ATO: The Key to the Future of Rail?

Navigating digital safety systems on the rail network

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Introduction

Rail is integral to the transportation industry worldwide. It is known for its safety, efficiency, and eco-friendly characteristics. However, the industry still faces challenges in maintaining its competitiveness in the transportation market and meeting the increasing demands of passengers and freight.

To address the obstacles blocking the tracks of rail development, the industry has invested in new technologies to improve its performance and capacity. Two of these technologies are ATO and ERTMS/ETCS.

In this paper, we will discuss the benefits of Automatic Train Operation (ATO) over the European Train Control System (ETCS) and its potential to enhance rail's productivity and performance.

What is ERTMS/ETCS?

The European Rail Traffic Management System/European Train Control System (ERTMS/ETCS) forms a standardized system providing a common interface between trackside and onboard equipment. ETCS includes an Automatic Train Protection (ATP) function ensuring train speed compliance at permitted limits. It also offers other functions, from train detection to rapid communication with the control center.

What is ATO?

ATO uses onboard computers to control train movement, eliminating the need for human intervention. Serving as a fundamental component of metro and light rail networks, ATO utilises sensors and communication systems to monitor train positions and speeds, automatically adjusting train movements to ensure safe and efficient operations.

Although ATO can provide for driverless operation, there are different levels of automation within the system:

SEMI-AUTOMATIC TRAIN OPERATION (STO):	The basic ATO. At this level, the system only executes the movement of trains from one station to the next, following the speed profile under the supervision of the ATP system and considering information from the signalling system (e.g. stop signals). A driver is needed to operate doors and intervene in emergencies or operational disruptions.
DRIVERLESS TRAIN OPERATION (DTO):	Adding the function of door control to the STO system results in DTO. The driver is no longer needed but an attendant is still required, offering customer services and assuming driver functions if the ATO system fails.
UNATTENDED TRAIN OPERATION (UTO):	At this level, there is no driver or attendant on board; the train is fully automated. This implies additional requirements to guarantee safety and handle failures. For example, greater protection against intrusion or obstacles needs to be considered. Another important feature that should be considered is the improvement of safety in stations. In a more traditional manner, this goal is achieved through the use of platform screen doors. By integrating an ATO system with a sensor suite, such as a camera-based system with image recognition or infrared curtains, and ensuring high-precision train positioning and stop control, passenger safety is enhanced. Typically, the responsibility for enabling doors at a station falls to the driver, in conjunction with the Train Control and Monitoring System (TCMS) sub-system.

Benefits of ATO over ETCS

By defining a standard for ATO and ETCS, rail operators can reduce the cost and time needed for implementation, comply with industry regulations, and ensure that technology meets the required quality standards, achieving interoperability across European networks.

The European Green Deal has set ambitious goals for the railway industry, requiring a drop in transport emissions of 55% by 2030 and 90% by 2050. To meet these targets, the overall network needs to increase capacity, punctuality and CO2 reductions while bringing down the total cost of ownership. ATO technology over ETCS brings key benefits for railway operators, including:

Increased transport capacity improving punctuality and timetable stability: ATO systems can increase transport capacity by optimizing train movement and reducing headways between trains and delays. ATO systems can also reduce the time needed for train acceleration and deceleration, reducing the total journey time. This can increase the number of trains operating on a given line, maximizing transport capacity. ATO systems can adjust train movements to make sure trains arrive at their destination on time, improving punctuality. This can result in a more reliable timetable and improved customer satisfaction.

Reduced human factors dependency: ATO systems reduce the dependency on human factors, enhancing safety, availability and reliability. ATO systems use onboard computers to control train movements, reducing human error risk. This can improve safety and reduce the likelihood of accidents. They also reduce human driver dependence, lowering the chances of driver fatigue and improving availability and reliability within the network.

Infrastructure build-up: Requirements placed on grid expansion in light of the climate crisis have further increased due to recent geopolitical and supply security issues. The European Commission estimates that investment worth €584billion is required in the T&D grid by 2030.

Enhanced driving profile leading to energy savings: ATO systems can enhance the driving profile of trains, offering energy savings. ATO systems can optimize train movements in terms of acceleration and braking (among others) to lower energy consumption, reduce CO2 emissions and promote sustainability. This can result in reduced energy costs and a more eco-friendly railway system.

Increased passenger comfort: ATO systems can increase passenger comfort by maximizing train movements and reducing the total journey time. ATO systems can reduce the time needed for train acceleration and deceleration, leading to a smoother and more comfortable ride – increasing customer satisfaction.

ATO offers standard interfaces and interoperability. This enables railway operators to enhance the safety, reliability and punctuality of their services, while also reducing trains' impact on the environment.

The first baseline of ATO over ETCS establishes the standard for operating a train automatically for GoA2 and defines the exchanged data between ATO systems and ETCS, unlocking interoperability at an early stage of ATO.

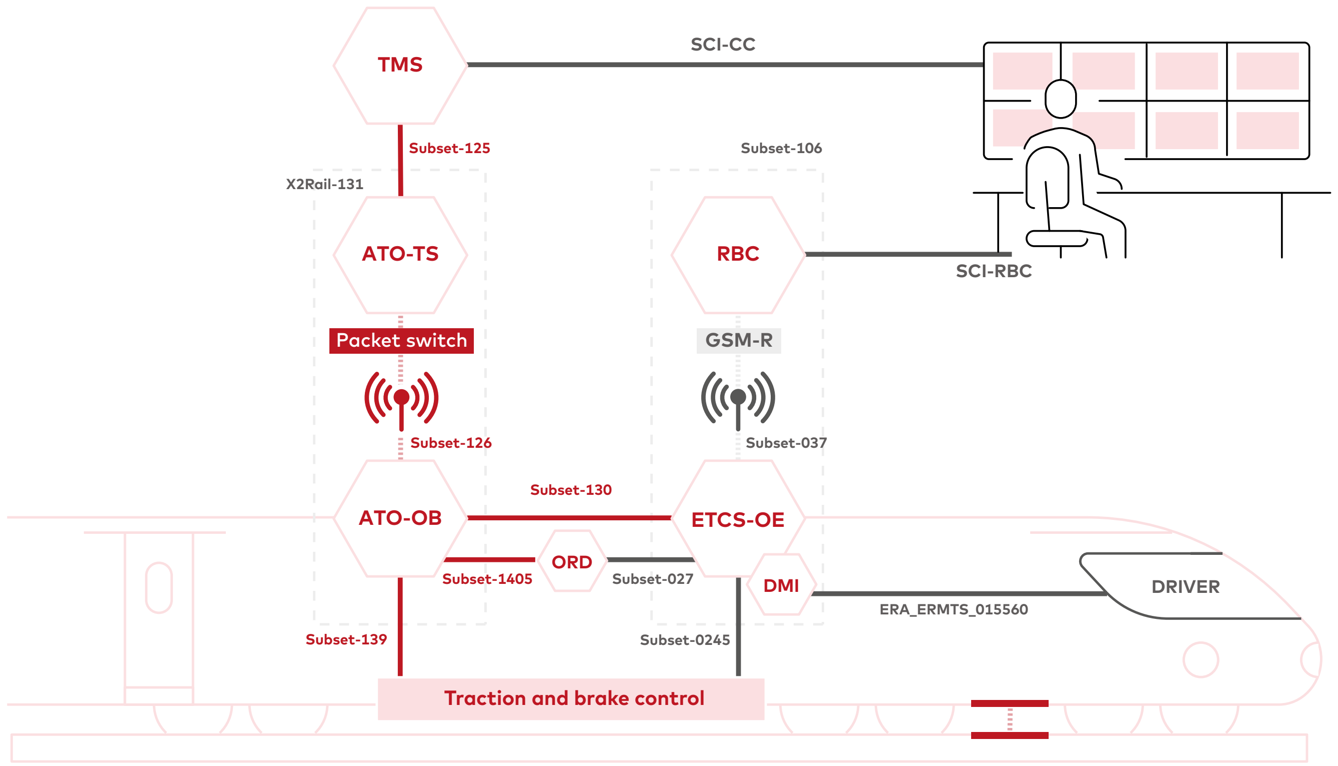


Figure 1 *High-level architecture and interfaces of the ERTMS/ETCS based ATO*

The standard interfaces for data exchanged between ATO On-board and ATO trackside have been defined by the European Union Agency for Railways (ERA) in subset-126. These interfaces allow for the exchange of information related to the start/stop, journey and segment profile data. The start/stop data includes information on the train's starting and stopping points, while the journey data includes information on the train's route, speed and acceleration/deceleration profiles. The segment profile data includes information on the track characteristics and any speed restrictions and other relevant information.

Additionally, the information exchanged between the European Train Control System - On Board (ETCS-OB) and ATO-OB is defined in subset-130. This subset includes data on driver inputs, dynamic and static data, and information to be displayed in the Driver Machine Interface (DMI). The driver inputs include information on the train's speed, braking and acceleration, while the dynamic includes similar information.

Path to GoA4

ATO systems have historically been used in isolated environments, such as driverless metro trains and people movers. However, implementing Grade of Automation 4 (GoA4) train operations in other settings requires new or improved systems to overcome obstacles.

Some systems forming part of may include:

Obstacle Detection: Obstacle detection is essential for ensuring the safety of passengers and trains. It involves identifying objects on the track, including fallen trees and even people. Obstacle detection can be achieved using various sensors like cameras, LiDAR, radar and infrared.

Refined Positioning: Refined positioning is necessary to ensure that trains stop at the correct place in a station. It provides additional train-local information, enabling the ATO system to make more accurate decisions. This can be achieved by leveraging technologies like GNSS, sensors and wireless communication systems.

Passenger Transfer Supervision: Passenger transfer supervision ensures safe boarding and deboarding without any personnel or screen doors on the platform. This can be achieved using sensors, camera and other technologies, monitoring passenger movements and ensuring their safety.

Rolling Stock Adaptation: Rolling stock adaptation is needed to allow ATO control through removing driver input dependency. This involves modifications to the train control system in safety related functions, onboard equipment, and other components to make them compatible with the ATO system.

Cyber security: Cyber threats are a potential risk associated with increased digitalization in rail. Therefore, implementing GoA4 train operations demands robust cyber security measures, ensuring the safety and security of the system

However, implementing GoA4 train operations is not without its challenges and risks. Some of these include:

Perception Risks: Referring to the perception of the target public and political decision-makers regarding the safety and feasibility of GoA4 train operations. Overcoming these risks requires effective communication and education programs to raise awareness about the safety and benefits of the new technology.

Reluctance to Change: Reluctance to change is a common challenge associated with implementing new. Overcoming this challenge requires effective change management programs and stakeholder engagement to ensure that all relevant stakeholders are involved and supportive of the change.

Staff Reductions: The implementation of GoA4 train operations could result in staff reductions. As such, it is crucial to establish effective transition programmes and retraining opportunities, ensuring that affected employees have the means to move into alternative roles within the organisation. This approach also facilitates overcoming some of the challenges associated with the ageing workforce in the railway domain.

Cost-Benefit Analysis: Implementing GoA4 train operations requires a cost-benefit analysis to ensure that the benefits of the technology outweigh the costs. This analysis should consider factors like capital and operating costs, safety benefits, operational efficiencies, and passenger experience.

Pilot projects using ATO

Some pilot projects in rail have already implemented Automatic Train Operation (ATO) technology, allowing trains to run without human drivers.

1.

German railway operator, Deutsche Bahn (DB), and Siemens Mobility have presented the world's first self-driving train, which was expected to be operational by 2021. The train is equipped with a digital signaling system and onboard sensors that allow it to operate without a driver. The train will be capable of operating at speeds of up to 100km/h and will initially be used for freight transport. The technology is expected to be rolled out to passenger trains in the future.

The self-driving train is part of the German government's Digitale Schiene Deutschland (Digital Rail Germany) program, which aims to digitize the country's rail network. The program aims to improve the efficiency, capacity, and safety of the rail network by using digital technologies like artificial intelligence, big data, and the Internet of Things.

2.

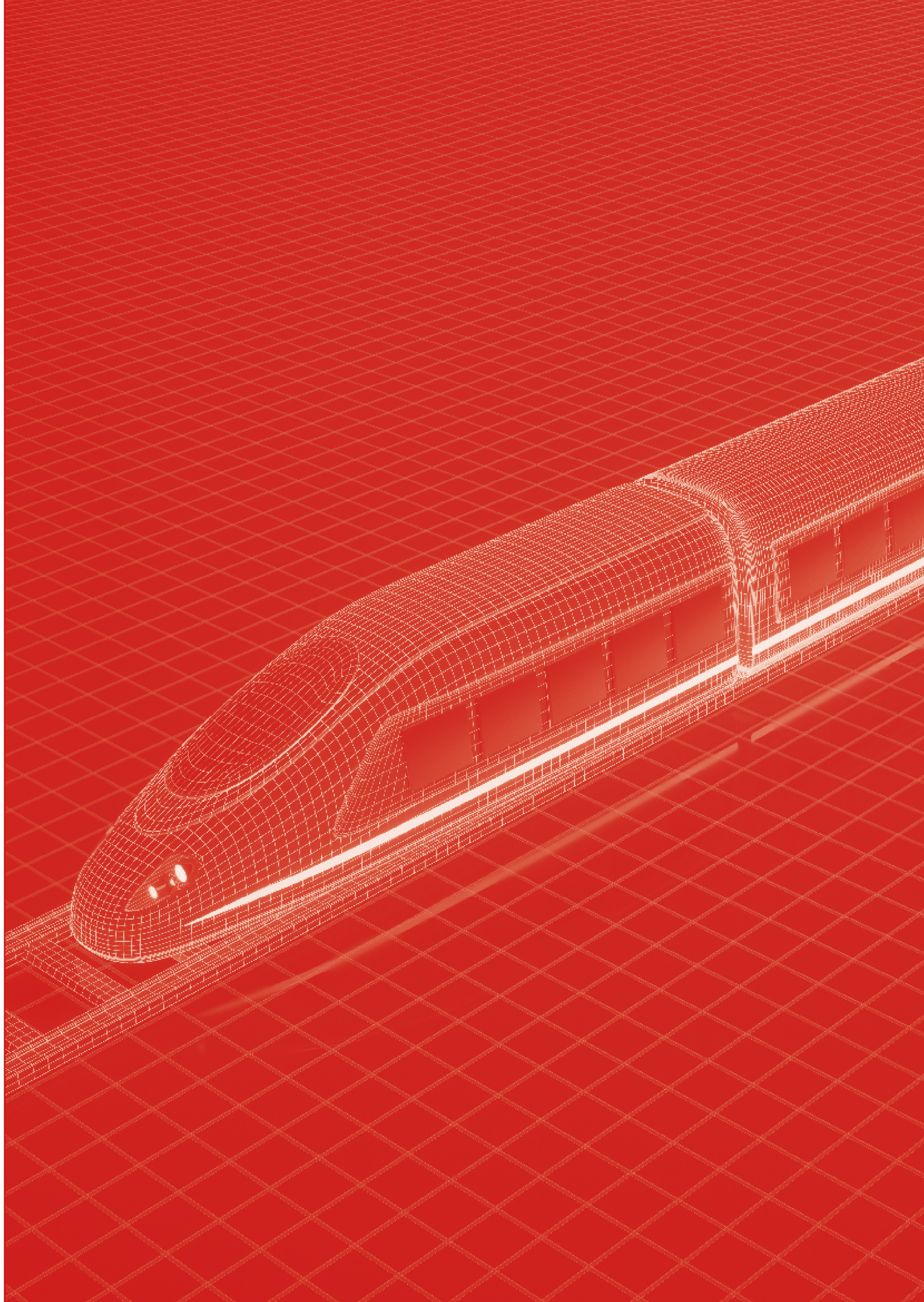
The French National Railway Company (SNCF) has successfully tested a mainline autonomous train at Grade of Automation 2 (GoA2), marking a significant milestone in the development of autonomous train technology. The test was conducted on a 100km stretch of track between Toulouse and Bordeaux, using a modified regional passenger train equipped with an ATO system.

The autonomous train was able to operate at speeds of up to 200km/h and successfully completed all required tests, including emergency braking and obstacle detection. The test demonstrated the potential of autonomous trains to revolutionize the railway industry by improving safety, capacity, and efficiency.

3.

The Dutch Infrastructure Manager, ProRail, is set to expand its main line Automatic Train Operation (ATO) trials, following the successful completion of initial tests on the Betuwe Route. The Betuwe Route is a dedicated freight line that connects the port of Rotterdam with the German border.

The ATO trials will be expanded to include the Amsterdam-Utrecht corridor, one of the busiest rail lines in the Netherlands. The trials will also involve passenger trains, as well as freight trains, to test the technology's suitability for different types of trains and routes.



1 *https://press.siemens.com/global/en/pressrelease/world-premiere-db-and-siemens-present-first-self-driving-train*
2 *https://www.railjournal.com/locomotives/sncf-successfully-tests-mainline-autonomous-train-at-goa2/*
3 *https://nltimes.nl/2022/06/21/dutch-power-grid-cant-handle-influx-electric-car-charging-points*
4 *https://www.railjournal.com/infrastructure/dutch-to-expand-main-line-ato-trials/*

How Critical Software can help

Critical Software has extensive experience in developing, testing, and assuring the quality of ATO system for major rail companies. We have been able to help not only in system development activities but also in commissioning ATO systems worldwide. We were involved in the system development of one of the first ATO systems the world, resulting in several metro systems being deployed without a driver and with different automation levels in geographies from the USA to Australia. In the UK, we have improved the headway of several London Underground lines, with a keen focus on the performance levels of the ATO and ATP systems.

We have empowered new market players to develop their own ATO system, harnessing innovative technologies and new paradigms to reach GoA4 and SIL 4 certifications for future metros systems in large metropolises.

When it comes to safety, we led an independent assessment for the Automated People Mover system in Shanghai: a comprehensive process encompassing all aspects of the system. This included the onboard control system (TCMS), vehicle architecture, ATC, communication, power distribution, platform screen doors, track switches, and supervision of the planned maintenance activities. The assessment identified any potential safety hazards or risks and ensured that all necessary safety measures were put in place to mitigate them.

The focus was on conducting safety and quality audits and witnessed testing sessions to make sure all safety-critical components of the system were functioning as intended. The assessment also involved inspection of all RAM (Reliability, Availability, and Maintainability), Operation & Maintenance (O&M), and safety manuals to ensure that they were complete and accurate.

The ultimate goal of the assessment was to certify the ATO system as compliant with the CENELEC EN 5012x standards, the industry standard for safety in rail applications. By conducting this independent safety assessment, we helped ensure the APM was safe and reliable for the millions of passengers who use it every day.

ATO principles, hitherto mainly used in closed metro systems, are gradually being adopted on the mainline. We have been involved in several projects, R&D and commercial, to drive the state-of-the-art to a new paradigm of operation on mainlines across the globe. The use of automatic collision warning and avoidance is pivotal in achieving the maximum amount of automation on locomotives. Fortunately, we are fully equipped to guide you safely down the tracks towards an ATO future.

We are CMMI Maturity Level 5 rated.

For a list of our certifications & standards
visit our website.& **standards visit our website.**

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