Operations control system in the Lötschberg Base Tunnel

The new Lötschberg Base Tunnel, which is partially single-track, is equipped with its own operations control system, called AF (Automatic Function). The AF system solves operational conflicts automatically or with the intervention of the dispatcher, according to situation.

Switzerland's railway companies probably operate the world's most complex railway network. There is a highly ambitious timetable, the so-called „Taktfahrplan", with regular intervals and extremely dense traffic at the major rail network nodes. Almost all the main lines are used for both passenger and freight trains. Train operations are controlled by a centralized and fully automatic system based on the given schedule and a train identifier for each train. Most interlockings are controlled remotely from the central control system (system ILTIS by Siemens).

1 Challenging single-track tunnel section

In the Lötschberg Base Tunnel, which is to be operated at a maximum speed of 250 kilometres per hour, train operations have to be controlled by a wireless signalling system according to ETCS Level 2. Being the infrastructure manager, Bern-Lötschberg-Simplon AG (BLS AG) chose Elektra 2 interlockings by Thales Rail Signalling Solutions (formerly Alcatel).

However, the Lötschberg tunnel poses one even more intriguing challenge. At present, a 21 kilometres long section of the tunnel (overall length 34.6 km) is to be operated as a single-track line. In order to guarantee the schedule's stability and to maximize the tunnel's capacity, the operations control system provided by Thales contains software-based automatic functions (AF). The AF part was developed by systransis AG, Switzerland, as a subcontractor of Thales.

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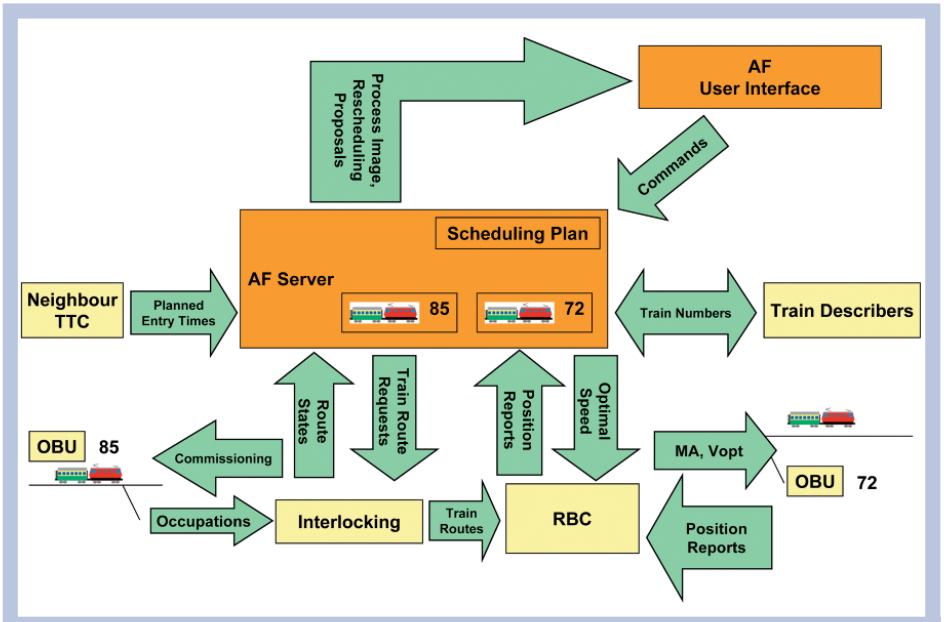

Fig. 1: Operations control system, ETCS Level 2, in the Lötschberg Base Tunnel

2 The requirements

The expectations of BLS AG on the new train operations control system can be summarized as follows:

- ▷ To provide stable, predictable traffic patterns according to the given schedule;
- ▷ to minimize the exit delays in case of irregularities;
- ▷ to minimize train stops in the tunnel;
- ▷ to optimize the speed of trains involved in conflicts in order to gain time.

For most of the aforementioned requirements, conventional operations control systems for mainline railways provide automated support to a very limited extent only. This is why, in a complex railway network, finding an optimal solution would take far too much time. In addition, the sensors and communication equipment needed to acquire the relevant data for such computation are, in most cases, not in place with sufficient ubiquity.

3 The solution: The semi-automatic AF system

However, systransis AG was able to develop software which provides for automatic train operations control to a large extent. In case of irregularities, the system computes the optimal solution, which is then proposed to the dispatcher. Optimizing the train speed and transmitting it as an advisory speed to the train driver reduces delays. Furthermore, proposing the optimal tunnel evacuation strategy in the case of a fire or water inrush in the tunnel augments the safety.

The tunnel-specific AF system was implemented according to the following principles:

- ▷ It exactly follows the given scheduling plan as taken from the operator's existing systems. Even in case of major delays, the AF system does not make automatic, unpredictable changes to the plan.
- ▷ Information about the composition of the trains and other parameters are continu-

ally acquired from several neighbouring systems: The "ILTIS" operations control system of BLS, the dispatching system "Prosurf" of the Swiss Federal Railways (SBB), and the BLS Radio Block Centre (RBC) that knows the exact position of each individual train. Based on this information, the AF system decides whether a train may enter the tunnel in the first place. Trains that are not equipped with ETCS Level 2 are not allowed.

- ▷ According to the train properties, the operations control system requests the optimal number of train routes from the interlockings. Very fast trains need more routes or block sections than conventional, slower trains.
- ▷ For each train, the AF system computes a forecast of its passing time and of the exit delay. The forecast calculation is based on the so-called "Opentrack" simulation algorithms developed at Zurich's University of Technology (ETHZ). These algorithms incorporate numerous parameters, for example the composition of the train and the aerodynamic drag, allowing for very exact predictions with only a few seconds of tolerance.
- ▷ In order to optimize the movement of trains, the AF system computes a weighted sum of exit delays, based on forecast. Trains considered important are allocated a higher weight than less time-sensitive trains. If the sum thus computed exceeds a certain pre-defined threshold, the system tries to find a better solution.
- ▷ The AF system also detects conflicts. A conflict occurs if one train is obstructing a second train by releasing a train route too late, so the second train can't travel according to the scheduling plan. If this happens, the AF system tries to find alternative scheduling options. This is done either by shifting the trains' crossing location (when trains travel in the opposite direction) or by changing the order of trains travelling in the same direction. A third possible option, the use of alternative tracks, is not applied: Changing tracks would confront the dispatchers of the neighbouring stations with unpredictable situations, and was not considered a viable option in this case.
- ▷ The result of the conflict resolution is not implemented automatically. Instead, it is presented to the dispatcher as a proposal. The dispatcher's decision is respected absolutely. If the dispatcher does not take a decision within a certain timeframe, the system will discard the proposal. In any case, the AF system shall adapt the scheduling plan accordingly if needed.
  In earlier versions of the software, the proposals were automatically implemented if the dispatcher did not react. This was changed in the final release because the users often found the assumed alternatives quite surprising in an unwelcome way.
- ▷ For trains involved in conflicts, the speed optimizer of the FA system computes an optimal speed curve. The train is decelerated immediately to the optimal speed so it doesn't arrive at the conflict location too early. Otherwise, it would have to come to a complete stop which is highly undesirable within a tunnel. At the correct time, the FA system recommends to accelerate again.
- ▷ To get the speed information to the trains, the AF system communicates with the RBC that in turn uses the GSM-R wireless protocol to transmit the speed change instructions to the Screen in the driver's cab. Due to this optimization, a train can gain up to several minutes. Besides this, its energy consumption is lower as it generally never needs a full stop on its route.

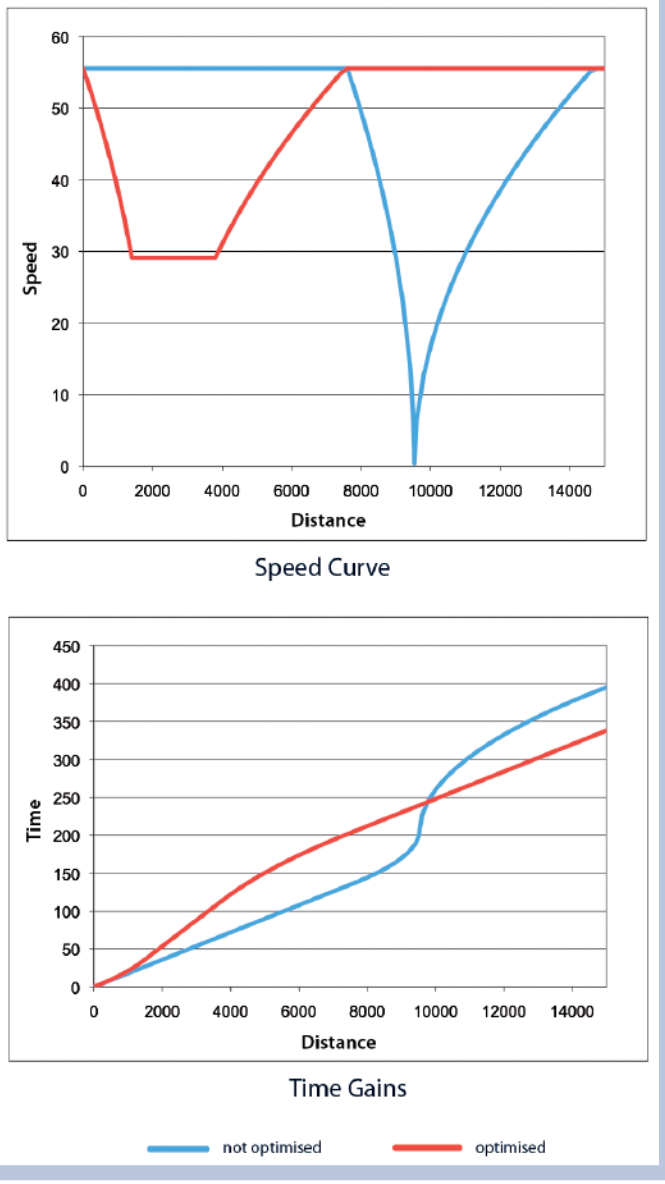

Fig. 2: Saving time by optimizing the speed of the train

4 Successful operation

In December 2006, the AF system was connected to the ILTIS operations control centre of BLS. Until March 2007, the new functionality and the data exchange between the two systems were tested extensively. Trial operation according to a schedule began in June 2007, and full operation started in December 2007.

Since then, the AF system is working according to specification and without any significant technical problems. Initially, some users had difficulties adapting to the new workflow situation. Based on this feedback, the system was further optimized. With the changes implemented according to the experiences from the first few months of operation, the AF system now enjoys the broad acceptance of its users.