Background information on Automatic Train Operation (ATO) and Grades of Automation (GoA) for smartrail 4.0

SBB is working with several partners from the railway sector within the smartrail 4.0 programme to use the new technological opportunities of digitisation to find ways to continue to show the strengths of the railway, namely reliability, safety, high capacity and sustainability, in the future. The railway should remain attractive and competitive for its customers. Swiss rail operations are already partially automated today: More than 90% of signal boxes are operated from one of the six train-control centres of SBB, BLS and SOB. With step-by-step enhancement of digital and automated train control, combined with enhancement of systems such as the digital signal box, the Swiss railway industry can get more out of its existing infrastructure. The goal is to further increase safety and capacity, optimise energy consumption and thus cut costs.

One of the many outcomes of smartrail 4.0 will be a better utilisation of the route capacity of the existing track network. This means that there will be a greater density of trains travelling more frequently, especially on the main lines. This will culminate in a moving block, in which the trains travel closely together depending on their respective speed and thus remain close to the braking curve. One sub-programme of smartrail 4.0 deals with the subject of Automatic Train Operation (ATO). In this context, pilots are being carried out to determine the potential of automation approaches to support the locomotive driver. Automation is a building block to simplify the consolidation of train journeys. It allows the locomotive driver to hand over control of the journey to the system by means of autopilot during journeys with short train sequence times and with high attention requirements.

ATO is generally divided into different Grades of Automation (GoA). This refers to the extent to which the train performs the journey independently and which tasks are taken on by the staff on the train. The breakdown of the different GoA levels and the current activities of smartrail 4.0 in the field of ATO are explained below.

<table>
<thead>
<tr>
<th>Grade of Automation (GoA)</th>
<th>Journey</th>
<th>Departure</th>
<th>Stopping at the station</th>
<th>Door closure</th>
<th>Disruption management</th>
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<tbody>
<tr>
<td><strong>GoA 1</strong></td>
<td>Locomotive driver with train protection system (ZUB, ETCS, etc.)</td>
<td>Locomotive driver</td>
<td>Locomotive driver</td>
<td>Locomotive driver</td>
<td>Locomotive driver</td>
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<tr>
<td><strong>GoA 2</strong></td>
<td>Locomotive driver with Automatic Train Operation (ATO) train protection system (ETCS)</td>
<td>Locomotive driver or automatic (ATO)</td>
<td>Automatic (ATO)</td>
<td>Automatic (ATO) or by locomotive driver</td>
<td>Locomotive driver</td>
</tr>
<tr>
<td><strong>GoA 3</strong></td>
<td>ATO, without locomotive driver, with train crew on board</td>
<td>Automatic (ATO)</td>
<td>Automatic (ATO)</td>
<td>Automatic (ATO) or by train crew member</td>
<td>As required: member of train crew</td>
</tr>
<tr>
<td><strong>GoA 4</strong></td>
<td>ATO, completely autonomous train journey without staff</td>
<td>Automatic (ATO)</td>
<td>Automatic (ATO)</td>
<td>Automatic (ATO)</td>
<td>As required: automatic, remote or with intervention staff</td>
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</table>
GoA1 – Locomotive driver responsible for driving, system responsible for safety

The first stage of automation involves vehicles controlled by the locomotive crew, primarily with a train control system which may be supplemented with an assistance system on the vehicle. In this case, assistance systems such as adaptive control are only responsible for support functions, whilst the actual train management is performed entirely by the locomotive crew. The train journey is monitored by an Automatic Train Protection (ATP) system. The ATP performs a protective function and uses automatic emergency braking to prevent incidents such as passing stop signals or exceeding the permitted speed. The existing vehicle fleets in Switzerland currently operate in accordance with GoA1. The ATP is performed by the ETCS (European Train Control System) or ZBMS (metre-gauge standard train control) train control system.

GoA2 – Autopilot supports locomotive driver

GoA2 is the equivalent of autopilot. Here, the ATO system supports the locomotive crew by taking control of the journey on request. The locomotive driver hands over control of the actual driving and intervenes if necessary, especially in the event of disruptions or incidents. The train driver monitors the route, and the train is not necessarily equipped with any further sensors, even though some train manufacturers are currently developing further assistance systems for track monitoring. In this mode, the door closure could either continue to be performed by the train or locomotive crew or by the system. As soon as the doors are closed, the locomotive driver has activated the ATO function and permission is given for the journey, the vehicle automatically departs and then automatically stops again at the next station. The train’s ideal speed is calculated using ATO driving profiles for the route, depending on factors such as punctuality, track conditions, operating conditions and energy. In the future, ATP will be implemented throughout Switzerland via ETCS or ZBMS (metre-gauge standard train control).

GoA3 – Autonomous, accompanied train journey

The train travels fully automatically, monitors the route itself (with sensors or object recognition) and stops at designated stopping places. There is at least one train crew member in the passenger compartment on the train, who mainly performs customer service duties and can intervene in the event of disruptions on the vehicle. In the event of an incident, the person can supervise safety-related functions such as evacuations. If required, the doors can also be closed by the train crew member. Here too, the driving profiles are also continuously calculated and optimised. Train protection is performed by ETCS or ZBMS.

GoA4 – Fully autonomous, unaccompanied train journey

In fully automated train management, just like in GoA3, the ATO system performs the train management. However, there are no longer any staff on the train, as the train responds independently to most incidents. In the event of major incidents, a control centre intervenes via remote control of the train, or else there are stationary on-site intervention personnel, especially for the event of an incident.

Special case remote control (shunting or in the event of an incident)

In GoA3 and GoA4, the journey is completely taken over by the system, along with the track monitoring. With remote control, by contrast, a person monitors and is responsible for the train journey using a device, for example outside the train in the station throat or from a train-control centre.

For more information, visit www.smartrail40.ch