SHIFT2RAIL
Innovation Programme 2
Advanced Traffic management and Control Systems

FIF
Levallois
2015 December, 15th

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Context and objectives of the Innovation Programme 2

Context

- IP2 Fields: Telecommunications, Train Separation, Supervision, Engineering, Automation, Security
  → Enhancement of performances, availability, easiness in terms of application, cost reduction
- Backward compatibility with ERTMS system + extension to all the railway transportation segments (High Speed Lines, Regional, Urban & Suburban, Freight)
  - Integrating existing ERTMS standards + typical CBTC functionalities

Global objective

- The goal is to develop a new generation of interoperable signaling and control systems, on top of current ERTMS standards, enabling intelligent traffic management, improving automation on board, and safe train control as well as high performance and resilient communication networks.

Context and objectives of the Innovation Programme 2

Objectives

- Keeping the dominance of ERTMS as a solution for railway signaling and control systems across the world, while:
  - Extending synergies and interoperability to urban and mass transit railway sectors
  - Speeding up the time-to-market
- Ensuring continuity and backward compatibility with the current signaling and supervision systems through ERTMS standards but fostering the highest integration possible in terms of technology, operational rules, engineering processes, supervision and communication network
- Main goals:
  - Improving interoperability
  - Achieving high performance
  - Reducing cost (CAPEX and OPEX)

→ Strong integration of different technologies coming from segments today not familiar with Railway application

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Structure of the Innovation Programme 2

IP2 scope

- Signaling systems and technology
  - Moving Block, Virtual coupling, Safe train Integrity, Safe Train Positioning
- Signaling architecture
  - Smart object controllers
- Supervision and Automation Systems
  - Traffic Management System, On board Automatic Train Operation (ATO)
- Communication Networks and Security Systems
  - New communication systems, Cyber security
- Engineering, Testing & Validation processes for designing and complete verification of a signaling & supervision system
  - Formal methods and standardization
  - Zero On-site testing

IP2 Technical Demonstrators (TD)

TD Description	Funding Member TD leader	Who	email
TD2.1: Adaptable communications	SIEMENS / THALES	Anne-Sophie Chazel / Peter Nuechter	anne-sophie.chazel@siemens.com / peter.nuechter@thalesgroup.com
TD2.2: Railway network capacity increase	ALSTOM	Benoit Bienfait	benoit.bienfait@transport.alstom.com
TD2.3: Moving Blocks	SIEMENS	Simon Chadwick	simon.chadwick@siemens.com
TD2.4: Fail-Safe Train positioning	ANSALDO STS	Christian Lotti	christian.lotti@ansaldo-sts.com
TD2.5: On-Board Train Integrity	ANSALDO STS	Gianluigi Fontana	gianluigi.fontana@ansaldo-sts.com
TD2.6: Zero on-site testing	THALES	Hans-Peter Koerrenz	hans-peter.koerrenz@thalesgroup.com
TD2.7: Formal methods and standardization for smart signaling systems	TRAFIKVERKET	Christer Lofving	christer.lofving@trafikverket.se
TD2.8: Virtual-Coupled Train Sets (VCTS)	ANSALDO STS	Bertil Sjöbergh	bertil.sjoebergh@ansaldo-sts.se
TD2.9: Traffic management evolution	BOMBARDIER	Roland Kuhn	roland.kuhn@de.transport.bombardier.com
TD2.10: Smart radio-connected all-in-all wayside objects	THALES	Sabrina Naussedat	sabrina.naussedat@thalesgroup.com
TD2.11: Cybersecurity	ALSTOM	François Hausman	francois.hausman@alstom.com

Implications in IP2 TD

	TD2.1	TD2.2	TD2.3	TD2.4	TD2.5	TD2.6	TD2.7	TD2.8	TD2.9	TD2.10	TD2.11
ALSTOM	FM	FM TD leader	FM	FM	FM	FM	FM	FM	FM	FM	FM TD leader
ANSALDO STS	FM	FM	FM	FM TD leader	FM TD leader	FM	FM	FM TD leader	FM	FM	FM
BOMBARDIER	FM	FM	FM	FM	FM	FM	FM	FM	FM TD leader	FM	FM
CAF	FM	FM	FM	FM	FM	FM	FM		FM	FM	FM
NETWORK RAIL	FM	FM	FM		FM	FM		FM	FM		FM
SIEMENS	FM TD leader	FM	FM TD leader	FM	FM	FM	FM	FM	FM	FM	FM
THALES	FM TD leader	FM	FM	FM		FM TD leader	FM	FM	FM	FM TD leader	FM
TRAFIKVERKET	FM	FM	FM	FM	FM	FM	FM TD leader	FM	FM	FM	FM
AZD		AM		AM	AM			FM	AM		AM
DB	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
HaCon									AM		
Indra	AM	AM	AM	AM	AM	AM	AM			AM	AM
Kapsch	AM					AM					AM
MERMEC		AM	AM	AM	AM	AM				AM	
SmartRaCon	AM			AM	AM	AM	AM	AM	AM	AM	AM

Funding Members (FM)
FM TD leader
Associated Members (AM)

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Railenium is associated through SmartRaCon consortium

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DLR

Smart Railway **Con**trol

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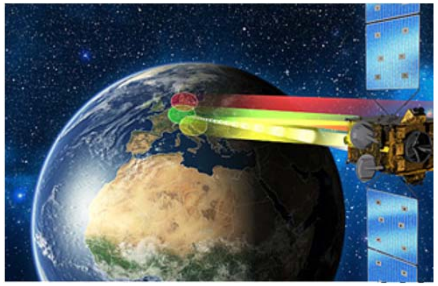
TD2.1 – Adaptable communications for all railways



Link to other TDs
- TD1.2 - Train Control and Monitoring System

Objectives

- Definition, development and test of **adaptable train-to-ground IP communication system**
  - Ensuring **backward compatibility for ERTMS** by answering current specification of ETCS and CBTC systems, including voice services
  - Adding requirements to **support enhancements** of the signaling system (new technologies)
- Design of a "technology independent" system **resilient to radio technology evolution**
  - Avoiding specific railway solution
  - Allowing future evolutions of radio bearer without impact on reliability of signaling system
- Shift from **"network as an asset" to "network as a service"** model vision

Specific Technical outputs

- Two demonstrators for signaling applications for all the railway segments: HST / regional + urban / suburban
  - Relying on key technologies considered: **Cognitive Radio, SDR, SDN, IP networks**…
  - Investigating **new functionalities** and related technologies: routing capabilities, vertical handover among mobile heterogeneous networks, use of network redundancy, …
  - Demonstrating feasibility to **use public networks** instead of a dedicated network
  - Considering **satellite communication** technologies for regional areas
  - Demonstrating capacities of **emerging technologies** to fulfil the key QoS requirements (5G)

Expected impacts

- Support the **attractiveness and competitiveness** of the EU railway industry
  - Costs reduction (sharing of the communication network / possibility to use public network)
  - Additional performance and service
  - Support to capacity increase
- Help European rail industry to consolidate its **leadership** on the global market
  - Modular architecture allowing taking into account evolution of communications technologies
- Achieve the **Single European Railway Area**
  - Interoperability provided by a solution suitable to different railway sectors
  - Fulfill needs of ETCS and CBTC

TD2.2 – Railway network capacity increase (ATO up to GoA4 - UTO)

Objectives

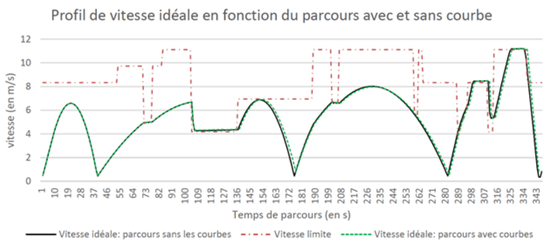
- Investigate, develop and validate **Automatic Train Operation over ETCS** up to GoA4
  - Increasing capacity on existing lines, limiting investment for new infrastructure
  - Reducing operating costs, saving energy, having more efficient use of resources (staff)
  - Making important contribution to the vision of a fully automated rail freight system

Specific Technical outputs

- Interoperable system specifications for
  - **Semi-automated** operation (GoA2) (High Speed Trains, intercity, regional and freight)
  - **Driverless** or **unattended** operation (GoA3 and 4) (urban and suburban)
- Specifications include
  - Definition of the **mitigations for hazards** identified in feasibility study
  - Identification of **impacts on current ERTMS** specification
  - Specification of
    - System **Requirements and Architecture** of overall ATO over ETCS
    - **Interfaces** and exported constraints on relevant external systems
  - Requirements/specification for **reference Test Facility** (integrate new ATO function up to level GOA4 and demonstrate interoperability of GoA3 and GOA4)

Expected impacts

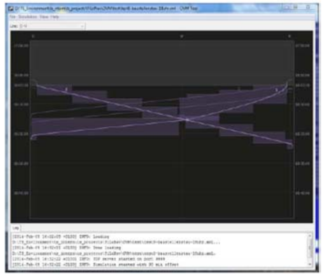
- Improved **reliability**
  - Better punctuality (arrival / departure times no more dependent on driver way to drive)
- Enhanced **capacity**
  - By reducing minimum operational headway between trains due to automatic driving
- **Energy** saving
  - Optimized speed profiles taking into account different parameters
- Enhanced **interoperability**
  - Specification for interoperable ATO over ETCS lead to TSI adaptation
- Reduction of operation **costs**
  - Reduction of fixed cost (increase of staff productivity)



Link to other TDs

- TD5.6 - Autonomous Train Operation
- TD2.1 - Adaptable communications
- TD2.3 - Moving Block
- TD2.4 - Fail-Safe Train Positioning
- TD2.7 - Formal methods and standardization for smart signaling system
- TD2.9 - Traffic Management evolution
- TD2.11 - Cyber security

TD2.3 – Moving Block



Link to other TDs

- TD2.1 - Adaptable communications
- TD2.2 - ATO
- TD2.4 - Fail-Safe Train Positioning
- TD2.5 - On-board Train Integrity
- TD2.7 - Formal methods and standardization for smart signaling system
- TD2.9 - Traffic Management evolution
- TD2.11 - Cyber security

Objectives

- Define, develop and test a high capacity, low cost, high reliability signaling system, based on **Moving Block** principles
  - High **Capacity** based on Moving Block principles, allowing decoupling of the infrastructure from train performance parameters
  - Low **Cost** achieved by reduction in use of trackside train detection
  - High **Reliability** achieved by reduction in trackside equipment (for train detection)
  - Enhanced **interoperability** achieved by working collaboratively on specifications for Moving Block Signaling System

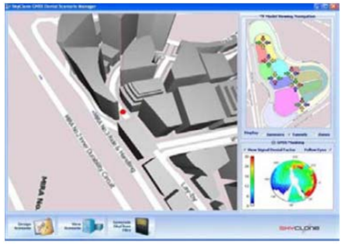
Specific Technical outputs

- Use of concept of a Moving Block Signaling System = use Moving Block principles to localize the trains, and to determine Movement Authorities
- Technical Demonstration of
  - **Moving Block Signaling Systems**, including prototype signaling equipment aimed at the different railway segments
    - o Operation principles for moving block
    - o Rules for application of moving block principle
  - **Transitions** in and out of Moving Block area, and of running with mixed equipped and non-equipped trains (mixed traffic)

Expected impacts

- Increased **capacity**
- Reduction of **costs**
- Enhanced **reliability**
- Enhanced **interoperability**

TD2.4 – Fail-Safe Train positioning (including satellite technology)



Link to other TDs

- TD1.2 - Train Control and Monitoring System
- TD2.2 - ATO
- TD2.5 - On-board Train Integrity
- TD2.6 - Zero on-site testing
- TD2.7 - Formal methods and standardization for smart signaling system
- TD2.9 - Traffic Management evolution
- TD2.11 - Cyber security

Objectives

- Development of an **absolute train positioning** system allowing
  - Reduction in the number of conventional train detection systems and limitation/removal of ground infrastructure
  - → Establishment of the **"virtual balise"** concept
- Absolute, interoperable and safe positioning of trains based on
  - Application of the **GNSS technology on ERTMS** system
  - **Scalable concept** allowing integration of future sensor technologies

Specific Technical outputs

- Study of **different solutions** to achieve absolute positioning functionality in railway environment
  - Single and multi constellation approaches, GNSS algorithm improvement, mono and multifrequencies receivers, alternative augmentation systems and additional kinematic sensors
- Analysis and modeling of **Local effects** (obstruction, multipath, NLOS)
  - MOPS error models, 3D models, RTK Method in railways applications
- Development of **alternative solutions** to ensure the continuity of localization: terrestrial communication systems, UWB systems, RFID …

Expected impacts

- The use of an absolute location not requiring ground infrastructure involves
  - A reduction in installation and maintenance **costs**
  - A protection against **vandalism**
- The use of GNSS under ERTMS involves
  - Increased **interoperability**
  - Improved **maintainability**

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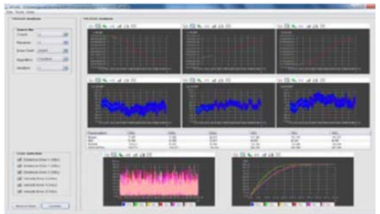
TD2.5 – On-board Train Integrity



Link to other TDs

- TD5.1 - Freight electrification, brakes and telematics
- TD2.1 - Adaptable communications
- TD2.3 - Moving Block
- TD2.4 - Fail-Safe Train Positioning

Objectives

- Prototype and related tools for **On-board Train Integrity (OTI)** determination system
  - More efficient signaling systems in terms of capacity (shorter headways)
  - Capital and maintenance cost
  - Resilience
  - Compatibility among lines
  - …

Specific Technical outputs

- OTI determination system relying on
  - **Autonomous localization of train tail** without interaction with trackside equipment
  - Capability to establish a **wireless communication between tail and front cabin**, to transfer confirmation of integrity, without trackside network support, in case of absence of hardwired train communication line
  - **Safe detection** (SIL-4) **of train interruption**, filtering false alarms conditions
  - Innovative solution to **supply the required power for OTI equipment** in freight convoy, where the solution involve both generation of energy and its possible storage

Expected impacts

- Support of **competitiveness** of the EU railway
  - Achieve a technological leadership and high safety targets
  - Start and consolidate a standardization process of the final solutions, taking into account broader system requirements
  - Offer tangible benefits to the end user
- Reduction of investment and operation **costs**
  - Withdrawal of ground infrastructure needed today for the detection of train integrity
- Increase of **capacity**
- Increase of **safety levels** of signaling systems

TD2.6 – Zero on-site testing (control command in lab demonstrators)

Link to other TDs

- TD2.1 - Adaptable communications
- TD2.7 - Formal methods and standardization for smart signaling system
- TD2.9 - Traffic Management evolution

Objectives

- Realize a zero on-site testing environment using simulation tools and demonstrators remotely interconnected in laboratories

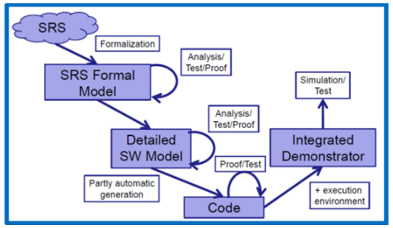
Specific Technical outputs

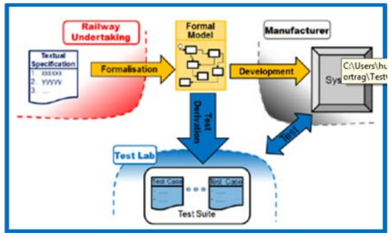
- Implementation of **lab tests** strictly focused on real needs
  - Definition of a dedicated system test architecture for the lab tests
  - Specification of a standardized method to derive and describe test cases
  - Fixing a common test process framework
- Achievement of a **system test architecture**
  - Allowing a flexible creation of signaling environments
  - Serving for stepwise integration approaches and for different ranges of complexity
  - Providing a unified interface concept and standardized interface specifications to allow several suppliers and also third parties to contribute to the same testing project
- **Support of application** of real system components and simulated environment elements in various mixes

Expected impacts

- Reduction of installation and commissioning **costs**
  - Reduction in testing costs given that on-site tests require about 5 to 10 times the effort compared to similar tests done in the lab
- Improved **environmental footprint**
  - Minimized test drive efforts yielding reduction of CO_2/energy savings, noise pollution
- Increased operational **reliability**
  - Increased automation of testing
- Enhanced **interoperability**
  - Early detection of interoperability issues
- Improved **standardization**
  - Due to inherent "plug testing"

TD2.7 – Formal methods and standardization for smart signaling systems





Link to other TDs

- TD2.3 - Moving Block
- TD2.5 - On-board Train Integrity
- TD2.6 - Zero on-site testing

Objectives

- Development of **formal methods** for requirements capture, design, verification and validation
- **Standardization** of crucial interfaces between parts of selected System Platform Demonstration scenarios using formal methods

Specific Technical outputs

- **Formal methods** adapted and applied to the **standardization** of interfaces and operational scenarios
- **Standardized interface** between the selected subsystems (FIS, FFFIS) of the system demonstration platform scenarios
- Use of **advanced formal methods** through information processing equipment for signaling and control
  - Languages and tools for the **specification**
  - Various analyzes of the **model checking**
  - Automation of **development activities**
- **Semi-formal languages** with a less rigid semantics will be integrated to cover areas difficult to formalize and to involve people with a less formal background

Expected impacts

- Increase of **competitiveness** of the rail sector
- Improved **interoperability, reliability, standardization**
- Reduction of **costs**, including LCC costs of signaling systems (ERTMS), design, implementation, tests and commissioning, operation and maintenance, training, upgrading
- Shortening **time-to-market** of new products

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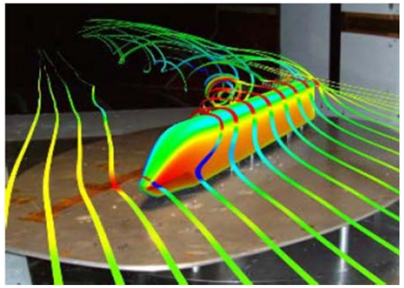
TD2.8 – Virtually - Coupled Train Sets (VCTS)



Link to other TDs

- TD1.2 - TCMS
- TD2.2 - ATO
- TD2.3 - Moving Block
- TD2.5 - On-board Train Integrity
- TD2.6 - Zero on-site testing
- TD2.10 - Smart radio-connected all-in-all wayside objects
- TD2.11 - Cyber security

Objectives

- Explore the innovative concept of "**virtual trains**"
  - Capable of operating physical trains much closer to one another (inside their absolute braking distance)
  - Dynamically modifying their own composition on the move
  - Starting from the current interoperable signaling system
- **New required functionality** = extreme limit of moving block on relative braking to compact several trains dynamically on the fly, up to have logical coupling, "virtual coupling", of trains while they are moving (remove "one block, one train" limitation)
  - Not limited to on board environment
  - Requiring new features and upgraded functionalities in the wayside signaling and supervision systems

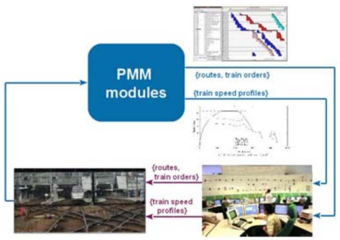
Specific Technical outputs

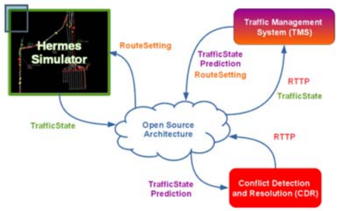
- Investigation of the different sub-functions of **Virtually-Coupled Train Sets** (VCTS) and smart switching and crossing
  - Increase the length of a (virtual) train to allow more passengers and/or freight wagons to pass in a given time (reduce headway between physical trains in virtual train)
  - For passenger traffic, overcome platform length limitation (1st part of train going to platform x; 2nd part to platform y)
  - For freight traffic, allow longer and heavier virtual trains designing lines with shorter passing sidings than would otherwise be required
  - Reduce the headway, the distance between two trains, when the 2nd (i.e. the following) train has to change direction / route

Expected impacts

- Increase of line **capacity**
- Reduction of investment maintenance and operational **costs**

TD2.9 – Traffic management evolution





Link to other TDs

- TD2.3 - Moving Block
- TD2.11 - Cyber security
- TD3.6 - Dynamic Railway Information Management System
- TD3.9 - Smart Power Supply Demonstrator
- TD4.2 - Travel Shopping
- TD4.4 - Trip Tracker
- TD5.1 – Freight Electrification, Brake and Telematics
- TD5.2 - Access & Operations
- TD5.5 – New Freight Propulsion Concepts

Objectives

- Development of a **Traffic Management System** (TMS) based on
  - Standardized data structures
  - Real-time data management
  - Automation of processes
  - Higher integration of status information of wayside infrastructure, trains, maintenance service and energy resource management
  - Communication infrastructure including interfaces for internal and external communication between different subsystems, applications and clients
- Design of an **interoperable framework** and flexible bearer independent **communication infrastructure** to fulfil high performance and high availability requirements

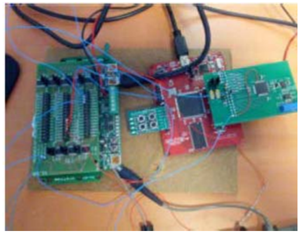
Specific Technical outputs

- **Standardized workstation** to address previous heterogeneous working processes
- **New functionalities** to incorporate rules and control on the TMS level
- Functional modules
  - Improvement of **functionalities already existing**, such as Conflict Detection and Resolution
  - **New applications** such as the operation of new drive modes "Moving Block", ATO integrated with advanced Driver Assistance Algorithms

Expected impacts

- Improved **reliability** of train operations
- Increase of **capacity**
- Reduction of investment and operating **costs**
- Improved **interoperability**
- Reduction of **environmental footprint** and energy consumption

TD2.10 – Smart radio-connected all-in-all wayside objects



Link to other TDs

- TD2.1 - Adaptable communications
- TD2.6 - Zero on-site testing
- TD2.9 - Traffic Management evolution
- TD2.11 - Cyber security
- TD3.6 - Dynamic Railway Information Management System
- T3.7 - Railway Integrated Measuring and Monitoring System
- TD3.8 - Intelligent Asset Management Strategies Demonstrator

Objectives

- Demonstration of a solution of **object controllers** realizing a decentralized approach to **rail automation**
  - **Fully de-centralized control of remote trackside objects** without requiring trackside cabling
  - **Scalable** from high performance lines to regional and freight applications
  - Higher bandwidths used for **transmission of status reports / maintenance information** and further required data
  - **Safety and security** of transmitted data

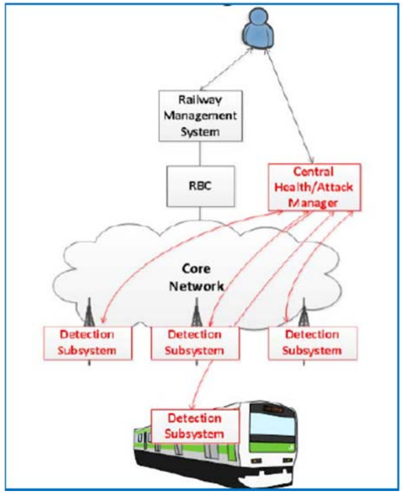
Specific Technical outputs

- **Fully de-centralized control of remote trackside objects**
  - **Locally derived power**
  - **Radio communications** to individual remote trackside objects
  - **Energy harvesting** solutions
  - Application within **safety context** of railway signaling
- Dedicated data communication **cables replaced** by exploiting
  - Existing **radio communication** systems
  - **Public IP network access points**
  - **Satellite** communication systems

Expected impacts

- **Lowering of effort** for project specific engineering, installation and commissioning
- Reduction of LCC and investment **costs**
  - Minimization of deployment of dedicated data communication cables
  - Elimination of cost for replacement of cables
- Raise of **levels of safety and operational efficiency** of signaling systems
- Reduction of **energy losses** by using locally derived supply power

TD2.11 – Cyber Security



Link to other TDs

- TD2.1 - Adaptable communications
- TD2.6 - Zero on-site testing
- TD2.7 - Formal methods and standardization for smart signaling system
- TD2.10 - Smart radio-connected all-in-all wayside objects

Objectives

- Development of a **security system for railway** allowing
  - **Improved safety and security of the railway system** by
    - Data protection against unauthorized disclosure, modification or destruction
    - Computers protection against unauthorized use, modification or denial of service
    - Protection of railway network against attacks and malicious acts
  - Improved compatibility and interoperability through **standardization of a security system** at European level

Specific Technical outputs

- **Definition of a security system** dedicated to railways
  - Security system intended to be comprehensive, easily sustainable and integrated/interconnected
- **Application of the methodology** to railways
  - Definition and development of demonstrators of railways applications based on methodology defined to ensure infrastructure, train and communication protections
- Develop a network of **Railway Cyber Security Experts** (CERT)
  - Development of a network of security experts in the railways community who would be the basis of a CERT (Computer Emergency Response Team) dedicated to railways

Expected impacts

- Increase of **interoperability**
  - By specifying a **common solution** and development of a **standardized cyber security system**
- Increase of **security**
  - By defining standardized and reliable design methods
- Reduction of maintenance and deployment **costs**

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Thank you for your attention

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