Europe's Rail

FP6-FutuRe

Cost effective regional lines

Flagship Project FP6 – FUTURE

Delivering innovative rail services to revitalise capillary lines and regional rail services

Regional Rail CCS & Operations for G1 Lines

Final Event

November 4-5th, 2026

Founded by the European Union. Views and opinion expressed are however those of the author(s) and do necessarily reflect those of the Union. Neither the European Union nor the Granting Authority can be held responsible for them. This project has received funding from the European Union's Horizon Europe's research and Innovation program me under Grant Agreement No 101101962

Antitrust statement

While some activities among competitors are both legal and beneficial to the industry, group activities of competitors are inherently suspect under the antitrust/ competition laws of the countries in which our companies do business.

Agreements between or among competitors need not be formal to raise questions under antitrust laws. They may include any kind of understanding, formal or informal, secretive or public, under which each of the participants can reasonably expect that another will follow a particular course of action or conduct. Each of the participants in this initiative is responsible for seeing that topics which may give an appearance of an agreement that would violate the antitrust laws are not discussed. It is the responsibility of each participant in the first instance to avoid raising improper subjects for discussion, notably such as those identified below.

It is the sole purpose of any meeting of this initiative to provide a forum for expression of various points of view on topics

(i) that are strictly related to the purpose or the execution of the initiative,

(ii) that need to be discussed among the participants of the initiative,

(iii) that are duly mentioned in the agenda of this meeting and

(iv) that are extensively described in the minutes of the meeting.

Participants are strongly encouraged to adhere to the agenda. Under no circumstances shall this meeting be used as a means for competing companies to reach any understanding, expressed or implied, which restricts or tends to restrict competition, or in any way impairs or tends to impair the ability of members to exercise independent business judgment regarding matters affecting competition.

As a general rule, participants may not exchange any information about any business secret of their respective companies. In particular, participants must avoid any agreement or exchange of information on topics on the following non-exhaustive list:

Prices, including calculation methodologies, surcharges, fees, rebates, conditions, freight rates, marketing terms, and pricing policies in general;

any kind of market allocation, such as the allocation of territories, routes, product markets, customers, suppliers, and tenders;

production planning; marketing or investment plans; capacities; levels of production or sales; customer base; customer relationships; margins; costs in general; product development; specific R&D projects;

standards setting (when its purpose is to limit the availability and selection of products, limit competition, restrict entry into an industry, inhibit innovation or inhibit the ability of competitors to compete);

codes of ethics administered in a way that could inhibit or restrict competition;

group boycotts;

validity of patents;

ongoing litigations.

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Context & Methodology

Introduction

Today's Regional (G1) Lines

- ❑ Essential function as **green transport**
- ❑ Feeder lines for passengers and freight traffic connecting remote locations with other transport services and the Single European Railway Area (**SERA**)

Main Barrier

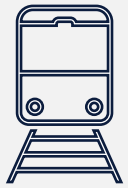
Mounting pressure on these lines on account of **increasing costs** of investment and operation that threat viability

Challenges

Make regional lines viable through:



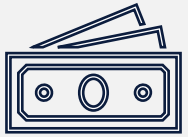
Improving **competitiveness**



Reinforcing the **role** of rail



Meeting evolving **customer needs**



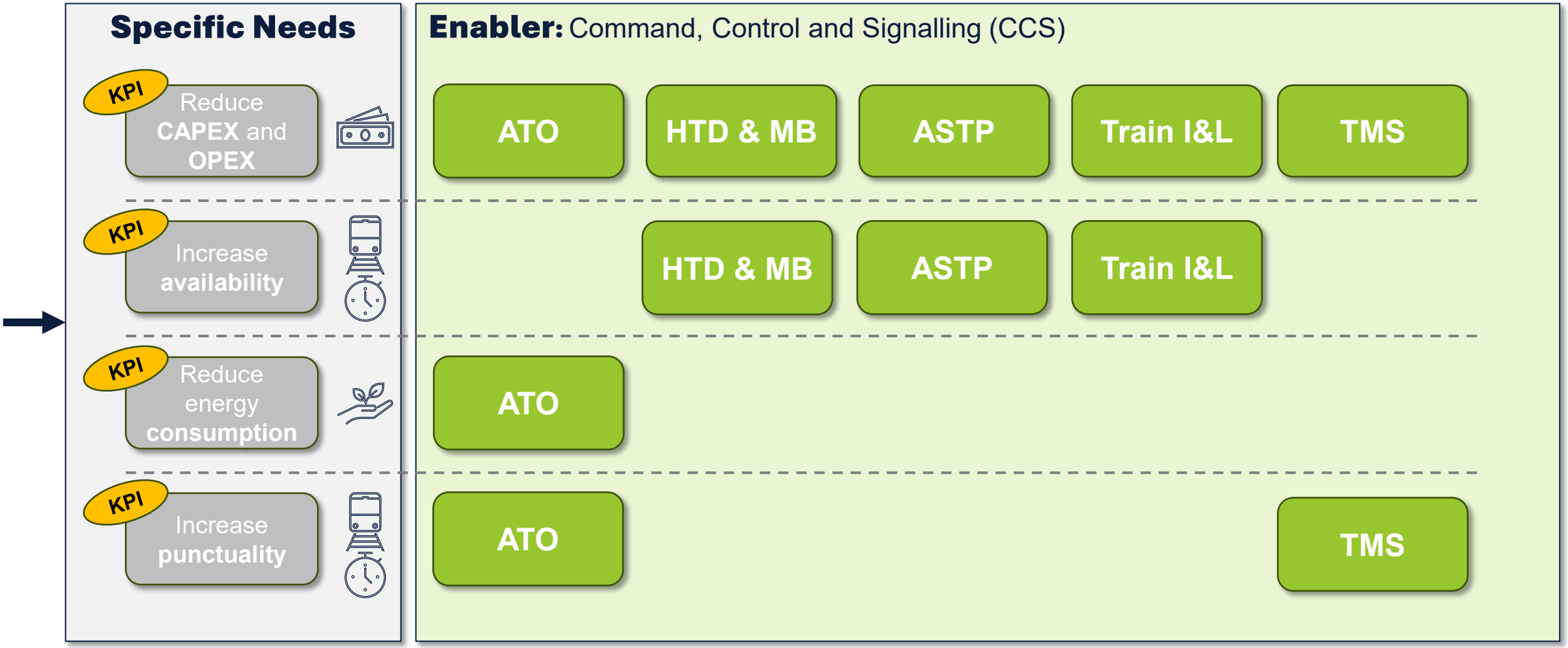
Reducing **costs**



Sustainable and **resilient** transport

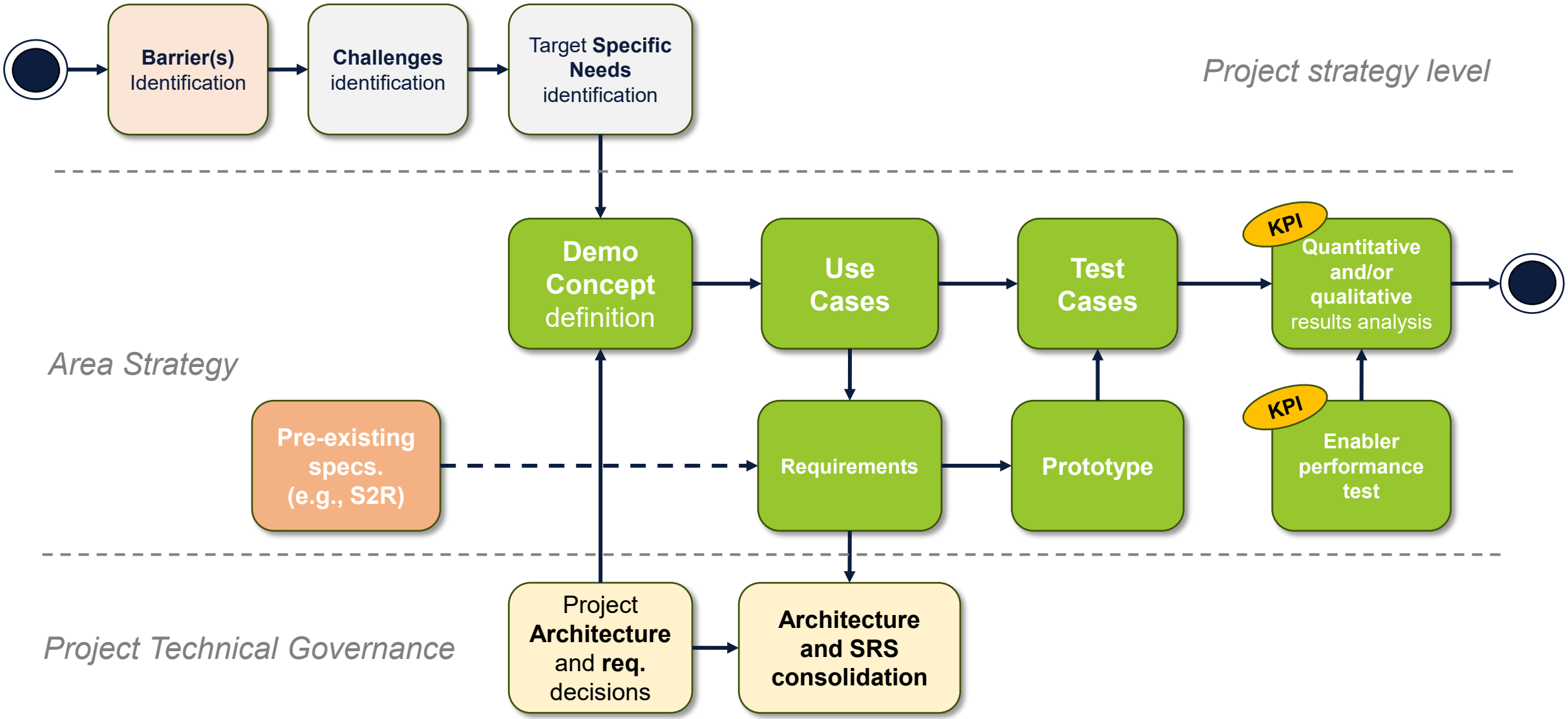
Context & Methodology

Introduction



Context & Methodology

Methodology



Demonstrator concepts

Demonstration topics and related KPI(s)

Demo Concept	Enabler	Concept definition	Specific Need	Related KPI
Stop-on-demand	ATO GoA4	**Operational stops** requests	▪ ↓ CAPEX and OPEX ▪ ↑ Punctuality ▪ ↓ Energy consumption	▪ ↓ OPEX and CAPEX by 15% ▪ ↑ Punctuality by 15% ▪ ↓ energy consumption by 10%
Perception	ATO GoA4	Ensure **safe train reaction** in relevant regional operational scenarios	▪ Validate a perception stack tailored to the operational realities of low-density regional lines	▪ ↑ System availability by 10%
Adhesion Management	ATO GoA2	Provide ATO-OB with **Location-specific adhesion values**	▪ ↓ CAPEX and OPEX ▪ ↑ Punctuality ▪ ↓ Energy consumption	▪ ↓ OPEX and CAPEX by 15% ▪ ↑ Punctuality by 15% ▪ ↓ energy consumption by 10%
Remote Driving as back-up	Remote Driving	**Back-up** for ATO	▪ ↓ CAPEX and OPEX ▪ ↑ Punctuality ▪ ↓ Energy consumption	▪ ↓ OPEX and CAPEX by 15% ▪ ↑ Punctuality by 15% ▪ ↓ energy consumption by 10%

Demonstrator concepts

Demonstration topics and related KPI(s)

Demo Concept	Enabler	Concept definition	Specific Need	Related KPI
Reduced Trackside Assets	HTD & MB	**Reduce trackside assets where possible** while ensuring system safety, performance and availability.	▪ ↓ CAPEX and OPEX ▪ ↑ System availability	▪ ↓ OPEX and CAPEX by 15% ▪ ↑ System availability 10%
Conflict Resolution	TMS	**Early detection of timetable conflicts** and their resolution.	▪ ↓ CAPEX and OPEX ▪ ↑ Punctuality	▪ ↓ OPEX and CAPEX by 15% ▪ ↑ Punctuality by 15%
Precise, continuous, and accurate positioning	ASTP	**Cost effective continuous positioning capabilities** on less complex tracks	▪ ↓ CAPEX and OPEX ▪ ↑ System availability	▪ ↓ OPEX and CAPEX by 15% ▪ ↑ System availability by 10%

Demonstrator concepts

Demonstration topics and related KPI(s)

Demo Concept	Enabler	Concept definition	Specific Need	Related KPI
Reduce railway track maintenance cost	ASTP	**Reduce railway track maintenance cost** by providing accurate faulty track locations	▪ ↓ CAPEX and OPEX ▪ ↑ System availability	▪ ↓ OPEX and CAPEX by 15% ▪ ↑ System availability 10%
Train I&L determination	Train I&L	Provide **train length and integrity information**.	▪ ↓ CAPEX and OPEX ▪ ↑ System availability	▪ ↓ OPEX and CAPEX by 15% ▪ ↑ System availability 10%

Demonstrator concepts

Demonstration topics' relevance

Demo Concept	Enabler	Concept definition	Approach description
Stop-on-demand	ATO GoA4	**Operational stops** requests	Stop-on-Demand allows trains to call at request stops only when needed—**reducing energy use and journey times**—without compromising punctuality, or passenger service quality.
Perception	ATO GoA4	Ensure **safe train reaction** in relevant regional operational scenarios	**Verify that perception functions remain robust, safe, and performant** under regional lines conditions.
Adhesion Management	ATO GoA2	Provide ATO-OB with **Location-specific adhesion values** from the train itself	**Establish better planning and regulation strategies**.
Remote Driving as back-up	Remote Driving	**Back-up** for ATO	Remote operation based on public networks contributes to a **cost-efficient way towards ATO**.

Demonstrator concepts

Demonstration topics' relevance

Demo Concept	Enabler	Concept definition	Approach description
Reduced Trackside Assets	HTD & MB	**Reduce trackside assets where possible** while ensuring system safety, performance and availability.	Trackside related costs account for a significant share of a signalling project, so **cost reduction measures** are crucial.
Conflict Resolution	TMS	**Early detection of timetable conflicts** and their resolution.	Artificial Intelligence algorithms, which support the early detection and resolution of timetable conflicts, helps to **enhance operational efficiency and service reliability**.
Precise, continuous and accurate positioning	ASTP	**Cost effective continuous positioning capabilities** on less complex tracks	The generic ASTP is appropriately adapted to the existing infrastructural conditions (**less complex stations and single track lines**).

Demonstrator concepts

Demonstration topics' relevance

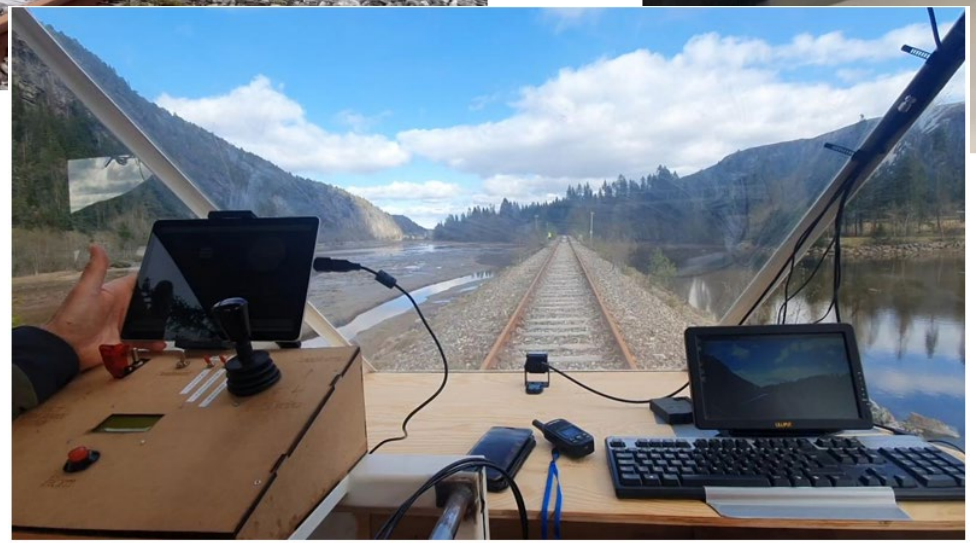
Demo Concept	Enabler	Concept definition	Approach description
Reduce railway track maintenance cost	ASTP	**Reduce railway track maintenance cost** by providing accurate faulty track locations	Precise **reporting to maintenance teams and reducing search effort/costs** vs traditional trackside/GNSS-based methods.
Train I&L determination	Train I&L	Provide **train length and integrity information**	**Critical for innovative train separation implementations** (HTD & MB)

Demonstrator concepts

Remote Driving as back-up



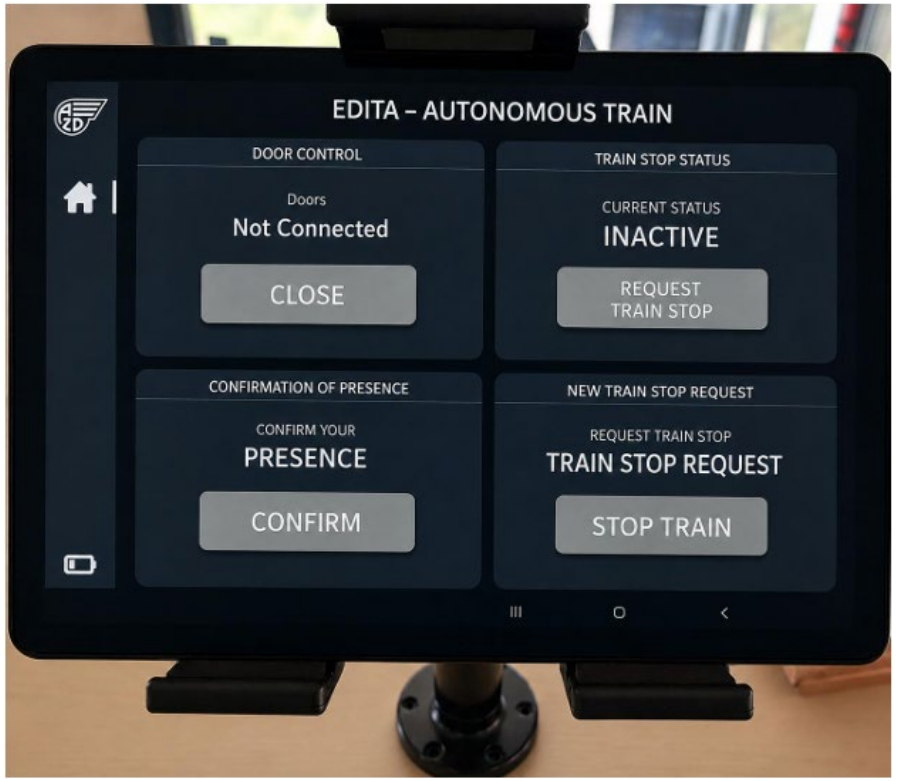




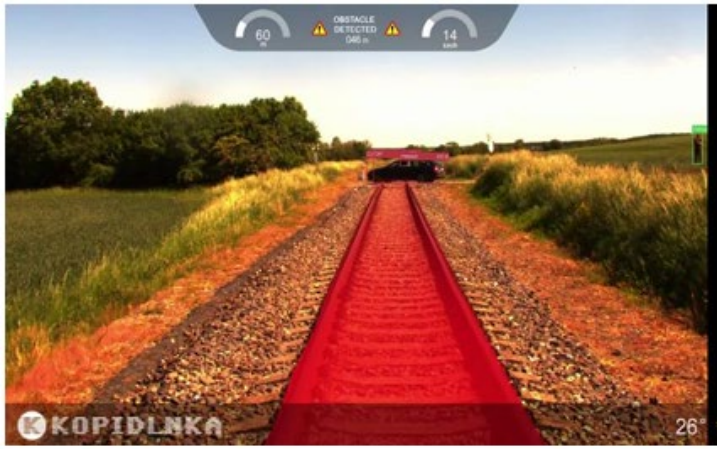
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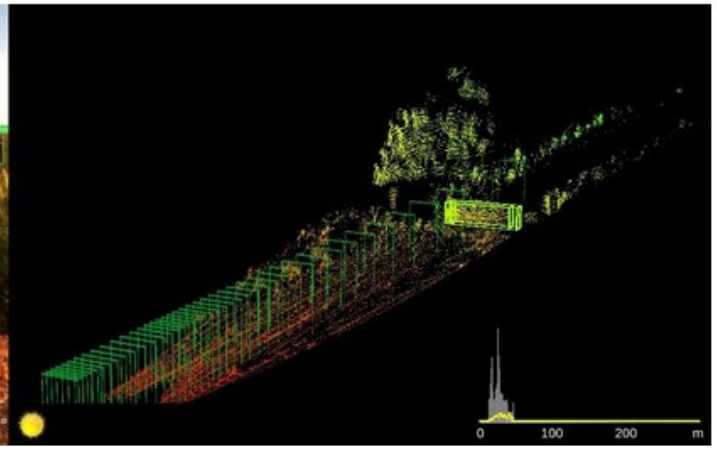
Demonstrator concepts

Stop-on-demand & Perception









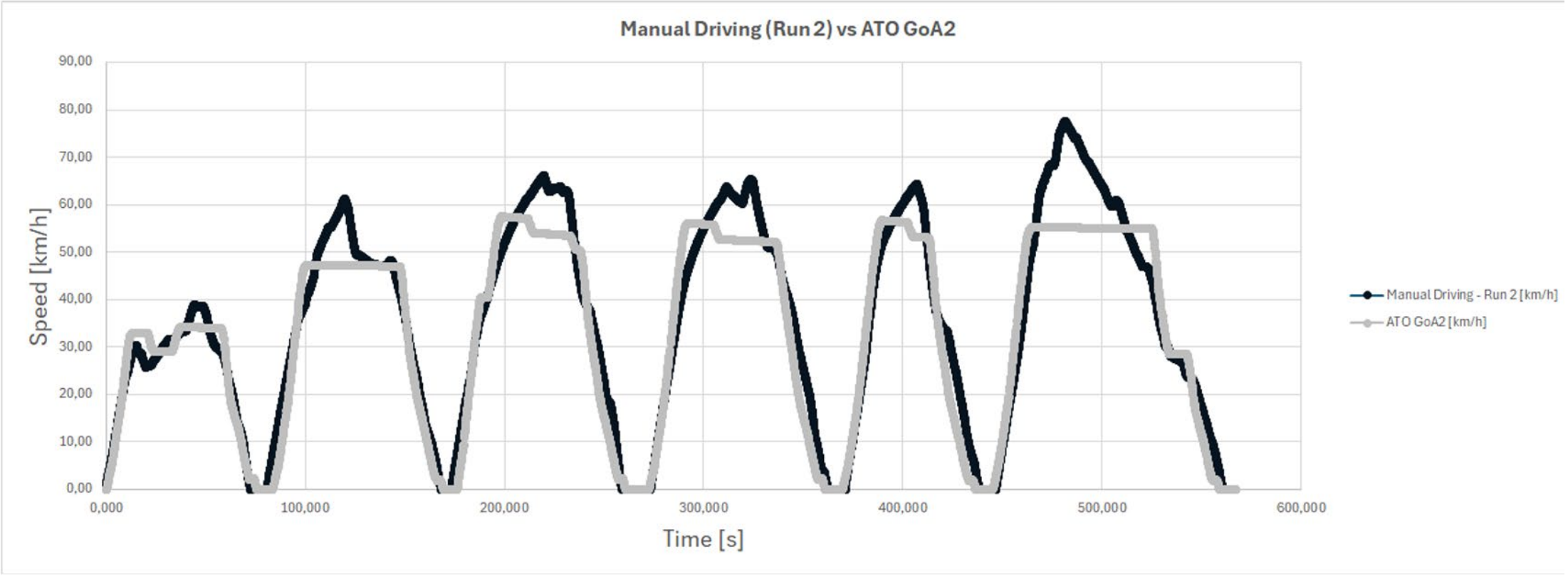
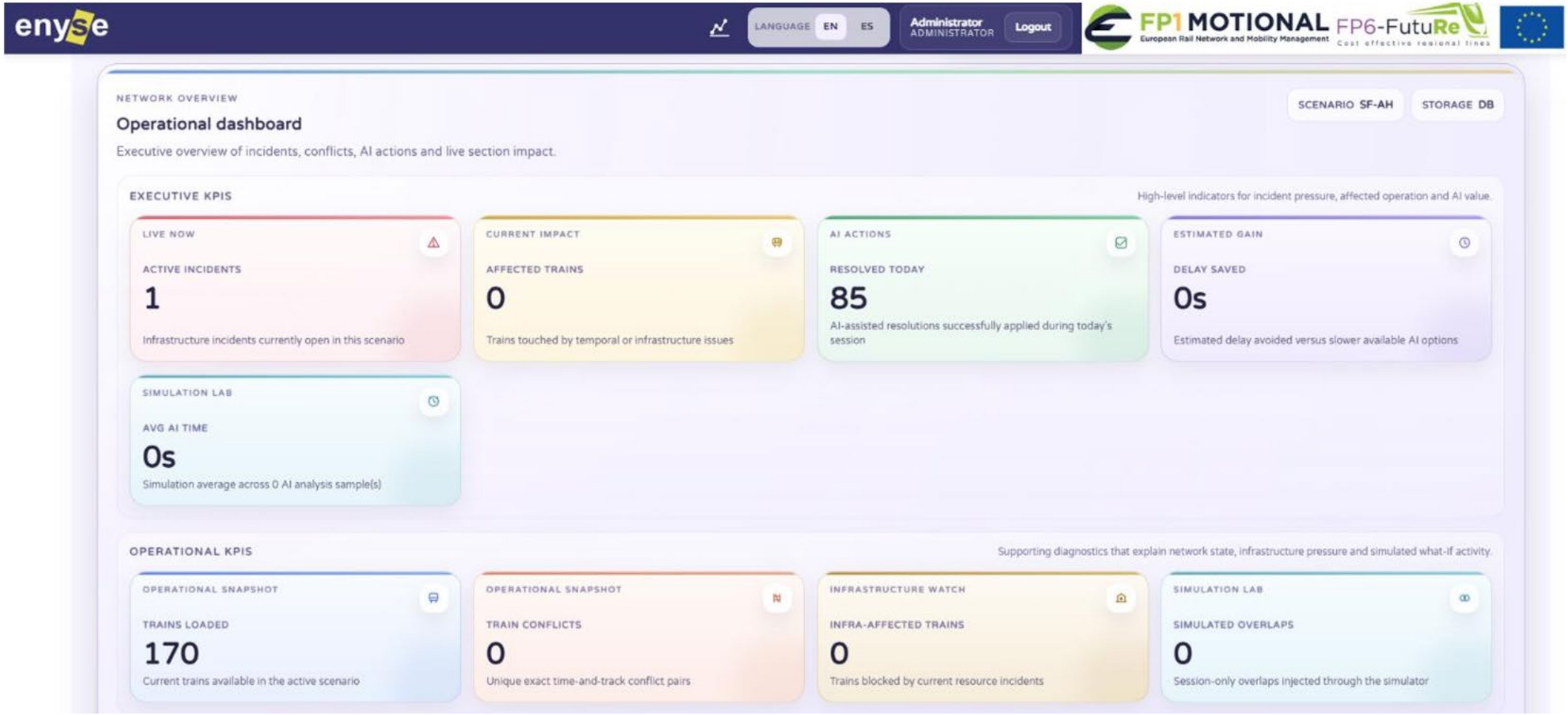


Figure 7: Manual Driving (Run 2) vs ATO GoA2

Demonstrator concepts

Conflict Resolution



Demonstrator concepts

Precise, continuous, and accurate positioning

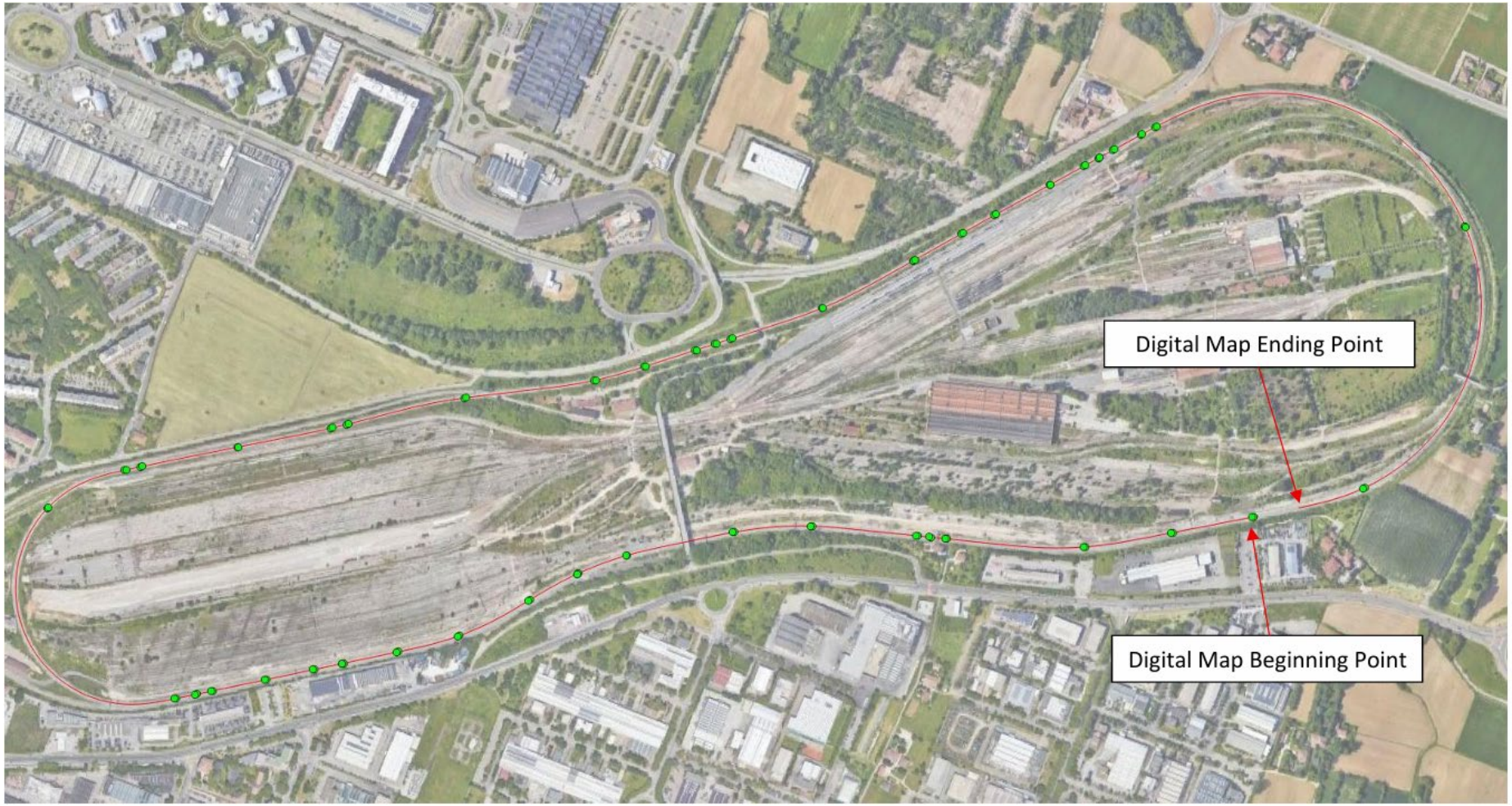


Figure 3.3 San Donato Test Circuit – Balises in green

Demonstrator concepts

Results vs Target KPI

*Regional Rail **CCS** & Operations for **G1** Lines*

Demo Concept	Demo(s)	Measurement	Reference	Target KPI	Result
Stop-on-demand **Perception**	**ATO GoA4**	**Perception** • Object on track • Unprotected level crossing • Animals near track • Fire near track • Parking lot near track **Stop on demand** • Request from train (on-time or late) • Request from platform (on-time or late)	**Perception** • Human driver behaviour • Real world Peception test • Perception unit according to R2DATO specs **Stop on demand** • Subset-126 • ATO GoA3-4	**Stop on demand:** ▪ Lower energy consumption by 10% ▪ Increase punctuality by 15%	**FULL OPERATIONAL DAY 9 % fuel consumption saving** • Reference 119.1l • Actual average run with Stop on Demand 108.9l
Adhesion Management	**ATO GoA2**	▪ ATO Journey vs Manual Driving Journey: ❑ Energy consumption ❑ Punctuality	▪ **Energy:** Real Driver's traction commands data ▪ **Punctuality:** Reference target timetable	▪ Lower energy consumption by 10% ▪ Increase punctuality by 15%	▪ Energy reduction > 10% ▪ Punctuality ≈ 100%

Lab demo Track demo Quantitative analysis Qualitative analysis

Demonstrator concepts

Results vs Target KPI

*Regional Rail **CCS** & Operations for **G1** Lines*

Demo Concept	Demonstrator	Measurement	Reference	Target KPI	Result
Remote Driving as back-up	**Remote Driving** TRAFIKVERKET vti	With standard equipment and public networks latency be kept under 300ms. No specific measurements targeted towards KPIs.	NA	▪ Reduce OPEX and CAPEX by 15%	RTO will contribute to target KPIs but can't be quantified as a back up solution.
Reduced Trackside Assets	**MB** CAF	Cost reduction percentage with **only one TTD with axle counters on the block line** (only TS related costs are accounted for).	Conventional train separation function with full implementation of TS assets.	▪ Reduce OPEX and CAPEX by 15%	Trackside CAPEX reduction ≈ 50%
	HTD ALSTOM	**Amount of track circuits, axle counters, LX treadles, balises** used for equipping the reference regional line.	Real Regional G1 line equipped with ERTMS L2 system applying standard national engineering rules	• Reduce OPEX and CAPEX by 15%	CAPEX/OPEX reduction for the measured assets ≈ 50%

Lab demo Track demo Quantitative analysis Qualitative analysis

Demonstrator concepts

Results vs Target KPI

*Regional Rail **CCS** & Operations for **G1** Lines*

Demo Concept	Demonstrator	Measurement	Reference	Target KPI	Result
Reduced Trackside Assets	**HTD** indra	**Amount of track circuits that the implementation** of this technology can bring to the real León-Guardo regional line in the track part used for the simulation	Current state of the regional line, prepared for ERTMS L2 operation	▪ Reduce OPEX and CAPEX by 15%	OPEX/CAPEX reduction for the measured assets ≈ 17%
Conflict Resolution	**TMS** enyse	• Average **daily conflicts** detected • Average daily conflicts **resolved without operational impact** • Average **staff actions** required per conflict • Average conflict resolution **time** (from detection to resolution)	• 10 • 3 • 4 • 10min	About daily conflicts resolution: • **increased by at least the 15%** About actions and time: • **reduced by at least the 15%**	• The solution identified and resolved all **85** potential conflicts (in less than **10 min**) • Actions reduced to **2** • Time shorten to **3-4min**

Lab demo Track demo Quantitative analysis Qualitative analysis

Demonstrator concepts

Results vs Target KPI

Demo Concept	Demonstrator	Measurement	Reference	Target KPI	Result
Precise, continuous and accurate positioning	**ASTP** ALSTOM	**Amount of balises used** for equipping the reference regional line	Real Regional G1 line equipped with ERTMS L2 system applying standard national engineering rules	Reduce OPEX and CAPEX by 15%	CAPEX/OPEX **reduction** in two measured Italian Regional Lines. Line 1: **18%** Line 2: **58%**
	ASTP AZD	• Radio hole – Length of confidence interval, recovering time; • Initialization on parallel tracks – occupied track determination, convergence time of conf. intervals	Current infrastructure state regarding balise number; Unavailable performance parameters for continuous positioning.	Increase reliability by 15%	Reliability increased through a possible **25%** reduction of track-side elements (balise groups)

Lab demo Track demo Qualitative analysis

Demonstrator concepts

Results vs Target KPI

*Regional Rail **CCS** & Operations for **G1** Lines*

Demo Concept	Demonstrator	Measurement	Reference	Target KPI	Result
Precise, continuous and accurate positioning	**ASTP** indra	• Integration of GNSS-based positioning, speed sensors and IMUs • Integration of digital maps into the positioning algorithm • Evaluation of GNSS augmentation technologies, to improve positioning accuracy	Real Regional line equipped with ERTMS L2 system	▪ Reduce OPEX and CAPEX by 15%	- Reduce trackside infrastructure requirements - Lower installation and deployment costs - Reduced maintenance costs
Reduce railway track maintenance cost	**ASTP** Jernbane-direktoratet	**ASTP position error** for track fault localisation (camera-corrected vs high-precision ground truth)	**GNSS** (2–4 m error in open-sky; unavailable in signal outage) **GNSS/IMU/ odometer fusion** (~1.25–3.20 m avg. error)	Reduce CAPEX and OPEX by 15% Increase system availability by 10%	Avg. error: 0.62 m (open sky), 0.45 m (GNSS weak/denied), Significantly better than GNSS-based methods; supports reduced maintenance costs & trackside assets.

Lab demo Track demo Quantitative analysis Qualitative analysis

Demonstrator concepts

Results vs Target KPI

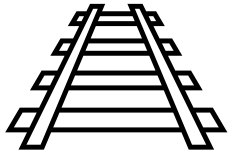
Demo Concept	Demonstrator	Measurement	Reference	Target KPI	Result
Train I&L determination	**Train I&L** MERMEC AN ANGEL COMPANY	• Check the time for recognising the integrity status • Check the time for recognising the train length valid value	2 sec	• KPI 01 • KPI 03 • KPI 04 • KPI 05 • KPI 08	In the tests performed, the train integrity status and train length value were provided in less than 2 seconds

Lab demo Track demo Quantitative analysis Qualitative analysis

Technological Readiness Level (TRL)

FP6.1 – Current status

Track demo



TRL5

*Basic technological components integrated within realistic context under a fully controlled environment in or **outside the lab**.*

ATO GoA4 — ÅZD

Remote Driving — vti

ASTP — Jernbane-direktoratet

ASTP — indra

ASTP — ÅZD

ASTP — ALSTOM

ASTP — mermec AN ANGEL COMPANY

Lab demo



TRL5

*Basic technological components integrated within realistic context under a fully controlled environment outside or **in the lab**.*

MB — CAF

ATO GoA2 — CAF

HTD — ALSTOM

HTD — indra

TMS — enyse

TMS — mermec AN ANGEL COMPANY

ATO GoA3 — indra

HTD — mermec AN ANGEL COMPANY

I&L — mermec AN ANGEL COMPANY

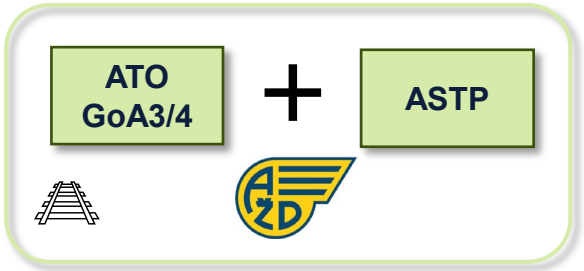
Technological Readiness Level (TRL)

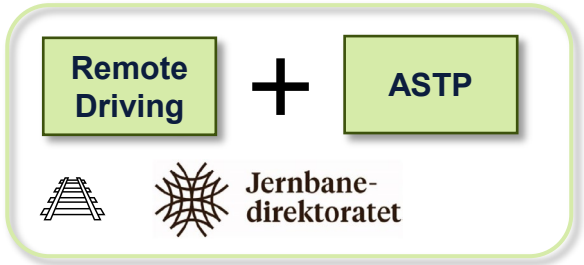
FP6.2 – Future status

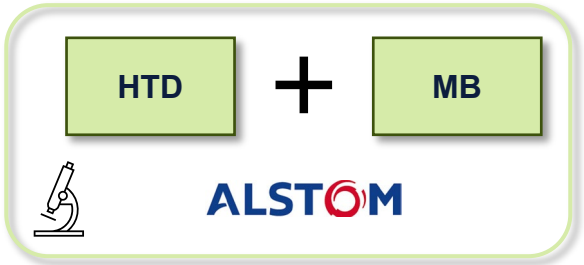
TRL6

A functional version of the product working on a realistic environment able to draw conclusions on the technical and operational capabilities of the product.













Lab demo Track demo

Europe's Rail

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