Pioneering ATO over ETCS Level 2

Interoperable ATO over ETCS is seen as key for the future automation of main line railway operations in Europe. Valuable experience and feedback is expected from an early implementation project on the Mexico City – Toluca suburban line.

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Automatic Train Operation is widely seen as the next big boost for the productivity and performance of main line railways. Automation has been used by metros for almost half a century, and today the technology is well proven. Urban transit operators around the world have been reaping important benefits, yet the number of main line applications remains limited.

Several railways have announced trials with ATO over the coming years, while a handful of commercial applications are taking shape. One of the major challenges is adapting ATO to the very different operating conditions found on mixed traffic networks.

It is relatively straightforward to provide automation within a closed system, where the trains are all essentially the same, with similar performance characteristics and a handful of standard stopping patterns. But this is clearly not the case where fast and slow passenger and freight trains must share the same tracks, sometimes run by different operators. Some form of interoperable technology is needed, which as yet is not available off the shelf.

When discussing ATO, it is important to distinguish between the four grades of automation (Table I), which require diminishing levels of human involvement up to GoA 4 which is fully unattended. In terms of technology, the typical configuration can be represented as a triangle, with the onboard ATO equipment driving the train using routes and commands set by an Automatic Train Supervision function in the control centre and a separate Automatic Train Protection system providing the safety overlay.

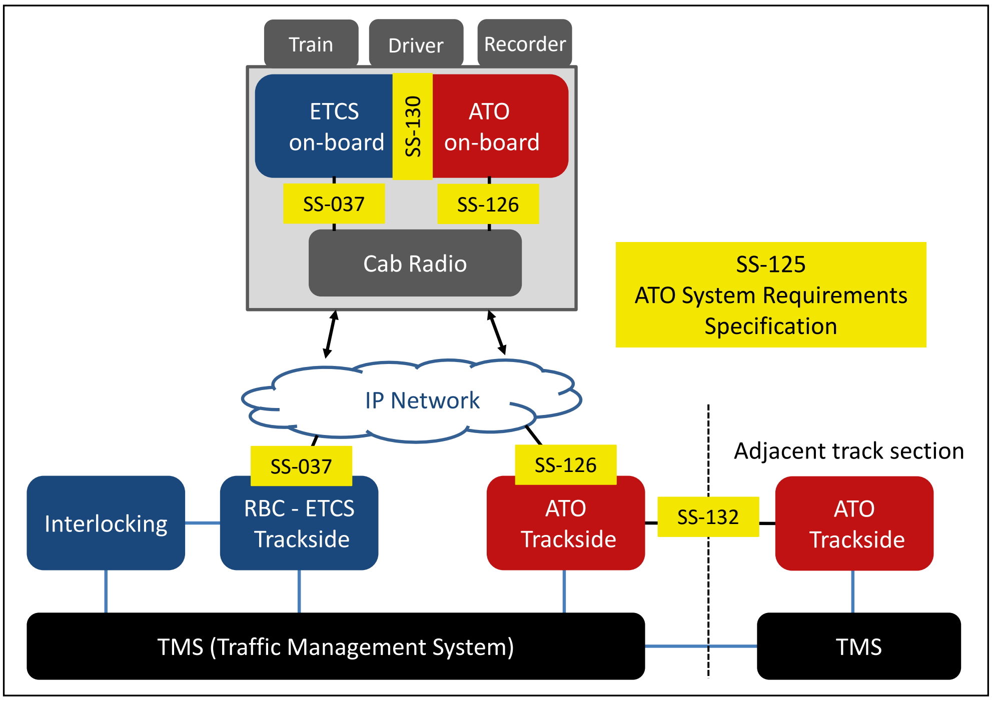

Fig 1. Being developed by the ERTMS Users Group, UNISIG and ERA, the proposed architecture for an interoperable ATO over ETCS is initially envisaged for GoA 2, retaining a driver in the cab.

ATO over ETCS

In the main line arena, the European Train Control System offers a standardised ATP function as part of the architecture of the European Rail Traffic Management System. This was originally created to achieve signalling interoperability across Europe, but it is being applied more and more outside Europe, thanks in part to the availability of most elements off the shelf from multiple suppliers.

It seems logical for any main line automation project to incorporate ETCS to provide the ATP functions. But ERTMS is also about interoperability, and it will be essential to ensure seamless operations across boundaries if the European rail network is to become more competitive against other transport modes.

To ensure the maximum benefit from automation, the same system approach and interoperability requirements should extend to the ATO. Any compliant train should be able to run safely with the target level of automation as long as it is running over a compliant infrastructure. That means complementing ETCS with interoperable ATO, while minimising the impact on the existing ETCS specifications. This approach at the level of the wider railway system goes far beyond the traditional project-oriented approach, in order to ensure a smooth migration towards automation.

Fig 1 shows a proposed architecture for interoperable 'ATO over ETCS'. This is initially envisaged for GoA2, which retains a driver in the cab. The ATO overlay is split into two subsystems. The trackside elements are linked to the control centre, and closely related to traffic management over a wide

Table I. Grades of Automation

Grade of Automation	Train operation	Setting train in motion	Stopping train	Closing doors	Operation in the event of disruption
GoA 1	ATP with driver	Driver	Driver	Driver	Driver
GoA 2	ATO with driver	Automatic	Automatic	Driver	Driver
GoA 3	Driverless	Automatic	Automatic	Train Attendant	Train Attendant
GoA 4	Unattended	Automatic	Automatic	Automatic	Automatic

SPOTLIGHT Signalling

Civil works for the Mexico City – Toluca line are well underway. The installation of railway systems, including track, electrification and signalling, is expected to start by the end of this year.

geographical area. The onboard system handles the actual driving, ensuring optimum performance while considering factors such as energy consumption, journey time and headway, as well as passenger comfort.

The key to interoperability is a fully standardised interface between these two elements. Using an overlay approach, the ETCS and ATO components are kept functionally distinct, although there must clearly be some onboard links to achieve the desired functionality. For example, the ATO needs to exchange data with the ETCS onboard equipment to drive the train automatically as close as possible to the permitted speed curve, achieving higher performance than manual driving. ETCS subsystems such as the odometry and event recorder can be shared, as well as the Driver-Machine Interface which presents both ETCS and ATO information to the driver.

The same track-train communications system would be used, but with independent channels. Use of an IP-based network instead of GSM-R would enable two different data communication sessions to be provided by the same on-board radio equipment, giving the necessary quality of service for each application.

From concept to specification

The AoE concept has been developed by a team drawn from the ERTMS User's Group and the UNISIG suppliers' association as part of a TEN-T project running from 2012 to 2014. This produced a system requirement specification and a number of interface specifications, which were presented to the European Agency for Railways at the end of 2014. The aim at that time was to include the AoE function in the Baseline 3 Release 2 specification adopted earlier this year. Additional technical work in 2015 included discussions with representatives of the wider European rail sector about integrating AoE into the agency's longer-term strategy for the development of new functions linked to ERTMS.

Although AoE was not formally included in Release 2 as envisaged, it was included in the Longer-Term Strategy Report recently published by ERA. It is described as a relevant 'main contributor' to the evolution of ETCS. A detailed roadmap is due to be defined this year, working with the sector to finalise the specifications; the aim is to have the first GoA2 applications running by 2018-19.

UNISIG is continuing to work on AoE development, although the lead will pass to Shift2Rail as this programme becomes operational over the coming months. As part of the IP2 workstream, Shift2Rail will also address higher levels of automation up to GoA 3 and 4. Early implementation projects in Europe are also envisaged to provide feedback under real conditions and take the specifications to a higher level of maturity.

Early implementation in Mexico

While the final specifications are still under discussion, CAF Signalling has had the opportunity to pioneer a commercial application of AoE on the Mexico City – Toluca commuter line now under construction. Electrified at 25 kV 60 Hz, this 57·7 km double-track line with five stations will serve a suburban region with around 800 000 inhabitants; it has been designed to carry around 270 000 passengers per day. With the trains running at up to 160 km/h, the end-to-end journey time is expected to be 39 min, whereas the same trip by road can take 2 h today.

Under the €690m contract awarded at the end of 2014, CAF is leading the consortium, which also incudes Isolux-Corsán for the civil works, AZVI for the track and electrification, and Thales.

CAF itself will supply a fleet of 30 trainsets equipped with regenerative braking. CAF Signalling is responsible for the control centre, ETCS onboard equipment and the full ATO system including both onboard and trackside equipment. Thales is providing the trackside signalling equipment, including the interlocking and ETCS Level 2 radio block centre, as well as the telecommunications network.

The project began in 2015, allowing the train control system to be designed from the outset using the AoE draft specifications. The route has been

designed for high-density operation using metro-style 'distance to go' principles and attended ATO to GoA 2. Driving between stations will be automatic, but the drivers will be required to close the doors at each stop; they will also be able to operate the trains manually during periods of disruption. Trains will run at a peak headway of 2·5 min, with a maximum of 24 trains/h.

The line will be fitted with ETCS Level 2 following SRS Version 2.3.0d. Although AoE development is mainly being made in the context of ETCS Baseline 3, this early implementation should demonstrate that the interoperable concept will also work with Baseline 2. The critical interface specifications follow the draft AoE standards, notably Subset 126 for the interface between ATO onboard and trackside and Subset 130 for that between the ETCS and ATO onboard equipment.

The same GSM-R radio system will serve both ETCS and ATO functions, but using independent channels. This guarantees that the quality of service required for ETCS communications is not affected by the ATO. No modifications to the RBC are needed to accommodate ATO.

The automatic driving system will control the train between stations, and includes a 'skip-stop' function, allowing the train to run through selected stations at a safe reduced speed. Four different profiles are being defined for each inter-station journey, such as 'fastest possible' where the ATO drives as close as possible to the maximum speed allowed by the ETCS, or a more energy-efficient profile which uses as much coasting as can be reasonably accommodated.

The ATO trackside equipment will receive the traffic management instructions from the regulation system at the control centre, transmitting the journey profiles and target timetable to the trains through the interoperable interface.

Further evolution

Although the Mexico City – Toluca line is not yet operational, the project development work so far confirms that interoperable AoE offers many advantages. Most significantly, it has confirmed that a standard and interoperable approach to GoA2 is feasible, combining ETCS as the ATP function to ensure safety with an ATO overlay based on the draft specifications.

This configuration ensures a high level of functional independency between ATO and ETCS. The automation functionality and performance is not limited by ETCS, except for the safety constraints imposed by the ATP. No modifications have been needed to the RBC, and the concept can be implemented using ETCS trackside equipment to either Baseline 2 or 3.

AoE is a powerful concept built on interoperability and standardisation. While it can be applied to a standalone project such as Mexico City – Toluca, the concept itself is oriented to a wider railway network. Having a configuration that allows an ATO-equipped train to run automatically over any equipped section of the network should simplify the deployment and migration process, reducing the level of investment needed and delivering huge benefits to railway operators.

Using the AoE interface specifications, both ATO and ETCS information can be displayed to the driver on the same DMI.