



Proceedings of 8th Transport Research Arena TRA 2020, April 27-30, 2020, Helsinki, Finland

Collaborative field test of Freight ATO marks Shift2Rail milestone

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Abstract

European rail freight operator DB Cargo together with locomotive manufacturer Bombardier and ETCS supplier Siemens are realizing the most comprehensive testing of state-of-the-art autopilots from a range of industry suppliers on a legacy freight locomotive. For the Shift2Rail joint undertaking this collaboration project marks a key milestone by promoting standardized on-board solutions for automated driving, quick wins in the field of freight transport and a shift of freight to rail on the European mainline. The project is outstanding in many regards: It will provide critical results for definition of future standardized and open interfaces, the future mode of rail freight automation and performance-based migration planning. One of the key success factors is the outstanding collaborative set-up, which also encompasses full testing of ATO (Automatic Train Operation) modules within the Swiss Smart Rail 4.0 initiative..

Keywords: Automation; Automatic Train Operation; Autonomous driving, Shift2Rail; Freight; Innovation

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Nomenclature

ARCC	Automated Rail Cargo Consortium
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ETCS	European Train Control System
EVC	European Vital Computer (core of ETCS on-board)
FFFIS	Form Fit Function Interface Specification
GoA	Grade of Automation 1-4 [International Association of Public Transport]
GoA2	Semi-automated driving: ATP and ATO with driver
GoA4	Unattended Train Operation with ATP, ATO and support systems
IM	Infrastructure Manager
IP	Shift2Rail Innovation Program
IP2	IP “Advanced Traffic Management and Control Systems”
IP5	IP “Technologies for Sustainable & Attractive European Rail Freight”
JTI	Joint Technology Initiative
MVB	Multifunction Vehicle Bus
OBU	On-board Unit
RU	Railway Undertaking
TCMS	Train Control & Management System
TMS	Traffic Management System
TRL	Technology Readiness Level

1. The IP5 Vision as motivation

The Shift2Rail Joint Undertaking has been established to achieve the goals set out by the Commission's 2011 Transport White Paper “Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system”. With a view on rail freight corridors as the backbone of the EU freight transport system, Shift2Rail funds research and development particularly in the field of Automated Train Operation (ATO), its self-declared nr.1 innovation capability.

The Shift2Rail Innovation Programme 5 “Technologies for Sustainable and Attractive European Rail Freight” is the platform for industry and operators to design, test and mature, among other topics, solutions for ATO in rail freight. Under the chairmanship of DB Cargo, IP5 has further developed the high-level objectives of Shift2Rail, as shown in the vision for future freight; see figure 1 below. This vision showing digitalized assets and automated trains supervised from an operator’s control tower at its core, has been the motivation to set up the Automated Rail Cargo Consortium (ARCC), in the very beginning of Shift2Rail.

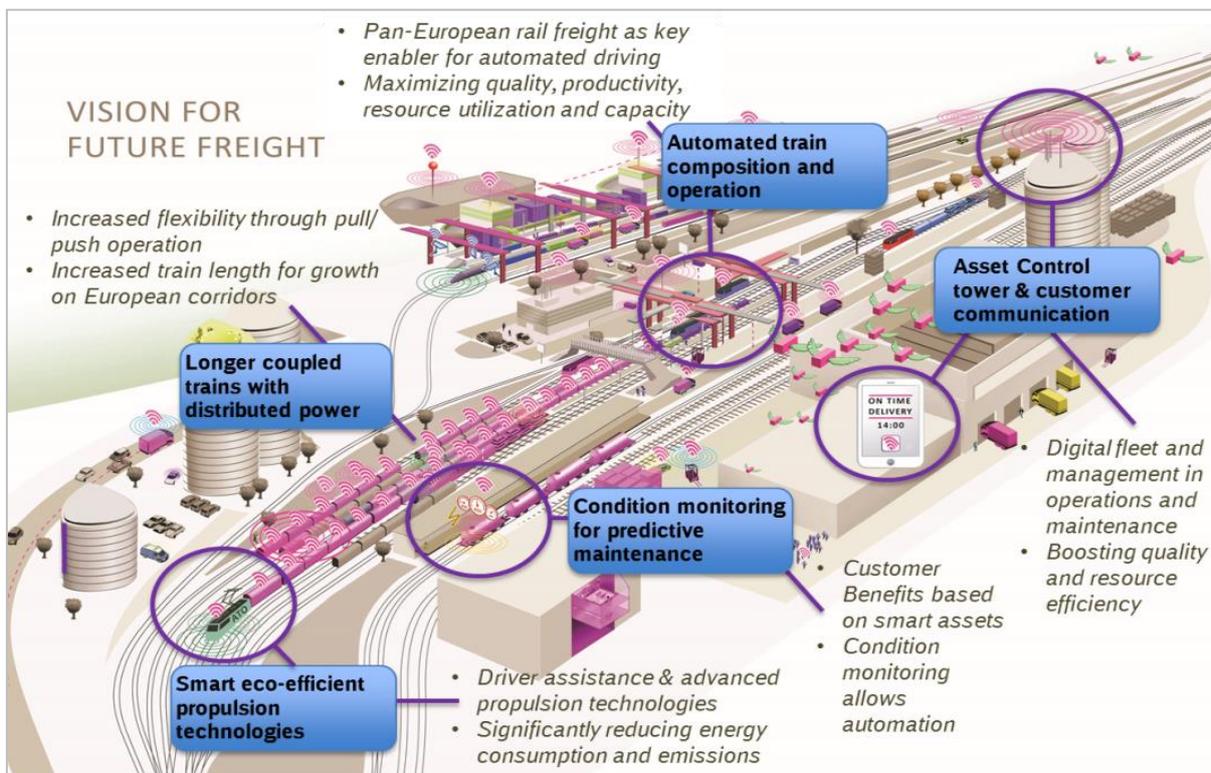


Figure 1: Shift2Rail vision for future freight

2. The benefits and relevance of ATO

Automated driving is of key importance for rail freight haulage, although this has generated less public interest than the hype about future autonomous cars. Analysts agree that individual transport by personal car is a rather unattractive future market. Instead shared mobility service models such as ride pooling are commonly named a key driving force for future autonomous driving. As another commercial, high-mileage mobility service, also trucking is named a highly attractive future market for autonomous driving, starting with the “platooning” of multiple trucks behind one driver and gradually evolving to completely self-driving trucks. Automation of cargo transport shall thus enable maximum ton-kilometers twenty-four hours a day. Rail freight is challenged to leverage the innovation potential first and make ATO a reality on mainlines, before it will revolutionize trucking.

The benefits of an automated freight transport system are manifold. The first and most obvious benefit is the direct saving of energy due to optimized driving profiles that are calculated and followed by the ATO system. Whilst

rail transport already is the most environmentally friendly mode of transport due to renewable energy sources, ATO can yet provide another 15-20% energy saving on top. These optimizations calculated by the autopilot also serve to increase the punctuality and the throughput of train routes. Consequently, ATO systems can reduce the running costs and increase the maintenance intervals of vehicles due to less wear of the components. The before mentioned improvements are dependent of each other and can be achieved in different qualities depending on the operational needs and requirements. This is all possible with the same system by defining how the trains shall be automatically driven.

3. The objective of the freight ATO project

The ARCC addresses operation digitalization topics such as automatic brake testing and real-time yard management. However, the final demonstrator it strives to deliver, will be a freight train running in commercial operation with ATO over ETCS Level 2 u using digital track and segment files within the open network (TRL 7).

The objectives of the ATO demonstration are:

1. Test the currently available ATO on-board units developed in Shift2Rail IP2 against the freight user requirements / operational rules
2. Test the three critical UIC interfaces required for ATO over ETCS (i.e. SS 125/26, SS 130, SS 139 – see Figure 2) for their maturity and interchangeability at the current level of specification
3. Test ATO against general performance criteria to confirm the business case

Based on the final results, the ARCC partners will provide input into standardization (e.g. TSI CCS), the strategic roadmap for development (e.g. next steps drafted below) and procurement (i.e. ATO invest planning). Figure 2 depicts the three critical interfaces for automated driving in rail freight and European railways in general, from an RU point of view.

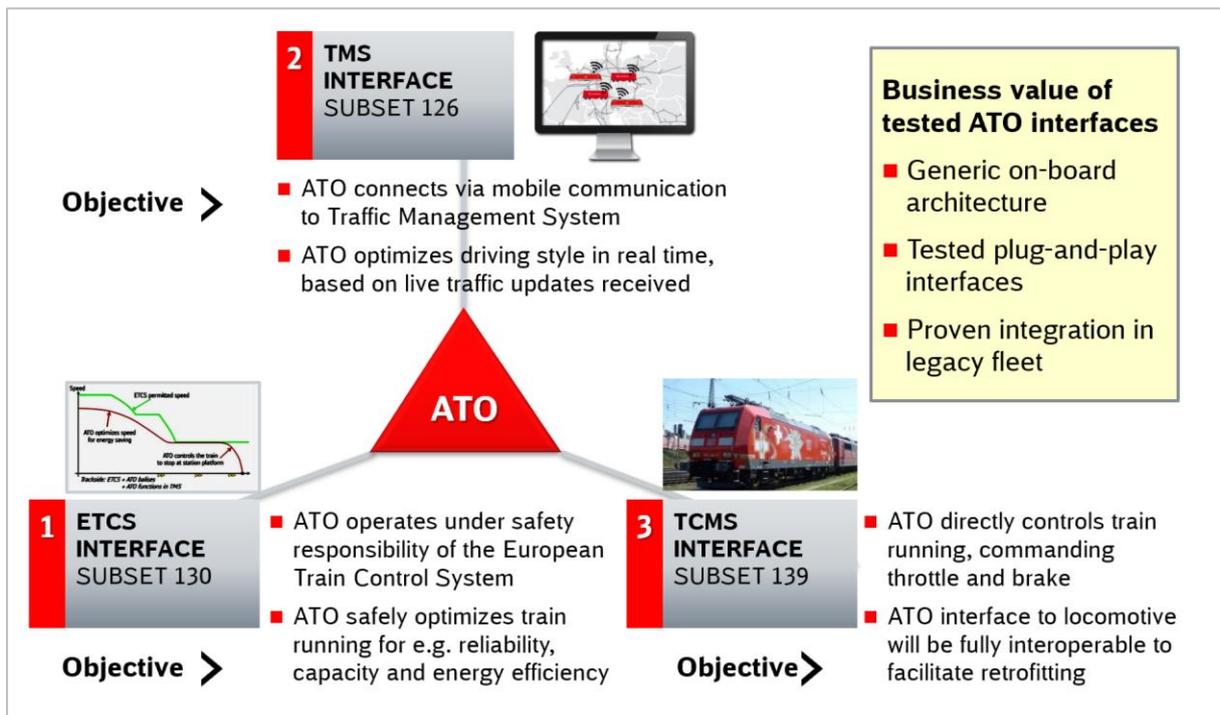


Figure 2: The project delivers key interfaces for any automation system

4. Project planning for the the freight ATO project

Shift2Rail is the first Joint Technology Initiative (JTI) between the European Commission and the European Railway Sector, focussing exclusively on innovation in railways within the framework of Horizon 2020. Within Shift2Rail, IP5 project boldly declared in the very beginning of the JTI that it would provide the first technology

demonstrator including fully operational testing of ATO in rail freight. By setting up the ARCC, DB Cargo as coordinator embraced the challenge and managed to set up a project involving the most relevant partners for such an endeavor, including competent suppliers out of the Shift2Rail consortium X2Rail-3.

Bombardier, as dominant locomotive manufacturer inside Shift2Rail IP5, was the reason for DB Cargo to focus on the core fleet across Europe of approx. 400 TRAXX AC 1 (class 185) locomotives. These locomotives are equipped with Siemens ETCS L2, BL2.3.0d, which provided Siemens the possibility to develop the required gateway with the afore mentioned interface (SS130). With a link to SBB Infrastruktur as supplier of the ETCS Level 2 test track and the required data from the ATO track-side, the ARCC made the best choice possible for a demonstrator project inside Shift2Rail.

A joint architecture and interface specification document between all ARCC and X2Rail-3 project partners has been gradually developed until mid-2019. It defines the binding set-up of the ATO over ETCS GoA2 solution for the freight demonstrator, providing the possibility for four different ATO OBU suppliers, namely Alstom, AZD, Hitachi and Siemens to test their product. Figure 3 shows the central on-board architecture design, highlighting the critical interfaces in green.

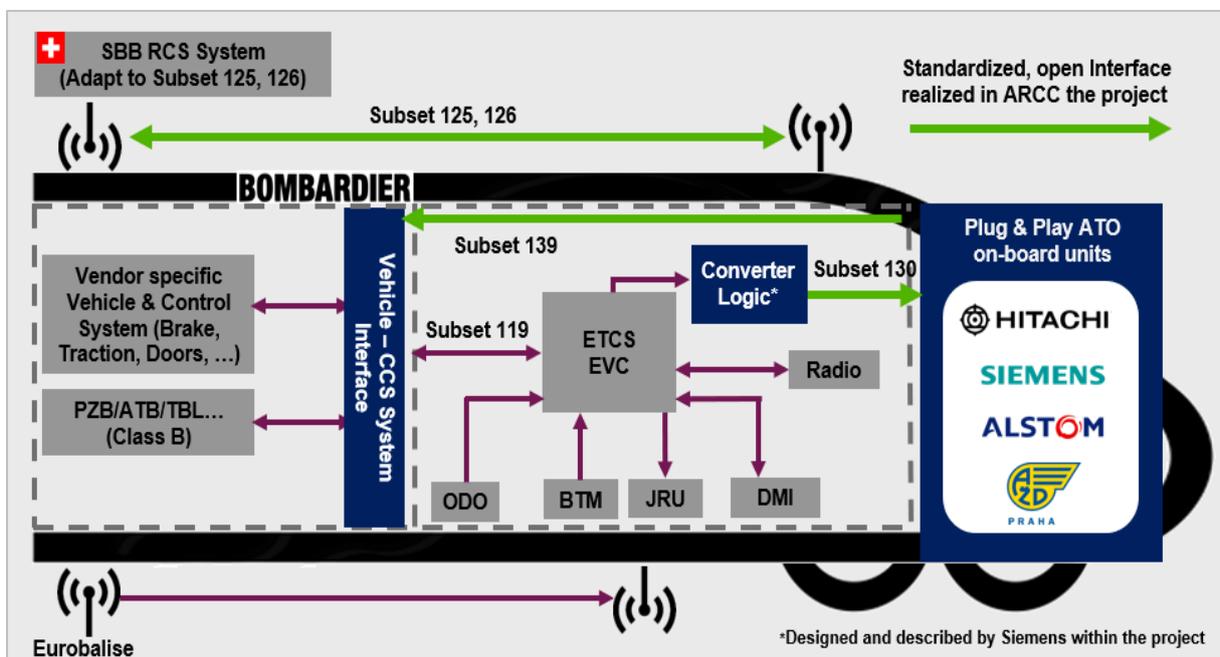


Figure 3: Standardized ATO/ETCS architecture as basis, defined in the binding architecture document

In the second half of 2019, the focus has then been on the suite of testing admission documents including installation guide, operations manuals, the safety concept and the system change reports by Siemens and Bombardier. As this paper is being submitted in early November 2019, the integration testing of the ATO modules is about to start in the Bombardier laboratory in Mannheim. Testing is scheduled to start in the second quarter of 2020, in parallel to TRA.

5. Innovation in the freight ATO project

Looking back at the latest endeavors for a proof-of-concept for automated driving, this demonstrator is one of most ambition ones within European rail freight. The innovation potential of the ARCC ATO demonstrator is impressive in many regards.

5.1. Technology Innovation in the Freight ATO project

On the technology side, the scope of the project includes numerous innovative aspects:

1. As existing ETCS Vehicles do not comply with the future standardized ATO over ETCS architecture an innovative approach to recreate the needed ETCS Interface from existing information was used.. Potentially it will be a low cost, quick win solution to upgrade the existing legacy ETCS fleet without major and costly ETCS upgrades.
2. The ARCC project is the first to test the provisional SS 139 in rail freight, and to provide the completed specification for standardization and procurement thereafter. The challenge of vendor lock-in regarding ETCS fleet equipment must not remain an obstacle to freight automation.
3. First testing of an ATO freight train of 500m length and 1500t weight will turn in more precise results on the performance
4. By turning the European core fleet into a testing platform, DB Cargo creates an efficient and attractive opportunity for advanced ATO testing in various set-ups and demonstrates the willingness for next steps towards future ETCS migration
5. Inside ARCC, also the topic of obstacle detection is covered which will be one of the functions required for the higher grades of automation leading up to GoA 4.

5.2. Collaborative Innovation in the Freight ATO project

Besides the technology set-up the ARCC project also features innovation in the unique way of collaboration with the partners, both inside and outside IP5 and Shift2Rail. This is substantiated by following aspects.

1. The collaborative field test of freight ATO will mark a Shift2Rail milestone in the year of 2020, when Shift2Rail contractually declares the final round of annual funding. Why? The project partners have joined in the effort to provide an important lighthouse and the strong message “Together, we can innovate!”
2. The active Shift2Rail partners in ARCC did not wait for perfect structures of the innovation program but started to act at the first chance. This spirit to overcome organizational obstacles and to shape the project landscape within the Joint Undertaking has made the project outstanding and resilient.
3. The partners agreed to tackle the challenge without requesting any compensation flows among each other. In fact, every partner provides his competency and brings in his assets at own cost.
4. Taking collaboration beyond the borders of Shift2Rail, the ATO demonstrator has become rooted in yet another innovation platform, with Swiss sector initiative SmartRail 4.0. With a view to the testing admission, the constant exchange with further users in the Swiss program has been secured early on.
5. The user initiative and clear focus on standard interfaces has been key. It is fair to say that DB Cargo as RU and essential user has been successful in pointing out the business opportunities for all partners involved. A win-win situation has been achieved attracting both the locomotive and ETCS suppliers, as well as the competing providers of the ATO OBUs to collaborate.

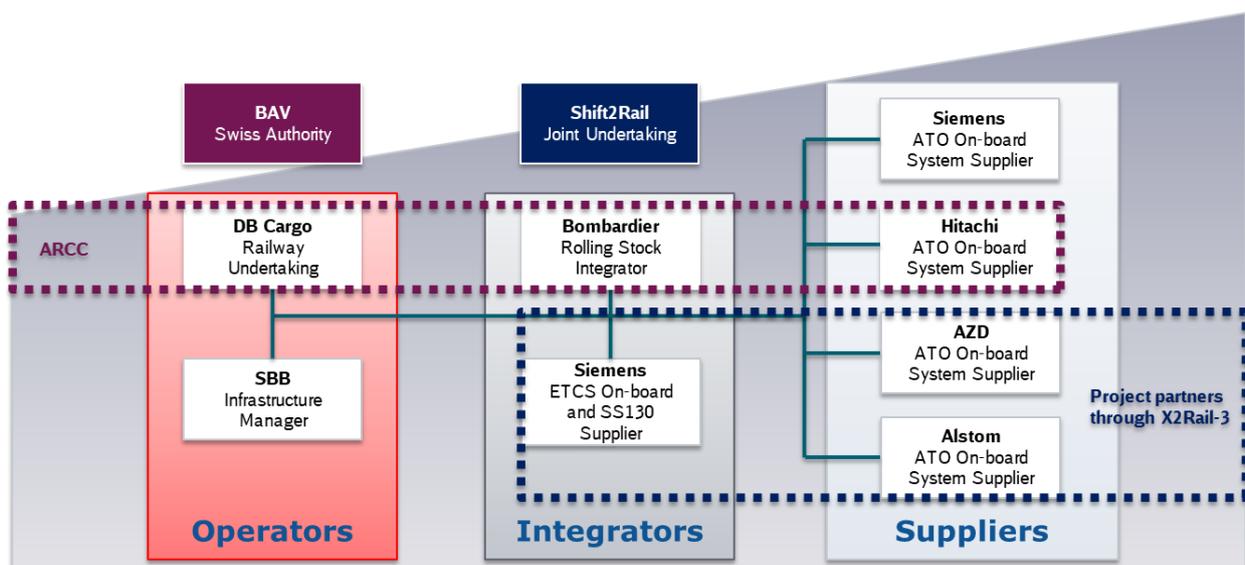


Figure 4: Unique collaborative project set-up including members of two Shift2Rail consortia and SBB

6. Outlook

According to the ambitious project schedule, the ARCC will perform its comprehensive freight ATO field tests in the first half of 2020 and therefore also during the week of TRA 2020. The ongoing ATO testing will be a unique opportunity to provide more up-to-date insights and first-hand results from the testing field at the TRA conference. However, the ARCC will only achieve a first step. By testing the three critical UIC interfaces required for ATO for their maturity and interchangeability, the specifications will be improved, and specifications be derived as basis for first procurement of ATO for commercial use.

Before this can become a reality however, the operational processes and rules for how to use ATO in rail freight will need to be defined and tested between the railway undertakings and infrastructure managers involved in the migration. This step will then raise the questions concerning future roles and responsibilities, qualifications, operations processes and more. Following comprehensive simulation and field testing of various use cases and incidents, a first-in-series pilot will receive the certification. Looking at Switzerland, a first attractive use case would be e.g. the Gotthardt base tunnel, where trains already run largely automatic under full supervision.

It is already clear that the journey towards automation in rail freight will continue, driven by European partnerships. Partnerships, an innovation eco-system including a pilot line and test bench, as well as strong stakeholder communication resulting in political support, and societal acceptance of the change will be decisive. The technologically focused ARCC has only been a first step, covering not even the operational processes in full.

Future activities which have been inspired by the ARCC such as e.g. the joint development of an open CCS on-board reference architecture, shall also be leveraged at the TRA 2020 conference. Besides, ARCC members are already actively contributing to the development of the next JTI, "Shift2Rail 2". Eventually the ambition of the European Union, that thirty per cent of road freight over 300 km should shift to other modes such as rail by 2030, and more than 50% by 2050, will be greatly facilitated by ATO-optimized and green freight corridors.



Subject: ARCC Publication “Collaborative field test of Freight ATO marks Shift2Rail Milestone”

— This project ARCC within this document has received funding from the Shift2Rail Joint Undertaking (JU) under grant agreement No 730813. The JU receives support from the European Union’s Horizon 2020 research and innovation programme and the Shift2Rail JU members other than the Union”.

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