Development of the Preliminary Stages for ATO Lab Prototype in Sight of a Future Inspection Vehicle

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OUTLINE OF THE PRESENTATION

- FP2-R2DATO main goals and expected results
- Logical arquitecture of the ATO system defined in X2RAIL-4
- ATO system developed by CEIT
- Simulation environment
- Summary

FP2-R2DATO MAIN GOALS AND EXPECTED RESULTS

Some highlights extracted from the R2DATO Project description:

CEIT **is participating in different WorkPackages** of the project in very interesting topics, such as, train positioning, communications, ATO, RAMS, DevOps, self propelled freight wagon, etc, All these efforts are focused on one main goal, **the autonomous inspection vehicle**. This vehicle will help to reduce the costs of the maintenance and to improve the maintainability of the infraestructure.

FA2R2DATO MAIN GOALS AND EXPECTED RESULTS

CEIT is developing an autonomous train operation (ATO) system in GoA 3&4 to drive an autonomous inspection vehicle. The main features of the system are:

- Autonomous driving
- Absolute safe position system
- Automatic deployment/retraction of inspection devices, sensors and actuators
- Environment perception
- Multiconnectivity platform (5G/4G)
- Vehicle interaction using TCMS
- Remote control and operation

	Grade of Automation	Type of train operation	Setting train in motion	Stopping train	Door closure	Operation in event of disruption
	GoA1	ATP[1] with driver	Drive	Drive	Drive	Drive
	GoA2	ATP[1] and ATO[2] with driver	Automatic	Automatic	Drive	Drive
	GoA3	Driverless	Automatic	Automatic	Train attendant	Train attendant
	GoA4	UTO[3]	Automatic	Automatic	Automatic	Automatic

[1] ATP: Automatic Train Protection, [2] ATO: Automatic Train Operation, [3] UTO: Unattended Train Operation

ADVANTAGES:

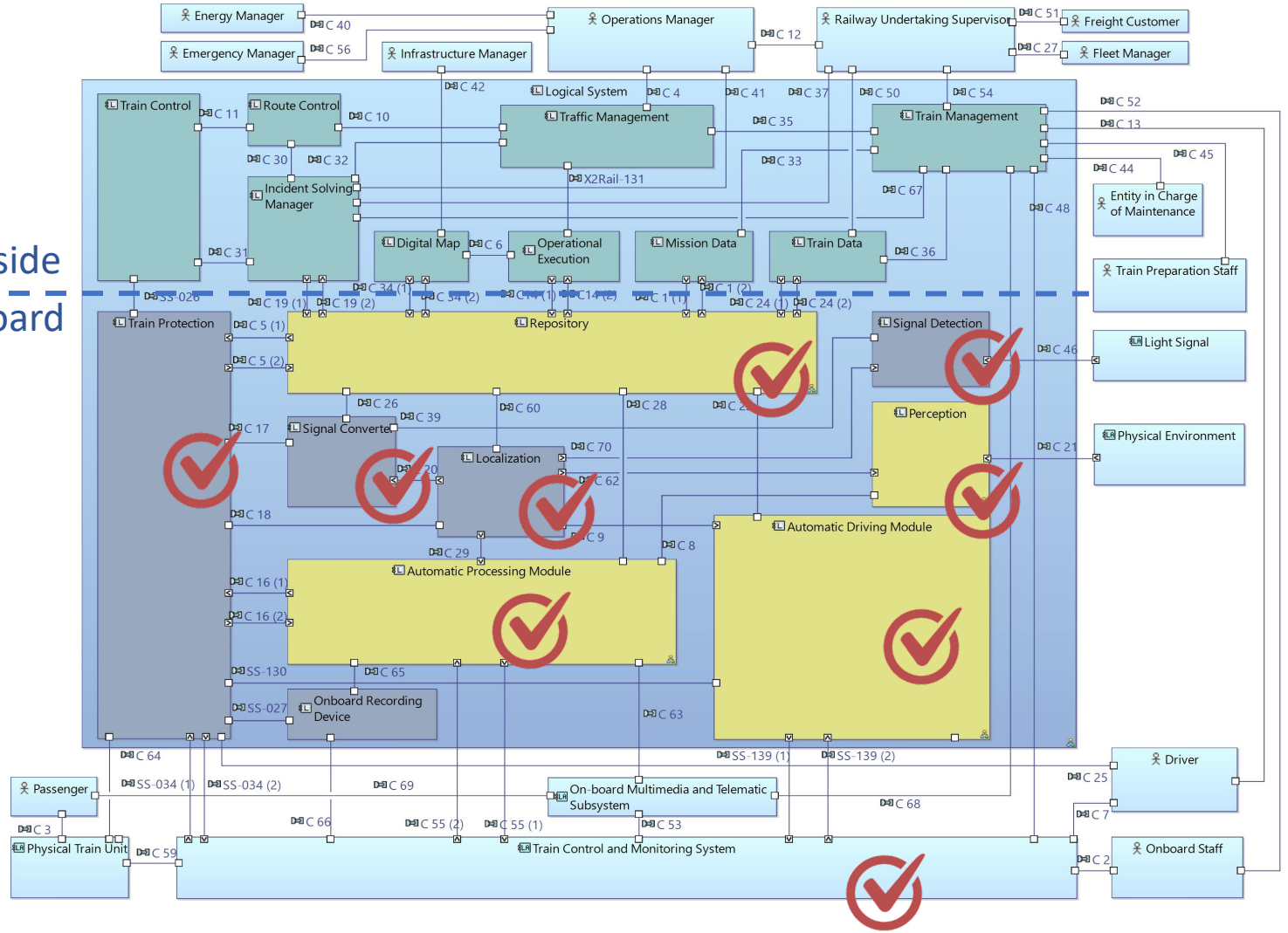
- No dependence on the availability of drivers to carry out tasks.
- Possibility of smaller vehicles since no personnel are on board, leading to more energy-efficient operations.
- More agile maintenance operations, even interspersing inspection vehicles between traffic.
- Greater environmental awareness and more parameters to be analyzed in each maintenance mission.
- More immediate information on potential failures thanks to more efficient communications.

LOGICAL ARQUITECTURE OF THE ATO SYSTEM DEFINED IN X2RAIL-4

In the framework of X2Rail projects the following architecture was defined, last version is SRS 1.0.1

The ATO systems that CEIT is developing Includes the following modules:

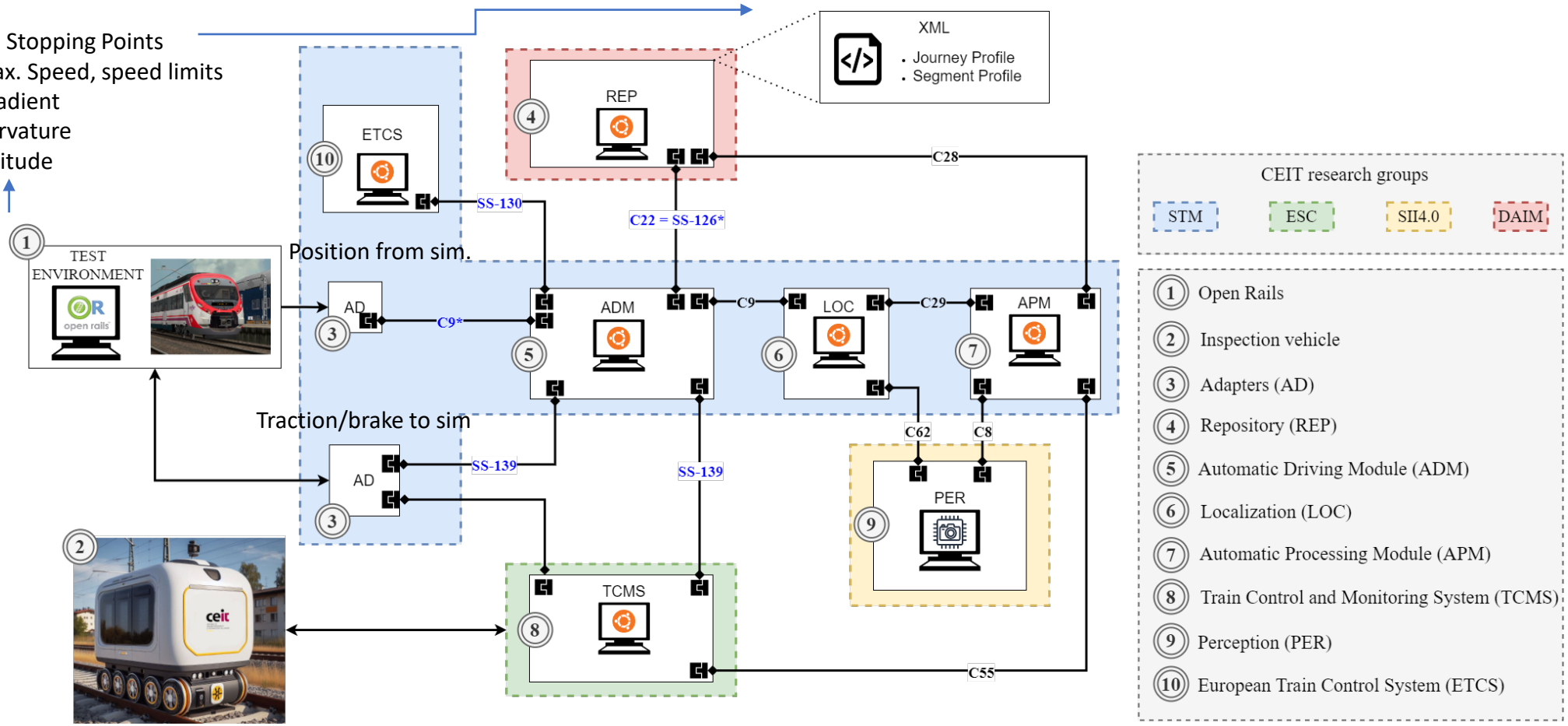
- ADM: Automatic driving module
- APM: Automatic processing module
- TCMS: Train control and monitoring system
- PER: Perception module, including:
  - Obstacles identification
  - Signal detection
  - Signal converter
- REP: Repository
- LOC: Localization system
- ATP: Automatic train protection
- Remote operation



ATO SYSTEM DEVELOPED BY CEIT

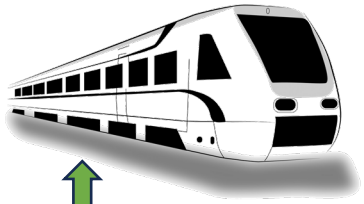
This scheme represents the architecture of the system that CEIT is developing.
JP and SP information extracted from the simulator.
We are implementing the following interfaces: C28, C29, C62, C8, C9, C55, C22, C9, C9* SRS 1.0.1
and subsets: SS126, SS139, SS130

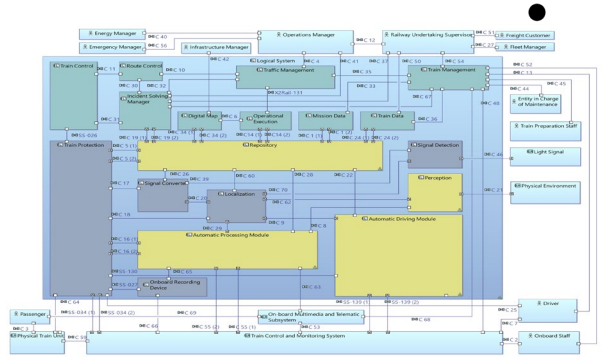
- KP, Stopping Points
- Max. Speed, speed limits
- Gradient
- Curvature
- Altitude



ATO SYSTEM DEVELOPED BY CEIT

Modular implementation of the ATO system based on Vbox systems certified for railway use





BER OF
UE RESEARCH
CHNOLOGY ALLIANCE

ATO

APM, decission making, replace driver

Positioning

ADM, speed profiles calculation and tracking

TCMS

Communications with the vehicle, traction and brakes actuation

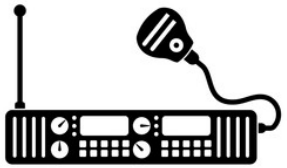
Perception system

Vbox for image processing and environment detection

Cameras for perception (Optics cameras, Lidar, IR, radar)

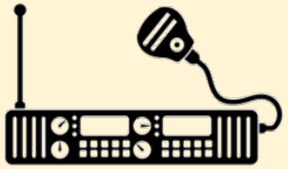
REPOSITORY, COMMUNICATIONS

OB Database TD, MP, DP, etc…



Communication OB

TRACKSIDE



Communication TS

Remote control system

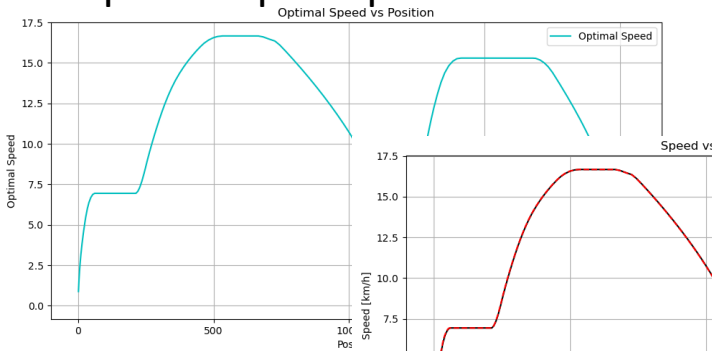
Creation of TD, JP. SP, MP

ATO SYSTEM DEVELOPED BY CEIT, SIMULATION ENVIRONMENT

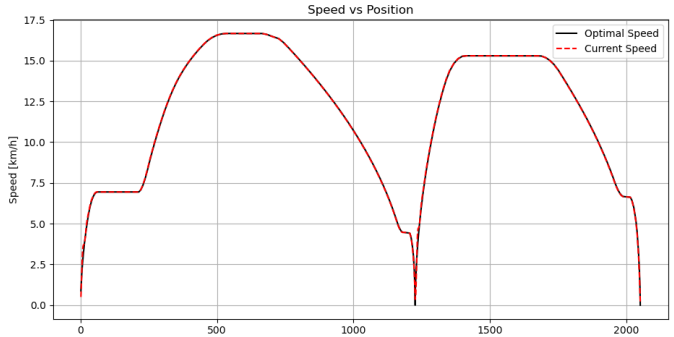
Laboratory test environment using three simulators to analyze system performance in different situations:

- **Train Simulator 4:** Commercial simulator, includes a complete interface for possible remote driving.
- **Open Rails**: Open source, digitalized nearby lines.
- **RailVOS (OPTICON)**: Complete network simulation, developed by CEIT.

Optimal speed profile



Tracking control



- Acquire virtual position from the simulator
- Full interaction with the simulator, full traction-brake control
- Availability of data to create JP, SP of the routes included in the simulator

SUMMARY

• CEIT has an **active participation** in FP2-R2DATO Project developing **different technologies to be integrated in the autonomous inspection vehicle**.

• CEIT is developing an **ATO system** to drive the inspection vehicle.

• Mainly, CEIT is working on the **following components**:

- ADM: Automatic driving module
- APM: Automatic processing module
- TCMS: Train control and monitoring system
- PER: Perception module, including:
  - Obstacles identification
  - Signal detection
  - Signal converter
- REP: Repository
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• **Three simulators** are being used to **test and validate** the ATO system of the inspection vehicle

Thanks for your attention!

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State of the art of inspection vehicles:

In the State of the Art, there are inspection vehicles that integrate a large number of sensors and devices to analyze real-time data from the track, the catenary, and even the surroundings. However, there are no alternatives that operate at GoA4.

Full Vehicles: usually derived from locomotives or track inspection cars, are self-propelled but do not have any type of automation in their operation. They are typically guided by a driver and have personnel on board who control the analysis systems.

State of the art of inspection vehicles:

Hi-rail vehicles: Typically, road vehicles that deploy a secondary set of wheels to allow them to travel on railway tracks in the inspection area. They are not autonomous and are always operated by drivers.

Robot-type vehicles: They have a higher degree of autonomy. They are usually self-propelled with electric motors and batteries. In terms of operation, they are typically controlled remotely but do not incorporate Automatic Train Operation (ATO) modes.