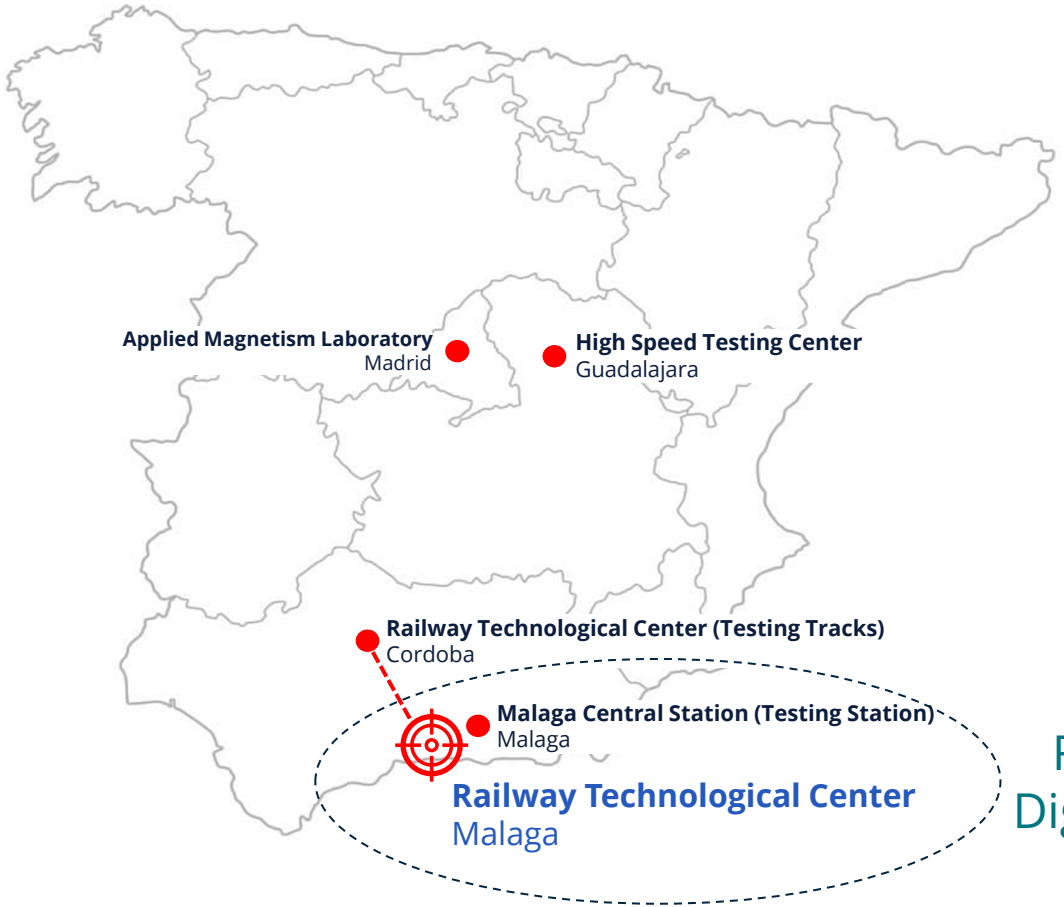
Europe's Rail

Mid-Term Event

Day 1 - Our promises

Technology Presentation and Integration Plan

WELCOME



Railway Digital Hub

Wawrzyniec PERSCHKE

Policy officer
European Commission - Unit - Rail Safety and Interoperability

Wawrzyniec Perschke is a Policy Officer in the Directorate-General for Mobility and Transport of the European Commission.
He is working on the policy of rail interoperability. He focuses on CCS TSI and ERTMS (including FRMCS), as well as Europe's Rail Joint Undertaking (System Pillar, CCS related projects of Flagship Areas 2 and 6, and CCS related Deployment group aspects). He is also involved in the economic analysis of Polish reforms in the field of transport of the European Semester.
His experience in the Commission includes work as an economist on broad intellectual property issues (e.g. support to SMEs, standard essential patents, IP management, access to and ownership of big data and relations with the EUIPO), on industrial policy for EU candidate countries and competitiveness analysis of EU Member States.
Prior to work in the Commission he worked as an academic assistant (economics) at the College of Europe, Natolin campus.

CCS for the society

Wawrzyniec Perschke
DG MOVE Interoperability and safety unit

European Commission

High level policy

- Smart and Sustainable Mobility Strategy (↗modal share of rail,↗HS,↗rail freight)
- Mission letter of the Commissioner (visibility, proximity to citizens, HS network, intermodal, integrated, societal, digital/ERTMS, new tech – hyperloop)
- Clean industrial deal (upcoming 2025)
- High speed rail plan (upcoming mid 2025)

Master Plan objectives to FA2

- Adapting to customers
- Efficiency
- Reduced costs
- Harmonised approach
- Rail as a backbone of EU transport
- EU RSI competitiveness

Societal needs behind Master Plan

- Overall increased demand, but more heterogenous
  - More time scattered people flows
  - More just in time delivery
- Lower costs due to other needs from public budget and overall limited resources
- Resilience (cyber, modularity, etc.)
- Ageing society – less personnel and more demand for passive transport
  - Automation
  - Integration with traffic management and with other modes of transport
- Geopolitical context

Links with System Pillar

How results integrate with policies?

- Innovation pillar delivers demonstrators to prepare products
- Policy perspective:
  - need for (some) products deployable on the entire network
  - Need harmonized system vision
- Your work with SP = input to interoperable solutions => via STIP
  - Technical specifications for interoperability
  - Standards
  - System pillar documents
- Making individual innovations fit in the overall system

Links with FA6

How to deliver on some societal objectives?

- Transport poverty
- Better life perspectives (access to services, schooling, health care, broader choice of jobs…)
- Climate adaptation, especially in poorer and more remote areas
- Through:
  - Lower costs of train, and rail system overall (adaptable CCS subsystem)
  - Better integration with the other parts of the mobility system
  - Higher frequency of transportation service, at an affordable cost to society

Léa PATIES

Senior Programme Manager | Europe's Rail Joint Undertaking

Léa Paties joined Europe's Rail in March 2017 and oversees the Flagship projects dedicated to Network management planning & control and Digital & Automated up to Autonomous Train Operations.

Between 2010 and 2017, she was Project Manager at UNIFE where she was first involved in the Association's research and innovation activities and then UNISIG, the consortium gathering the European ETCS suppliers, taking care of the promotion of ERTMS in Europe and Worldwide.

Léa holds a Masters degree in European Affairs and EU Project Management from the University of Strasbourg, France.

FP2-R2DATO – Mid-Term event – Malaga – 05 February 2025

Towards a reliable integrated European railway network

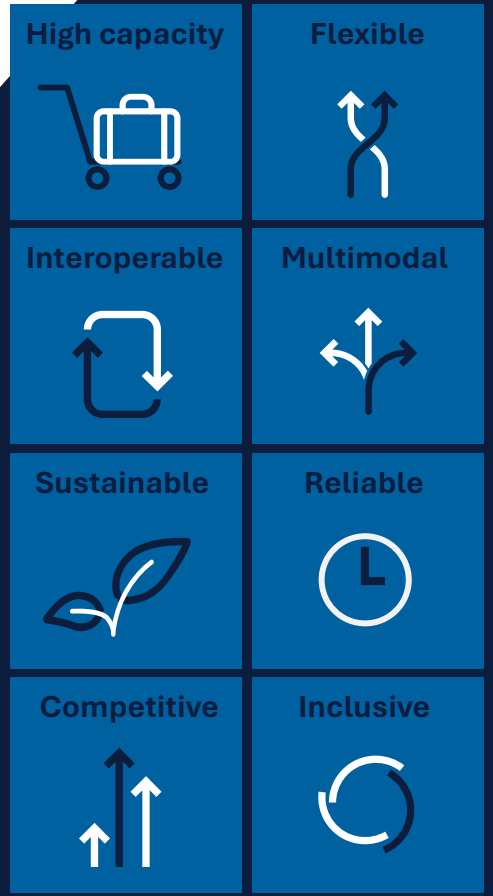
Europe's Rail

Léa PATIES

Senior Programme Manager

Vision

To deliver a **fully integrated European railway network for citizens and cargo.**



Towards a green and digital Europe

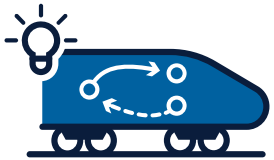
EUROPEAN GREEN DEAL
climate neutrality by 2050

DIGITAL DECADE
bringing Europe to the forefront of digitalisation and automation

SUSTAINABLE AND SMART MOBILITY STRATEGY
articulating the pathways towards digitalisation and greening the transport sector

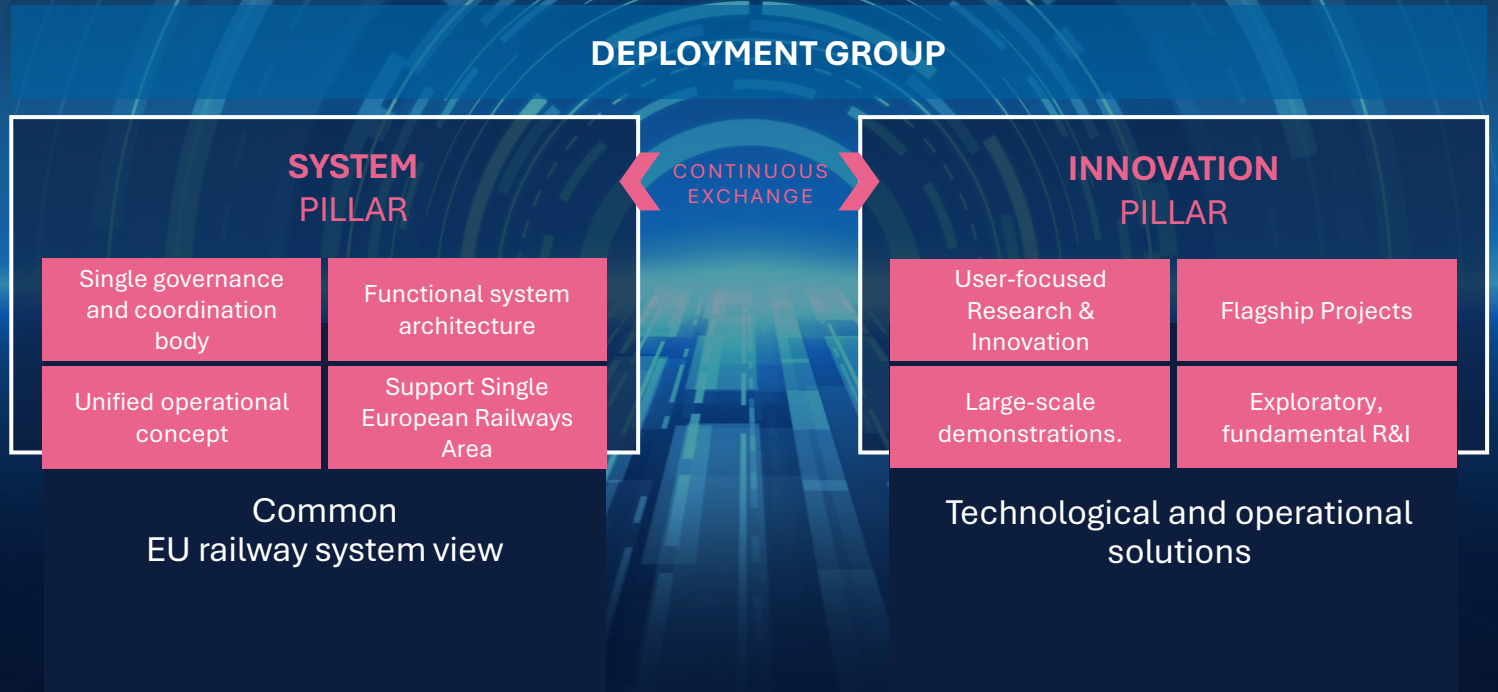
INDUSTRIAL STRATEGY
enhancing Europe's rail supply industry competitiveness

EU-Rail will play an instrumental role
in the achievement of the specific milestones
for rail research and innovation



Europe's Rail

Single R&I Programme based on a system view



Flagship Areas leading to Flagship Projects

- Network Management planning and control & mobility management in **a multimodal environment**
- Digital and automated up to **autonomous train operations**
- Intelligent and integrated **asset management**
- **Sustainable and green rail system**
- Sustainable **competitive digital green rail freight** services
- Regional rail services / innovative rail services to **revitalise capillary lines**
- Innovation for new approaches on **guided transport modes**

Exploratory research activities

Technologies and innovations from other sectors
Game changing methodologies
Disruption of innovation cycle

Results

Key Performance Indicators (KPIs)

Quantitative input delivered by the innovative **technological** and **operational** solutions

- KPI's for each Flagship Area
- Reporting of quantitative and qualitative metrics via Annual Activity Report

Analysis of social impacts

- Selection of most relevant KPIs
- Societal impact measurement methodology
- Calculation of the impact after each round of demonstrators (2025, 2027 and 2031)
- Specific Horizon Europe implementation indicators

Thank you

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Giuseppe RIZZI

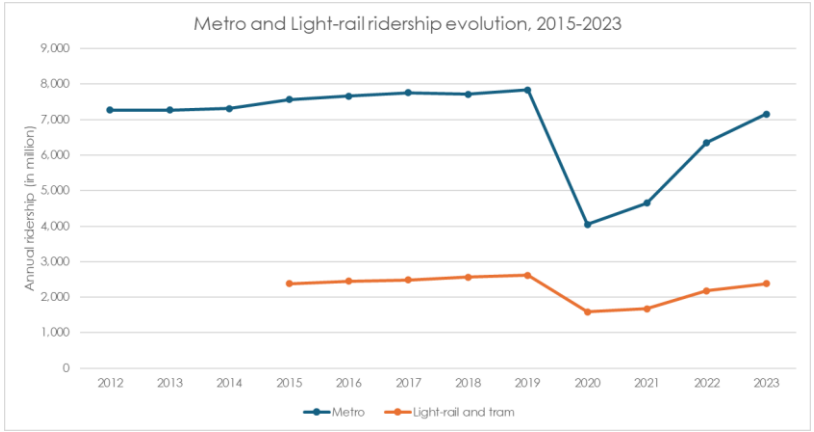
UITP, Project Manager
Knowledge & Innovation

Michael Meyer zu Hörste

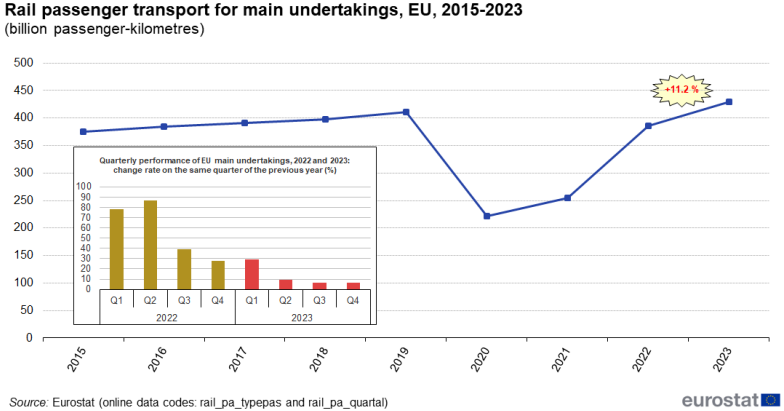
DLR – Cluster Leader « Innovative Operational Solutions »

1. What are the needs of the rail end users?

Global rail transport demand is growing despite COVID challenges



- An analysis of urban rail ridership trends in the 18 largest European cities reveals that **mobility demand is growing**, despite a temporary setback caused by COVID-19.
- Estimation for 2024: Ridership numbers are projected to surpass those of 2019.



- The same trend is observed for mainline railways: demand is growing, and passenger transport performance in 2023 surpassed pre-COVID levels.

The primary goal of the FP2-R2DATO project is to enhance the capacity and efficiency of existing rail networks to meet the growing demand for both passenger and freight transportation.

Global public transport trends identified by UITP

EXTERNAL FACTORS

Societal Changes

1. Aging population
2. Political changes
3. Modal Shift
4. Personalized Everything

Technology Trends

5. Electric cars deployment
6. AV Deployment
7. Automation & Robotics
8. (Generative) AI and Digitalization
9. 5G & Smart Cities
10. Cyberattacks ramping up

INTERNAL FACTORS

Operation challenges

11. Ridership slowdown due to COVID
12. Financial challenge (Revenue Vs. Cost)
13. Climate action and Financing
14. Sustainability
15. Social instability: Safety & Security

Challenges and Needs of Railways Addressed by FP2-R2DATO

Achieving a modal shift requires public transport to be fast, efficient, environmentally friendly, decarbonized, accessible, affordable, reliable, widely available, modern, well-covered and integrated.

Increased capacity →bigger and smarter offer

Better punctuality, reliability and productivity of staff, rolling stock and infrastructure

Addressing the issue of the workforce shortage

Breaking interoperability barriers to facilitate the development of a fully integrated European railway network, enabling seamless travel across Europe

Challenges and Needs of Railways Addressed by FP2-R2DATO

Achieving a modal shift requires public transport to be fast, efficient, environmentally friendly, decarbonized, accessible, affordable, reliable, widely available, modern, well-covered and integrated.

Mobility users are increasingly making more conscious choices toward sustainable transportation

Rail is already a safe mode of transport but automation and digitalisation can further contribute to achieving the Zero Vision

Improving communication between the fleet, infrastructure, and other transport modes to deliver truly seamless and efficient travel.

Who expects and/or needs what?

Expectations of the end users of the rail system:

- Train running at the expected / announced time => punctual and matching the demand
- Getting the connection => punctual
- Having a seat => capacity matching the demand
- Affordable => cost-efficient operation

Rail operation needs to be:

- Punctual => reserves needed to react to disturbances
- Cost efficient => Low OPEX (OPerational EXpenses) e.g. Energy consumption and high staff productivity
- Adaptive to the demand => trains running when needed and in the right capacity

Examples from Air Traffic Management (CESAR ATM)

Source: ASD and CANSO Europe: SESAR – Investing in digital European Sky, July 2024

What is a KPI?

Top Speed of an electrical Car: 275 km/h

Making our promises countable

Key Performance Indicators (KPI) addressed by FP2-R2DATO given in the Grant Agreement (GA):

Responsiveness: Reaction time on a request from Traffic Management System (TMS) (represented by FA1) to 2 Minutes (from 2 hours)

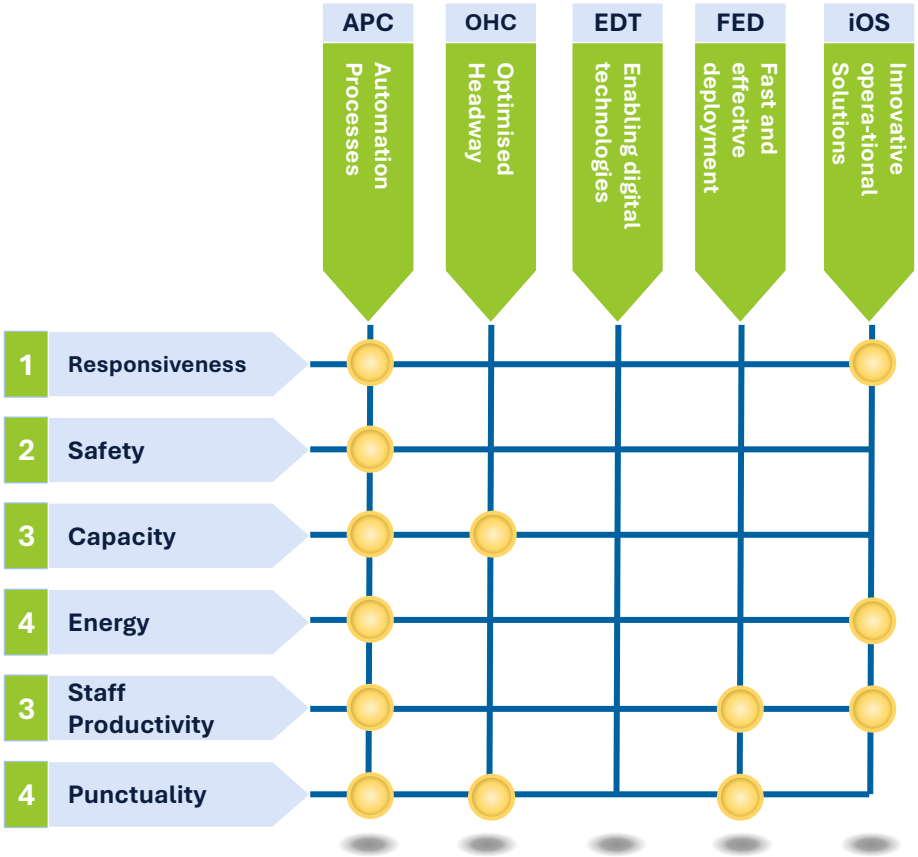
Safety: 50% decrease of no. of collisions with 3rd parties per 10.000 km travelled (ca. from 0.2 to 0.1)

Capacity: 10% Increase of no. of trains on a line per hour and direction

Energy: 10% decrease of energy consumption in kWh compared to human driver average

Staff productivity: 30% increase of productive hours

Punctuality: 50% decrease in delay Minutes



What are the associated Cluster which need to contribute to the KPI ?

1 KPI Responsiveness

Reduction from 2 hours to 2 min as reaction time to a request from FA1

Automation Processes will provide an improvement in the responsiveness, verified by measuring the time required to prepare a train for a new service from its switch on to the readiness to leave the depot or the yard. Automating functions and remote driving should contribute to this KPI.

Innovative Operation Solutions: As the innovative Operational Solutions are preparatory, the validation and KPI assessment will be done in subsequent projects.
Nevertheless, the approach is to have an offer more responsive to the demand: Flexibility in the responsiveness will be addressed by fully automatic up to autonomous operation in specific cases and networks. Up to the TRL at the end of the project this can be done by simulation.

2 KPI Safety

50% decrease of no. of collisions (ca. from 0.2 to 0.1) **with 3rd parties per 10.000 km travelled**

Automated Processes: Accidentology indicator for light urban rail. Since urban uses cases only refer to depot operations, this KPI is not applicable.

3 KPI Capacity

10% increase of no. of trains on line per hour and direction

Automated Processes will lead to a capacity increase verified by measuring punctuality, headways and travel times during test runs in the demonstration phase and applying simulation tools for getting the whole network perspective.

Optimized Headway will lead to a capacity increase and stability increase, verified by determination of punctuality figures, headways and travel times based on data gained from test runs in the demonstration phase and the application of simulation tools for getting the whole network perspective.

4 KPI Energy

10% decrease in kWh consumption compared to human driver average

Automated Processes will lead to energy consumption reduction, verified by measuring consumption during test runs in the demonstration phase.

Innovative Operation Solutions: As the innovative Operational Solutions are preparatory the validation and KPI assessment will be done in subsequent projects.
Nevertheless, the approach is to have an offer more responsive to the demand: reduction of cost by Energy consumption, addressed by running tailored trains and services matching to the demand

5 KPI Staff Productivity

30% increase of productive hours

Automated Processes shall lead to increased staff productivity, verified by measuring the reduction of waiting, shuttling and commuting times of the working force in depots and yards in the demonstration phase.

Innovative Operation Solutions: As the innovative Operational Solutions are preparatory the validation and KPI assessment will be done in subsequent projects.
Nevertheless, the approach is to have an offer more responsive to the demand: increased staff productivity, addressed by running tailored trains and services matching to the demand

Fast and Effective Deployment will lead to a reduction of cost by operational measures for deployment

6 KPI Punctuality

50% decrease in delay minutes

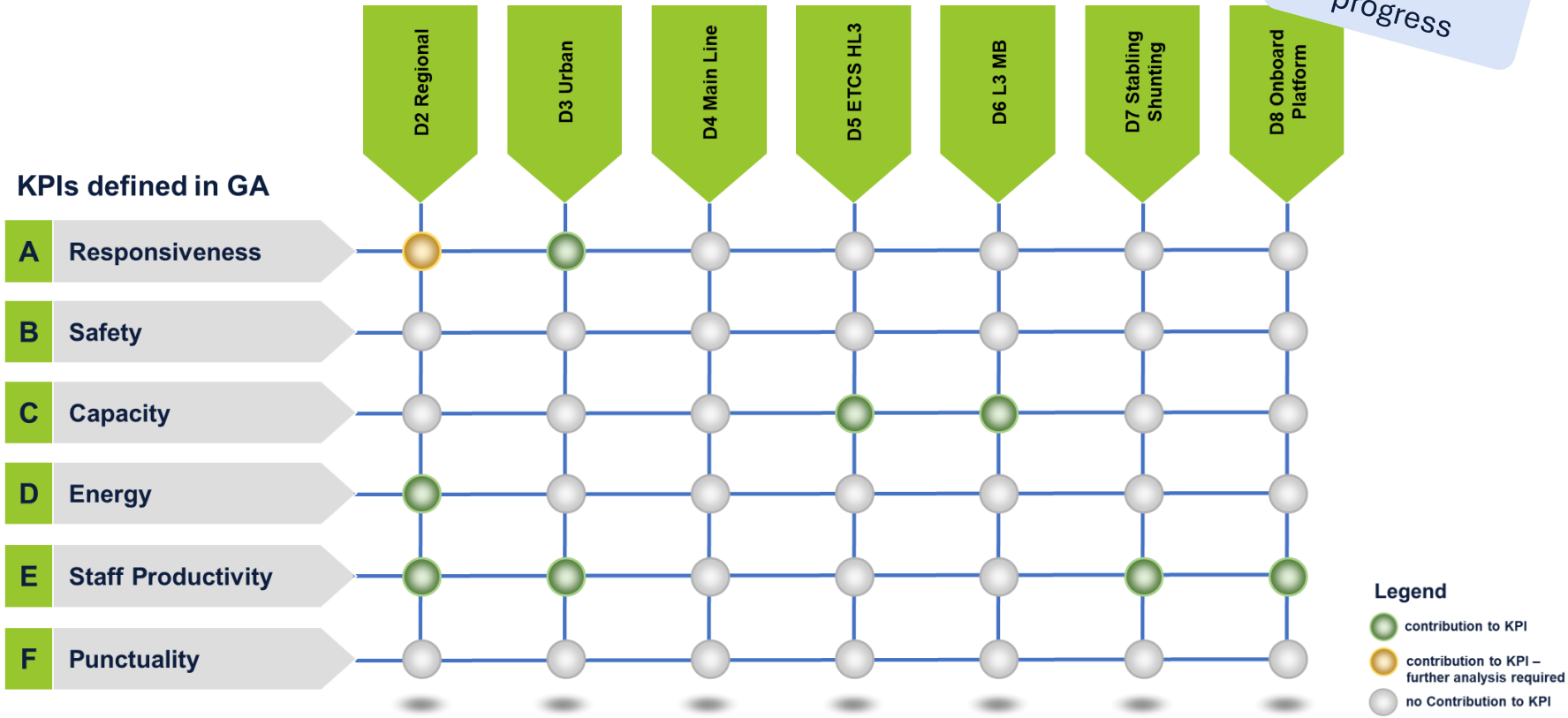
Automated Processes: with the stepwise introduction of the GoA3/4 technologies, the reduction of the human factors of the operators during operation will decrease and lead to the expected improvement. Automatic procedures react faster and more precisely to changes in environmental conditions

Optimized Headway: increasing capacity will improve the robustness of the system, having positive impact on compensating potential disturbances.

Fast and Efficient Deployment: the specific focus on virtual testing and approval will lead to reduced downtimes during the time of setting new or improved systems into operation

By which Demonstration will the KPI be demonstrated ?

Work in progress



Example Demonstration: Urban

1 KPI Responsiveness	2 KPI Safety	3 KPI Capacity	4 KPI Energy	5 KPI Staff Productivity	6 KPI Punctuality
Reduction from 2 hours to 2 min as reaction time to a request from FA1	**50% decrease of no. of collisions** (ca. from 0.2 to 0.1) **with 3rd parties per 10.000 km travelled**	**10% increase of no. of trains** on line per hour and direction	**10% decrease in kWh consumption** compared to human driver average	**30% increase of productive hours**	**50% decrease in delay minutes**

• baseline can be known [SVT]
• start, test driving to exit of depot
• mean time to have tram ready for service [ready to exit depot]
	NOT RELEVANT	NOT RELEVANT	NOT RELEVANT	• perimeter is depot
				• solutions [a] RTO [b] GoA4
				• baseline can be known
				• driver shift
				  • driving hours of tram
				  • msn driving hours [walking, waiting]
				  • use intensity of drivers
					NOT RELEVANT

How to do this? - Approach

The expected Impact needs to be quantified and there needs to be a credible pathway to calculate them:

- (Note: “real” KPI can be measured, when a system is in operation)
- For estimating the impact there is a quantified baseline and a relative or absolute improvement value needed
- The approach in R2DATO is to use the demonstrators as source for baseline **and** improvement value, because:
    - Conditions are as identical as possible
    - Even if some impact factors are not known or quantified
    - They are “real world” values
    - They are reflecting highest possible Technology Readiness Levels (TRL)
- The target of the KPI calculation is to show the impact of R2DATO and show the positive benefits

What categories of KPI do we have?

EU Rail Project Implementation

- Aim: Monitoring project *progress* & GA *fulfillment*
- Examples:
  - % Punctual Deliverables
  - % WP fulfillment
  - No. of activities for Communication, Dissemination and Exploitation
- Part of the GA of **FP2-R2DATO**

Commercial Project Implementation

- Aim: Contractual condition in exploitation projects
- Examples:
  - Capacity, Reliability, Punctuality, etc …
- Best case / normally quantified
- Typically condition for Payment
- **Not applicable in Europe‘s Rail**

Impact of Results

- Aim: Prediction / Estimation of *technological* or *operational* impact of innovations if deployed
- Examples:
  - 10% increase of no. of trains per hour & dir.
  - 10% decrease in kWh consumption
  - 30% increase of productive hours of staff
- Part of the GA **of FP2-R2DATO**

Socio-Economic Impact

- Aim: Estimation of *socio-economic* impact of innovations once deployed
- Examples:
  - High level: Rail market share (passenger and freight)
  - Next level: Life cycle cost; rail attractiveness
- Part of the GA of **Academics4Rail**

Bettina DOETSCH

FP2-R2DATO FPM – Hitachi Rail GTS

Cedric GALLAIS

FP2-R2DATO Coordinator – SNCF

2. FP2-RDATO Ecosytem Part 1

FP2-R2DATO in numbers

28
Partners

6 Clusters

48 WPs

588
Experts

202
Deliverables

28 Partners

FP2-R2DATO Partners

FP2-R2DATO partners together represent the railway sector in Europe :

Operators & Infrastructure managers

SNCF

DB BAHN

adif

FERROVIE DELLO STATO ITALIANE

ProRail

Jernbane-direktoratet

sporveien trikken

TRAFIKVERKET

SBB CFF FFS

ÖBB

Association

UITP ADVANCING PUBLIC TRANSPORT

Suppliers

ALSTOM · mobility by nature ·

CAF

Hitachi Rail STS

SIEMENS

AZD

COMSA CORPORACIÓN

KNORR-BREMSE

Faiveley Transport A Wabtec Company

kontron

mermec AN ANGEL COMPANY

GEOSAT

indra

Research Institutes

ceit

DLR

588 Experts

FP2-R2DATO Experts

FP2-R2DATO is composed of the best european experts on CCS (Command, Control, and Signalling) accross Europe with a rich variety of profiles:

Careers

- Researchers
- Managers
- Technical experts
- And many more...

Skills

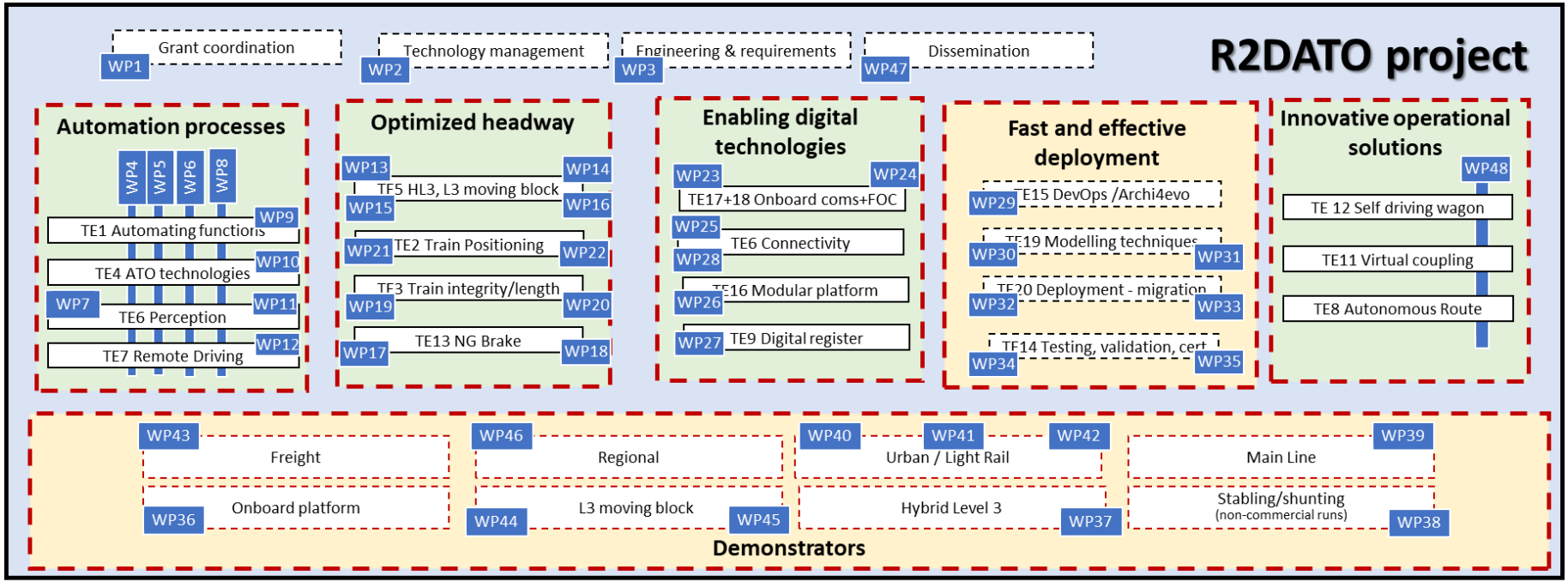
Area

6 Clusters

48 WPs

FP2-R2DATO Implementation Framework

FP2-R2DATO is composed of 6 clusters to manage the production of 48 Work Packages (WPs):



R2DATO clusters | Technical enablers/demo | R2DATO Work packages

202 Deliverables

FP2-R2DATO Deliverables

FP2-R2DATO is producing 202 deliverables with a great variability of outputs:

15 Use Cases

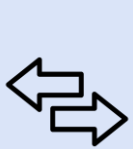
5 Simulations

13 Prototypes

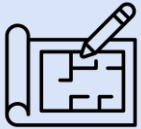
23 Demonstrators

2 Test benches

2 Business Case Analysis



1 Migration Strategies



11 Architecture

29 Specifications

19 Requirements

Inputs to TSI
(Technical Specifications for Interoperability)

35 deliverables for CL1: Automation processes	34 for CL2: Optimized headway	27 for CL3: Enabling digital technologies	33 for CL4: Fast and effective deployment	55 for CL5: Demonstrators

Javier Goikoetxea

CAF

Lucas Heinke

Deutsche Bahn

Marcus Fischer

Knorr-Bremse

3. the functionalities developed by FP2-R2DATO to address its KPI

Monique de Wit

ProRail

Arne Borälv

Prover/Trafikverket

Thibault Laroumagne

SNCF

APC : Automation Processes Cluster

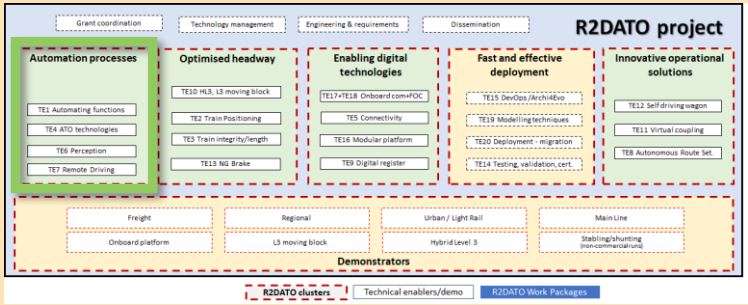
How is APC delivering impact ?

What are the challenges / painpoints we want to address ?

- High dependency of human factors in daily rail operations, leading to inefficiency and variable performance, leading to an unpredictable system
- Rather inflexible rail operations due to human resources management and long reaction times, also leading to poor overcoming of incidents, which may cause delays and cancellations.
- High number of non-productive operations in depots, for train preparation, and stabling requiring additional drivers and lowering productivity
- Complex urban light rail operations with multiple road users, and high workload for drivers, leading to frequent but many times avoidable incidents impairing service quality.

What are the goals, objectives of that topic ?

- To deliver scalable automation in rail operation up to GoA4 (Grade of Automation 4) for all segments, including freight and urban light rail.
- To implement operational solutions for automation up to GoA4 to be demonstrated in specific use cases through demonstrators and technical enablers.



APC : Automation Processes Cluster

What impact are we delivering ?




- Development of validated prototypes for different operational environments and uses cases of key **technical enablers** for automation, which are the **ATO technologies**, the **safe perception systems**, the **remote driving** and the **automating functions**.
- Collection of use cases and requirements and completeness of the architecture in collaboration with the System Pillar are previous steps leading to the development of building block prototypes and integrated demonstration, aiming to:
- Provide higher efficiency and flexibility to the railway system, enabling new operational approaches (e.g. on demand services) and optimising the available capacity.
- Reduce reactions times and increase resilience in case of accidents
- Improve overall productivity and reduce OPEX (OPerational EXpenses)
- Reduce the number of accidents in urban light rail operations, leading to reduce human fatalities or injuries and to increase of service reliability .

APC : Automation Processes Cluster

How does it contribute to our KPIs ?

Responsiveness	Safety	Capacity	Energy	Staff Productivity	Punctuality
Reduction from 2 hours to 2 min as reaction time to a request from TMS (Traffic Management System)	**50% decrease of no. of collisions** (ca. from 0.2 to 0.1) **with 3rd parties per 10.000 km travelled**	**10% increase of no. of trains** on line per hour and direction	**10% decrease in KWh consumption** compared to human driver average	**30% increase of productivity hours**	**50% decrease in delay minutes**
We will provide an improvement in the responsiveness, verified by measuring the time required to prepare a train for a new service from its switch on to the readiness to leave the depot or the yard. Automating functions and remote driving should contribute to the KPI.	Accidentology indicator for light urban rail. This KPI will be applicable in next steps of FA2, when the uses cases will refer to highly assisted driving in commercial service. Perception and ATO (Automatic Train Operation) Technologies (decision-making) will play a major role here.	We will lead to a capacity increase verified by measuring punctuality, headways and travel times during test runs in the demonstration phase and applying simulation tools for getting the whole network perspective.	We will lead to energy consumption reduction, verified by measuring consumption during test runs in the demonstration phase. Automating functions and ATO Technologies .	We shall lead to increased staff productivity, verified by measuring the reduction of waiting shuttling and commuting times of the working force in depots and yards in the demonstration phase.	With the stepwise introduction of the GoA3/4 technologies, the reduction of the human factors of the operators during operation will decrease and lead to the expected improvement. Automatic procedures react faster and more precisely to changes in operations.

APC : Automation Processes Cluster

Towards demonstration

TRL4/5

TRL6/7

WP4
System View & Coordination

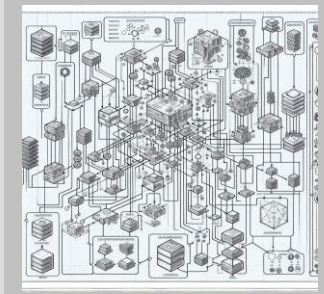
Needs

WP5
Use cases

Specifications

WP6
Specifications

WP8
Safety
Analysis



Development

Validation

WP7
Data Factory

WP9
Automating Functions Prototypes

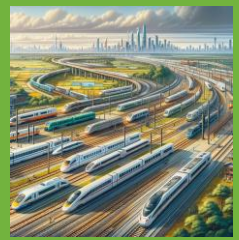
WP10
ATO Prototypes

WP11
Perception Prototypes

WP12
Remote Driving Prototypes

Demonstration

Demonstrators



How is R2DATO delivering impact ?

What are the challenges/ pain points we want to address?

- **Increasing** operational **capacity** on current infrastructure.
- **Reducing operational/life cycle costs** by ETCS (European Train Control System) Hybrid Level 3,
- **Enabling ETCS Level 3 Moving Block** with new train positioning technologies.
- Achieving **reproducible braking distances** / improved braking performance.

What are the goals, objectives of that topic?

- **Use cases**, **requirements** and compilation of the system **architecture** in collaboration with the System Pillar and WP3 as steps leading towards the **development** of prototypes and integrated demonstration.
- The **validation of prototypes** ready to demonstrate the ERTMS game changers in different **operational environments**, with:
  - mixed radio based ETCS levels with Hybrid Level 3, ETCS L3 moving block,
  - absolute train position, train integrity and train length management,
  - optimised and reproducible braking performance.

Cluster 2: OHW
Optimized Headway

What impact are we delivering?

- **Capacity and stability increase,** verified by:
  - determination of **punctuality figures**,
  - **headways** and travel times based on data gained from test runs in the demonstration phase,
  - application of **simulation tools** for getting the whole network perspective.
- **Improve the robustness** of the system with the increased capacity having positive impact on the potential to **compensate disturbances**.

How does it contribute to our KPIs?

Capacity

- **KPI 3, capacity:**
  increase of number of trains on railway track per hour and direction.

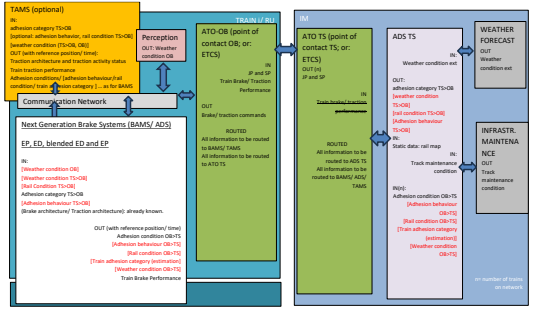
Punctuality

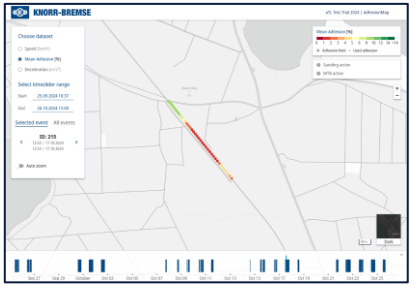
- **KPI 6, punctuality:**
  significant decrease of delay times.

Overview on WP17/18: NG Brake

(Next Generation Brakes)

- Cluster goals addressed:
  Improve **capacity, stability, punctuality**.
- Facilitated by:
  improved braking performance/ reduced braking distance prolongation at **low adhesion conditions**.
- **Enable the future use** of solutions: use cases/ architecture integration, impact analysis, certification, etc.
- Test rig tests and on-train **validation of BAMS/ADS** performed:
  - proof of concept for **adhesion mapping**,
  - validation of **adhesion improvement** (sanding) and **performance validation** of WSP algorithm.
- Test rig tests to examine options of **ADS**:
  - contactless technologies analyzed on **multi axle roller rig,**
  - **hazard analysis** for implementation on train demonstrator,
  - testing phase: define potential of selected technology.
- Further testing/ validation activities (test rig, on-train) planned for WP18.





ADS: Adhesion Determination System

BAMS: Brake and Adhesion Management System

cluster 2 [OHW] – optimized headway

overview on MB [WP13|14] & HL3|HTD [WP15|16]

objectives of the technical enabler [TE]

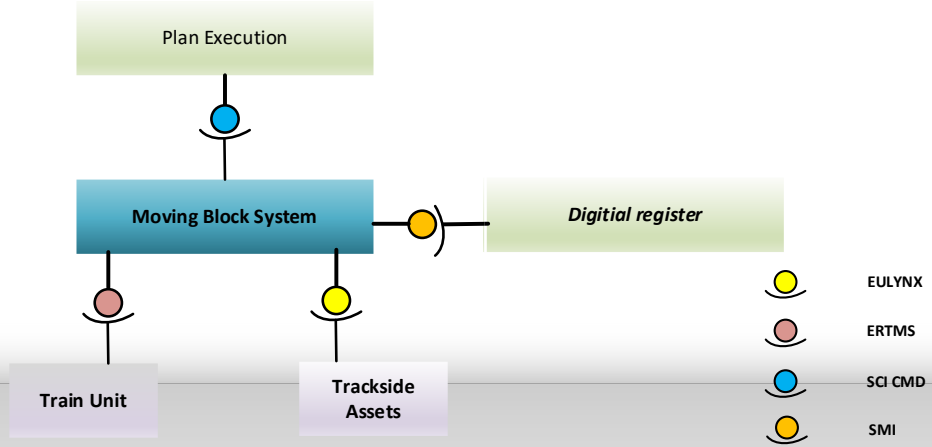
- to specify and define concepts of a high capacity signalling System
- to align the architecture and requirements with the involved stakeholders
- to support the maturity of the specification by demonstrators

challenges:

to align with involved stakeholders

Milestones of the technical enabler [TE]

- 3 Moving Block Specifications released and corresponding implementations designed, developed and delivered to the demonstrator WP
- Specifications for HTD released, to be used in the demonstrators

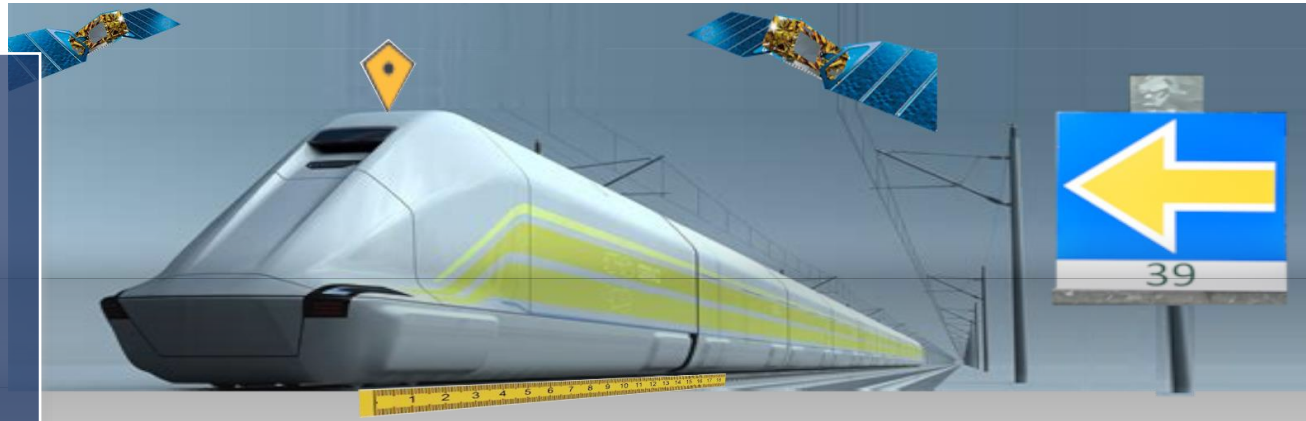


cluster 2 [OHW] – optimized headway

overview on ASTP [WP21/WP22]

objectives of the technical enabler [TE]

- To describe operational needs and ASTP system capabilities
- To define ASTP requirements and performance
- To define generic ASTP high level architecture and assess RAMS
- To test ASTP in operational environment and demonstrate performance KPI



Train Positioning Challenge:

How to integrate satellite navigation safely into ETCS
How to increase ETCS performance while reducing legacy infrastructure
How to find a common ASTP architecture for significant diverse demonstrators

cluster 2 [OHW] – optimized headway

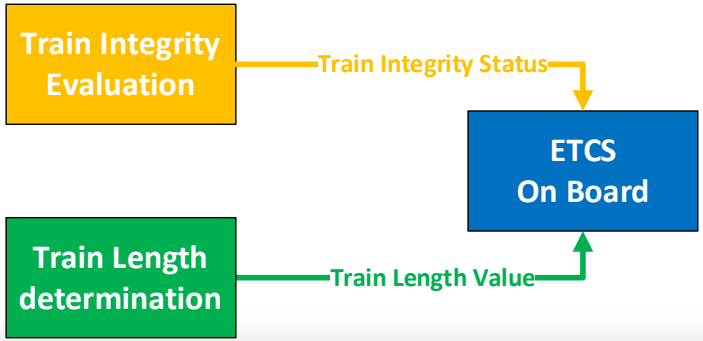
overview on Train Integrity Trail length [WP19|20]

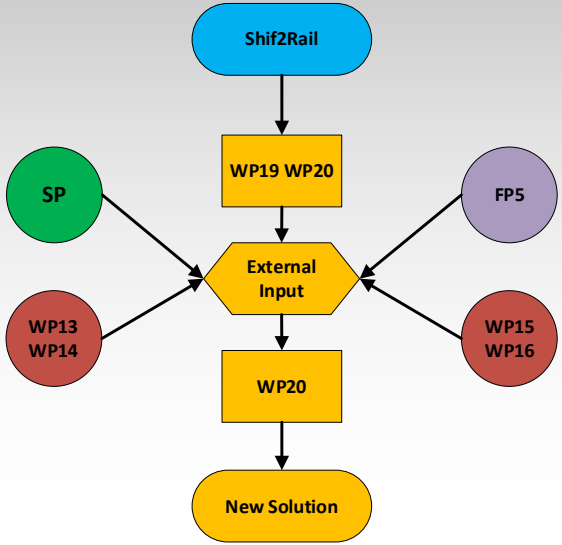
objectives of the technical enabler [TE]

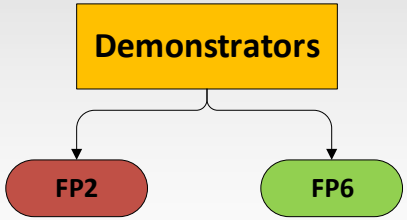
- Identify standard solution suitable for all kind of trains
- to be compatible with the needs of MB and HL3/HTD
- Support the maturity of the specification by demonstrators
- Provide solution that doesn't affect the signalling performances

challenges:

to align with involved stakeholders







How is EDT delivering impact ?

What are the challenges / painpoints we want to adress ?

- Development of foundations for onboard network communication
- Definition of CCS (Common Components System)/TCMS interoperability (Train Control and Monitoring System)
- Further specification work for FRMCS (Focus Onboard-System and Trackside Gateway)
- The specification of Computing Platforms is crucial to support modular certification and efficient and interchangeable deployment of safe and basic integrity railway applications
- Developing the architecture and specifications for the implementation, testing and certification of Specification, development, and implementation of the Digital Register in the sense of a database supporting assisted and automated train operations
- Investigate how multiple radio bearers can be used concurrently to serve the needs of both the Gigabit train and future rail operations, and how the FRMCS architecture and specifications can potentially be expanded in this direction

What are the goals, objectives of that topic ?

"To achieve substantial progress in specification work, establishing a solid foundation for future demos."

- Deliver input for TSI2025 update, SS 147 V. 2.0 (common bus)
- Specifiaction of interface between FRMCS (Future Railway Mobile Communications System) and ATO (Automatic Train Operation)
- Provide specifications for modular platforms
- Further develop specifications for the digital register

5 → **Demonstrators are supported by work of the EDT cluster**

How is EDT delivering impact ?

What impact are we delivering ?

Standardization topics:

- Standardisation of Computing Environment
- Configuration management
- Data interface between DR and CCS/TMS Components (Phase 1)
- Data interface between DR and CCS/TMS Components (Phase 2)

1

TSI Update planned from Enabling Digital Technologies Cluster

4

Standardisation Requests from Enabling Digital Technologies Cluster

- Update of Subset 147 V2.0 is included in the standardization roadmap of EU-Rail, with plans for inclusion in future TSI change request process

How does it contribute to our KPIs ?

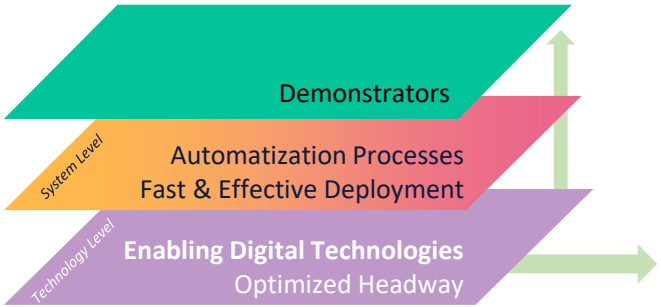
- Development of Digital Technologies that enable the performance of the solution
- Enabling the Clusters *Automation Processes* and *Optimized Headway* to reach project KPIs that are well defined and measured in the Demonstrators Cluster

DR: Digital Register
CCS: Common Components System
TMS: Traffic Management System

Enabling Digital Technologies Cluster

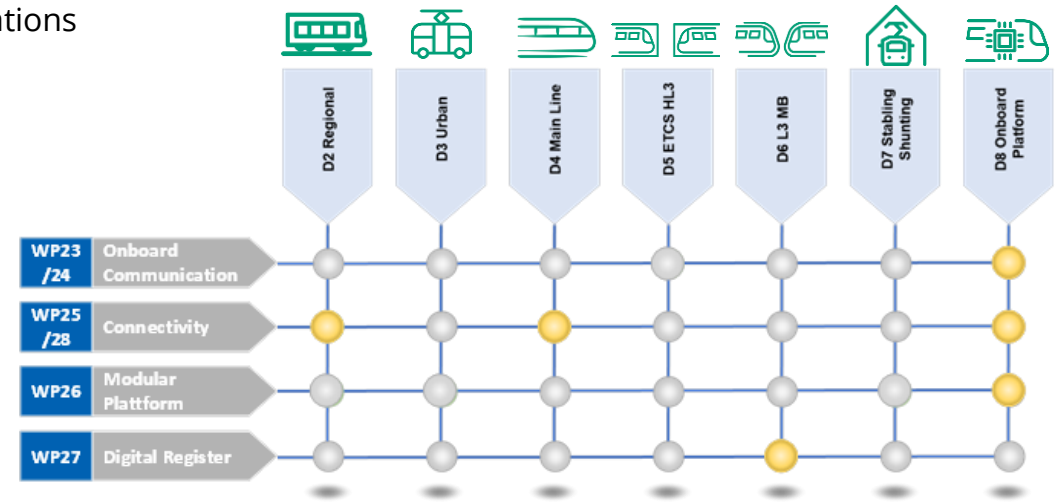
Objective: Provide the connectivity, IT (Internal Tool) and data platforms required for the automation of rail operations and increase the cost efficiency in the rail system by:

- Leveraging off-the-shelf IT solutions
- Decoupling the life cycles of railway applications and connectivity, IT and data platforms
- Allowing to aggregate multiple railway applications on common platforms



The cluster serves as a foundation for the development of additional clusters in FP2-R2DATO and demonstrators. Pivotal elements for ATO systems such as the Digital Register and FRMCS as well as technologies ensuring evolvability and adaptability such as the modular platform are developed in our cluster.

The cluster includes the following Technical Enablers (TE) and related Demonstrators :



How is R2dato delivering impact ?

What are the challenges / painpoints we want to address ?

- Authorisation of products and modification of railway assets is still based on **human judgement** (risk and cost driver)

Main question: How can we speed up and optimize?

- **How to reduce** on site testing and detect errors as early as possible to save time and costs?
- **Long lifecycle**, adaptions (maintenance) **vs. short release** cycles (new features and fixes)
- **Lack of standard requirements** (e.g. ATO onboard) will increase risks and costs

What are the goals, objectives of that topic ?

Fast and effective deployment

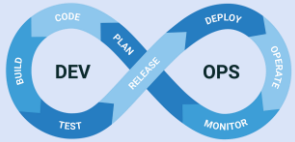
By providing generalizable frameworks, we can deploy faster, cheaper and improve quality!

- To improve operational excellence **by enhancing the evolvability** of architecture and using a DevOps strategy
- To improve quality, reduce costs and risks **by automating the authorisation** of products and modifications of railway assets
- To improve quality and reduce costs and risks **by developing and delivering a model** for ATO on board and TCMS Data Service
- Cost efficient deployment of products **by providing a common strategy, tools and process** for testing, validation and certification
- To support the sector's decision-making process **by delivering a business case (value) framework**

ATO: Automatic Train Operation
DevOps: A set of practices that combines software development (Dev) and IT- operations (Ops)
TCMS: Train Control and Monitoring System

How is R2dato delivering impact ?

What impact are we delivering ?



- Shorter lead times
- Higher quality
- Reduced costs
- Standardisation

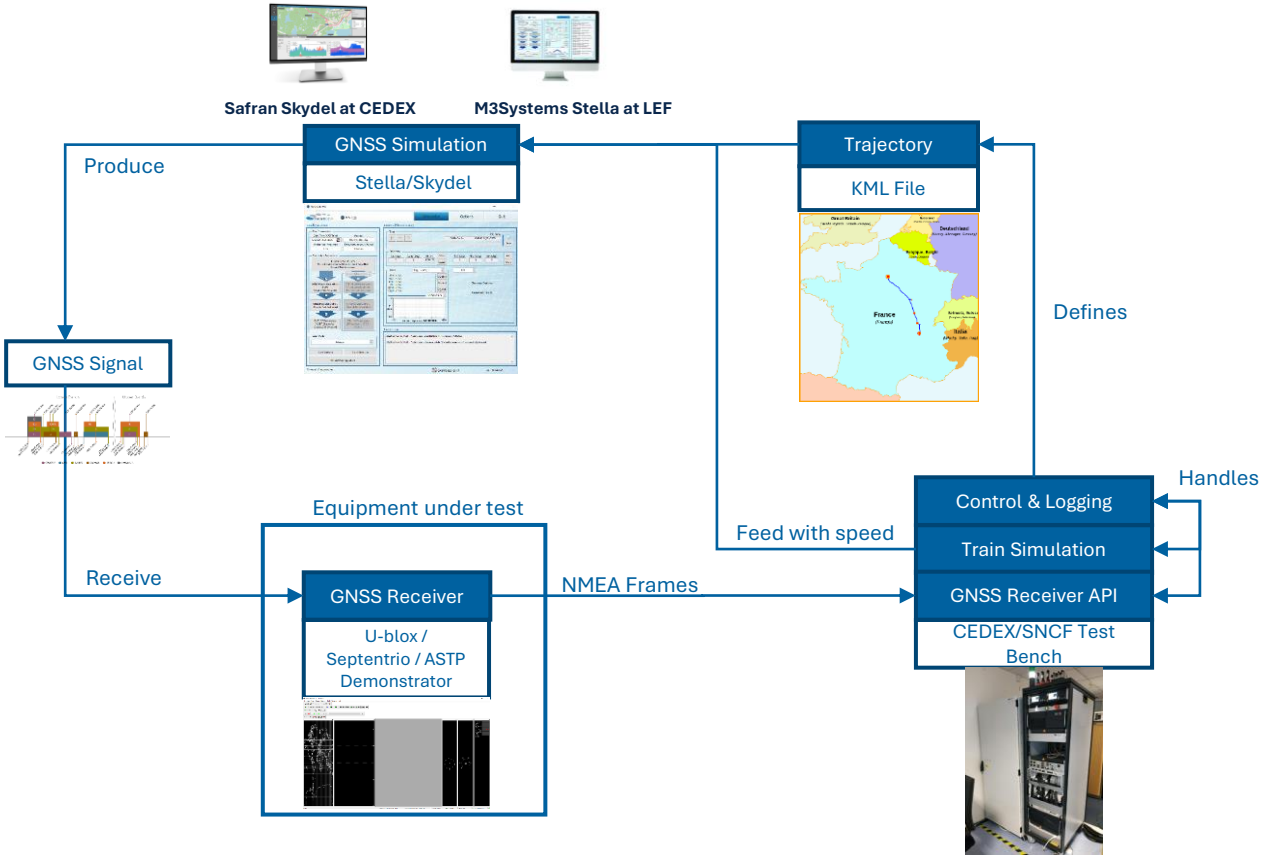
- Collaborative network of European laboratories to **validate** and **certify** new onboard systems efficiently
- Virtual prototyping from the specification to the validation **to increase speed and quality of development**
- **Better decision-making** based on CostBenefitAnalysis & value framework
- **Guidelines and concepts** for migration and deployment

How does it contribute to our KPIs ?

Provide Process KPI's as input for the demonstrators / R2DATO KPI's

- Process efficiency, e.g.:
  - Staff productivity
  - Unit costs
- Process cycle time, e.g.:
  - Total lead time of software development/releases
- Process effectiveness, e.g.:
  - Quality of test results, validations, software releases
  - Error rate
  - Customer satisfaction

WP34 GNSS Constellation Simulation in ETCS laboratories

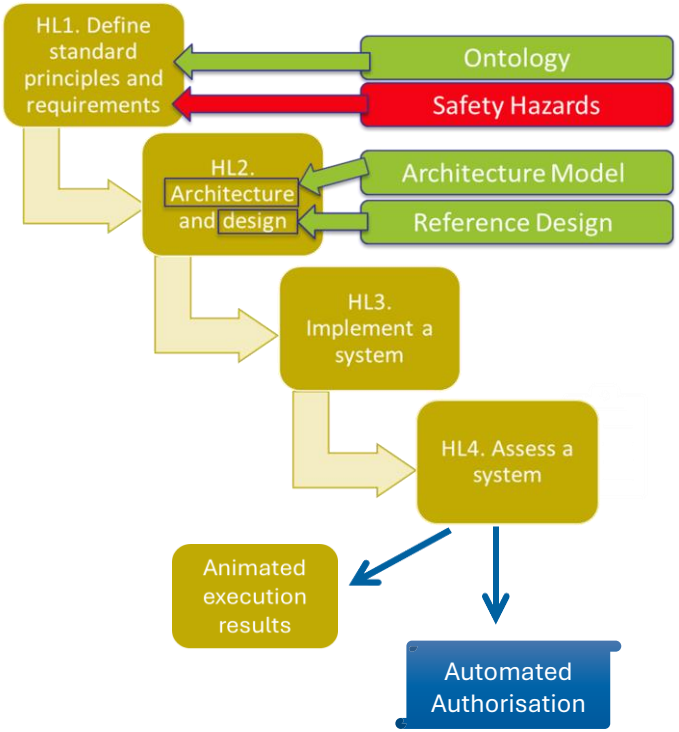


- Development to interface ETCS test bench with a GNSS Simulator
- First evaluation of the KPI defined in WP22.4 to evaluate a demonstrator
- Comparative study between Skydel and Stella GNSS simulator
  - ✓ Skydel-Stella input/output: check if there is any drift of the position
  - ✓ Check of the consistency between the input trajectory and the estimated position on the same GNSS receiver

ASTP: Advanced Safe Train Positioning
ETCS: European Train Control System
GNSS: Global Navigation Satellite System

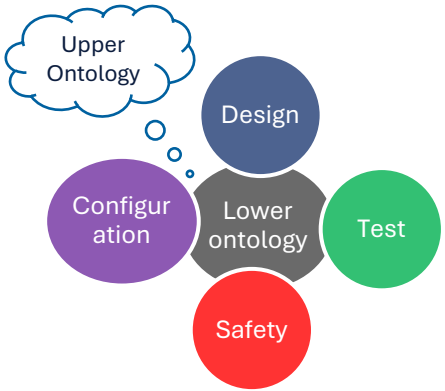
WP30 Demonstrator of ETCS L3 Trackside (Task 30.2)

- Modelling techniques to enable automated authorization
  - ✓ Reduce risks, improve quality, manage complexity
  - ✓ Builds on Shift2Rail TD2 Formal methods and standard interfaces
- Demonstrate formal methods for automated authorization
  - ✓ Based on Formal Methods-friendly ontology (upper/lower)
  - ✓ Reference model of trackside system with moving block
  - ✓ Enable to explore different architectures



Ontology (basis for requirements)

Ontology as an object model



Coffee break

It’s time to go visit
the 4 cluster posters :

Details of the development content and interaction between subfunctions

Hélène Arfaoui Kaynak

SNCF - WP leader (deputing Ton Visser)

4. Demonstration of solutions integration and their maturity for the railway system

Introduction of the demonstrators

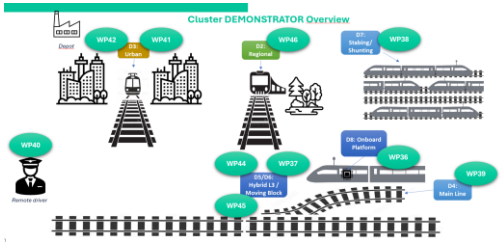
The Demonstrator Cluster is paving the way to the deployment of future innovations

What are the key challenges of the Demonstrators ?

- **Understanding** what we are integrating and demonstrating
- **Integrating** the on-board and trackside solutions into **one system** and for **one or several use cases**
- (Re)creating the railway environment with **representative parameters and models** (train dynamics or infrastructure BIM or 3D-models)
- Demonstrating the **correct functioning** under various operational scenarios **addressing nominal and degraded modes thanks to simulators, test benches and architectural platform**
- Assessing the
  - **technological maturity**,
  - the **overall costs and benefits,**
  - the **operational challenges,**
  - the deployment strategy and **migration steps,**
  - and identifying **exported constraints towards adjacent systems** (e.g. TMS/CMS, TCMS,…) **or towards operations**
- in order to provide **feedback** to the other Clusters and FPs
- Validate the **interfaces and architecture** principles in a **real environment encountering failures, errors and delays**

What are the different areas covered by the Demonstrators?

- Operational uses cases and Functional use cases (add the figure)



What will be the key results of the Demonstrators?

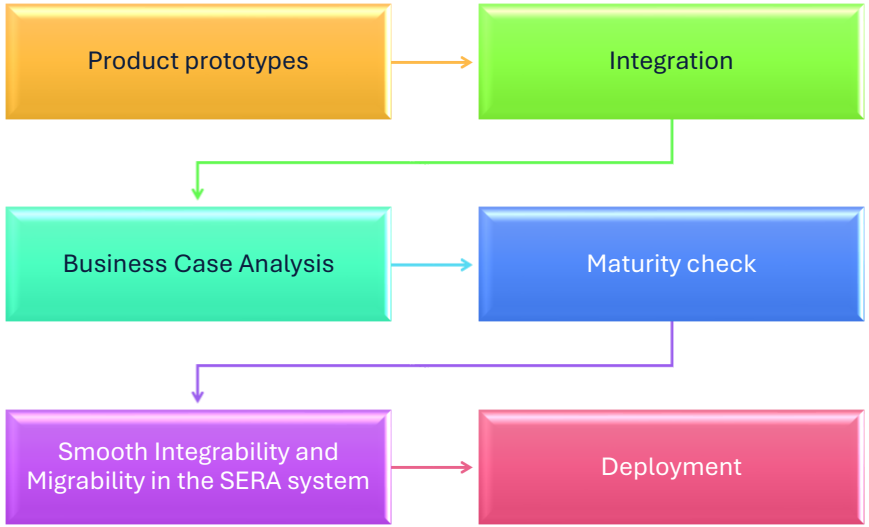
- Results on the **FP2-R2DATO KPI:** Are they realised, sufficient, representative, and correct?
- Results on FP2-R2DATO **use cases maturity** : are products and prototypes sufficiently mature and performant for a given use case?
- Results on FP2-R2DATO **testing coverage of use cases** : is the use case sufficiently covered by tests in nominal and degraded modes?
- Results on **Business Case** of the Use Case in terms of **operational impact and integration and migration** effort

How are the Demonstrators doing it?

- The “midterm” answer will be provided on DAY 2…

Results from the demonstrators

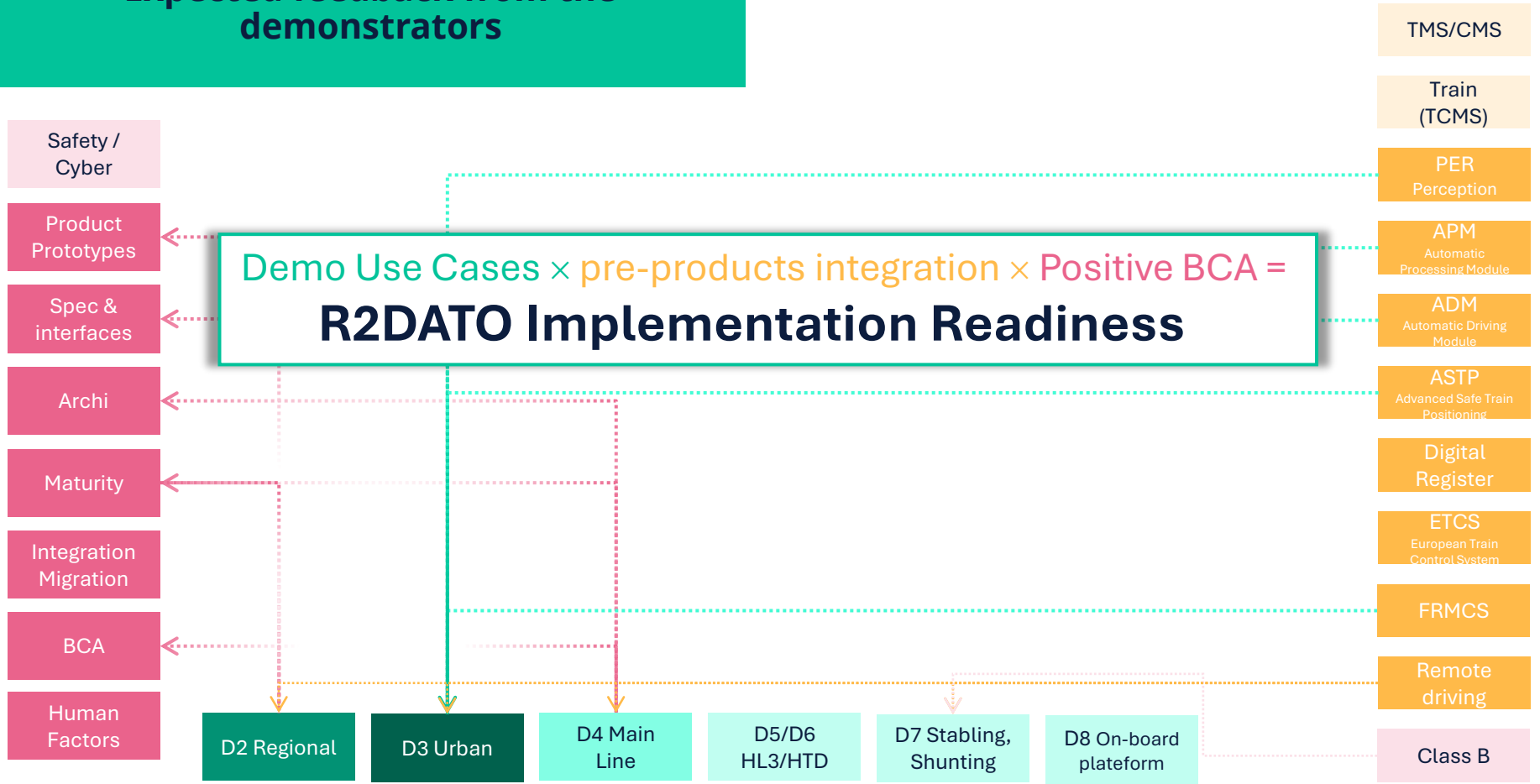
The Demonstrator Cluster is paving the way to the deployment of future innovations



Expected feedback in wave 1 on:

- Product prototypes
- Interfaces and specifications
- Architecture
- Maturity level of Use Cases
- Migration and integration strategy
- Business Case Analysis (BCA)
- Human factors

Expected feedback from the demonstrators



FRMCS: Future Railway Mobile Communication System

Thomas van den Berg

ProRail

Giacomo Barbieri

University of Twente

5. Integrate CCS Innovations into the daily business

Cooking Business Cases for Autonomous Train Operations

A. Team Presentation

B. Context and objectives

C. Methods and tools

D. Expected Outcomes
   - BuCa Outline Framework
   - BuCa Guidelines
   - Semi-quantitative BuCa

E. Conclusion and future steps

A. **Team Presentation**

B. Context and objectives

C. Methods and tools

D. Expected Outcomes

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- Semi-quantitative BuCa

E. Conclusion and future steps

WP32: DATO Assessment and Potential identification

ProRail — Thomas van den Berg, David Koopman, Monique de Wit, dr. Julia Lo

Jernbane-direktoratet — Geir Hansen

DB Cargo — Dr. Simon Funke

Rowan van Pelt, Dr. Gerben Scheepmaker

adif — Miguel Letona Otaño, Ramiro Valdes

renfe — Jesus Sánchez Domínguez

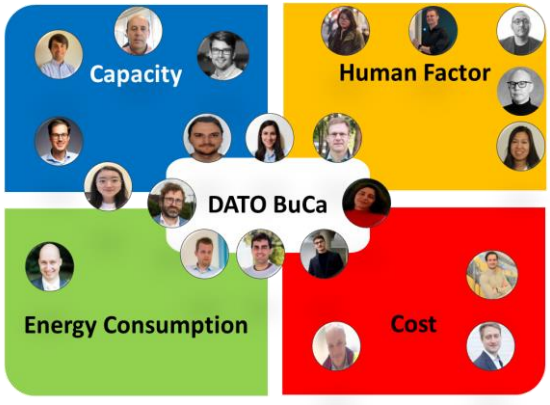
UNIVERSITY OF TWENTE. — Prof.dr. Jan Braaksma, dr. Willem Haanstra, dr. Giacomo Barbieri, PhD'er Zeinab Mowlaei, Dr. Sarah Kusumastuti, dr. Simone Borsci, Tom Kolkman

NTNU Norwegian University of Science and Technology — Prof.dr. Nils Olsson, PhD'er Xavier Morin

KTH Vetenskap och Konst — PhD'er Emil Jansson

TU Delft — PhD'er Julian (Chunyan) He

Luleå University of Technology — Mattias Holmgren



Cooking Analogy

...makes the process relatable and hands-on, helping to **BREAK DOWN COMPLEX CONCEPTS**

..supports the **STRATEGIC ALIGNMENT** necessary for the success of the project

... provides a common language and context, FACILITATING DISCUSSION AND CO-CREATION

... fosters empathy and makes keener to COLLABORATE WITH OTHER PARTIPANTS

A. Team Presentation

B. Context and objectives

C. Methods and tools

D. Expected Outcomes

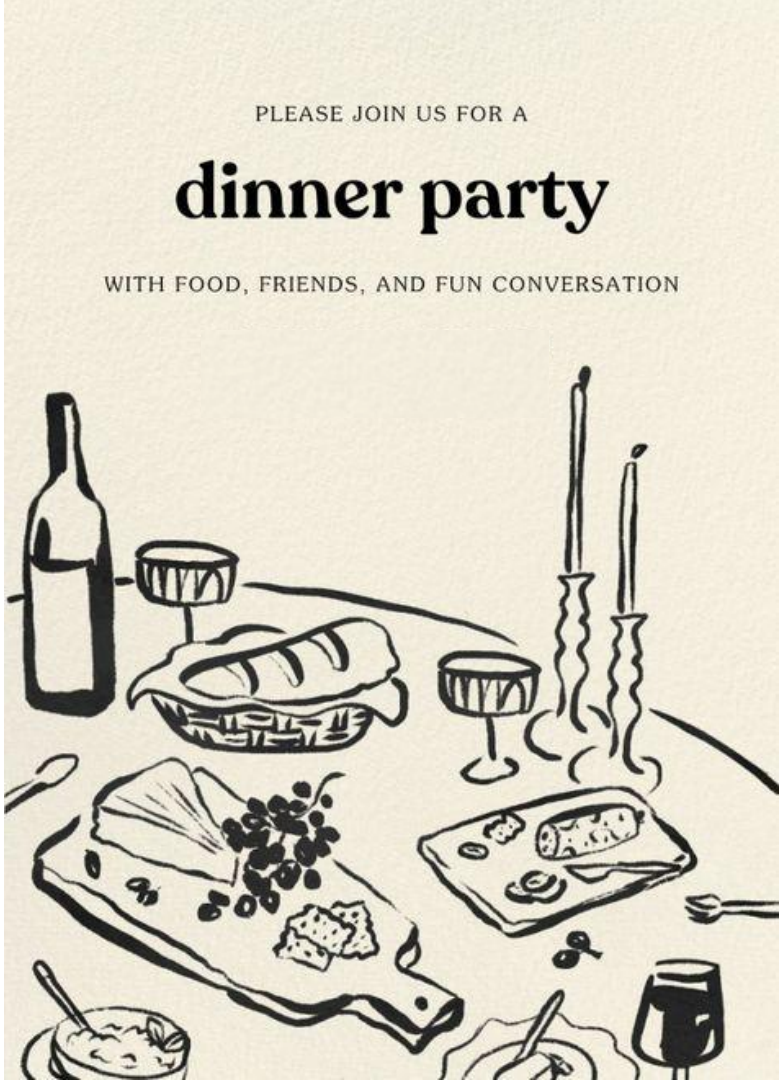
- BuCa Outline Framework
- BuCa Guidelines
- Semi-quantitative BuCa

E. Conclusion and future steps

WP Objectives

Illustrate the Attractiveness of DATO:
To facilitate and accelerate the deployment of DATO technologies across European networks

Develop a Robust BuCa Methodology:
To create a robust and generalizable methodology for societal business cases supporting the adoption of DATO technologies

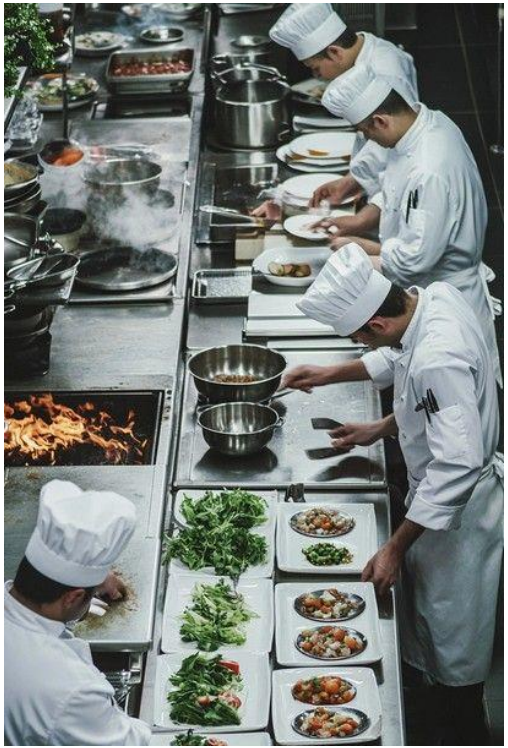


BuCa: Business Cases

Literature review

Family Cooking

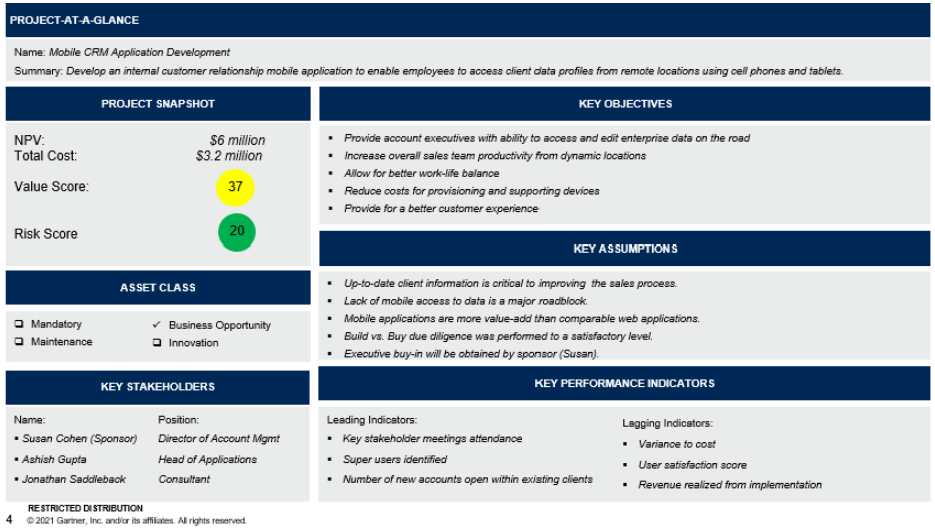
Cruise Ship Kitchen



- **Multiple guests** with several cultures and from different countries
- **Guests** with several preferences
- Cooking should integrate different **ingredients, knowledge, methods and tools**
- **Family cooking approaches** can provide useful guidelines but…

Literature review

Project Business Case



PROJECT-AT-A-GLANCE

Name: *Mobile CRM Application Development*

Summary: *Develop an internal customer relationship mobile application to enable employees to access client data profiles from remote locations using cell phones and tablets.*

PROJECT SNAPSHOT

NPV: *$6 million*
Total Cost: *$3.2 million*

Value Score: 37

Risk Score 20

ASSET CLASS

- ❑ Mandatory
- ❑ Maintenance
- ✓ Business Opportunity
- ❑ Innovation

KEY STAKEHOLDERS

Name:	Position:
▪ *Susan Cohen (Sponsor)*	*Director of Account Mgmt*
▪ *Ashish Gupta*	*Head of Applications*
▪ *Jonathan Saddleback*	*Consultant*

KEY OBJECTIVES

- *Provide account executives with ability to access and edit enterprise data on the road*
- *Increase overall sales team productivity from dynamic locations*
- *Allow for better work-life balance*
- *Reduce costs for provisioning and supporting devices*
- *Provide for a better customer experience*

KEY ASSUMPTIONS

- *Up-to-date client information is critical to improving the sales process.*
- *Lack of mobile access to data is a major roadblock.*
- *Mobile applications are more value-add than comparable web applications.*
- *Build vs. Buy due diligence was performed to a satisfactory level.*
- *Executive buy-in will be obtained by sponsor (Susan).*

KEY PERFORMANCE INDICATORS

Leading Indicators:	Lagging Indicators:
▪ *Key stakeholder meetings attendance*	▪ *Variance to cost*
▪ *Super users identified*	▪ *User satisfaction score*
▪ *Number of new accounts open within existing clients*	▪ *Revenue realized from implementation*

RESTRICTED DISTRIBUTION

Megaproject Business Case

- **Multiple stakeholders** across various companies and countries
- Diverse **value drivers and outcomes** among stakeholders
- The BuCa development requires integrating **multidisciplinary knowledge, methods, and tools**
- **Traditional CBA and MCDA** provide useful guidelines, but the results…
  - …must be *self-explanatory*, clearly tracking the *rationale* behind decision-making
  - …highlight *critical trade-offs* and the *need for alignment* among stakeholders

A. Team Presentation

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- BuCa Outline Framework
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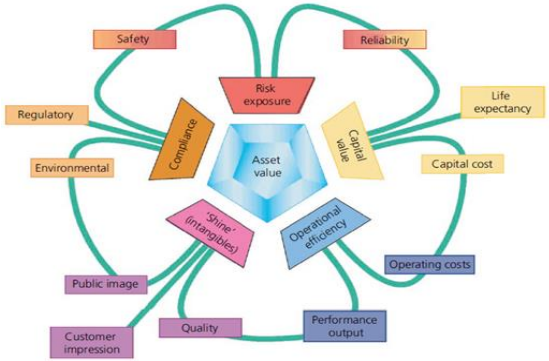
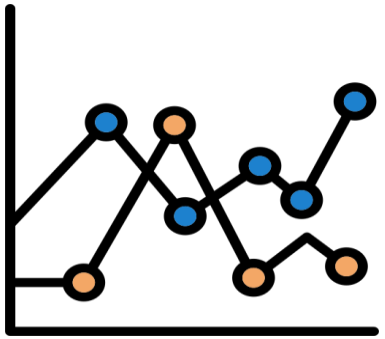
- Semi-quantitative BuCa

E. Conclusion and future steps

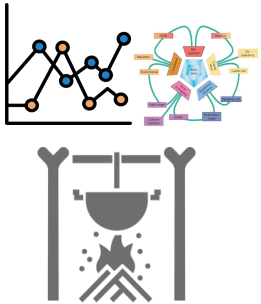
Value-based decision making



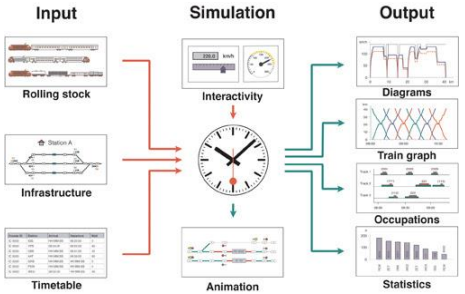
Value Frameworks

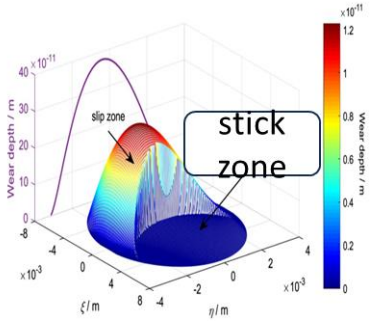


Value Curves



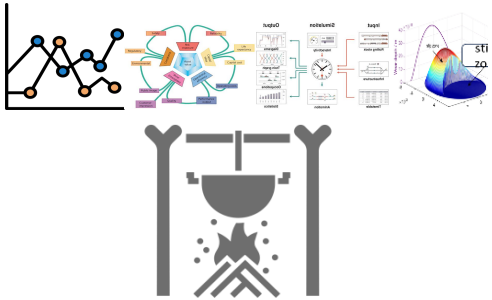
Simulations



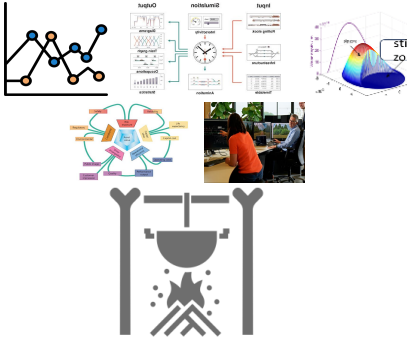


Capacity Simulations

Wear Simulations



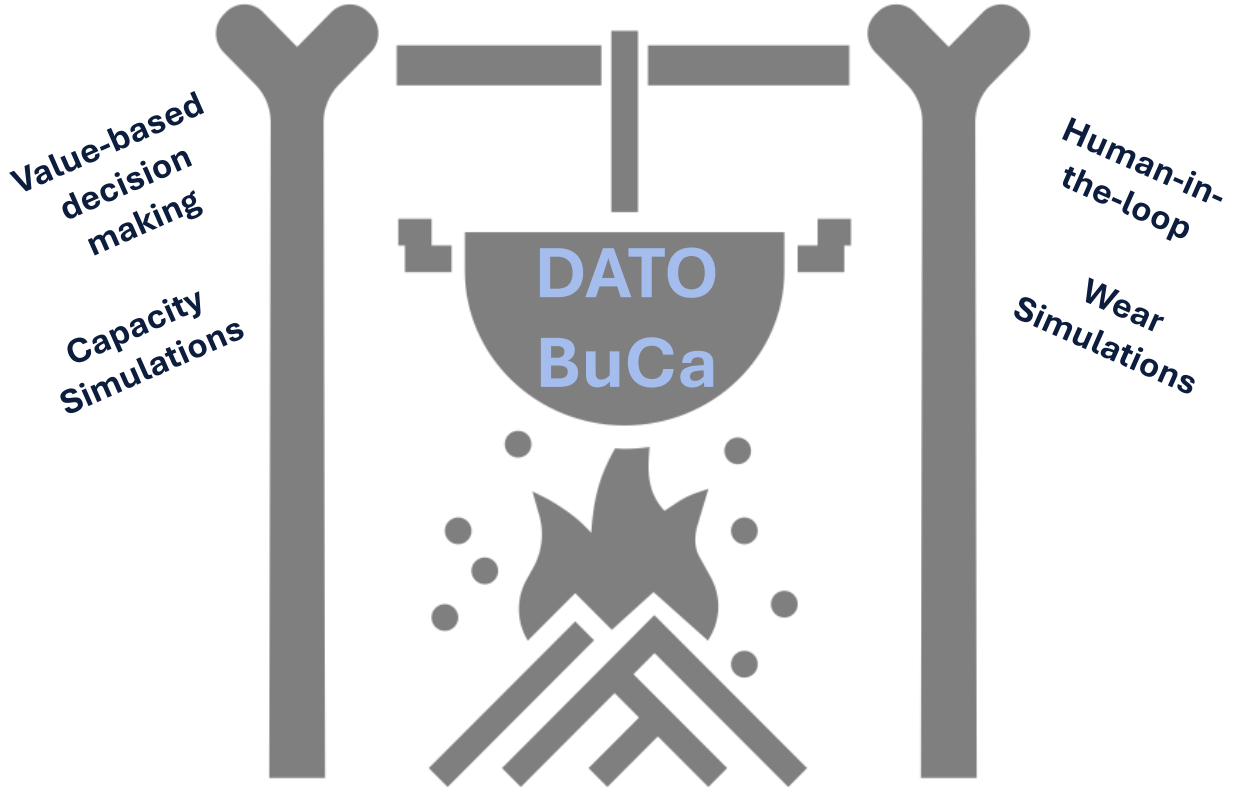
Human in the loop



Human-centric approaches

Analogy

Co-design Workshops



Human-Centric Approaches

A. Team Presentation

B. Context and objectives

C. Methods and tools

D. Expected Outcomes

- **BuCa Outline Framework**
- **BuCa Guidelines**
- **Semi-quantitative BuCa**

E. Conclusion and future steps

Outcomes

Semi-quantitative BuCa

Operational Layer

BuCa Guidelines

Tactical Layer

BuCa Outline Framework

Strategic Layer

Quantitative: Application scenario specific

Qualitative: Generically applicable

Semi-quantitative BuCa

Operational Layer

BuCa Guidelines

Tactical Layer

BuCa Outline Framework

Strategic Layer

Quantitative: Application scenario specific

Qualitative: Generically applicable

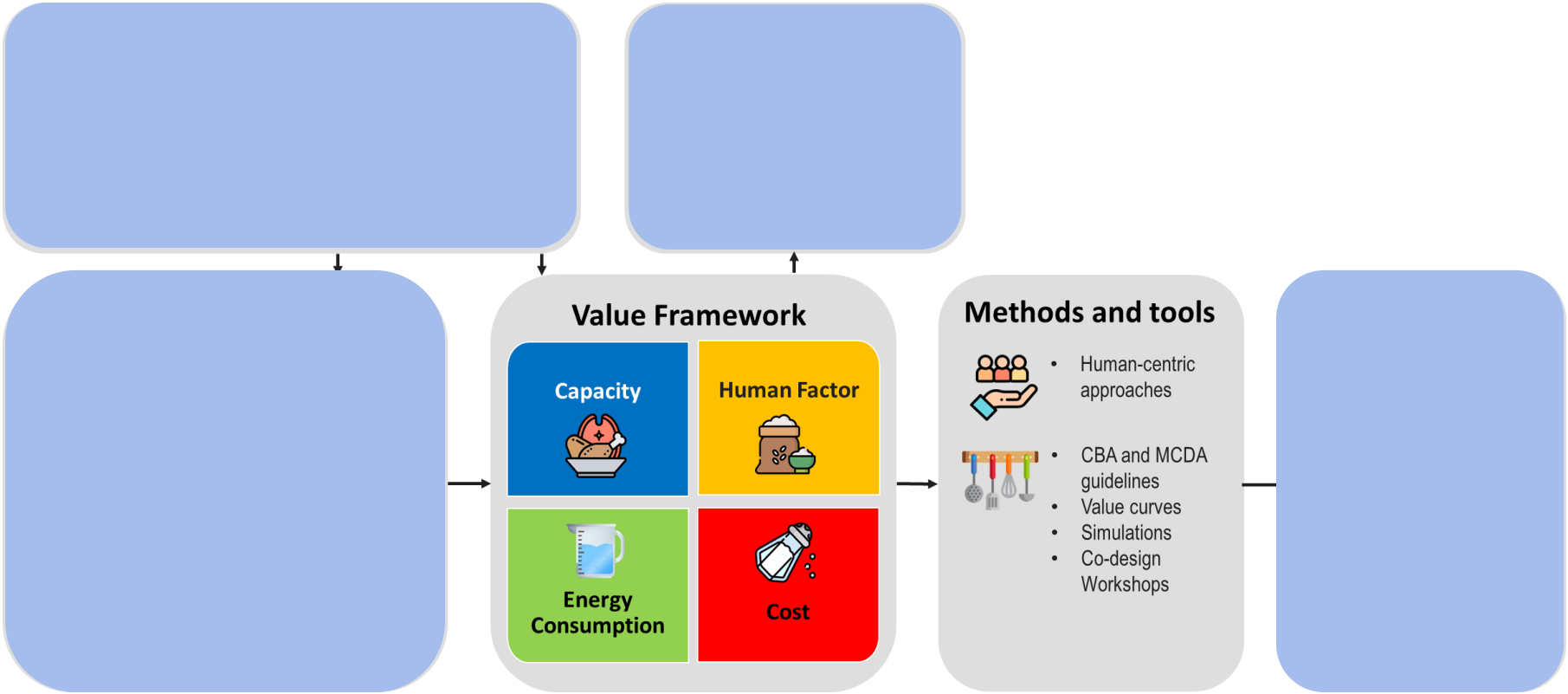
BuCa Outline Framework

Methods and tools

- Human-centric approaches

- CBA and MCDA guidelines
- Value curves
- Simulations
- Co-design Workshops

BuCa Outline Framework



BuCa Outline Framework

DATO Concepts

C-DAS	ETCS HTD	NG Brake
ATO GoA2	ETCS MB	DAC
ATO GoA4	TMS	Remote Operation

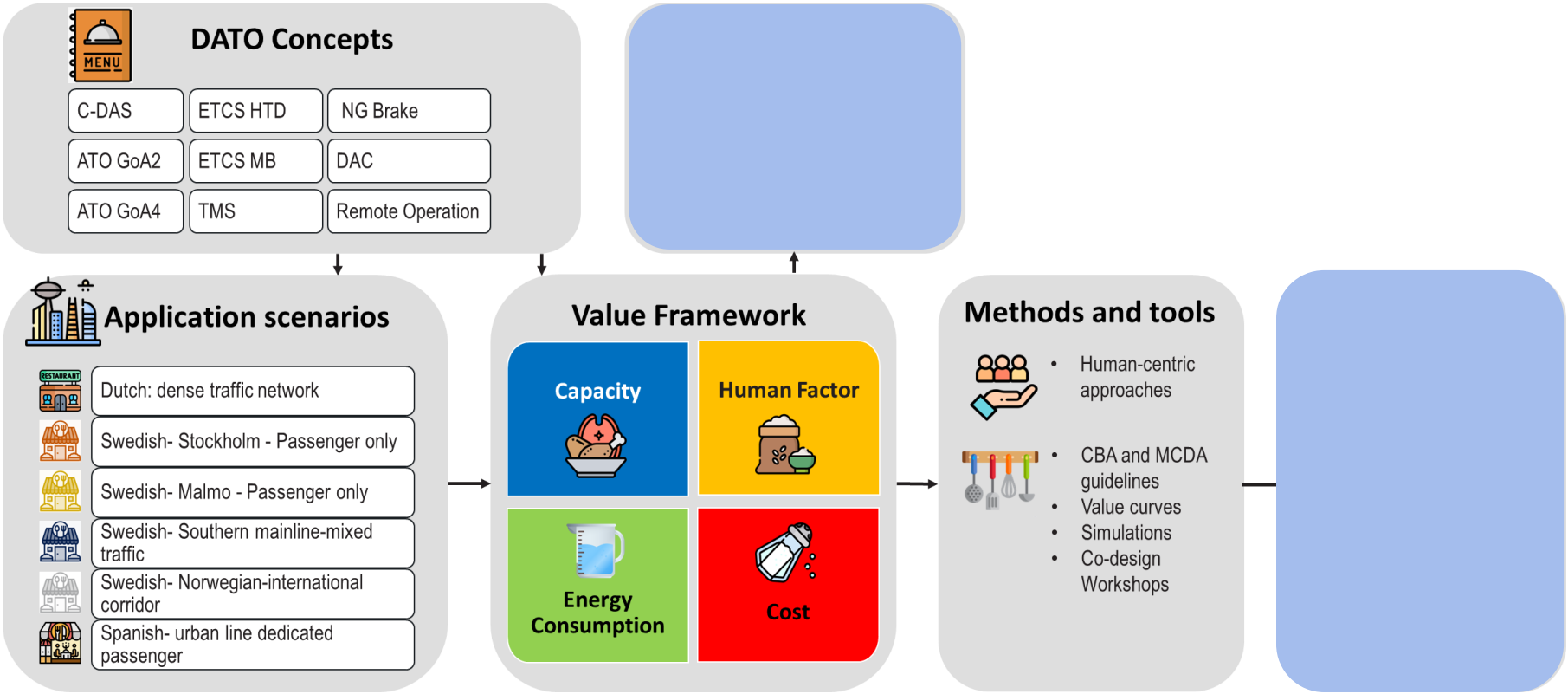
Value Framework

- Capacity
- Human Factor
- Energy Consumption
- Cost

Methods and tools

- Human-centric approaches
- CBA and MCDA guidelines
- Value curves
- Simulations
- Co-design Workshops

BuCa Outline Framework



BuCa Outline Framework

DATO Concepts

C-DAS	ETCS HTD	NG Brake
ATO GoA2	ETCS MB	DAC
ATO GoA4	TMS	Remote Operation

Stakeholders

Infrastructure Managers, Railway and Freight Operators and Academia

Society, Government and OEMs

Application scenarios

- Dutch: dense traffic network
- Swedish- Stockholm - Passenger only
- Swedish- Malmo - Passenger only
- Swedish- Southern mainline-mixed traffic
- Swedish- Norwegian-international corridor
- Spanish- urban line dedicated passenger

Value Framework

- Capacity
- Human Factor
- Energy Consumption
- Cost

Methods and tools

- Human-centric approaches
- CBA and MCDA guidelines
- Value curves
- Simulations
- Co-design Workshops

BuCa Outline Framework

DATO Concepts

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ATO GoA2	ETCS MB	DAC
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Deliverable 32.2

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- Co-design Workshops

Outcomes

BuCa Outline Framework

BuCa Guidelines

Semi-quantitative BuCa

Outcomes

Semi-quantitative BuCa

Operational Layer

Quantitative: Application scenario specific

BuCa Guidelines

Tactical Layer

BuCa Outline Framework

Strategic Layer

Qualitative: Generically applicable

BuCa Guidelines

Recipes
BuCa
Guidelines

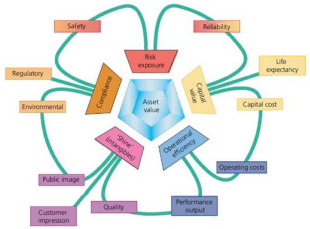
Deliverables
32.3, 32.4 and
32.5

Preparation Instructions

Deliverable
32.1

Integration Instructions

Value Drivers



Simulation

Assessment matrices

Value curves

Value Drivers

Ingredients

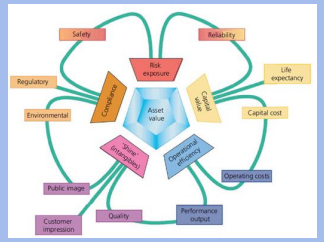
Ingredients: Enriched Corn Meal (Corn Meal, Ferrous Sulfate, Niacin, Thiamin Mononitrate, Riboflavin, Folic Acid), Vegetable Oil (Corn, Canola, and/or Sunflower Oil), Cheese Seasoning (Whey, Cheddar Cheese [Milk, Cheese Cultures, Salt, Enzymes], Canola Oil, Maltodextrin [Made from Corn], Natural and Artificial Flavors, Salt, Whey Protein Concentrate, Monosodium Glutamate, Lactic Acid, Citric Acid, Artificial Color [Yellow 6]), and Salt.
CONTAINS MILK INGREDIENTS

Nutrition Facts
3 servings per container
Serving size 3 pretzels (28g)

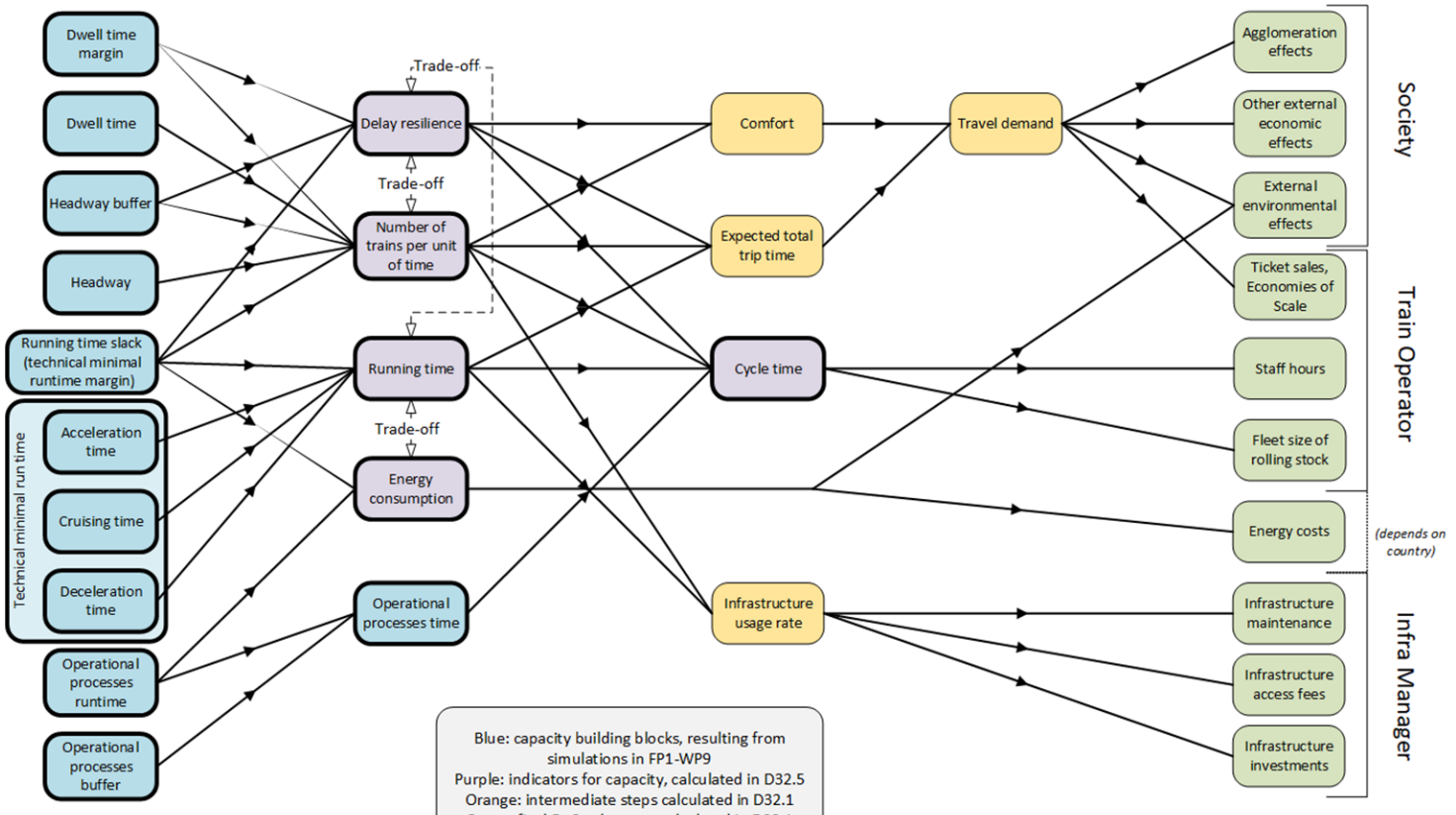
	Per serving	Per container
Calories	**110**	**330**
	% DV*	% DV*
Total Fat	0.5g 1%	1.5g 3%
Saturated Fat	0g 0%	0g 0%
Trans Fat	0g	0g
Cholesterol	0mg 0%	0mg 0%
Sodium	400mg 17%	1200mg 52%
Total Carb.	23g 8%	69g 24%
Dietary Fiber	2g 7%	6g 21%
Total Sugars	<1g	3g
Incl. Added Sugars	0g 0%	0g 0%
Protein	3g	9g
Vitamin D	0mcg 0%	0mcg 0%
Calcium	10mg 0%	30mg 2%
Iron	1.2mg 6%	3.6mg 19%
Potassium	90mg 0%	270mg 5%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Conversion from technical to internal and external stakeholder's metrics



Co-design workshops



Semi-quantitative BuCa

Operational Layer

BuCa Guidelines

Tactical Layer

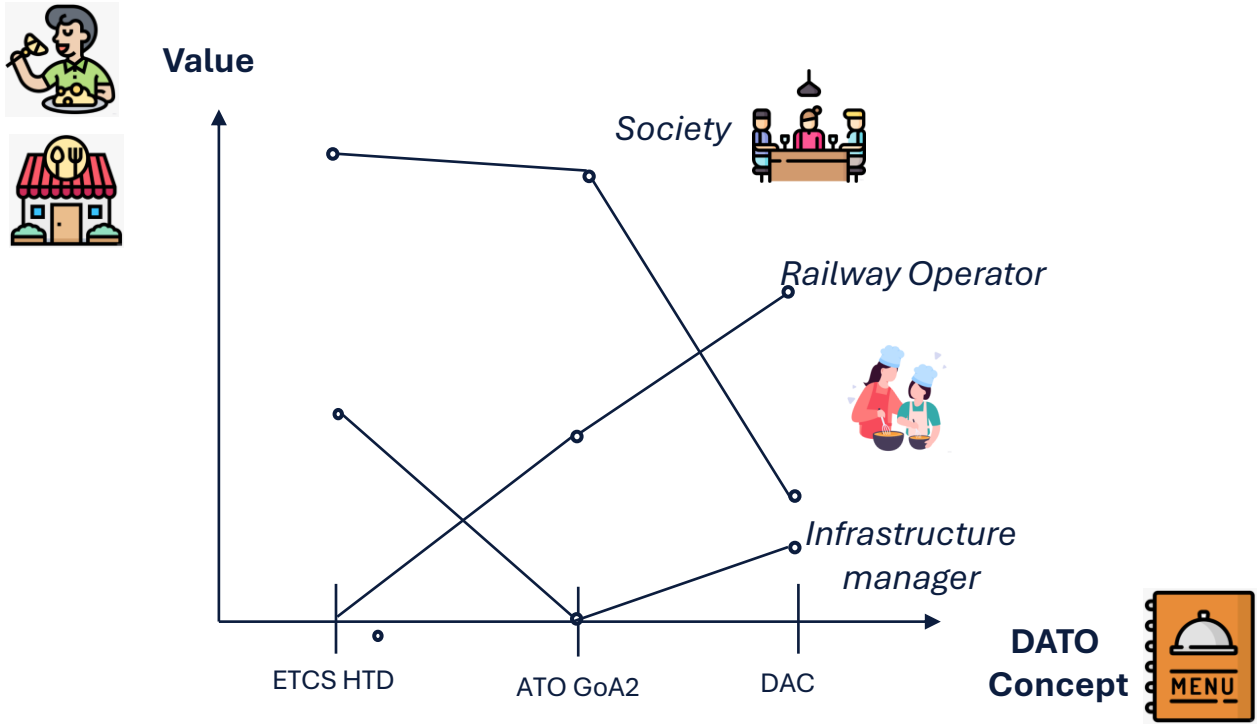
BuCa Outline Framework

Strategic Layer

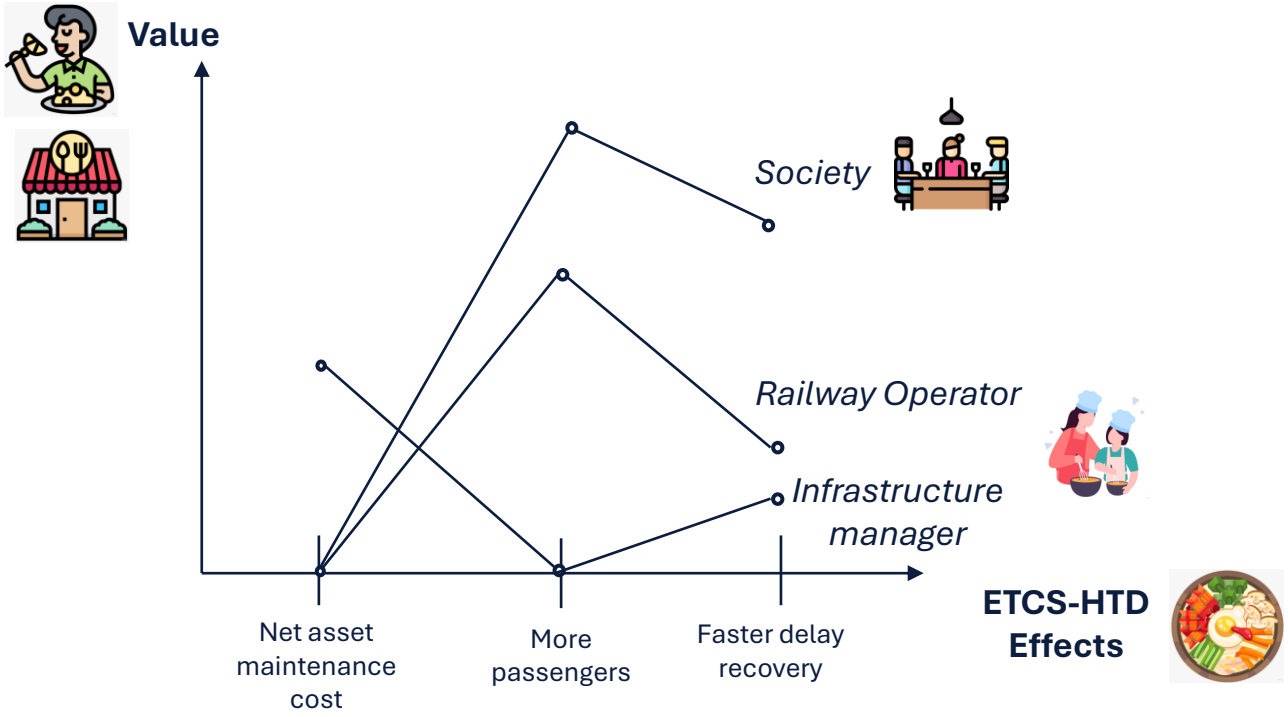
Quantitative: Application scenario specific

Qualitative: Generically applicable

Example: Visible trade-off and the need of alignment



Example: Visible trade-off and the need of alignment



A. Team Presentation

B. Context and objectives

C. Methods and tools

D. Expected Outcomes

- BuCa Outline Framework
- BuCa Guidelines
- Semi-quantitative BuCa

E. Conclusion and future steps

Results and Discussions

Illustrate the Attractiveness of DATO:
To facilitate and accelerate the deployment of DATO technologies across European networks

Develop a Robust BuCa Methodology:
To create a robust and generalizable methodology for societal business cases supporting the adoption of DATO technologies.

Semi-quantitative BuCa

BuCa Guidelines

BuCa Outline Framework

Conclusion

Three-dimensional assessment

Stakeholders | Value Drivers | DATOconcepts




Semi-quantitative assessment

CBA / Value


Layman's terms

We will decompose the effects by stakeholder, then compare different application scenarios as result.

Project Planning

Achievements : what have we done already

- Business Case outline including application scenarios
- BuCa outline framework V2
- Delivered a matrix of cost categories, defined simulations capacity scenarios and human factor toolkit
- Interface model: model that shows the relations between technical indicators and value drivers (Capacity/wear and Human Factors)

Key exploitable results

- D32.2 Business Case outline

Roadmap

Q1/Q2 - 2025 | Q3/Q4-2025 | Q1/Q2 2026 | May 2026

WP32 DATO BuCa

WP33 DATO Migration

First Step

- Assessment matrices
- Draft version of Wear report (D32.3)
- Workshop & scoping

Second Step

- ATO impact on infrastructure assessment report (D32.3)
- DATO capacity and impact simulations report (D32.5
- Lessons learnt from other WPs

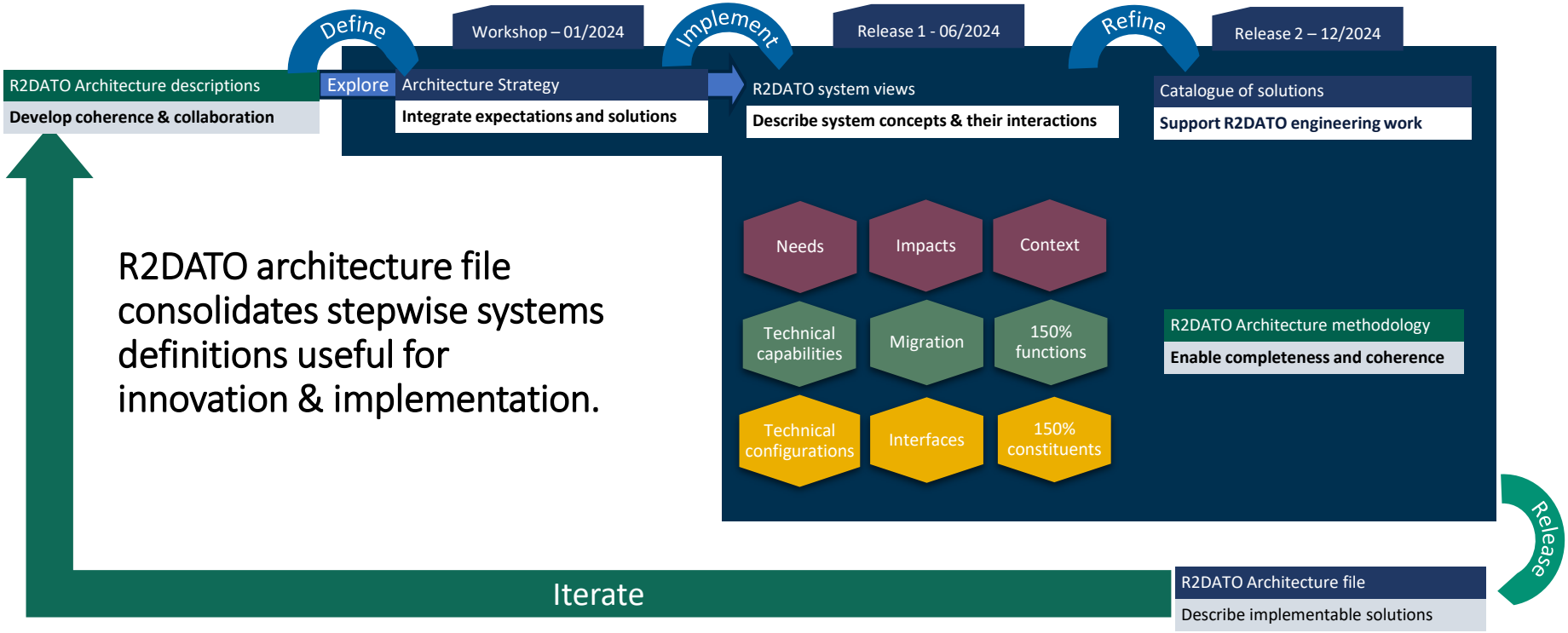
Third Step

- Human Factors report (D32.4)
- DATO BuCa (D32.1)
- Migration guidelines and concepts (D33.1 and D33.2)

Jean-Baptiste Simonnet
Leader R2DATO WP3 - SNCF

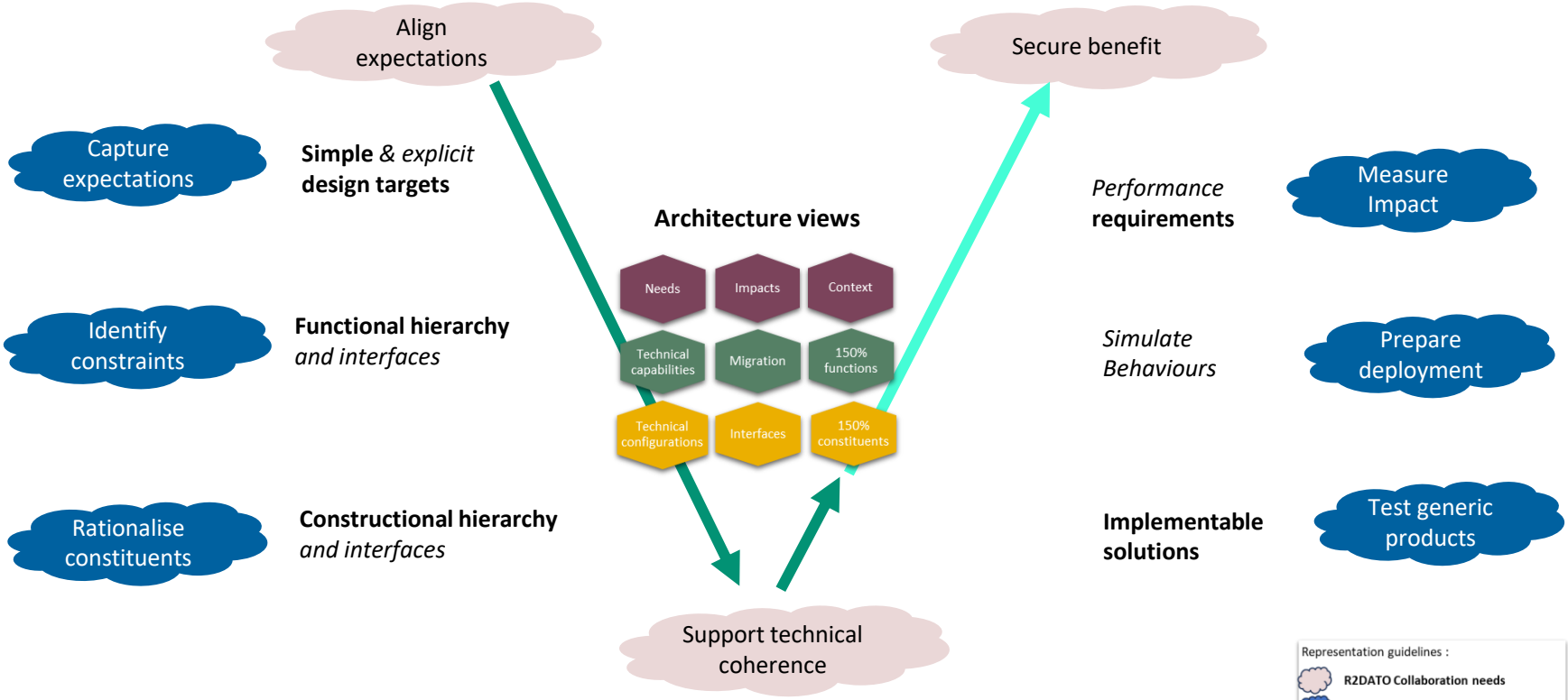
Architecture
Catalogue of Solutions

A path is open for R2DATO Architecture



Why using R2DATO architecture file

Collectively overcome engineering challenges

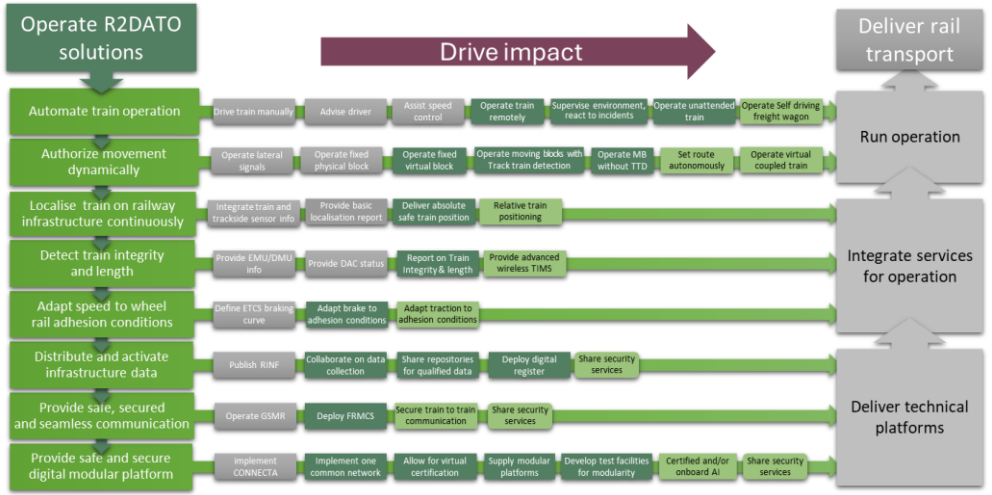


R2DATO functional states: migration view

Opportunity to capture low hanging fruits and desirable concepts

Representation guidelines:

- R2DATO technical capabilities
- State of the Art implementation
- Migration targets
- Concept beyond targets



Rationalizing migration targets is a precondition for compatibility and sustainable benefits.

Michael Meyer zu Hörste

DLR – Cluster Leader “Innovative operational Solutions”

6. New Solutions investigated

How IoS proposes solutions beyond FP2-R2DATO capabilities

What comes next?

- Automatic Train Operation (ATO) Grade of Automation 4 (GoA4) and Remote Train Operation (RTO) are reaching high technology readiness
- Identify suitable use cases
- Definition of “full autonomous rail operation” and identify relevant technologies:
  - Connection to automatic / demand-driven traffic management
  - De-centralised autonomous route setting
  - Automatic adaptation to capacity
  - Prepare self-organisation
  - Etc.

Picture: DLR

How IoS proposes solutions beyond FP2-R2DATO capabilities

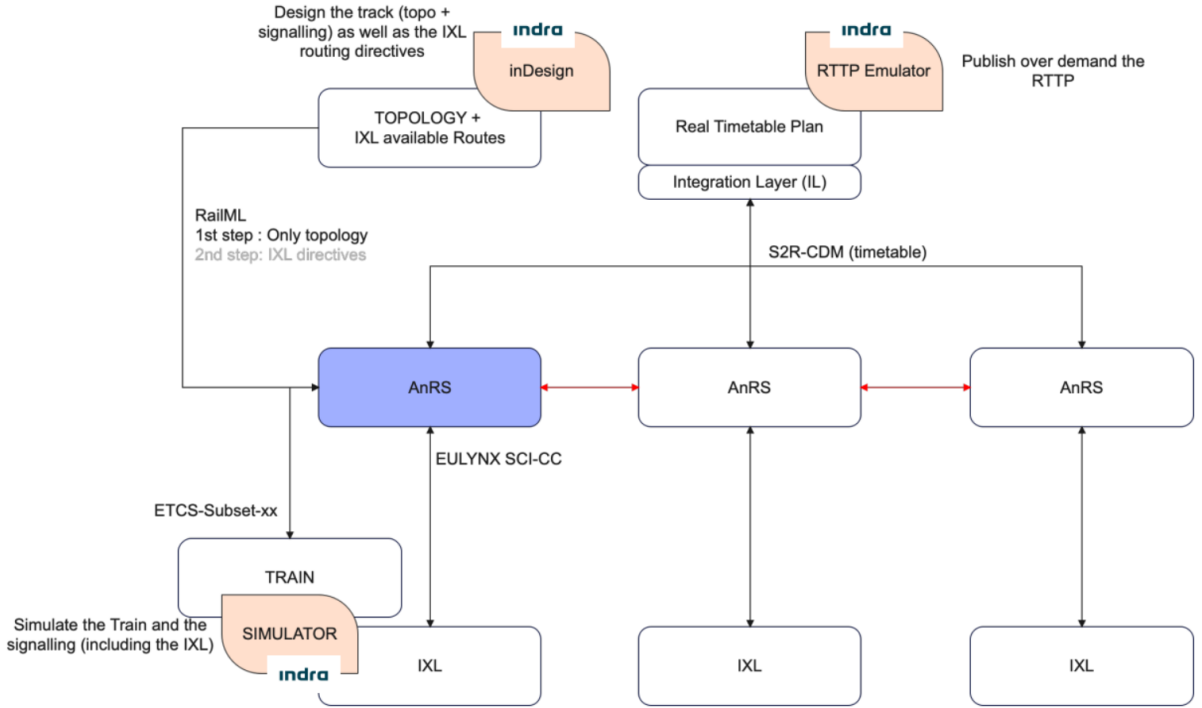
Autonomous Route Setting (AnRS)

Target

- Technical Enabler TE8
- Increase Flexibility and Efficiency up to real autonomy on the basis of ATO GoA4
- Enable autonomous train operations / autonomous maneuvers
- Develop a decentralized route setting

Approach

- Identify Use Cases for fully autonomous operation
- Analyze trackside systems and related future developments
- Develop “automation islands” with very high local degree of automation



Source: D48.1

How IoS proposes solutions beyond FP2-R2DATO capabilities

Virtual Coupled Train Sets (VCTS)

Target

- Technical Enabler TE11
- Increase Flexibility and Efficiency of passenger lines – especially on frugal lines
- Enable automatic train size adaptation
- Reduce weight and disturbance from mechanical coupler
- Prepare dynamic maneuvers

Approach

- Identify or update operational use cases for VCTS (Virtually Coupled Train Set) e.g. from FP6-FutuRe or X2Rail-3
- Keep existing systems for communication and absolute positioning
- Adding systems for relative positioning and short-range / train-to-train communication system

FP2R2DATO

Control of virtual coupling operation

Short range / Train-to-Train Communications

Radio Ranging & Relative Positioning

FP6-FutuRe
Cost effective regional lines

Development of Train for frugal lines

Picture: DLR

How IoS proposes solutions beyond FP2-R2DATO capabilities

Self-Driving Freight Waggon (SDFW)

Target

- Increase Flexibility and Efficiency of freight wagon operation in yards, industrial areas and operational lines by enabling:
  - automatic train formation
  - automatic individual freight wagon maneuvers
  - automatic individual freight wagon maneuvers

Approach

- Analysis of the State of art
- Identify or update operational Use cases for the Self-Driving freight wagon based on the use cases for the SPFW from FP5-TRANS4M-R
- Analysis FP1-MOTIONAL and FP5-TRANS4M-R synergies
- Definition of the architecture of the SDFW from Type 1 to Type 5
  - Adding systems from FP1-MOTIONAL and FP5-TRANS4M-R Adding systems for relative positioning and short-range communication system
- Preliminary OPEX (Operational Expenses) and CAPEX (Capital Expenses)

Self-Driving Freight Wagon (SDFW)

- System for automatic Operation
  - SS: Self Shunting
  - SD: Self-Driving
- Short-range communication
- Relative positioning

Self-Driving Freight Wagon (SDFW)

- Type 1 to Type 5

How IoS proposes solutions beyond FP2-R2DATO capabilities

Enabling additional technologies

For virtual coupling and self-driving freight waggons additional technologies are relevant to reach the required level of performance

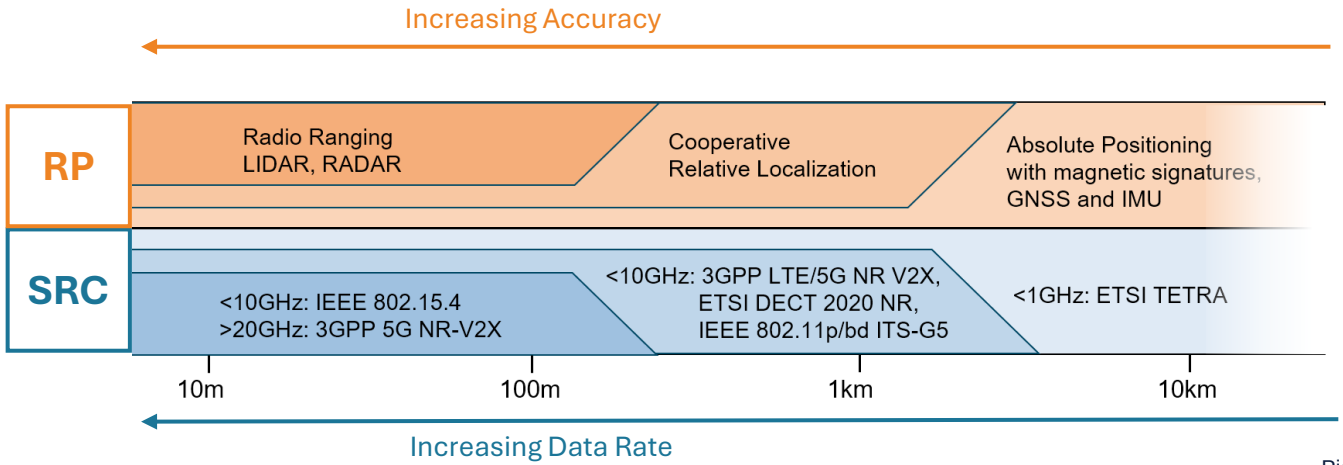
Tests planned in cooperation with the shunting and stabling demo

Short-range Communication (SRC)

- Securing low latencies
- Increasing data rate
- Ensuring redundancy with safety

Relative Positioning (RP)

- Increase (relative) precision with safety
- Increase data rate
- Increasing redundancy



Picture: DLR

How IoS proposes solutions beyond FP2-R2DATO capabilities

Perspective

Concluding specification of short-range communication and relative positioning

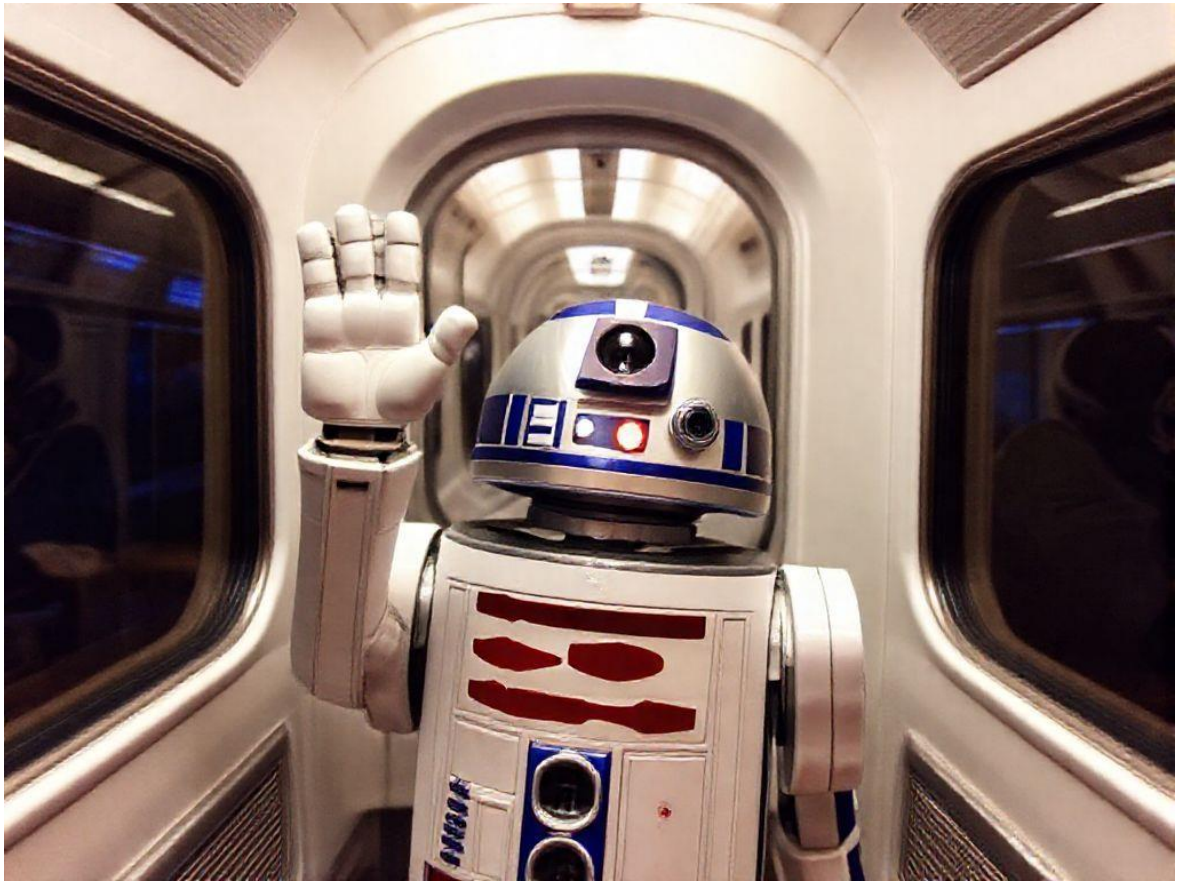
Definition of test plan

Preparation of tests in real environment

Analysing the test results

(If required: Adopting use cases)

See you tomorrow



We have 2 buses to offer you :

- **18h35** : bus to **Malaga center** (if you want to go to your hotel, then meet us at the restaurant at 7:30)
- **18h45** : bus straight to the **restaurant**

Day 2 - Delivery

Status Update and Progression Roadmap

WELCOME BACK !

Bettina DOETSCH

Senior Project Manager EU funded Projects - Hitachi Rail

Bastian SIMONI

Design Authority - Alstom

Andreas Steingröver

Senior Principal Key Expert Rail Automation Solutions - Siemens

Christoph Klose

Head of Technology Strategy - Siemens

1. Ecosystem Interaction

Ecosystem Framework

Innovation & Development Activities

Europe Rail Joint Undertaking

System Pillar [SP]

harmonised architecture of European Railway system

Harmonised operational concept

Development of specifications based on top-down system engineering approach

Innovation Pillar [IP]

Development of innovative technical solutions

Demonstrator's to show feasibility

Standardisation, Regulation & Deployment

Standardisation & TSI Input Plan [STIP]

Collection of the topics from SP and IP relevant for harmonisation

Alignment with the EC request for TSI revision

Allocation of harmonisation channel & time planning to topics

European Standards

- CEN
- CELENEC
- ETSI

TSIs

Deployment

- Development of products
- Investment plans
- Broad deployment
- Migration targets

IMs, RUs, suppliers

align

EC request for TSI revision & standardisation [EC, ERA]

Ecosystem Interaction

DEPLOYMENT GROUP

System Pillar

- harmonized Operational Concept
- Support Single European Railways Area
- Functional system architecture

single gouvernance & coordination body

common EU railway system view

CONTINUOUS EXCHANGE

Innovation Pillar

Flagship Projects

- User-focused Research & Innovation
- Exploratory, fundamental R&I
- Large-scale demonstrations.

Technological and operational solutions

System Pillar Setup

Core Group	Coordination and Project Management	Regular Plenaries
Operational Harmonization	Operational Processes and Rule Books	
Traffic CS	Architecture and Specification for Wayside CCS (Command, Control, and Signalling)	TPS / PE Specification
Train CS	Architecture and Specification for on board CCS	Consist Network, TL /TI, ASTP
Trackside Assets	Architecture and Specification for Wayside Object Controller	
Computing Environment	Architecture and Specification for Vital Computing Platform	Specification for Safe Computing Platform
Transversal CCS	Specification for Digital Register, Maintenance, Configuration & Diagnostic	Specification for Common Data Model
TMS / CMS	Architecture and Specification for Traffic Management / Capacity Management System	
PRAMS	Specification for common Measures for Safety, Performance and RAM	Methods for Safety Case
Security	Specification for common Cyber Security Measures	Definition of Security Aspects

What inputs do we need?

DEPLOYMENT GROUP

System Pillar

- harmonized Operational Concept
- Support Single European Railways Area
- Functional system architecture

single gouvernance & coordination body

common EU railway system view

CONTINUOUS EXCHANGE

Innovation Pillar

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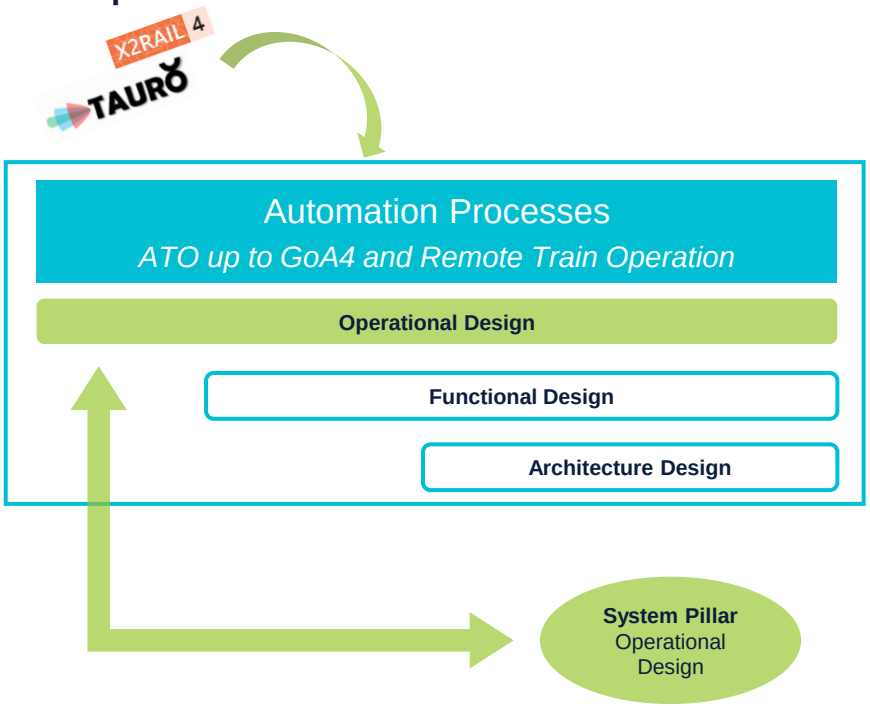
Technological and operational solutions

What inputs do we need?

ATO up to GoA4 example



Obstacle detection

Remoted use of ERTMS/ETCS

ERTMS: European Rail Traffic Management System
ETCS: European Train Control System

What inputs do we need?

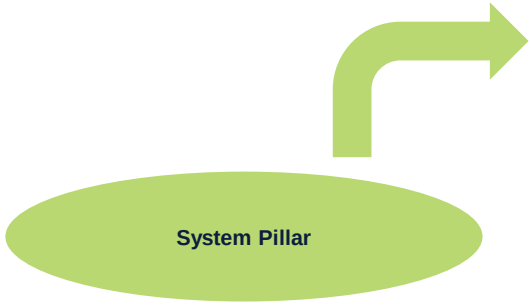
Digital Register example

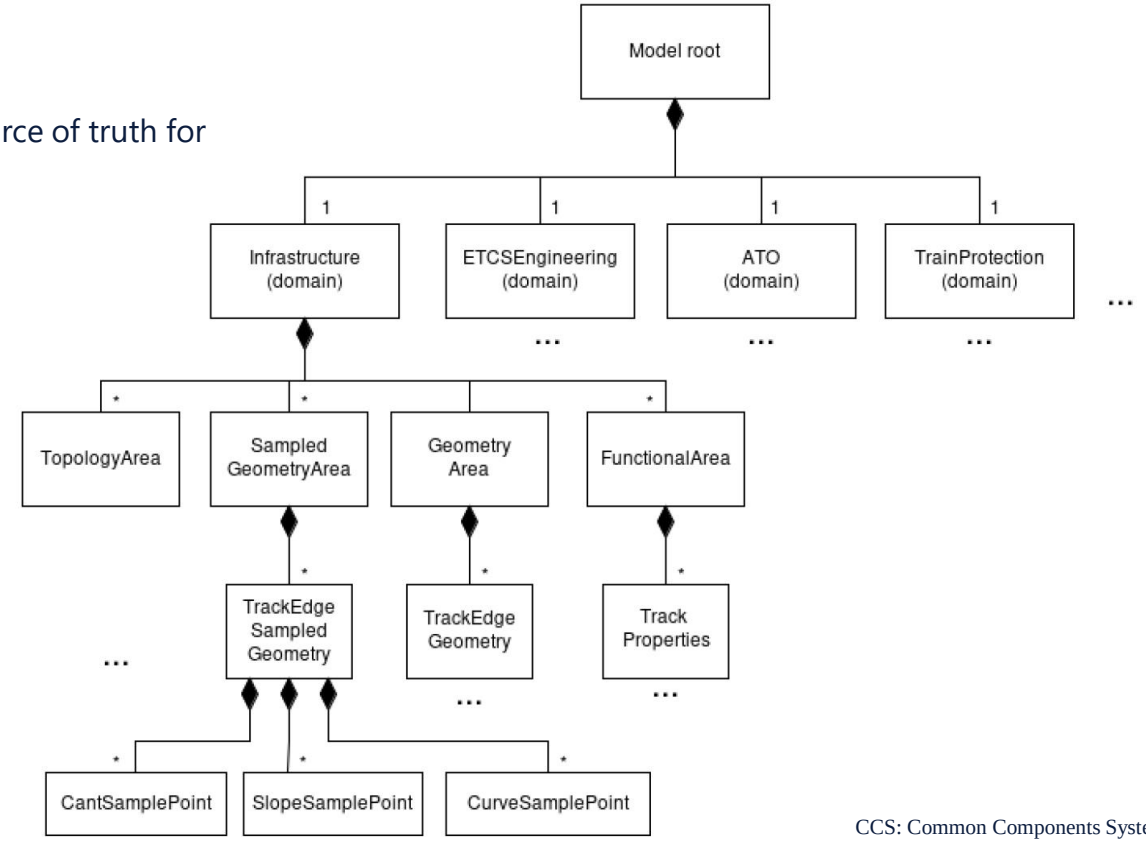
The Digital Register shall be the single source of truth for infrastructure related data to be used by:

- Trackside systems
- Onboard systems

Input from System Pillar:

CCS/TMS Data Model

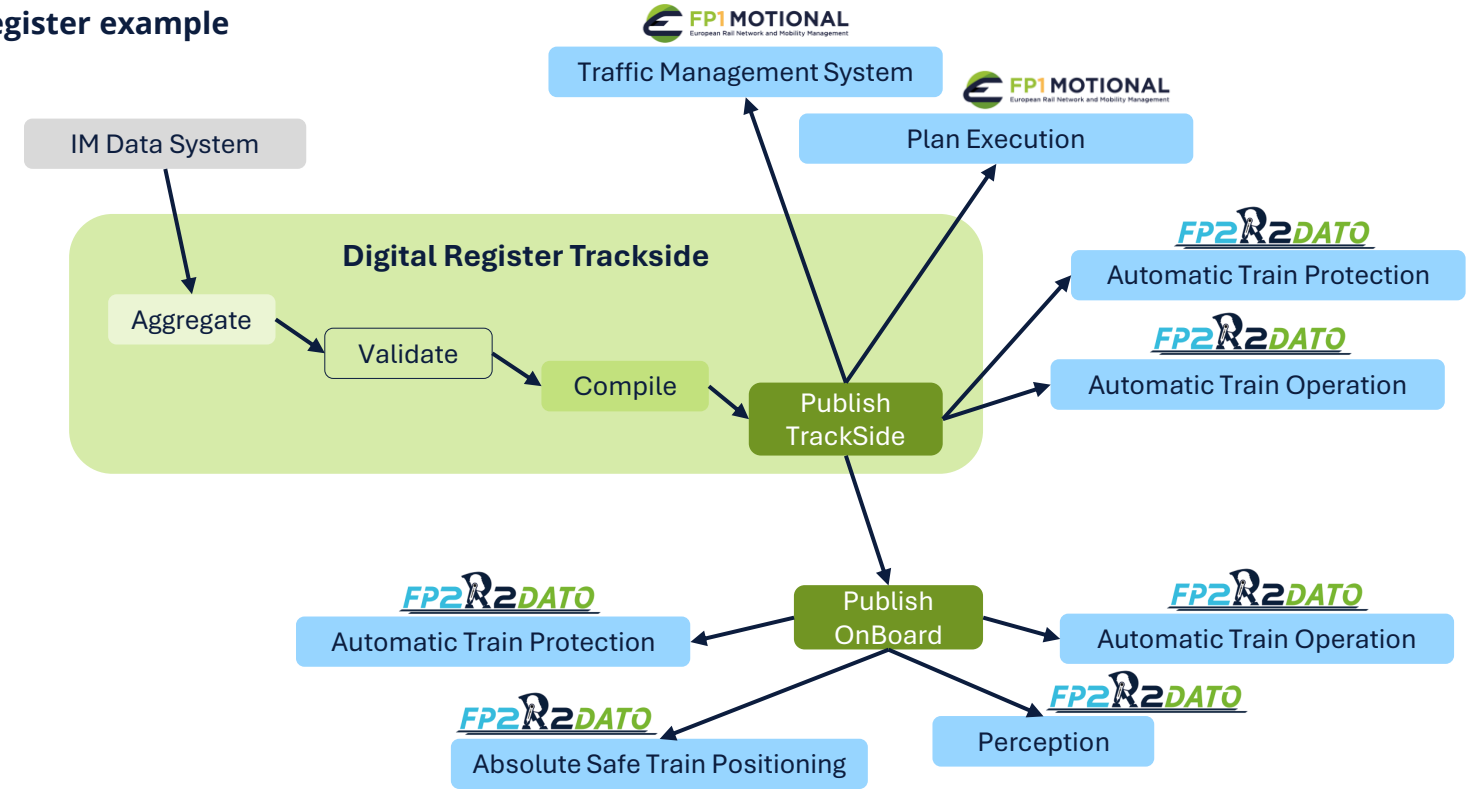




CCS: Common Components System
TMS: Traffic Management System

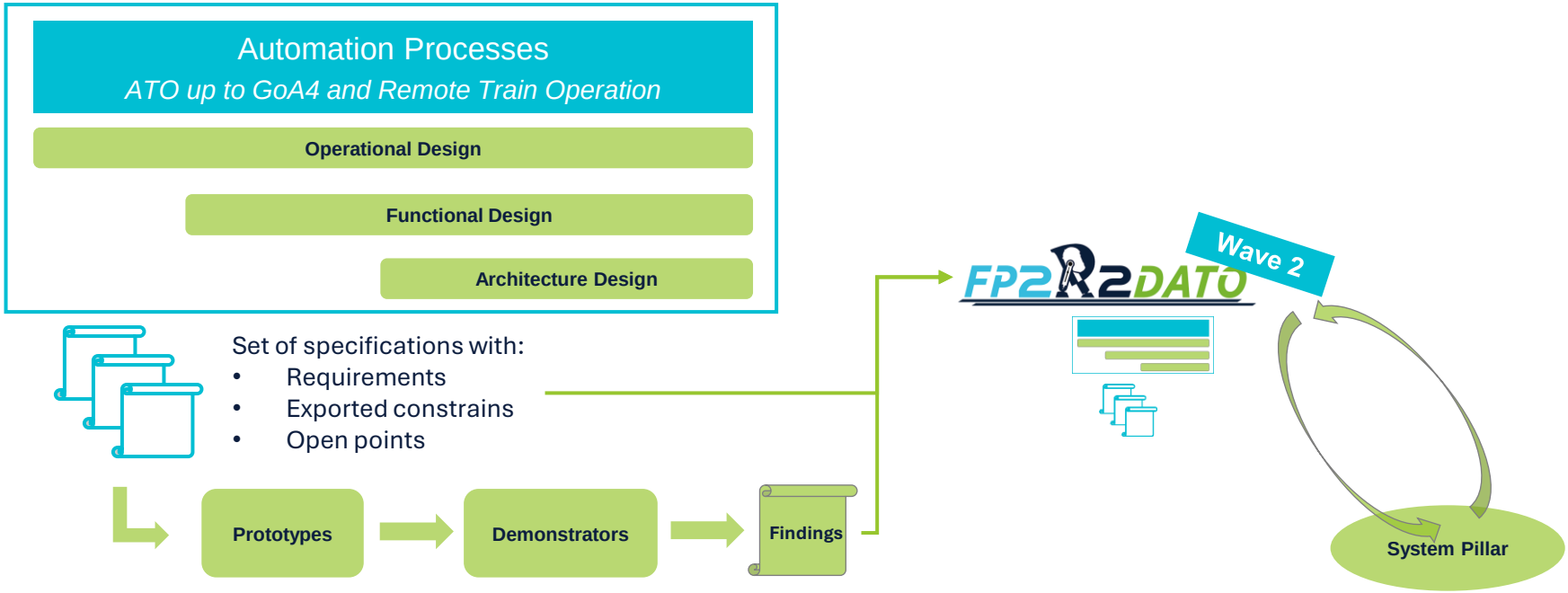
Project Legacy : Who is expecting our results for what purpose?

Digital Register example



Project Legacy : Who is expecting our results for what purpose?

ATO up to GoA4 example



Joelle Aoun

Prorail, Project Manager

Oliver Mayer-Buschmann

DB, Onboard Platform Architect

Jasper van Zanten

NS, Sr. Business Consultant Treindigitalisering

2. How are we going to verify we answer the project expectation ?

Nacho Celaya

CAF, Autonomous Vehicle Project Manager

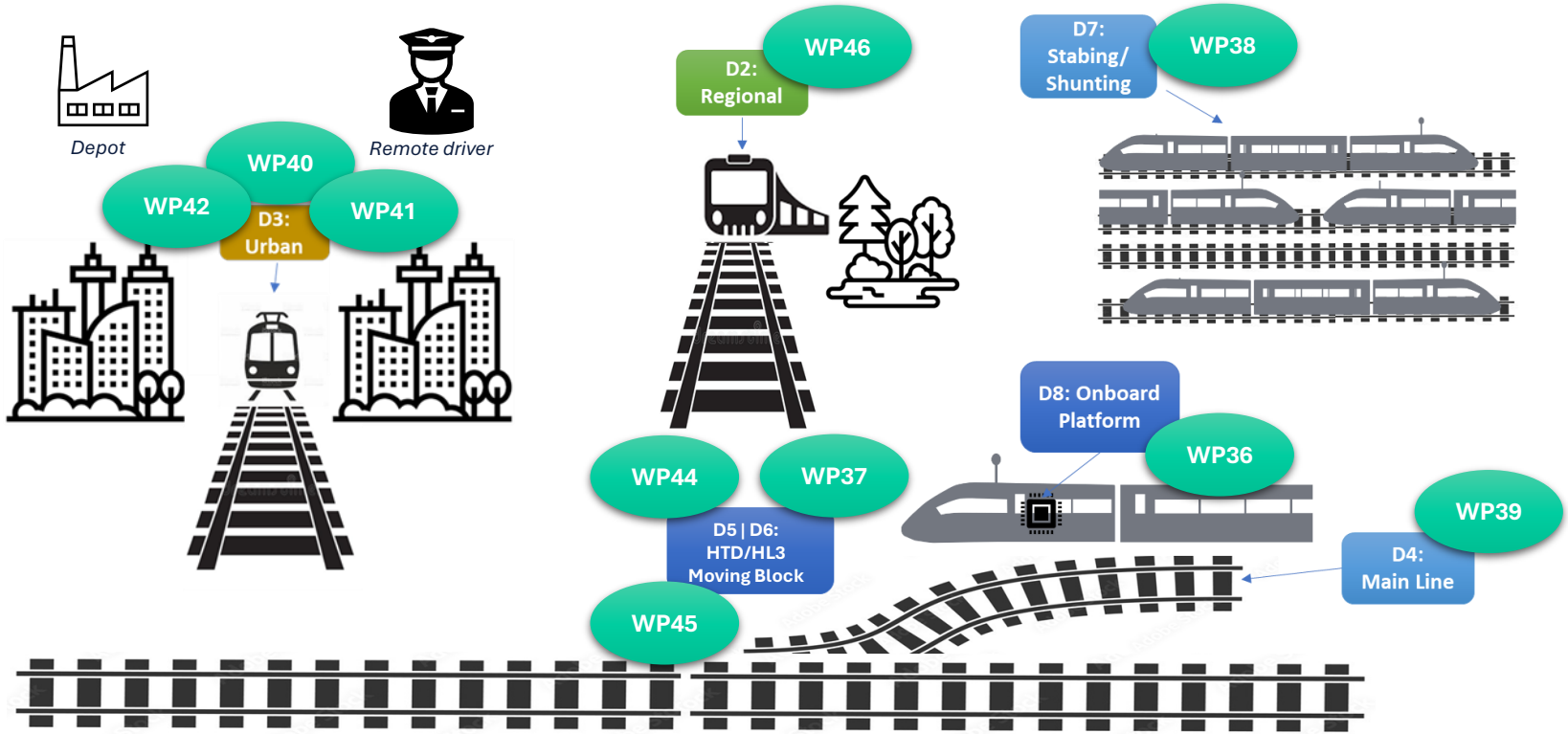
Gregor Kolokewitzsch

DB, Teamlead APS

Michal Novák

AZD, Lead Researcher

Validation of the use cases benefits with the demo cluster



The Demonstrator WPs and WP leader Overview

The FP2-R2DATO Demonstrators	Demo	The WP leaders		Link with other FP/SP
WP36 - On-board platform	D8  On-board Platform	DB	Oliver Mayer-Buschmann	SP
WP37 - ETCS HTD deployment strategy	D5  HTD	ProRail	Joelle Aoun	SP, FP2 and FP1
WP38 - Automatic Stabling, Shunting, and Non-commercial runs Demonstrator	D7  Stabling	NS	Jasper van Zanten	FP2
WP39 - ATO over ERTMS demonstration on mainline	D4  Mainline	FS (RFI)	Nazzareno Filippini	SP and FP1
WP40 - Autonomous Tram Demonstrator	D3  Urban	CAF	Nacho Celaya	-
WP41 - Remote Driving and Telecommand Demonstrator				
WP42 - Tramway autonomous movements in depot demonstrator				
WP44 - Moving Block ETCS L3 Demonstrator – Specification	D6  Moving Block	DB	Gregor Kolokewitzsch	SP, FP1
WP45 -Moving Block ETCS L3 Demonstrator – Realisation				
WP46 - Regional line demonstrations	D2  Regional	AZD	Michal Novák	SP, FP6

Demonstrator D2 : Regional (WP46)

DEMO Input from

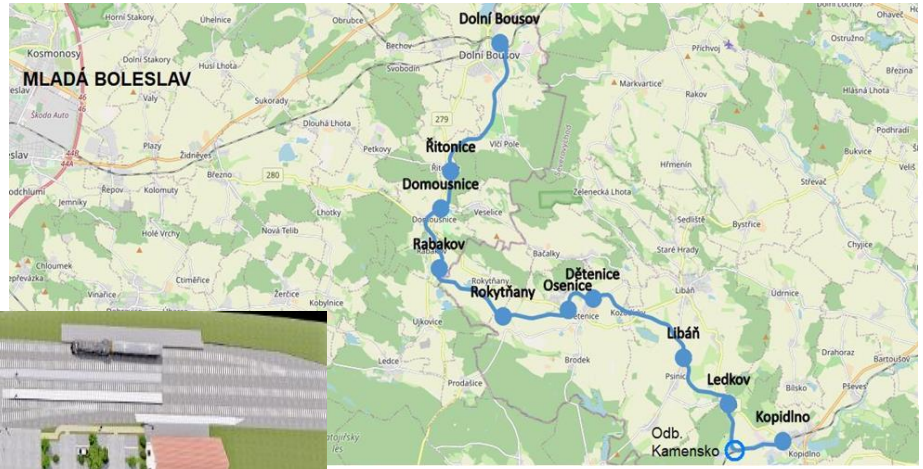
- **TE1** Automatic functions
- **TE2** ASTP
- **TE4** ATO Technologies
- **TE6** Perception
- **TE7** Remote Driving

- Main objective is to support validation and testing of technical enablers developed in R2DATO in regional line environment
- Focus is on demonstration of ATO up to GoA4 functionality in full operation with onboard and trackside components, following defined architecture, use cases and requirements (from R2DATO relevant clusters)
- Major ambition is to demonstrate interchangeability of specified components like Perception, Repository, Automatic Driving Module, Positioning, etc. provided by various suppliers

Interfaces to

SP Specification | Architecture | STIP

FP6 Specification, Operational Procedure



D2 : Regional (WP46)

Status and goals

Achievements: what have we done already and Key Exploitable Results

- **Use cases for demonstration** agreed among partners
- **Specification baseline** agreed among partners
- Discussion ongoing to resolve **specification gaps** for demonstration purposes
- **Track preparation** in progress (ETCS L2)
- **Vehicle preparation** in progress

Use cases to be tested

- **Autonomous train drive** including unprotected level crossing on regional line
- Autonomous train **reaction to obstacle**
- Perform **routine driving** by remote driver
- Perform **shunting operations** by remote driver

Road map

Now

Q1 2025

First Step

Reach full alignment among partners on the **specifications of demonstrator prototypes** and the **sequential diagrams** of use cases

Q3 2025

Second Step

Prototype development provided by WP9 – WP12 and WP22
Finalization of **train and track preparation**

Q2 2026

Third Step

Laboratory and on-site **tests**
Preparing the **report**

May 2026

Demonstrator D3 : Urban (WP40, 41, 42)

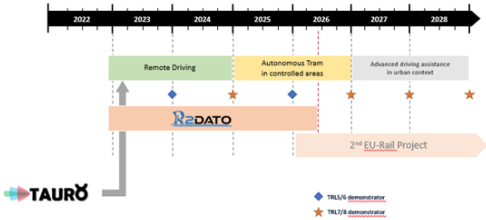
DEMO Input from

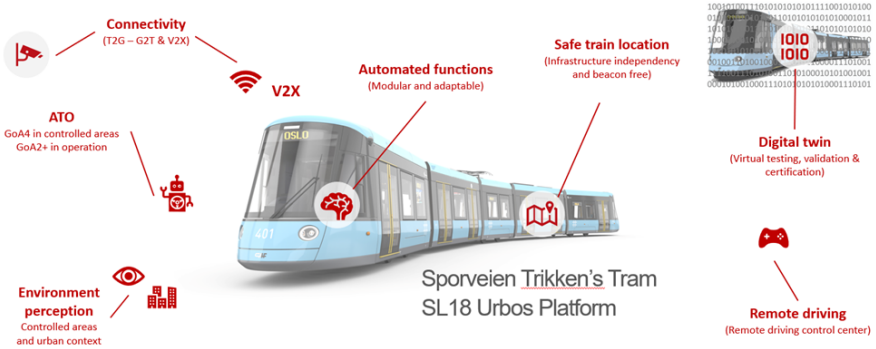
- **TE1** Automatic Functions
- **TE3** Train Integrity
- **TE4** ATO Technologies
- **TE6** Perception
- **TE6.1** Data Factory
- **TE7** Remote Driving

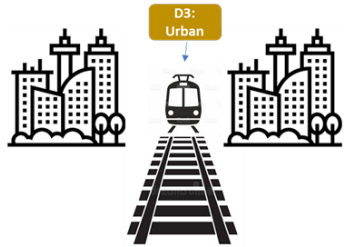
- make **two trams ready for demonstration** of different use cases and technologies along the project lifetime, which means to design, modify, and integrate appropriated systems which **allows development of autonomous driving functions**
- implement a **Remote Driving and Telecommand demonstrator**
- implement an **Autonomous Movements demonstrator up**

Interfaces to

No interfaces to other projects







D3 : Urban (WP40, 41, 42)

Status and goals

Achievements : what have we done already and Key Exploitable Results

- Agreement on the use cases to be considered by all project partners. >300. (WP40).
- Integration engineering in existing vehicles. (WP40).
- Modification of two SL18 vehicles. (WP40).
- Approval by the Norwegian transport authorities for testing in the described environments. (WP40).
- Execution of proof-of-concept tests, final demonstration, and reporting in local trials (Oslo-Oslo) and remote trials (Madrid-Oslo and Berlin-Oslo). (WP41)

Use cases tested

1. Remote driving and telecommand from a centralized remote-control center:
   - System initialization + Cab selection + Remote movement + System shutdown
2. Autonomous movements in depots:
   - Development of a trackside solution for fleet and mission control.
   - Obstacle detection and train control actions.
   - Definition of missions composed of static sequences and dynamic movements
   - Interfaces with depot systems.

Road map

Now — Q2 2025 — Q4 2025 — Q2 2026 — May 2026

First Step

Recording campaign for development and training of onboard perception systems.

Final modification of the units for integrating final equipment, replacing the prototypes used so far.

Second Step

Initial proof-of-concept tests in the depot. Validation of integration between perception, decision-making, and automatic driving systems.
Initial tests of the ground-based mission management system.

Third Step

Final demonstrators in the depot. Mission dispatch and management of contingencies during execution.

Deliverables and final activities.

Demonstrator D4 : Mainline (WP39)

DEMO Input from

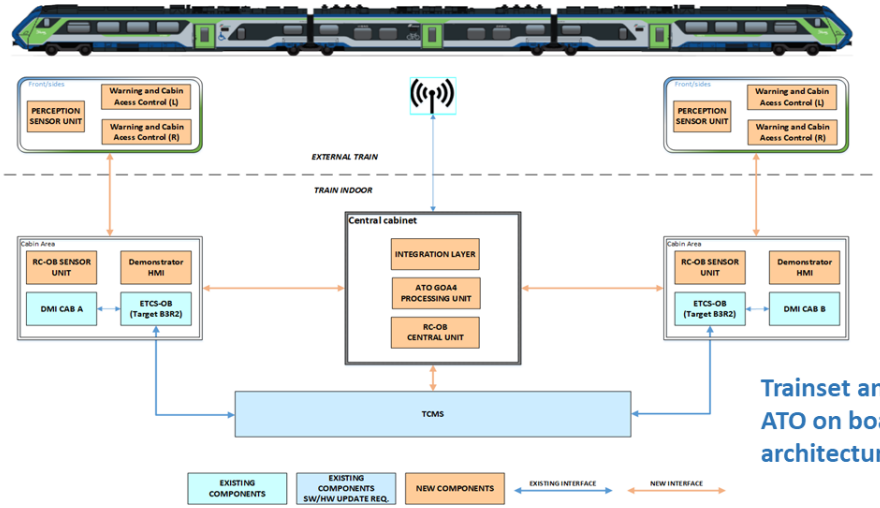
- TE1 Automatic functions
- TE4 ATO technology
- TE6 Perception
- TE7 Remote Driving

- Prepare to demonstrate the solutions DATO over ERTMS technology can bring to relieve bottlenecks in main lines in high-density networks with heterogeneous traffic
- Showing the relevant advantages deriving from the synergy between the digital automatic train operation up to GoA 4 and the CCS evolution, increasing the capacity and punctuality of railway lines

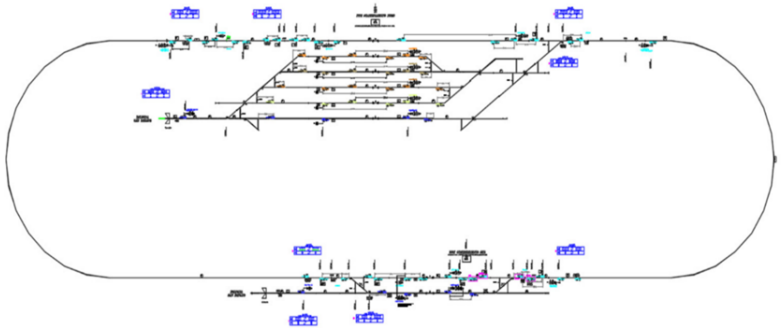
Interfaces to

SP Specification | Architecture | STIP

FP1 | **FP2/FP6**



Trainset and ATO on board architecture



D4 Mainline (WP39)

Status and goals

Achievements : what have we have done already and Key Exploitable Results

Task 1: Update **interfaces framework** between FP2 WP39.1 and other WPs/FPs and the System Pillar. Prepare **preliminary version of test specification for DATO and TMS** interface for **mainline** operations. Organise **workshop** among WPs in different FPs and the System Pillar to further develop needs and expectations, interfaces and **Operational Concept** definition.

Task 2: D39.3 **Demo specifications**

Use cases TO BE tested

Task 1: Prepare train unit for a mission and Train Path Envelope calculation; Perform Mission and TMS-ATO Feedback Loop; Case Study Mainline SAAL corridor in the Nehterlands.

Task 2:
Shunting movement in remote driving until transition in full supervision; Train operation in GoA4 including multiple train service and “End of train service”; Wake up in GoA1, train operation (in GoA2), transition in GoA4, train operation (in GoA4), transition in GoA2, train operation (in GoA2).

Road map

Now — Jan 2025 — Dec 2025 — Apr 2026 — May 2026

First Step

Task 1: Iterative feedback on the **preliminary version** of **test specification** for DATO and TMS interface for mainline operations.
Task 2: D39.3 **Demo specifications**

Second Step

Task 1: With SP, definition of the **Operational Concept** in the test specification for DATO and TMS interface for mainline operations. **Align** test specification with the **demonstrators in FP1 WP16**.
Task 2: Detailed **design for ATO** on train; **Laboratory** tests.

Third Step

Task 1: Complete the test specification for DATO and TMS interface for mainline operations. Follow-up on **results from capacity studies** in FP1 WP8/9 to include in the **best practices report**.
Task 2: On site tests; Tests data **log analysis**; Test **reports**.

TMS: Traffic Management System
ATO: Automatic Train Operation

Demonstrator D5 : ETCS HTD (WP37)

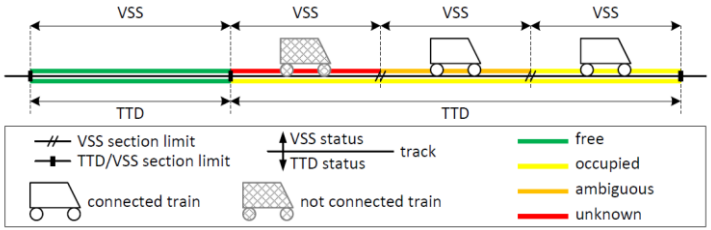
DEMO Input from

- **TE3** Train Integrity
- **TE10** HTD
- **TE20** Deployment - Migration

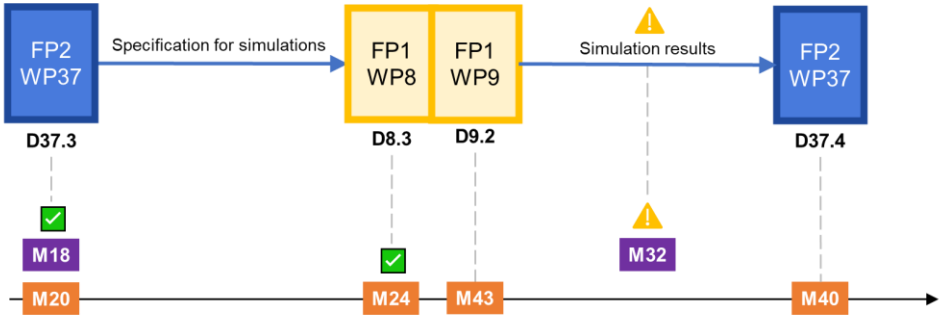
Develop **migration and deployment strategies** to accelerate the **application of ETCS Hybrid Train Detection** (HTD) to reap the benefits as quickly as possible, thus avoiding costly investments in infrastructure.

Interfaces to

- **SP** Specification | Architecture | STIP
- **FP1** Planning & Simulation
- **FP2** Business case & Migration



Source: EUG – HTD Principles, 2024



D37.3 Requirements specification to FA1 WP8/9; **COMPLETED**
D8.3 Developed simulation methods and models for capacity evaluation of ETCS and C-DAS/ATO; **COMPLETED**
D37.4 Determining ETCS HL3 capacity impact analysis using simulations; **PLANNED**
D9.2 Report: Capacity studies of optimised ETCS Level 2, Hybrid Level 3 and C-DAS/ATO; **PLANNED**

D5 ETCS HTD (WP37)

Status and goals

Achievements : what have we done already and Key Exploitable Results

- **HTD Survey** completed in 2024 with 38 responses.
- **HTD Workshop** completed in 2024 with various EU stakeholders.
- Deliverable D37.3 (**test specification** to FP1 WP8/9) completed and published.
- Alignment with FP1 WP8/9 (**capacity simulations**) and FP2 WP32 (**business case**).
- Task T37.4 (**Assessment of HTD deployment**) kicked-off.
- **KERs:** Publications on capacity evaluation of HTD and timetable improvement.

Use cases TO BE tested

- 13 **Capacity** use cases and 2 **Robustness** use cases
- 7 case studies in **Spain**: Atocha commuter tunnels, Madrid C-5 cercanías, Madrid – Torrejón de Velasco, Barcelona – Figueras, León – Guardo, Lérida – Reus, and Cercanías Barcelona.
- 2 case studies in **France**: Lille and Bretagne pays de Loire (LNOBPL).
- 3 case studies in **Sweden**: Stockholm Citybanan, East Link and Southern mainline (Norrköping – Mjölby).
- 1 case study in **the Netherlands**: SAAL-corridor: Schiphol – Amsterdam – Almere – Lelystad.

Road map

Now — Jun 2025 — Oct 2025 — Mar 2026 — May 2026

First Step

Align **input-output flow** with FP1 WP8/9 (**capacity simulations**) and deliverables' delivery plan.

Complete T37.4 (**Assessment of HTD deployment**) scope and start developing the analysis of the **product and project development life cycles**.

Second Step

Complete **best practices and lessons learned** on existing case studies for HTD deployment and **challenges** in terms of **capacity** and **standardization**.

Report HTD survey and workshop **outcomes** in WP37 deliverables.

Third Step

Complete HTD **capacity impact** analysis from **simulation results** in FP1 WP9 and formulate HTD **optimal methodology** of line signalling design.

Develop **multi-criteria analysis** and **deployment strategies** for HTD.

Demonstrator D6 : Moving block

(WP44, 45)

DEMO Input from

- **TE3** train integrity | length
- **TE5.1** FRMCS
- **TE9** digital register
- **TE10** HL3, L3 moving block
- **FP1** Plan Execution [PE]

- Prepare the ground for a successful demonstrator:

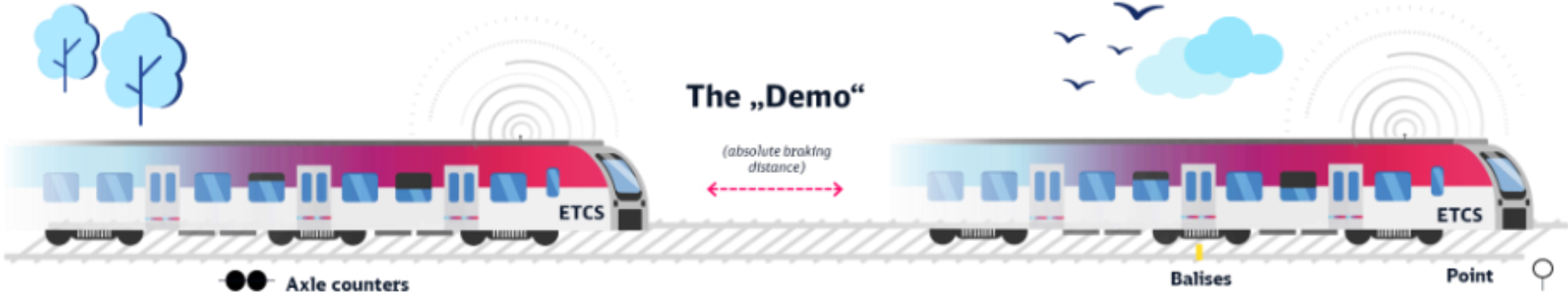
  (a) identify relevant use cases/test cases to demonstrate

  (b) provide a demonstrator specific specification (architecture, functional requirements, interfaces)

- Demonstrate a **modular train-centric** trackside protection system enabling moving block operations with **generic safety core up to TRL6** in R2DATO

Interfaces to

- **SP** Specification | Architecture | STIP
- **FP1** Plan Execution [PE]



D6 Moving Block (WP44, 45)

Status and goals

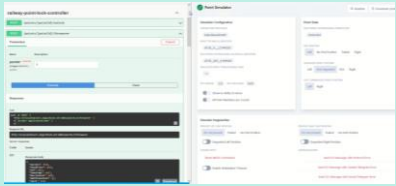
Achievements : what have we done already and Key Exploitable Results

- **R1** Control and supervise point in the field (Sim.) ✓
- **R2** Handling of trains and authorize train movements ✓ (Sim.)
- **R3** Moving Block, Train maneuvers (Sim. + Test field)
  Spec. ✓Subsystem Spec. ✓ Subsystem Spec. Implementation ✓
  Simulation pre. ✓ Testbed pre. (infra. + Train + connectivity) ✓
- **R4**
  System def. + require ✓ PE subsystem req. ✓

Use cases tested

Release 1:
- Registration and initialization of TACS ✓
- Control Point ✓
- Report degraded modes of Point ✓

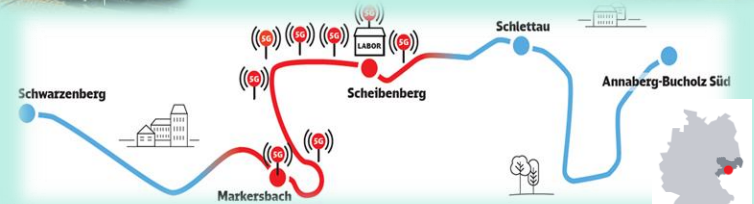
Release 2:
- Control Train Detection System
- Provide Domain Data
- Perform Start of Mission of train
- Perform End of Mission of train



Road map

29.08.2025 — Now — **08.01.2026** — **29.05.2026** — May 2026

R3: Moving Block, Train manoeuvres
(Simulation & Field Test)
- Train movement
- Subsequent train movement
- Train maneuvers



R4:

Restriction Areas & Degraded Situations
(Simulation)

- Recovery from degraded modes of Point & Train Detection System
- Recovery from degraded modes of Train Unit
- Perform planned usage restrictions & train movement during restricted or degraded situations

R5:

Dependencies between train runs, Shunting & Activation of Domain Data
(Simulation)

- Update engineering data
- Digital Register: Distribution and activation of Configuration Data
- Dependencies between train runs
- Perform supervised shunting movements

Demonstrator D7 : Stabling / shunting (WP38)

- TE7 Remote Driving
- TE4 ATO Technologies
- TE6 Perception
- TE13 NG Brake

Demo #1:
NS SNG Train (CAF Civity)
Testing of 38.2, 38.3, 38.4, 38.6, & 38.8
(ATO & RTO in shunting operations)

Status:
Retrofit: ✅
Derogation: March 2025
Demonstration: May - June 2025

Demo #2:
NS SNG Train (CAF Civity)
NG Brakes (Knorr-Bremse)
Testing of 38.5

Status:
Retrofit: Jul-Aug 2025
Derogation: Jun 2025
Demonstration: Sept - Oct 2025

Key Interactions

- WP10: Prototype development of Automated Driving (ATO Technologies) > Task 10.1
- WP11: Prototype development of perception system. > Task 11.2
- WP17: Design conception of integration of NG-Brakes system

D7 Stabling / shunting (WP38)

Status and goals

Achievements : what have we done already and Key Exploitable Results

Demo #1
- Currently focus on **Preparations** for the demos upcoming summer.
- **Remote Operation Center** is moved to Utrecht and is currently undergoing upgrades to prepare for ERJU-experiments. Potential **upgrade to 5G** including Application Priority for improved network stability.
- **Hardware retrofit** of CAF Civity (SNG) train for ATO/RTO demo is complete.
- **Derogation and test plans** are nearing completion and are expected to be filed by the end of January.

Demo #2
- **System design** of the brake system modification
- Starting up **derogation and test plans**
- **Planning** of the installation

Use cases TO BE tested

Demo #1
- RTO-GoA1, RTO-GoA2 & ATO-GoA4 to be tested in Groningen (NL) on a 4km operational trajectory between the central station and shunting yard (De Vork).
- Remote Driving & Remote Supervision to be performed from Utrecht (NL) in a dedicated Remote Operation Center.

Demo #2
- Next Generation Brakes to be tested on the Hanzelijn (ETCS / ATB).

Road map

Now — Jun 2025 — Sep 2025 — Dec 2025 — May 2026

Milestone #1

Demo #1
Finalization of demonstrator **design** and **on-board integration** of ATO/RTO Initiation **of two-month test campaign** as input for D38.2, D38.3, D38.4, D38.6, D38.8, D38.9.
Demo #2
Preparation of installation in the depot

Milestone #2

Demo #1
Completion of ATO- & RTO-field tests. Initiation of **Asset**
Demo #2
On-board integration and field experiments with NG Brakes as input for D38.5.

Milestone #3

Completion of all field-tests and restoration of test assets to original configuration.
Publication of D38.1 & D38.8 in Dec 2025 (M36)
Publication of D38.2, D38.3, D38.4, D38.5, D38.6, D38.9 in May 2026 (M42).

Demo #1

The yard and track to Groningen Central Station

Remote Operating Center Utrecht

Remote controlled train

Demo #2

West view test track

East view test track

CAF Depot “Leidschendam”

Demonstrator D8 : Onboard Platform (WP36)

DEMO Input from

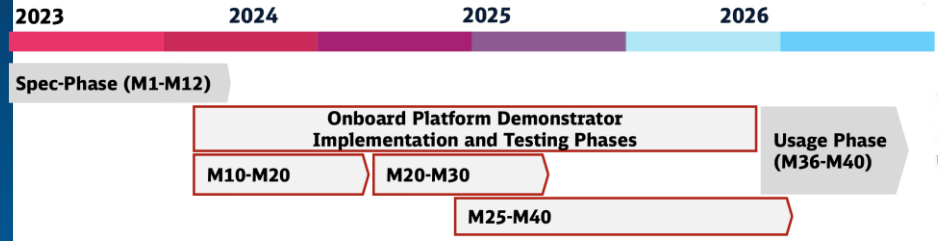
- **TE5** Connectivity
- **TE5.1** FRMCS
- **TE16** Modular platform
- **TE17** onboard COM networks
- **TE20** Deployment - Migration

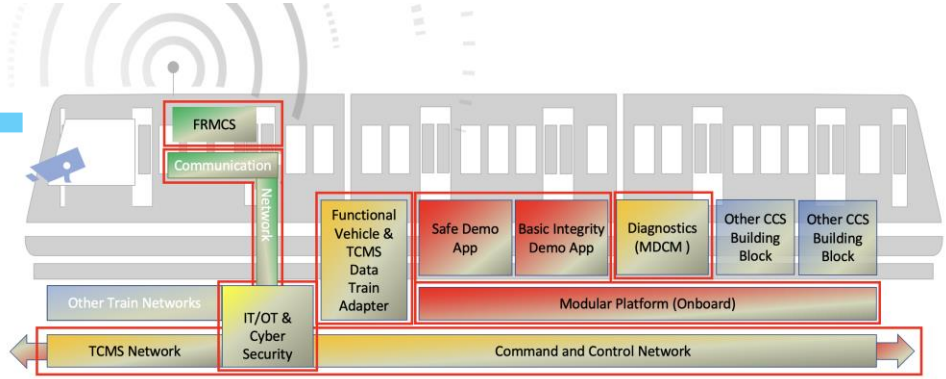
- Validate platform technologies for the CCS-Onboard
- Enable migration and evolution for future onboard architectures, where connectivity & modularity are required in a highly automated and evolving rail system
- Implement & validate in lab environment (up to TRL 5/6) how railway applications can be hosted on a functional safe Modular Computing Platform (up to SIL4), making use of standardized Platform Independent Interfaces, FRMCS functions and diagnostics services

Interfaces to

SP Specification | Architecture | STIP

Comp. Env. | **Train-CS** | **Transversal**





D8 Onboard Platform (WP36)

Status and goals

Achievements : what have we done already and Key Exploitable Results

- D36.1 provides a comprehensive **Demonstrator Specification**, architecture and implementation plan for demonstrator activities
- D36.2 files a report on a set of first **12 User Stories**, **realised** in a virtual and automated development and test environment
- Task 36.3 already sets a major corner stone for the implementation of **FRMCS communication** and integration **on the Modular Platform (MP)**
- The WP36 architecture gets continously further developed and activities towards the **realisation of further use cases in a laboratory** (e.g., application and diagnostics development) have been kicked off

Use cases tested (selected User Stories)

Supporting **exemplary safety critical and non-safety critical use cases (ETCS-OB, ATO-OB, etc.) on Modular Platform**:

- Run Multiple Applications (basic integrity and safe) on RTE
- Communication between Applications on the RTE (and **Applications** running parallel on the MP)
- **Communication** between Applications running on RTE & MP and external Basic Integrity Application
- Execute Declarative Configuration
- Replace and reintegrate **failing** (virtual) **Hardware**

Road map

May 2025 | End 2025 | March 2026 | May 2026

Communicate over FRMCS

Collect & Provide Diagnostics Data

Data Exchange via Vehicle Network

First Step

- On the MP hosted applications **communicate transparently over FRMCS**
- **Collect Diagnostics Data** from Basic Integrity App
- FRMCS Gateway connections via Ethernet based **vehicle network**

Second Step

- **Reuse FRMCS Platform Functions for multiple Applications**
- Collect Diagnostics Data from Basic Integrity App on RTE & from the vehicle (TCMS data exchange)
- Setup laboratory environment completed

Third Step

- **Study on failover** to Redundant FRMCS Platform Functions
- **Integrate Safety App**, collect & provide Diagnostics Data from Safety Layer to external entities
- **Safe and secure end-2-end communication on-board to wayside**
- Dissemination and outlook

3. Presentation of project delivery plan and legacy

Posters visit

Online SURVEY

Please take the time to answer our **survey**, and share **your thoughts on our Seminar** :

Coffee break

4. Open discussion with the audience

Jean-Baptiste SIMONNET

Leader R2DATO WP3 - SNCF

Bastian SIMONI

R2DATO APC System expert - Alstom

5. Architecture Requirements for Innovation and Implementations

Expectations towards R2DATO architecture

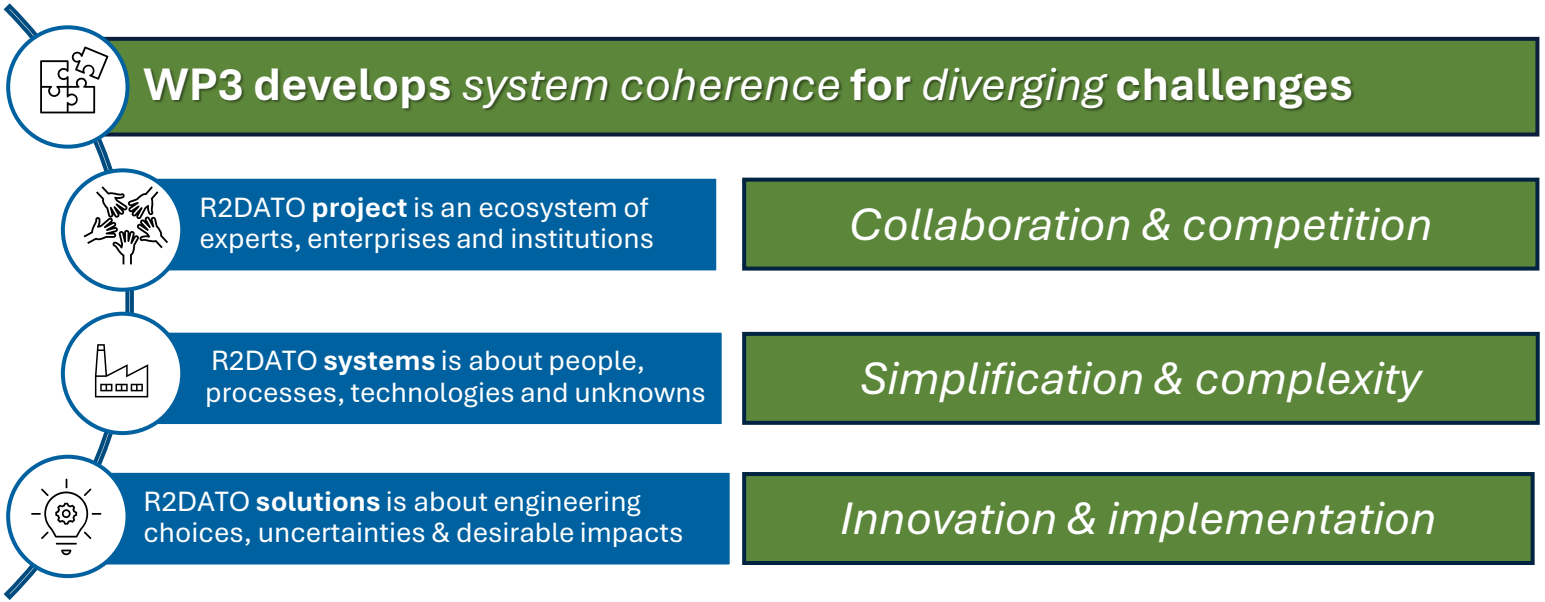
Overcome rail system complexity, without oversimplification nor complication…

vs

vs

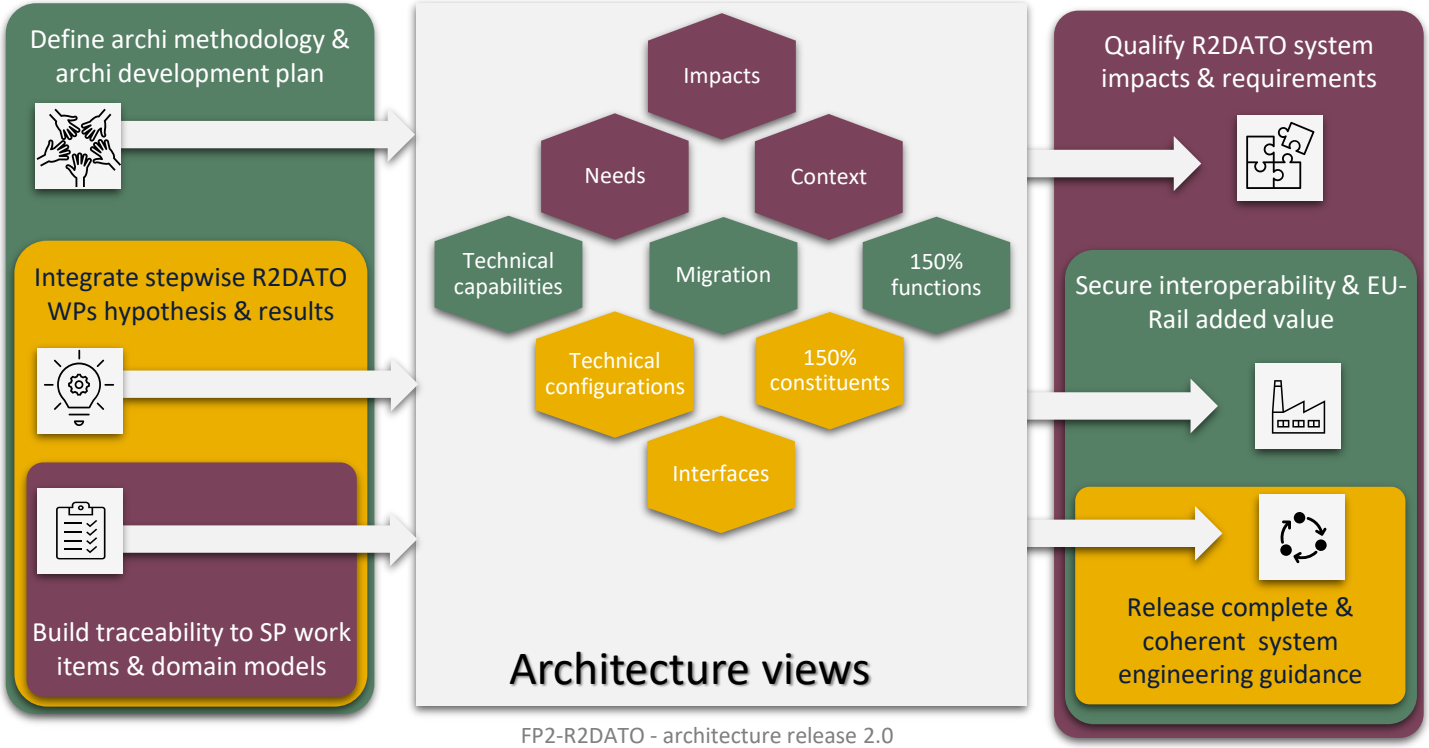
R2DATO is a project and not “one system” but R2DATO systems’ requirements could be rationalised through a collective learning process

Integrate R2DATO architecture

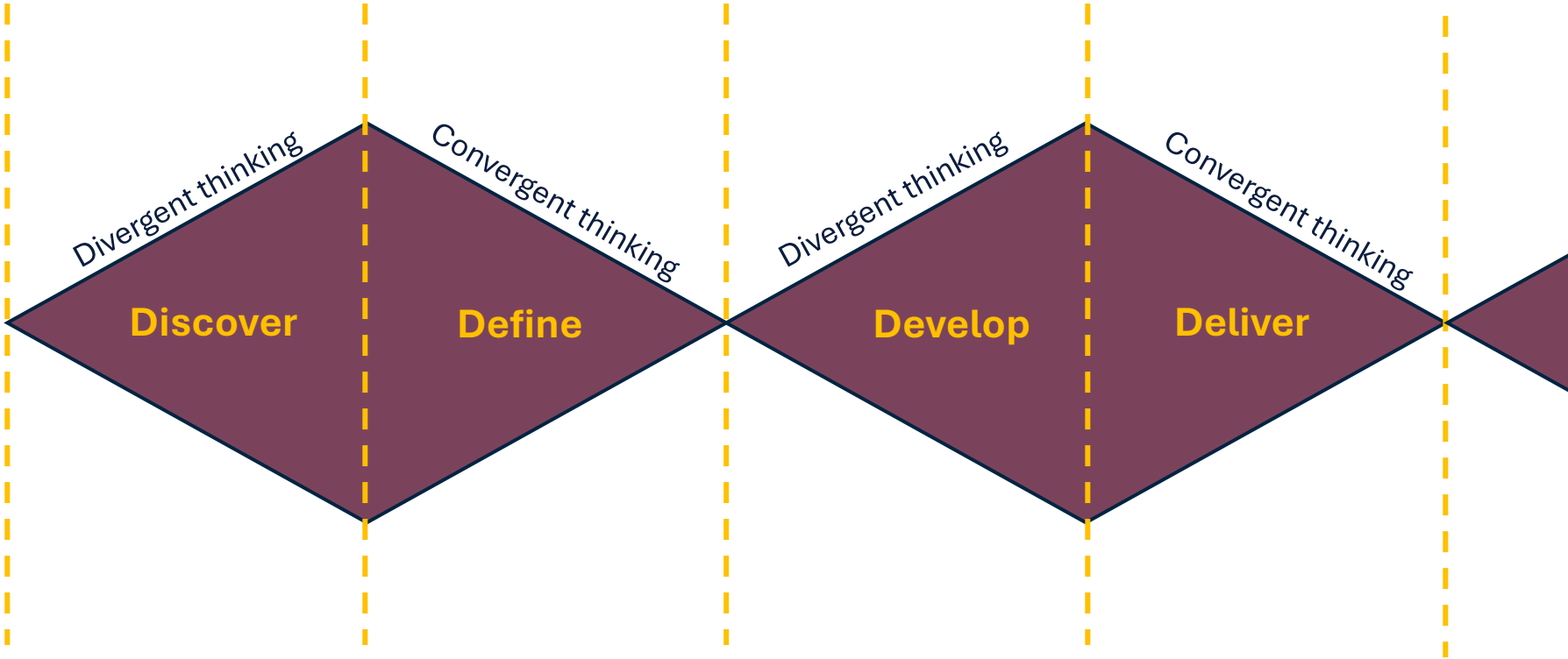


R2DATO architecture approach

The architecture provides solid foundation for collaboration, implementation & innovation.



Learning from Architecture



From divergence to focus

Learning from Architecture

Today's heritage

2026

>2030

Maintain safety

Virtual blocks

Moving blocks

Authorise movement dynamically

Secure shorter braking distance

R2DATO results contribute to rail transport efficiency

Secure more transport capacity

Provide secured & decentralised control

Provide safe secured & seamless communication

Enable rapid digital transitions

Computing platform

FRMCS-ACS

Registers

On-board network

Develop compatibility

Develop attractive business cases

Provide digital services

Manage residual risks and positive human factors

ASTP

Automate train operation

Next-Gen Brakes

Train integrity & length

ERTMS B4

Secure punctuality

ATO up to GoA4

Testing

Remoted driving

Automated functions

Today's solution

Constituents

Capabilities

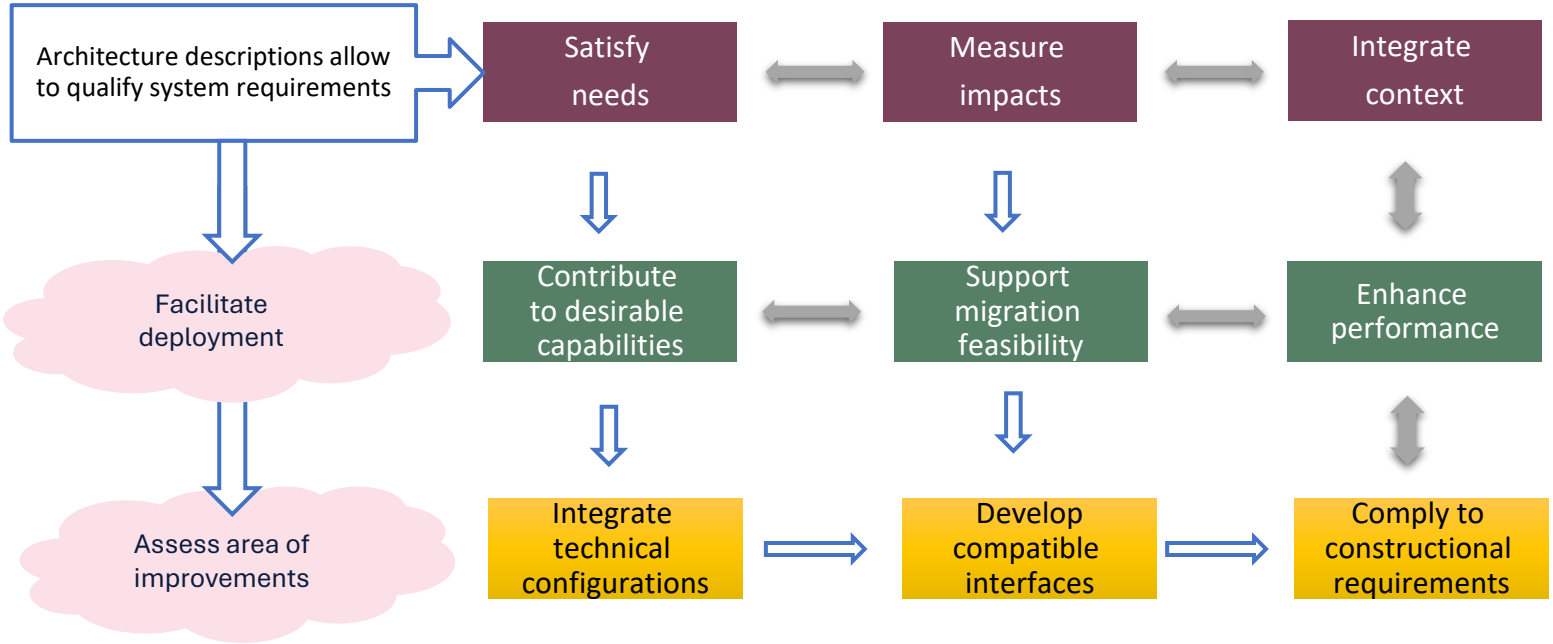
Desirable impacts

Leverage data

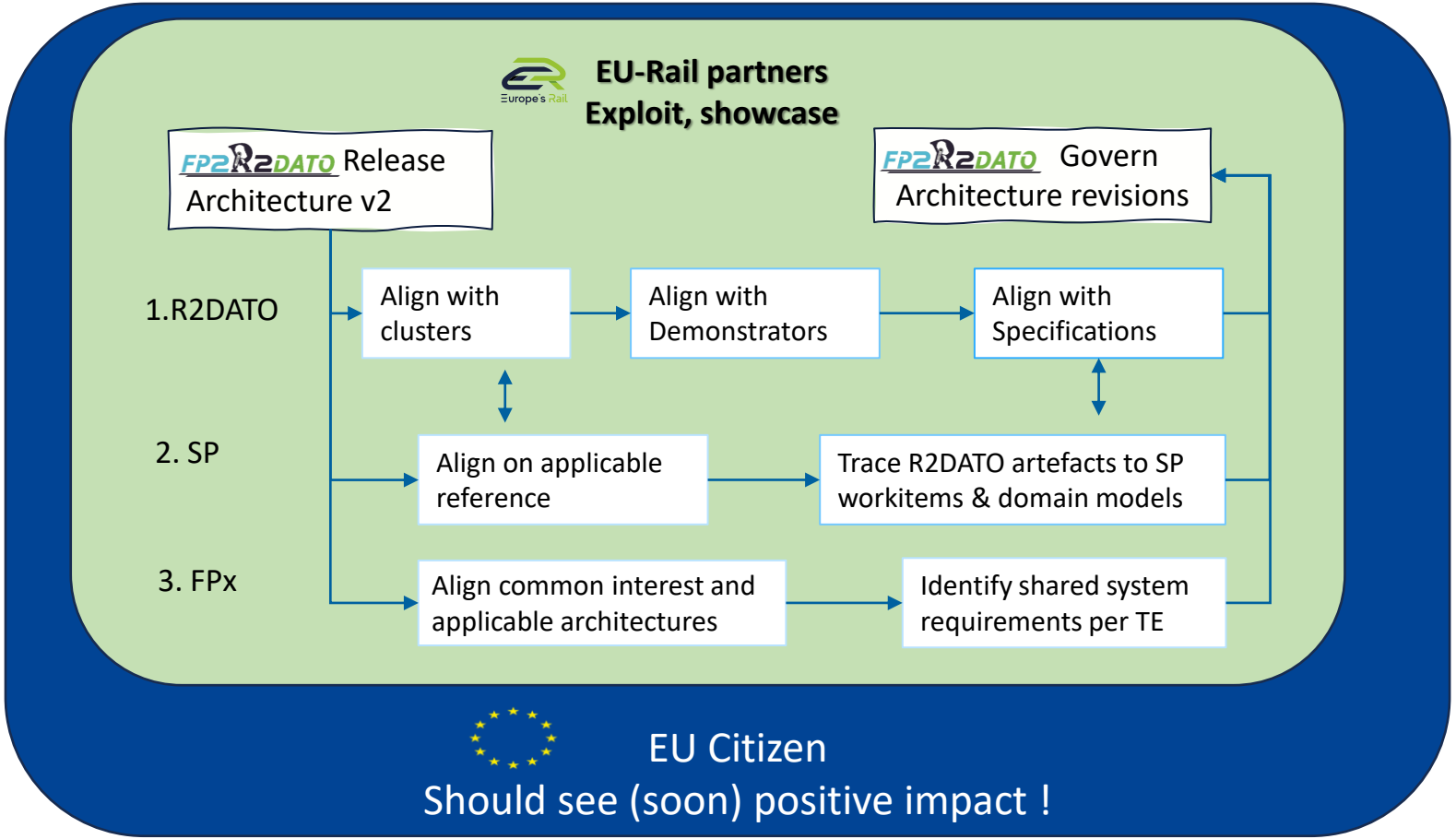
Redesign human interface to rail systems

Building generative system requirements

Integrate a variety of solutions but keep diversity under control



R2DATO usability process



Architecture documentation strategy

Applicable architecture

9 views

Architecture general approach

- Release note
- *Catalogue of artefacts / configuration index*
- *Catalogue of R2DATO use cases*
- Catalogue of interfaces
- System requirements
- Reference documents (R2DATO+SP)

R2DATO systems baseline

Qualify expectations

Integrate context

Simplify migrations

Rationalise configurations

Consolidate requirements

Methodology

- Describe metamodel
- Define objectives and use cases
- Describe enterprise context
- Validate completeness & coherence

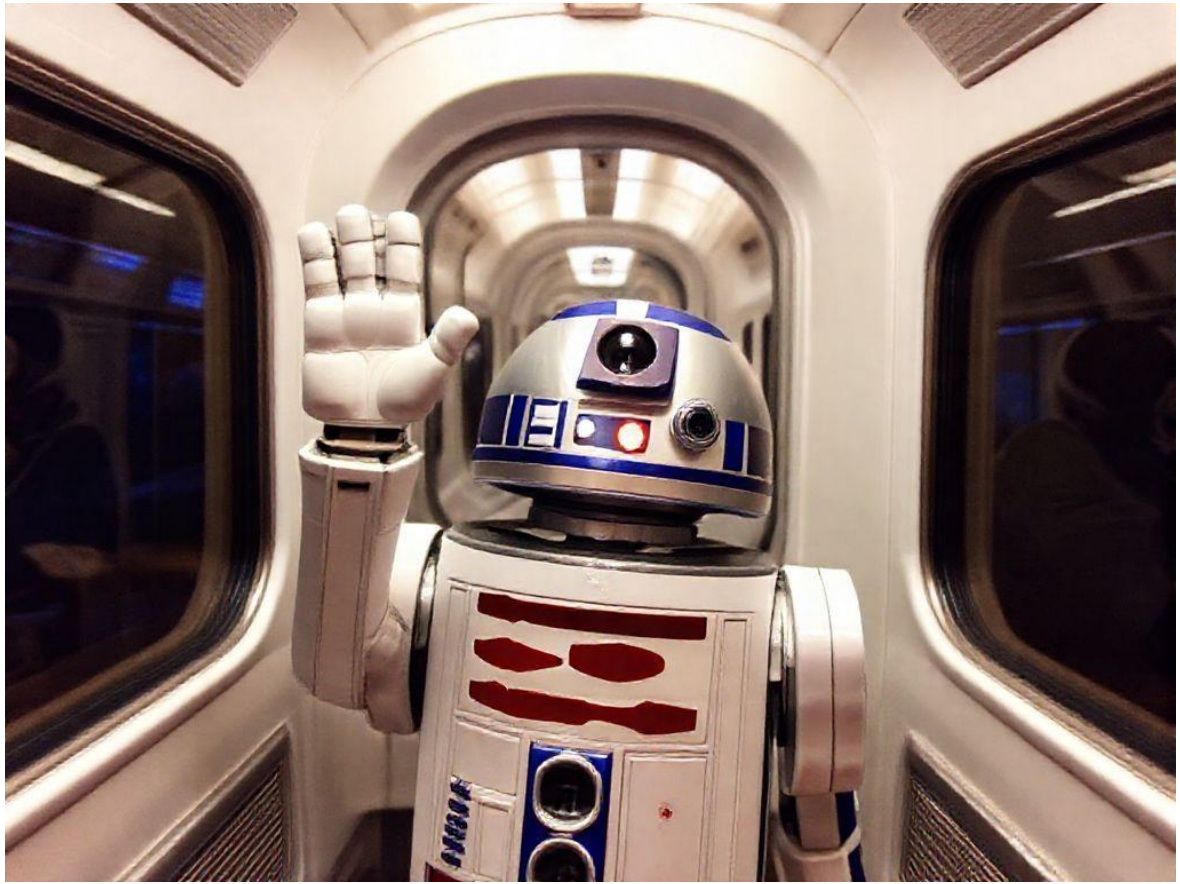
Governance

- Documentation strategy
- Roles & responsibilities, usability, communities
- Baseline release roadmap / review planning
- Architecture maturity

R2DATO architecture file : consolidate a design heritage

6. Conclusions

Thank you !



Please take the time to answer our **survey**, and share **your thoughts on our Seminar** :

We have 2 buses to offer you, both **leaving at 1:30** :

- bus to **Malaga center** (Viala + Calle Larios)
- bus the **airport**