

DIGITAL FOUNDATION DEMONSTRATION & VALIDATION

"Before smart trains, we need smart data."

Event Date: 29.04.2026



About the Event

Experience how European Rail Joint Undertaking's Flagship Project 1 Motional is accelerating digital rail transformation across Europe.

Agenda – Digital Foundation

Time	Topic	Presenting Company	Demo Leader
9:00 – 9:15	Introduction – Welcome Speech	Deutsche Bahn AG	Patrick Marsch
9:15 – 10:05	Digital Asset Engineering		
9:15 – 9:20	Digital Asset Engineering – Overview 27,3	Deutsche Bahn AG	Quivira Macías Robles, Waseem ul Aslam, Peer
9:20 – 9:30	Data Acquisition and Object Extraction	MERMEC	Mario Colapinto, Fabrizio Caramia
9:30 – 9:40	Data Platform 2D, 3D Representation	Deutsche Bahn AG	Waseem ul Aslam, Peer
9:40 – 9:55	Outcome of the Planning Data - Planning Tool and Validation	Deutsche Bahn AG	Bernd Gimborn, Christian Mangold
9:55 – 10:05	Industrialized Tool for CCS TMS Data Model	INDRA	Tenorio Dominguez Ernesto
10:05 – 10:10	Exploitation of Digital Engineering Data for Digital Twins	DLR	Julia Stadlmeier
10:15 – 11:05	Multimodal Decision Support (Łódź) / Load Estimation & Multimodal Planning (Demo 21.2 & 25...)	PKP	Hantz Krzysztof
11:05 – 11:15	Break		

Agenda – Digital Foundation

Time	Topic	Presenting Company	Demo Leader
11:05 – 11:15	Break		
11:15 – 11:25	Digital Twin overview	DLR	Andreas Heckmann
11:25 – 11:45	Braking & Traction	CAF	Blas Blanco
11:45 – 12:05	Point Machine	Hitachi Rail	Vijaya Bhaskar Adusumalli, Rama Ambur
12:05 – 12:55	Lunch Break		
12:55 – 13:45	Federated Rail Data Space	Virtual Vehicle, DLR, voestalpine, TMC, Knorr-Bremse & NRD/IFE	Alex Meierhofer
13:45 – 13:55	Break		
13:55 – 14:45	Conceptual Model & Ontology	UIC	Airy Magnien
14:45 – 15:15	Use Case Repository Tool	NRD/IFE	Anthony Junior Bokolo
15:15 – 15:30	Closing and Survey, QnA	Moderation by DB	

Introduction & Opening Speech

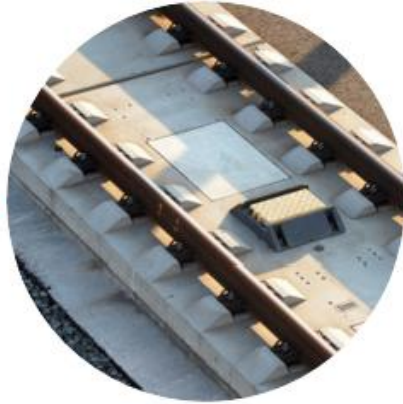
FP1MOTIONAL Event

Digital Foundation Demonstration & Validation

Dr. Patrick Marsch



DB InfraGO, same as other Railway Infrastructure Managers, is facing major challenges ...



- Lack of cross-border interoperability in rail transport



- Failure-prone signalling systems with poor condition ratings



- Labour-intensive legacy systems and processes
- Demographic challenges



- Ageing and eventually obsolete technology (such as GSM-R)

... and responding to these through comprehensive digitalisation

More specifically, the digitalization comprises ...



**Modern interlockings
and operation**

BASICS



**Automatic Train
Operation (GoA2)**



**Capacity Traffic Mgmt
System (CTMS)**

(AI-based disposition)



**Digital basic
infrastructure**

(e.g., IP networks, data
centers, FRMCS)



**European Train
Control System - ETCS**

FUTURE TECHNOLOGIES



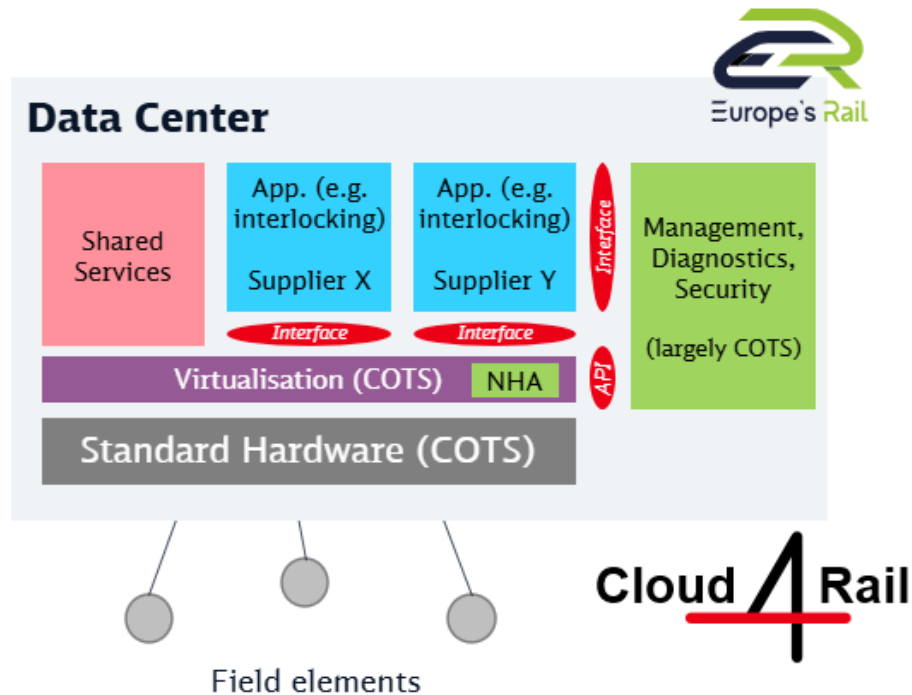
**“Autopilot for
interlockings”**

(full digital control from
disposition to interlocking)

Our department is specifically working on the IT/Cloud and data foundation and resilience of the rail system, e.g.

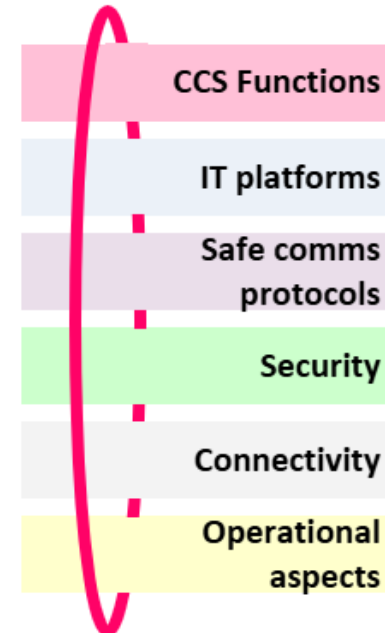
Migration of the rail system towards modern On-Premises-Clouds

(incl. remote/automated update, configuration, management, shared services)



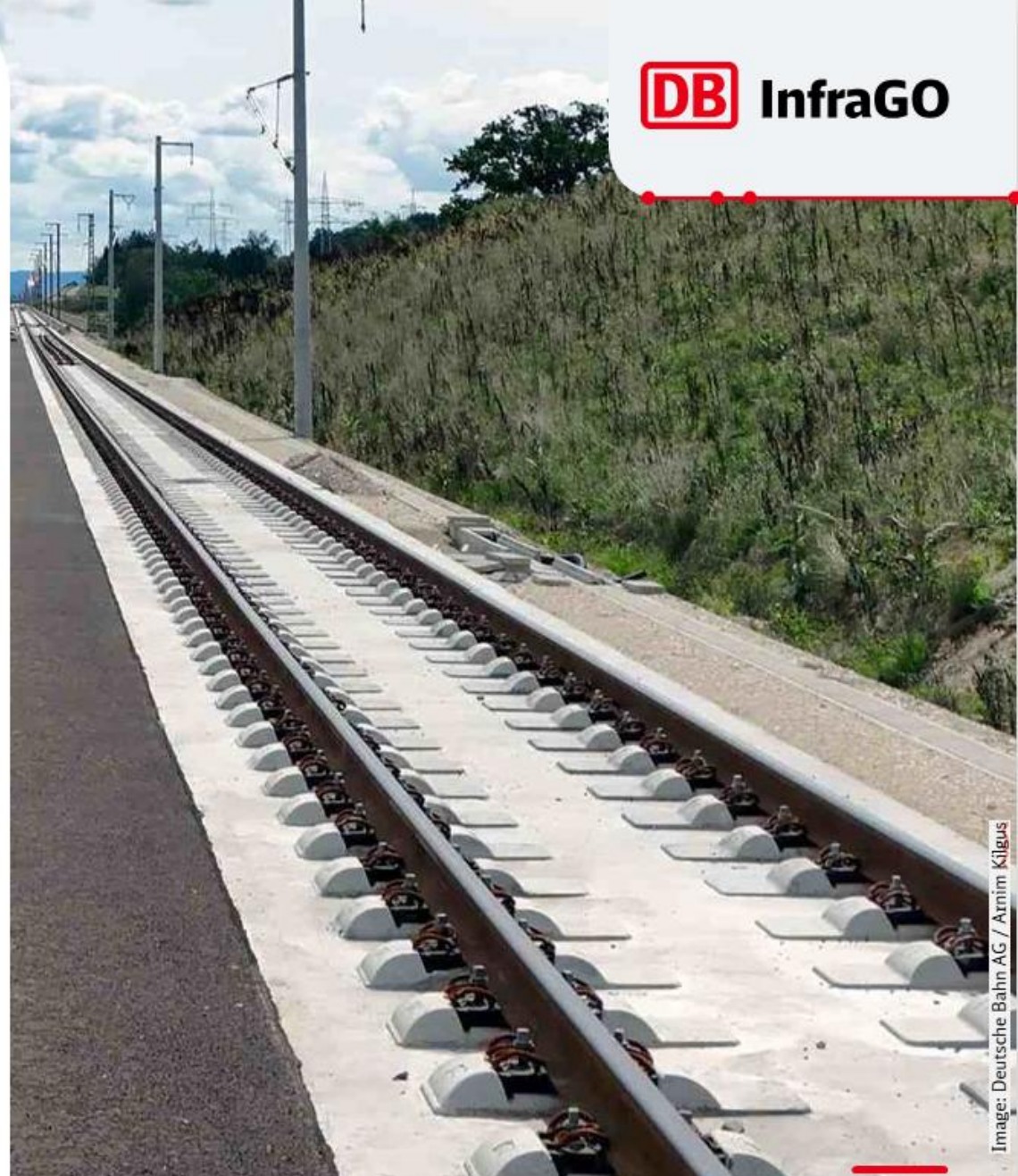
A resilient, redundant E2E rail system

(e.g., modeling of system vulnerability and design of resilience measures like georedundancy)



Data strategy, governance and architecture





The consistent implementation of our digitalisation strategy



Increases **infrastructure performance** and **availability**



Enhances **resilience**



Improves **punctuality** and generates **economic benefits**

**... and pays exactly into the
aforementioned points.**

For instance, **digital asset
engineering** is vital to

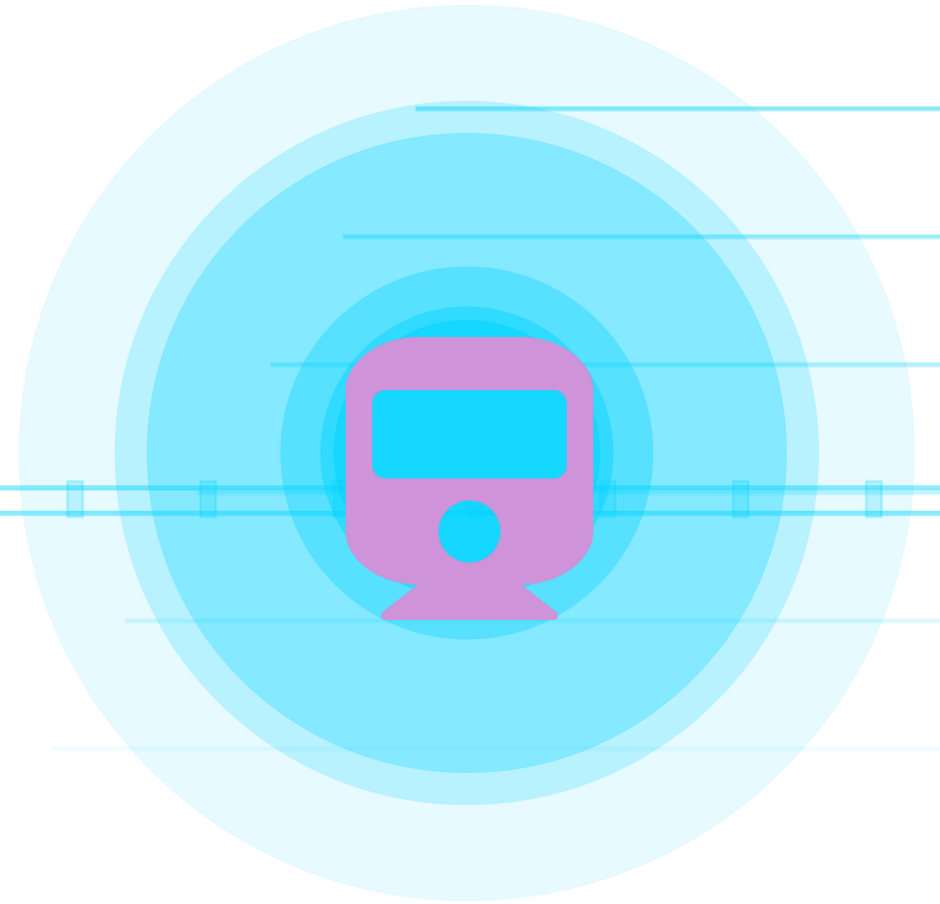
- **Accelerate rollout** through a fully digitalised process from asset mgmt to planning and rollout
- **Reduce efforts and costs** for railways and suppliers alike through standardized data and tools
- **Increase quality of planning and operations** through high data integrity



**We would like to thank you for the
great collaboration and are pleased to
host today's event!**

Flagship Project 1 MOTIONAL | 2026

A Journey Through the Future of European Rail



The Problem & Our Approach

The Challenge



Reactive Maintenance

Tracks & switches fail silently — expensive unplanned downtime.



Fragmented Stations

Rail, transit & private operators in silos — passengers can't plan seamlessly.



Disconnected Systems

Custom integrations block interoperability across Europe.

Our Approach

"Imagine you are a passenger. Your train arrives on time, the track is in perfect condition, the station guides you effortlessly — and if something goes wrong, there is already a plan. That is what FP1 Motional is building."

1
INFRASTRUCTURE
Tracks & Assets

2
STATIONS
Multimodal Hubs

3
THE TRAIN
Vehicle Systems

4
DATA BACKBONE
Connectivity

MOTIONAL

Infrastructure · Stations



VIEW 1: INFRASTRUCTURE

How do we know when a switch will fail before the train does?

Demo 29.3

Hitachi Rail Deutschland

Digital Twin of point machines using signaling data.

Demo 27.5

Deutsche Bahn AG

Digital planning of CCS objects — no more paper-based workflows.



VIEW 2: STATIONS

How do we turn a fragmented station into a true multimodal hub?

Demo 21.3

POLSKIE KOLEJE PANSTWOWE SPOLKA AKCYJNA (PKP)

Web trip planner unifying rail, city transit & private services in Łódź.
Includes B2B planner & real-time station dashboards.

Demo 25.1.2

POLSKIE KOLEJE PANSTWOWE SPOLKA AKCYJNA (PKP)

Load estimation & prognosis for transport management — data-driven capacity decisions via a centralised Data Lake.

The Train · Data Backbone



VIEW 3: THE TRAIN

Can we certify a train without hundreds of physical tests?

Demo 29.1

Construcciones y Auxiliar de Ferrocarriles, S.A. (CAF)

FMU-based Digital Twin for virtual validation & certification of braking & traction systems — fewer physical tests, lower costs, faster delivery.



VIEW 4: DATA BACKBONE

All these solutions only work if systems talk to each other — securely and at scale?

Demo 31.2,3,4

*Virtual Vehicle Research, DEUTSCHES ZENTRUM FÜR LUFT
UND RAUMFAHRT EV (DLR) & Knorr-Bremse*

Federated Rail Data Space: secure connectors, metadata broker & app store - built with 12 railway value chain partners. Scalable & deployment-ready.

Demo 30 Conceptual Model — Ontology


Shared ontologies & data models underpin interoperability — illustration through collaboration with FP5-TRANS4M-R.

Connecting the Dots


Many Views, One Rail Ecosystem.




1
INFRASTRUCTURE
Tracks & Assets
29.3 · 27.5



2
STATIONS
Multimodal Hubs
21.3 · 25.1.2



3
THE TRAIN
Vehicle Systems
29.1



4
DATA BACKBONE
Connectivity
31.2,3,4
Ontology Demo 30

"From the ballast under the track to the app on your phone — FP1 Motional has built a coherent, interoperable ecosystem for every view of European rail."



1

Infrastructure



2

Stations



3

The Train



4

Data Backbone

MOTIONAL



Infrastructure



VIEW 1: INFRASTRUCTURE

How do we know when a switch will fail before the train does?

Demo 27.5

Deutsche Bahn AG

Digital planning of CCS objects — no more paper-based workflows.

















DIGITAL ASSET ENGINEERING

Work Package Lead 27 : 2022-2026

Waseem ul Aslam Peer

Lead Data Strategy, Governance and Architecture



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Europe's Rail Objective



Delivering a high capacity integrated European railway network

U6CMOLK



Single European Railway Area

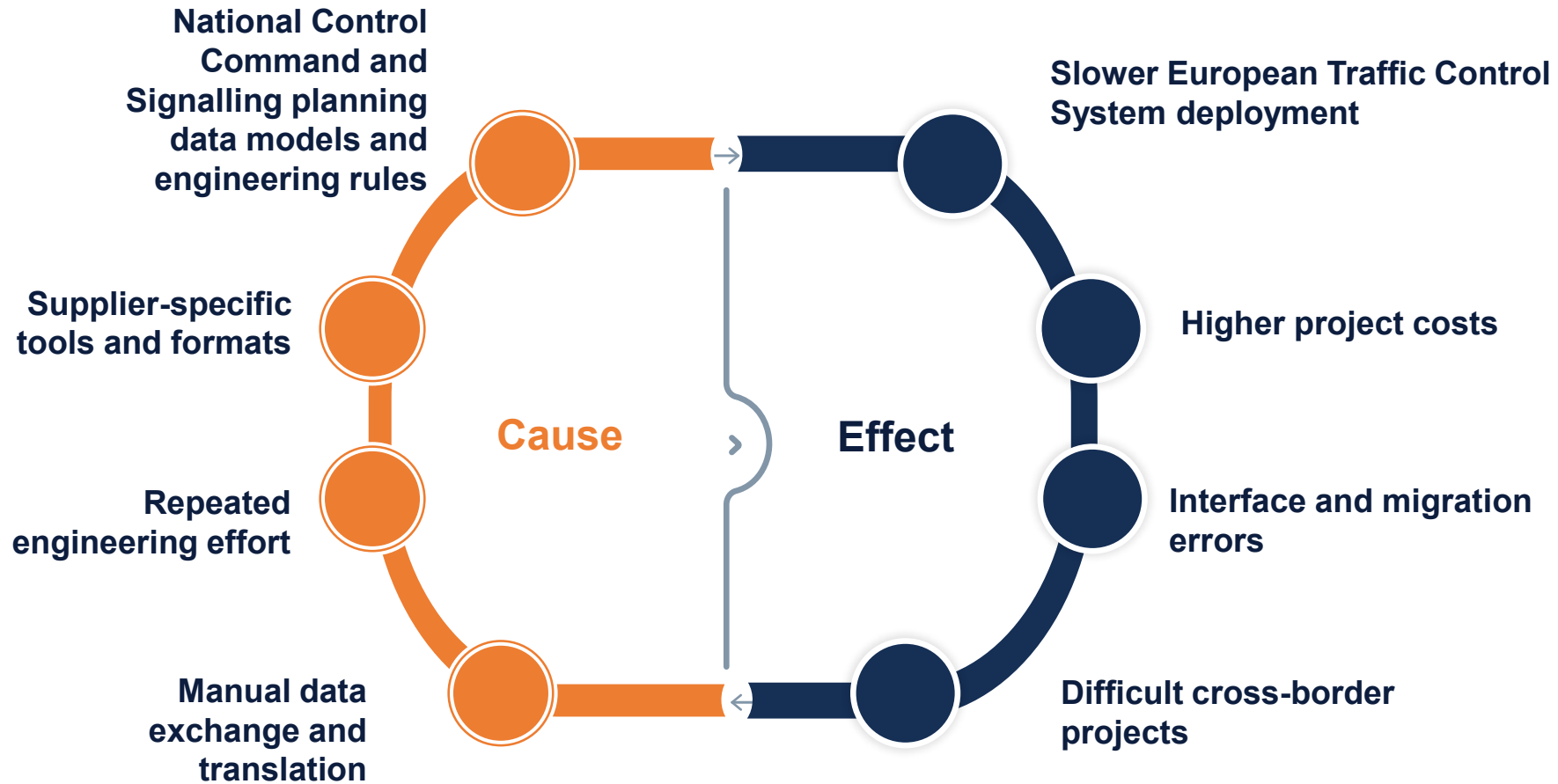


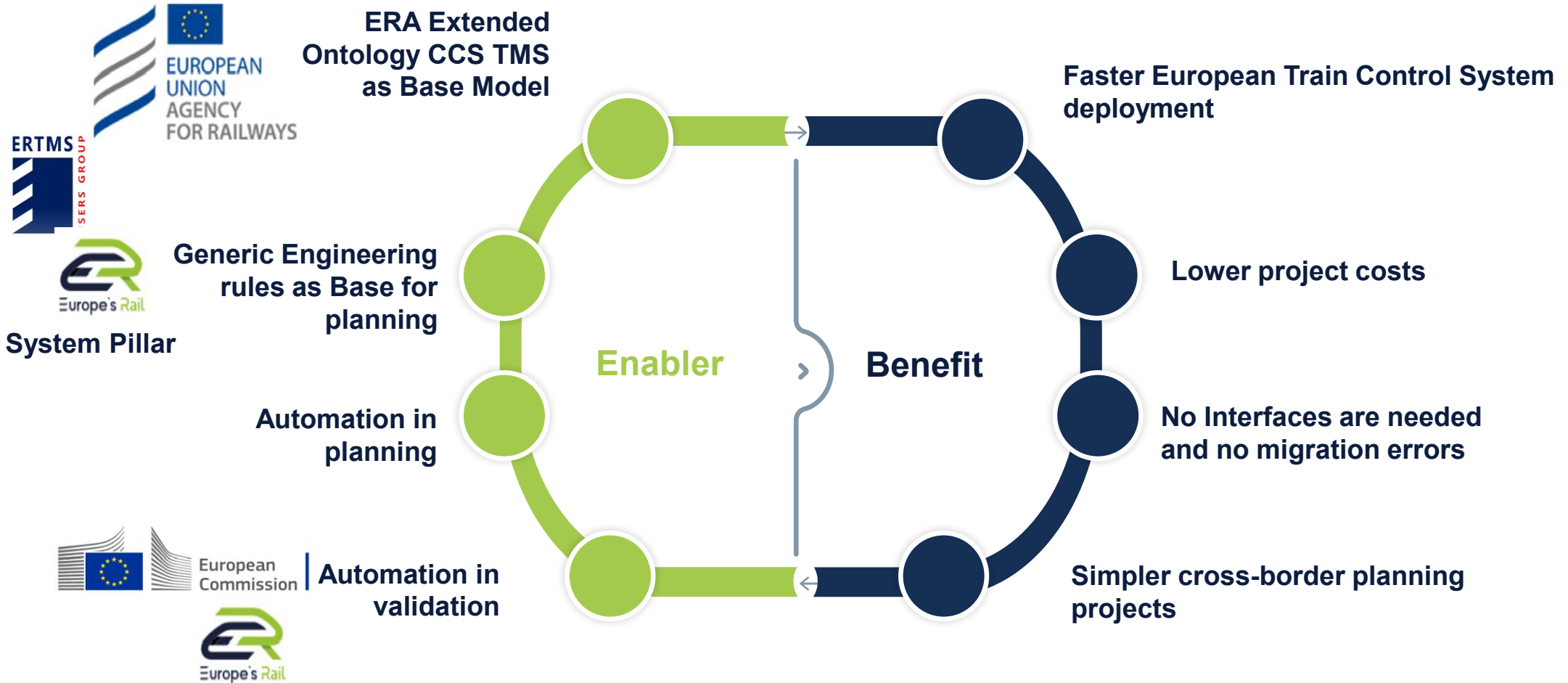
Cross-Border Rail Services



Digitalization and European Rail Traffic Management System Deployment

The Problem Today | Impact on Europe

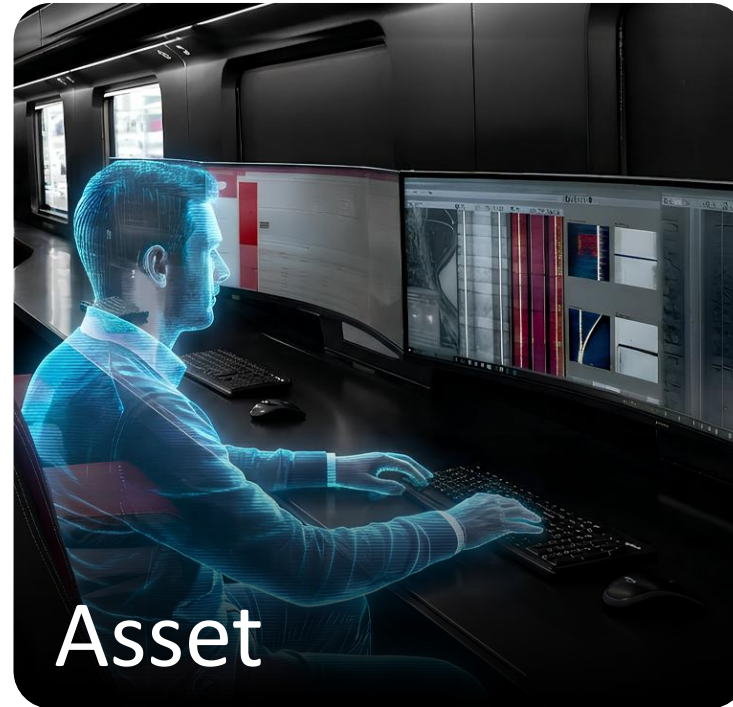




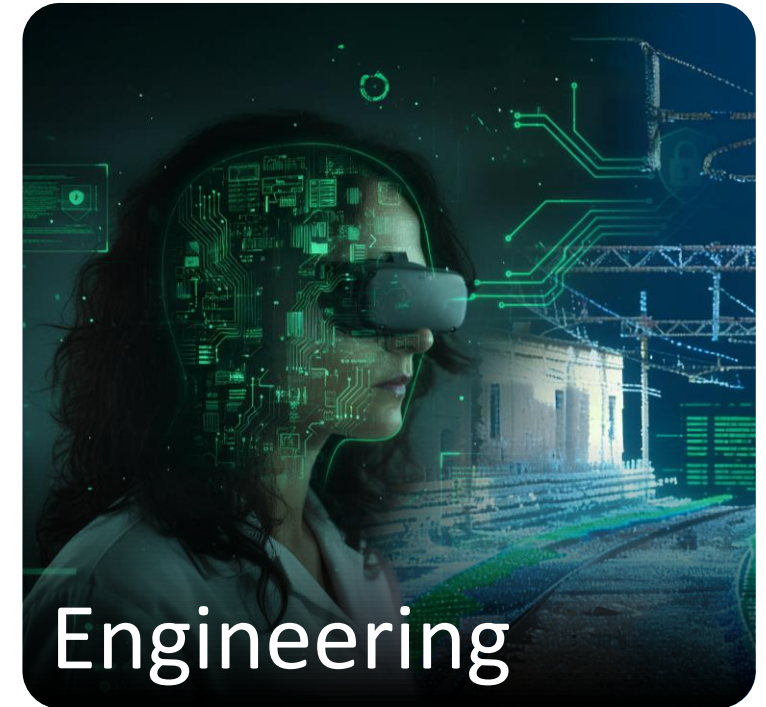
What is Digital Asset Engineering?



Exists in refined electronic form



Anything of value to railways, from rolling stock to infrastructure



A key organizational unit in any railway

Why Digital Asset Engineering?



Digital Asset Engineering makes railway systems digital, accurate, and trustworthy ensuring CCS (Control Command and Signalling) can be designed, operated, and maintained safely and efficiently.





1) Data Acquisition & Preparation

Raw data ingestion, partner coordination, gap analysis, and RDF conversion



3) ETCS Level 2 Planning

ETCS Level 2 object planning with engineering rules, ERA Extended Ontology CCS TMS



5. Industrialized Tool

Industrialized Tool for Schematic Design



7. Guidelines & Specifications

Guidelines & Specifications for Developing & Maintaining Digital Twins



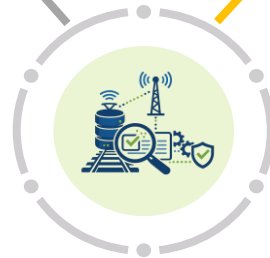
2) Object Detection & Analysis

LiDAR, image, and ground truth data integration with AI detection



4) Data Validation & Quality Assurance

Validation of the datasets



6. Digital Twins

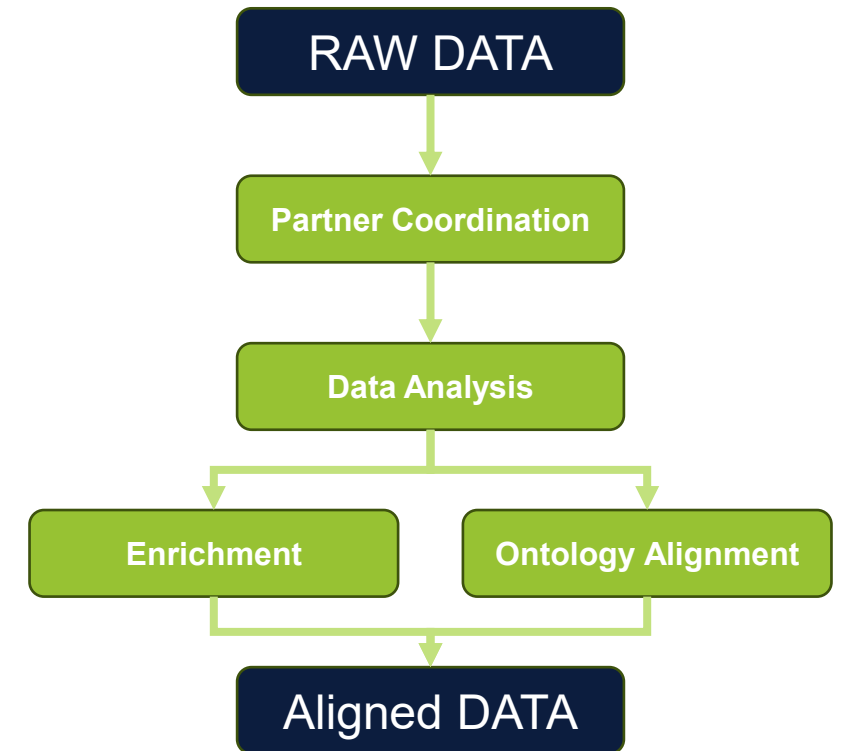
Exploitation of Digital Engineering/Planning Data for



1. Data Acquisition & Preparation



- 1 Raw Data Ingestion**
Initial collection and organization of infrastructure data
- 2 Partner Identification**
Coordinate with infrastructure managers and define requirements
- 3 Data Sharing Confirmation**
Secure formal approval and establish governance protocols
- 4 Gap Analysis**
Identify missing information and quality issues
- 5 Data Enrichment**
Supplement with additional data sources
- 6 Ontology Alignment**
Align with ERA Extended Ontology and CCS TMS model
- 7 RDF Conversion**
Transform to linked data format



2. Object Detection & Analysis



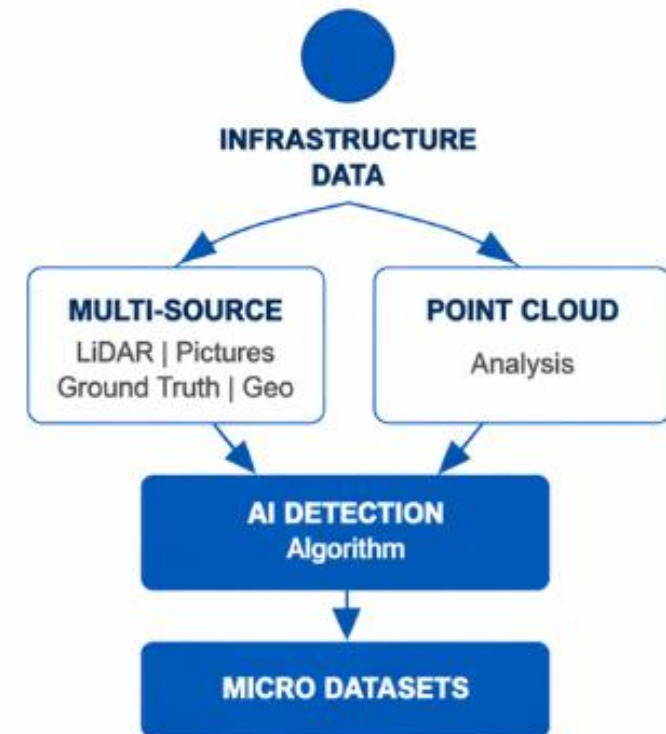
Multi-Source Data Integration

 LiDAR Data 3D point cloud scanning	 Picture Data Visual imagery capture
 Ground Truth Verified reference data	 Geo Data Geographic information

Key Processes

-  Point cloud analysis
-  AI-powered detection
-  Verification with images

INFRASTRUCTURE TO MICRO DATASETS



3. Data Platform






✓ IFC Representation
2D Representation of Assets




✓ REVET Representation
2D Representation of Assets

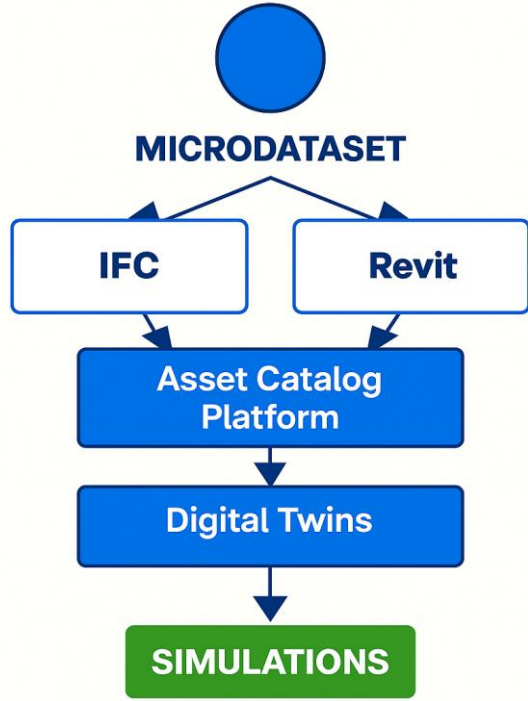
BIM methodology for the standardization of passenger stations. For this purpose, documents as aids for project work.

Key Processes

- 
2D Representation of Assets

- 
Data Asset Catalog – Data Platform

MICRO DATASETS TO SIMULATIONS



ETCS Level 2 without Signals Planning



Automation for intelligent placement of ETCS level 2 without signals objects along railway tracks

Planning Steps



Load RDF datasets



Apply engineering rules and constraints



Plan object placement without signals

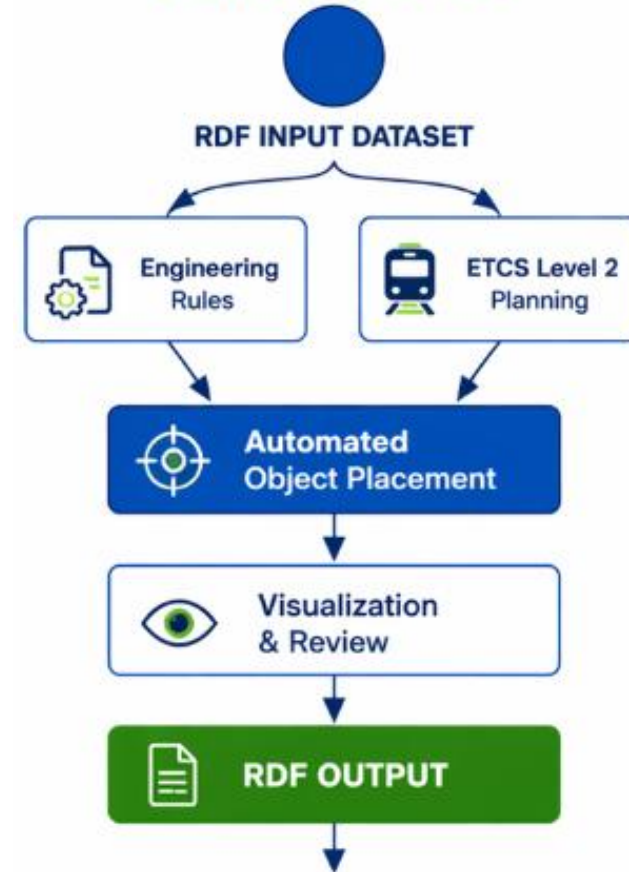


Generate visual models for review



Export planned data for validation

RDF INPUT DATASET TO RDF OUTPUT



5. Data Validation & Quality Assurance



Multi-Stage Validation



1. ERA Ontology Verification

Confirms alignment with European Railway Agency standards



2. SHACL Validation

Automated constraint checking for structural integrity



3. Custom Code Validation

Domain-specific checks and engineering rule verification



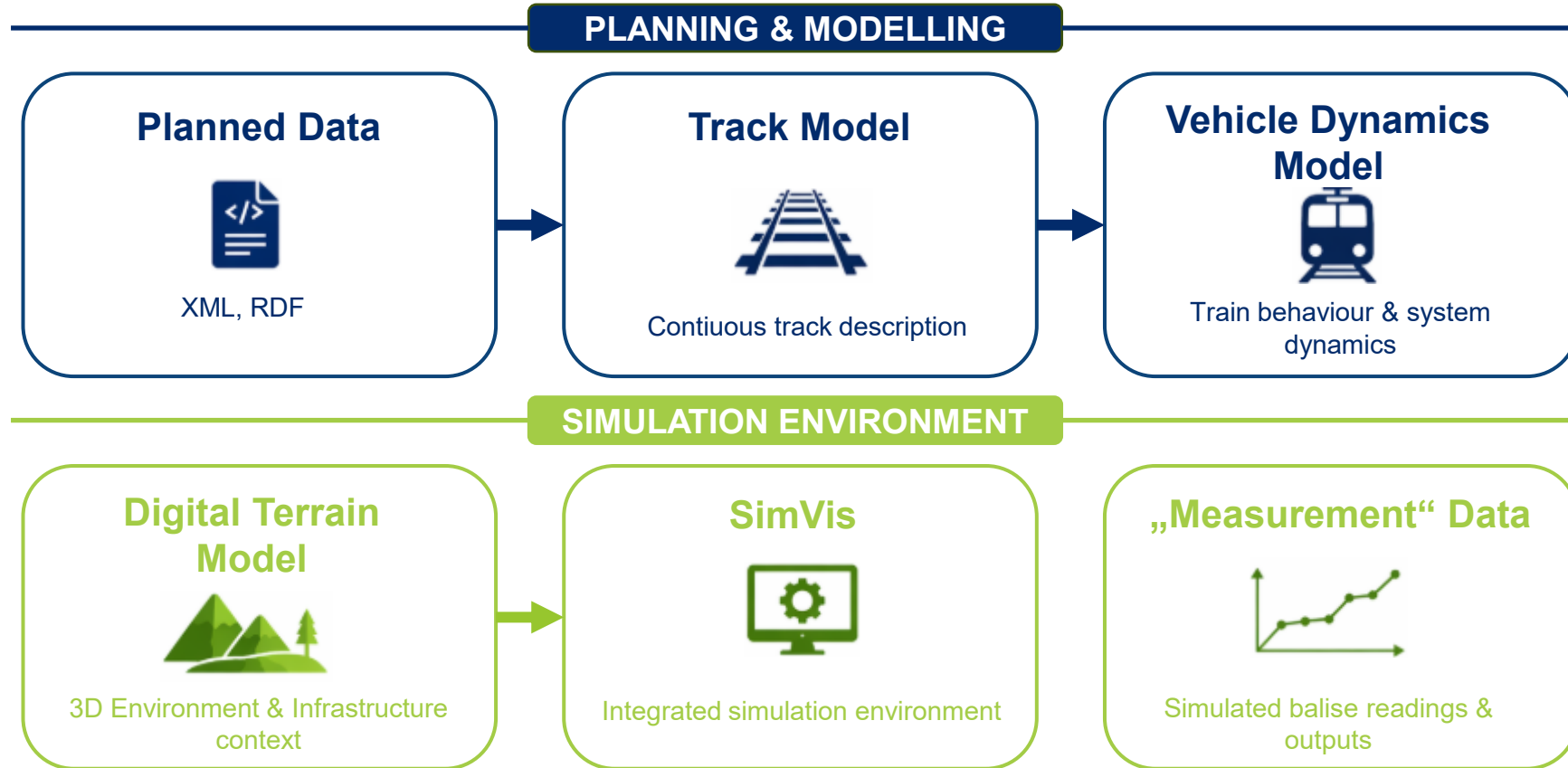
Feedback Loop

Results feed back for continuous improvement

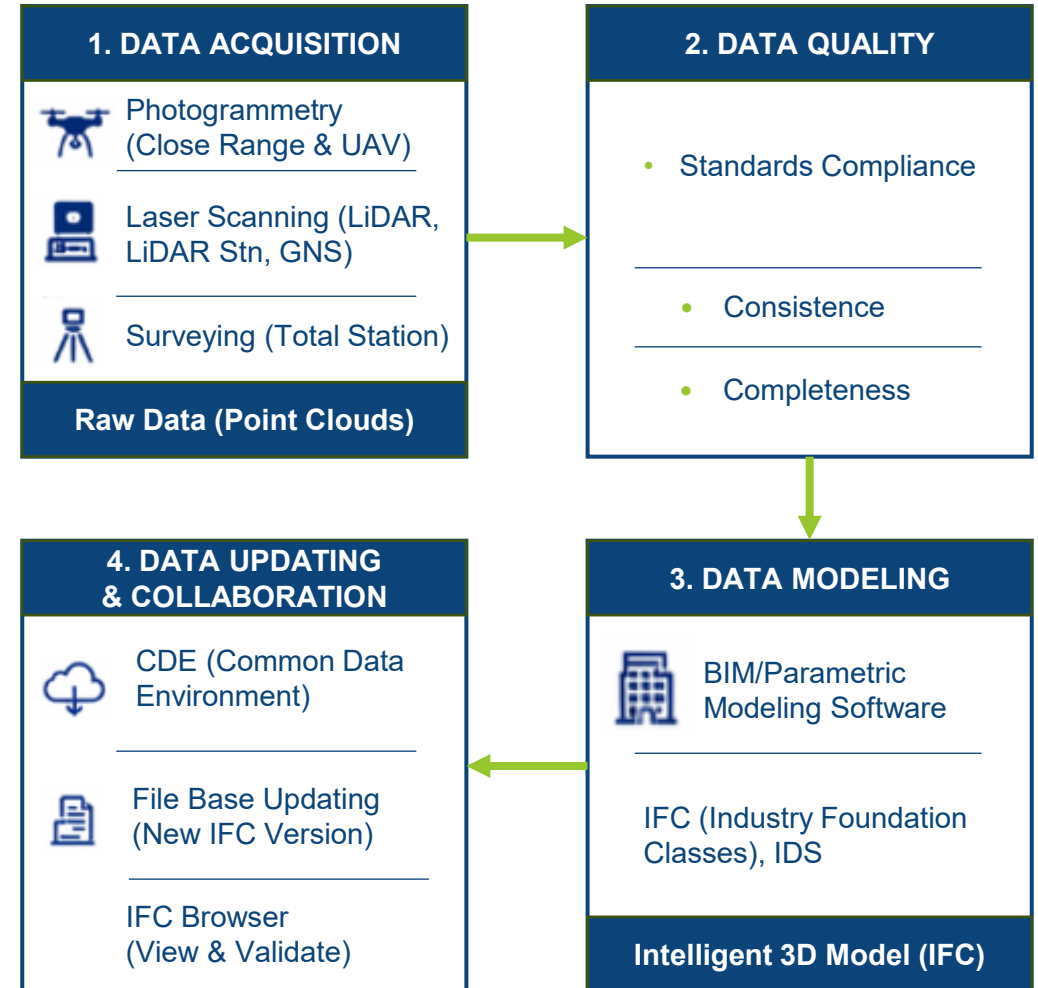
PLANNED DATASET TO VALIDATION REPORT



6. Exploitation of Digital Engineering/Planning Data for Digital Twins



7. Guidelines and Specifications for Developing and Maintaining Digital Twin



Key Technologies & Standards



RDF

- Resource Description Framework for Semantic Data



IFC

- Industry Foundation Classes for Infrastructure Modeling



ERA Ontology

- European Railway Agency data Standard



CCS TMS

- Control Command & Signaling Technical Management



ETCS-Level 2

- European Train Control System Specifications



SHACL

- Shapes Constraint Language for RDF Validation



LiDAR

- Light Detection & Ranging Point Cloud Data



OpenStreetMap

- Open Geographic Data & Mapping Platform



XML

- Extensible Markup Language for Structured Data



1



How to Identify the CCS Assets from Point Cloud Data?
Data Acquisition and Object Detection with Deep Learning

2



How to store these Digital Assets?
A Data Platform that stores the 2D representation – Asset Catalog

3



How to Digitally Plan ETCS Level 2 Objects without Signals?
By using the ETCS Level 2 Without Signals Planner and Validation Tool

4

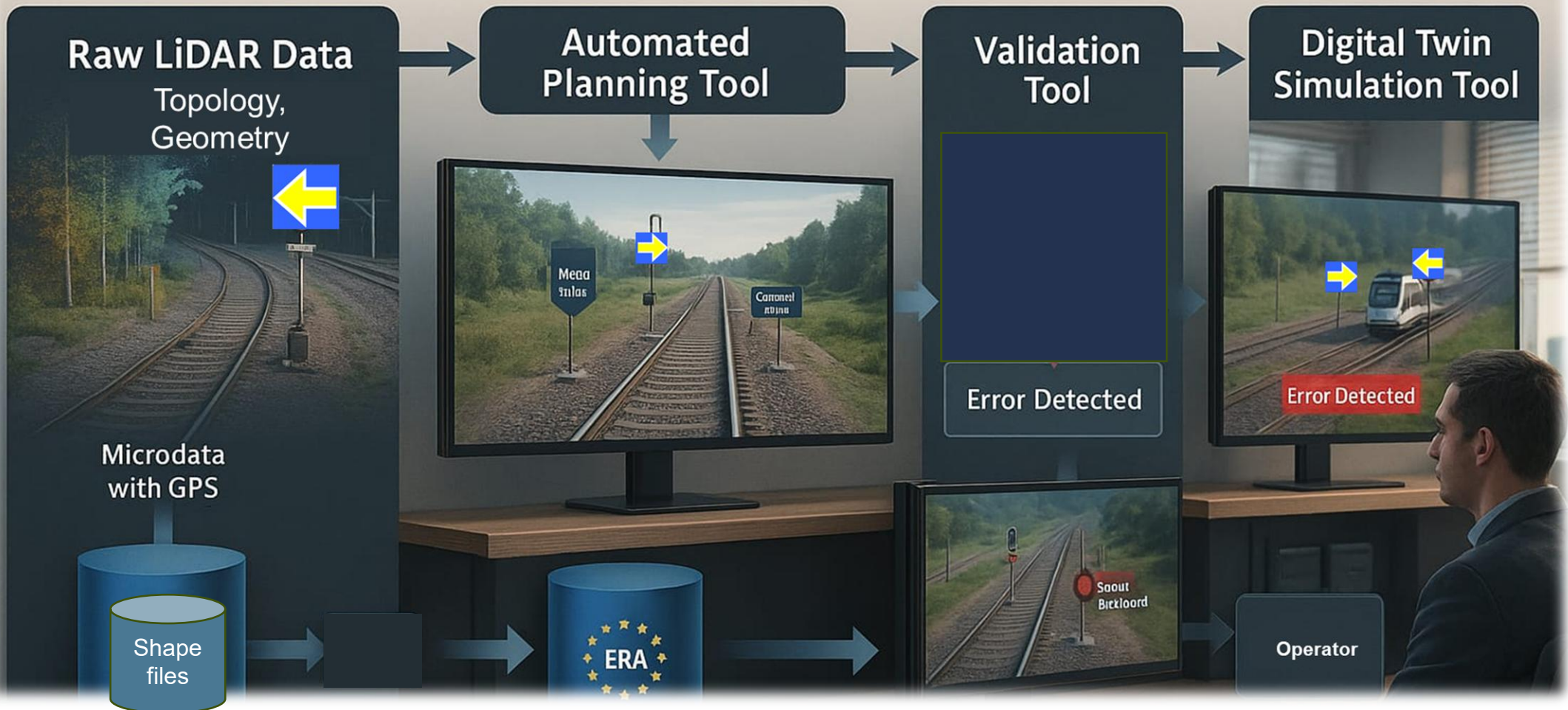


How to Import and Export Data from industrialized Tools ?
Planning with Industrialized Tools like TopRailDesigner

5



How to explore Digital Twins from planning data?
Identify Errors through simulation



Data Acquisition and Object Identification

Task Lead 27 : 2022-2026

Pace Pietro, Mario Colapinto, Fabrizio Caramia





Digital Asset Engineering

Europe's Rail - FP1 MOTIONAL WP27







Data for Digital Asset Engineering



Format & Structure

- Paper-based
- Unstructured
- Non-standardized



Consistency

- Duplicated
- Misaligned
- Fragmented



Completeness

- Missing
- Partial
- No Metadata



Storage & Organization

- Siloed
- Untraceable
- Not versioned



Verification & Validity

- Obsolete
- Inaccurate
- Unreliable



Usage & Governance

- Unused
- Inaccessible
- Unharmonized

Data challenges in the asset life cycle



ON FOOT MEASUREMENT:
slow, manual, and
safety-critical task





LiDAR via Train



LiDAR via Plane



LiDAR via backpack



Point Cloud

An aerial photograph of a mountainous region, likely in the Alps, showing a dense network of green and brown terrain. A red location pin is placed on the right side of the image, indicating a specific point of interest. The sky is a clear blue gradient.

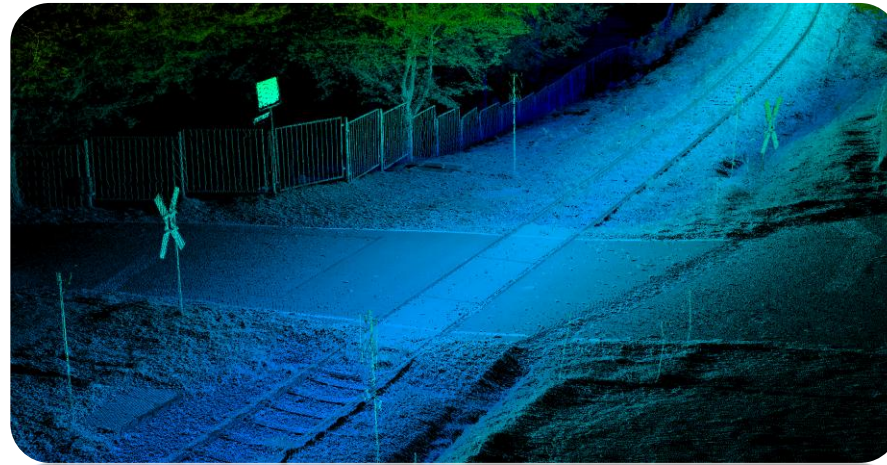
Scheibenberg Line

~ 6 km surveyed with LIDAR and video inspection

Images



Point Cloud



ERA Extended Ontology CCS TMS

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Additional Data Analysed

OBB Survey Data:

Point Cloud & Extracted Objects



SNCF Open Data:

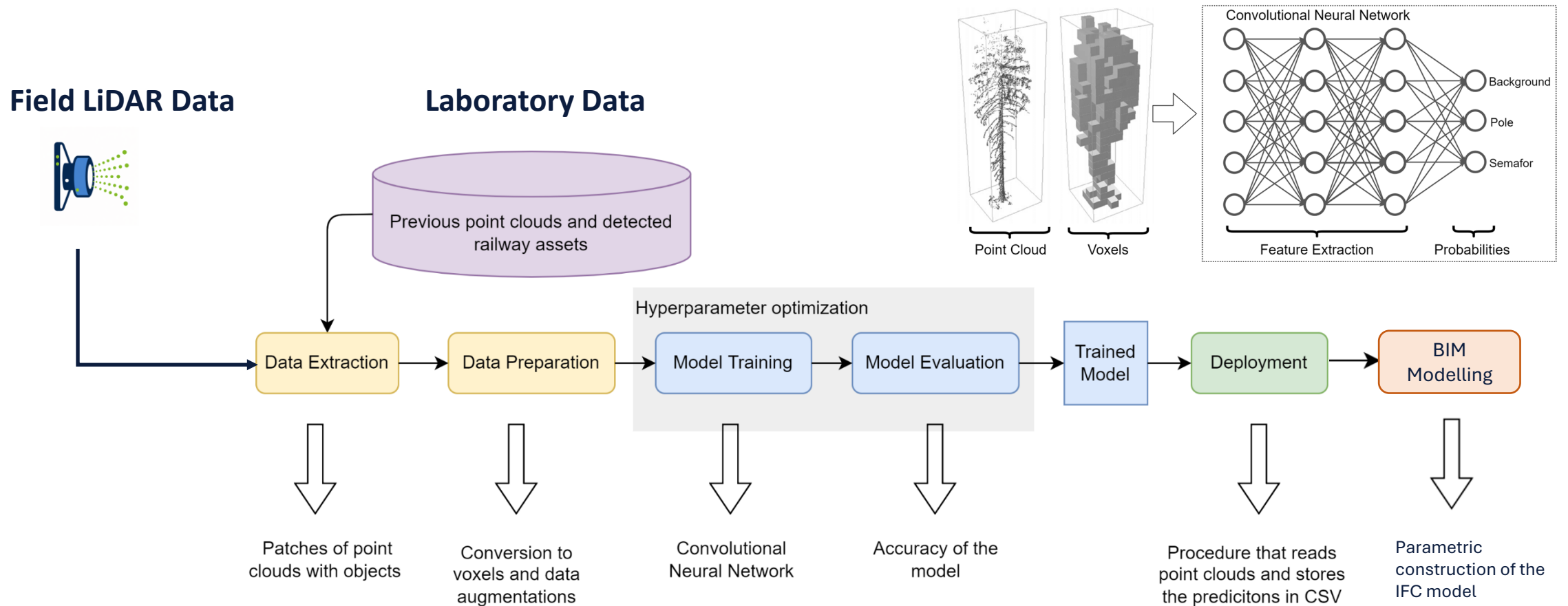
3D point cloud of railway infrastructure



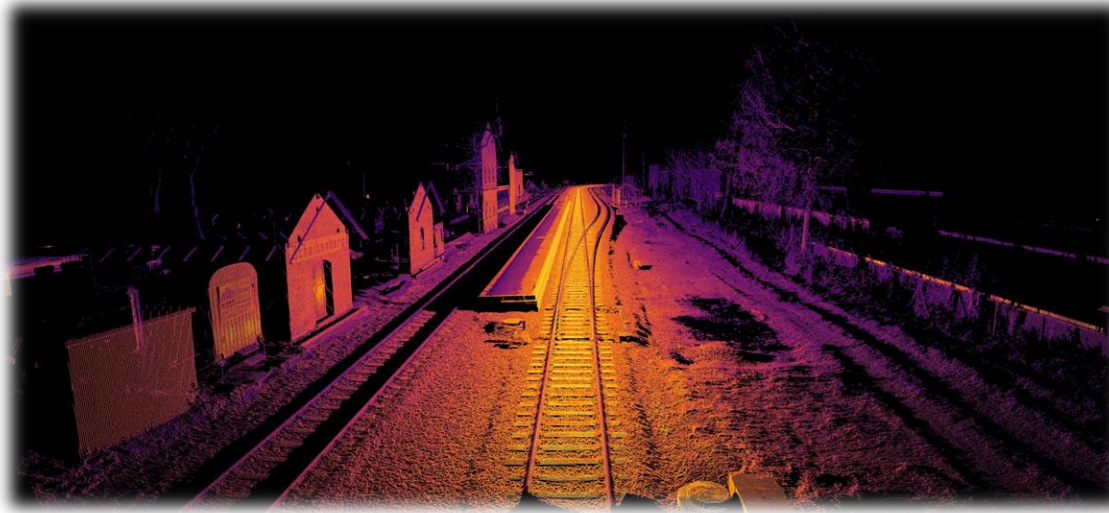
Manual Object Extraction



Implementation Framework



Use Case 1 - LiDAR Data → Object Detection



- POI-Type
- Switch
 - Balisegroup
 - Axlecounter
 - ETCS_Stopmarker
 - ETCS_Locationmarker
 - ETCS_Stopmarker_BS
 - Bufferstop
 - Levelcrossing
 - Platform
 - Bridge

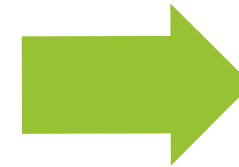
Input

- Point Cloud (.las)
- Images (.jpg)
- Planning Data (.xml)



Process

- Data Quality Check
- Object Detection
- AI Training



Output

- Identified Objects
- Locations
- Shapefiles



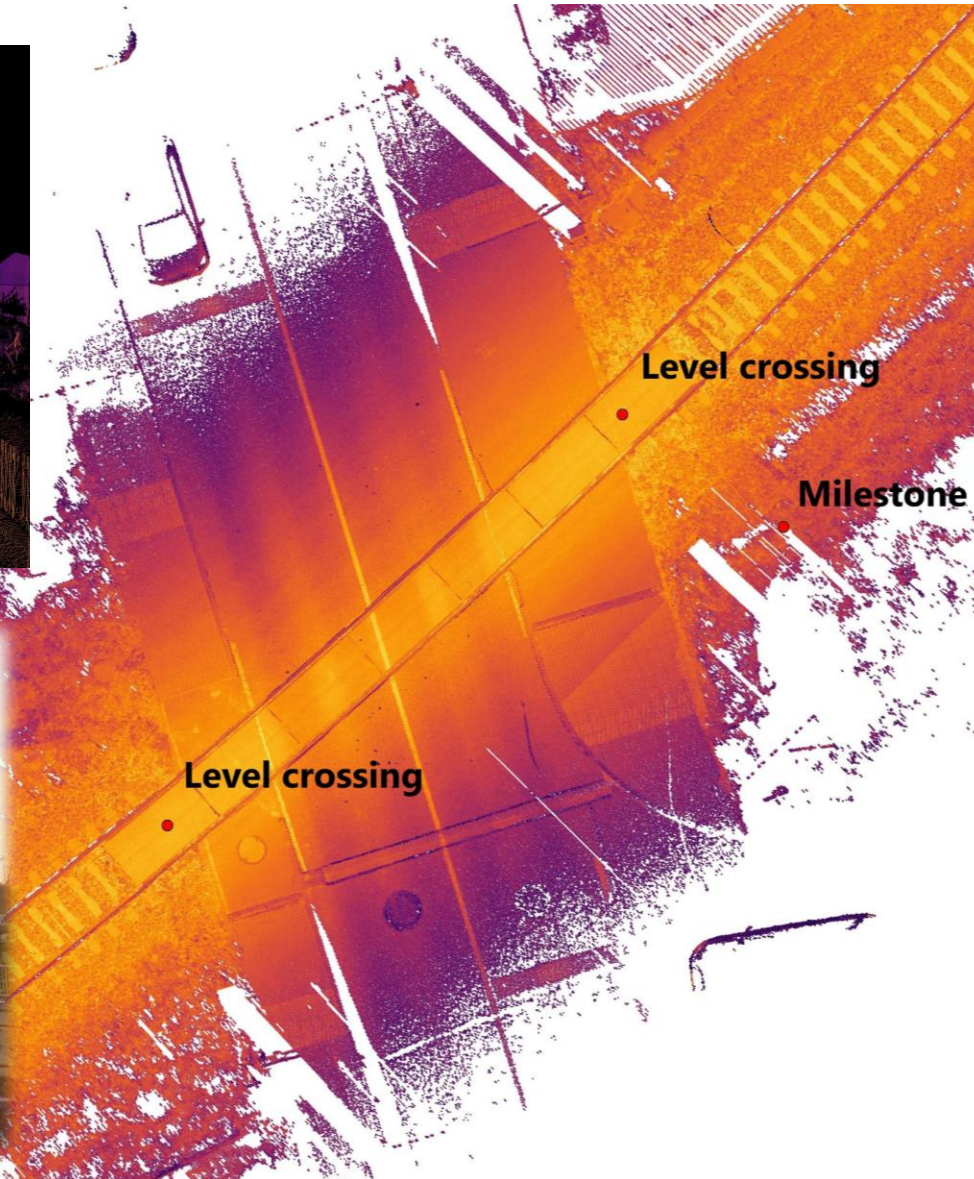
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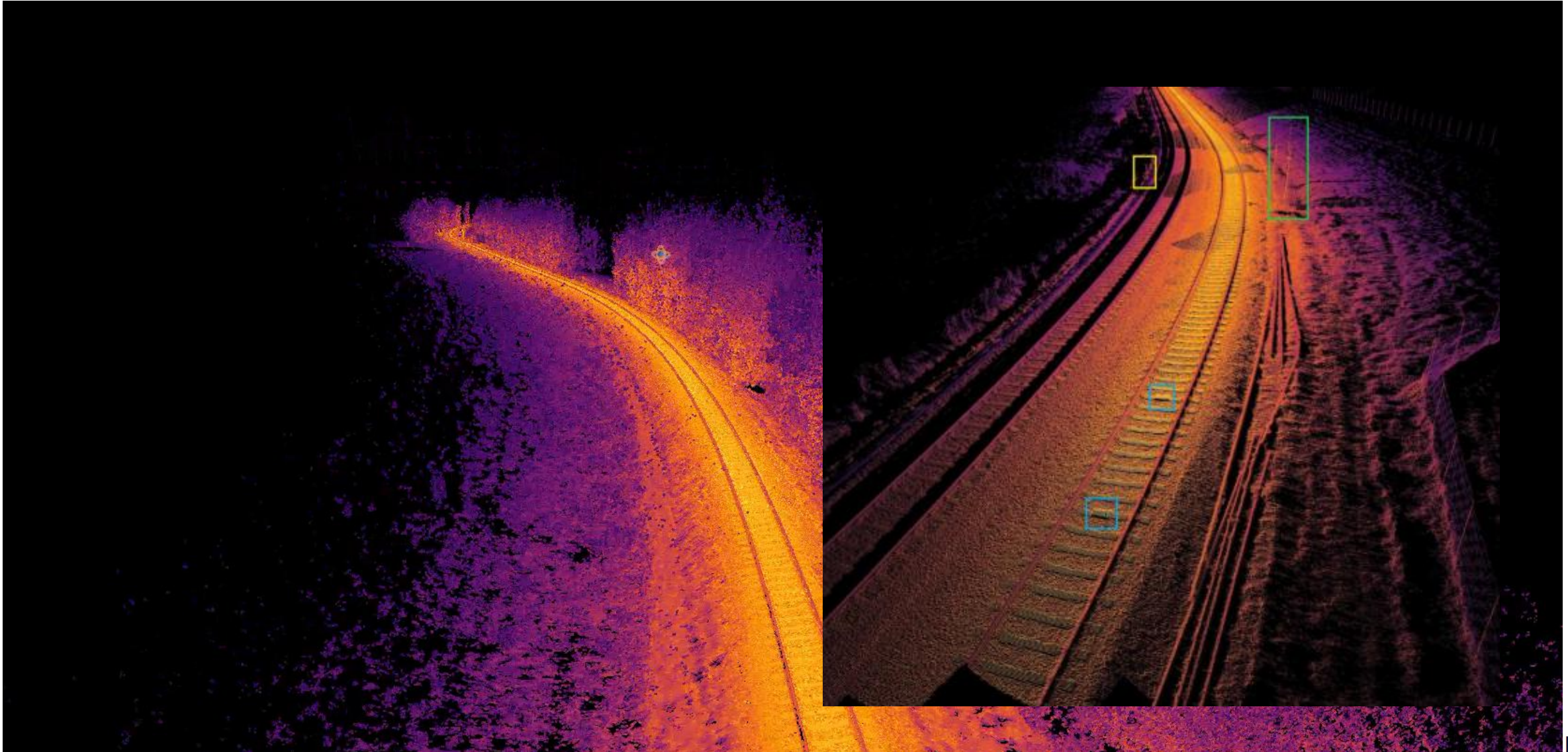
Level Crossing



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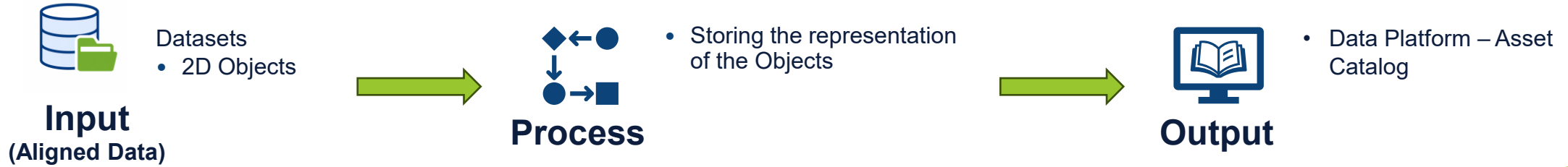


Data Platform and Digital Twins

Task 27 : 2022-2026

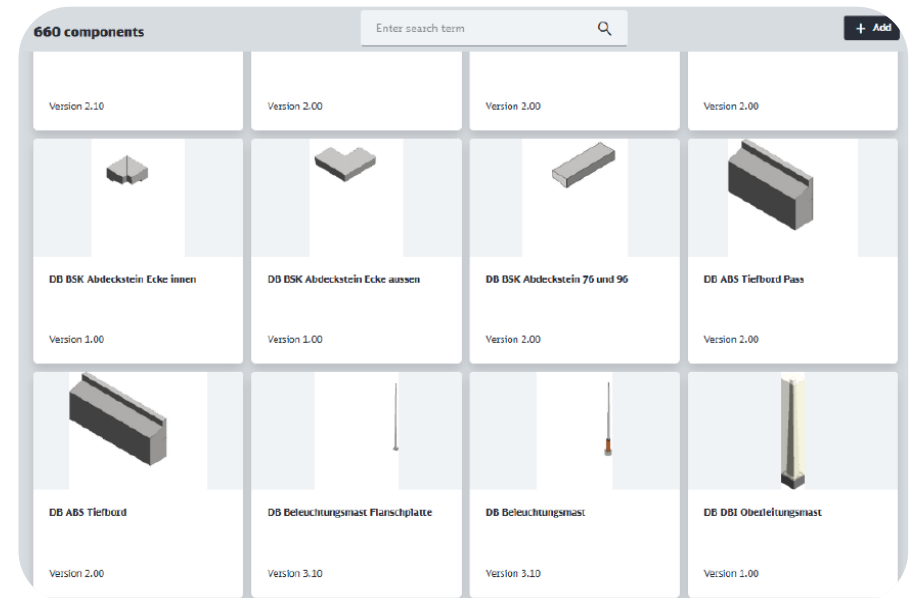
Stefanie S Werner, Rene Seeboth & Christian Stillger





Object library with 550+ components available in IFC and Revit format

DB InfraGO



Station 2 – Task 27.3, 4 DB - Station & Services
Demonstrate Data Platform.

🏠 Startseite

BIM-Content für Auftragnehmer

Die DB InfraGO AG nutzt die BIM-Methodik für die Standardisierung von Personenbahnhöfen. Dafür stellen wir dem Auftragnehmer verschiedene Unterlagen als Hilfsmittel für die Projektbearbeitung zur Verfügung.

BIM-Content Version



BIM-Content - 3.3

3.3 (aktuellste Version)

Die nachfolgend dargestellten Inhalte gelten in Verbindung mit den Vorgaben zur Anwendung der BIM-Methodik 3.3

Outcomes - Planning & Validation Tool

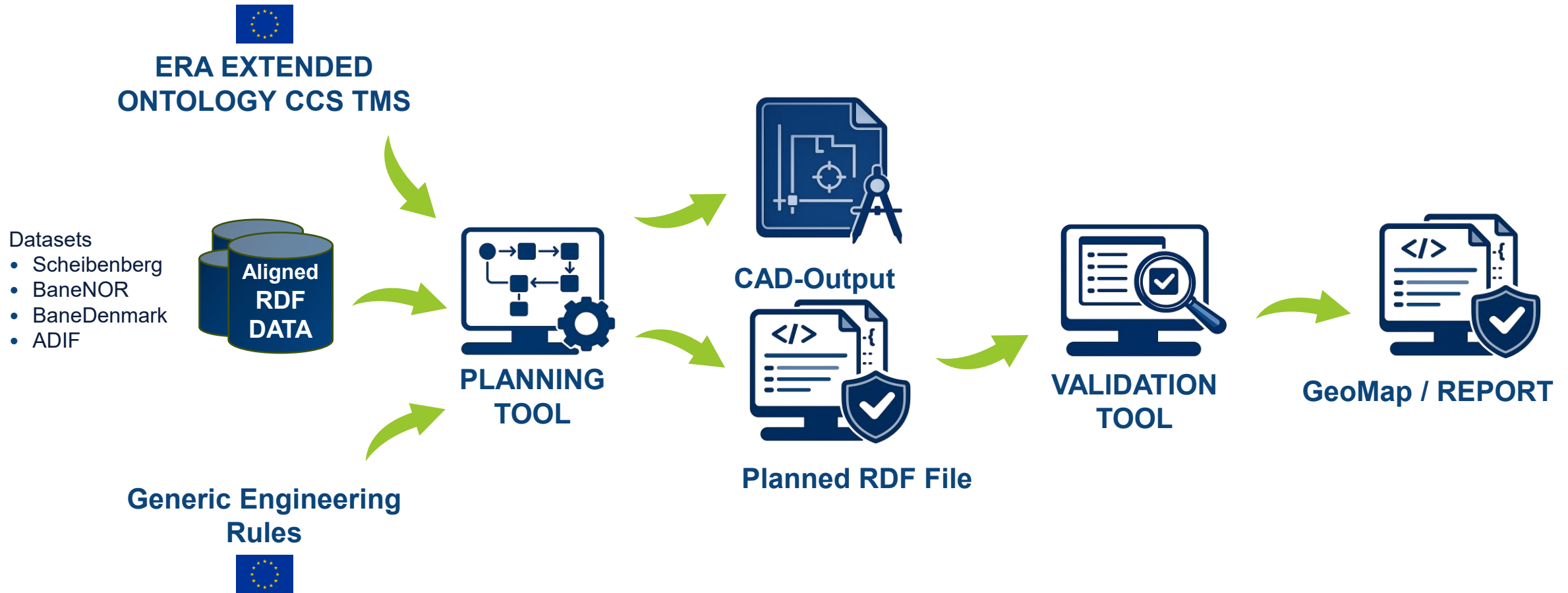


Task 27 : 2022-2026

Waseem ul Aslam Peer, Christian Mangold, Bernd Von Gimborn, Gabriel Naber



Use Case 3 - Data → Planned RDF Data



Planning Tool Video

Good morning and welcome to the presentation of the ERJU



Validation Tool Video



ERJU · WORK PACKAGE 27 · DEMONSTRATOR

ETCS Level 2 without Signals Validator Tool

Automated SHACL validation of railway planning data

EU · EUROPE'S RAIL · FP1 MOTIONAL

Co-funded by the European Union

MOTIONAL

Industrialized Tool for Schematic Design

Task 27 : 2022-2026

Ernesto Tenorio Dominguez

 INDRA



INDRA Industrialized Designing Tool — Overview



Schematic Design Tool

Rail infrastructures as 2D SVG diagrams — position and dimensions of each asset

Production-Grade

Industrialized and in use across real rail engineering projects

Multi-Format Export

Today's focus: the ERA CCS/TMS v1.3 JSON data model

Interoperability by Design

Bridges INDRA's internal model with the ERA Extended Ontology



1. Schema Import / Design

Start blank or import an existing schema
SVG canvas with topology & geometry



2. Visual Editing

Refine visual elements (+ data enrichment)
Interactive editing · optional ENG-domain data



3. Export to CCS/TMS JSON

ERA Extended Ontology v1.3 (INFRA + ENG)
Schema-ready output for ERA consumption

Task 27.3 / 27.5 · Digital Asset Engineering · INDRA
Industrialized export from TRD designs to the ERA CCS/TMS v1.3 data model

CCS/TMS JSON Export — Entities Covered



14 entities covered across INFRA + ENG domains

Switching & end-of-track

Switch · BufferStop · Derailer

Train detection

BaliseGroup · AxleCounter

ETCS markers

ETCS StopMarker
ETCS LocationMarker
ETCS StopMarker BS

Level crossings & platforms

LevelCrossing · Platform

Structures

Bridge · Tunnel

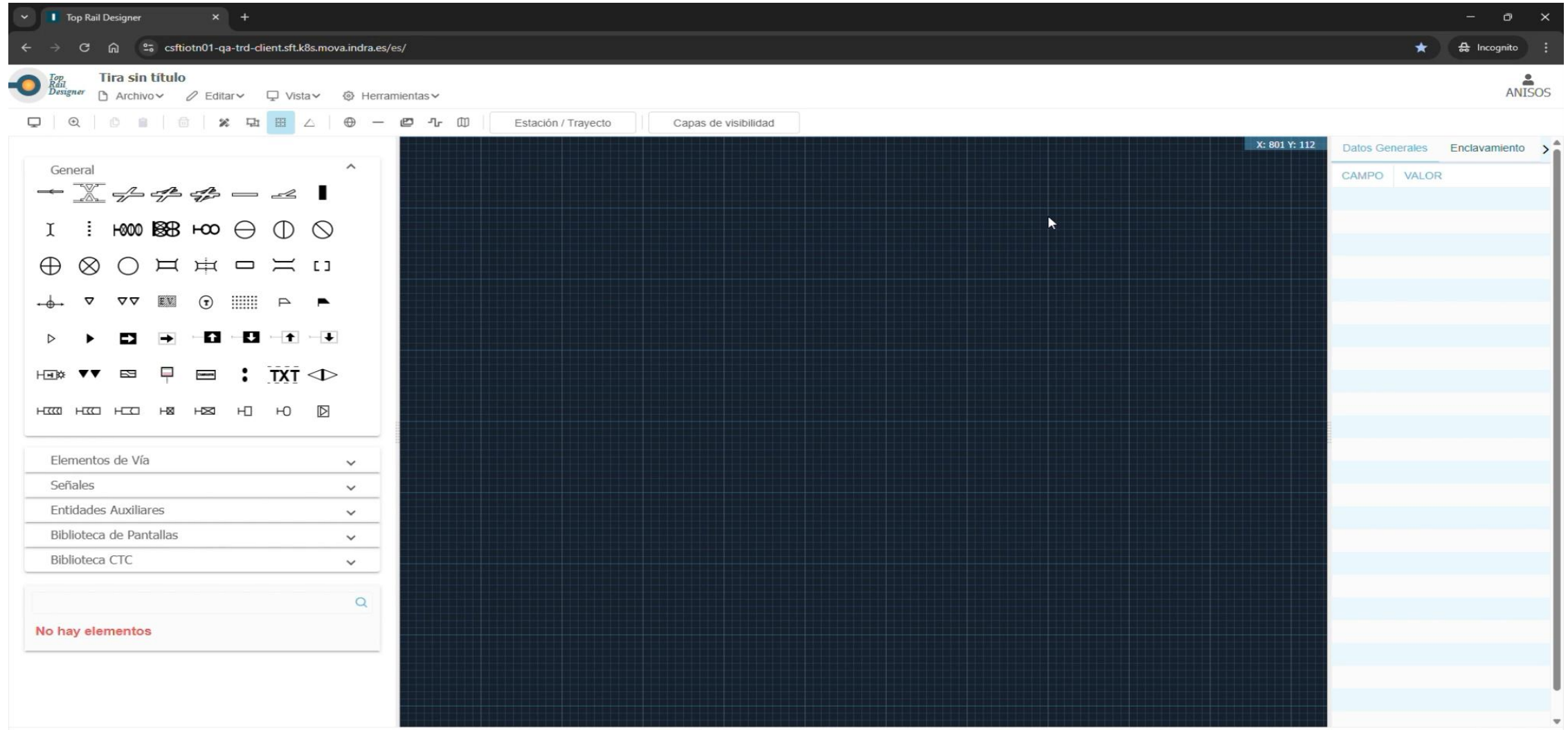
Safety engineering (ENG)

FoulingPoint · DangerPoint

- Topological relationships preserved — NetRelations graph + LinearElement references
- UUID-based cross-referencing across all exported entities

Task 27.3 / 27.5 · Digital Asset Engineering · INDRA
Export-ready · Schema-compliant · Interoperable across the rail CCS/TMS ecosystem

Video Demo of Export Feature



TRD — Sinoptic design view
Source of the industrialized export

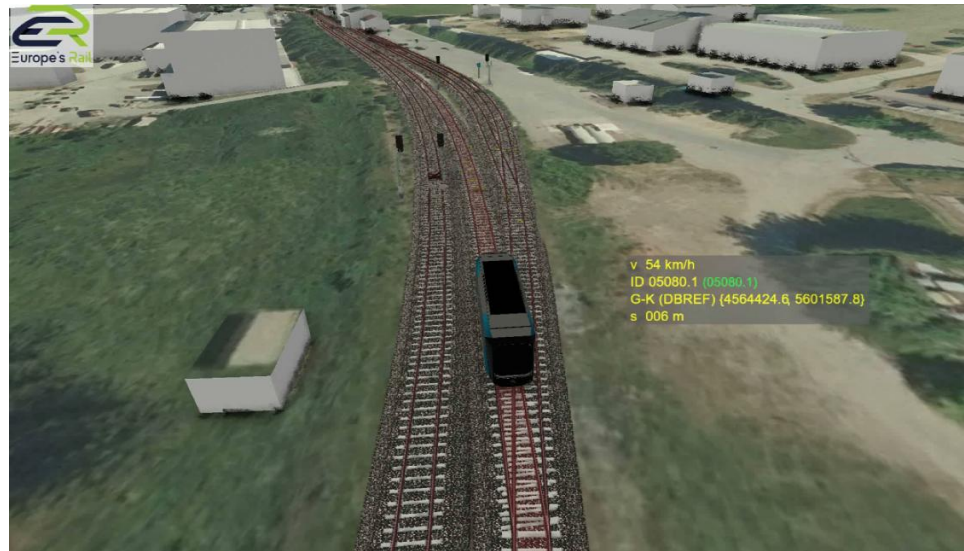
Exploitation of Digital Engineering Data for Digital Twins

Task 27 : 2022-2026

Andreas Heckmann, Julia Stadlmeier



- **Integrate Planning Data in Digital Twin**
 - Virtual Train driving along planned track
 - Visualization of dynamic scenarios
- **Check planned balises against reality**
 - Online Co-Simulation
 - Verify installation location
 - Detect broken balises



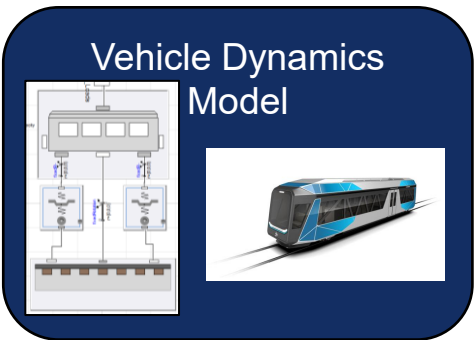
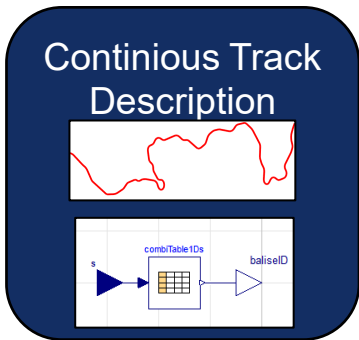
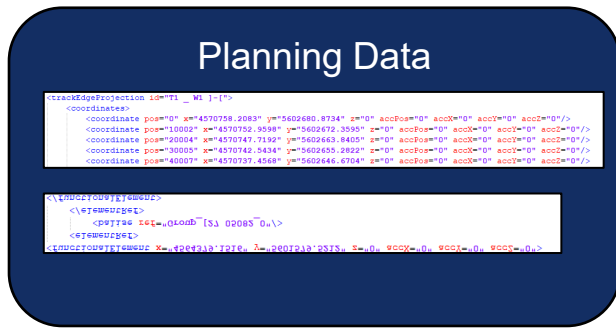
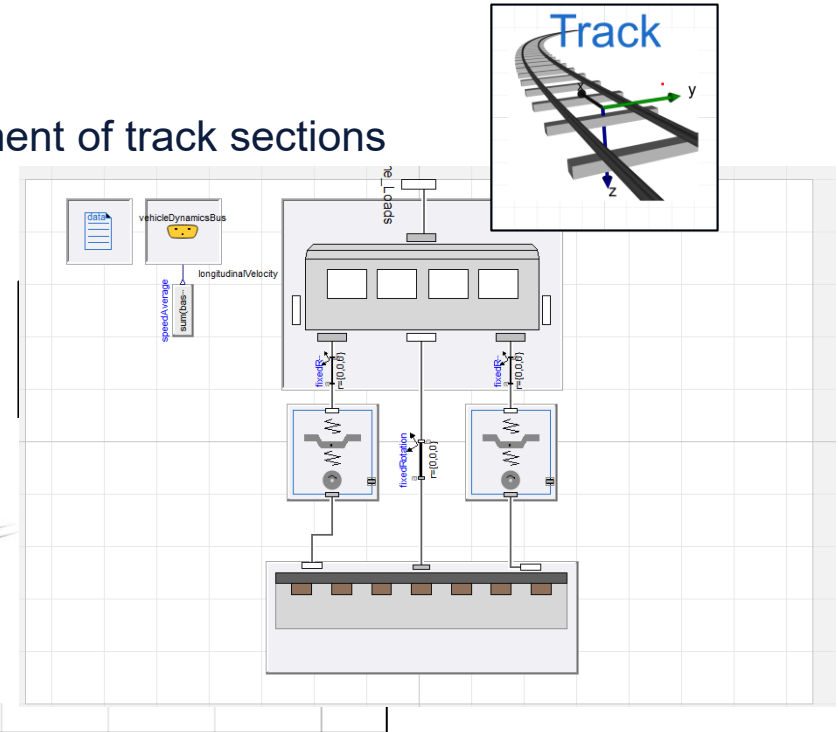
Track Data

- xml- file contains coordinate points in Gauß-Krüger System and arrangement of track sections
- Imported with Modelica
- Spline interpolation to create continuous track

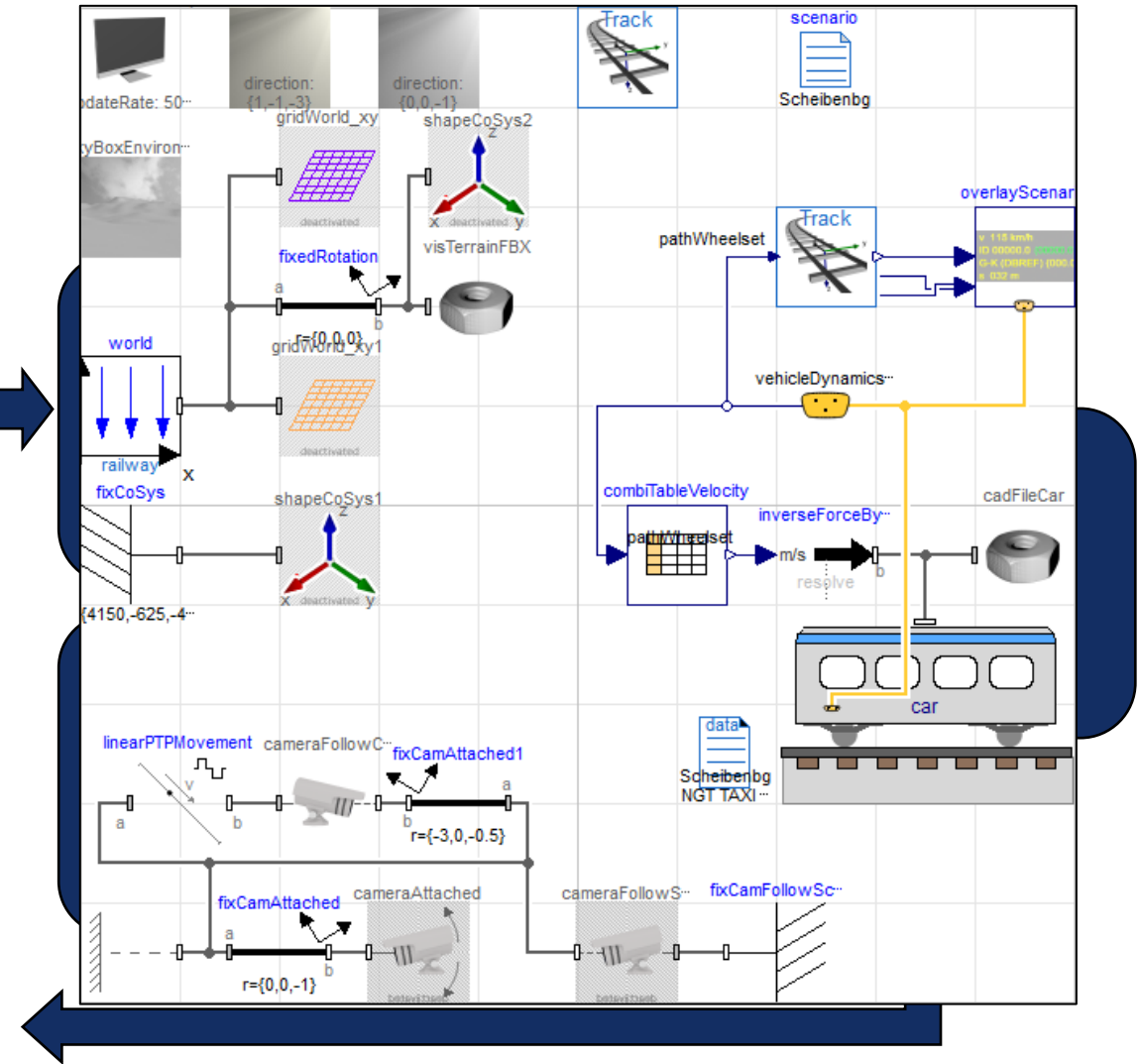
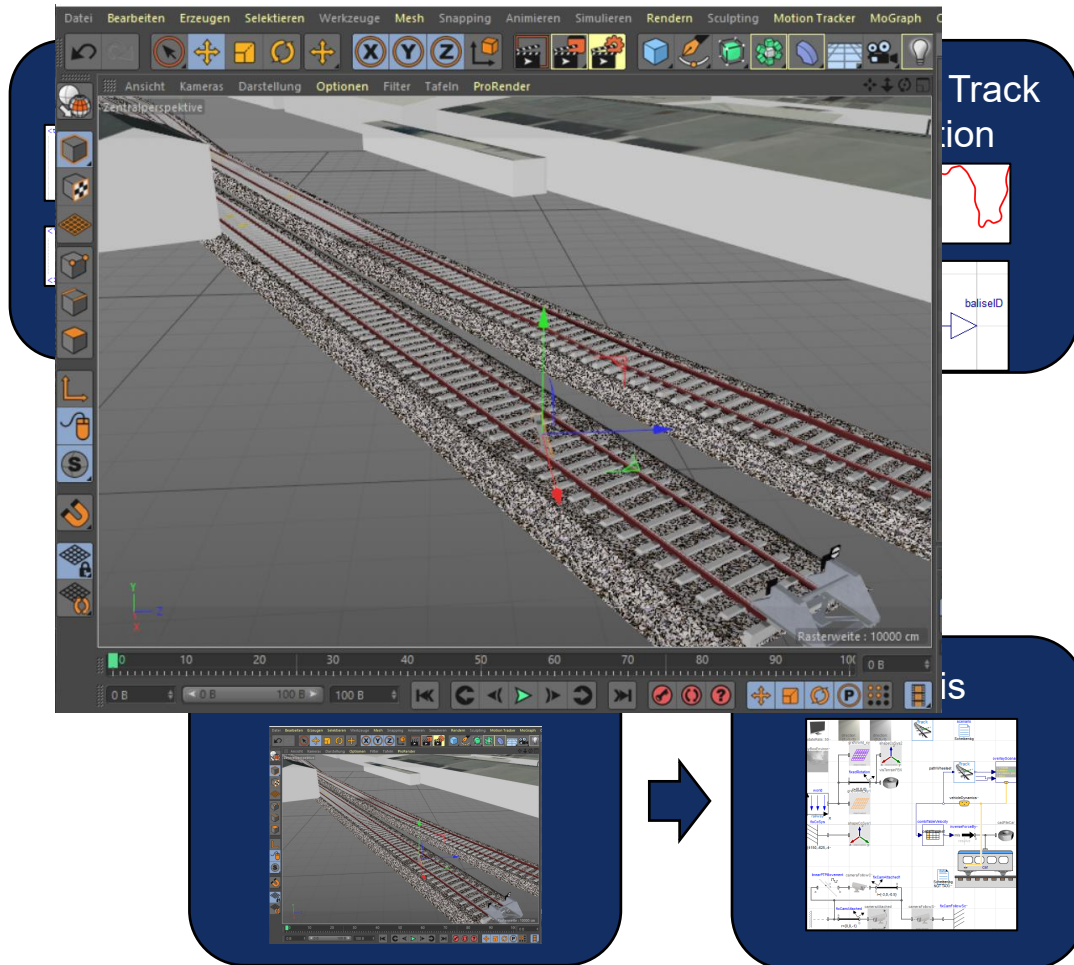
```
<trackEdgeProjection id="T1 _ W1 ]-[">
  <coordinates>
    <coordinate pos="0" x="4570758.2083" y="5602680.8734" z="0" accPos="0" accX="0" accY="0" accZ="0"/>
    <coordinate pos="10002" x="4570752.9598" y="5602672.3595" z="0" accPos="0" accX="0" accY="0" accZ="0"/>
    <coordinate pos="20004" x="4570747.7192" y="5602663.8405" z="0" accPos="0" accX="0" accY="0" accZ="0"/>
    <coordinate pos="30005" x="4570742.5434" y="5602655.2822" z="0" accPos="0" accX="0" accY="0" accZ="0"/>
    <coordinate pos="40007" x="4570737.4568" y="5602646.6704" z="0" accPos="0" accX="0" accY="0" accZ="0"/>
  </coordinates>
</trackEdgeProjection>
```

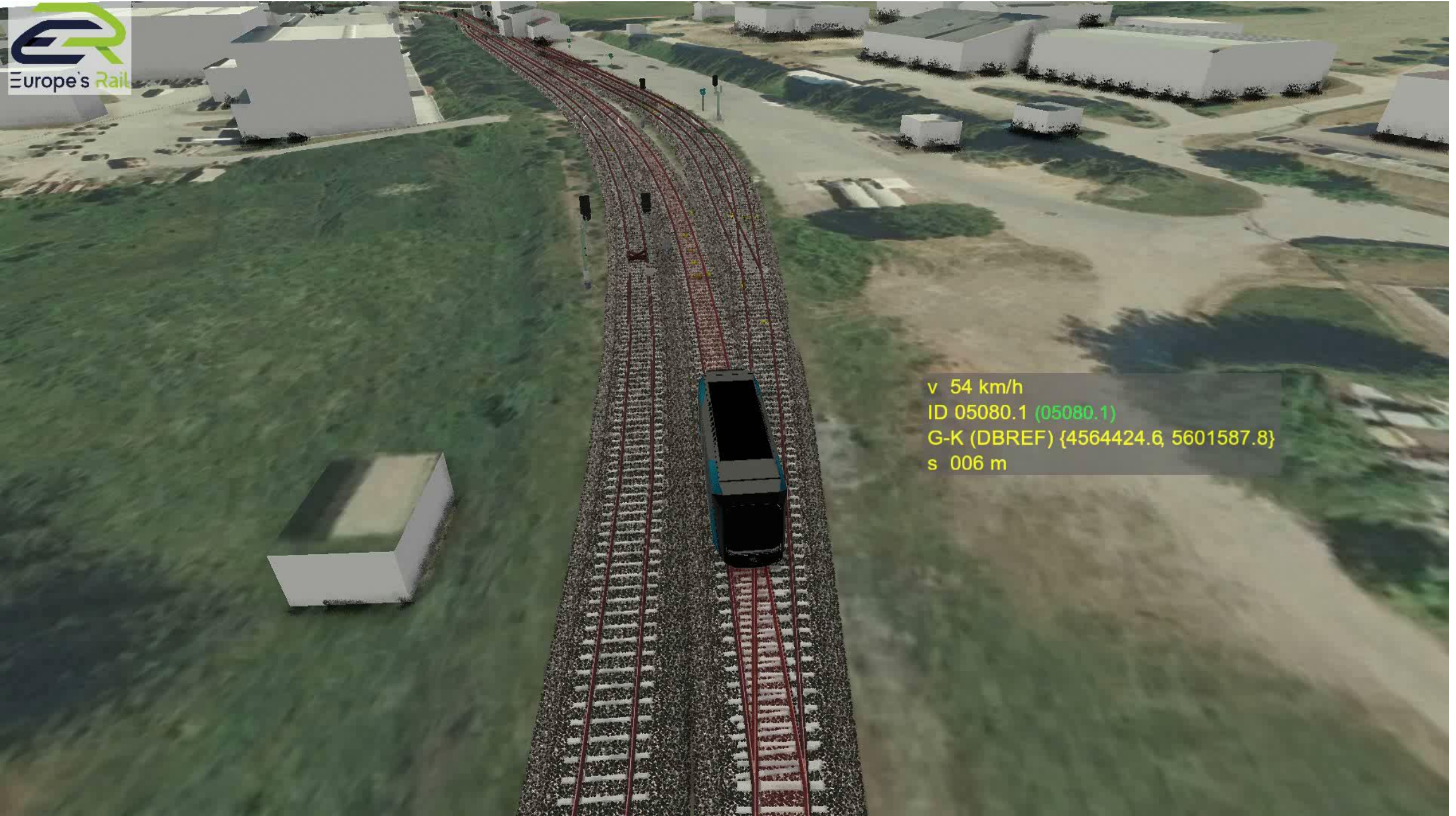
```
<functionalElement x="4564379.1516" y="5601579.5212" z="0" accX="0" accY="0" accZ="0">
  <elementRef>
    <balise ref="Group_[27 05082_0]"/>
  </elementRef>
</functionalElement>
```

BY-NC-ND 3.0



- Digital Terrain Model for surrounding area
- SimVis Library for visualization





v 54 km/h
ID 05080.1 (05080.1)
G-K (DBREF) {4564424.6, 5601587.8}
s 006 m

DIGITAL ASSET ENGINEERING

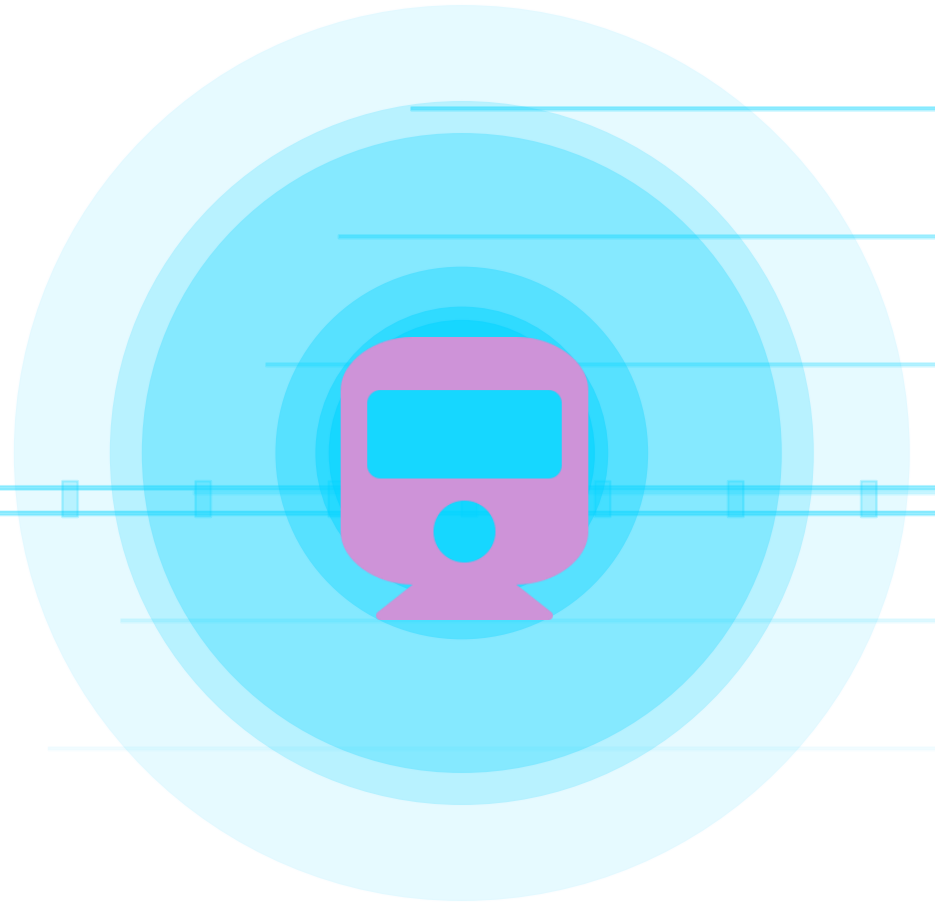
Integrating multiple data sources transforms raw data into a Digital Foundation for the future.



Flagship Project 1 MOTIONAL | 2026

Survey & Break

Please check the chat and answer the Survey
Back from Break at 11:05



Stations



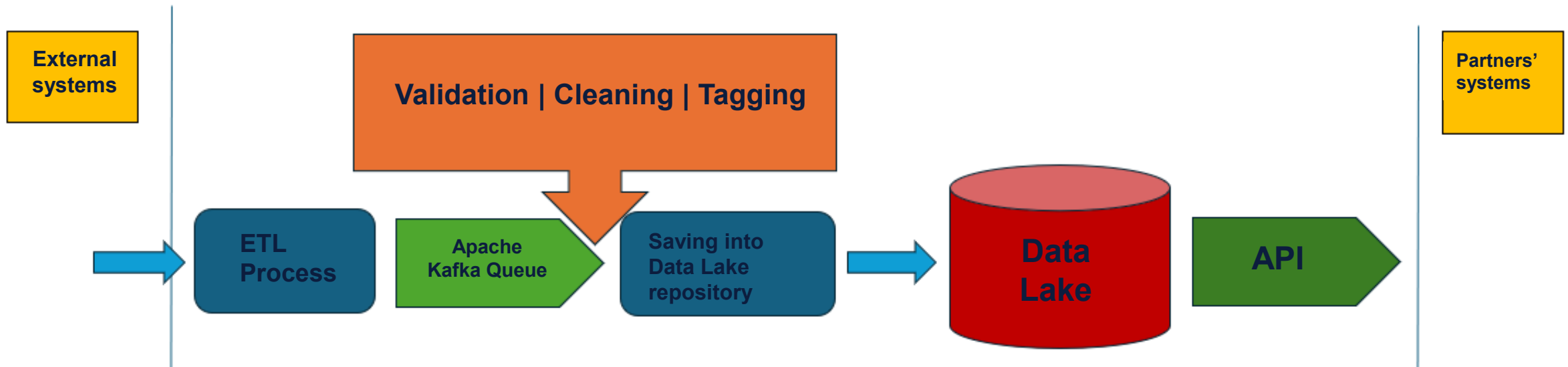
VIEW 2: STATIONS

How do we turn a fragmented station into a true multimodal hub?

Demo 21.3

POLSKIE KOLEJE PANSTWOWE SPOLKA AKCYJNA (PKP)
Web trip planner unifying rail, city transit & private services in Łódź. Includes B2B planner & real-time station dashboards.

The Data Processing Workflow in Data Lake



Central Data Platform — Why It Matters

(Business & risk overview)

Business benefits

- One trusted version of data — all teams work on consistent, up-to-date information
- Better and faster decisions — management, operations and maintenance see the same picture
- Lower integration costs — data is prepared once and reused many times
- Improved passenger services — reliable information across all channels
- Stronger analytics & planning — cross-domain insights that were not possible before

Security & risk

- The platform does NOT replace operational or safety-critical systems
- Critical railway systems remain isolated and independently secured
- The central platform works on controlled, read-only or replicated data
- Modern cybersecurity controls: access management, encryption, monitoring and auditing
- No single point of failure for operations — if the platform is unavailable, trains and core systems continue to run normally

Single point of truth without a single point of failure

For analytics and decision support — not for safety-critical real-time control.

Cluster Activity

Live Metrics

Unpaused DAGs

8

out of 13 total DAGs

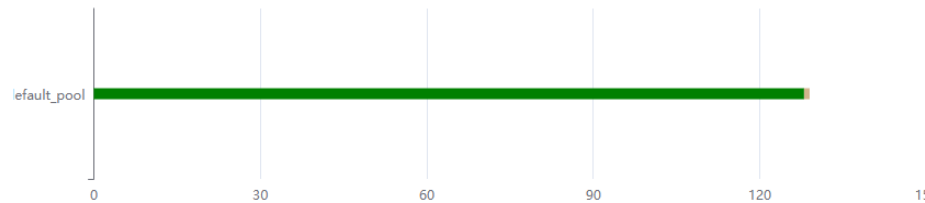
Top 5 longest Dag Runs to finish

DAG ID	RUN TYPE	DURATION
passengerflow	scheduled	66d23:32:05
train_two_stage_forec...	manual	10d22:31:25

out of 2 total running Dag Runs

Pools Slots

open queued running scheduled deferred



Health

MetaDatabase
status: HEALTHY

Scheduler
status: HEALTHY
last heartbeat: 2025-06-03, 15:35:22 CEST

Triggerer
status: UNKNOWN

Historical metrics

Start Date: 2025-06-02 16:35:06 End Date: 2025-06-03 16:35:06 for a period of 1d00:00:00

Clear Filters

Dag Run States

success failed queued running



on a total of 24

Dag Run Types

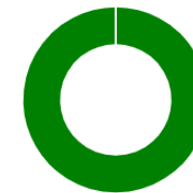
scheduled backfill datasetTriggered manual



on a total of 24

Task Instance States

success deferred failed noStatus queued removed 1/3



on a total of 28

DAG: train_shortterm_late_fusion_model Train hourly passenger flow forecasting model

Schedule: None Next Run ID: None

2025-06-03 15:37:43

All Run Types

All Run States

Clear Filters

Auto-refresh 25

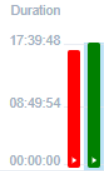
Press shift + / for Shortcuts

deferred failed queued removed restarting running scheduled shutdown skipped success up_for_reschedule up_for_retry upstream_failed no_status

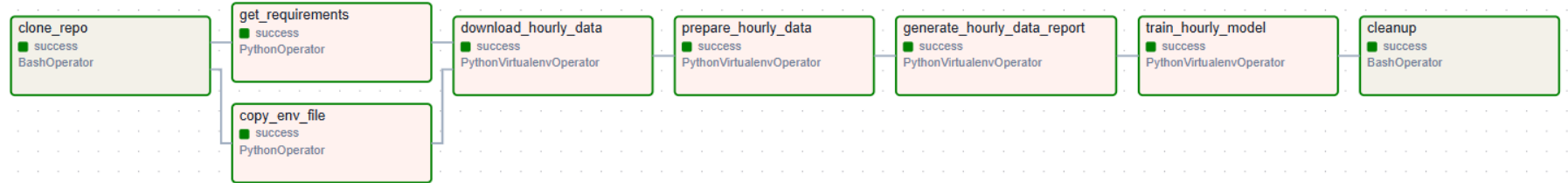
DAG Run
train_shortterm_late_fusion_model / 2025-05-27, 15:10:14 CEST

Clear Mark state as...

Details Graph Gantt Code Event Log

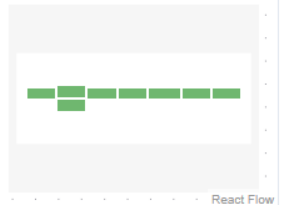


clone_repo	success
copy_env_file	success
get_requirements	success
download_hourly_data	success
prepare_hourly_data	success
generate_hourly_data_report	success
train_hourly_model	success
cleanup	success

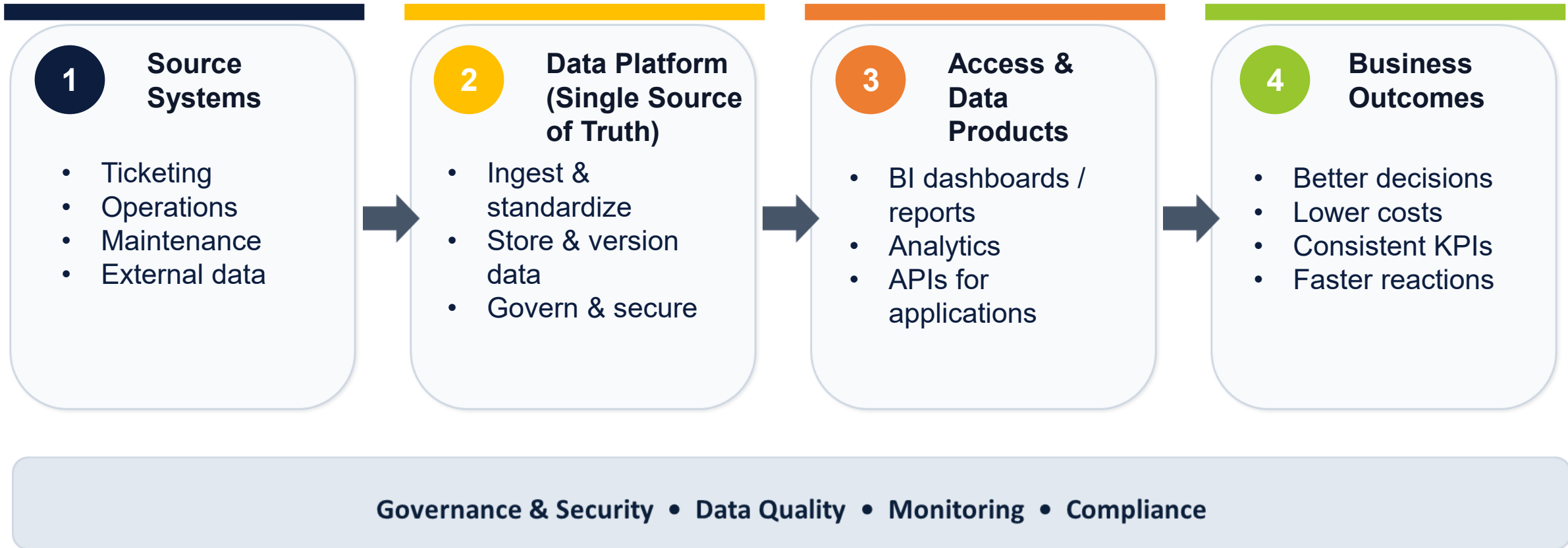


Layout: Left -> Right

+
-
🔄



Central Data Platform — Business view: from fragmented sources to trusted outcomes



Designed for analytics and decision support — not for safety-critical real-time control.

Data Lake Contents – Relations

Show SQL

Grid	stations	insert_at	A-Z timetable
1	[12]	2025-04-10 17:05:11.454	2022-2023
1.1	{"stationName": "Łódź Kaliska"		
1.2	stationId: "46706"		
1.3	"serviceType": "LKA"}		
1.4	{"stationName": "Łódź Żabieniec"		
1.5	stationId: "46789"		
1.6	"serviceType": "LKA"}		
1.7	{"stationName": "Łódź Radogoszcz Zach."}		
1.8	stationId: "251556"		
1.9	"serviceType": "LKA"}		
1.10	{"stationName": "Zgierz"		
1.11	stationId: "46805"		
1.12	"serviceType": "LKA"}		
2	[27]	2025-04-10 17:05:11.455	2022-2023
2.1	{"stationName": "Łowicz Gł."}		
2.2	stationId: "32904"		
2.3	"serviceType": "BUS"}		
2.4	{"stationName": "Łowicz Przedmieście"		
2.5	stationId: "33050"		
2.6	"serviceType": "BUS"}		
2.7	{"stationName": "Grudze"		
2.8	stationId: "46888"		
2.9	"serviceType": "BUS"}		

Data Lake content – passenger flow

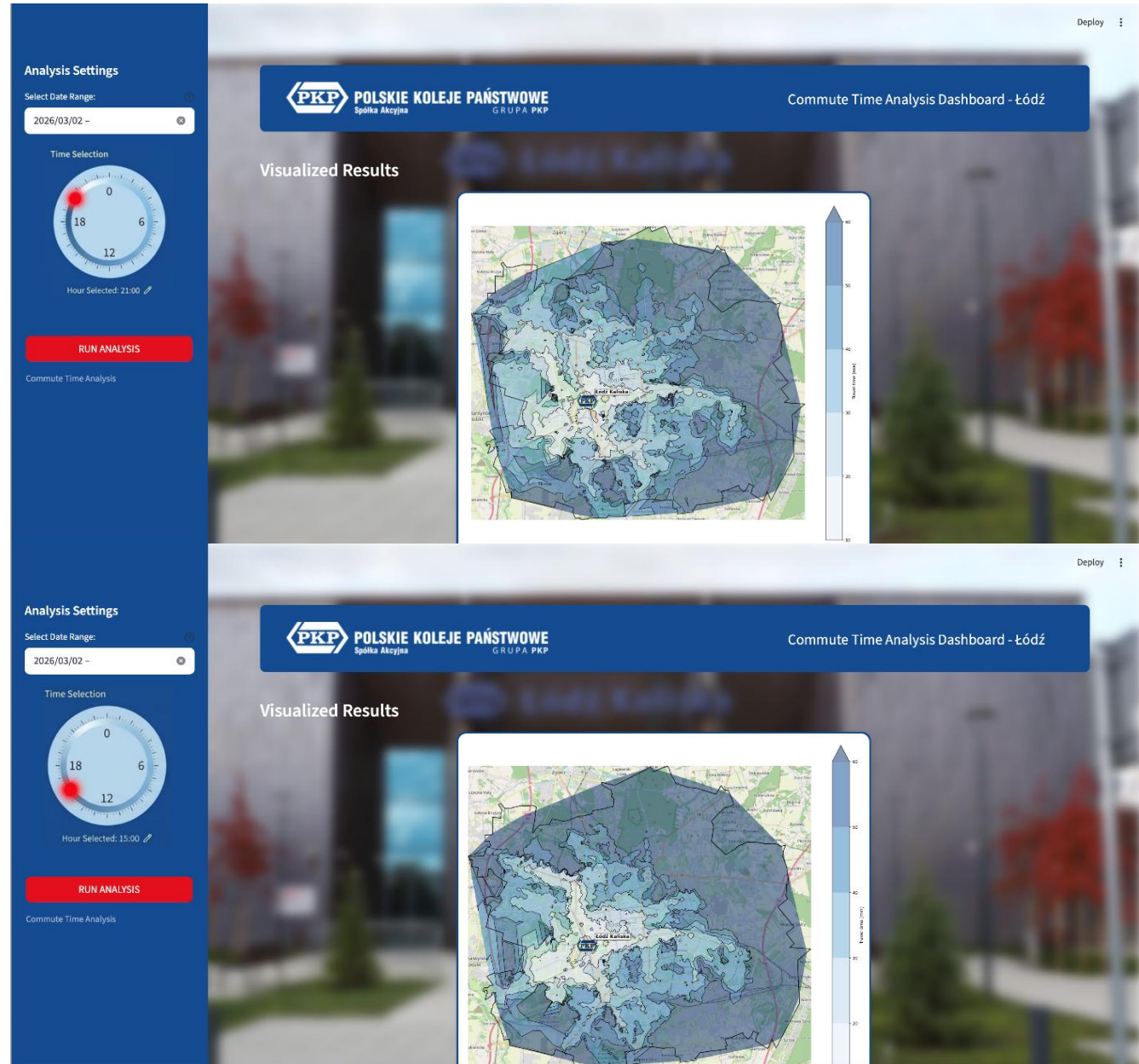
select * from passengerflow p limit 200 | Enter a SQL expression to filter results (use Ctrl+Space)

Grid	A-Z id	key	passengerflow	insert_at	A-Z number
▶ 1	c7c2600b65244944af6b864e71d4f5a2	▶ [{"operator":"LKA","vehicleName":"36WEd-008","c	▶ {"stationNo":1 [+29]	2025-03-15 20:28:07.690	0/0
▶ 2	eb31a0da67394295a9703a0fc7254cdd	▶ [{"operator":"LKA","vehicleName":"36WEd-009","c	▶ {"stationNo":1 [+35]	2025-03-15 20:28:07.820	0/0
▶ 3	29e68f38c52d4498b2f4ca8ad930664b	▶ [{"operator":"LKA","vehicleName":"36WEd-001","c	▶ {"stationNo":1 [+23]	2025-03-15 20:28:07.695	0/0
▶ 4	38cc93337b234cb68bafab45802a905d	▶ [{"operator":"LKA","vehicleName":"36WEd-003","c	▶ {"stationNo":1 [+17]	2025-03-15 20:28:07.664	0/0
▶ 5	0b2516d9399b4528b9a3df07dfb5347b	▶ [{"operator":"LKA","vehicleName":"36WEd-001","c	▶ {"stationNo":1 [+11]	2025-03-15 17:18:39.635	0/0
▶ 6	00c3fa9d514f4b238c4535baaa1906b5	▶ [{"operator":"LKA","vehicleName":"36WEd-007","c	▶ {"stationNo":1 [+11]	2025-03-15 17:18:39.075	0/0
▶ 7	405dfe6ded8a4a9cb7bc7530620a4b76	▶ [{"operator":"LKA","vehicleName":"36WEd-009","c	▶ {"stationNo":1 [+47]	2025-03-15 17:18:39.879	0/0
▶ 8	09a9a9d37f3d47c6a71cc98c81c998b1	▶ [{"operator":"LKA","vehicleName":"36WEd-006","c	▶ {"stationNo":1 [+11]	2025-03-15 19:44:57.870	0/0
▶ 9	750a9eae8834421e86c57e6f42e2c8c2	▶ [{"operator":"LKA","vehicleName":"36WEd-010","c	▶ {"stationNo":1 [+11]	2025-03-15 19:44:57.341	0/0
▶ 10	82ba8701e73c4c5fa6ba8b23c4b59fe4	▶ [{"operator":"LKA","vehicleName":"36WEd-007","c	▶ {"stationNo":1 [+35]	2025-03-15 10:02:02.062	0/0
▶ 11	6de05795e9bc4a8c9c1ca8aac99f4218	▶ [{"operator":"LKA","vehicleName":"36WEd-003","c	▶ {"stationNo":1 [+11]	2025-03-15 10:02:02.159	0/0
▶ 12	495d7ea6291c47f29e0a9c2c7d038052	▶ [{"operator":"LKA","vehicleName":"36WEd-009","c	▶ {"stationNo":1 [+41]	2025-03-15 02:02:25.289	0/0
▶ 13	0b80f6ba3af347f7b22063b5b3c53c2c	▶ [{"operator":"LKA","vehicleName":"L4268-016","d	▶ {"stationNo":1 [+53]	2025-03-14 18:06:25.085	0/0
▶ 14	dcfc54ead6f54cf8ba71d35d901a3aeb	▶ [{"operator":"LKA","vehicleName":"L4268-019","d	▶ {"stationNo":1 [+107]	2025-03-14 18:06:25.388	0/0
▶ 15	166d68aabc59401cb8521f1541eee221	▶ [{"operator":"LKA","vehicleName":"L4268-019","d	▶ {"stationNo":1 [+53]	2025-03-14 18:06:26.022	0/0
▶ 16	dc99a98d313d4bfd91b8481aee8b0bbf	▶ [{"operator":"LKA","vehicleName":"L4268-019","d	▶ {"stationNo":1 [+41]	2025-03-14 18:06:26.280	0/0
▶ 17	c3121bcee64e49d1826f495ca5faaa3d	▶ [{"operator":"LKA","vehicleName":"L4268-019","d	▶ {"stationNo":1 [+101]	2025-03-14 18:06:25.482	0/0
▶ 18	52c8ce72892c4322acdc9d2a814a3541	▶ [{"operator":"LKA","vehicleName":"L4268-019","d	▶ {"stationNo":1 [+89]	2025-03-14 18:06:25.307	0/0
▶ 19	f302e3b6414f456f96807a9df06a3042	▶ [{"operator":"LKA","vehicleName":"L4268-019","d	▶ {"stationNo":1 [+107]	2025-03-14 18:06:25.705	0/0
▶ 20	b171208787c3464998e7b7383a3097de	▶ [{"operator":"LKA","vehicleName":"L4268-019","d	▶ {"stationNo":1 [+95]	2025-03-14 18:06:25.921	0/0
▶ 21	c218b6d4b2c94f2c91c48eece2178c2	▶ [{"operator":"LKA","vehicleName":"36WEd-006","c	▶ {"stationNo":1 [+23]	2025-03-15 05:09:03.402	0/0

Multimodal time travel dashboard

Provides the operator with a comprehensive analysis of:

- Journey times to all parts of the city at selected times
- Comparison of timetable data and actual journey times
- The attractiveness of rail services in combination with other public transport connections



Stations



VIEW 2: STATIONS

How do we turn a fragmented station into a true multimodal hub?

Demo 25.1.2

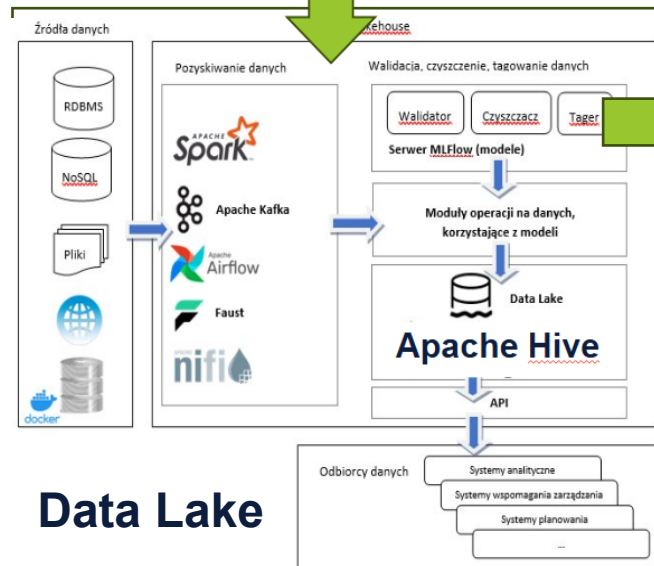
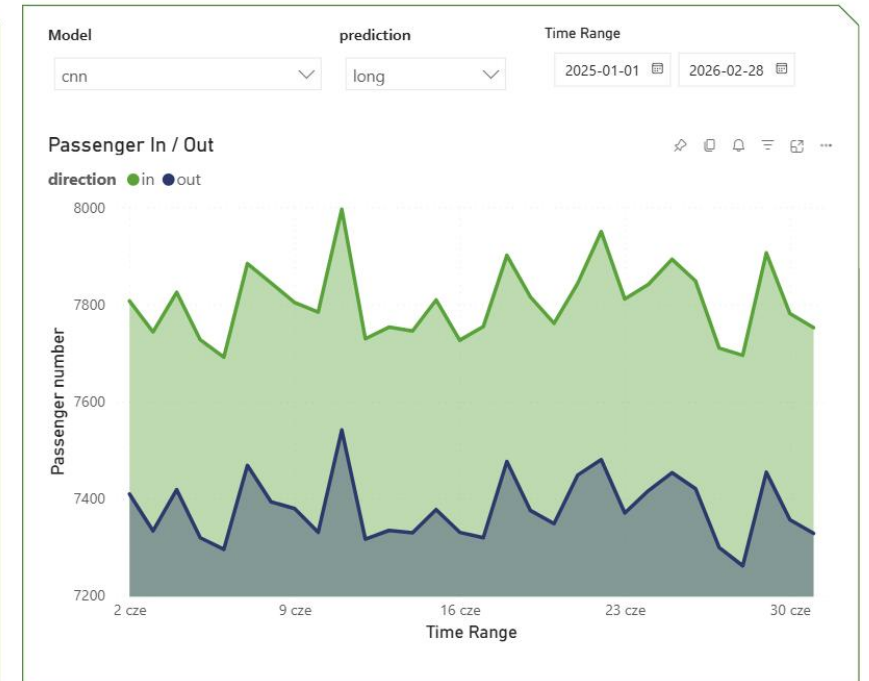
POLSKIE KOLEJE PANSTWOWE SPOLKA AKCYJNA (PKP)
Load estimation & prognosis for transport management — data-driven capacity decisions via a centralised Data Lake.

- External data**
- Transport relations
 - Passenger flow
 - Timetable
 - Weather forecast data
 - Disruptions

Prediction of passenger flow

Relation

Station No	Station name
1	Sieradz
2	Sieradz Warta
3	Sieradz Męka
4	Męcka Wola
5	Izabelów
5	Zduńska Wola
6	Borszewice
6	Zduńska Wola
7	Borszewice
7	Łask
8	Kolumna

Data Lake

Station

Operator

Aleksandrów Kujawski

LKA



Passenger flow

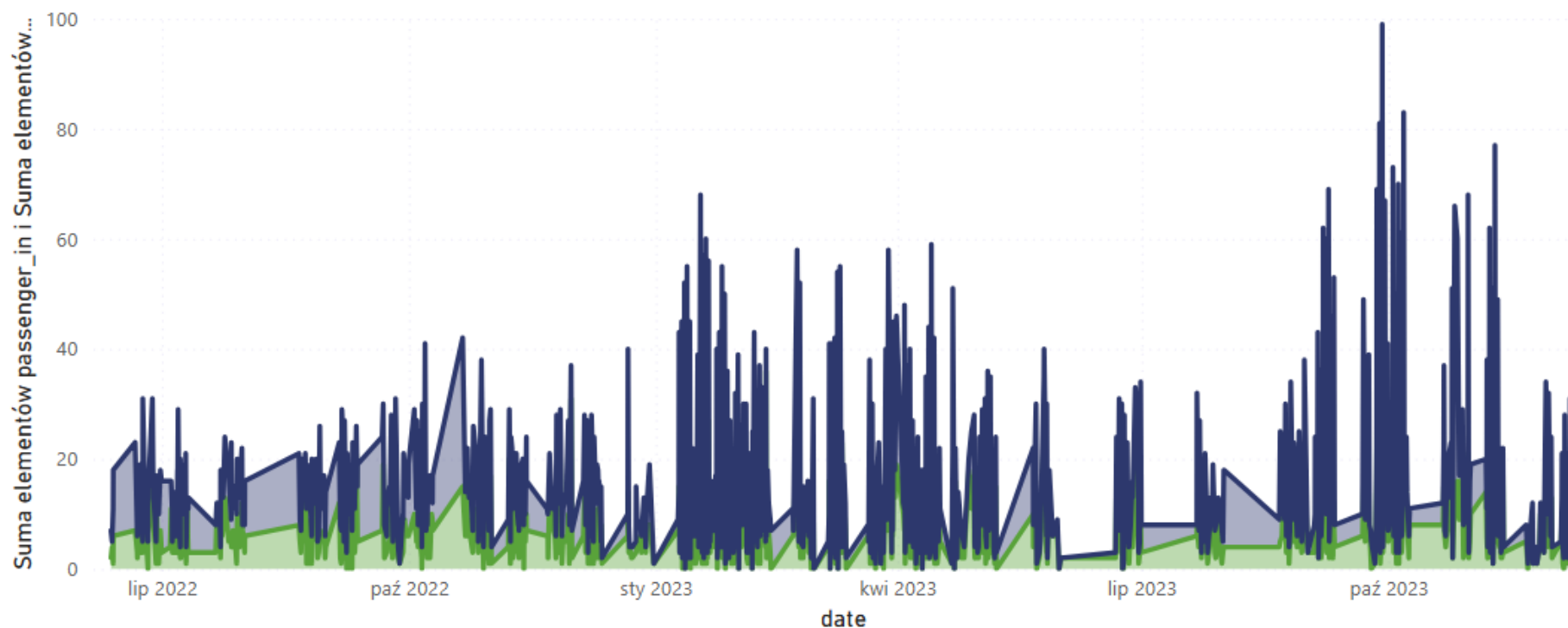
Time Range

2024-12-28

2024-12-31



● Suma elementów passenger_in ● Suma elementów passenger_out



IN MAX

36,0

IN AVG

7,31

IN MIN

0

OUT MAX

71,0

OUT AVG

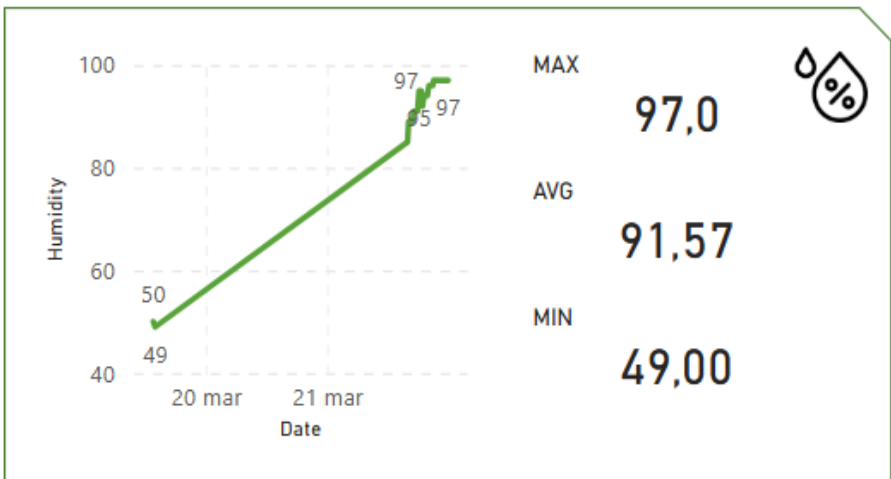
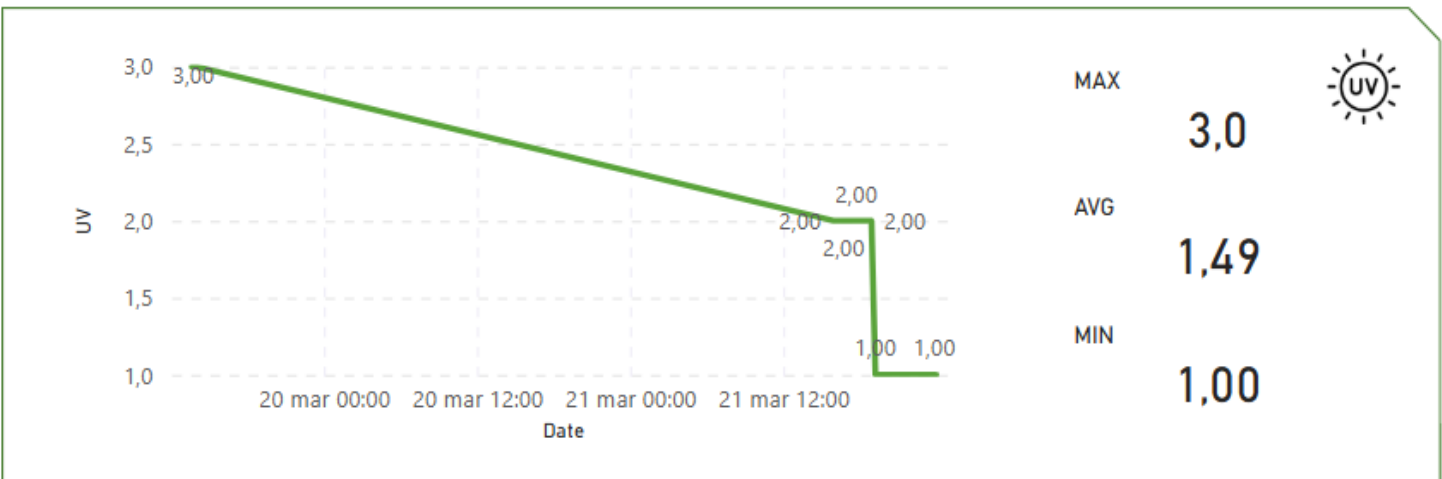
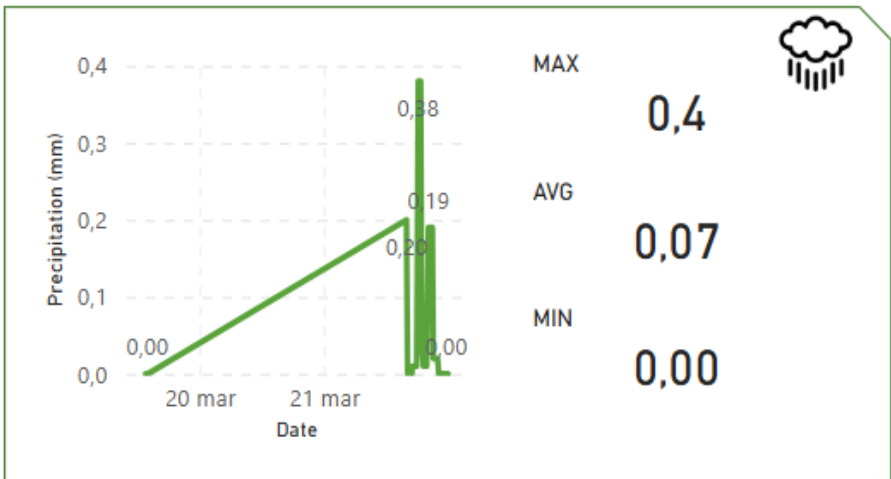
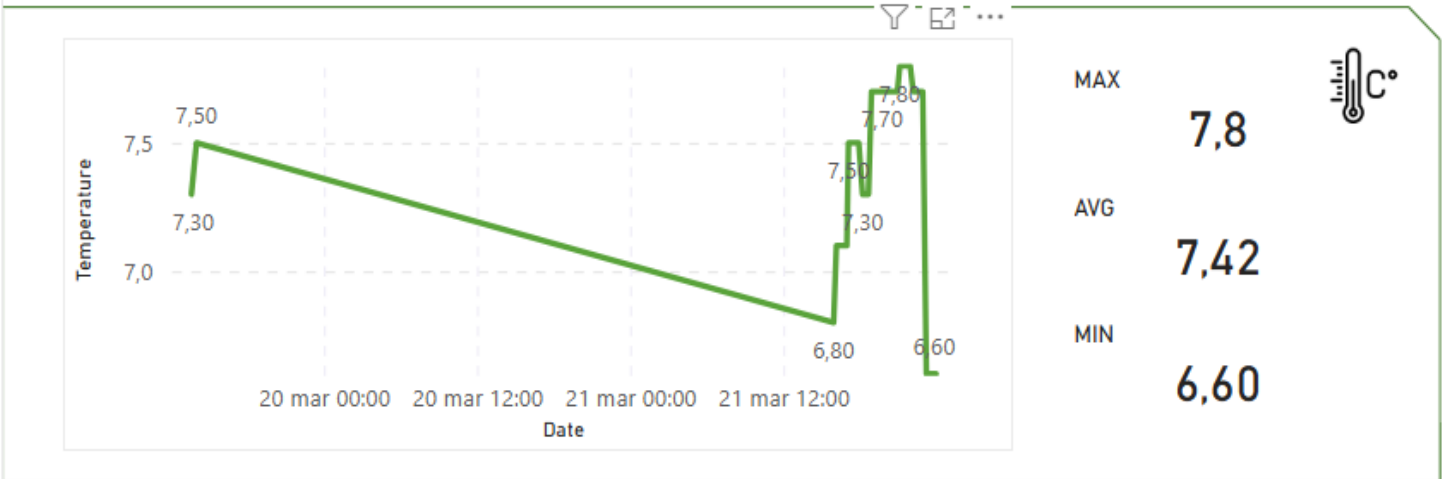
8,53

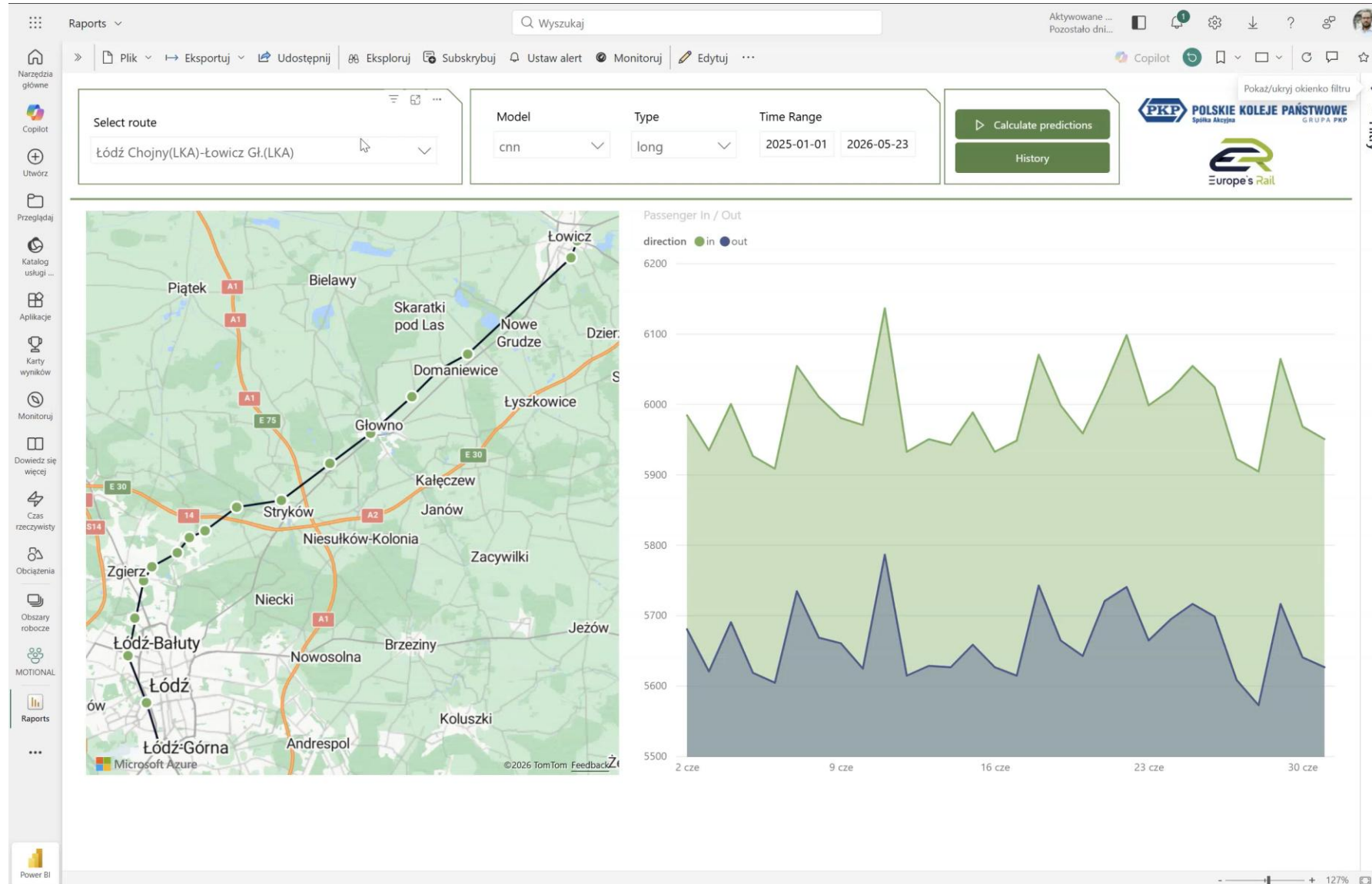
OUT MIN

0

Station: Aleksandrów Kujawski

Time Range: 2024-03-19 to 2024-03-21

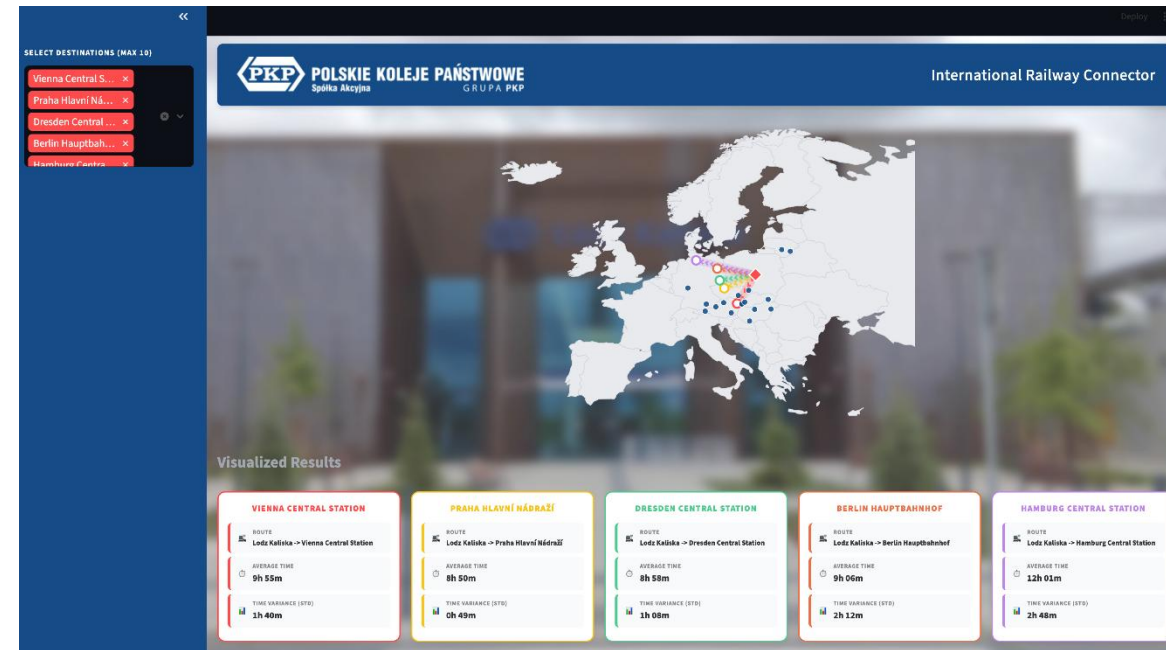




Cross-border travel dashboard

Provides the operator with a comprehensive:

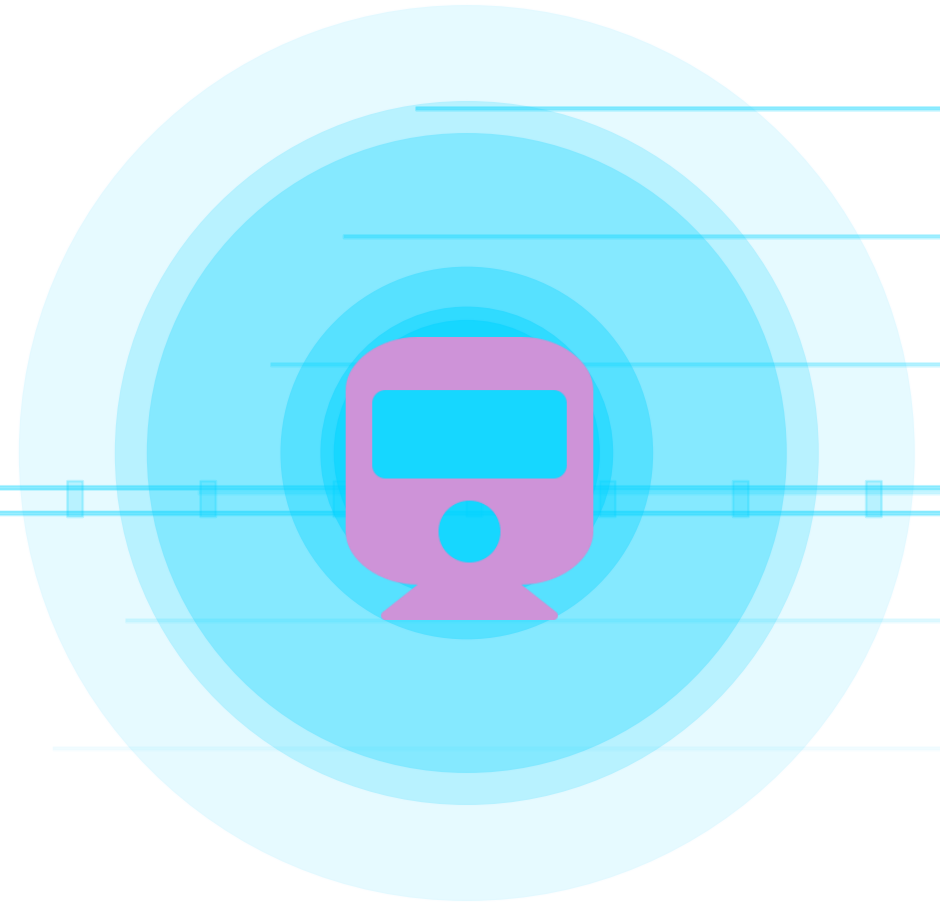
- Overview of connections from a selected station to neighbouring countries
- An overview of statistics for connections selected by the operator
- Comparison of journey parameters between selected countries



Flagship Project 1 MOTIONAL | 2026

Coffee Break

10 minutes - Please be back at 11:15



Flagship Project 1:

Mobility Management in a multimodal environment & digital enablers

Digital Twin Overview

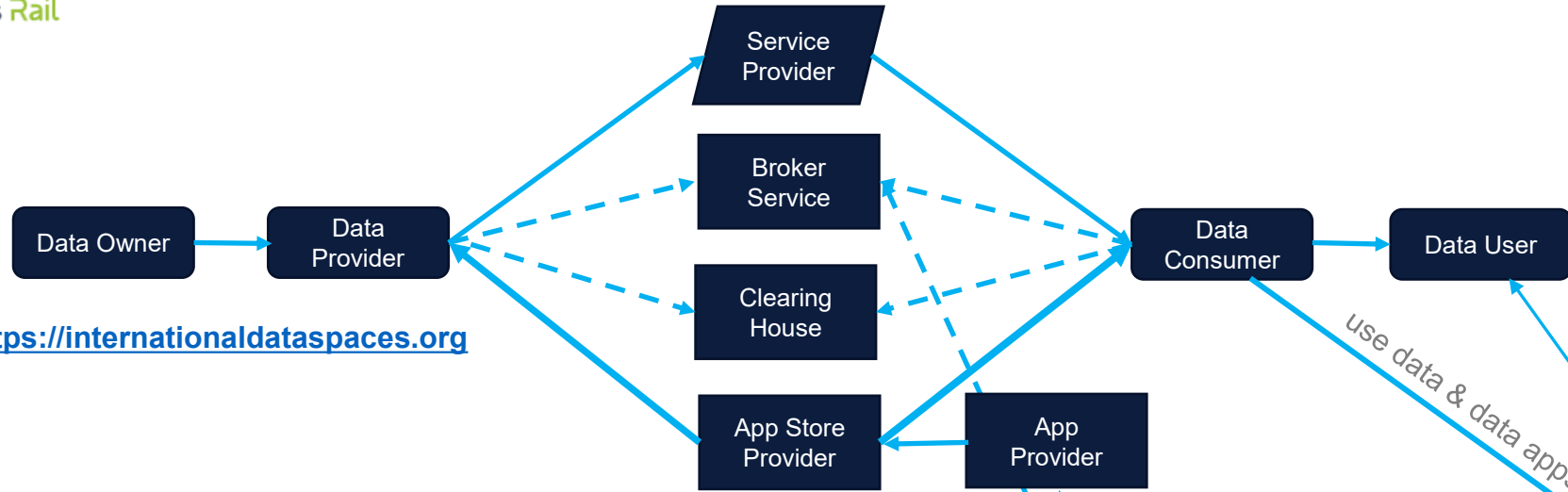
Modularized Digital Twins for Rail

WP 28 & 29: 2022-2026

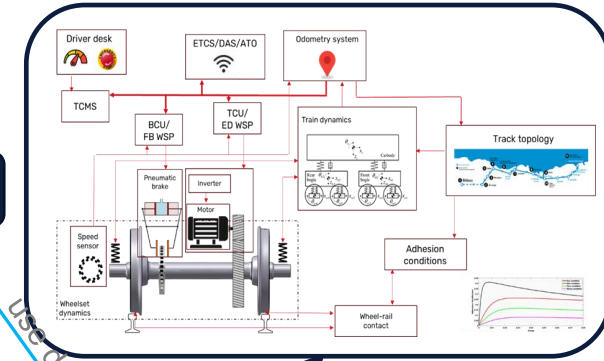
A. Heckmann¹ et al.

¹German Aerospace Center (DLR), Institute of Vehicle Concepts

The Digital Twin: conceptual view



cp. <https://internationaldataspaces.org>



fmi Functional Mock-Up Interface

cp. <https://fmi-standard.org/>

Proprietary instances

Proprietary instances

cp. Vehicle Interface Library 2006
Railway Dynamics Library 2019

DT runtime environment

- On-premises e.g. Matlab, OpenModelica..
- Cloud / SaaS e.g. AVL Model.Connect DLR Multi-Agent-Simulator, ..
- On-the-edge / embedded e.g. sensor data aggregation in the vehicle, IoT

Europe's Rail
GitLab

DT support environment repository with minimal models (FMUs)

vehicle dynamics, friction brakes, power train

DT design time environment library with minimal FMU assemblies, exemplary algorithms, test data



Use case name	Technical Criteria	Strategic Criteria	Interactions
ERTMS DT	HIL-environment in operation, high complexity	CCS	FP2 WP 22, 34/35 FP6 WP7
Pre-assessment of ATO Set-ups	Extension to ERTMS DT Open simulation environment	ATO up to GoA4	FP2 WP 5-11
DT on Graph Database	Graph database	Maintenance optimization	FP3 WP7
Braking/Traction DT Virtual Certification	Vehicle subsystems from different suppliers, Co-simulation	Virtual verification Standardization committees	FP2 WP 34/35 FP4 WP 16/17
Point Machine	Classic approach	Fault diagnosis	FP3 WP14/15 SP Diagnostics
Fault Diagnosis	Simpack, multi-sensor/-purpose approach, scientifically ambiguous with strong consortium	Diagnosis & maintenance	FP3 WP10/11 SP Diagnostics
Station	BIM	Asset management	FP3 WP 14/15
Bridge	BIM	Asset management	FP3 WP 12/13
HVAC	Thermodynamics	Failure & maintenance Eco-friendliness	FP3 WP 5/6 FP4 WP 18/19



Today: 4 use cases



- Virtual Certification Rolling Stock

Blas.Blanco@caf.net



- Maintenance Infrastructure

Vijaya-bhaskar.adusumalli@urbanandmainlines.com



- Co-Simulation of Balise Error Identification

Julia.Stadlmeier@dlr.de



- Use case „Track Settlement of Switches“

Proof of Concept: DT & Federated Dataspace

Alexander.Meierhofer@v2c2.at



The Train



VIEW 3: THE TRAIN

Can we certify a train without hundreds of physical tests?

Demo 29.1

Construcciones y Auxiliar de Ferrocarriles, S.A. (CAF)
FMU-based Digital Twin for virtual validation & certification of braking & traction systems — fewer physical tests, lower costs, faster delivery.

Digital foundation

Use case: Braking and traction DT

Blas Blanco, PhD
R&D engineer in CAF Innovation Department





Presentation

Blas Blanco Mula, PhD

R&D engineer in CAF Innovation Department.



Gerhard Hippmann, DLR

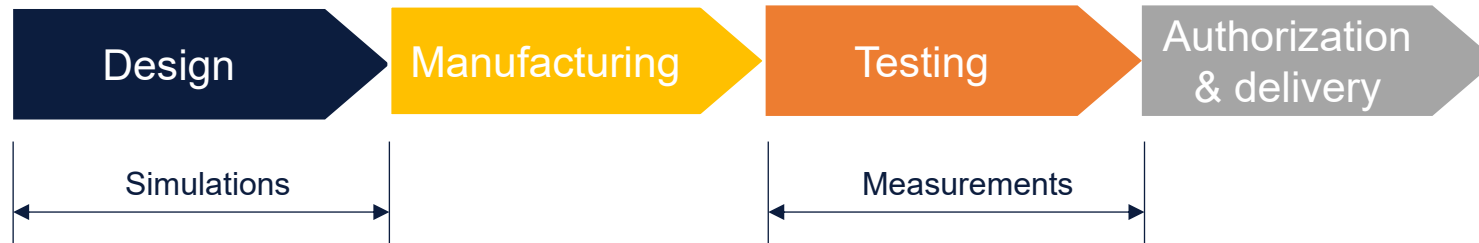


- From the **Innovation Department of CAF** (rollingstock manufacturer), we develop methodologies that strengthen CAF's engineering capabilities and support the competitiveness and sustainability of railway transport.
- Today's technological landscape is accelerating the adoption of **virtual validation and certification methods** to assess performance digitally, reduce physical testing, and speed up development.
- The work presented today has been developed collaboratively with DLR

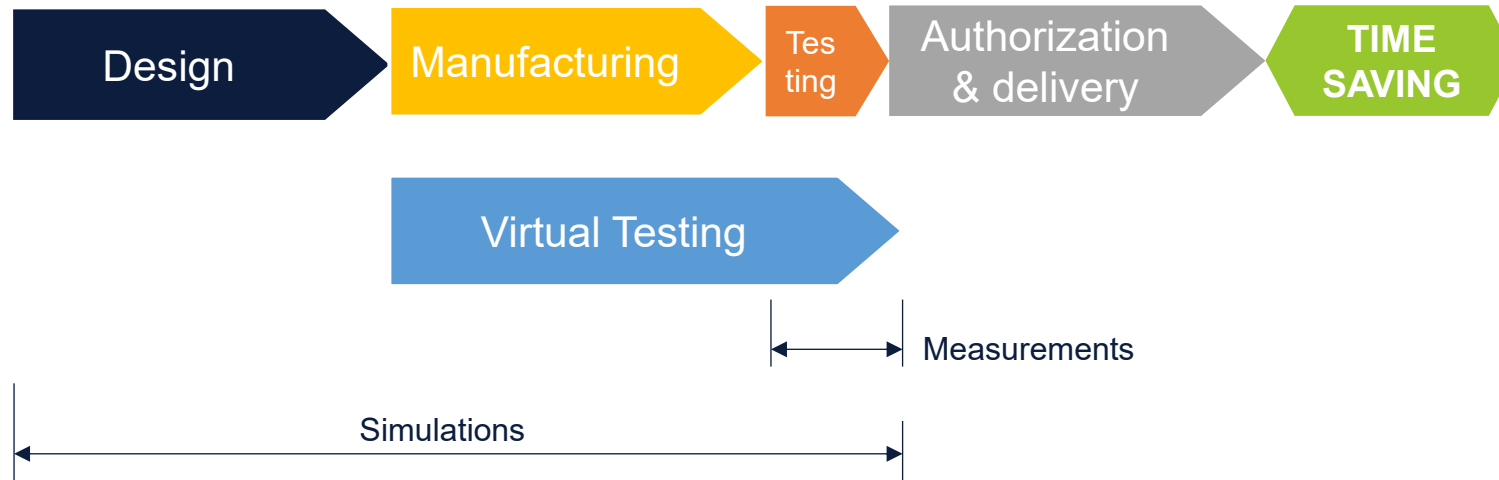
Virtual validation and certification



Traditional workflow



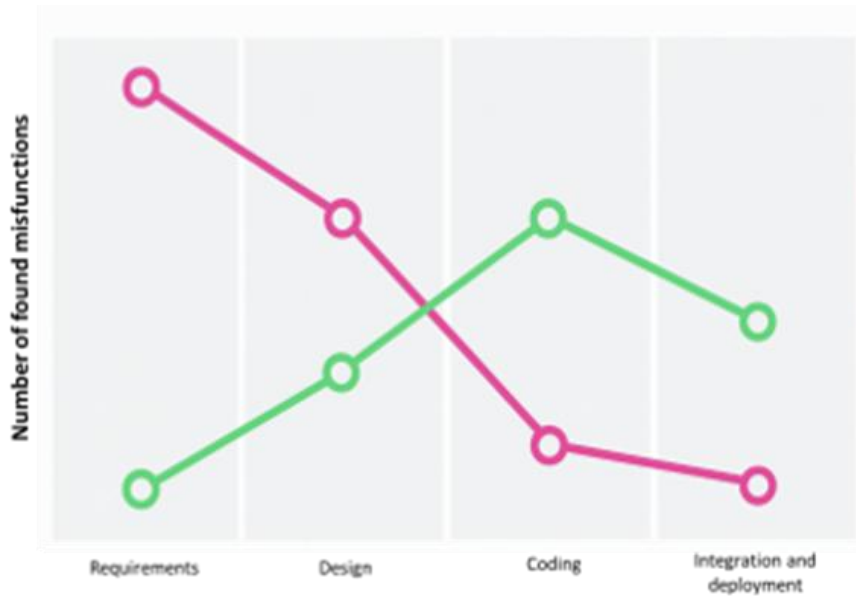
Virtual workflow



Shifting issue detection to earlier stages



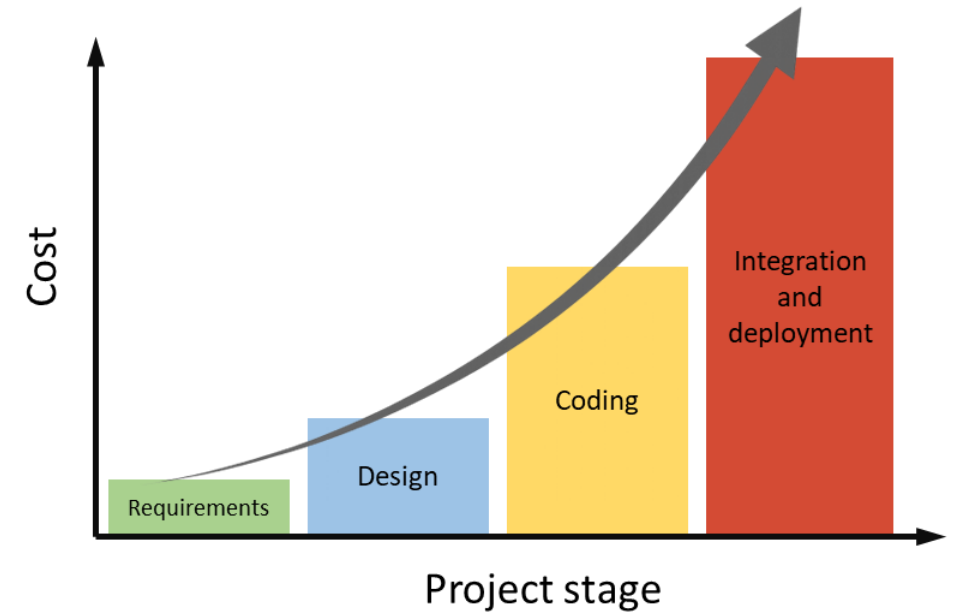
Found issue vs project stage



Traditional workflow

Virtual workflow

Fixing error cost vs project stage



Fixing error in earlier project stages has lower cost

Virtual workflow shifts issue detection to earlier stages of the project.

DIGITAL TWINS support implementation of virtual workflow

Why should anyone care about braking and traction performance?



- Passengers rely on trains to accelerate, brake and stop exactly as expected.
- Behind the scenes: an enormous amount of engineering, modelling, simulation, and safety validation.
- How braking and traction performance is developed and validated directly impacts safety, certification effort, delivery time and operational efficiency.

What does make braking a train a complex operation?



Stopping a Moving Building

- Car: ~1.5 Tn
- Train: 200-800 Tn
- Enormous kinetic energy to dissipate



Adhesion: Steel on Steel = Very low Grip

- Rubber-asphalt adhesion: 0.7-0.9
- Steel-steel friction: 0.05-0.2



Blending: A three-system Braking Orchestra

- Electrodynamic Brake (ED): **energy-recovery**
- Friction brake: **energy loss**
- Magnetic brakes: emergency cases



Braking distance: Counter-Intuitive Reality

- Car at 100 km/h: ~**100 m**
- Train at 100 km/h: ~**400 m**
- High-speed train at 300 km/h: ~**3000 m**

The ED effort must be maximized to ensure system efficiency, while still guaranteeing safe operations at every moment, especially under low-adhesion or degraded conditions.



If braking forces become too large, the limited wheel-rail adhesion can lead to defects such as wheel flats.



Why is a braking and traction DT useful?



1. Coordinated operation of multiple subsystems:

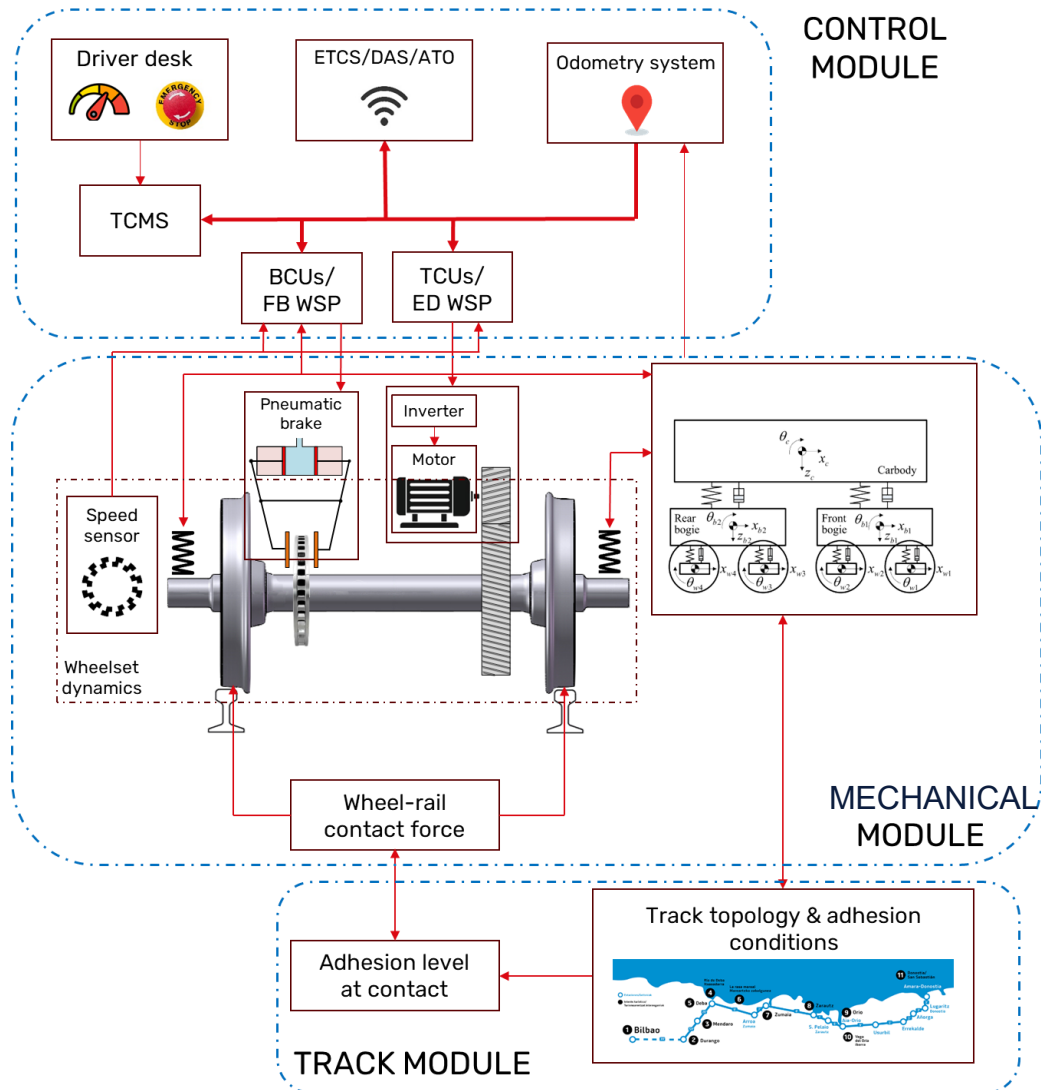
- Traction control, ED braking, friction braking, WSP, onboard control, ...
- Tuning cannot be done in isolation.

2. Interoperability across providers

- Components and software from different suppliers.
- Functional consistency among subsystems from different providers must be guaranteed

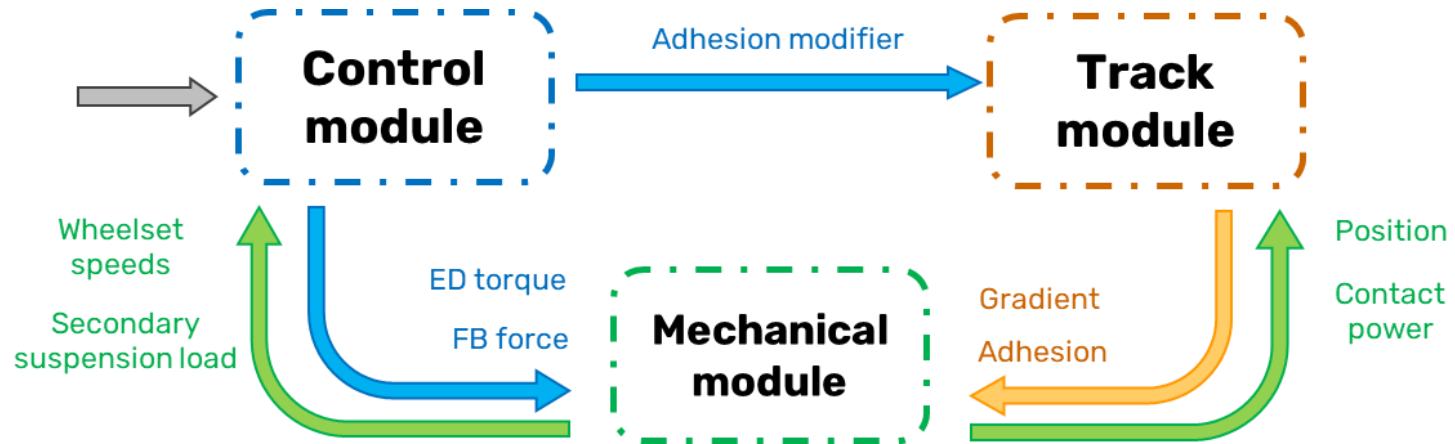


Digital Twin must keep modularity and representativity of system architecture



- **Control module:** On board control logics
 - Traction control units (TCUs). ED effort management
 - Braking control units (BCUs). FB effort management.
 - Train Control Management System (TCMS). On-board upper-level functionalities.
- **Mechanical module:** vehicle dynamics and forces
- **Track module:** geometry and adhesion conditions.

Architecture of the braking and traction system



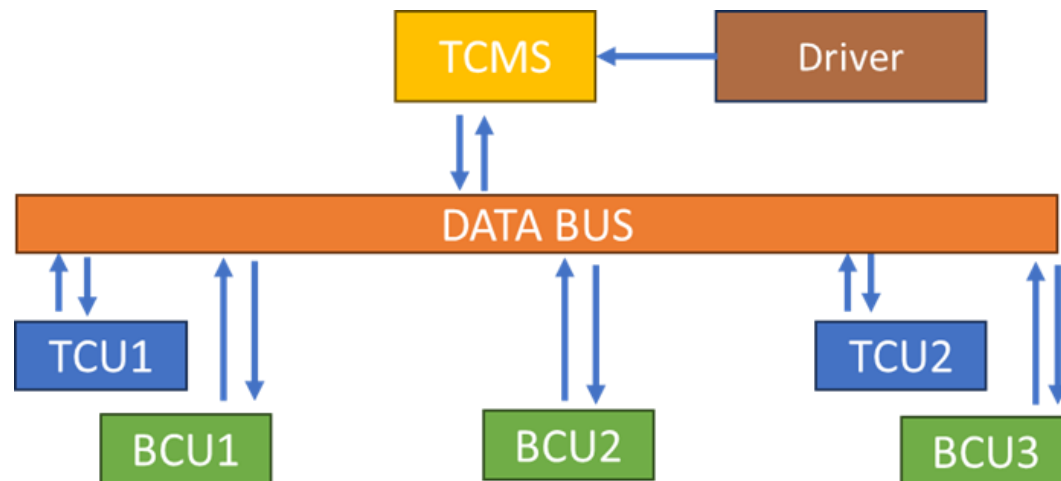
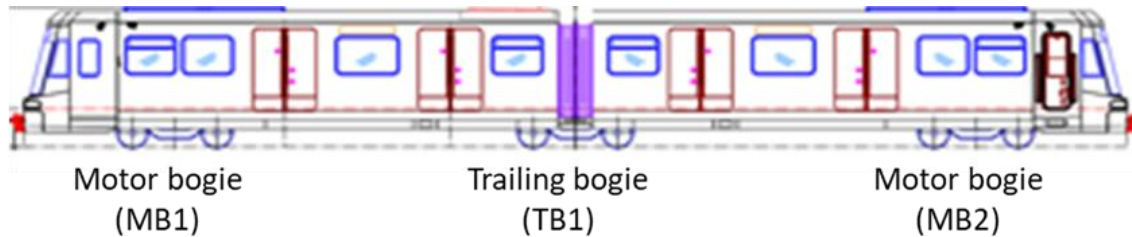
Stable and scalable interfaces:

- **Sensor signals** from mechanical to control modules
- **Actuator commands** from control to mechanical modules (motors, friction brakes,...)
- Specific details adapts to the actual vehicle topology (number of **TCUs**, **BCUs**, **wheelsets**, etc.)

Example of the DT generation methodology



Railway vehicle used to exemplify the methodology

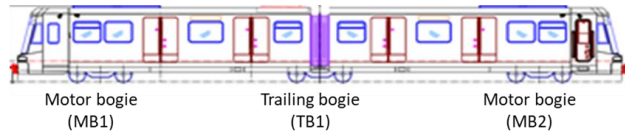


- Topology corresponding to a Light Rail Vehicle (LRV) with two carbodies.
- Maximum design speed around 80 km/h.
- About 30 meters length,
- About 200 passenger maximum capacity.
- Both outer bogies are motorized (2 TCUs), while the middle one is trailing type (only friction brake actuators)

Example of the DT generation methodology

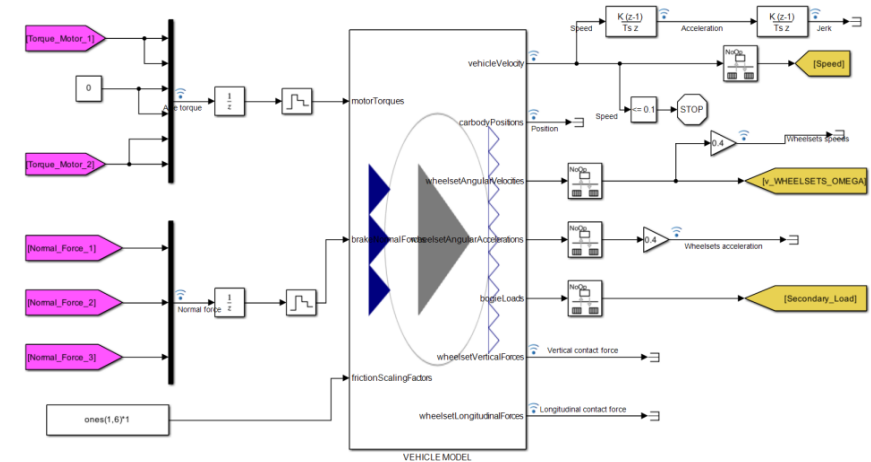
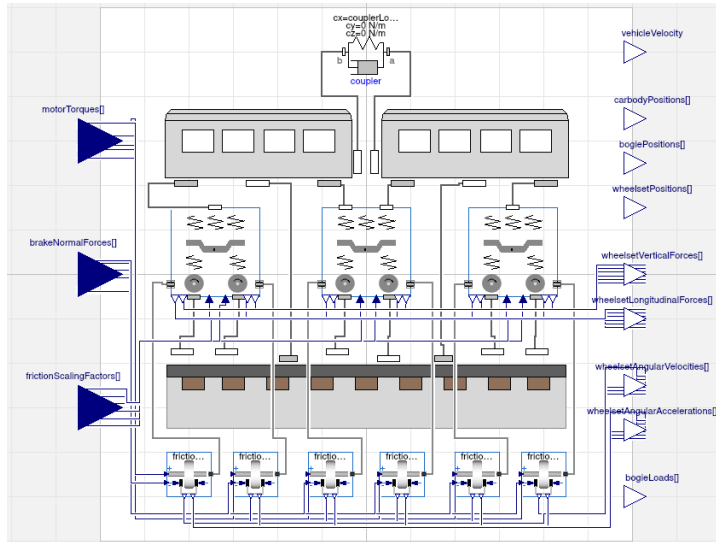


Railway vehicle used for methodology development



Developed FMUs for mechanical module

Mechanical module architecture



Scenario parameters

- Car occupancies
- Wheel-rail adhesion
- Pad-disc friction coefficients

Design parameters

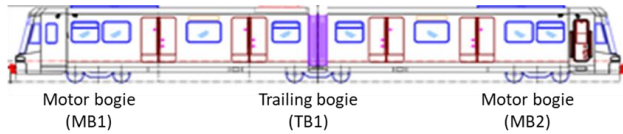
- Mass properties
- Stiffness and damping values
- Wind resistance coefficients



Example of the DT generation methodology

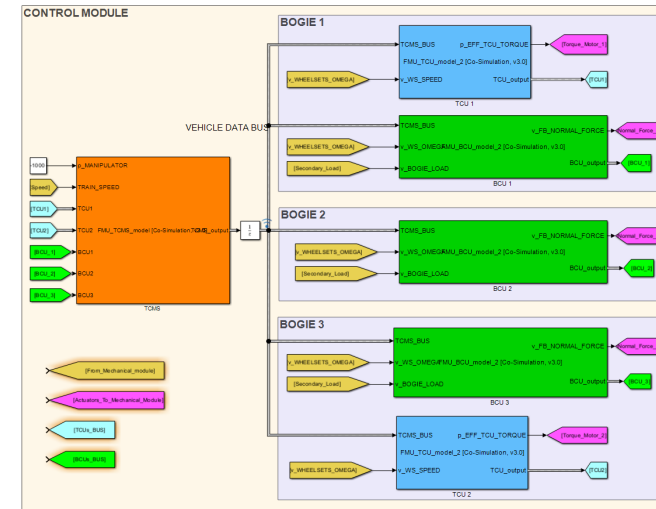
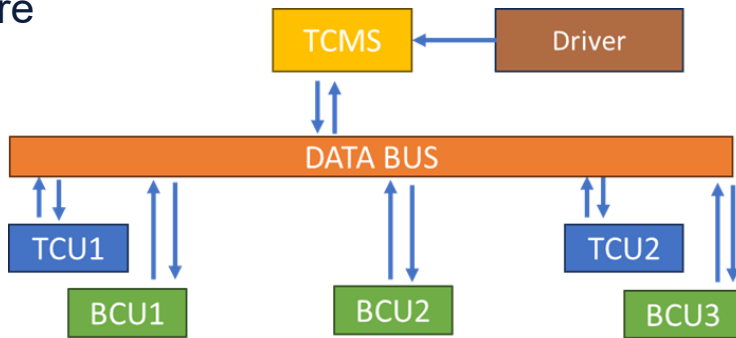


Railway vehicle used for methodology development



Developed FMUs for control module

Control module architecture



Scenario parameters
Failing unit

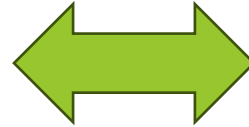
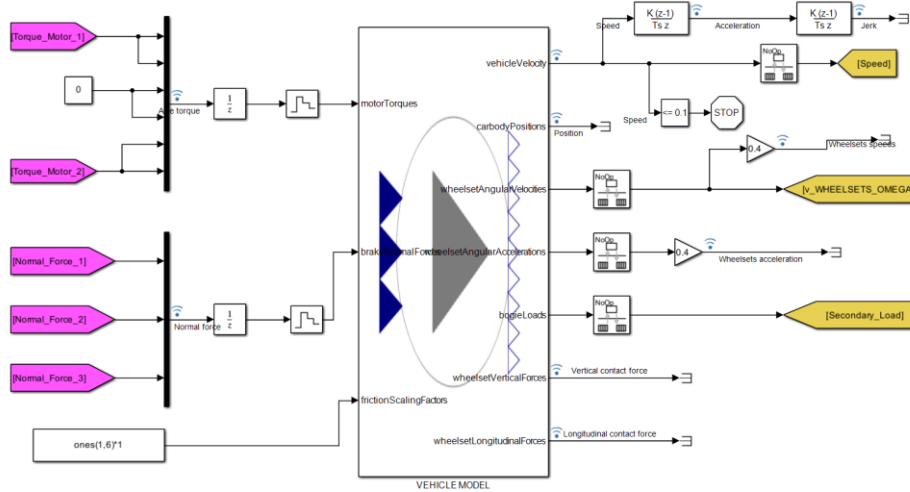
Design parameters
Maximum ED effort
Maximum ED power
...



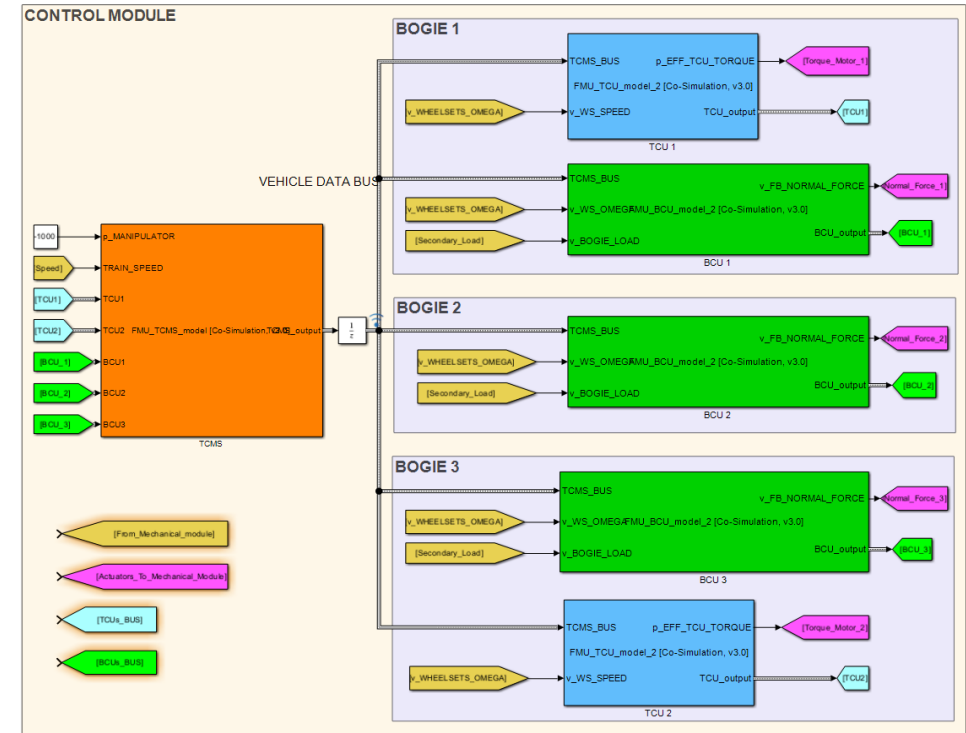
Example of the DT generation methodology



Mechanical module



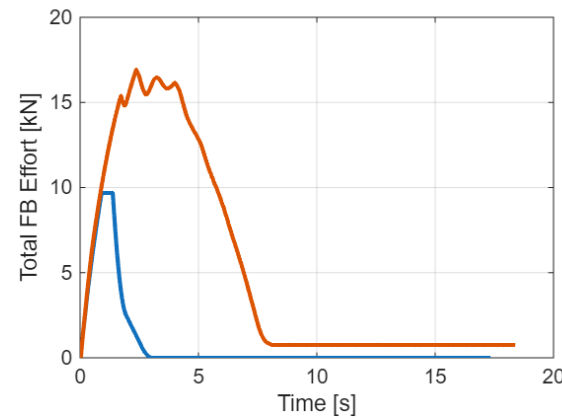
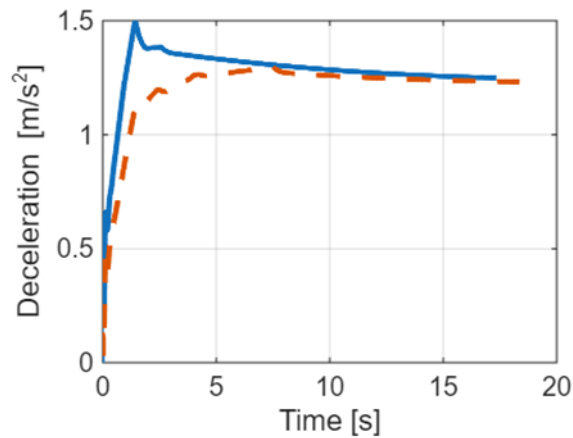
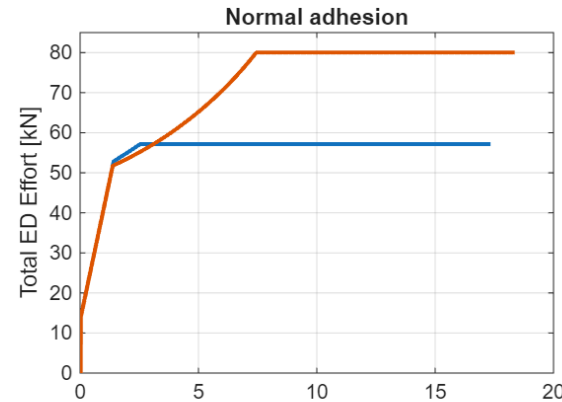
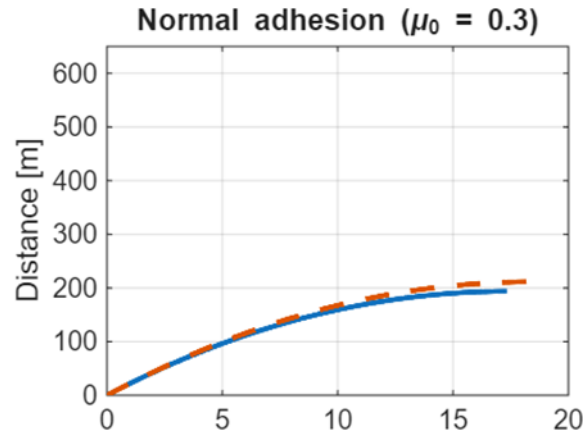
Control module





Scenario: Full-service brake from 80 km/h to stop

— Tare conditions — Fully-laden conditions

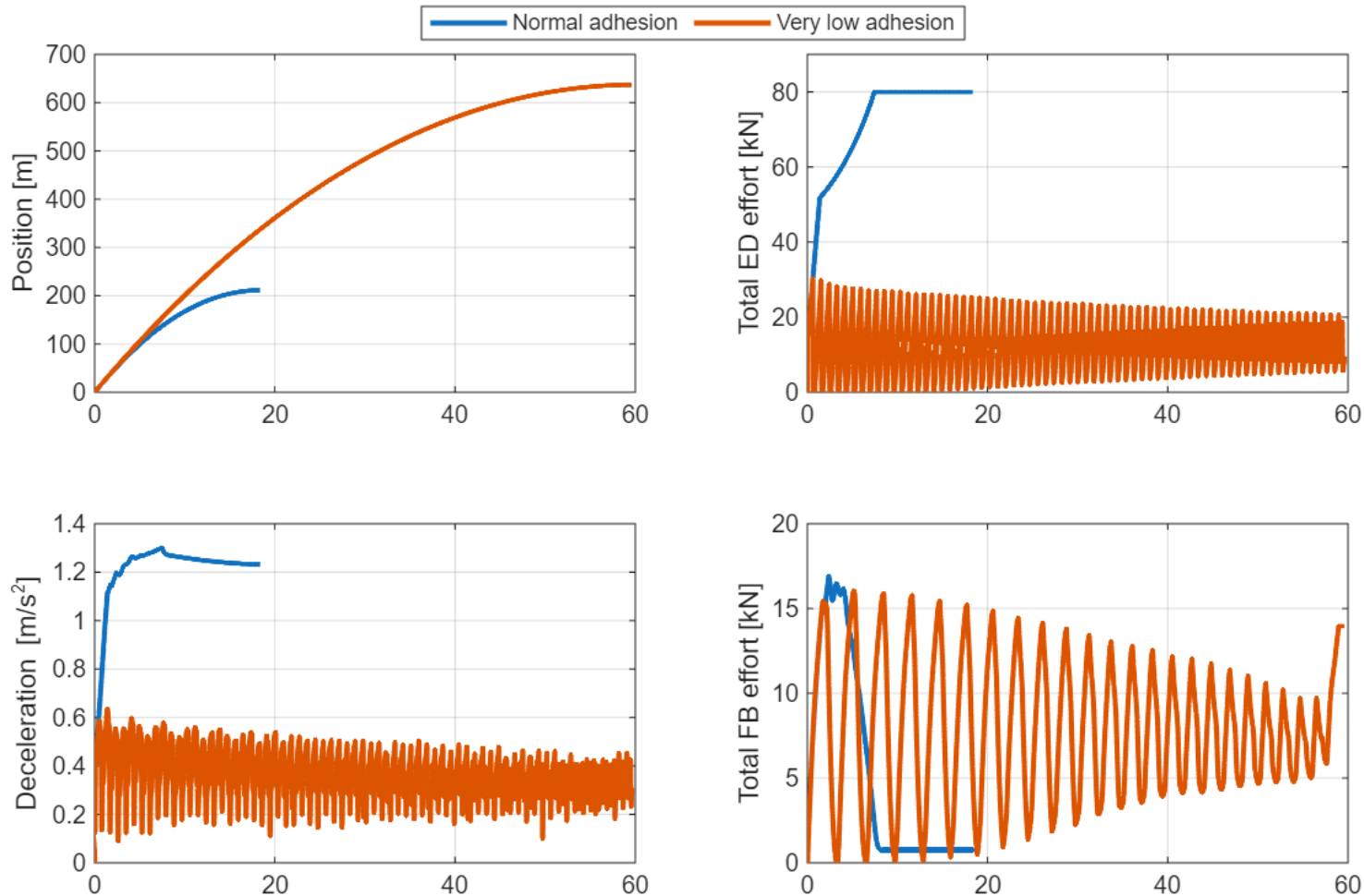


- Different loading conditions can lead to different deceleration profiles due to cross-interaction between TCUs and BCUs. Mainly when braking starts
- When fully-laden, TCUs are limited by power specifications, in that case BCUs compensate braking deficit to reach nominal deceleration

Verification results



Scenario: Full-service brake from 80 km/h to stop



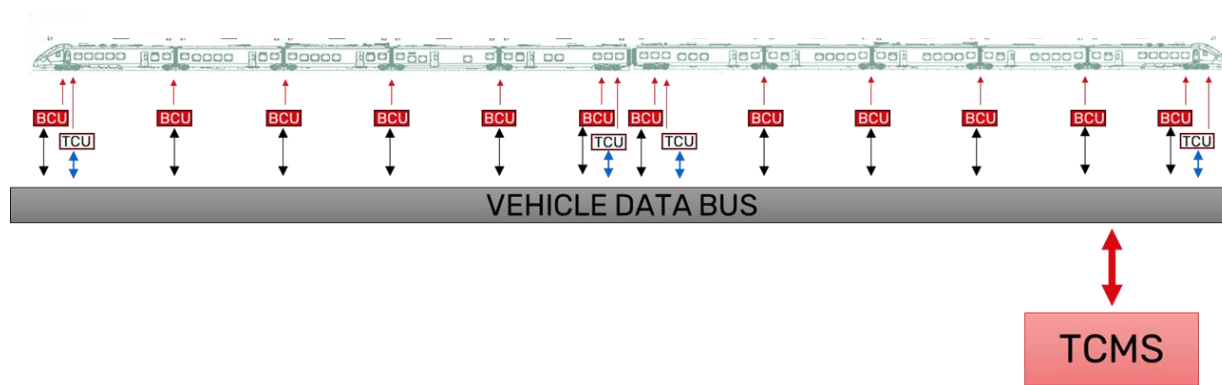
In low-adhesion condition WSP acts and prevents wheel block.



Validation model

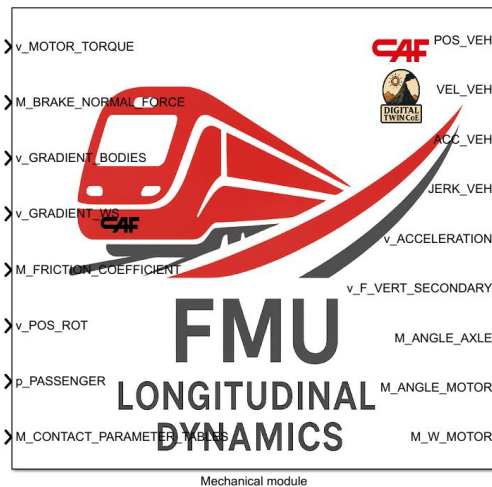


Railway vehicle used for methodology validation

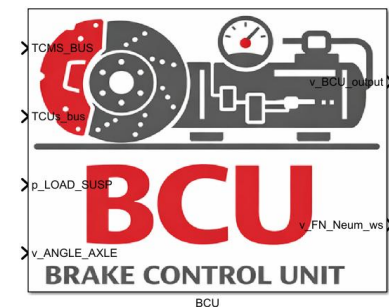
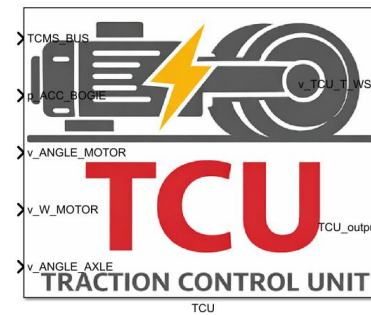
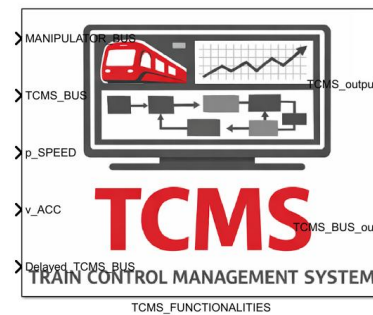


- Main line railway vehicle.
- Maximum design speed around 200 km/h.
- 10 carbodies, 12 bogies, with 4 of them motorized,
- Capacity for more than 400 passengers

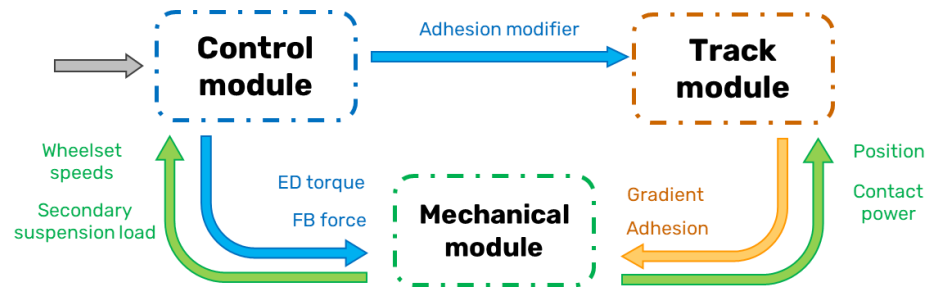
Single FMU modelling vehicle dynamics (mechanical module)



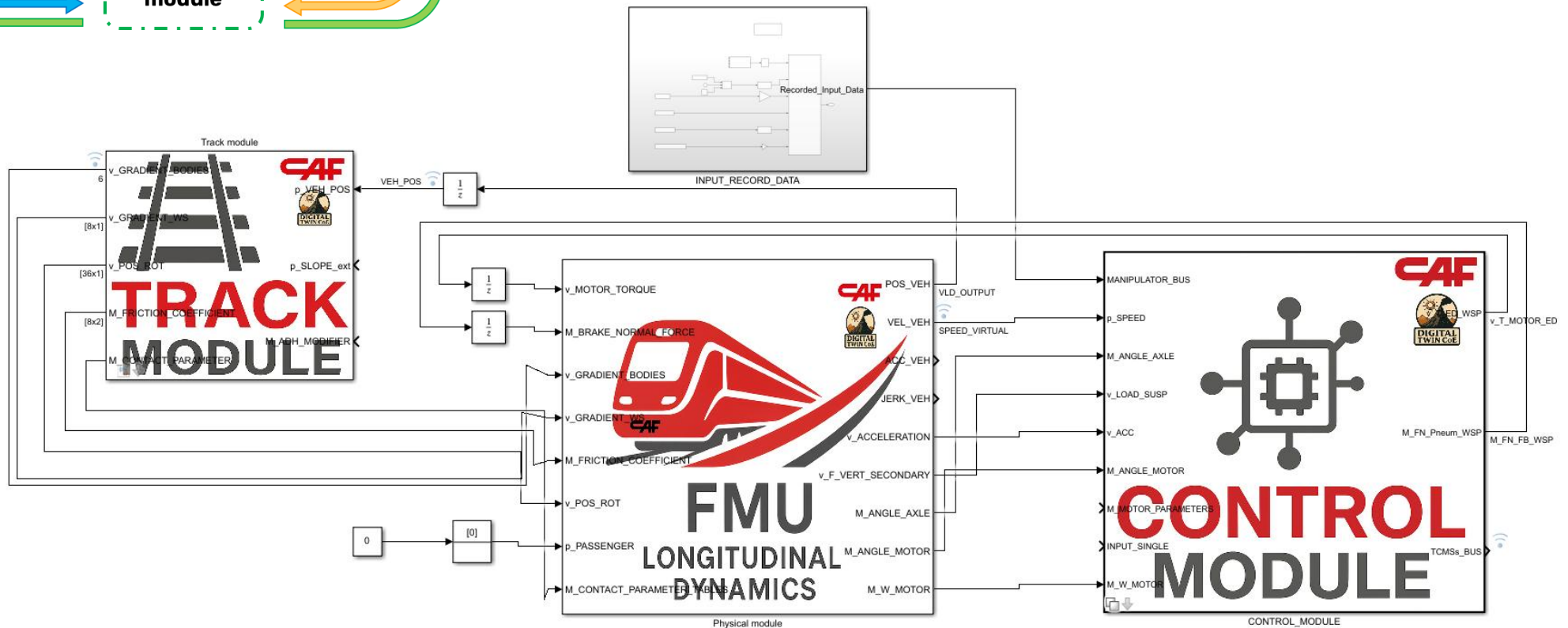
FMUs used to build the control module

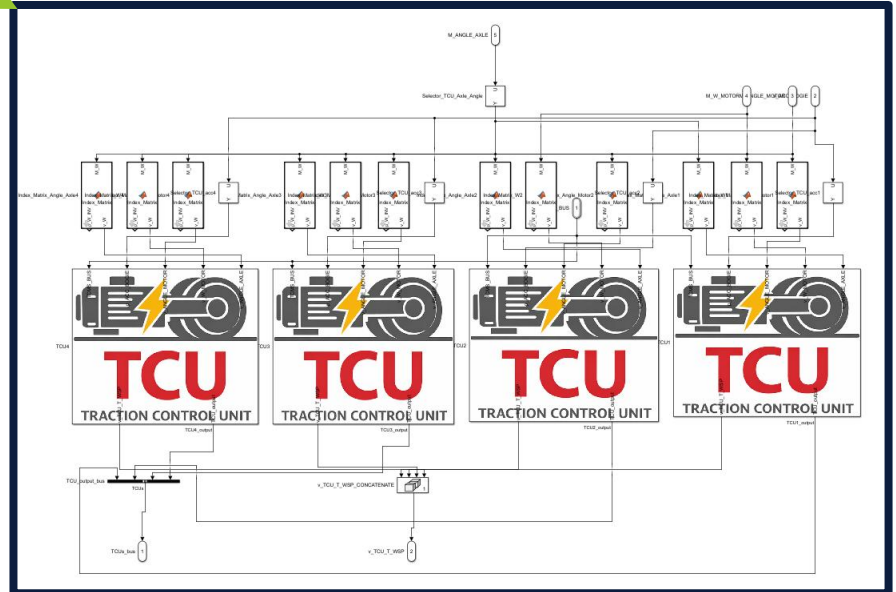
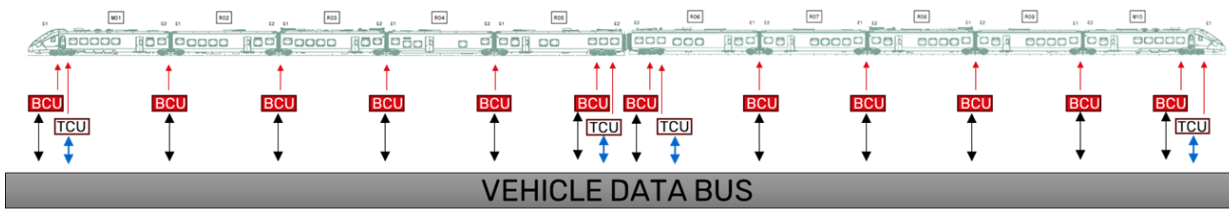
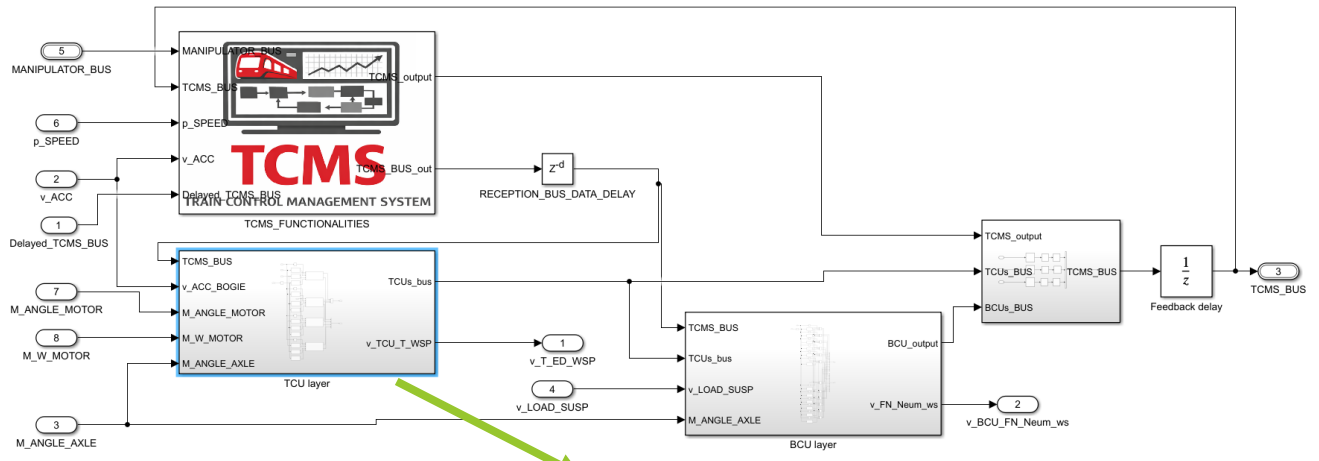
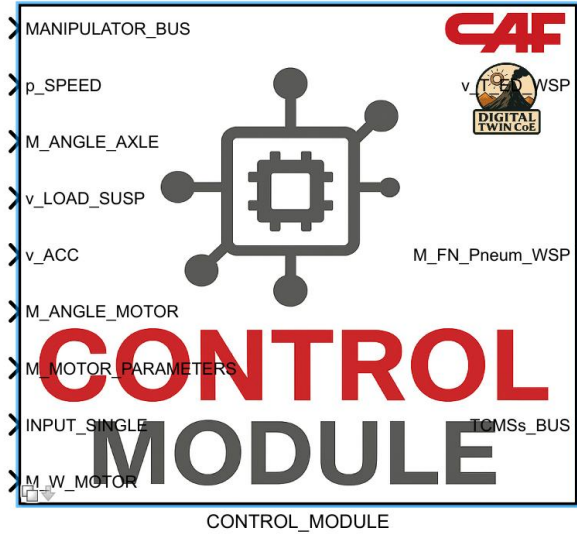


Validation model



In the validation model, interfaces have the same physical background as in the verification model.





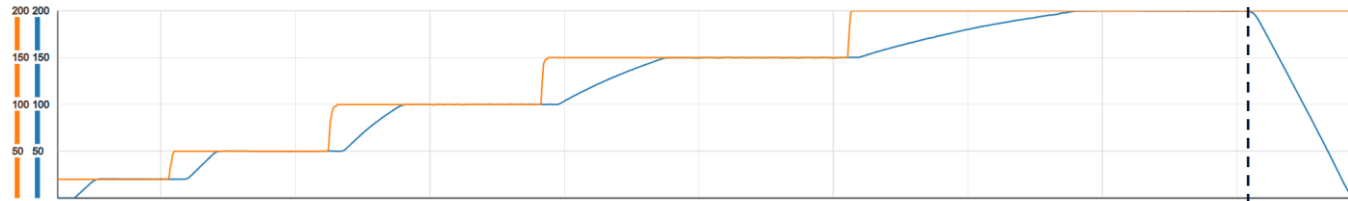
Modularity is preserved, each FMU represents an individual subsystem.



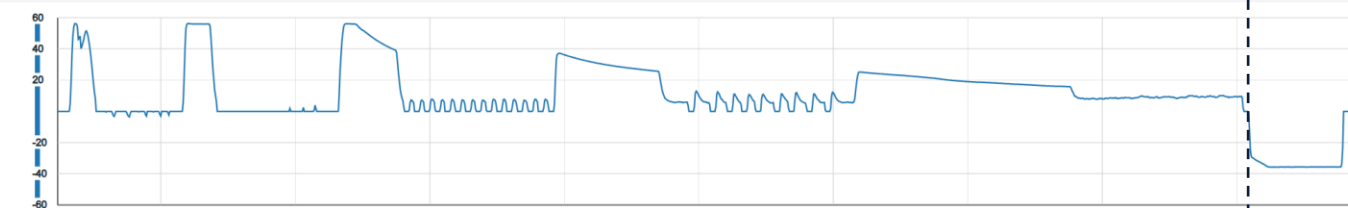
Variables

Ver histórico de las variables de las UTs

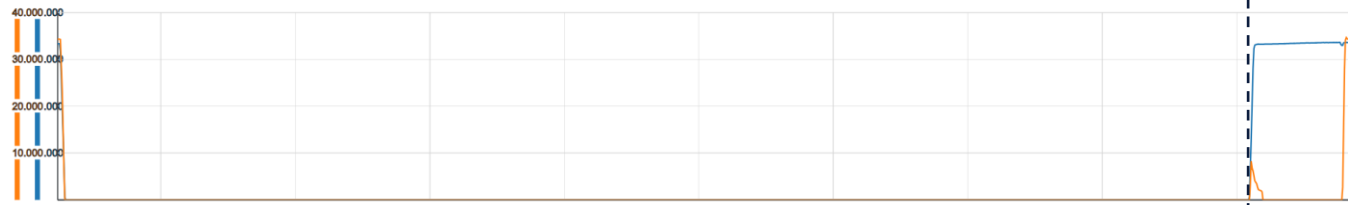
- × ● PLC_TRAIN_SPEED:
None
- × ● PLC_TRAIN_SPEED_TARGET:
None
- × ● TCU_M01_EFFA:
None
- × ● BCU1_R3_EP_EFF:
None
- × ● BCU1_M01_EP_EFF:
None



Vehicle and target speeds



ED effort



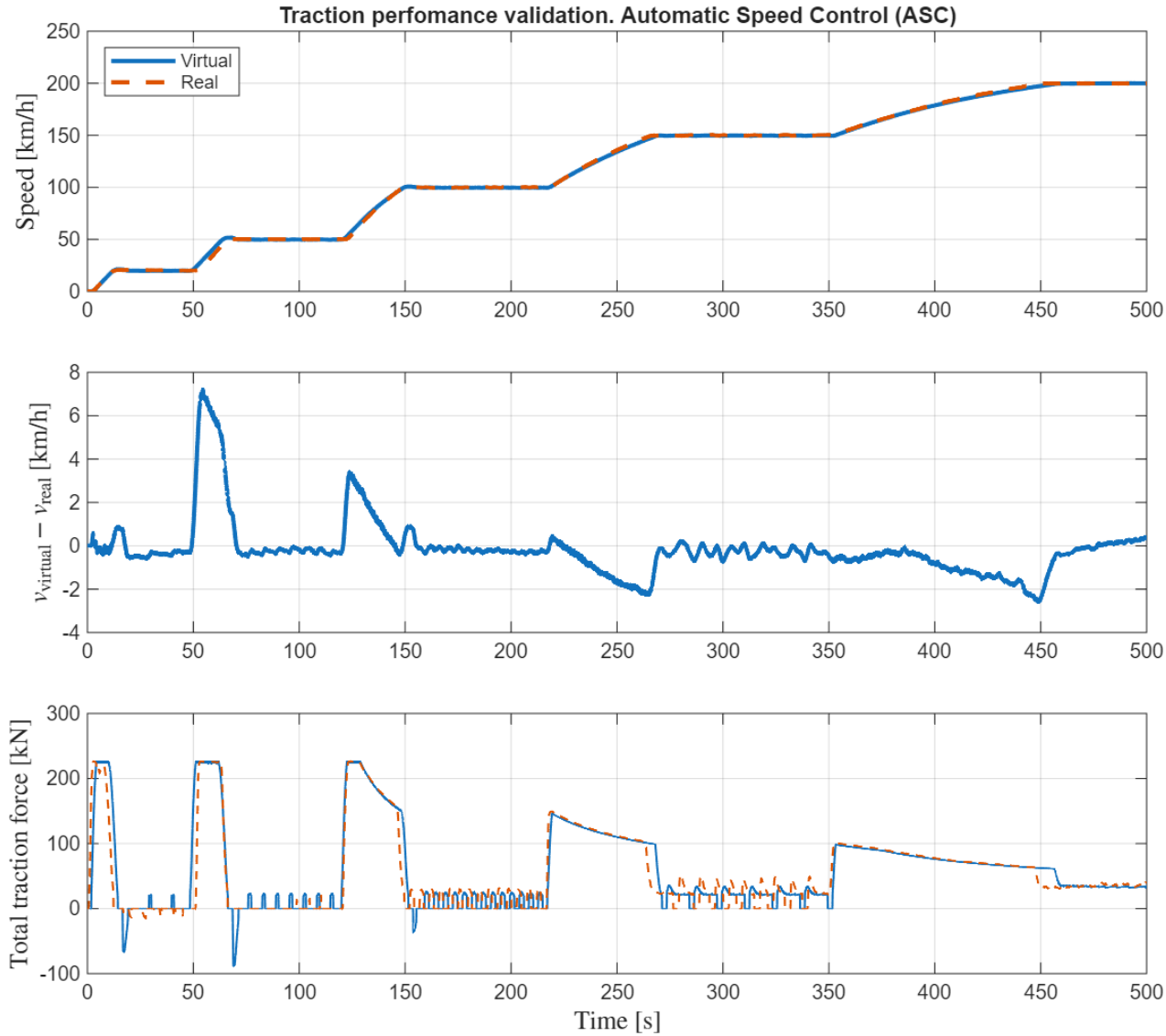
FB effort

Stepped traction process with Automatic Speed Control

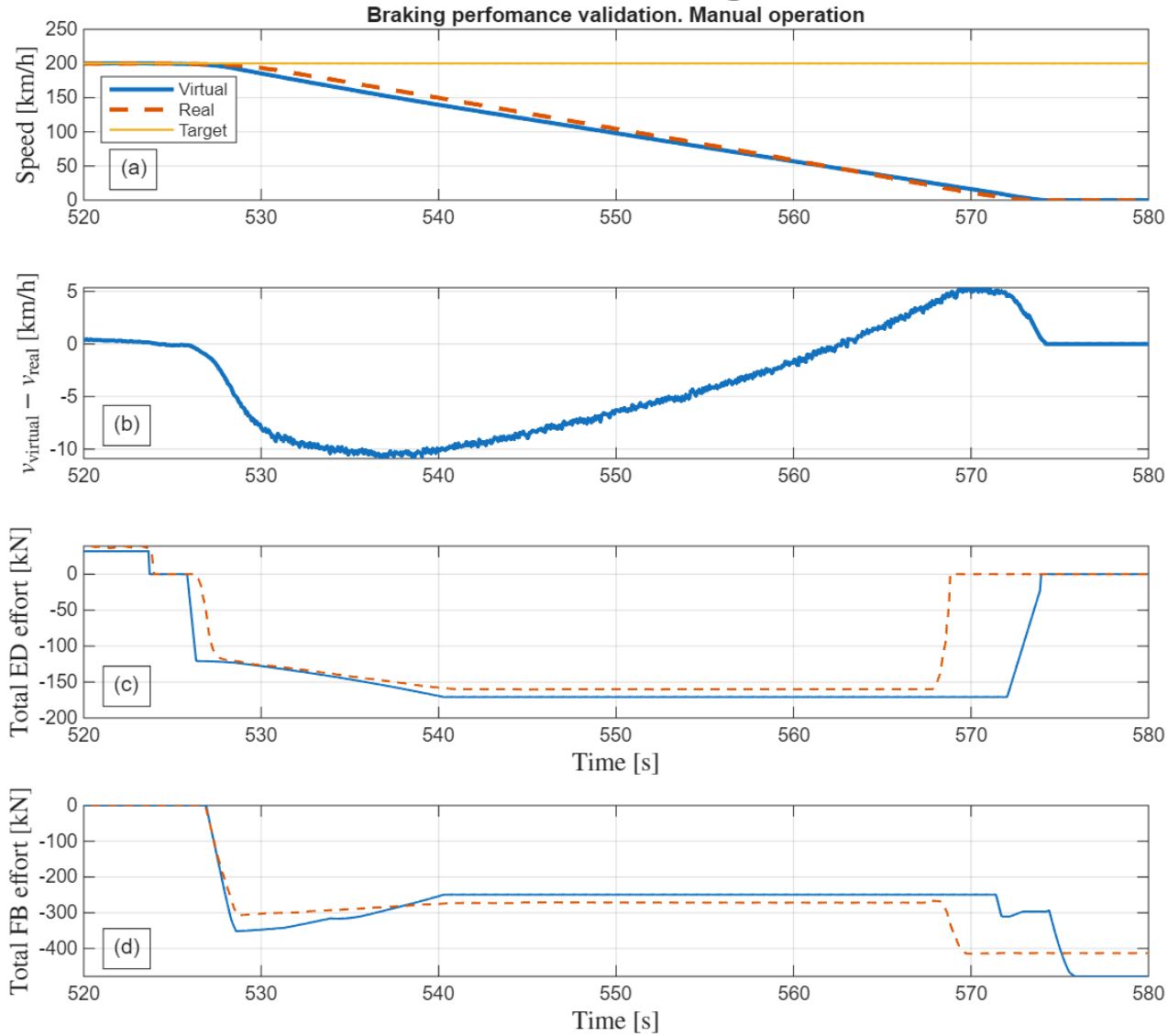
Manual braking

NO WSP ACTIVATION IS RECORDED: DRY ADHESION

Validation results. Traction



Validation results. Braking





Conclusion

- **Validated approach to build DTs based on FMI standard:**
 - Modular DTs (allow substitute elements by third-party)
 - Tunable modules allowing for parameter analysis and variable operational conditions
 - Verification example shows the ability to capture low adhesion behavior
 - Comparison with field measurements show validity of the DT in normal adhesion conditions
- **Future work:**
 - Include third-party software overcoming interoperability issues
 - Address validation in low-adhesion conditions

Thank you for your attention

Infrastructure



VIEW 1: INFRASTRUCTURE

How do we know when a switch will fail before the train does?

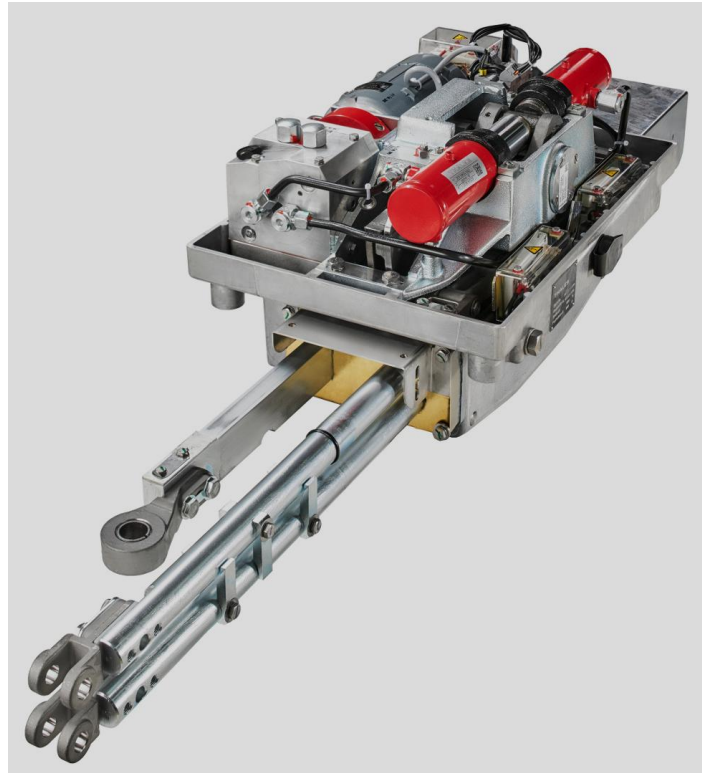
Demo 29.3

Hitachi Rail Deutschland

Digital Twin of point machines using live signalling data (speed, weather, vibrations).

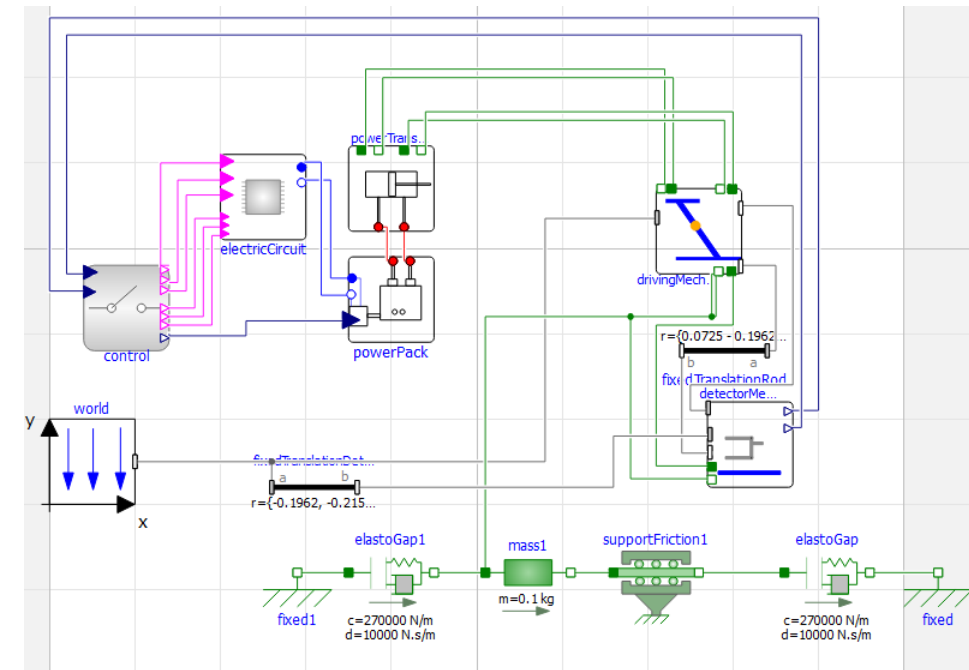
Use case: Fault Analysis of Point Machine using Digital Twin

L826H Electro Hydraulic Point Machine

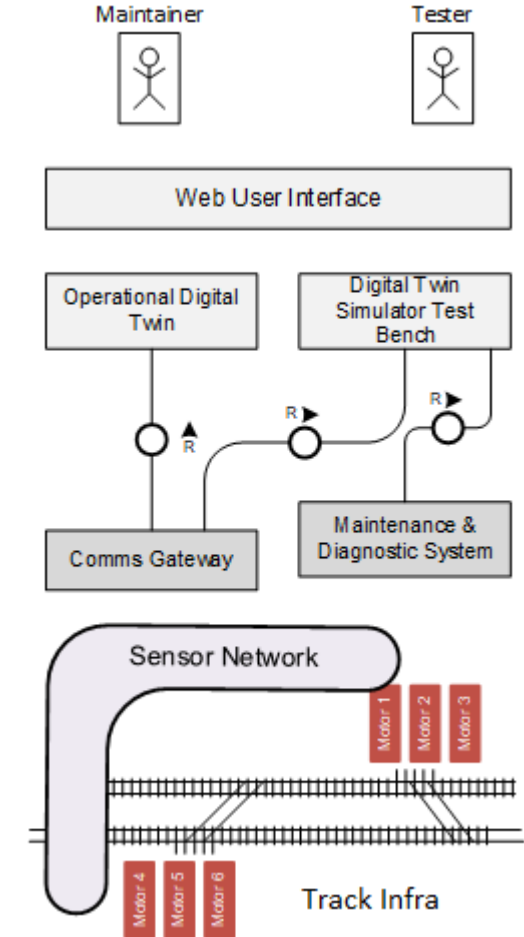
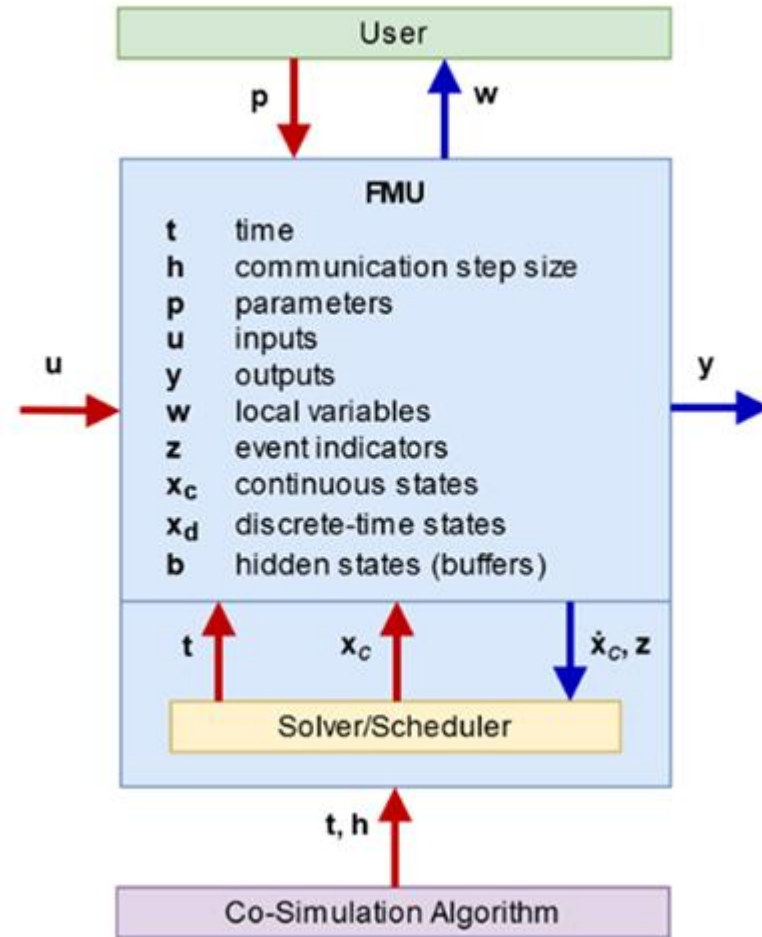


Digital Twin

Implementation in OpenModelica



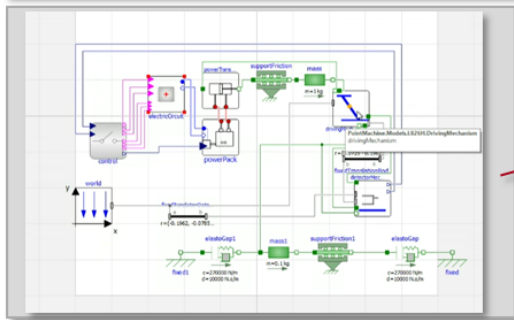
Rama Ambur
Vijaya Bhaskar Adusumalli
Hitachi Rail GTS Germany



Target – Intelligent Asset Management using Digital Twins

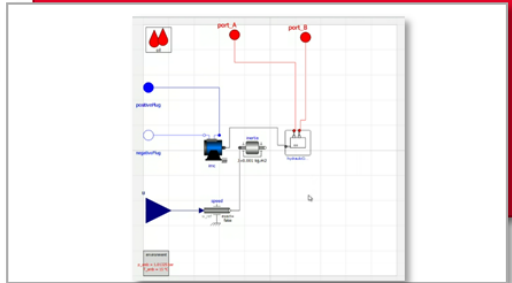
- A switch point contains several point machines
- Each point machine as well as the track is monitored by several sensors
- Data is transmitted to a remote server via a communications gateway
- The server analyzes the data received and interprets data with the help of FMUs
- Tester can simulate additional scenarios in a Lab environment with the help of Digital Twin and real data for better fault analysis
- Maintainer can visualize the status of point machine performance in digital twin for possible emerging faults
- A visual interface towards Digital Twin is possible via Asset Management System platform

L826 Model

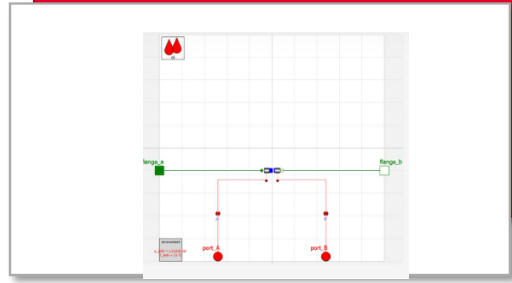


- ▼ L826H
- L826Hmodel
- PowerPack
- PowerTransmission
- DrivingMechanism
- DetectorMechanism
- ElectricCircuit
- Control
- SingelCyll...rationTest
- PowerPackUpd

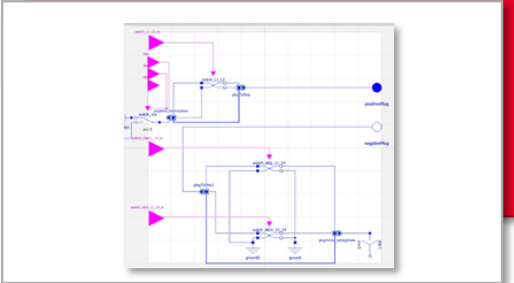
Power pack



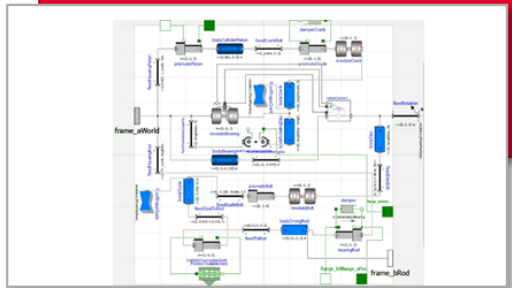
Power Transmission



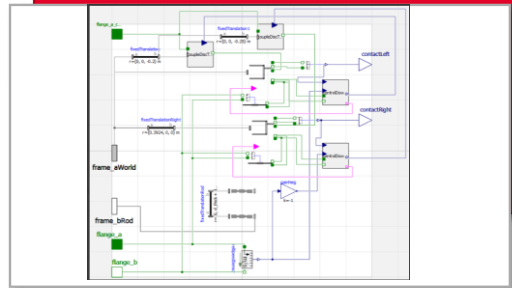
Electric circuit



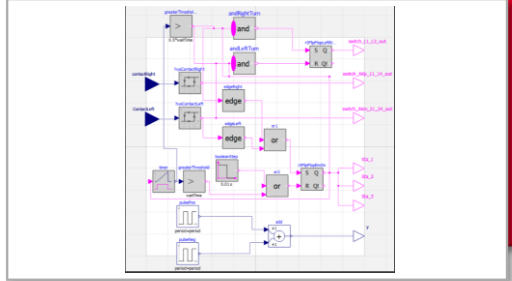
Driving Mechanism



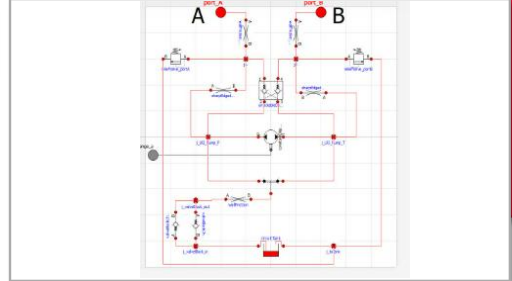
Detector Mechanism



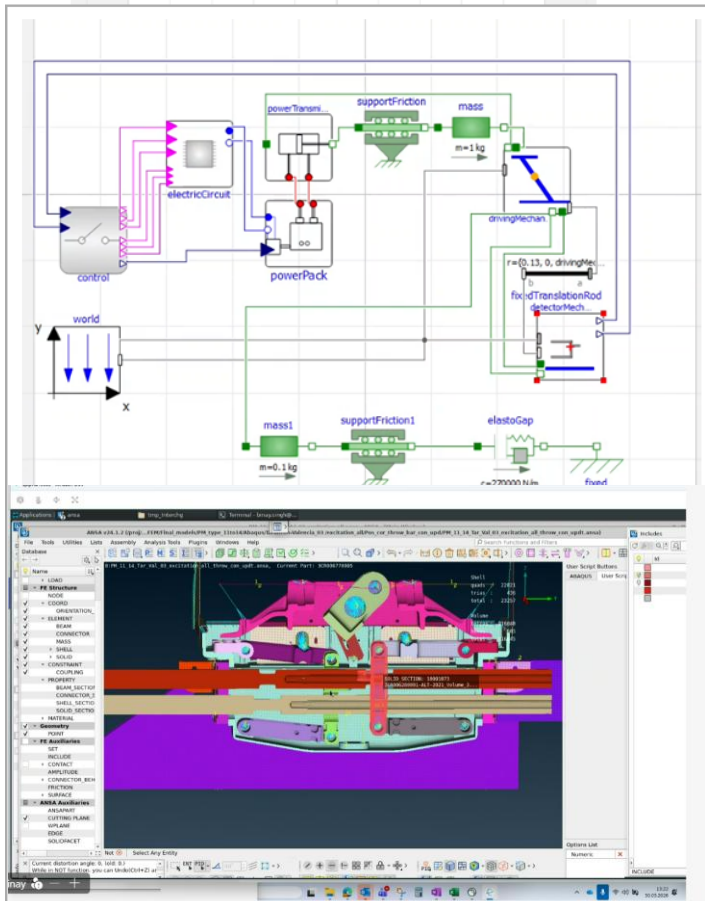
Control



Hydraulic Circuit



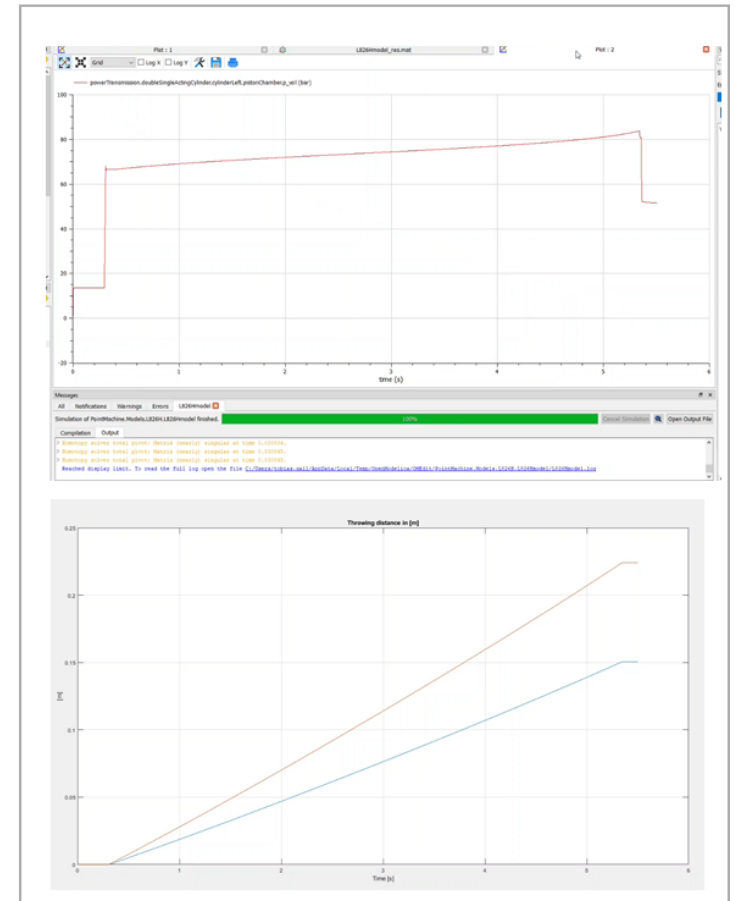
Model and Mechanism



Parameter Change

Parameter	Value	Unit	Description
L_throw	0.06	m	length of throw for thick middle part between thin parts
L_thickleft_l	1.084 - 0.2395 * detectorMechanism.L_throw - 0.026 - 0.064	m	length flange to first detection
L_thinleft_l	0.2395	m	length till cancellation
L_thinleft_r	0.064	m	length thin part first detection
L_thinright_l	0.026	m	length thin part second detection
d_thick	0.035	m	diameter thick parts
d_thin	0.02	m	diameter thin parts
L_thickleft_r	1.084 - 0.2265 * detectorMechanism.L_throw - 0.026 - 0.064	m	length flange to first detection
L_thinright_r	0.2265	m	length till cancellation
L_thinright_l	0.026	m	length thin part first detection
L_thinright_r	0.064	m	length thin part second detection

Output Illustration



Demonstrating the Digital Twin

Demonstrating the digital twin

Change the force required to move the turnout and observe the effect in the point machine

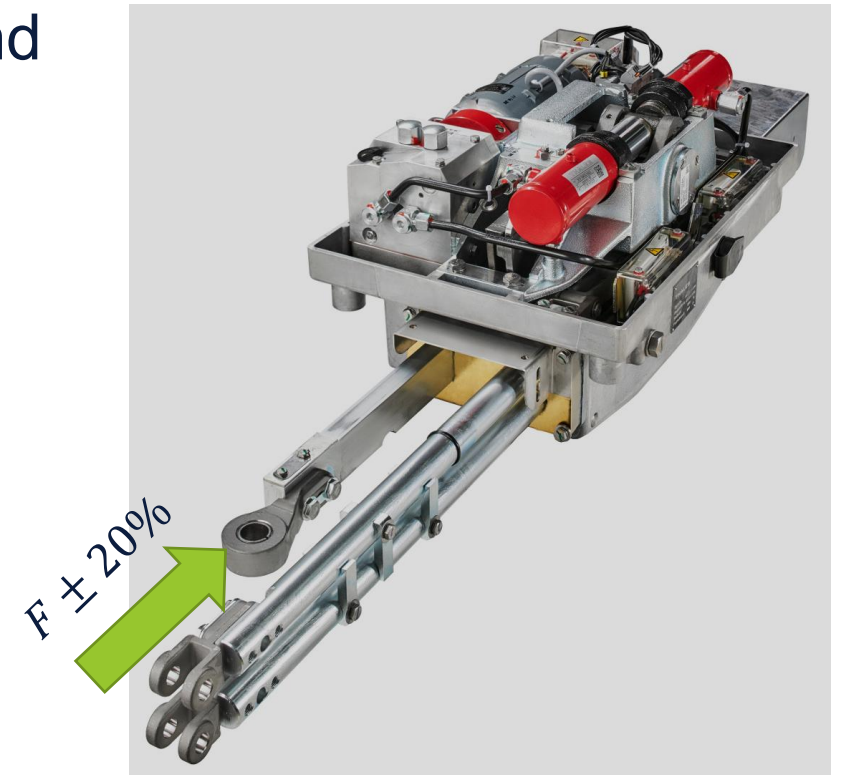
Input: Friction force at turnout changed by $\pm 20\%$

Output: Hydraulic oil pressure change;
Force exerted by cylinder

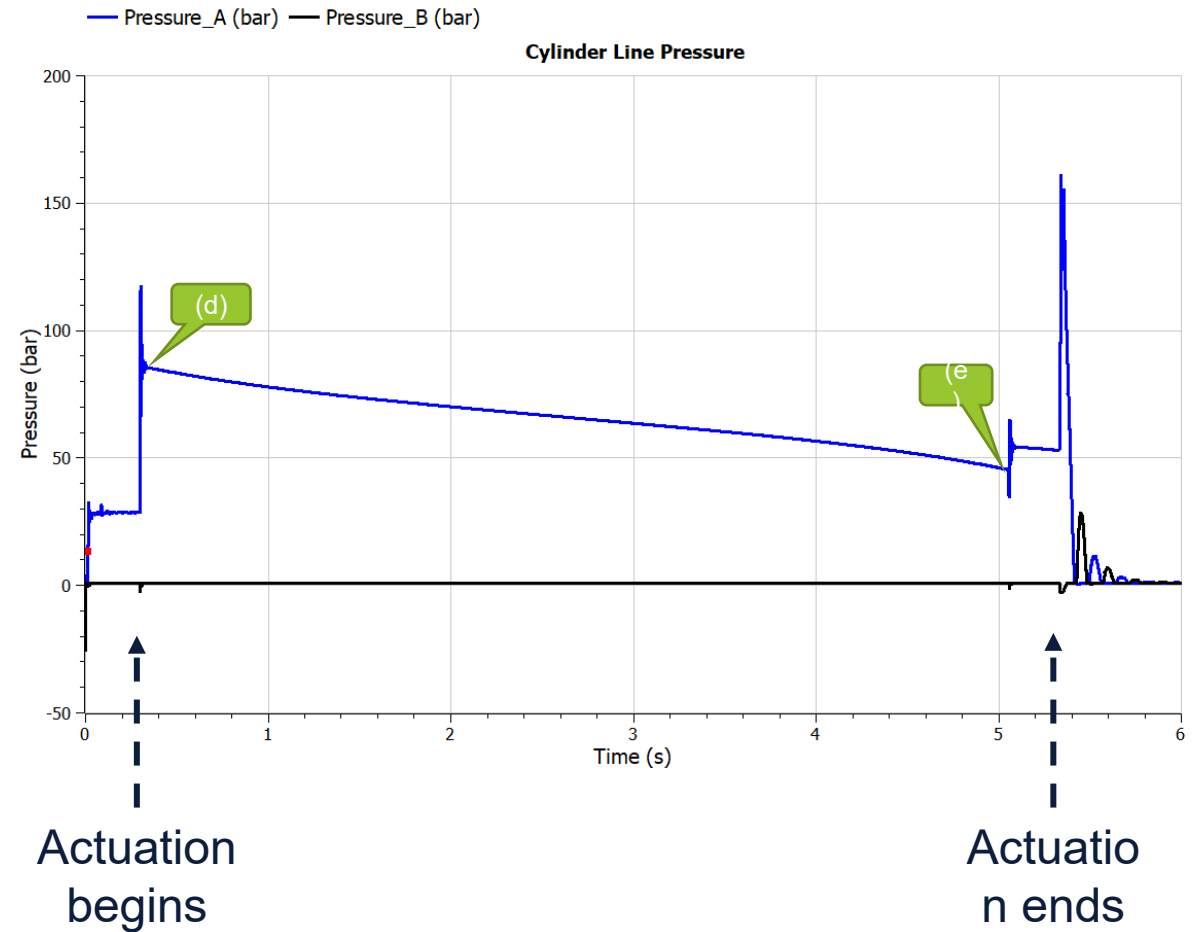
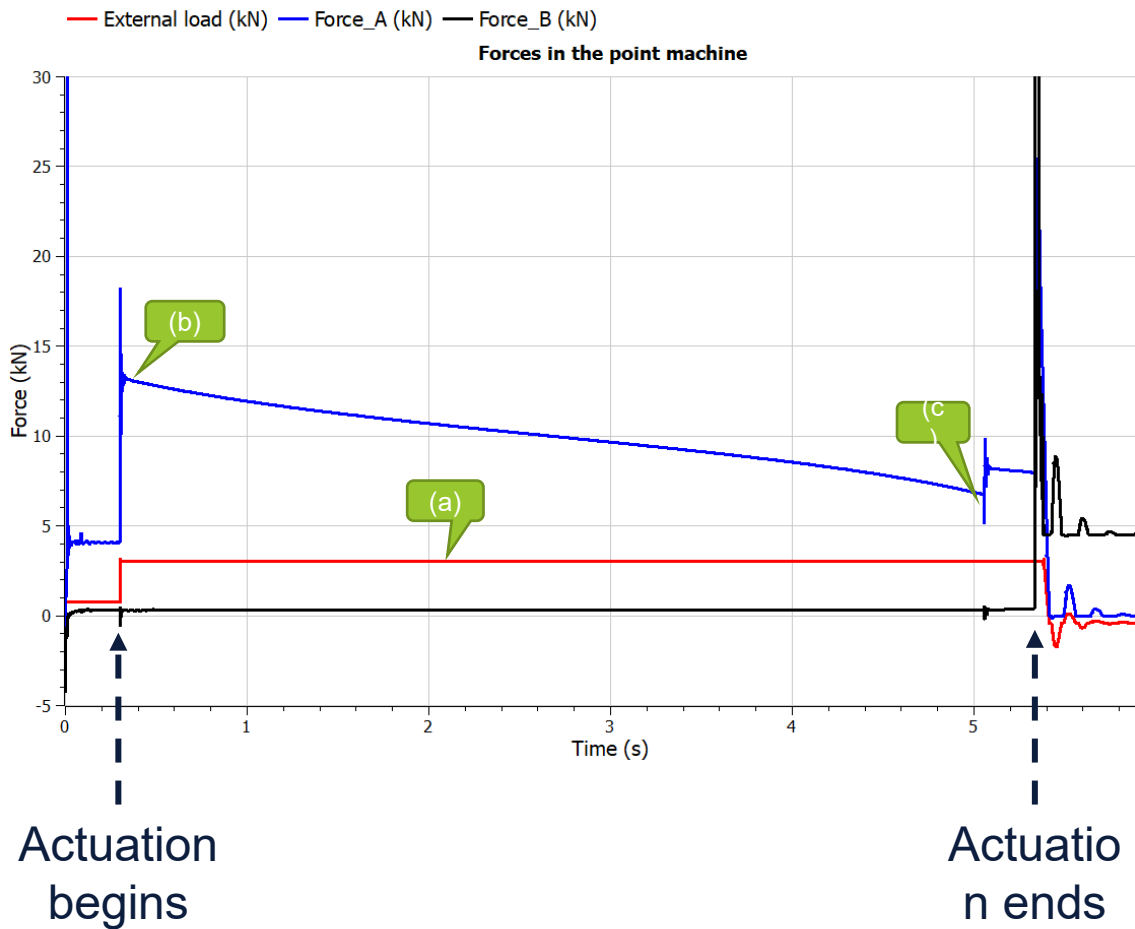
Example

Higher forces in reality: Debris or blockages in switch rails.

Lower forces in reality: Residual stresses in tongue rail

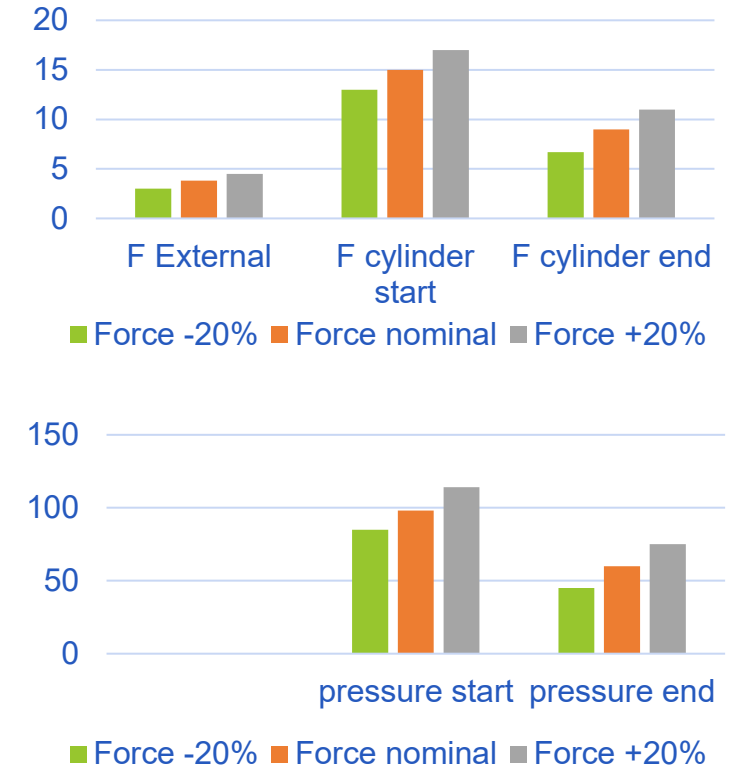


Comparison of results from Open Modelica



			External force (-20%)	External force (Nominal)	External force (+20%)
Force (kN)- Input		(a)	3	3.8	4.5
Force in cylinder piston (kN)	Actuation start	(b)	13	15	17
	Actuation end	(c)	6.7	9	11
Hydraulic line pressure (bar)	Actuation start	(d)	85	98	114
	Actuation end	(e)	45	60	75

Forces and pressures

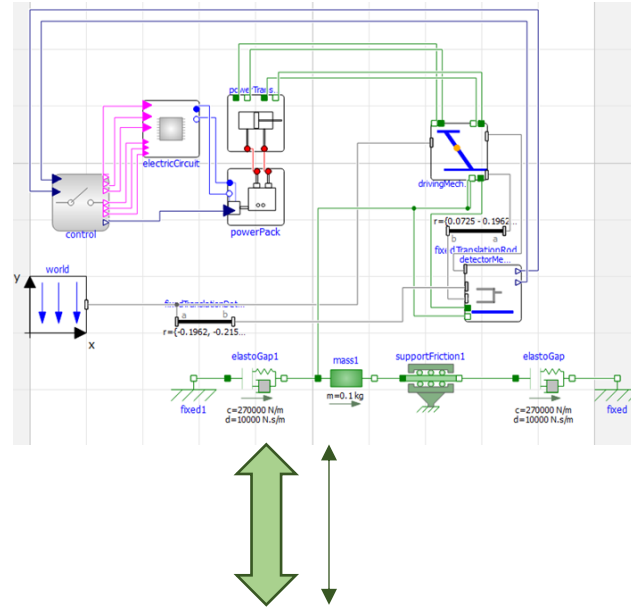
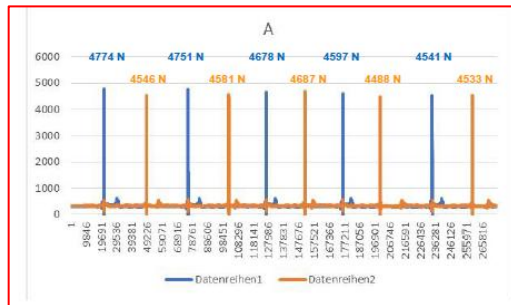
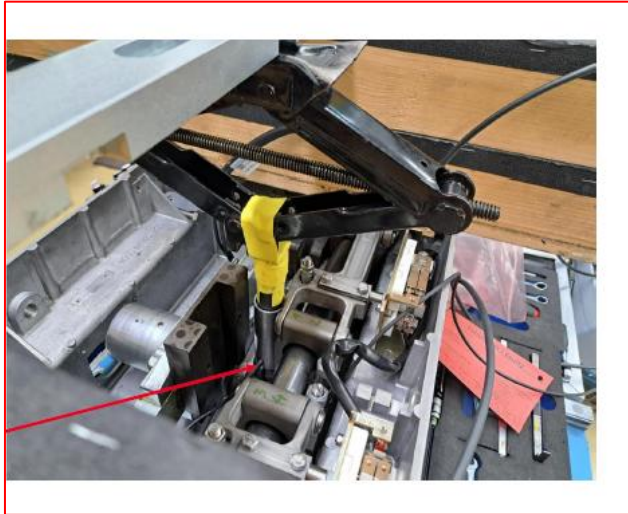


Reaction to the external force change is plausible, and as expected.

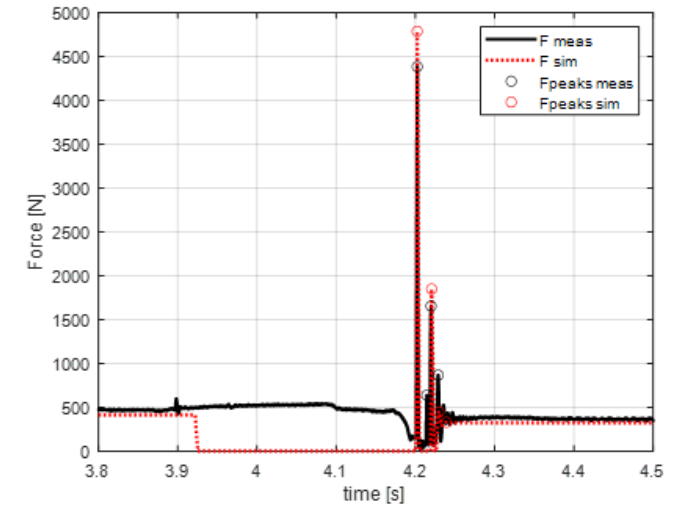
Digital Twin was also successfully validated against two lab experiments

- Performance of hydraulics under different ambient temperatures.
- Performance of specific components in detector mechanism.

Force measured in lab experiments



Results after optimisation



Parameter optimisation Techniques

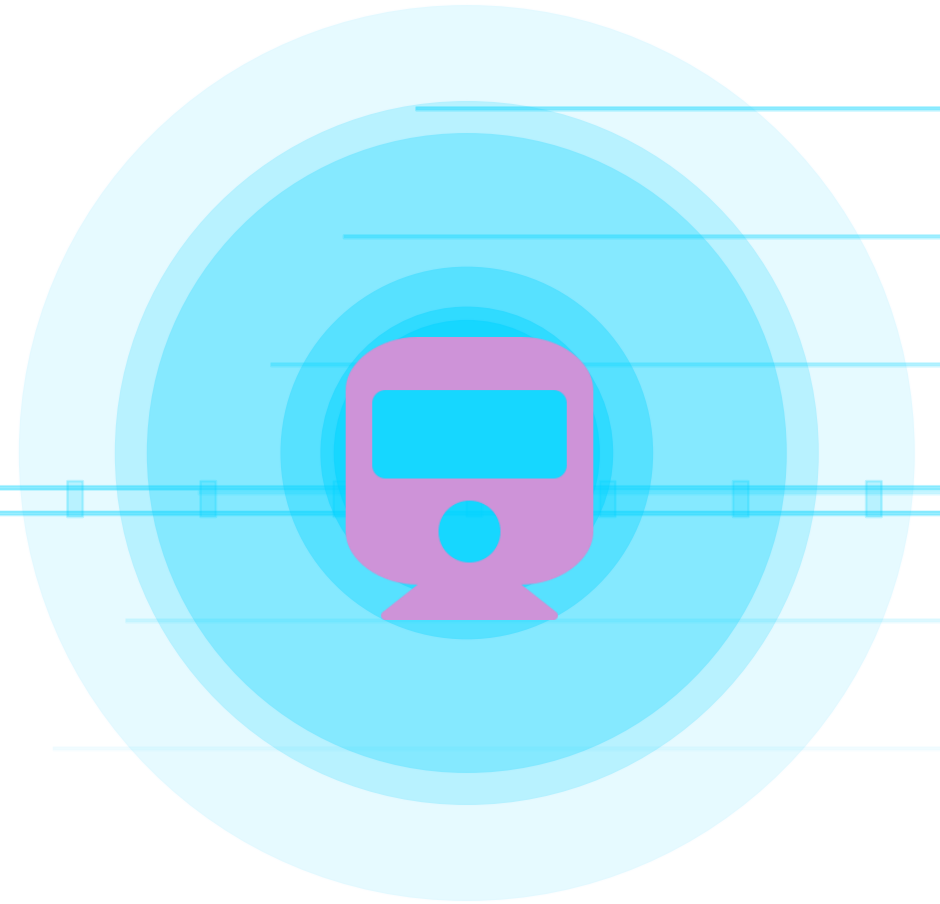
Parameter	Nominal Value	Optimised Value
Contact stiffness [MN/m]	3.0	2.35
Contact damping [kNs/m]	1.9	1.44
Spring damping [Ns/m]	3.0	1.87

Thank you for your attention

Flagship Project 1 MOTIONAL | 2026

Q&A Session

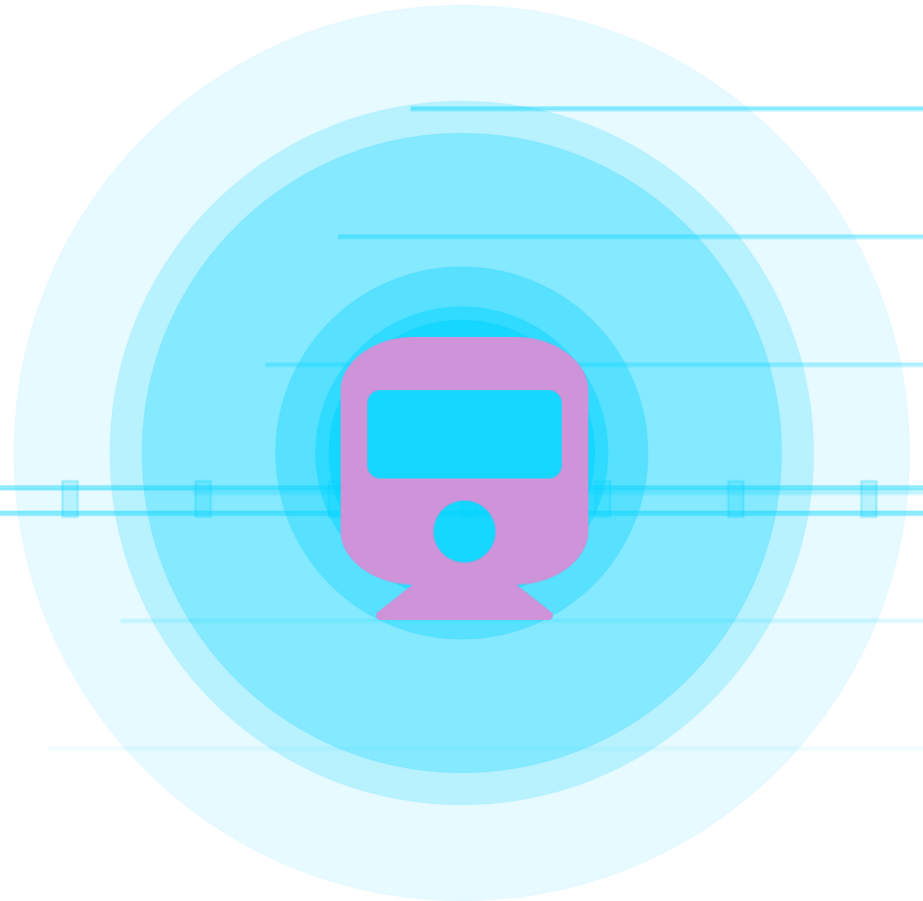
10 minutes



Flagship Project 1 MOTIONAL | 2026

Lunch Break

Please be back at 12:55



Data Backbone



VIEW 4: DATA BACKBONE

All these solutions only work if systems talk to each other - securely and at scale?

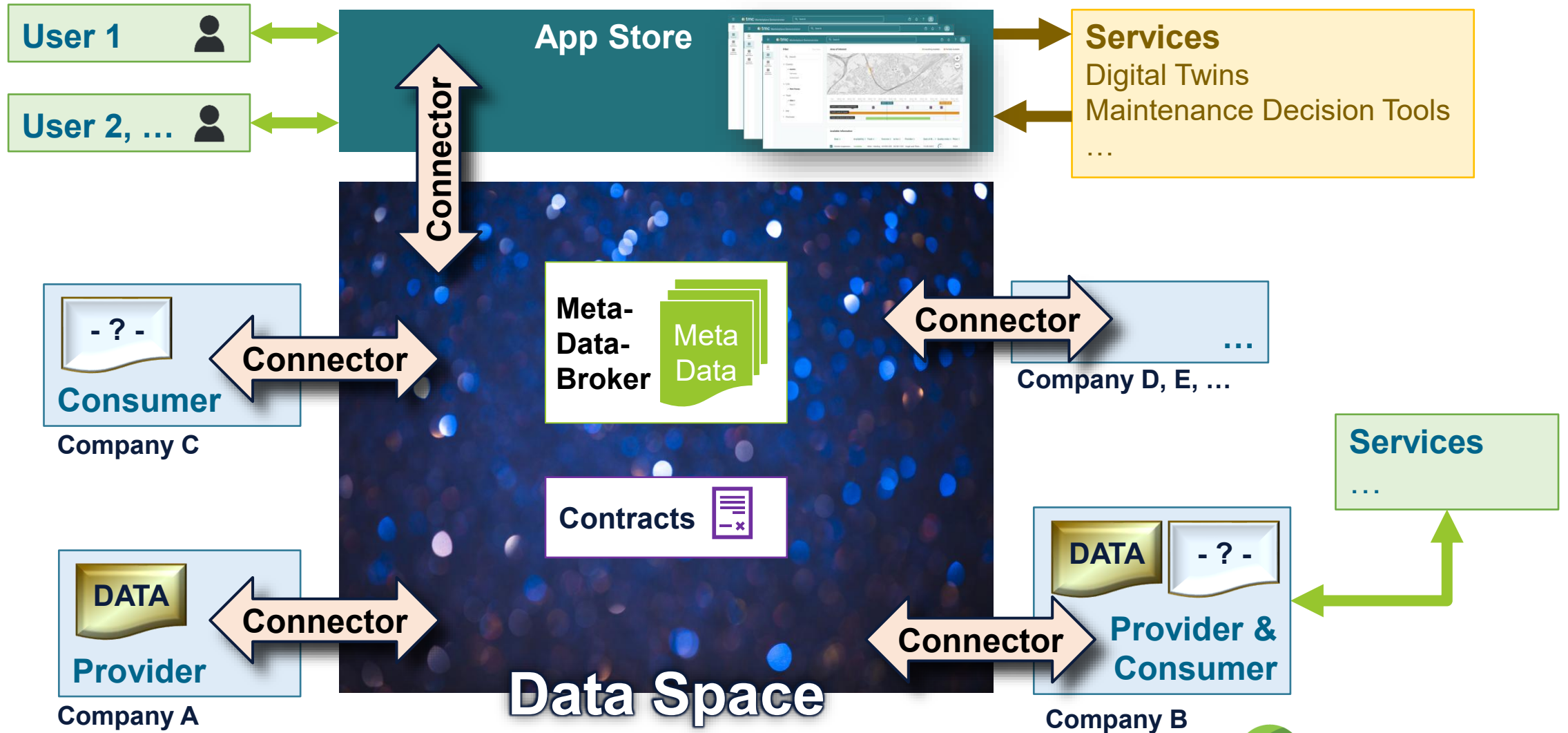
Demo 31.2,3,4

Virtual Vehicle Research, DEUTSCHES ZENTRUM FÜR LUFT – UND RAUMFAHRT EV (DLR) & Knorr-Bremse

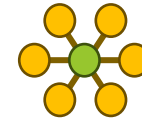
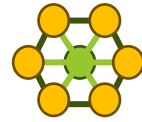
Federated Rail Data Space: secure connectors, metadata broker & app store - built with 12 railway value chain partners. Scalable & deployment-ready.



Overview of Data Space MotionRail-X



Why Data Space?



Criterion	Data Space	Direct B2B (EDI/API)	Data lake / central platform
Data Storage	At each party	At each party	Centralized
Data Sovereignty	Distributed	Distributed	Centralized
Single point of failure	None inherent	None inherent	Yes
Lock-in risk	Low	Medium–High	High
Discovery	Federated catalogues	None (“who knows whom”)	Centralized catalogue
Scalability	High	Low	High, but bottlenecks
Trust & identity	Centralized	Bilateral trust	Centralized
Standardization & Principles	Centralized	Fragmented and bilateral	Centralized
Governance	Centralized	Fragmented and bilateral	Centralized

Data Space:
combines
 advantages of
federated
 solutions with
centralization

Essential phases of sharing data via a Data Space

How to share data?



Essential phases of sharing data via a Data Space

How to share data?



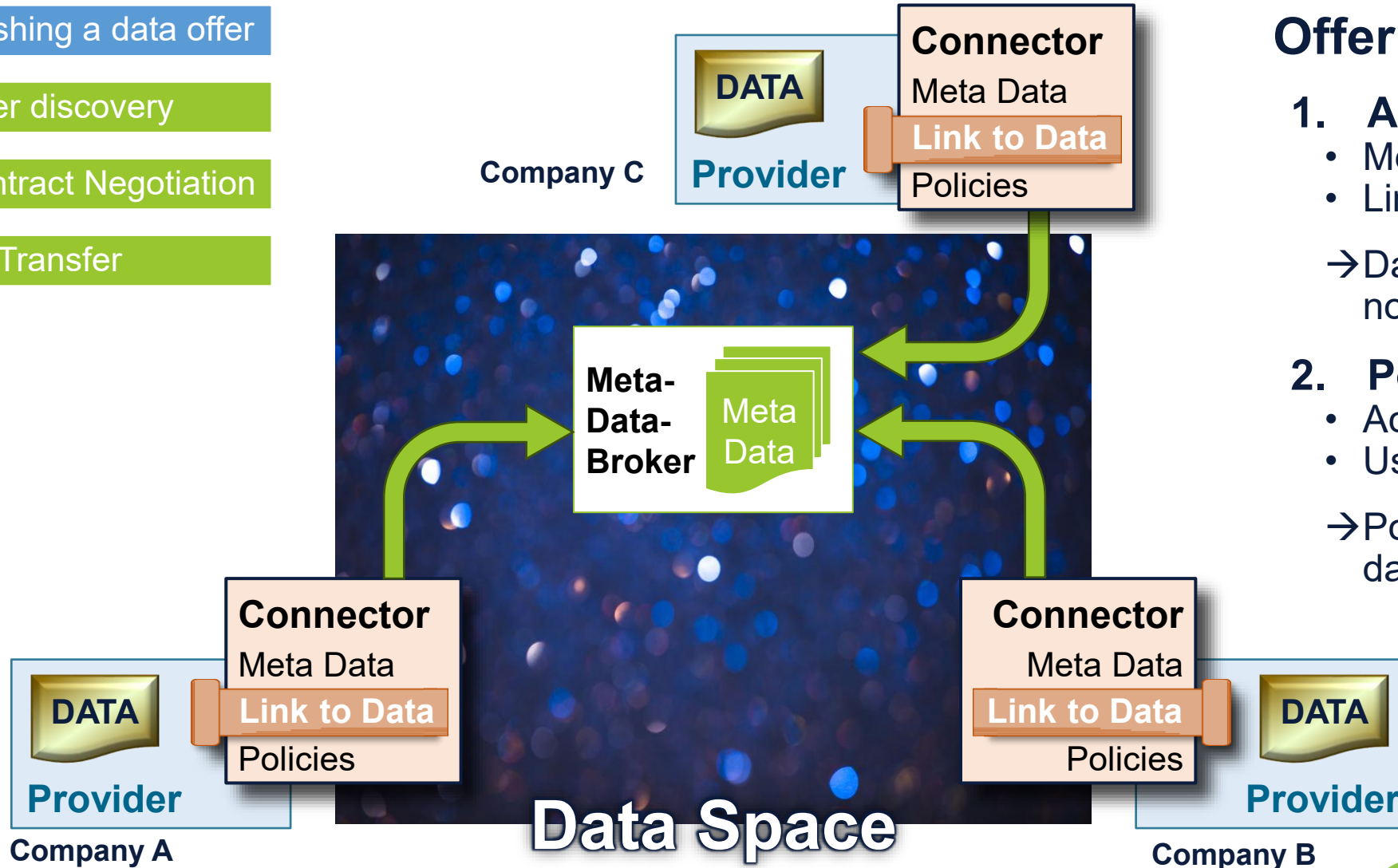
Overview of Data Space – How to share data

1 Publishing a data offer

2 Offer discovery

3 Contract Negotiation

4 Data Transfer



Offer consists of:

1. Asset

- Meta Data
- Link to actual Data

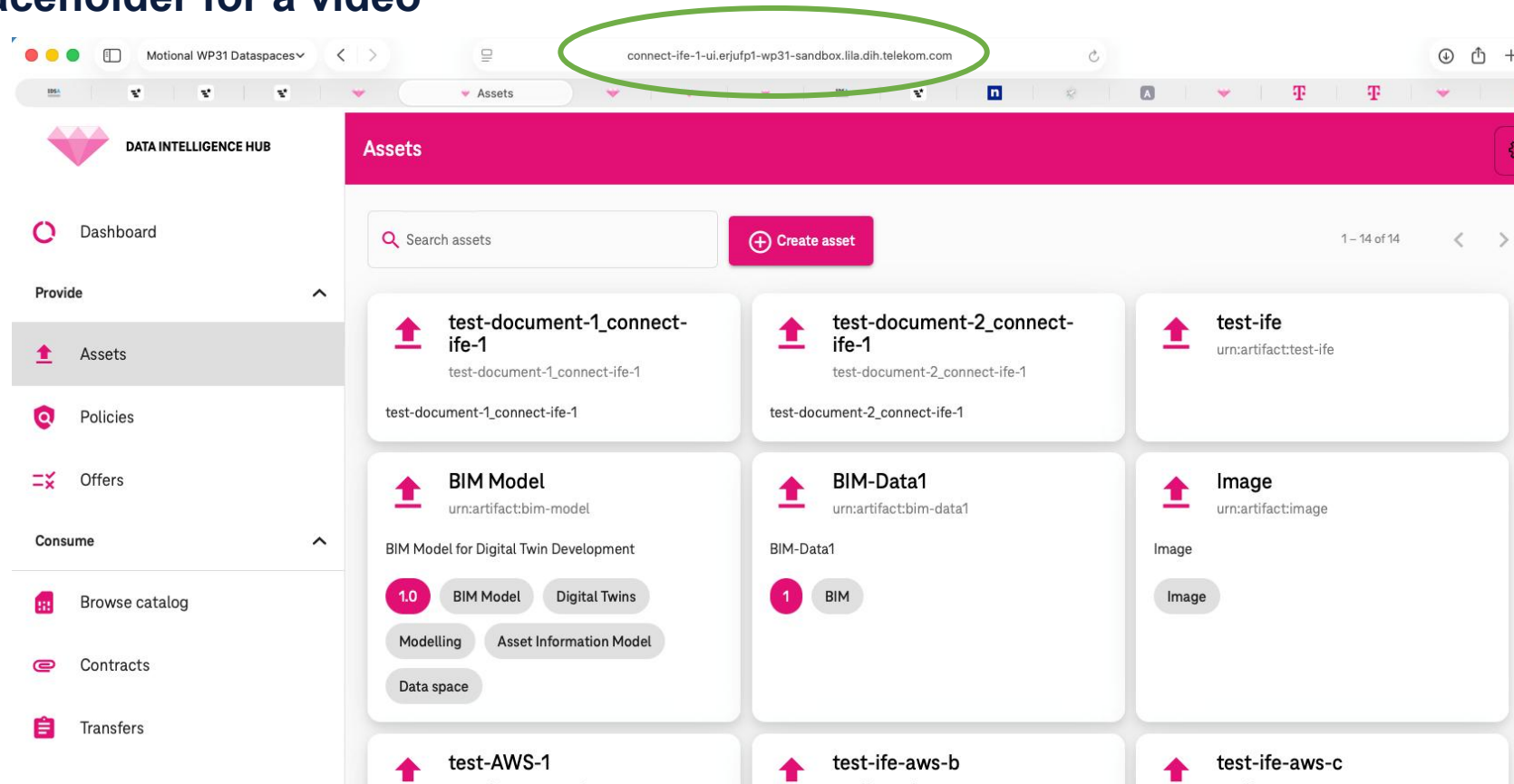
→ Data Space does not host the data!

2. Policies

- Access Policy
- Usage Policy

→ Policies defined by data provider

This is just a placeholder for a video



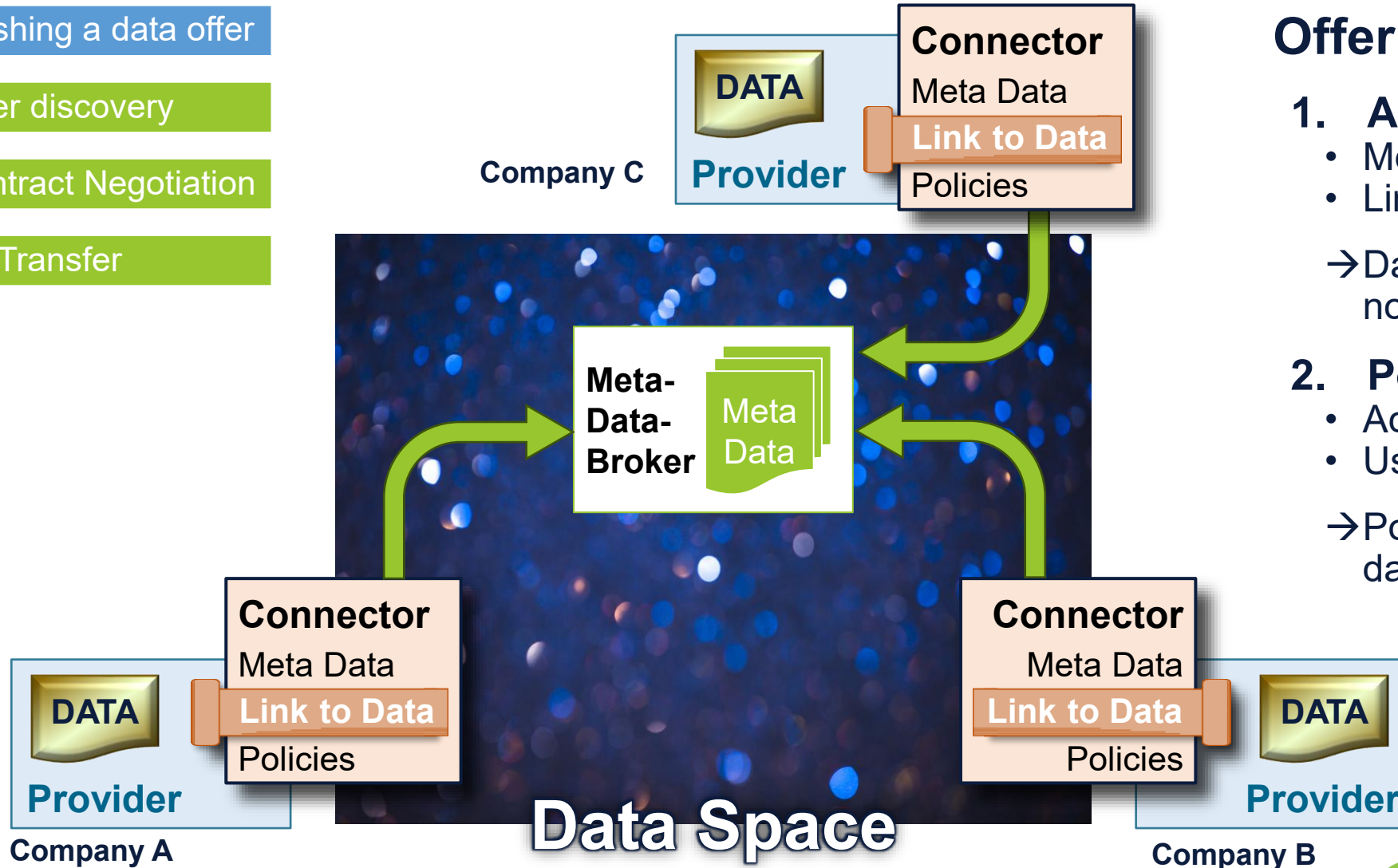
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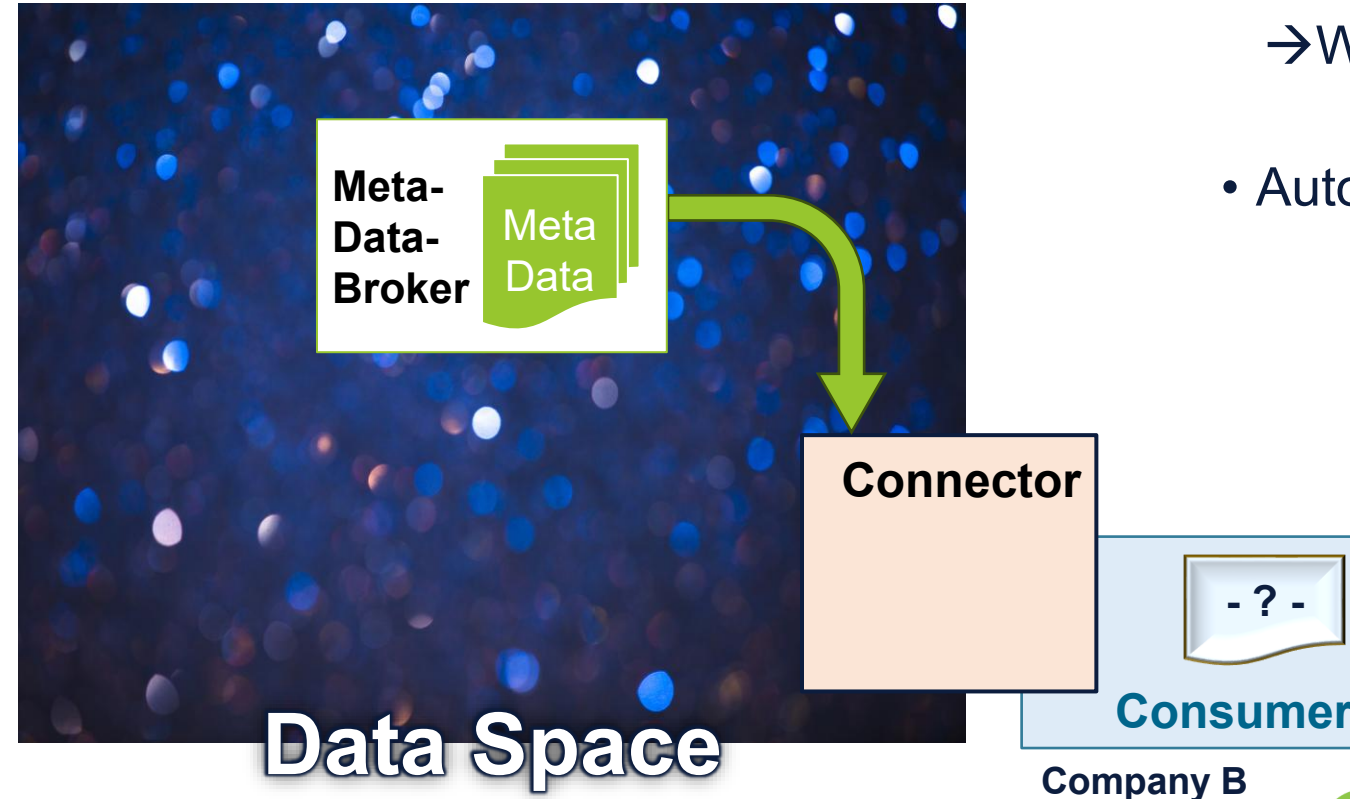
→ Policies defined by data provider

Overview of Data Space – How to share data

- 1 Publishing a data offer
- 2 Offer discovery
- 3 Contract Negotiation
- 4 Data Transfer

Interaction:

- Manual
→ Web UI
- Automatic



Overview of Data Space – How to share data

- 1 Publishing a data offer
- 2 Offer discovery
- 3 Contract Negotiation
- 4 Data Transfer

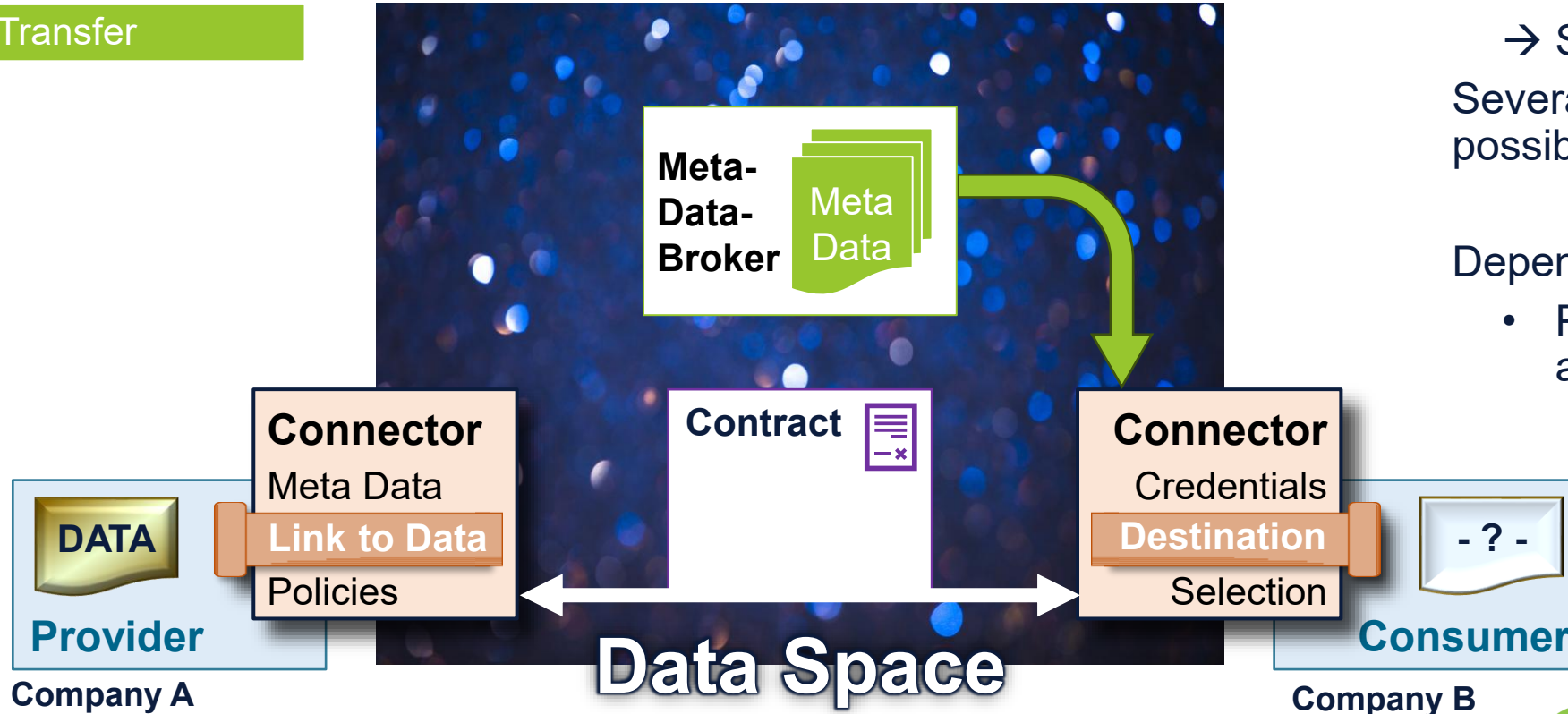
Negotiation guided by consumer

- Supply credentials
- Define destination for data
- Select a policy

Several active contracts possible

Depending on Policy:

- Provider may agree/disagree

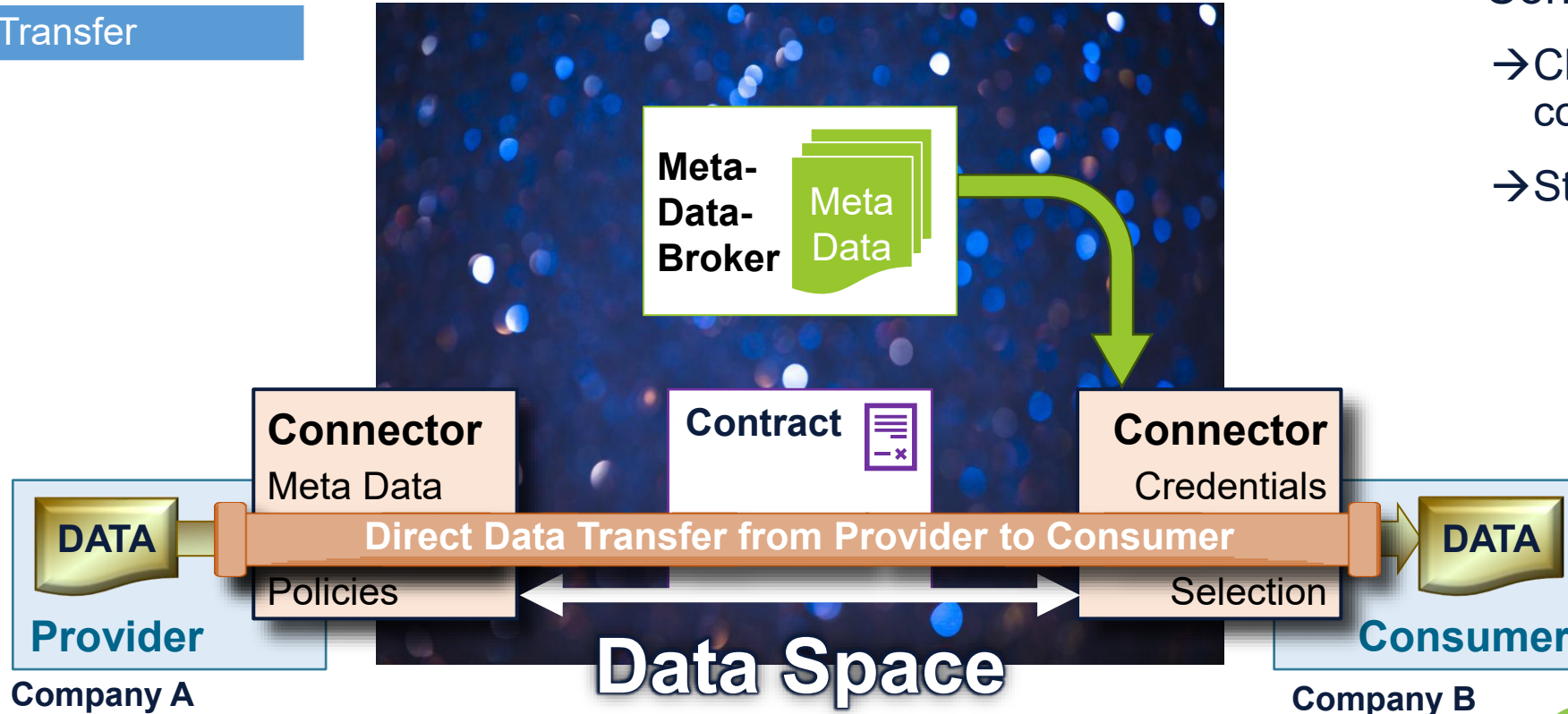


Overview of Data Space – How to share data

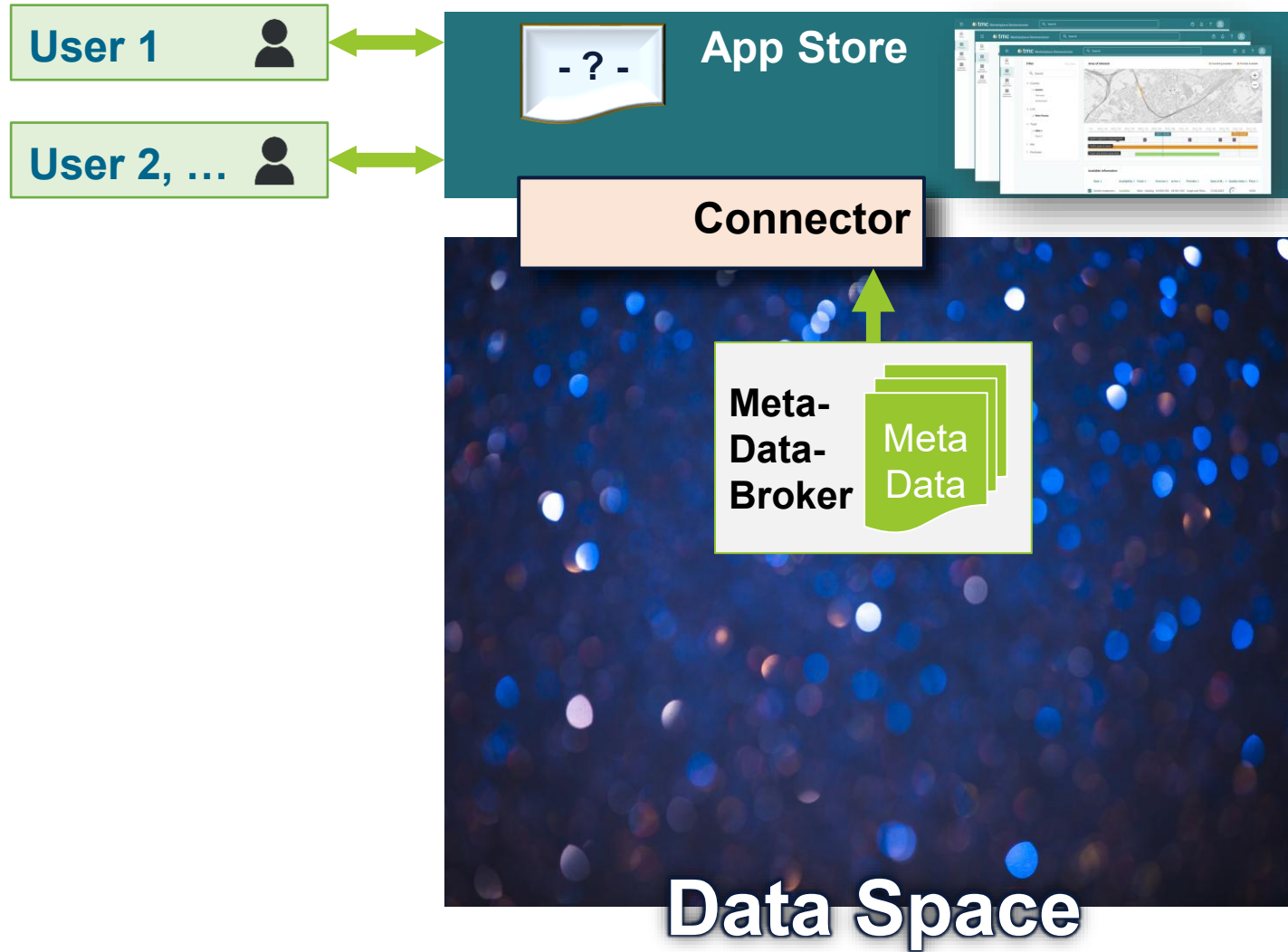
- 1 Publishing a data offer
- 2 Offer discovery
- 3 Contract Negotiation
- 4 Data Transfer

Automatic data transfer

- Connector
 - Checks usage conditions
 - Starts transfer

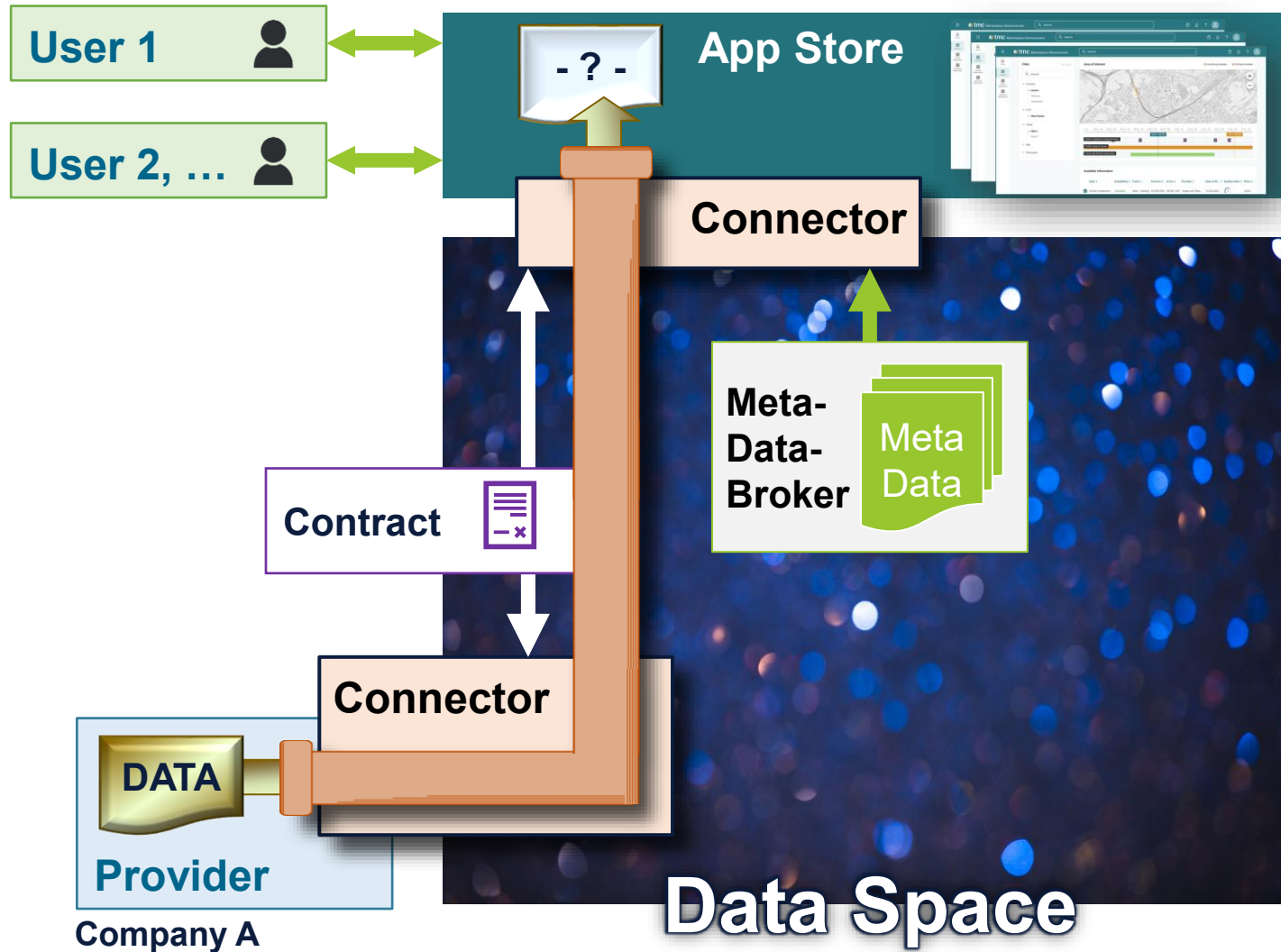


Overview of Data Space – App Store



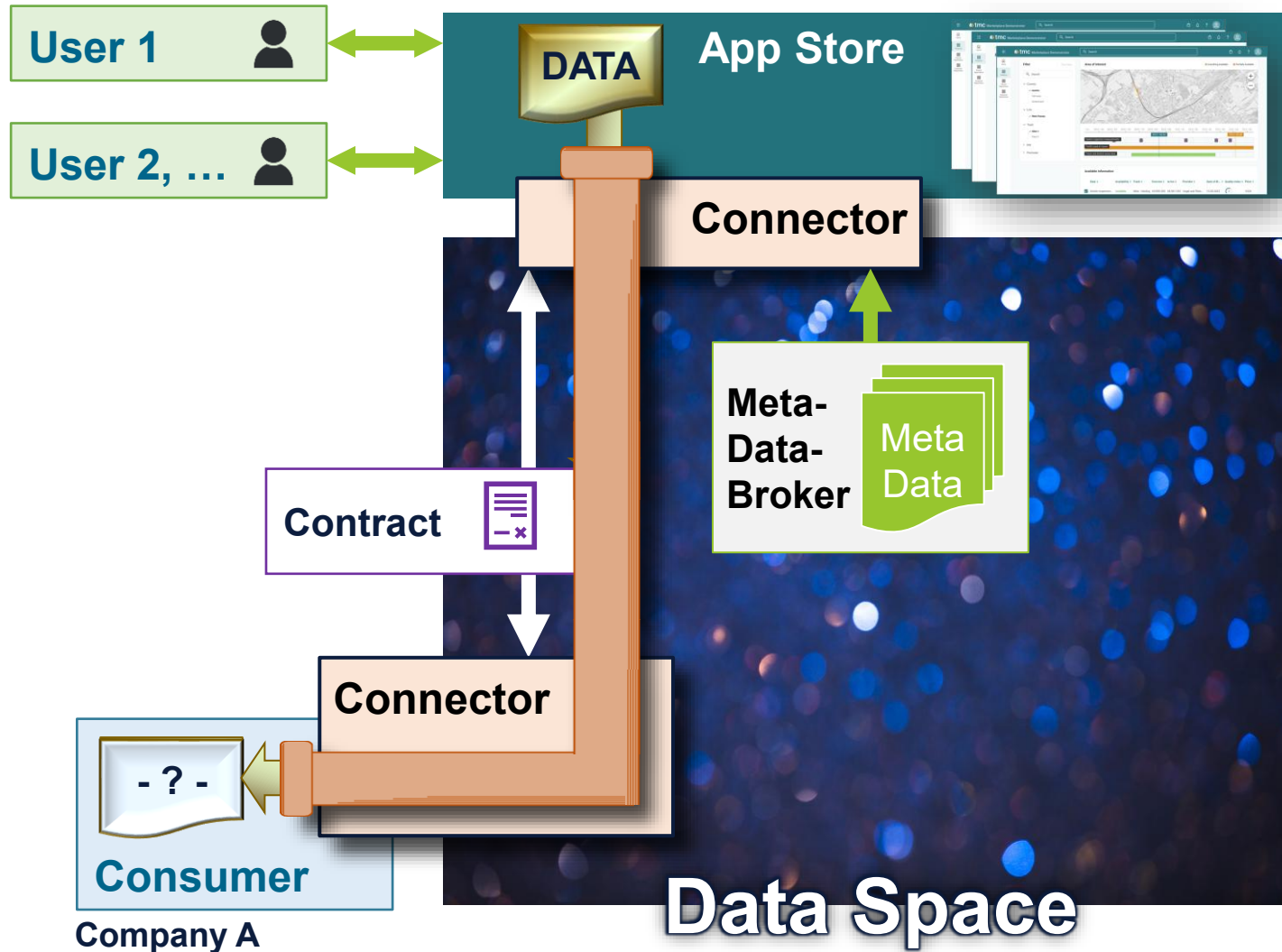
App Store

- Easy to use GUI for customers/users
- Hosts catalogue of available data



App Store

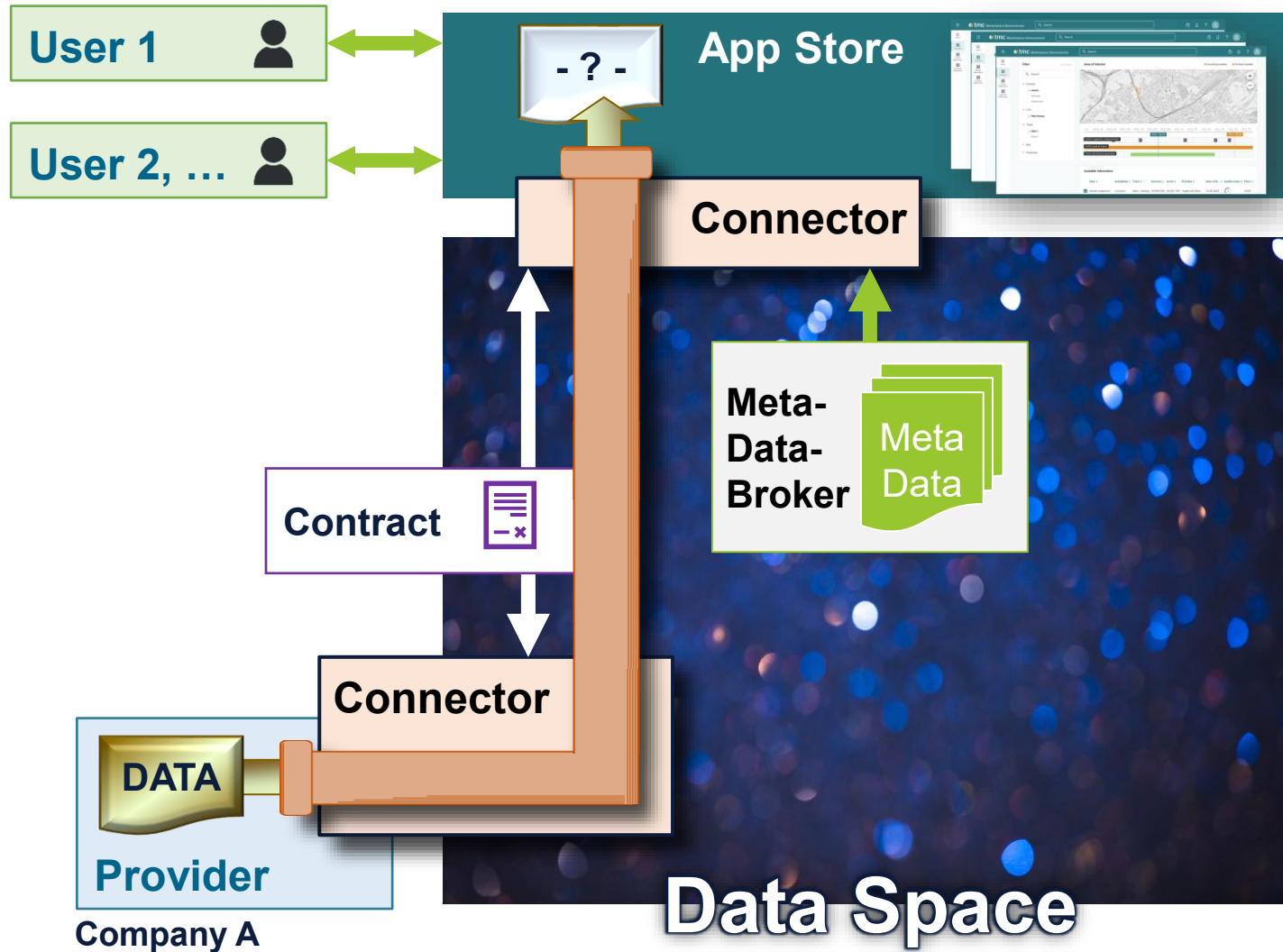
- Easy to use GUI for customers/users
- Hosts catalogue of available data
- Acts like any data consumer



App Store

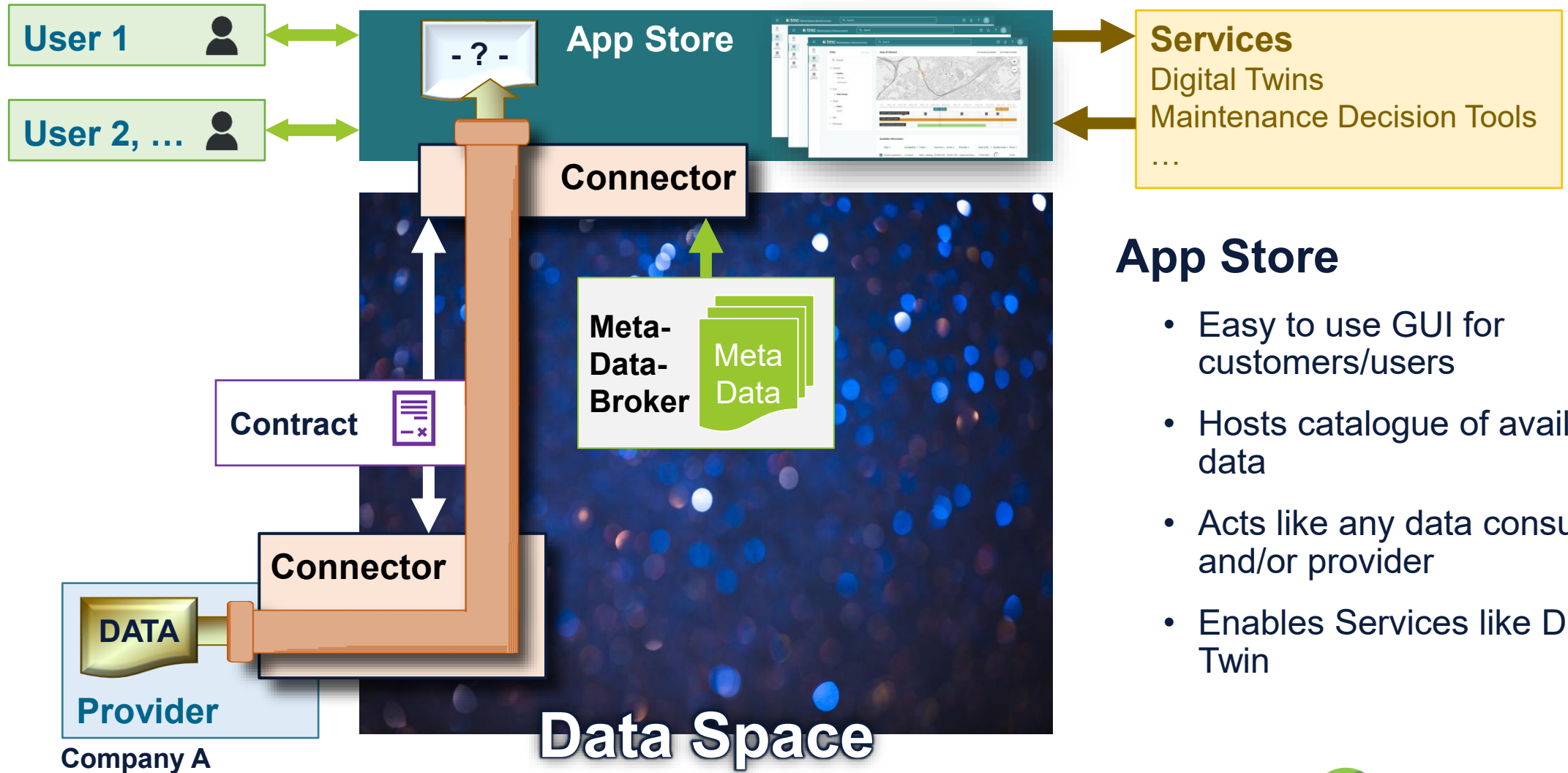
- Easy to use GUI for customers/users
- Hosts catalogue of available data
- Acts like any data consumer and/or provider

Overview of Data Space – App Store



App Store

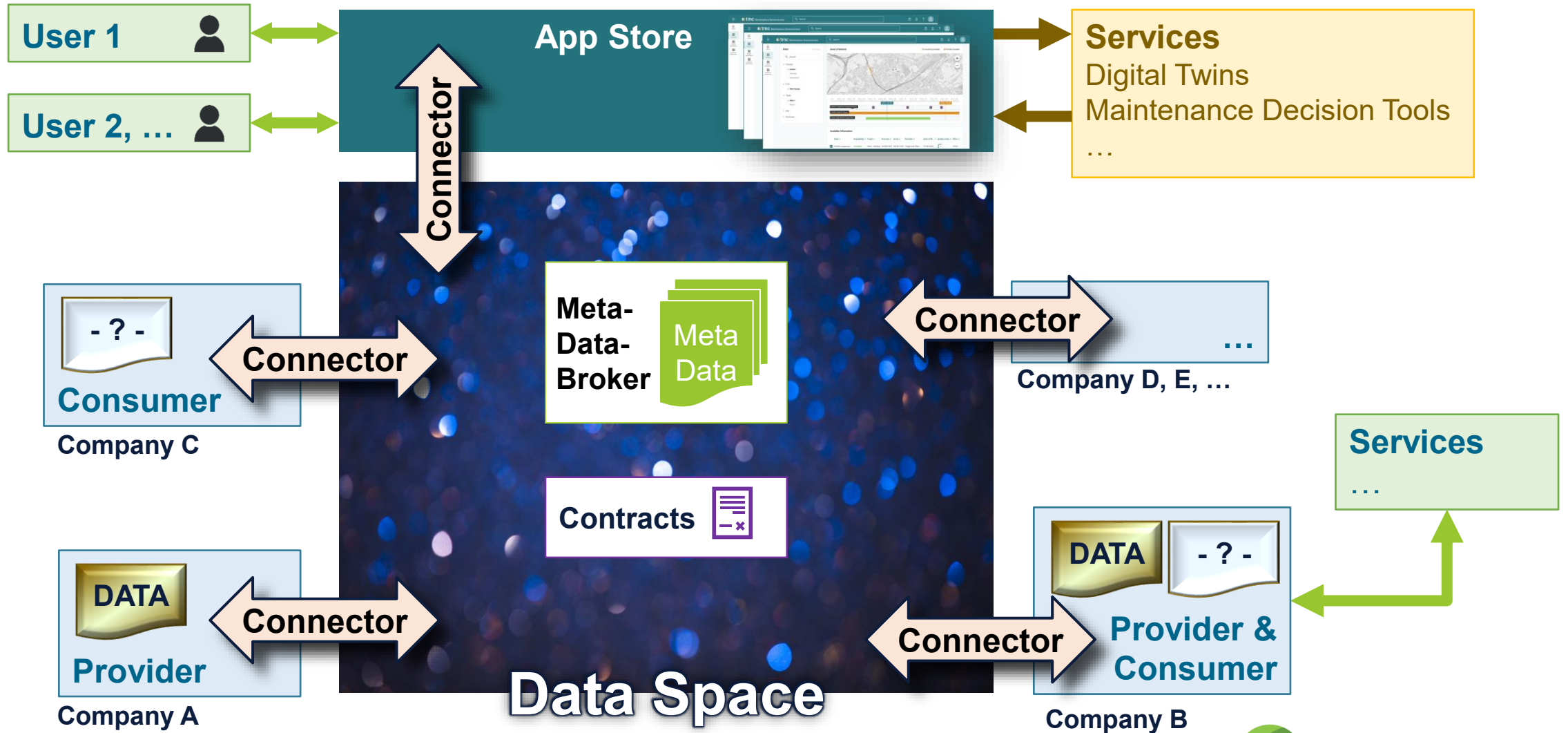
- Easy to use GUI for customers/users
- Hosts catalogue of available data
- Acts like any data consumer and/or provider



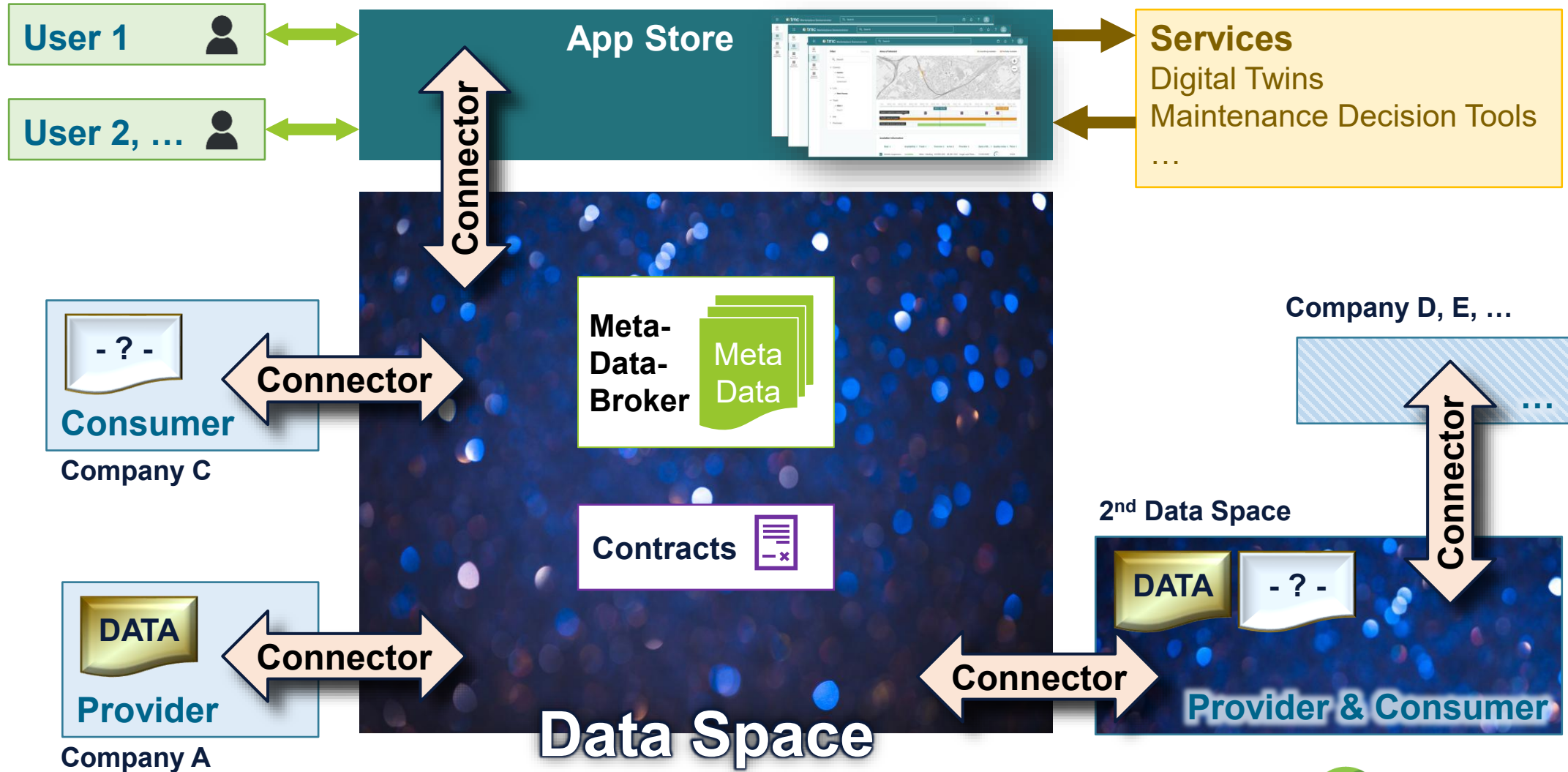
App Store

- Easy to use GUI for customers/users
- Hosts catalogue of available data
- Acts like any data consumer and/or provider
- Enables Services like Digital Twin

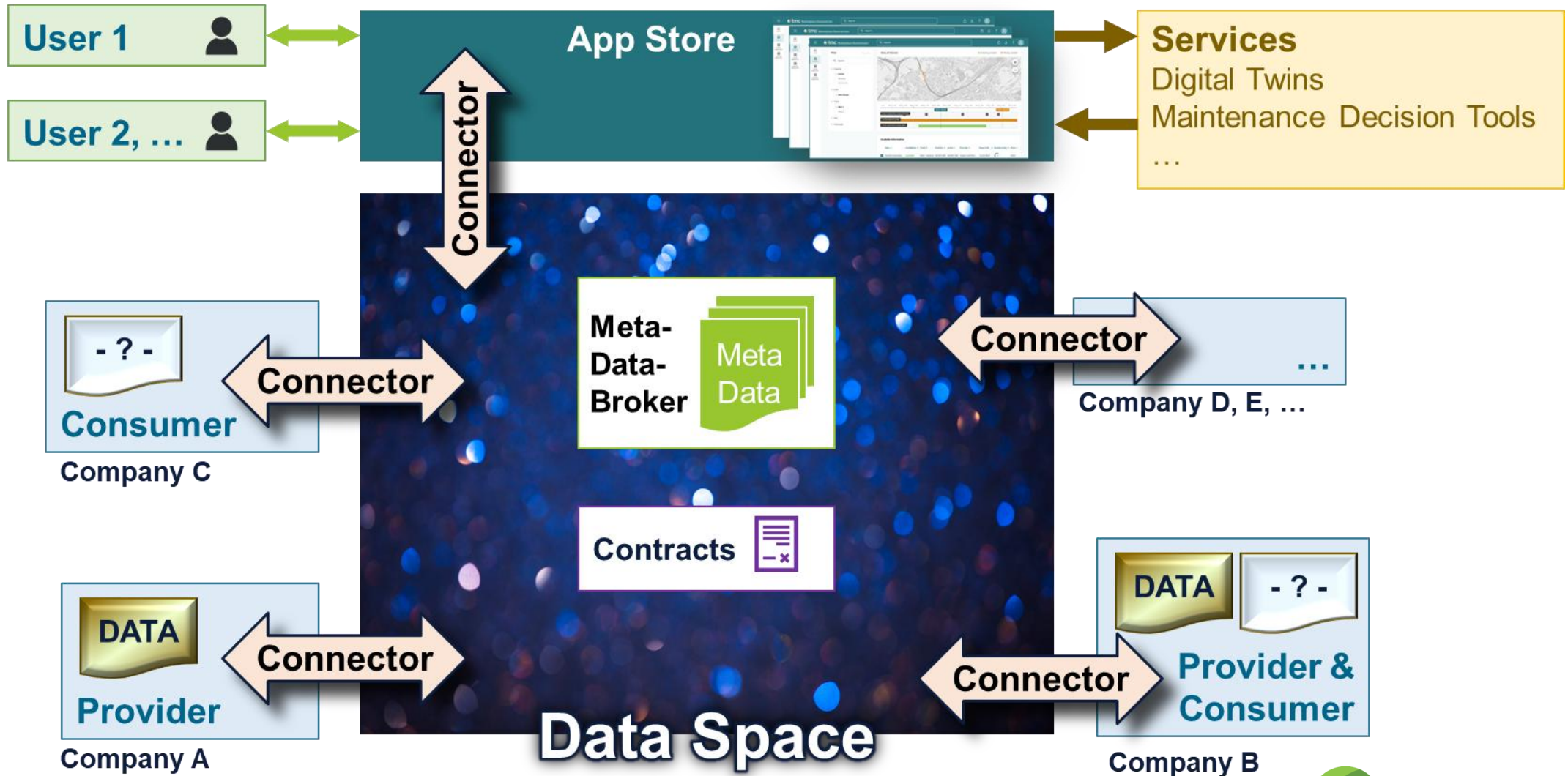
Overview of Data Space MotionRail-X



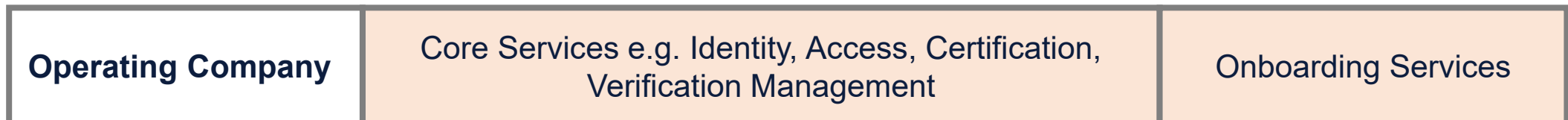
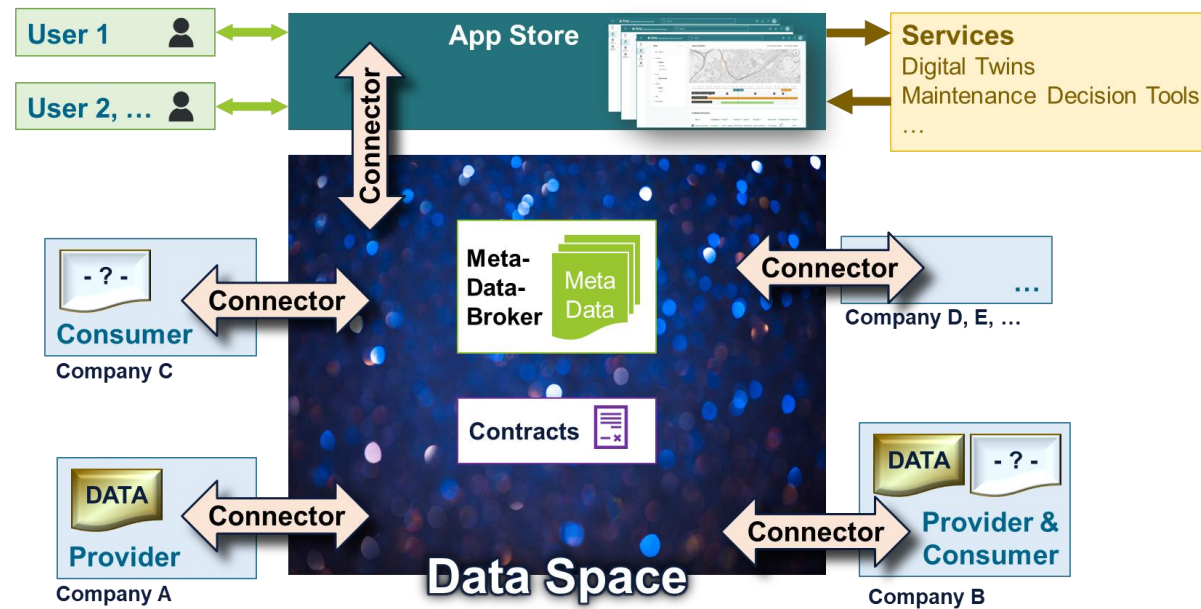
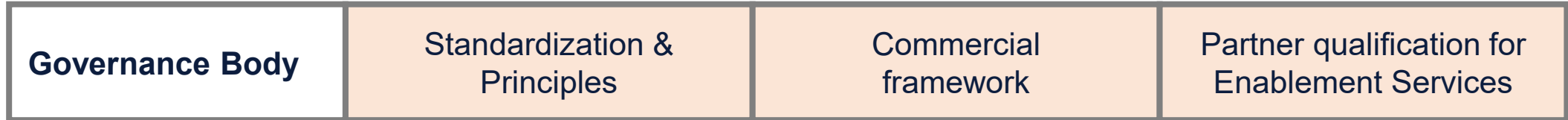
Overview of Data Space MotionRail-X



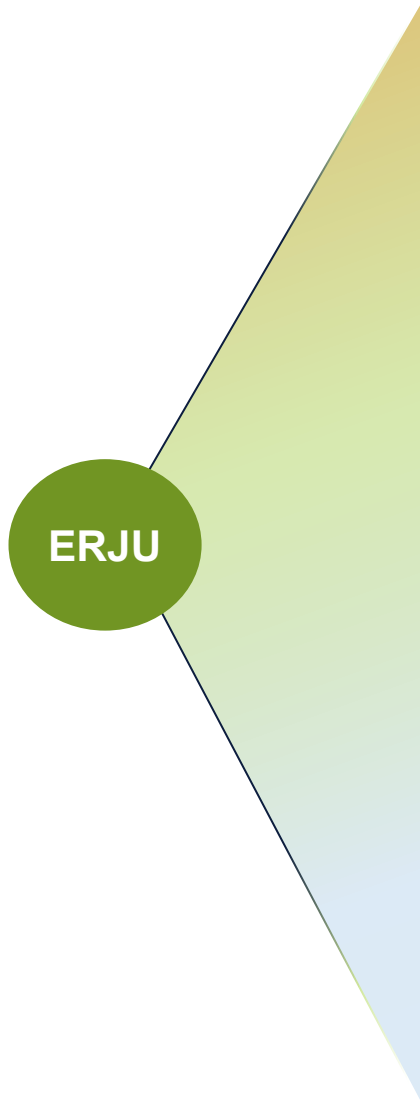
Overview of Data Space MotionRail-X



Overview of Data Space



What have we achieved so far...



Technical Architecture design

- Define architectural design including ways of work, methodology, typology and framework
- Align core service and use case priorities within consortium to set up development environment

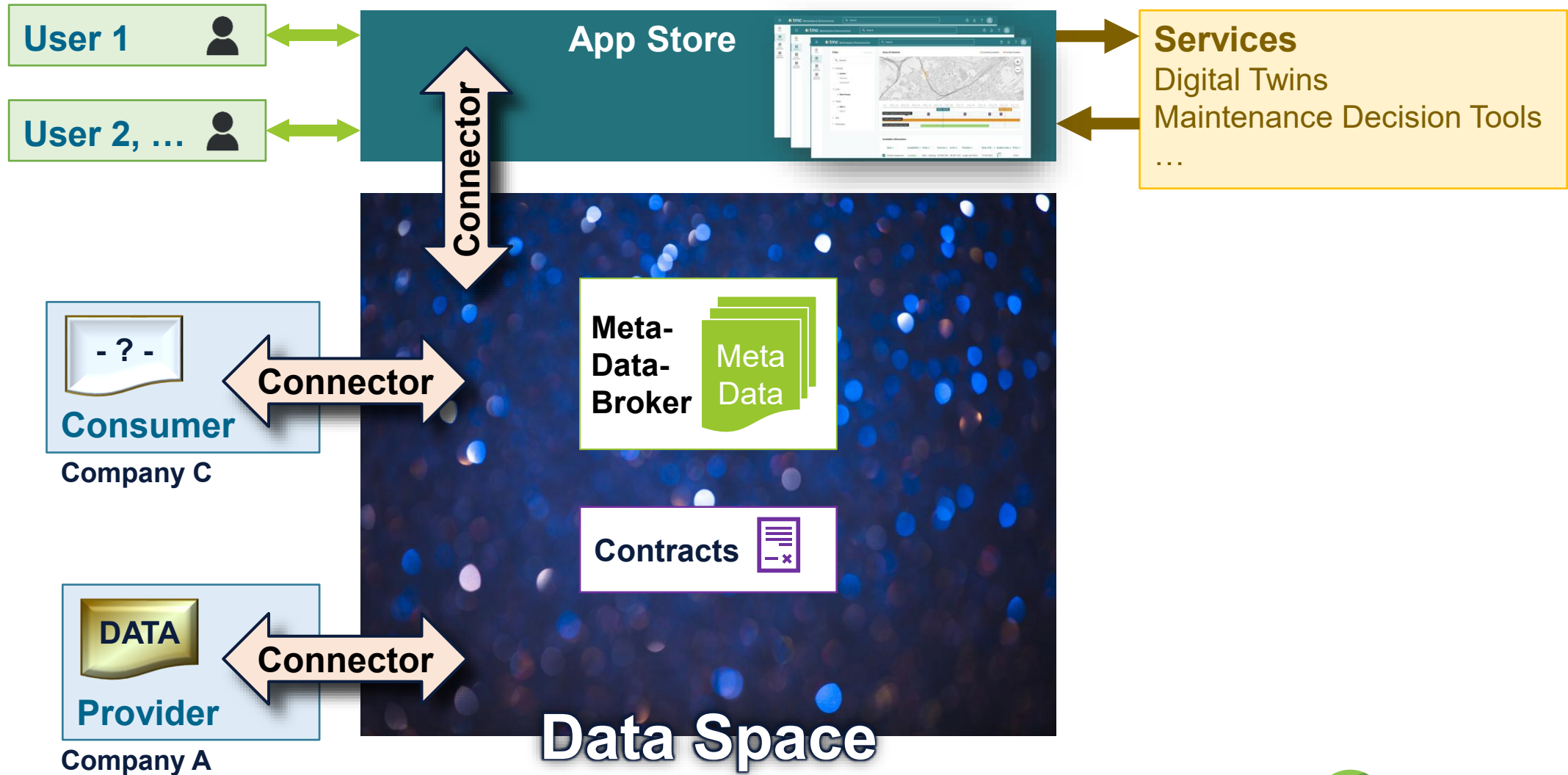
Use Case development

- Design format of use case development, conduct workshops on use cases, prioritize use cases for development
- Shape and align use case content within consortium
- Implement selected use case into data space and app store

Governance Model design

- Design framework for operating and business model in alignment with all players to shape work after/within second call
- Define respective roles within designed model and assign these

Implementation of Use-Case: 'Track Settlement at Switches'

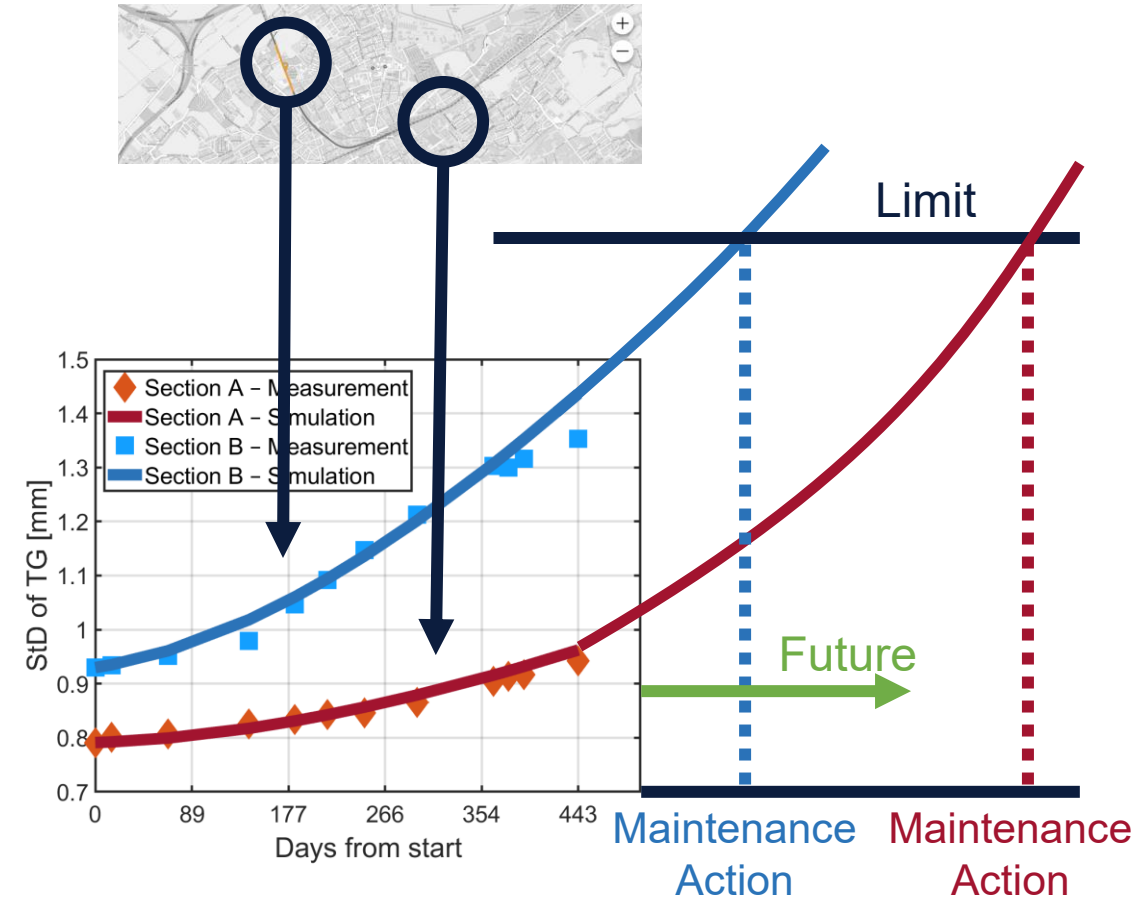


Monitoring of Track Settlement and Identification of Single-Faults in Switches

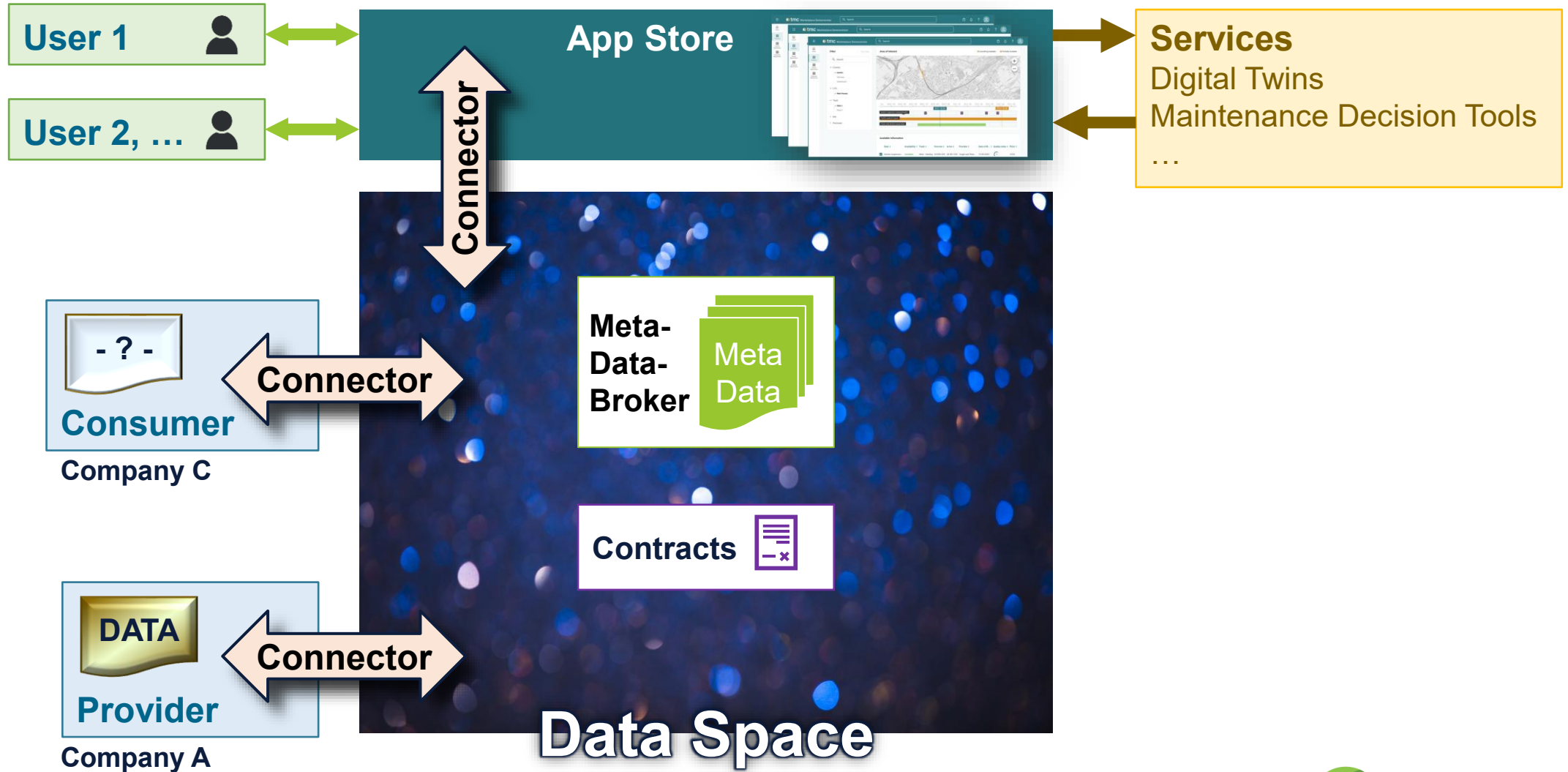
- How do elastic components influence the ballast settlement in switches?
- How good agree model predictions and measurements?
- Can the model predict voids under the frog?
 - What sensors/measurements are necessary to find the most important parameters regarding voiding and settlement?
- Improvements in understanding the complete switch-system
- What can the infrastructure provider realistically expect from the model and what will not be considered?

Developed and validated in FP3 – lam4Rail

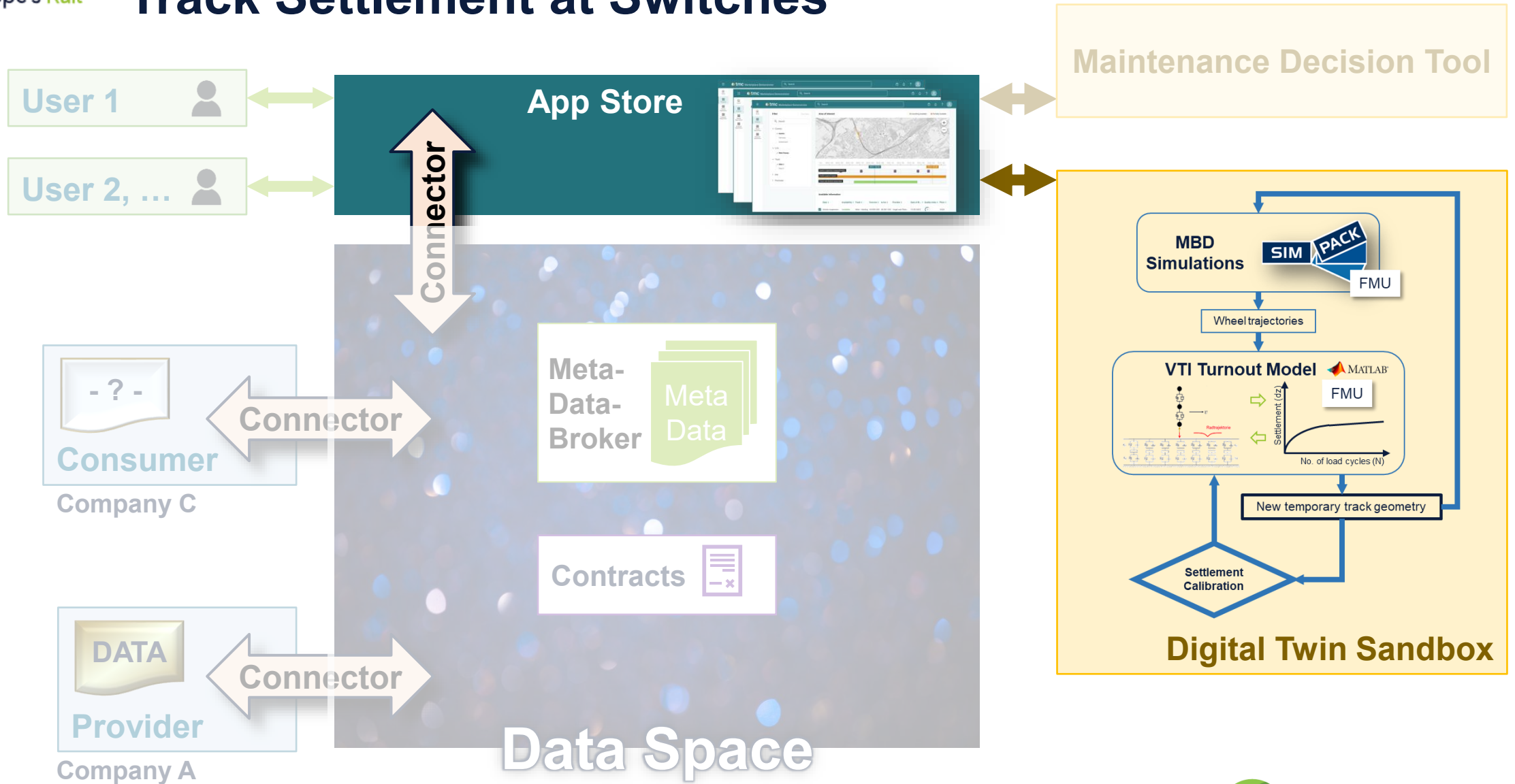
Here: IT-Infrastructure in Focus, not model quality



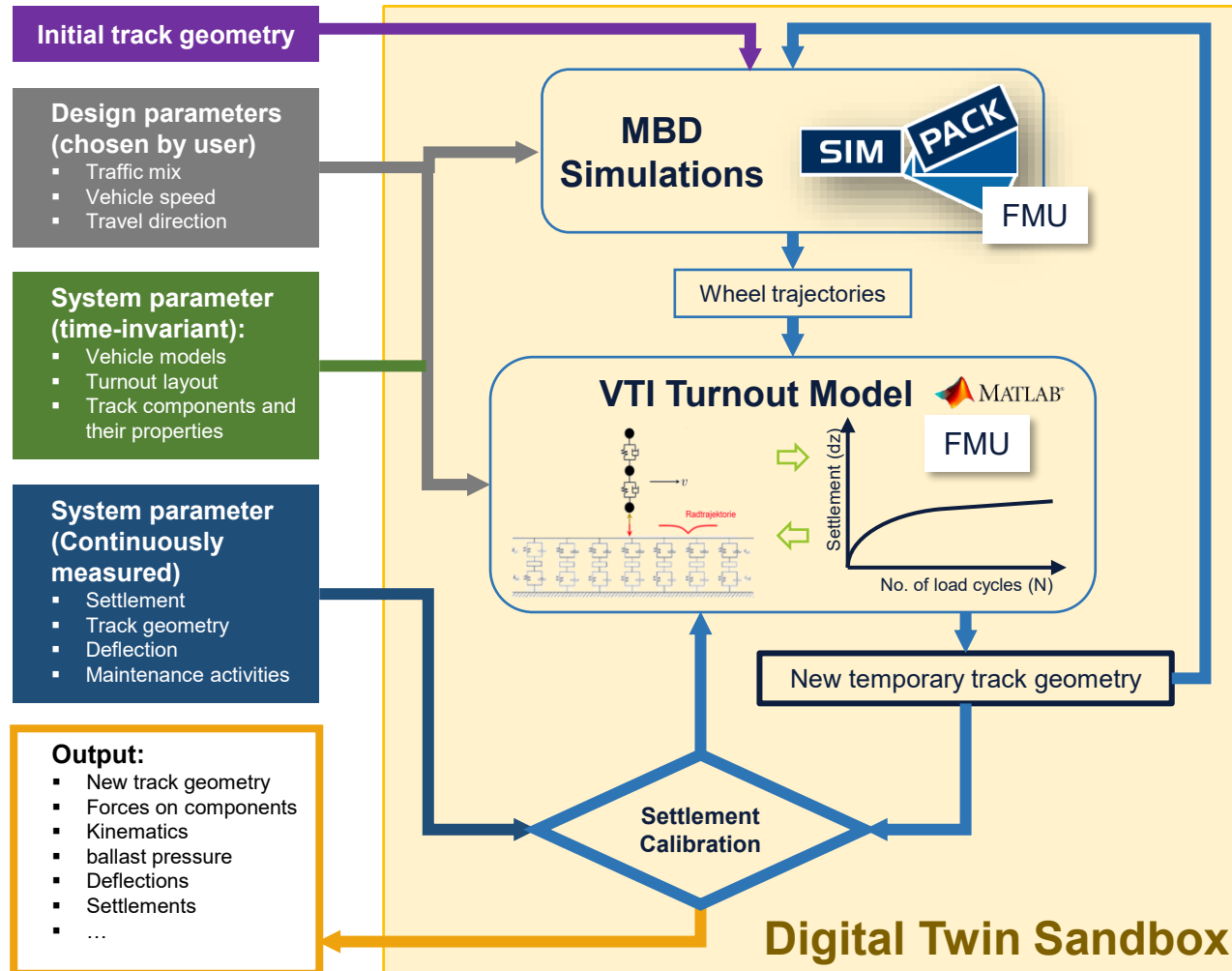
Implementation of Use-Case: 'Track Settlement at Switches'



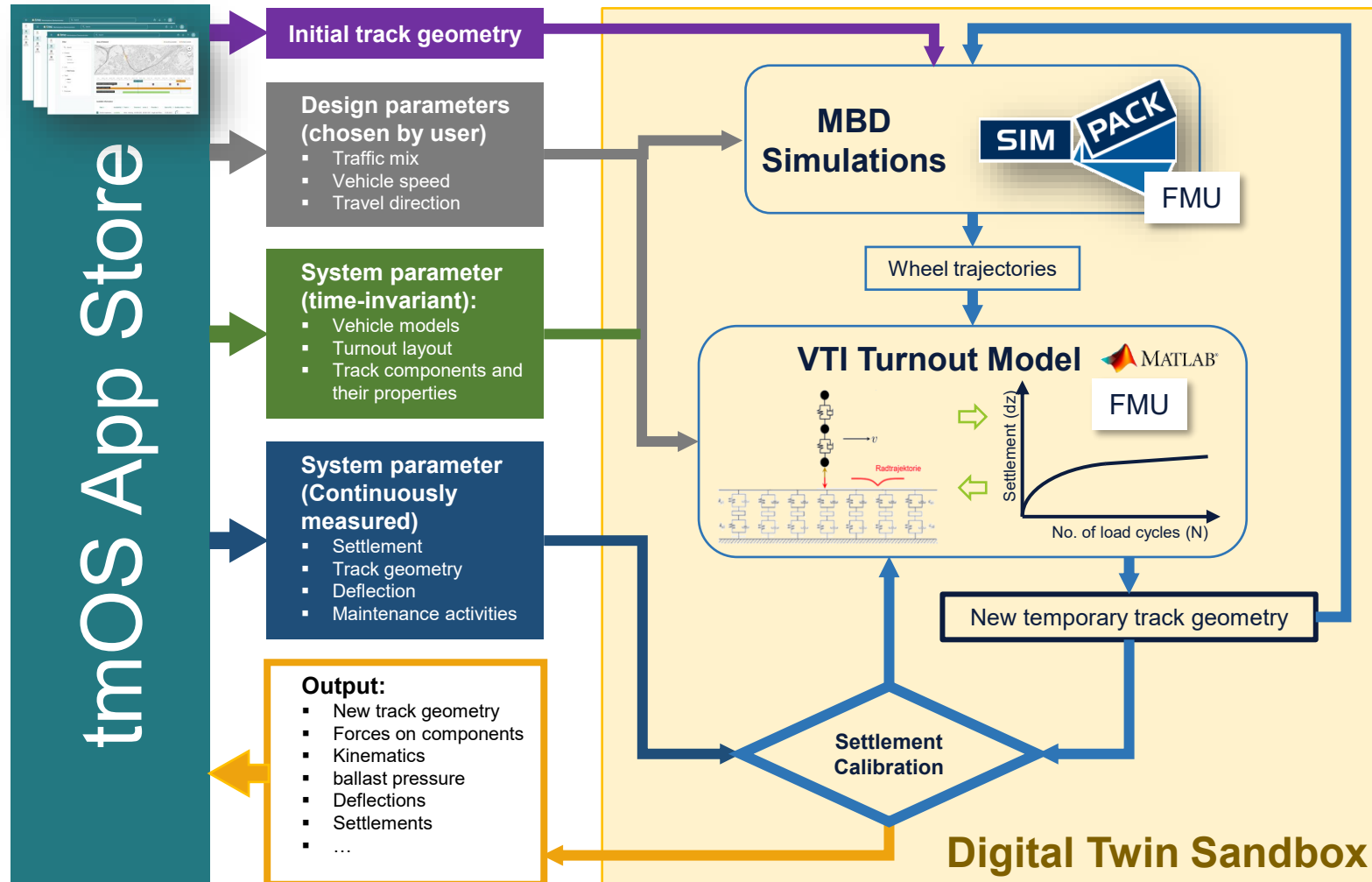
Implementation of Use-Case: 'Track Settlement at Switches'



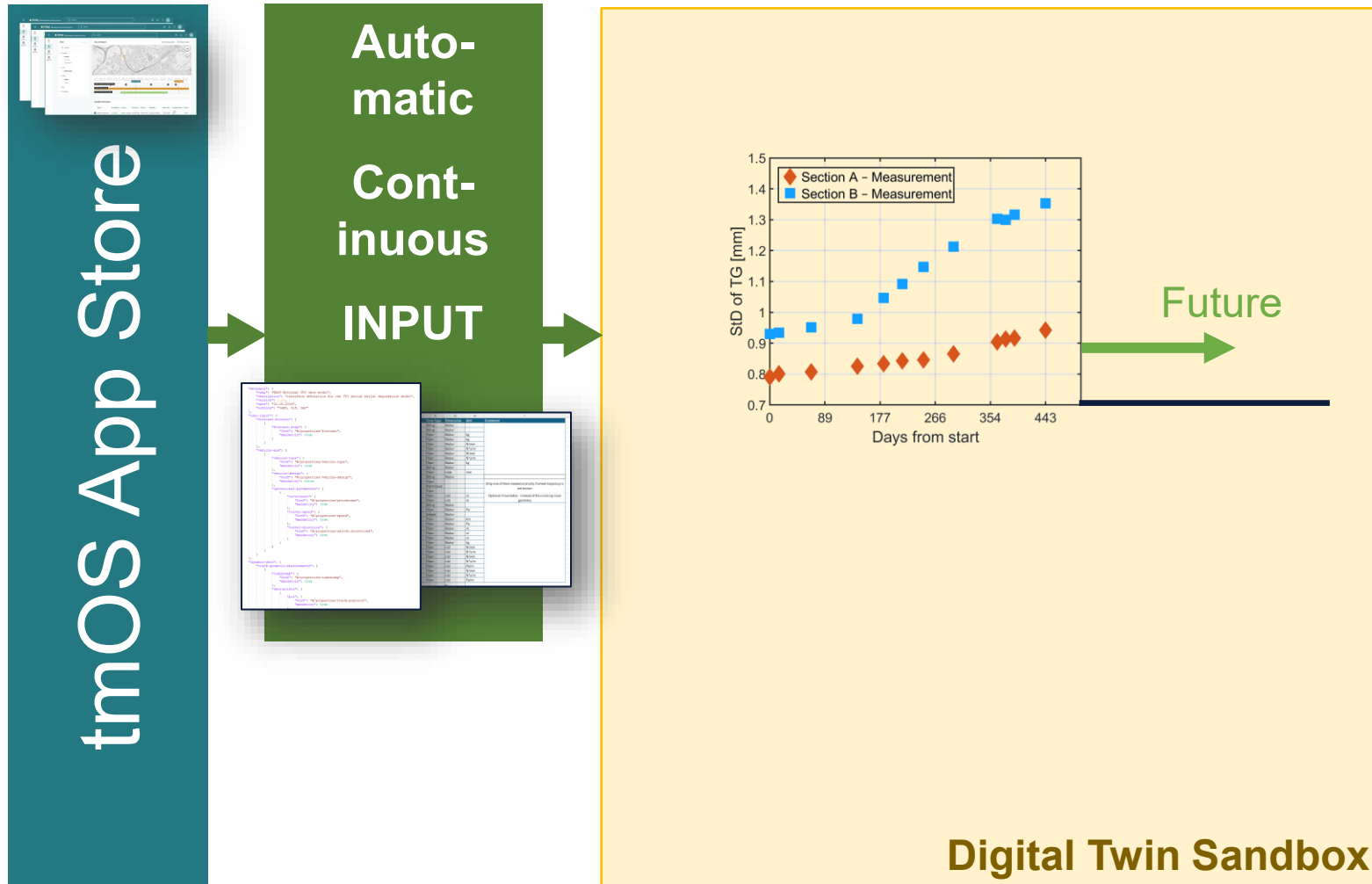
Implementation of Use-Case: 'Track Settlement at Switches'



Implementation of Use-Case: 'Track Settlement at Switches'



Implementation of Use-Case: 'Track Settlement at Switches'

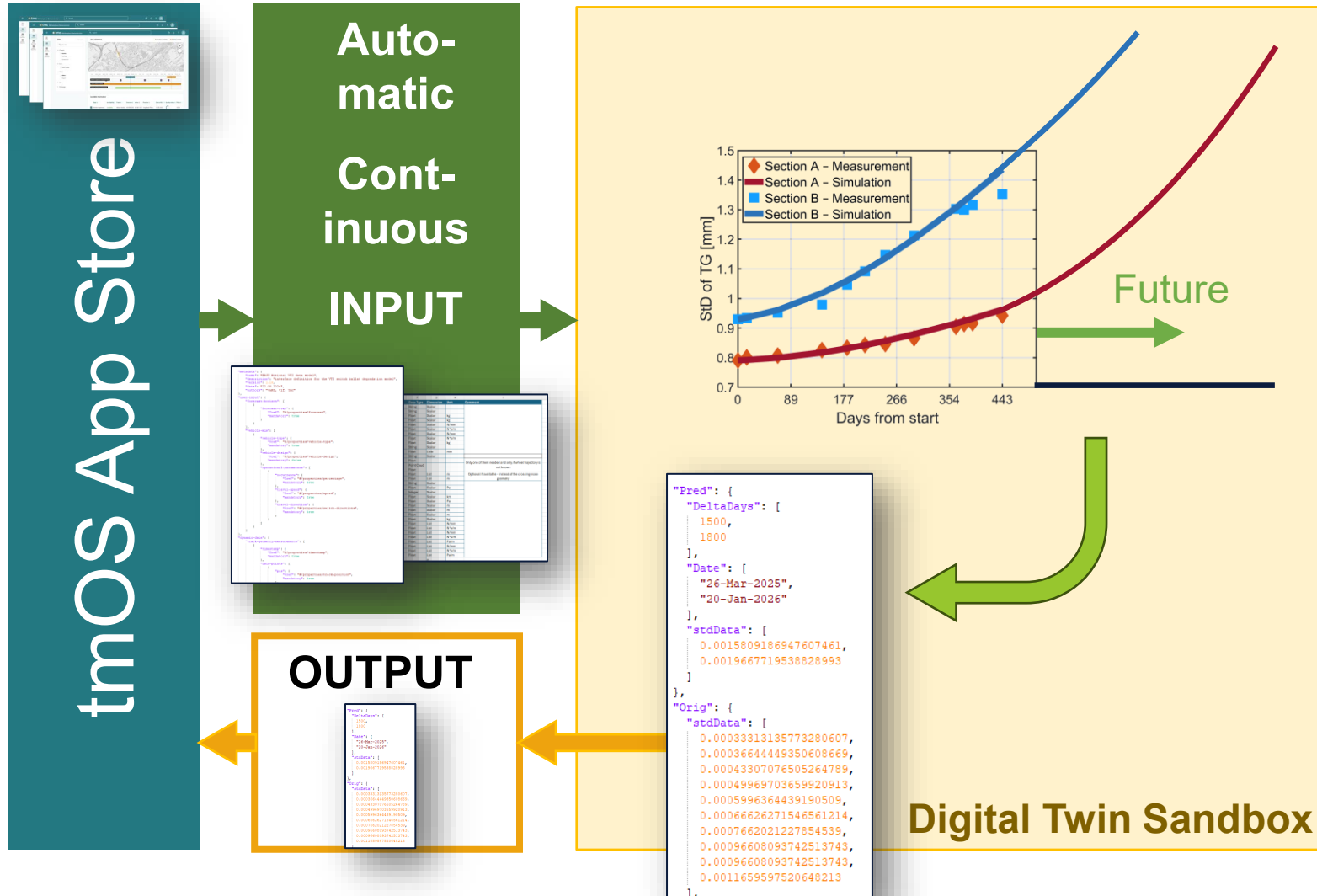


Challenges:

- **Data**
 - Availability
 - Format
 - Quality

- **Pipeline**
 - Models
 - Interfaces
 - Servers
 - Triggers

Implementation of Use-Case: 'Track Settlement at Switches'

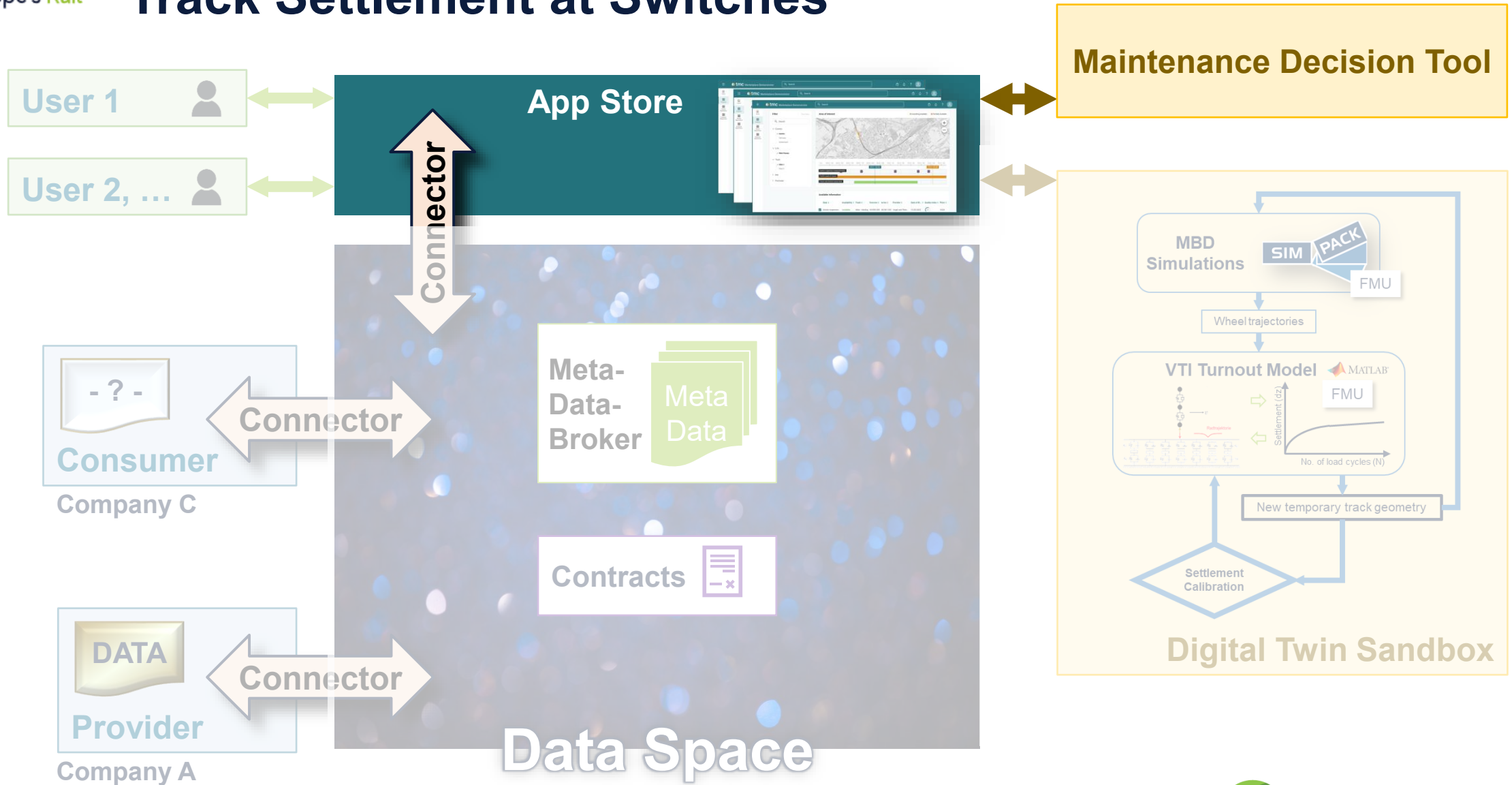


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 - Triggers

Implementation of Use-Case: 'Track Settlement at Switches'



Implementation of Use-Case: 'Track Settlement at Switches'

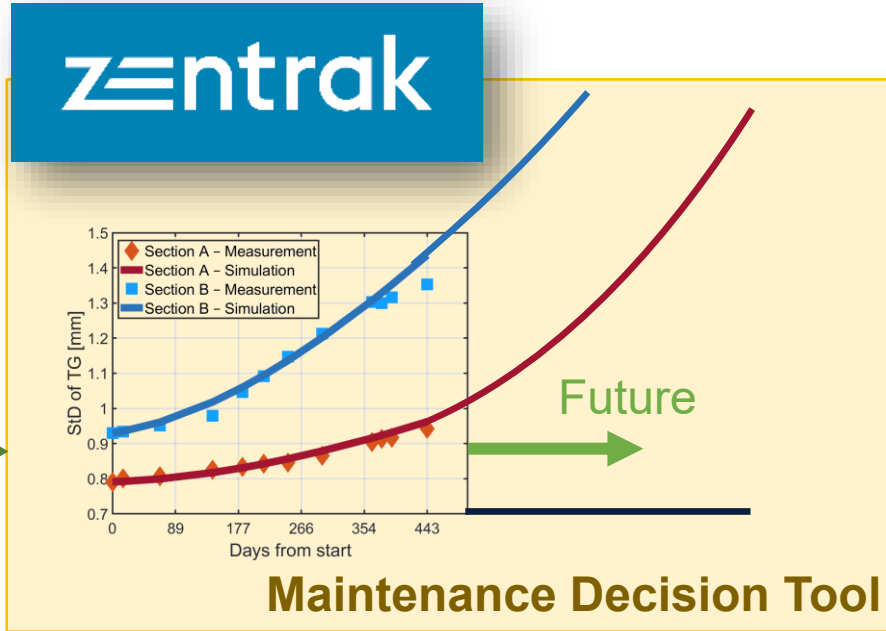
MOTIONAL

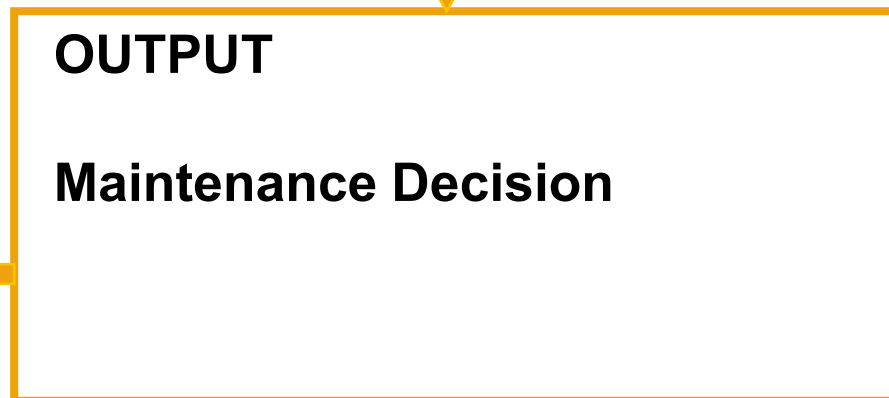
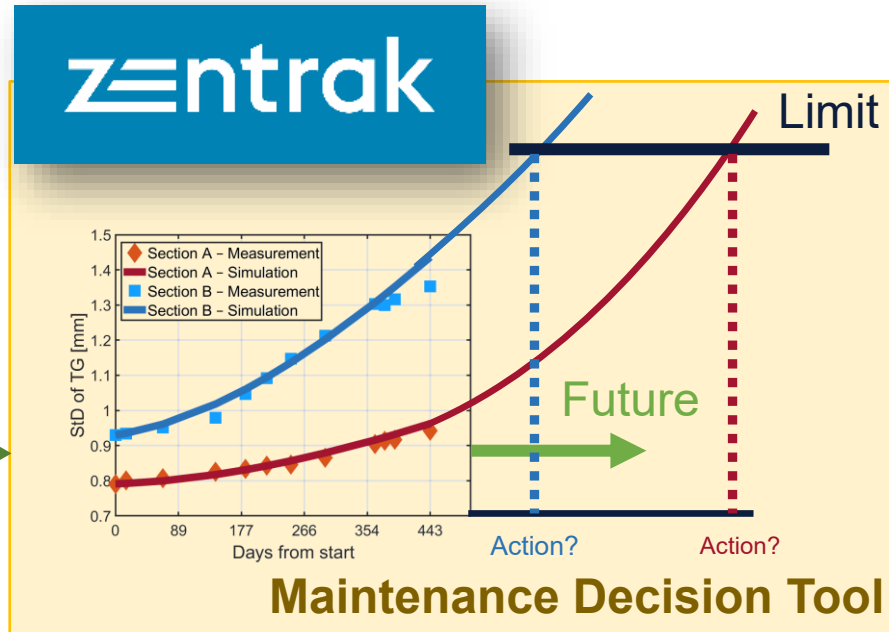
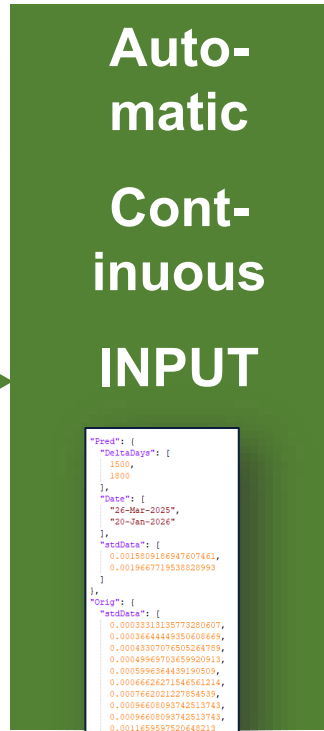
tmOS App Store

Auto-
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Cont-
inuous
INPUT

```

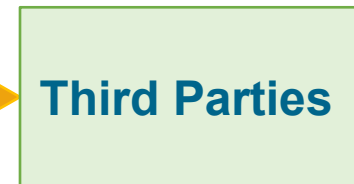
Feed: {
  "trackDays": [
    1500,
    1800
  ],
  "date": [
    "26-Mar-2025",
    "20-Jan-2026"
  ],
  "stdData": [
    0.0015909186947607461,
    0.0019467719538828993
  ]
},
"sig": {
  "stdData": [
    0.0003313185773280607,
    0.0003664444958060669,
    0.0004307076505248759,
    0.0004596970345902094,
    0.0005996364439190509,
    0.0006626271548561214,
    0.0007462031227854839,
    0.00094608093742513743,
    0.00096608093742513743,
    0.001165569520648213
  ]
}
    
```





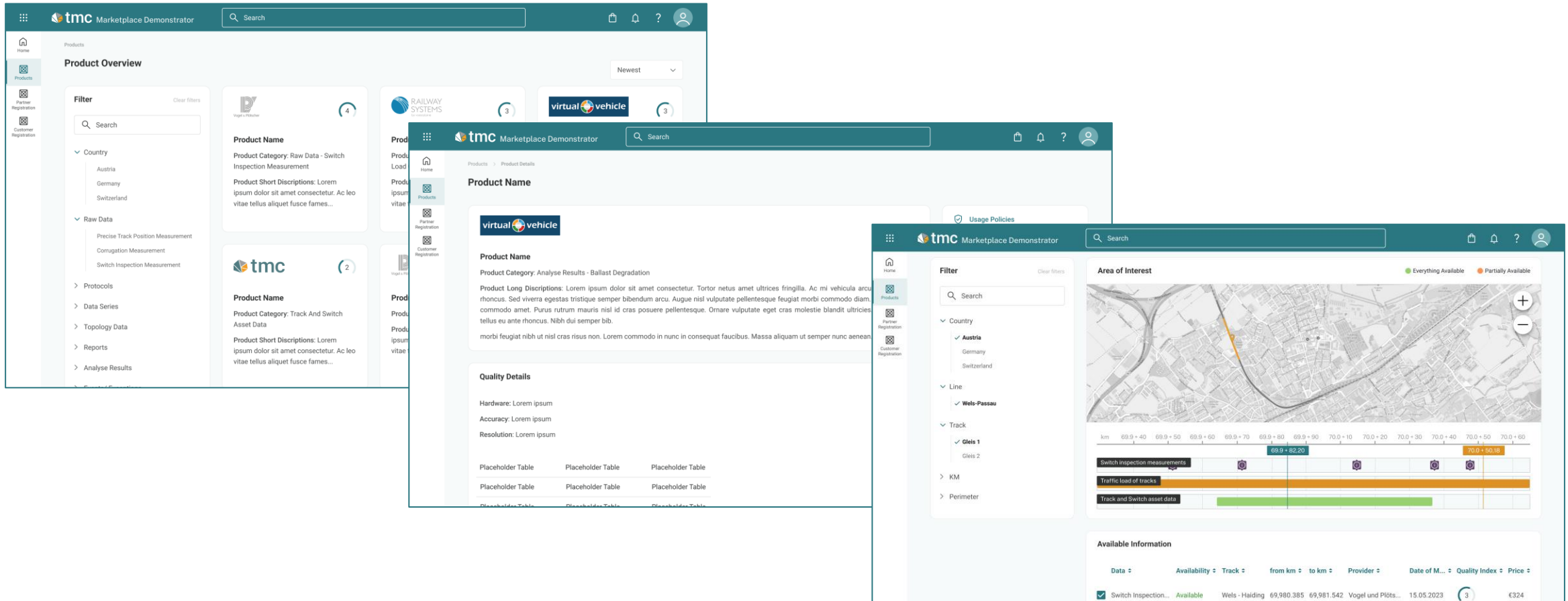
Maintenance Decision

- Definition of Limit
- Decision on type of maintenance
- Estimation of costs
- Maintenance of whole line or small segments?
- ...



Implementation of Use-Case: 'Track Settlement at Switches'

Mock-Up of App-Store



The mock-up consists of three overlapping screenshots of the 'tmc Marketplace Demonstrator' application interface.

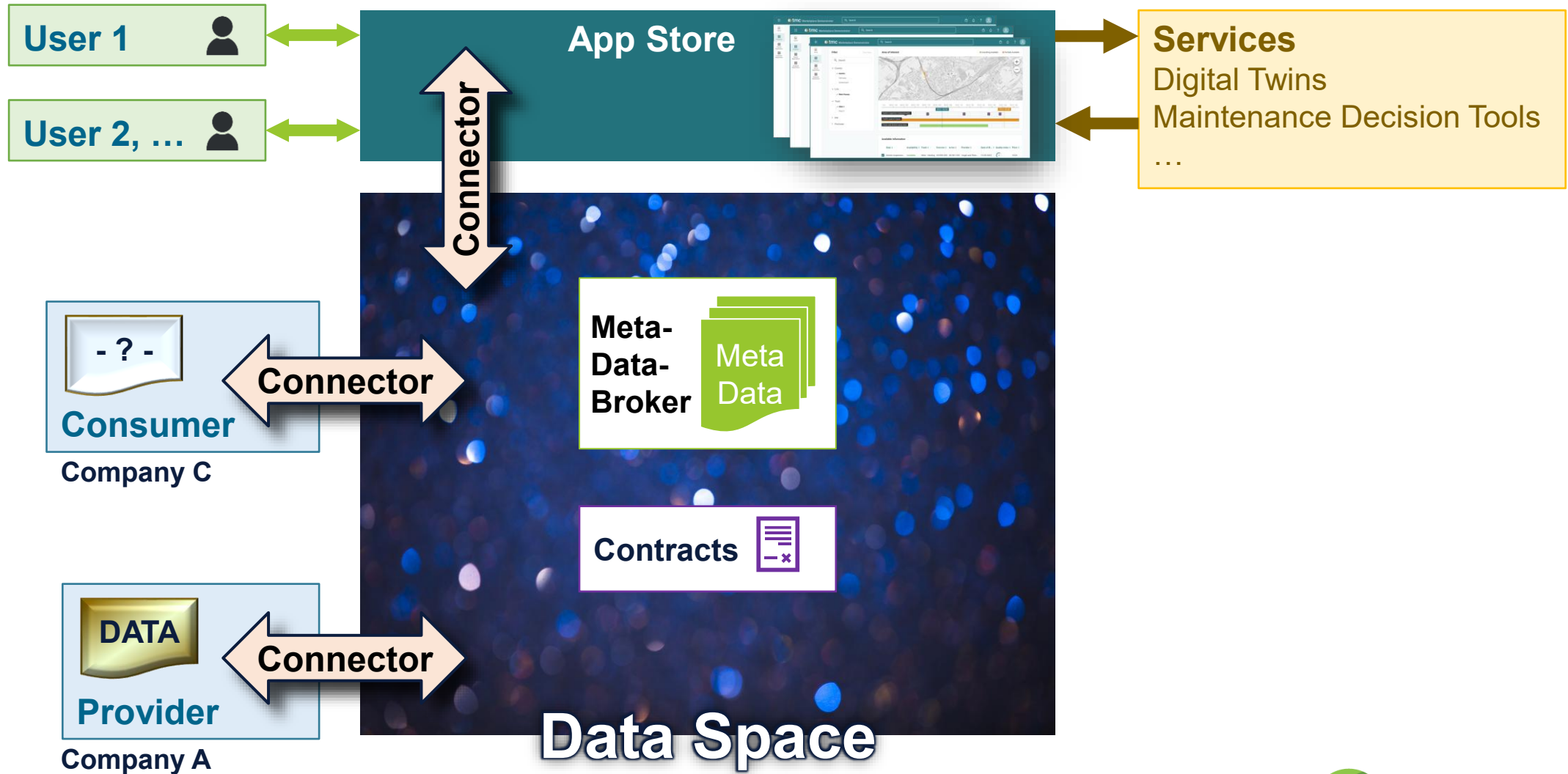
- Top-Left Screenshot (Product Overview):** Shows a dashboard with a search bar, a filter sidebar on the left (including Country: Austria, Germany, Switzerland; Raw Data: Precise Track Position Measurement, Corrugation Measurement, Switch Inspection Measurement; Protocols; Data Series; Topology Data; Reports; Analyse Results), and several product cards. One card is for 'virtual vehicle' with a '3' badge.
- Middle Screenshot (Product Details):** Shows a detailed view of a 'virtual vehicle' product. It includes a search bar, a 'Usage Policies' link, a product name, category ('Analyse Results - Ballast Degradation'), a long description, and a 'Quality Details' section with fields for Hardware, Accuracy, and Resolution. Below this is a table with placeholder text.
- Bottom-Right Screenshot (Map View):** Shows a map interface with a search bar, a filter sidebar (Country: Austria, Germany, Switzerland; Line: Wels-Passau; Track: Gleis 1, Gleis 2; KM; Perimeter), and an 'Area of Interest' map. Below the map is a timeline with markers for 'Switch inspection measurements', 'Traffic load of tracks', and 'Track and Switch asset data'. At the bottom, there is an 'Available Information' table with columns for Data, Availability, Track, from km, to km, Provider, Date of M..., Quality Index, and Price.



DEMO of App-Store

VIDEO or Live

Implementation of Use-Case: 'Track Settlement at Switches'





Other Use-Cases

Placeholder Slides for other Use-Cases

UC 1



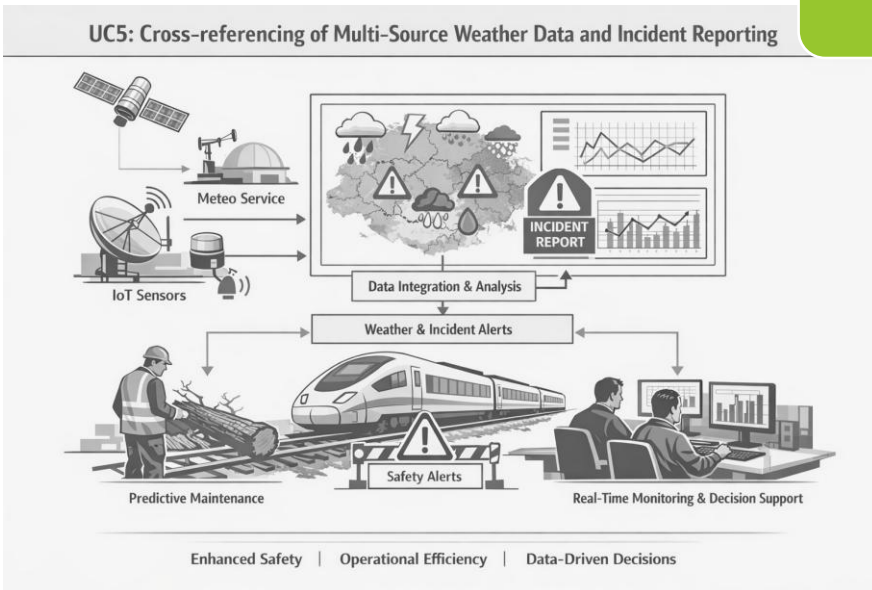
Other Use-Cases

Placeholder Slides for other Use-Cases

UC 2

UC 5 - Cross-referencing of multi-source weather data and incident reporting :

Developing an integrated system for weather data ingestion from multiple sources and robust data cross-referencing to be matched with incident reporting.



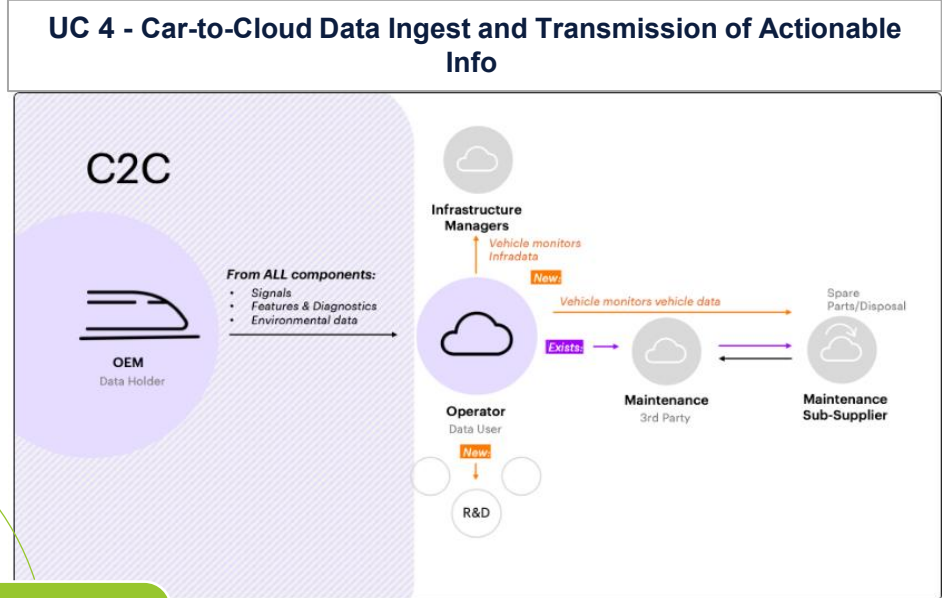
Legacy Systems and Data Silos

Limited Historical Data

Problem faced by ERDS

Data Quality and Consistency

Fragmented Data Sources



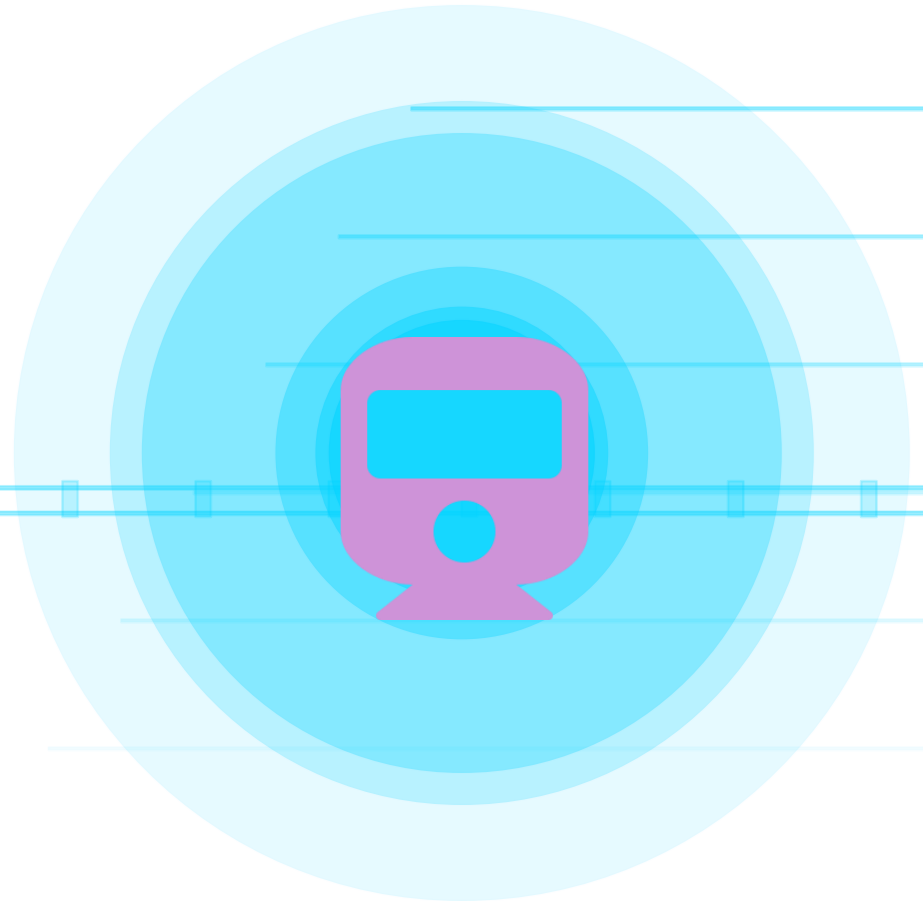
UC 4 - Car-to-Cloud Data Ingest and Transmission of Actionable Info:

Developing an integrated system for real-time data ingestion from train carriages and robust car-to-cloud communication to enhance data transmission, improve operational efficiency, and increase safety through seamless data communication with cloud systems.

Flagship Project 1 MOTIONAL | 2026

Coffee Break

Please be back at 13:40



Data Backbone



VIEW 4: DATA BACKBONE

All these solutions only work if systems talk to each other - securely and at scale?

Demo 30 – Conceptual Model & Ontology

UIC

Shared ontologies & data models underpin interoperability - illustration through collaboration with FP5-TRANS4M-R.



From Intelligent Video Gates to Shared Railway Meaning

What FP1-WP30 and FP5 learned about semantic interoperability in real railway operations

The Bottom Line: Semantics as a practical operational tool, not a theoretical exercise.

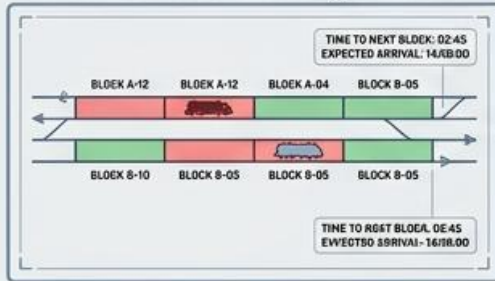


FP1 MOTIONAL
European Rail Network and Mobility Management

FP5 TRANS 4M-R
Transforming
Europe's Rail Freight

The Operational Reality: One Train, Many Views

Infrastructure Manager View

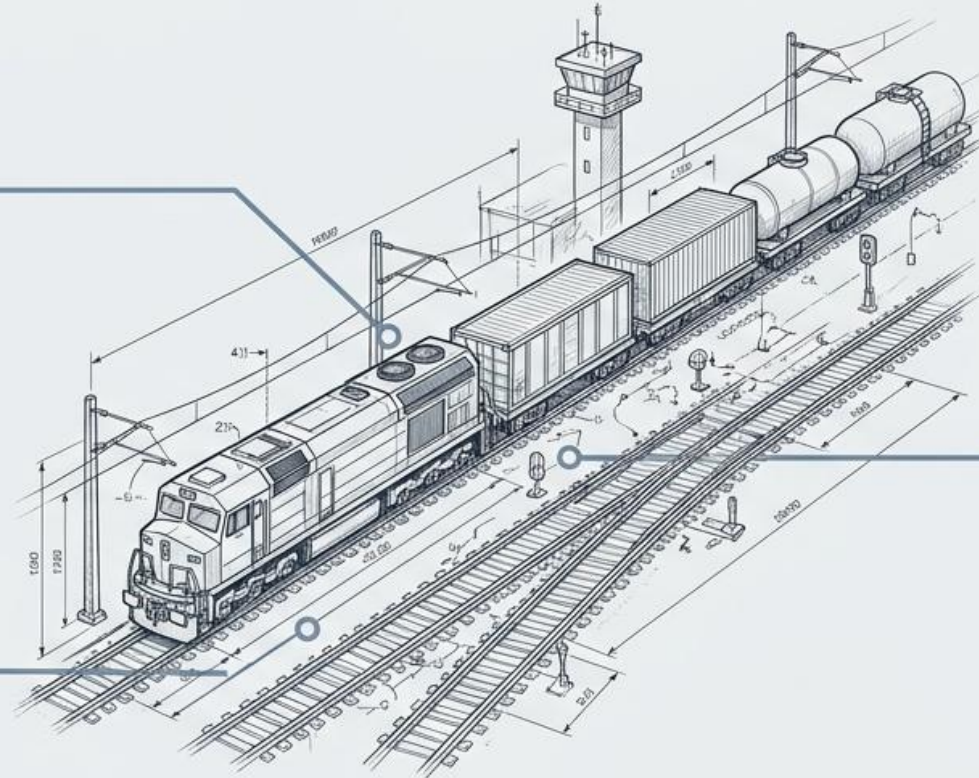


Sees only track occupation status, block sections, and timing.

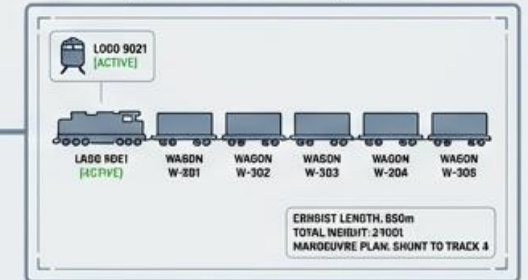
Terminal Operator View



Sees only Intermodal Loading Units (ILUs), dwell times, and cargo manifests.



Railway Undertaking View



Sees only the consist sequence, locomotive status, and manoeuvre planning.

The Integration Nightmare: Point-to-point custom integrations between these distinct views create brittle, unscalable IT architectures. The physical reality doesn't change based on who looks at it; our digital reality shouldn't either.

The Can Tunis Anchor: What the Gate Sees

The Setup:

Edge-computing portal installed at terminal entry/exit points.

The Input:

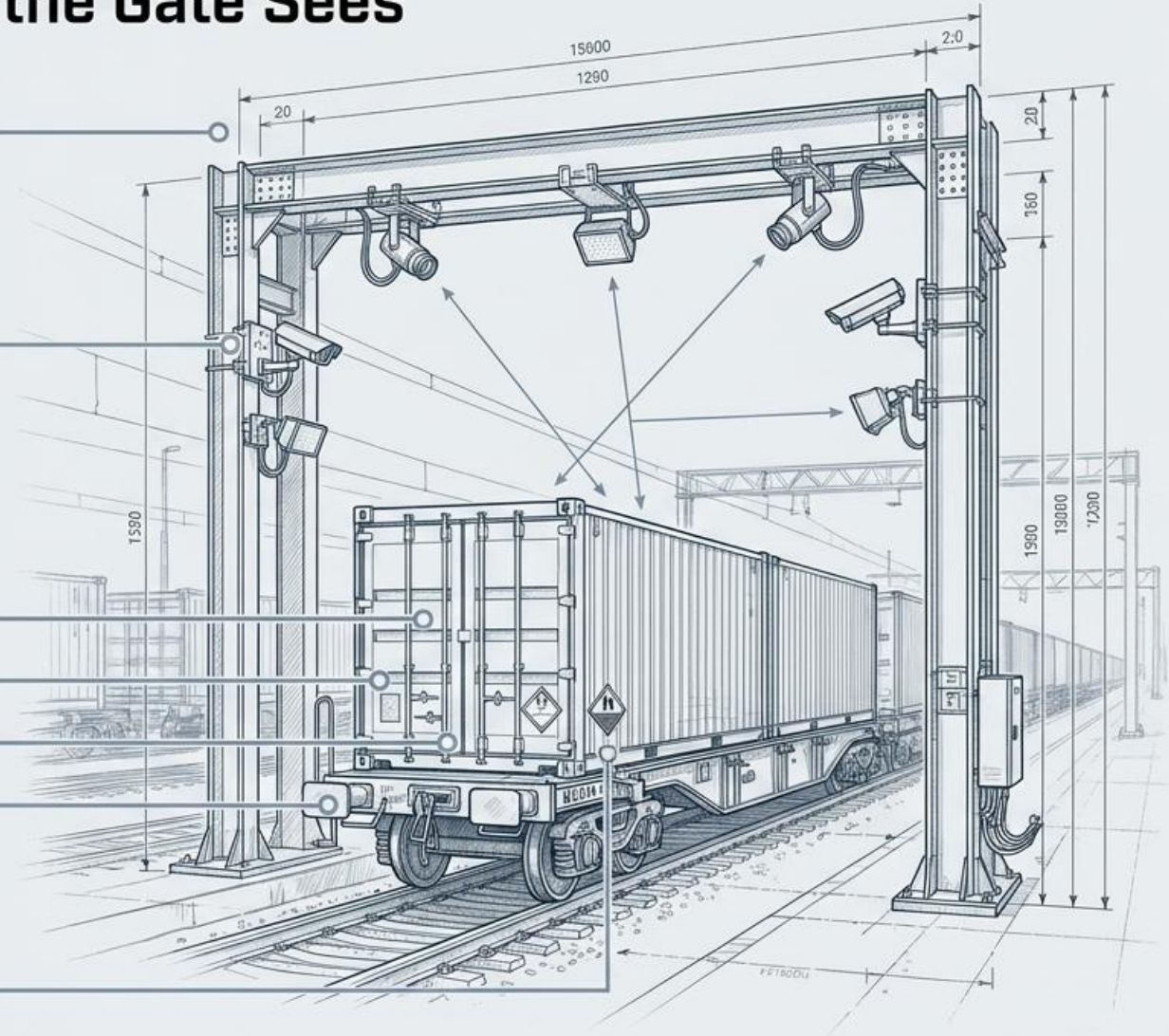
High-resolution multi-angle cameras and illumination capturing data at 15 km/h.

The Detection Zones:

1. Automatically reads 12-digit UIC wagon numbers.
2. Detects Intermodal Loading Units (ILUs).
3. Identifies Hazmat/Dangerous Goods placards.
4. Evaluates empty vs. loaded conditions.

The Raw Output:

A digital string of raw, localized observations pushed to an edge server.



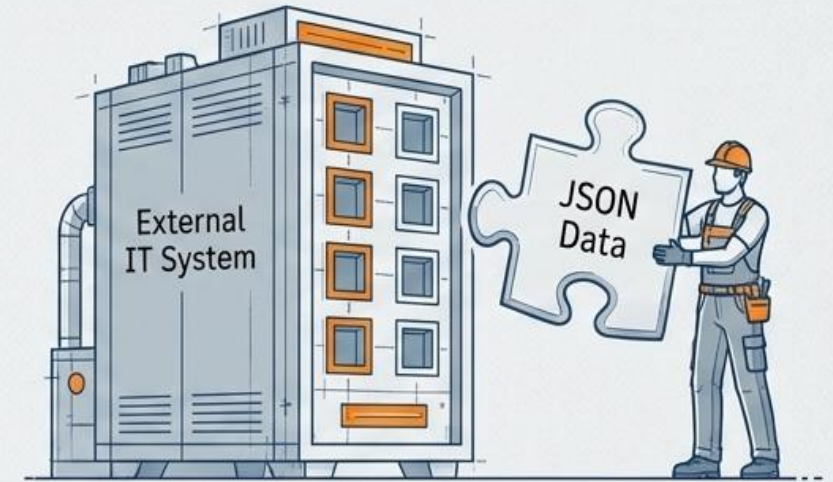
The JSON Illusion: Why Raw Messages Fail

The Format Trap

```
"SensorID": 3341,  
"Resources": {"3": 181}
```

- **Syntax vs. Semantics:** JSON provides perfect structure (syntax) but **zero context** (semantics).
- **The Local Trap:** A tag labeled '**TrainID: 181**' makes perfect sense to the edge server that generated it, but means absolutely nothing to a national Traffic Management System (TMS).

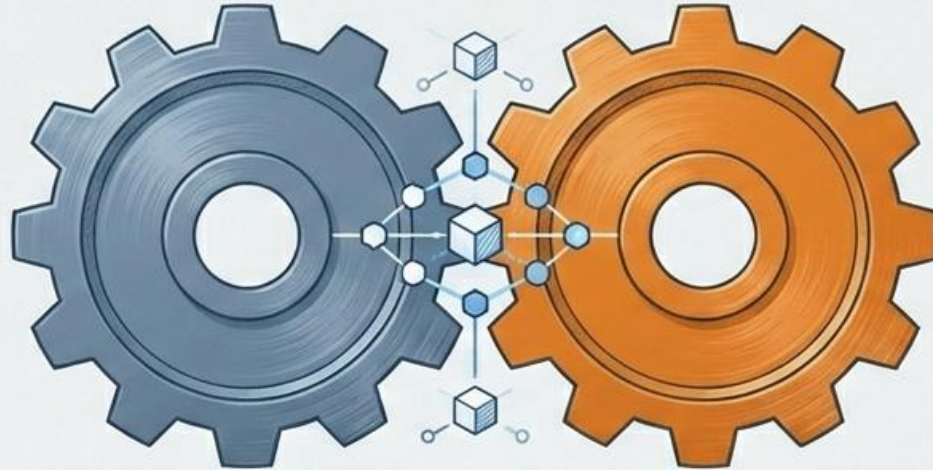
The Provenance Problem



- **Lost Provenance:** Once raw data leaves the native gate system, tracking **WHO** generated it, **WHEN**, and with **WHAT CONFIDENCE** becomes nearly impossible.
- **The Result:** Without shared meaning, safe and automated **reuse** across different organizational boundaries is **blocked**.


A Tale of Two Projects: The Collaboration


GEAR 1: FP5




GEAR 2: FP1-WP30


Gear 1: FP5 (The Operational Engine)

 Provided the live use cases and the Can Tunis terminal demonstrator.

 Deployed the sensors, Intelligent Video Gates (IVGs), and generated the raw JSON data outputs.

Gear 2: FP1-WP30 (The Semantic Architect)

 Provided the Conceptual Data Model (CDM) framework.

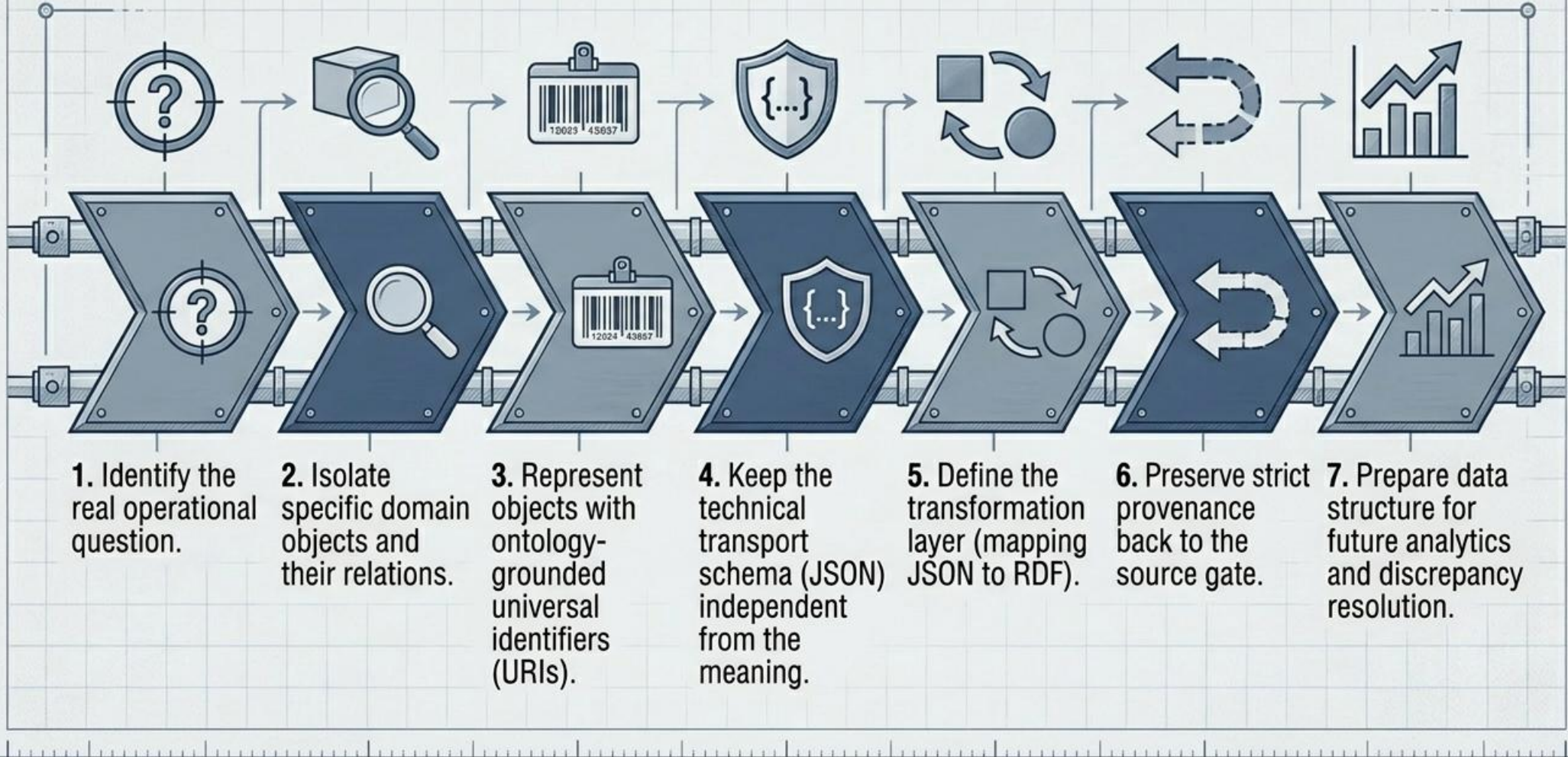
 Built the modular ontology stack and the translation methodology.



The Shared Goal: Prove that advanced conceptual models can solve immediate, localized operational problems without requiring a complete IT overhaul.

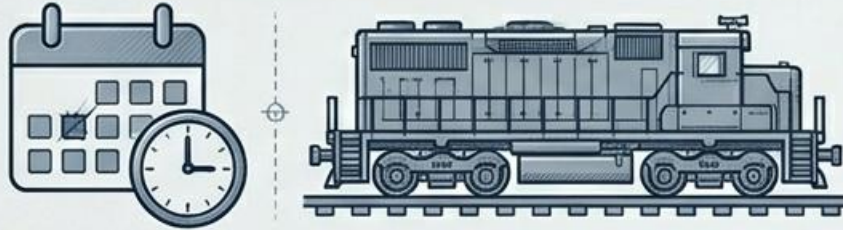


The 7-Step Semantic Method



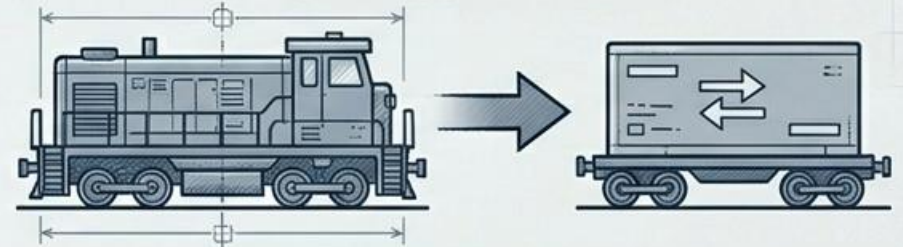
Translating the Real World: Key Railway Distinctions

Train Run vs. Train



The scheduled timetable event (the process) vs. the physical assembly of rolling stock on the track.

Object Type vs. Role



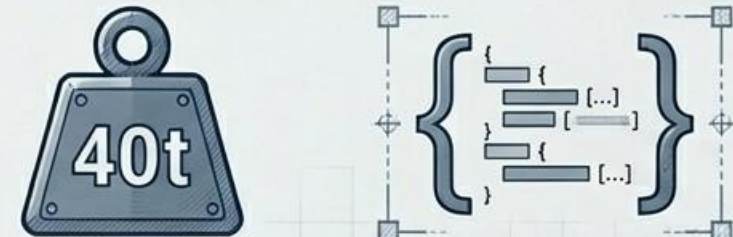
A locomotive (permanent object type) being hauled dead, temporarily acting as a wagon (temporary role).

Observation vs. State



“The camera saw the door open at 10:04” (a fleeting observation) vs. “The door is currently broken” (an ongoing state).

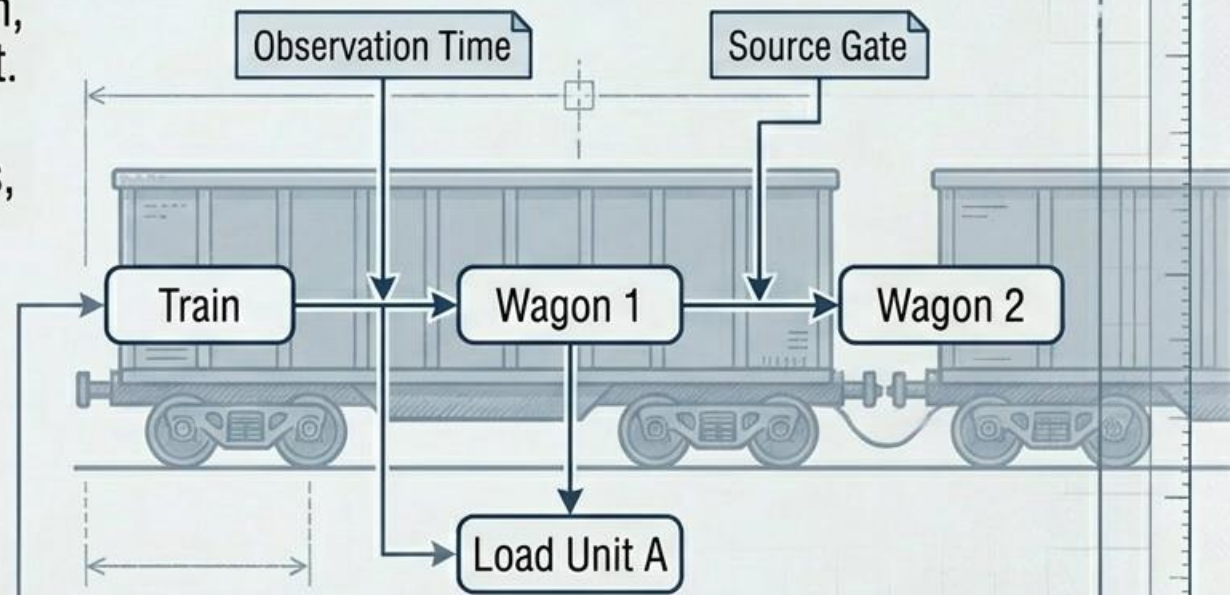
Information vs. Information Object



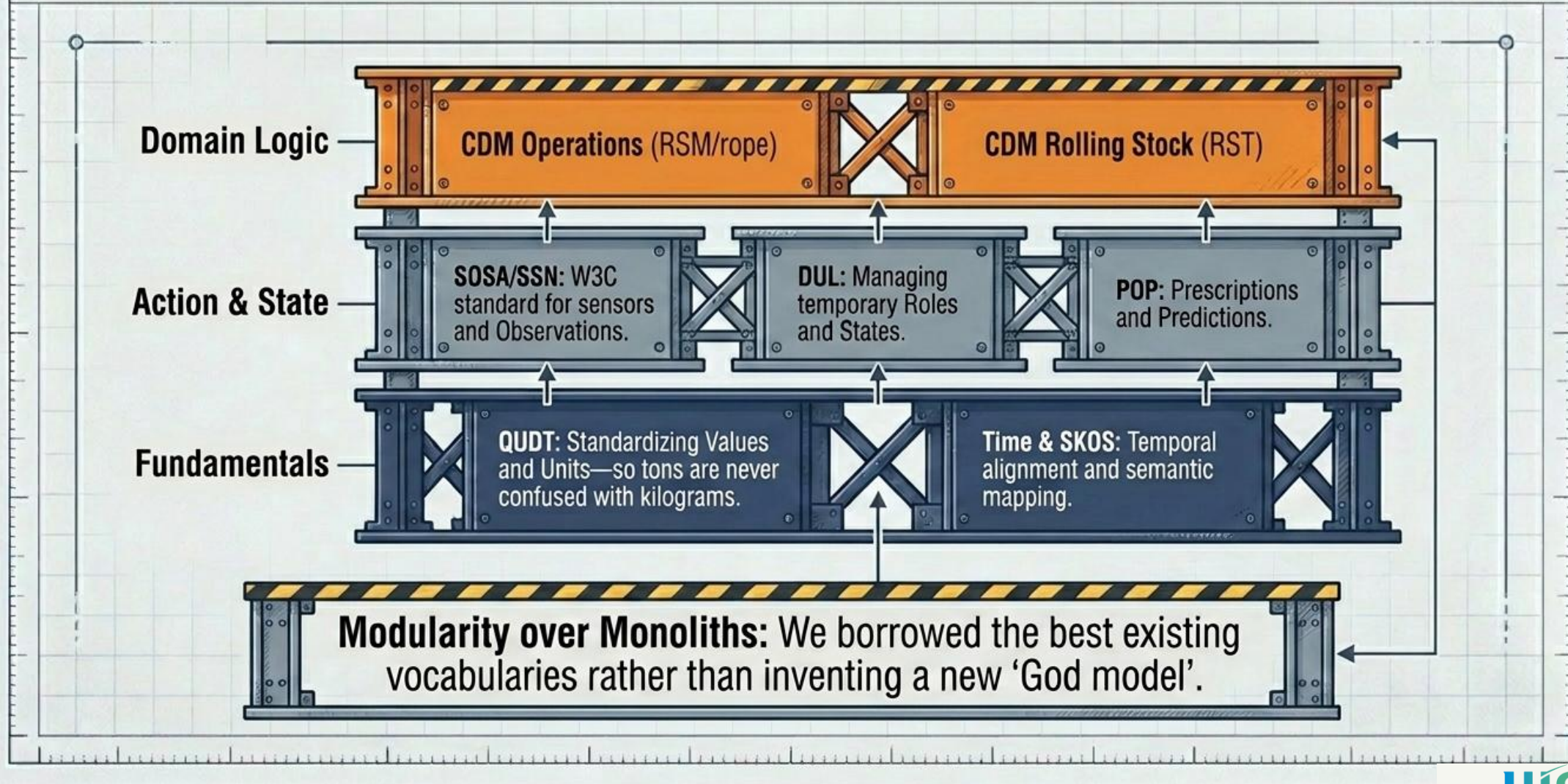
The actual payload value (“weight = 40t”) vs. the JSON telegram message carrying it.

Wave 1: The Minimum Semantic Core

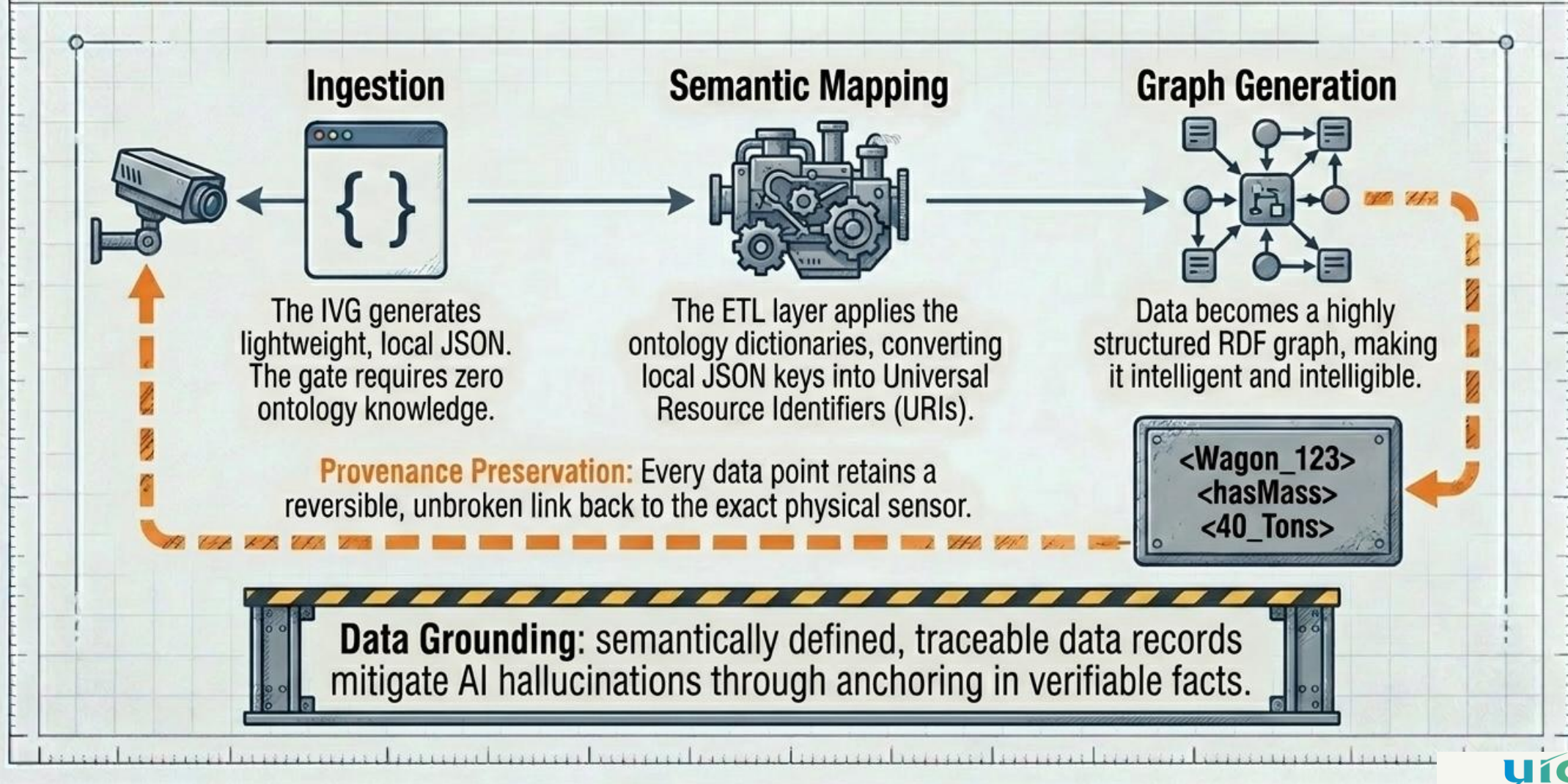
- **Train Identification:** Explicitly linking the train run to the physical train composition, including specific positions in the consist.
- **Rolling Stock & Cargo:** Defining wagons, load units, and the critical load-on-wagon relationship.
- **Event Context:** Anchoring data with checkpoint passage times, observation timestamps, and the specific source gate/message.
- **System Enrichment:** Bridging localized IVG camera IDs with broader Traffic Management System (TMS) data for network-wide context.



The Modular Ontology Stack



The Transformation & Traceability Pipeline



WP26, Task 26.1: Define a 'capture' process to handle use cases emanating from all Destinations about existing, planned and required digital enablers.

This process shall notably help classify and subsequently harmonize the inputs received from all Destinations to facilitate analysis and further consultation/distribution with other WPs within the MOTIONAL project.

Presents a presentation of the database for onboarding of use cases across all FAs/SP.

- Setup repository and harmonise formalisation and documentation as mechanisms to provide technical support on digital enablers.

As part of Task 26.3:

- Create documentation, sample code and examples for usage of digital assets engineering toolbox, Digital Twin environment, conceptual data model and federated data space.
- Set up support mechanisms to provide technical support on digital enablers.

- Home
- Use Cases - Overview
- Use Cases - Editing
- Stakeholders
- Work Packages - Overview
- Interested WP
- Demos - Overview
- Digital Artifacts
- Requirement Technical Enablers
- Transversal Topics Use Cases



ERJU Use Case Repository

This interactive repository is part of the results of FP1 Motional WorkPackage 26.

This work package coordinates the work performed in the development of common digital enablers (Workstream 2), connecting it to the MOTIONAL project's workstream 1, to all other Destinations and to System Pillar activities.

It designs, deploys and executes the MOTIONAL project's process to collect use cases from all Destinations, complementing them with System Pillar guidelines, in order to drive development of digital enablers according to the Destinations' actual requirements, constraints and timelines.

[FP1 Motional home page](#)

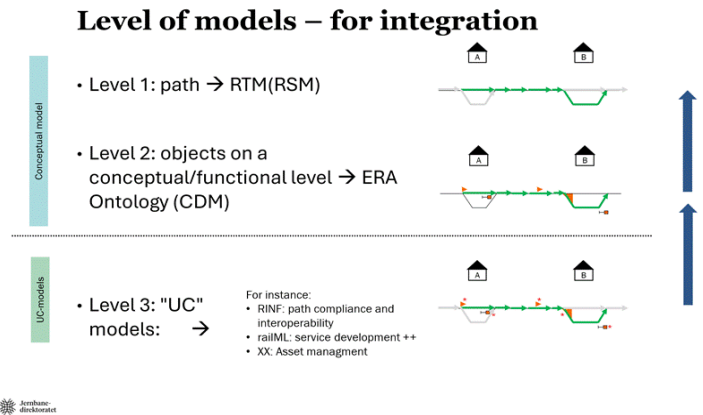
Enter the repository ▾

The project "FP1-MOTIONAL" is supported by the Europe's Rail Joint Undertaking and its members with grant agreement no 101101973. [\[Contact Us\]](#)

Thank you for your attention



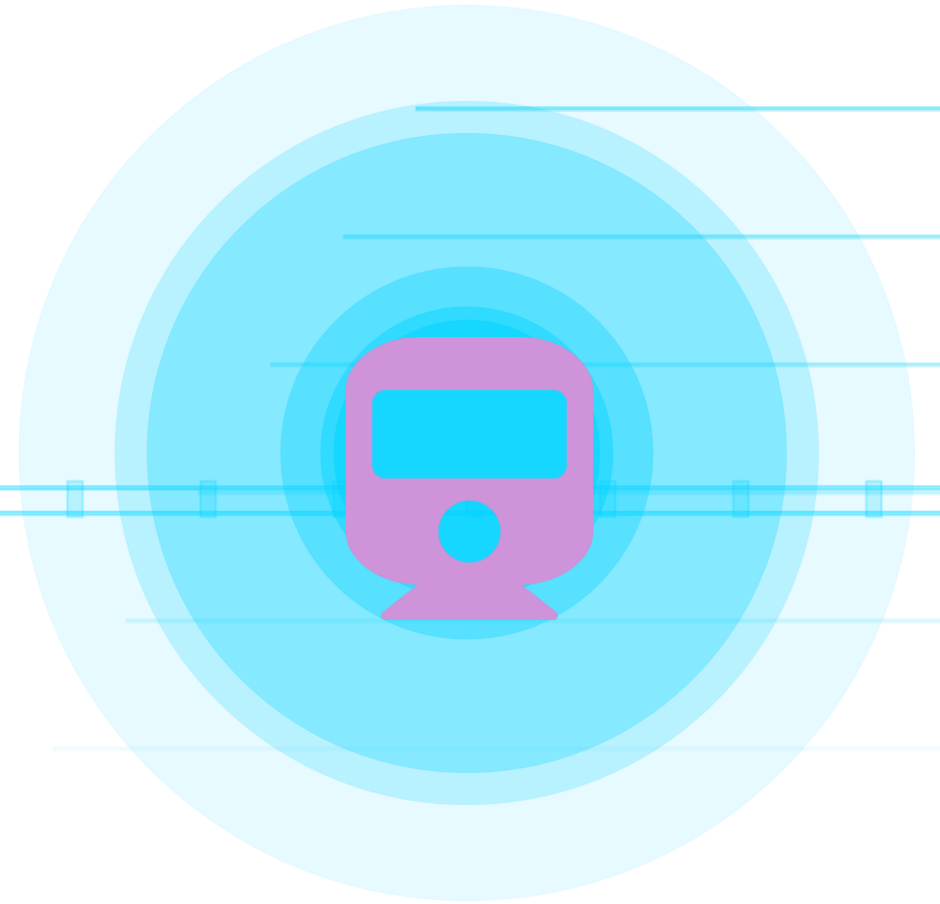
- Ontologies: localization, ports, rolling stock (typology, composition), telematics (domain-oriented) .
- Collaboration with FP5 on the Intelligent Video Gate (identifying possible extensions to the ERA ontology through telematics domain-oriented ontology).
- Exploring collaboration with FP3 around asset management.
- Norwegian Railway Directorate and Trafikverket -> basis for building other models on top, particularly facilitating cross-border developments in wave 2 and 3. Result: Common functional description of the Malmø-Alnabru line (railML)



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Q&A Session

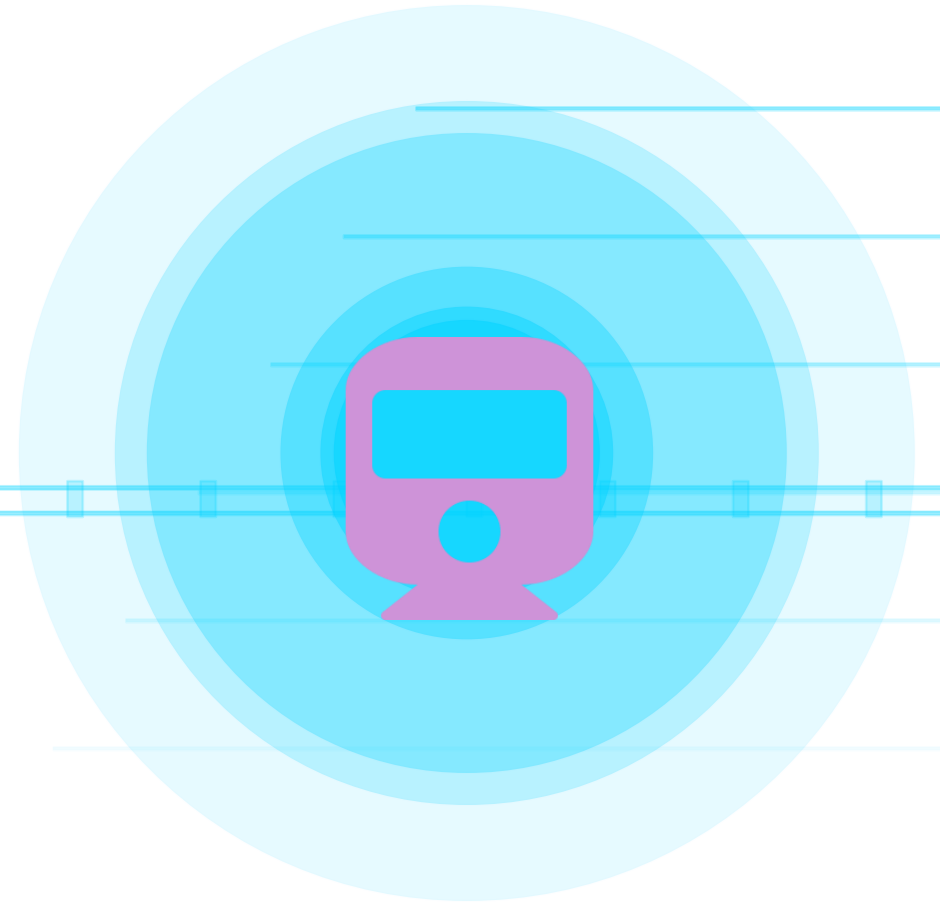
10 minutes



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Survey

Please check the chat and answer the Survey



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Thank you for your attention

Demonstration Event

