Digitale Schiene Deutschland

Gefördert durch: Bundesministerium für Wirtschaft und Klimaschutz aufgrund eines Beschlusses des Deutschen Bundestages

Finanziert von der Europäischen Union NextGenerationEU

AutomatedTrain

The next steps towards fully automated driving

DB InfraGO

DB Regio

codewerk

DUAGON

Red Hat

SIEMENS

Bosch Engineering BOSCH

TECHNISCHE UNIVERSITÄT DRESDEN

IAV

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DB

Look out for AutomatedTrain at our partners' booth Knorr-Bremse Duagon and Siemens Mobility too

The "AutomatedTrain" cooperation project enables more flexible use of trains through automated preparation of the vehicle and fully automated, driverless train dispatching and parking. A train from S-Bahn Stuttgart (Alstom BR 430) and a train from Siemens Mobility (Mireo) have been retrofitted with the necessary hardware and software. Thanks to intelligent sensor technology, the vehicles can detect their surroundings and react to obstacles automatically. The train from S-Bahn Stuttgart is on display in the outdoor area at InnoTrans. The Federal Ministry for Economic Affairs and Energy is funding the project with around 42 million euros.

Project Partner:

DB InfraGO
DB Regio
codewerk
DUAGON
Red Hat
SIEMENS
Bosch Engineering
BOSCH
TECHNISCHE UNIVERSITÄT DRESDEN
IAV

Project coordinator:

DB InfraGO

Funding amount: 42 million euros

Project duration: 07/2023 – 09/2026

Funded by the European Union
NextGenerationEU

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Visit us in the **Outdoor area** (Track 11 (T11/55)) **and in CityCube** Hall B, at the DB Booth

AutomatedTrain-Webseite

AutomatedTrain at the InnoTrans Convention

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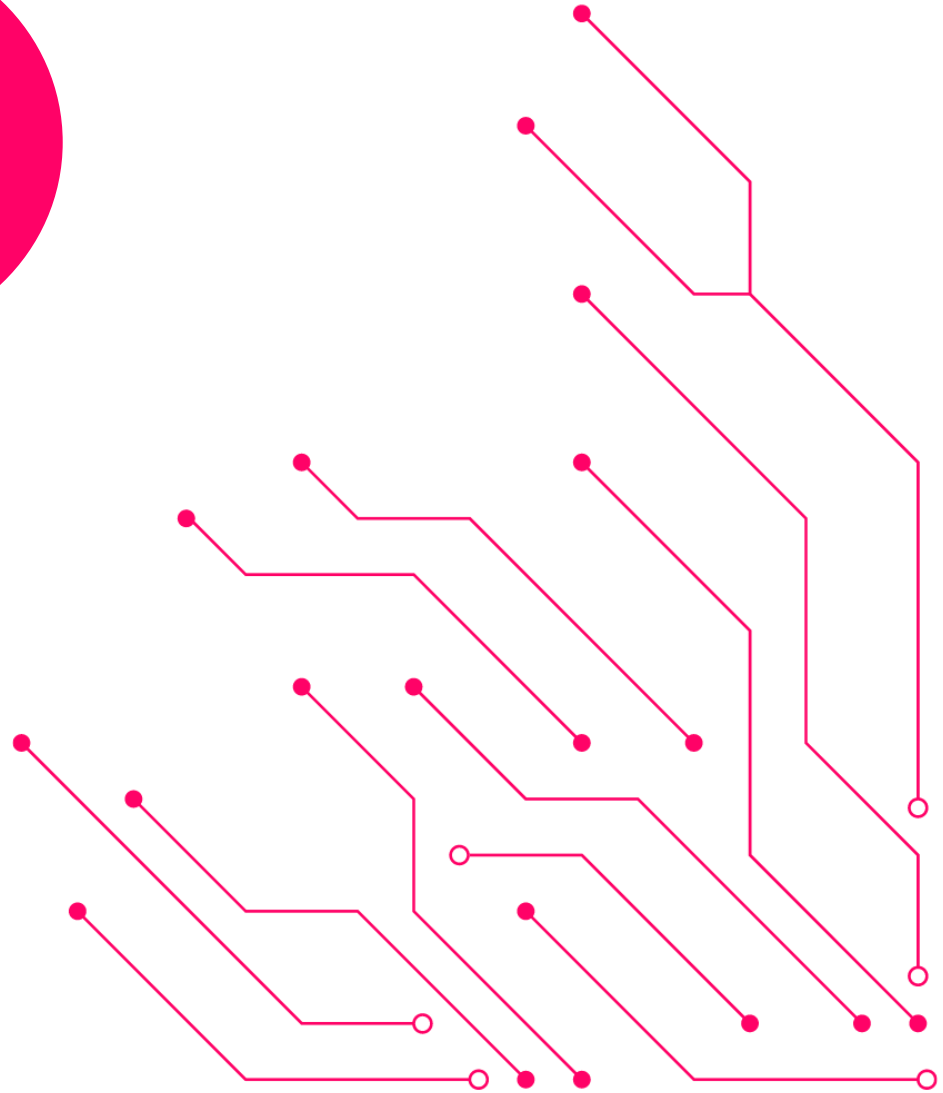
You will find the class 430 train on platform 11 (T11|55) in the outdoor exhibition area.
Guided tours of the train are available daily at 10am and 2pm (on Fridays at 10am only). No booking is required.

The Siemens Mireo operates on the Havelland Railway. A shuttle service is available.

Visit us in the
Outdoor area
Track 11 (T11/55)
and
in CityCube Hall B, at the DB Booth



Exhibition booths AutomatedTrain project partners:

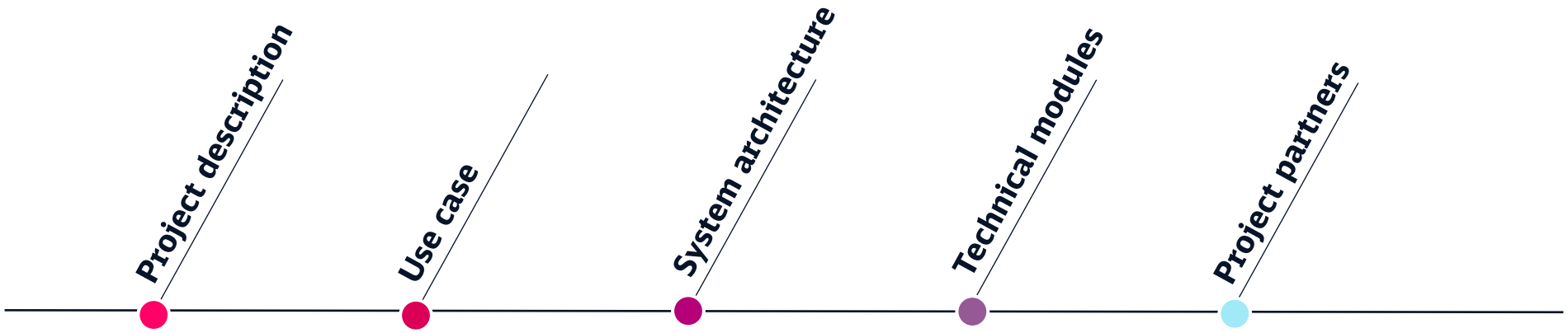
Bosch Engineering	Hall 20, booth no. 320
DB Regio	CityCube, Hall B
duagon	Hub27, booth no. 740 (Knorr-Bremse)
IAV	Hall 7.1a, booth no. 120
Siemens Mobility	Hub27, booth no. 230
Technische Universität Dresden	Outdoor exhibition area platform 11 (T11|55)

AutomatedTrain

Digitale Schiene Deutschland

The “AutomatedTrain” cooperation project enables more flexible use of trains through automated preparation of the vehicle and fully automated, driverless train dispatching and parking functionality. Intelligent sensors enable the vehicles to detect their surroundings and react independently to obstacles.

Website



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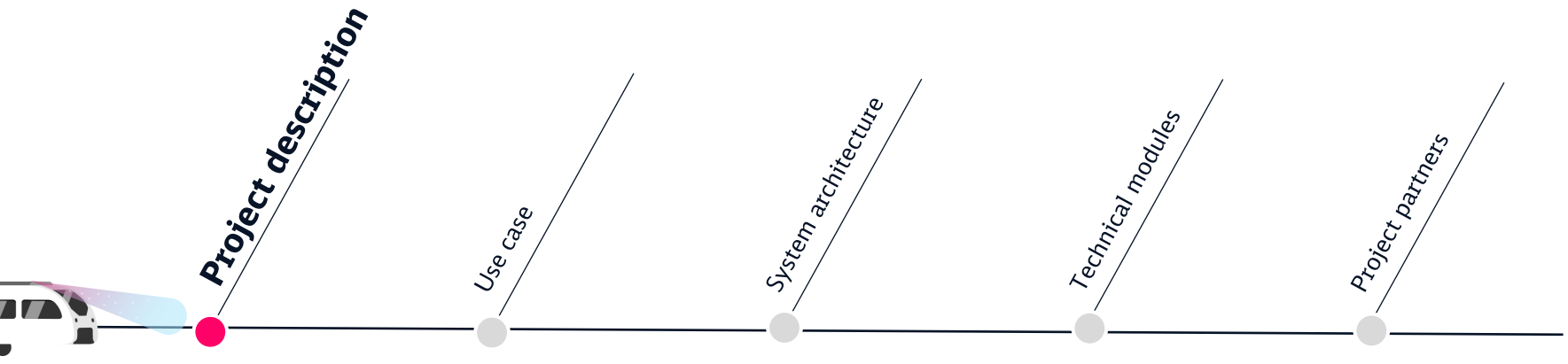


In the "AutomatedTrain" research and development project, DB InfraGO AG and eight other partners are trialling the fully automated, driverless dispatching and stabling of trains as well as their automated preparation and shutdown. Bringing together industry, rail transport companies, rail infrastructure operators and science, the project team forms a unique consortium from various sectors. The Federal Ministry for Economic Affairs and Energy is funding the project with around 42.6 million euros.

A train from Siemens Mobility (Mireo) and a train from Stuttgart S-Bahn (Class 430) have been equipped with the appropriate hardware and software for the use case. The Mireo covers the route from the siding area to the first platform at the Wegberg-Wildenrath test center fully automatically and without a train driver. The Object Detection System checks the route during the entire journey and reacts independently to any obstacles, e.g. by braking. The fully automated preparation and shutdown of the train has also been implemented and tested. In addition, Bosch's object detection system has been tested in shadow mode on the Class 430 train on the S-Bahn Stuttgart network.

2023

- Project start
- Operational concept
- Hardware freeze

2024

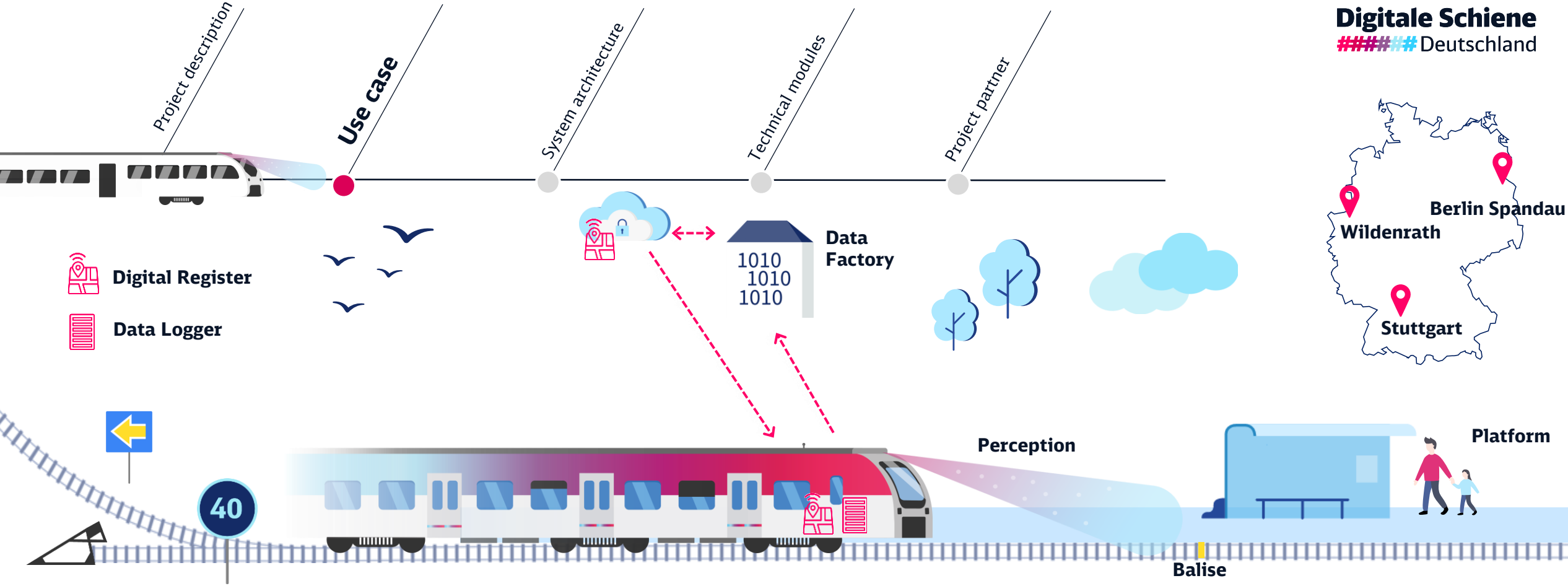
- Requirements specification
- Definition of the system architecture
- Start of software development
- Vehicle engineering

2025

- Retrofit of the vehicles
- System integration
- Test drives & continous testing in the laboratory

2026

- Demonstration drives
- Presentation of results at the InnoTrans 2026



Stabling area:

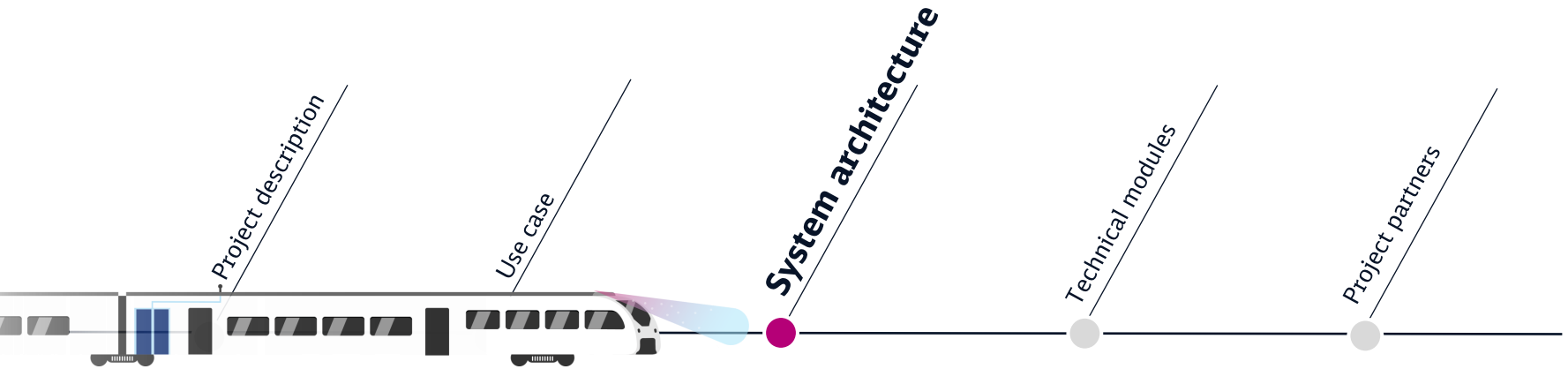
- Fully automated preparation of the vehicle
- Vehicle performs self-check
- Vehicle sends status to operation center (ready to go or not)

Driving the vehicle:

- After getting the drive command, the vehicle drives fully automated at a maximum speed of 40 km/h
- The Vehicle is using the perception system to observe its ego track during the drive, sensor data is recorded in a standardized way (Data Factory)
- In combination with the Digital Register and real-time localization, objects on the ego track are detected and a reaction is performed if necessary (e.g. horn, break)

Stopping at a platform and returning to park position:

- After receiving the drive command from the operations-centre, the vehicle stops at the requested position
- After receiving the drive command from the operations-centre the vehicle returns fully automated to the stabling area
- Fully automated parking of the vehicle
- Switch between GoA2 and GoA4 operation



System architecture, requirements and test specification

In AutomatedTrain a modular system architecture, requirements and test specification for ATO GoA4 were developed.

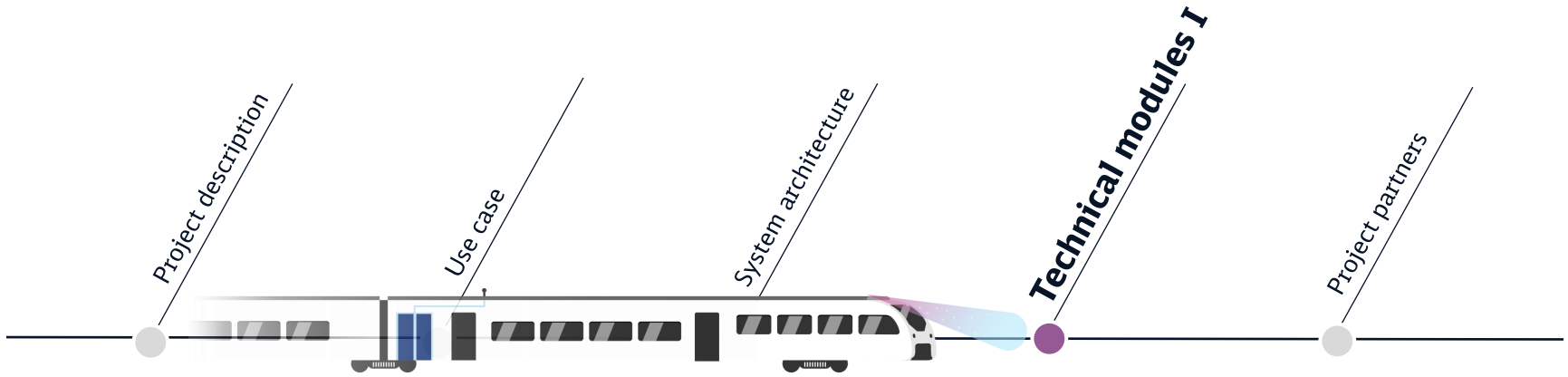
The system architecture and requirements specification were based on ATO (Automatic Train Operation) over ETCS (European Train Control System) under ETCS Level 2, while using the Full Supervision (FS) and Automatic Driving (AD) operating modes.

The sustainability of the system architecture and requirements specification has been ensured by a CENELEC-compliant (EN50126) project
framework with regard to V-model phases 1–5, as well as an assessment by the independent safety assessor, TÜV Süd.

In AutomatedTrain the functions developed for fully automated driving as well as automatic start-up and shutdown of the train have been based on these requirements specifications.

Project partners involved:

DB InfraGO DB Regio SIEMENS Bosch Engineering BOSCH



Object Detection, Digital Map, Vehicle Automation and Data Factory

Forming the core of AutomatedTrain are vehicle automation and perception systems. A sensor-based environmental perception system monitors the route and detects objects beside and on the track. If an obstacle is detected, the system assesses the situation and decides whether and how to respond: by sounding the horn, applying the brakes, or informing the control center. This assessment is carried out by a specialised automatic processing module.

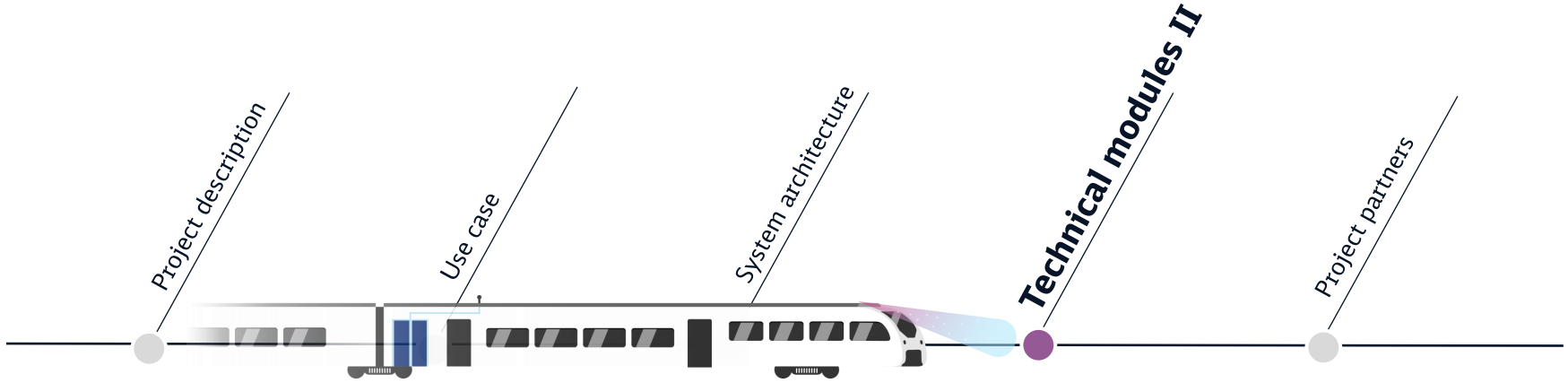
Objects detected in the train's surroundings are compared with a digital map. Based on this information, a response can be triggered. The digital map enables the system to correctly classify static elements of the railway infrastructure and avoid misinterpretations.

Furthermore, the automatic processing module serves as an interface to the vehicle control system, thereby enabling the automatic start-up and shutdown of the train.

The sensor data is recorded and stored with a standardized protocol in the "Data Factory" and there it is made openly available to the railway industry to support the future development of automated systems in the rail sector.

Project partners involved:

SIEMENS DB InfraGO Bosch Engineering BOSCH



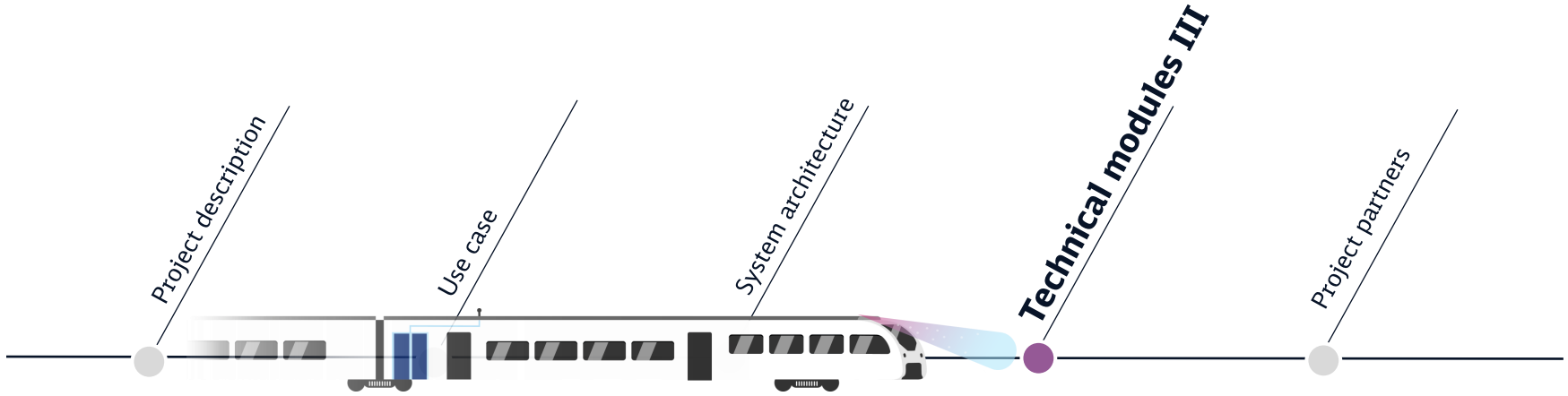
Vehicle and System Integration and Testing

AutomatedTrain is not just a theoretical concept: Two vehicles have been equipped with nearly identical hardware but differing software solutions featuring state-of-the-art environmental perception technology. The S-Bahn Stuttgart train, class 430, is collected data in the operational environment as part of the test campaign for the perception system. The second vehicle, a Mireo from Siemens Mobility, operated at the company's own test center. There, the complete system consisting of environmental perception and the automatic processing module was tested - including automatic start-up and shutdown of the vehicle.

System integration, verification and validation of the respectively implemented AutomatedTrain functions have been conducted. System integration in this context means the integration of subsystems into an overarching, coherent system. The aim of this was to confirm and evaluate that subsystems work in the overarching system. Prior to testing on the vehicles, the system was tested in the laboratory.

Project partners involved:

SIEMENS Bosch Engineering BOSCH DB InfraGO DB Regio



Diagnostics

The onboard systems for fully automated driving require advanced concepts for operational monitoring and automated fault management.

Therefore, a manufacturer-independent onboard diagnosis concept has been developed and prototypically implemented in the lab for the use case of sensors for environment detection.

Project partners involved:

DB InfraGO SIEMENS Bosch Engineering BOSCH IAV TECHNISCHE UNIVERSITÄT DRESDEN

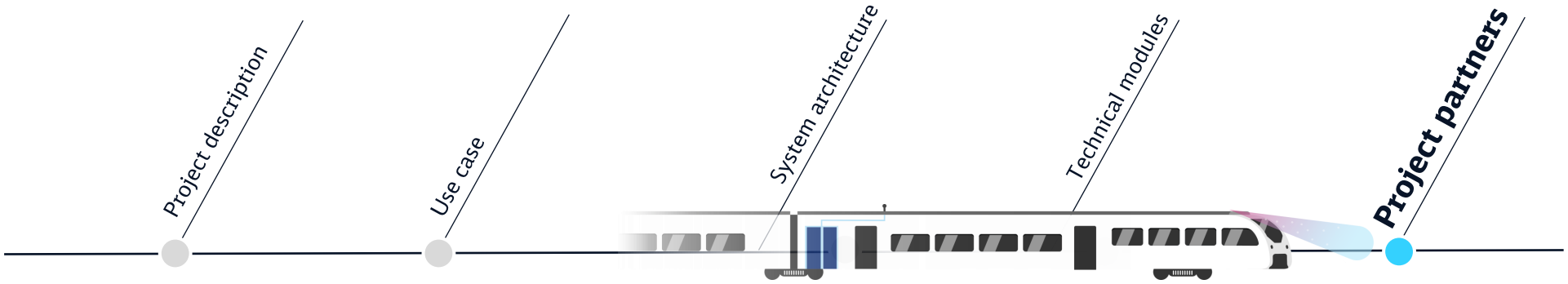
Onboard Compute Platform

For fully automated driving in GoA4, in particular for object detection functions, safe compute systems with an optimized hardware and software are required on the vehicles.

In AutomatedTrain compute platform architectures have been analysed, evaluated and specified. This now provides a basis for the development of a safe onboard high-performance compute platform.

Project partners involved:

DB InfraGO SIEMENS Red Hat codewerk DUAGON



Supported by the BMWE, we are initiating a major technological push for the German rail industry with 9 partners:

DB InfraGO | DB Regio | Bosch Engineering BOSCH | codewerk

IAV | DUAGON | Red Hat | SIEMENS | TECHNISCHE UNIVERSITÄT DRESDEN

DB InfraGO

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Our involvement in „AutomatedTrain“

DB InfraGO AG brings the perspective of a rail infrastructure manager and the overall rail system view to the AutomatedTrain project. As the project coordinator, DB InfraGO is responsible for the overall project management. Furthermore, DB InfraGO has contributed the following:

- together with the project partners, DB InfraGO developed the system architecture, requirements and test specifications
- Developed digital maps
- Development and operation of an end-to-end data infrastructure to record sensor data on the train, transfer the data from the train to the infrastructure and then save and manage data for processing and annotation
- Development and prototypical implementation of an onboard diagnosis concept
- Requirements for an onboard safe high-performance compute platform
- System integration, verification and validation auf the AutomatedTrain system implemented on the Class 430 train and in the DB labs

About DB InfraGO AG

As a rail infrastructure company, DB InfraGO AG is responsible for the operation, maintenance, new construction and expansion of the German rail infrastructure.

Here you can find us at InnoTrans:

CityCube, Hall B

More information about our involvement in AutomatedTrain:

AutomatedTrain Website

DB Regio

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About DB Regio AG

Every day, DB Regio, as part of DB AG, moves over 4.6 million passengers in 22,000 trains. Growing public transport services for a successful transport transition is a challenge that DB Regio is facing. In order to be able to deploy human resources efficiently, artificial intelligence, digitalization and automation will have to do much more of the work in the future than in the past and thus reduce the workload on employees. This is why DB Regio is involved in projects to automate its vehicles. In this case S-Bahn Stuttgart is leading the way as part of DB Regio. It is providing a 430 series vehicle for the AutomatedTrain project.

BR 430 as one of the test vehicles in AutomatedTrain

The BR 430 vehicle will be equipped with an obstacle detection system as part of AutomatedTrain and then undergo detailed testing. During this test phase, data will be collected on the Stuttgart S-Bahn network to verify and validate the obstacle detection system. The prototype of the obstacle detection system will be presented at InnoTrans 2026. DB Regio is thus taking a major step towards automating its stabling and shunting operations.

Here you can find us at InnoTrans:

CityCube, Hall B

More information about our involvement in AutomatedTrain:

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Link: https://www.dbregio.de

Bosch Engineering

BOSCH

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From road to rail

As an engineering service provider, Bosch Engineering is an experienced and reliable partner for the mobility industry. In the rail sector, we have been successfully transferring proven sensor and localization technologies from the automotive sector to rail for more than ten years and are working on comprehensive solutions to support the automation of driving functions, which include regular rail traffic, shunting operations as well as dispatching and parking functionality in train depots.

Our focus topics

- Transfer of automotive solutions to the rail system, for example radar, ultrasound and video technology
- Environment detection systems for assistance and automation
- Software and algorithms for safe obstacle detection
- Modular, scalable approach
    - Automation solutions available early, initially for low speeds
    - Assistance systems
    - Building on this, extended solutions for higher speeds

As part of the AutomatedTrain project, we are showcasing our expertise in environmental perception and the implementation of a demonstrator, both in the laboratory and on a rail vehicle. Our hardware and software can detect and warn of obstacles and objects next to the train in time. A multi-modal sensor system is being developed for robust monitoring of the track. This combines sensor technology, digital register and localization and detects obstacles in a verifiable manner. Together with our partners, the AutomatedTrain project enables us to develop an approvable system and thus drive forward automation on the railway.

Here you can find us at InnoTrans:

Hall 20, booth no. 320

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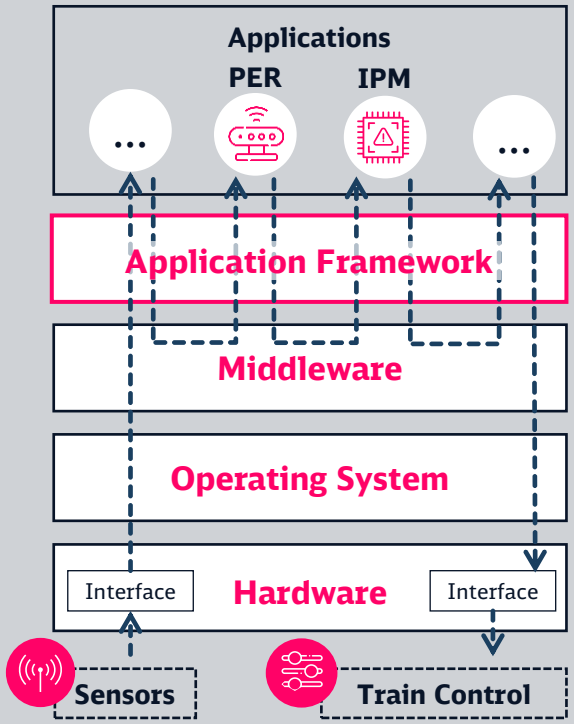
codewerk

Digitale Schiene Deutschland

The codewerk factor in AutomatedTrain

As a software development service provider in the railway sector, Codewerk brings comprehensive expertise for the technical, organisational and homologation-related requirements for all software in trains into the AutomatedTrain project. We make sure that the computing platform with the future applications for fully automated driving (GoA4) can be tested more flexibly and integrated more easily into the train control system.

Computing Platform



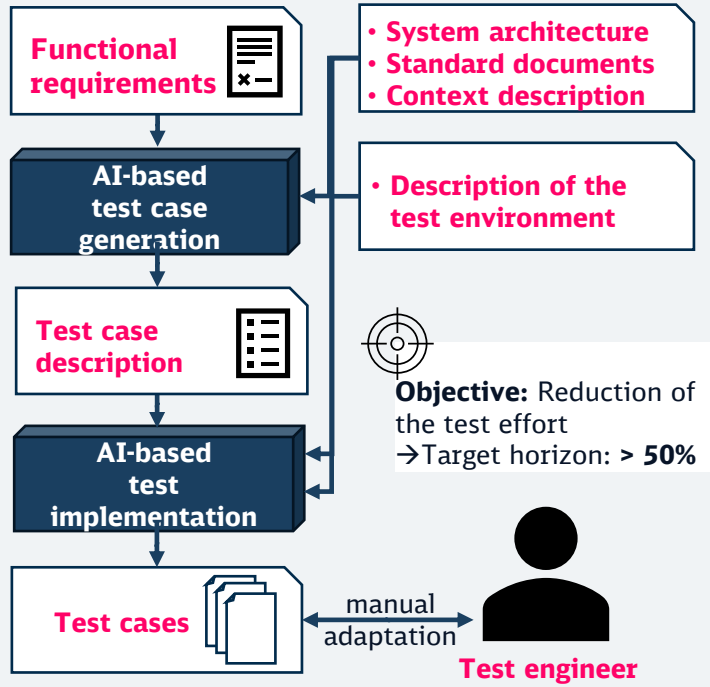
Specification of a computing platform for GoA4 applications

Key aspects	• Software components of the computing platform (middleware and application framework)
Approach	• Technology neutral evaluation of communication technologies
Results	• Suitability tests for existing technologies • Gap analysis for transferring suitable technologies

Integration + test of the middleware / application framework solutions

Key aspects	• Application framework requirements specification • Providing system and integration tests
Approach	• Automated test generation based on the functional requirements of the applications
Results	• AI-based tools to support the testing process • Test documentation

AI-based test generation



More information about our involvement in AutomatedTrain:

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DUAGON

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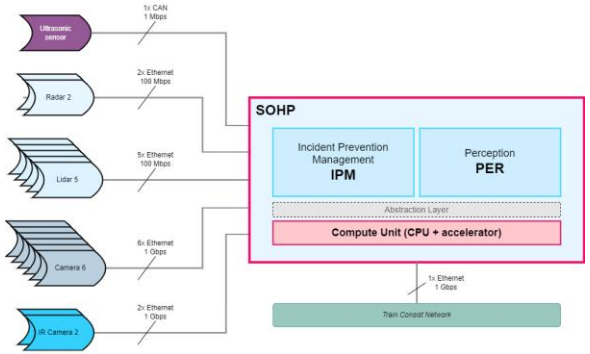
A new generation of a computer platform for fully automated rail vehicles

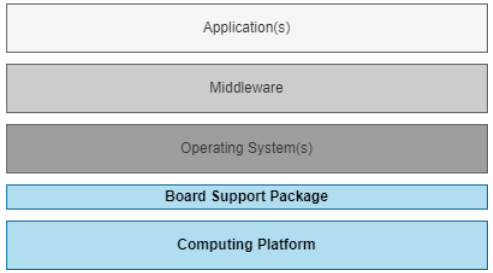
As part of sub-project 9 of AutomatedTrain, duagon, a global technology company specializing in embedded electronic hardware, software, and services for system-critical applications, is developing the specification for a modular and future-proof computer platform for fully automated rail vehicles. This platform will be specially optimized for AI and machine learning applications and includes high-performance computers, numerous interfaces and safety functions. It is robust enough to withstand the extreme conditions in the rail environment and meets all relevant safety and cyber security standards. A particular focus is on innovative cooling solutions and the integration of security functions.

Our work is closely linked to the three main aspects of the overall AutomatedTrain project: The elicitation of operational requirements, the development of a system architecture and the integration of technical solutions. By working closely with the other project partners, we contribute to the development of an effective overall solution that makes rail transport more innovative and competitive. Our involvement paves the way for the modern and efficient further development of rail transport and underlines the importance of joint innovation.

High-level System Overview



Computing Architecture



Innovation in a challenging regulatory environment

Innovation is part of our DNA. The AutomatedTrain project offers us the opportunity to develop important innovations for the rail market. The number and performance of computers in rail vehicles is constantly increasing, which brings major thermal challenges. Together with partners, duagon is developing new solutions to take the rail industry from the 'lagging edge' to the 'leading edge'. In order to achieve this, new concepts for the computer architecture are needed to develop a modular, future-proof computer platform and to reconcile this with regulatory requirements.

Here you can find us at InnoTrans:

Hall 27, booth no. 740

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Deutschland

IAV - As a Tech Solution Provider for Automated Driving Systems, we bring our series development expertise to the railway

As one of the world's leading engineering and technology partners to the automotive industry, IAV is developing the digital mobility of the future. The company has been developing innovative concepts, methods and solutions for more than 40 years. With 6,600 employees, IAV brings together the best of different worlds: Automotive and IT world, hardware and software world as well as product and service world. In addition to vehicle and drive development, the company focused on topics such as e-mobility and autonomous driving at an early stage and is now one of the leading technology providers in these areas. By transferring expertise from the automotive sector to other mobility solutions, such as rail, IAV is demonstrating its versatility and innovative strength. This commitment in the rail sector underlines IAV's endeavor to think mobility comprehensively and to develop and test innovative technologies beyond the boundaries of the automotive sector.

Rail topics and initiations

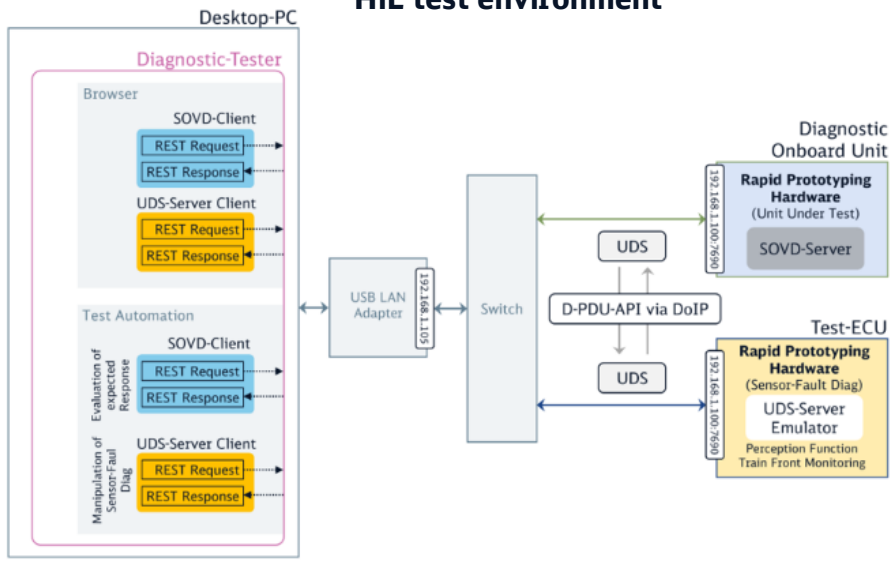
IAV contributes its strengths in process safety, control engineering, software, and interdisciplinary product development to create innovative solutions for the railway sector. Examples include:

- **EBA project:** Tree-fall detection using satellite data
- **Abandoned Object Detection:** AI-based detection of intentionally left objects
- **Cybersecurity:** CRA assessment covering management, processes, concepts and architecture, testing, and demonstration
- **AI Requirements Checker & AI Testing:** AI-supported requirements and test case management
- **WonderVision:** AI-based orientation assistance for visually impaired people

Diagnostics validation and verification (V&V) & construction of lab demonstrator

The onboard systems for fully automated driving require extended concepts for operational monitoring and automated fault management. In the sub project ‘diagnosis’ of the “AutomatedTrain” project, the diagnostic concept for the perception function - Train Front Monitoring (PER-TFM) sensor fault diagnosis use case is to be prototypically implemented and demonstrated; the target maturity level is TRL-6. In this sub-project, IAV is responsible for the validation and verification (V&V) of the developed diagnostic functions DIA-DHM (SOVD server), as well as the developed UDS services for the PER-TFM function. This includes test management, the design and construction of the test environments, as well as testing in general. Depending on the development maturity level (A, B and C prototypes), SiL and HiL test environments with corresponding test automation are developed and provided. The test case specification is based on requirements and experience and is coordinated with the partners involved. Test tools for a high degree of test automation are used for test implementation, execution and reporting. For the project tasks described, IAV contributes its process-related and methodological expertise as well as many years of experience in the testing environment in the automotive sector.

HiL test environment



Here you can find us at InnoTrans:

Hall 7.1 a, booth no. 120 &
BR 430 (T11/55)

More information about our involvement in AutomatedTrain:

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Red Hat

Digitale Schiene ##### Deutschland

About Red Hat, Inc.

Red Hat is the world's leading provider of enterprise open source software solutions, using a community-powered approach to deliver reliable and high-performing Linux, hybrid cloud, container, and AI technologies. Red Hat helps customers integrate new and existing IT applications, develop cloud-native applications, standardize on our industry-leading operating system, and automate, secure, and manage complex environments. Award-winning support, training, and consulting services make Red Hat a trusted adviser to the Fortune 500. As a strategic partner to cloud providers, system integrators, application vendors, customers, and open source communities, Red Hat can help organizations prepare for the digital future. https://www.redhat.com/en

What does Red Hat have to offer the rail industry?

- Red Hat provides unified platforms for applications from the cloud to distributed datacenters to edge computing on and off the train
- Red Hat Enterprise Linux as the enterprise Linux platform
- Long-term support for Red Hat Enterprise Linux
- Security profiles for Red Hat Enterprise Linux (for high security requirements)
    - CIS Benchmark Server Level 1+2
    - NIST 800-171
    - HIPAA
    - PCI-DSS 3.2.1 Control Baseline
    - DISA STIG
    - CCN Basic, Intermediate + Advanced
- Zero Trust, Confidential Computing
- Red Hat OpenShift as virtualization and container platform
- Red Hat OpenShift AI/ RHEL AI as an extension to the existing platform with sovereign AI/ML aspects and high-performance inference capabilities
- Red Hat Ansible Automation Platform as an end-to-end automation framework

Functional Safety with Red Hat In-Vehicle Operating System

Red Hat is fully committed to attaining continuous and comprehensive safety certification of Linux for critical security applications and has the industry's largest pool of Linux maintainers and contributors committed to this initiative. RHIVOS's successful ISO 26262 certification at the ASIL-B level (SEooC) by exida confirms the validity of the approach developed by Red Hat to align the process requirements of functional safety standards with the agile development cycles of complex open-source software such as Linux. Red Hat's commitment to open source principles remains integral to the development of software-defined vehicles (SDVs). Open source projects have consistently set industry standards, driving compatibility and interoperability across diverse systems, components, suppliers and manufacturers. By working with the broader open source community, Red Hat can make use of the rigorous testing and analysis performed by Linux maintainers, collaborating across upstream communities to deliver open standards-based solutions. This approach enhances long-term maintainability and limits vendor lock-in, providing greater transparency and performance.

More information about our involvement in AutomatedTrain:

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SIEMENS

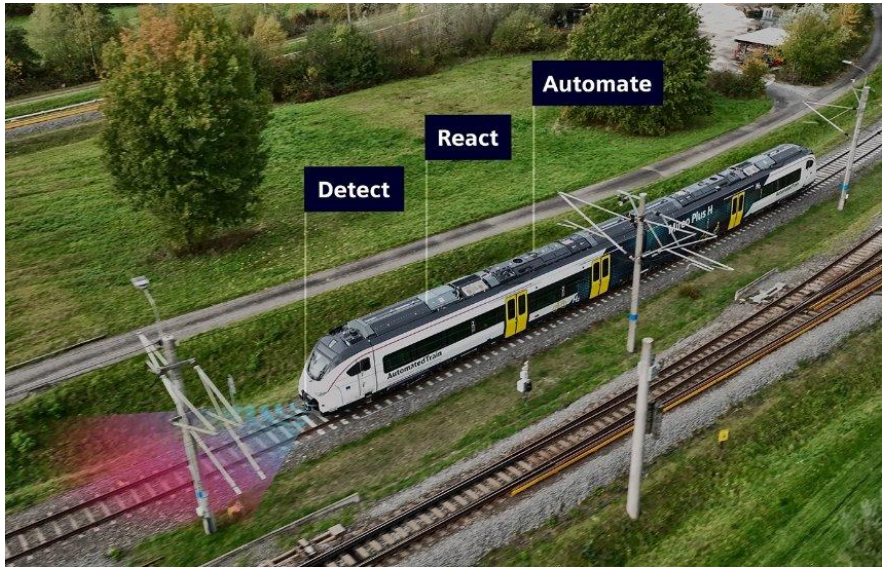
Digitale Schiene
Deutschland

Development and Demonstration of fully automatic provisioning and parking on a Siemens Mireo train

Siemens Mobility, as an experienced vehicle and system manufacturer, contributes the knowledge for the development of the necessary technology components and a Mireo vehicle for prototypical testing to the project.

Based on the expertise Siemens Mobility brings to the requirements and architecture definition, the system for perception (sensor set), incident prevention, and vehicle function automation is significantly developed, implemented, and prototypically integrated on a Mireo vehicle by Siemens Mobility. Subsequently, the interaction of subsystems is evaluated through system tests and demonstrations at the Siemens Mobility test site in Wildenrath and at HVLE in Berlin-Spandau. During InnoTrans2026 Live Demonstrations at HVLE are organized.

Demonstration of the technical feasibility of the fully automated dispatching and stabling journey
- ✓ automated preparation and stabling of trains
- ✓ driverless journey (GoA4)
- ✓ Obstacle detection with automated reaction
- ✓ Experience GoA4 live



Boundary conditions

- Testing in a protected environment
- Maximum speed: 40 km/h
- Track with ETCS infrastructure
- Only a safety driver is present on the train

Features / use cases

- Fully automated train preparation & self-check of the vehicle
- Fully automated provisioning- and stabling: perception (sensor set) and incident prevention management (reaction with interaction on train control e.g. brakes)
- Handover from GoA4 to GoA2

Here you can find us at InnoTrans:

Hall 27, booth no. 230

More information about our involvement in AutomatedTrain:

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TECHNISCHE UNIVERSITÄT DRESDEN

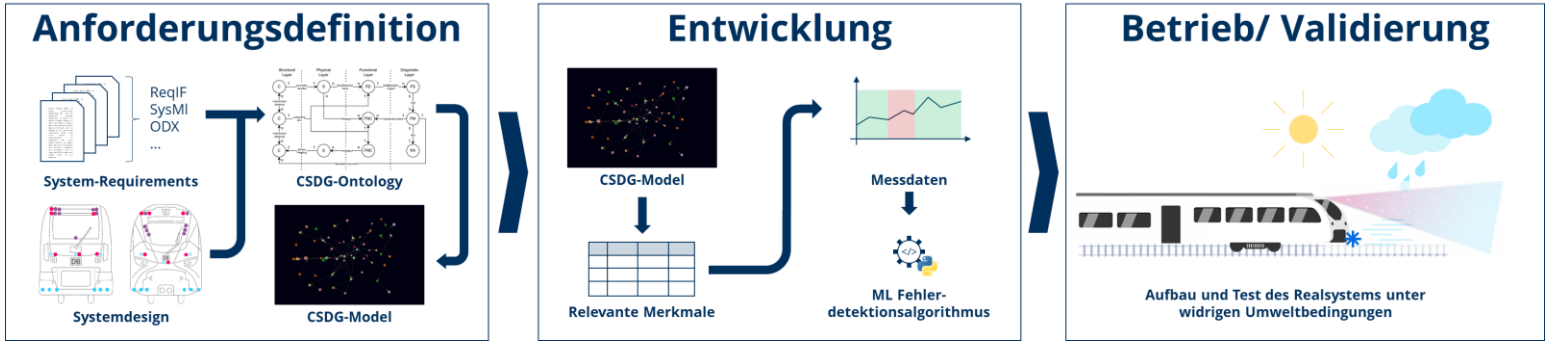
Digitale Schiene Deutschland

Sub-project ‘Diagnostic validation of environment detection systems with predictive algorithms’

In order to implement safe obstacle detection for the AutomatedTrain-Use Case, the vehicles will be equipped with environment detection sensors (camera, lidar, radar, ultrasound) and localization systems, among other things. To ensure reliable and safe operation of the GoA4 vehicles, a powerful system for operational diagnostics [1] is to be developed, taking operating and weather conditions into account.

For the development, design and validation of the diagnostic system, TU Dresden is testing a holistic approach, starting with the definition of requirements, through algorithm implementation and design, to validation. Diagnosis-relevant information is automatically extracted from system descriptions, requirements and development documents and modeled in a Causal-Structural-Dependency-Graph (CSDG) [2] using a general, system- and use-case-independent graph ontology. This knowledge graph represents the system to be analyzed (in this case the environment detection system), aggregates system information (including structure, functions, states) from different data sources and represents the dependencies between them in a joint model. Use-case-specific model analyses can be used to answer a wide range of diagnostic questions. Failures, including their effects in the sense of an FMEA, can be identified early on in the development process, relevant characteristics (measured variables/signals) for the design of data-driven (predictive) failure detection algorithms can be determined or failure causes can be determined in the sense of failure isolation.

The results are validated on a HiL test bench. Parts of the investigated environment detection system, including real sensors, are to be set up, faults fed in and unfavorable weather conditions stimulated. The performance to be evaluated of the fault detection algorithms developed using the CSDG is measured in terms of the extent to which system degradation can be quantified predictively and preventive measures can be initiated to shut down faults. The aim is to increase the safety of the environment detection system as well as the availability and reliability of operation.



[1] Schories, K.; Rabe, M.: Onboard diagnostics concepts for future train operation. In: Diagnose in mechatronischen Fahrzeugsystemen XVI: Software-Defined Vehicle, SOVD, Maschinelles Lernen und KI, Standardisierung, HU und ADAS, Dresden, p. 147 - 158, ISBN 978-3-95908-318-8, 2023.

[2] Rabe, M.D., Schories, K., Bäker, B., Unger, A.: Causal-Structural Dependency Graphs for Automated Diagnostic Validation in Vehicles. In: Kulzer, A.C., Reuss, HC., Wagner, A. (eds) 23. Internationales Stuttgarter Symposium. ISSYM 2023. Proceedings. Springer Vieweg, Wiesbaden. https://doi.org/10.1007/978-3-658-42048-2_34

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