to-Vehicle (V2V)
- Handle safety decisions and procedures for the coupling and uncoupling manoeuvres.

- Monitor and establish communication between the train composition and the train driver.

2.1.4.2 Key components (list of Technology Building Block)

The following Building Blocks (BB) are involved in the WP19 demonstrator:

- BB23.A "*Dependable Wireless Sensor Network with enhanced energy, robustness and QoS trade-off*"
- BB23.J "*Reliable Wireless Multi-hop Communications*"
- BB23.K "*Reliable Wireless PHY and MAC*"
- BB23.Q "*Towards a Safe Virtual Coupling*"
- BB26.A "*Autonomous Wireless Network*"

2.1.4.3 Simplified architecture of the demonstrator

A simplified structure for the WP19 demonstrator is shown in the figure below.

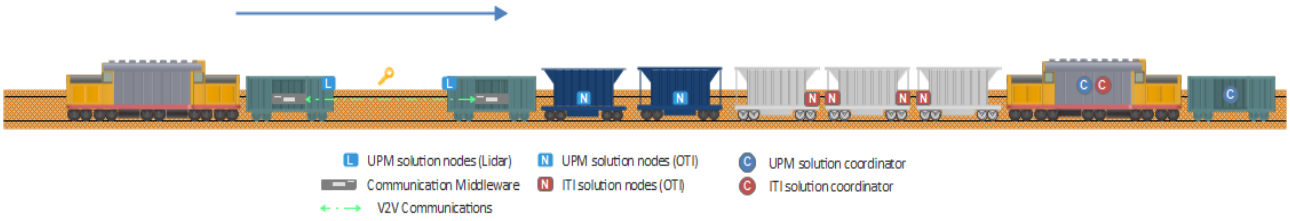

Figure 2: WP19 – Simplied structure of the demonstrator

2.1.4.4 Media (links to videos, pictures, diagrams)

2.1.4.4.1 Location

The following figure shows the different locations that are considered for the WP18, WP19 and WP20 demonstrators. Although, for this demonstrator is only considered from the location 1A to location 1B.

Figure 3: Locations Track and route between them on satellite picture of the area

2.1.4.4.2 Rolling Stock

The rolling stock chosen for the demonstrator is shown in the pictures below. It is distinguished between the traction and the wagons.

The locomotive V160 has been selected for the tests due to the bidirectional capabilities that are useful for the WP19 demonstrator.

Figure 4: Locomotive V160

Concerning the composition for the demonstrator, there are two different wagons required. One the one hand, it is necessary a flat wagon (See Figure 5) to install a cage with all the equipment for the communications.

Figure 5: Flat Wagon

On the other hand, the wireless sensor networks will installed on two types of wagons: White Hopper (See Figure 6) and Super Self Discharging Train (SSDT) (See Figure 7)

Figure 6: Faccns Hopper Wagon

Figure 7: SSDT Hopper Wagon

2.1.4.4.3 Wireless Sensor Network

In order to calculate the distance between trains, the LIDAR technology has been developed. The sensor is shown in the figure below.

Figure 8: Lidar Node

The properly operation of the Lidar for the virtual coupling manoeuvres is explained in a video that is available at the AVL platform.

https://projects.avl.com/16/0094/WP19/Documents/04_Documents/WP19_BB23.I_Test_lidar_distance_VC.avi

In addition, in each wagon will installed wireless sensor nodes (See Figure 9) for collect information about the position.

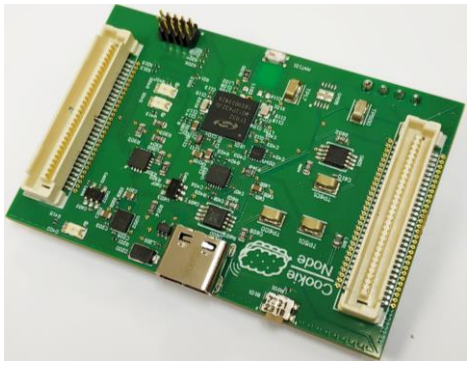

Figure 9: BB23.A node

2.1.4.4.4 Wireless Sensor Network Coordinator

The entity in charge of collect all the information gathered by the sensors and send it to the communication middleware is the wireless sensor network coordinator.

In Figure 10 is shown the WSN coordinator provided by ITI.

Figure 10: Wireless Sensor Network Coordinator

2.1.4.4.5 Communication MiddleWare

The hardware used for handle application messaging, formatting and representation is shown in the figure below. In order to perform the coupling manoeuvre, each train has to be equipped with one communication middleware.

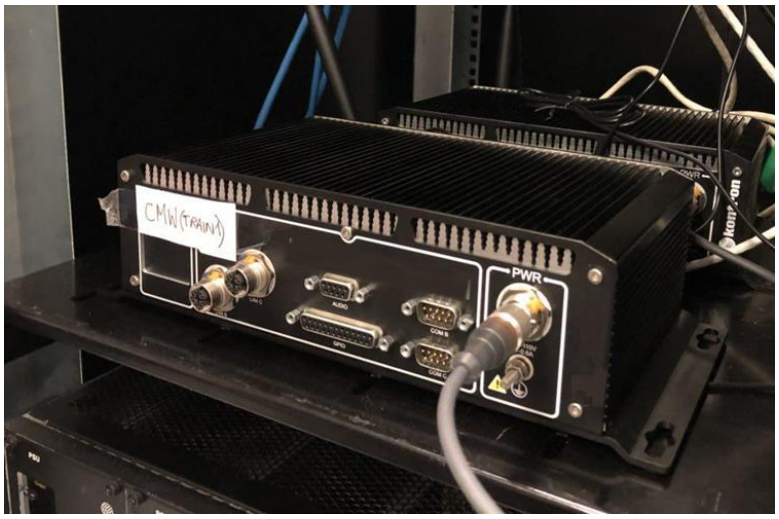

Figure 11: CMW hardware

2.1.4.4.6 Communications

For the wireless communications between trains (V2V), there have been developed two solutions. On the one hand, is the commercial solution that has been tested before at Indra facilities in Madrid.

Figure 12: V2V test laboratory

On the other hand, is the solution performed within BB23.K "*Reliable Wireless PHY and MAC*" in order to enhance the reliability of the wireless connectivity in railway scenarios.

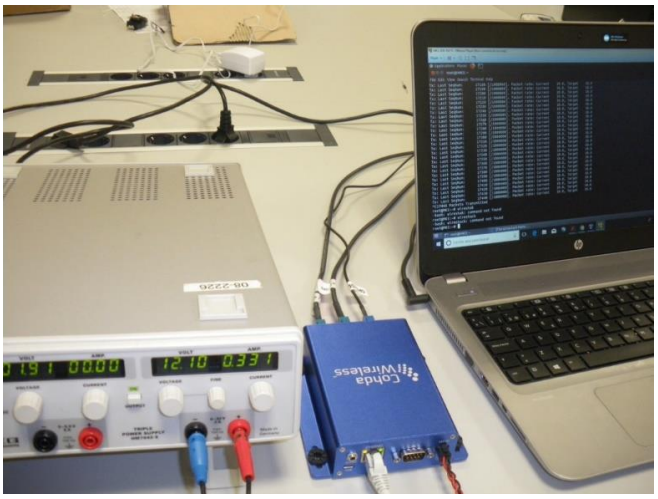

Figure 13: Cohda MK5 OBU equipment

A. ABBREVIATIONS AND DEFINITIONS

Term	Definition
BB	Building Block
HVLE	Havelländische Eisenbahn AG
INDRA	Indra Sistemas S.A.
ITI	Instituto Tecnológico de Informática
KP	Kilometre Point
MGEP	Mondragon Unibersitatea
SSDT	Super Self Discharging Train
UPM	Universidad Politécnica de Madrid
V2V	Vehicle to Vehicle