



SBB CFF FFS

The swiss way to
capacity optimization for Traffic
Management.

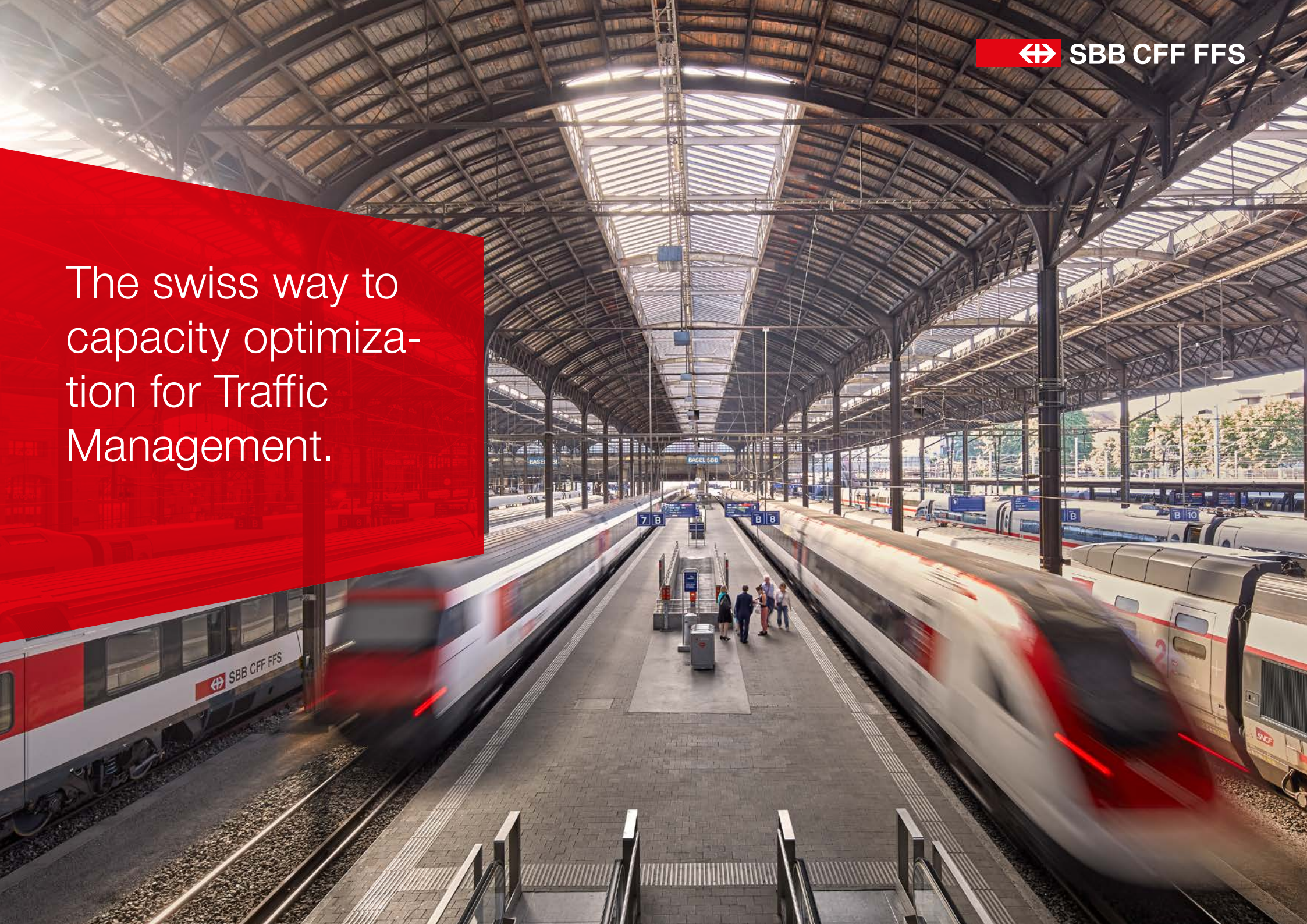


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Introduction to the topic.

RAIL CONTROL SYSTEM (RCS) – THE RAIL TRAFFIC CONCEPT OF THE FUTURE.

Switzerland has one of the busiest railway networks in the world. Every day, some 10,671 trains travel on SBB's 3,000 kilometres of track, which corresponds to 101.5 trains per main track. These trains carry more than one million passengers and 210,000 tonnes of freight to their various destinations each day¹. In terms of punctuality, too, SBB is a top performer in international comparison (UIC standard): SBB is Europe's most punctual railway company². The continued expansion of railway services and the growing demand for freight transport services are leading to ever greater traffic density. Safety and punctuality requirements are therefore increasing too.

This tallies with the rail traffic challenges being faced worldwide:

- More intensive network use
- Centralisation of locations
- Financial competitiveness
- Infrastructure maintenance
- Automation of repetitive tasks

Rail traffic management that is unique in the world

In order to tackle these challenges associated with increasing rail traffic, SBB has developed the mobility concept of the future: Rail Control System (RCS). The intelligent control system improves punctuality on all routes. What's more, RCS optimises use of the existing infrastructure and

boosts both the capacity of the rail network and the frequency of services – all without the need for high levels of investment to expand the track network.

RCS automates rail traffic control to a high level and promotes energy-efficient driving, with the result that SBB is making annual electricity savings of around 74 gigawatt-hours. This is the equivalent of the total electricity consumption of every household in a small town or 8.1 million Swiss francs. In 2016, SBB was awarded the "Watt d'Or" Swiss energy prize in the energy-efficient mobility category in recognition of this achievement³.

Controlling and monitoring with Swiss precision

RCS supplies information every second – from planning to controlling rail traffic. It calculates the traffic on the entire track network every two seconds with a forecast horizon of two hours, so conflicts are detected with speed and precision. RCS detects one million possible conflicts every day, thus offering exceptional timetable stability and optimising some 2,000 route setting operations.

The RCS system family is modular and scalable. The entire system consists of a versatile group of applications that can be combined and used as required. The RCS open system architecture means that the system can be extended with specific modules.

The key benefits of RCS

- Network-wide control of rail traffic
- Calculation of the actual state and visualisation of the target state of the track network
- Greater reliability thanks to better timetable stability
- Automatic conflict resolution
- Increased frequency of services
- Improved energy efficiency
- Precise, prompt and traceable communication

¹ SBB Facts and Figures 2017

² Statistics of the International Union of Railways UIC 2016

³ Media release by the Swiss Federal Office of Energy (SFOE) of 7 January 2016: "Bundesamt für Energie verleiht zum zehnten Mal den Schweizer Energiepreis"

An overview of RCS and its modules.

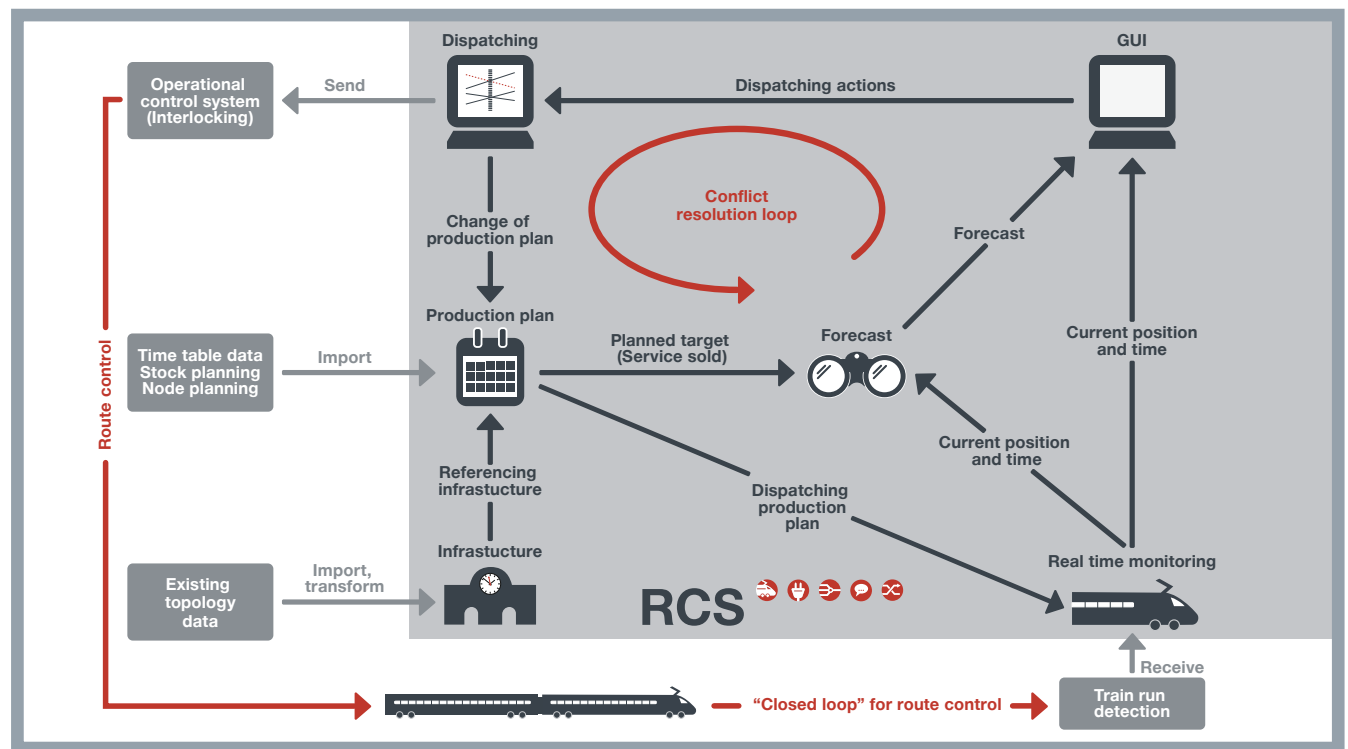
RCS-DISPO – THE HEART OF NETWORK OPERATIONS.

The basic module RCS-Dispo is key to controlling the network. It calculates the actual state and visualises the target state throughout the network. All of the units and staff involved in the process are provided with a standardised process map and a timetable display in real time. Operationally relevant information from various systems is merged on one standardised user interface. RCS-Dispo is therefore the most important tool used by rail traffic dispatchers and controllers in the train-control centres.

Core Functionality

RCS receives and handles several hundred messages per second from different peripheral systems (e. g., train position sensors) and processes this information, calculates train journey forecasts and delivers the resulting changes to railway dispatchers and customer systems.

A centralised and unified representation of all logical and physical railway elements in one model depicts the availability of the network infrastructure at any time. Systematic connection management forms a basis for optimised customer information. RCS provides different views of



planned, current and future network usage and occurring conflicts in near real-time, represented in graphical user interfaces, such as:

- Time distance diagram
- track allocation and occupation
- connections per station
- alarm monitor
- potential conflicts

With the implemented forecast model, a key precondition is satisfied in that the train dispatcher is provided with all critical information (e.g., reliable connection forecasts) needed to resolve conflicts and to achieve rapid recovery of the original operational plan.

The ability to interconnect with existing related systems allows automated route control, following resolution of conflicts by dispatching actions.

RCS-Dispo

- Simplifies rail traffic control
- Calculates precise and prompt forecasts concerning the progress of all trains
- Enables better utilisation of network capacity
- Offers a standard user interface for the entire flow of information

RCS-ADL – the energy-efficient speed advisor

As part of RCS-Dispo, RCS-ADL (adaptive control) calculates an energy-optimised driving profile in real time for the entire route. Based on these calculations, RCS-ADL supplies the locomotive crew with speed recommendations,

thus enabling trains to run smoothly and energy-efficiently, with less wear on materials. Unscheduled stops ahead of signals are avoided, saving electricity and resulting in better punctuality.

RCS-ADL

- Enables locomotive crews to drive more smoothly
- Prevents unnecessary stops and improves punctuality
- Boosts energy efficiency
- Protects rolling stock and the track

RCS-HOT – The automatic train route optimiser

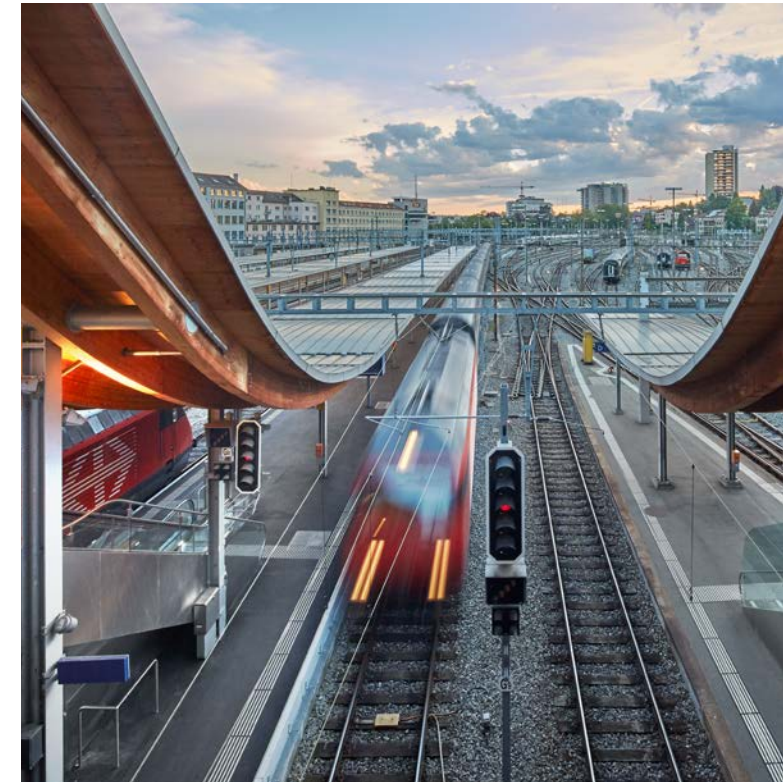
RCS-HOT (Hub Optimisation Technology) is a control programme that optimises train management at problematic points on the track network. It calculates the perfect driving profile for each individual train and signals this information to the locomotive crew via trackside installations or to a tablet in the vehicle. HOT also calculates the ideal sequence of trains and transmits the data to the control and safety systems automatically, thereby allowing the train-path capacity to be used more effectively.

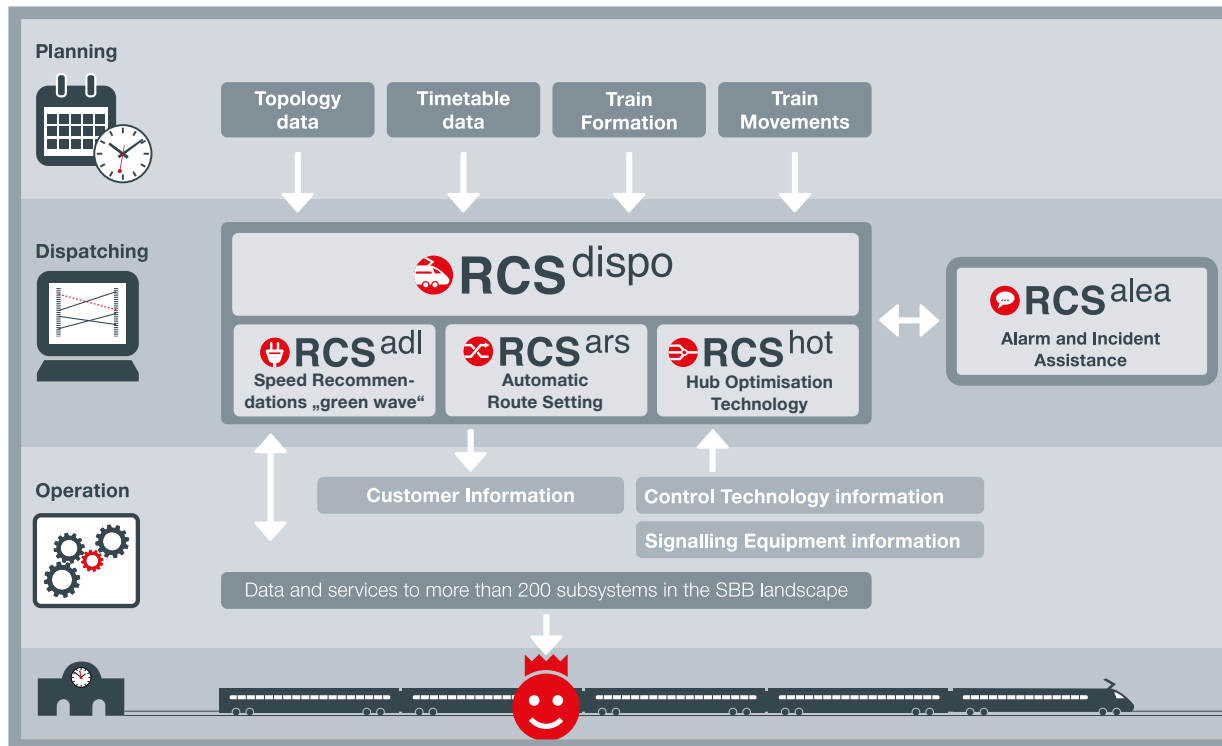
RCS-HOT

- Detects and resolves conflicts automatically
- Increases train-path capacity
- Improves timetable stability

RCS-ARS – Automatically optimising train routes

RCS-ARS bridges the gap between dispatching and operations. It identifies dispatching discrepancies between the RCS production timetable and the control system, automatically recalculates the route setting data for the affected sec-





tion of a train journey and transmits this data to the control system. This enables a partially automated central process and more efficient railway production during periods of increased capacity utilisation on the network.

RCS-ARS

- bridges the gap between dispatching and operations
- automatically adjusts route setting data to dispatches
- enables efficient railway production, even during periods of increased capacity utilisation on the network

RCS-ALEA – the reliable assistant when incidents occur

RCS-ALEA (alarm and incident assistant) is a communications tool used in the event of technical problems or unforeseen incidents in rail operations. The automated disruption management assistant is the perfect partner for RCS-Dispo and significantly improves communications when incidents occur. ALEA channels case-specific information and distributes huge volumes of data extremely rapidly. ALEA communicates decisions quickly, individually and in a targeted manner.

RCS-ALEA

- Coordinates the flow of information when an incident occurs
- Reduces the minutes of delay incurred as a secondary effect
- Visually covers the entire area of the incident
- Significantly speeds up incident management

RCS – a Swiss success story.

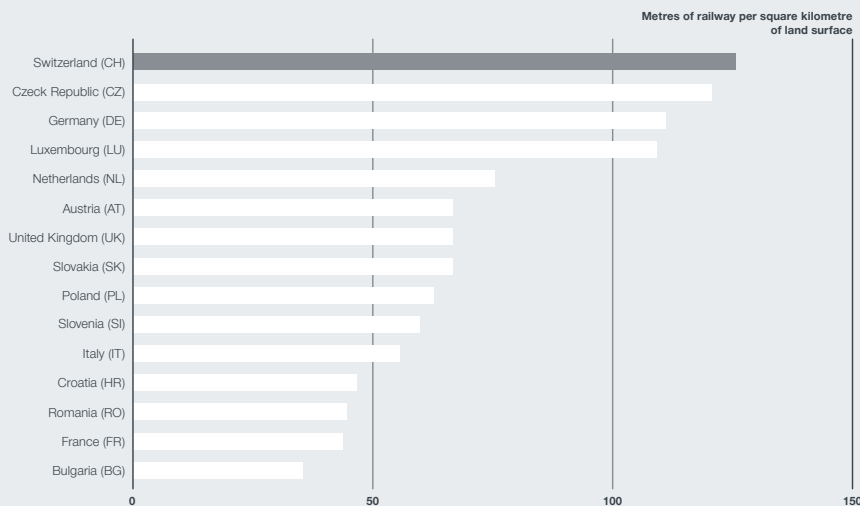
THE BEGINNINGS OF RCS.

In the past, each station had a staffed signal box. In 2005, SBB launched a centralisation project to merge rail control as a whole into four central locations. This is being implemented in stages. By 2016, thanks to the level of automation achieved, the majority of rail traffic was being controlled centrally from four train-control centres. It is only on secondary lines that around fifty stations are still being served locally.

In 2009, as part of the centralisation project, the two existing incompatible traffic management systems were replaced by a new system: the Rail Control System (RCS). After four years of intensive development work and a successful pilot phase, RCS was rolled out throughout Switzerland. To start with, the system was limited to connection and circuit control. However, a supplementary module was at the development stage, with the aim of being able to detect

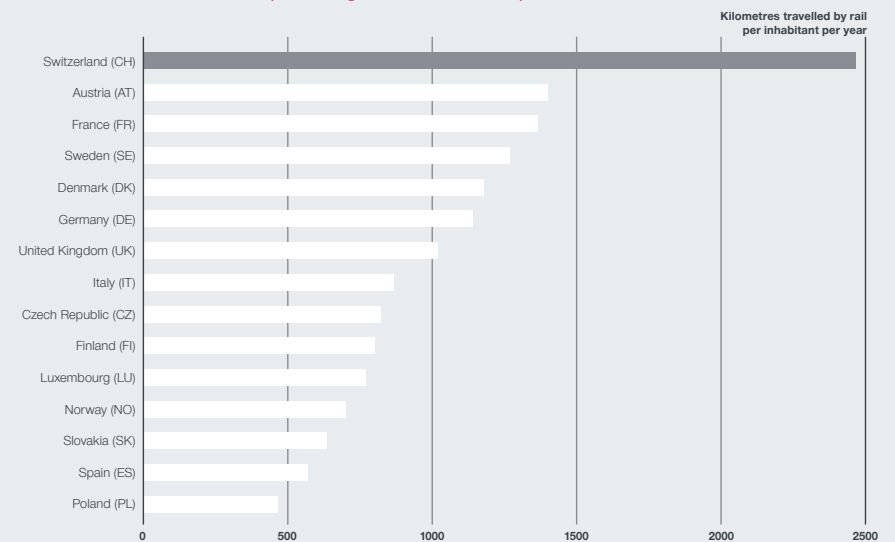
and resolve occupancy conflicts at an early stage. This gave rise to the first forecasting functions.

Network density in Europe.



Source: Eurostat, information for 2016; CH: 2015 (BFS).

Demand for passenger travel in Europe.



Source: Eurostat 2015.



Ongoing innovation

The amount of information that needs to be processed in the event of disruptions is extremely large. The processing involved is intricate in nature and leads to highly complex communication flows between the Railway Production and Passenger Traffic organisational units.

Both Infrastructure and Passenger Traffic staff needed a communication platform that was optimised for use in cases of disruption. This need gave rise to the RCS-ALEA module, which was brought into being in 2010, offering standardised incident management and simplifying communication. With the introduction of this module, SBB ushered in a new era in rail traffic control.

In the same year, the RCS-HOT module developed by SBB replaced the old train movement optimisation system. HOT offered new opportunities for managing the ever increasing density of trains on the Swiss track network. With its automatic calculation of the optimal train sequence at hubs and its automatic conflict resolution, HOT is now an absolutely indispensable element of efficient traffic control at complex railway hubs.

In 2011, SBB forged ahead with further development of the system for reasons relating to both commercial efficiency and the environment. The RCS-ADL module, which was also developed by SBB, was ready for use in 2014. The figures show that, with the recommendations for energy-optimised driving calculated by ADL, SBB used less electricity from that point on.

In 2015, SBB developed the new RCS-ARS (Automatic Route Setting) system on behalf of BLS Netz. This was an expansion within the existing RCS-Dispo application. It enables RCS to directly access the “Interlocking” control system, which is used by rail traffic controllers to set points and signals.

Scoring high for punctuality

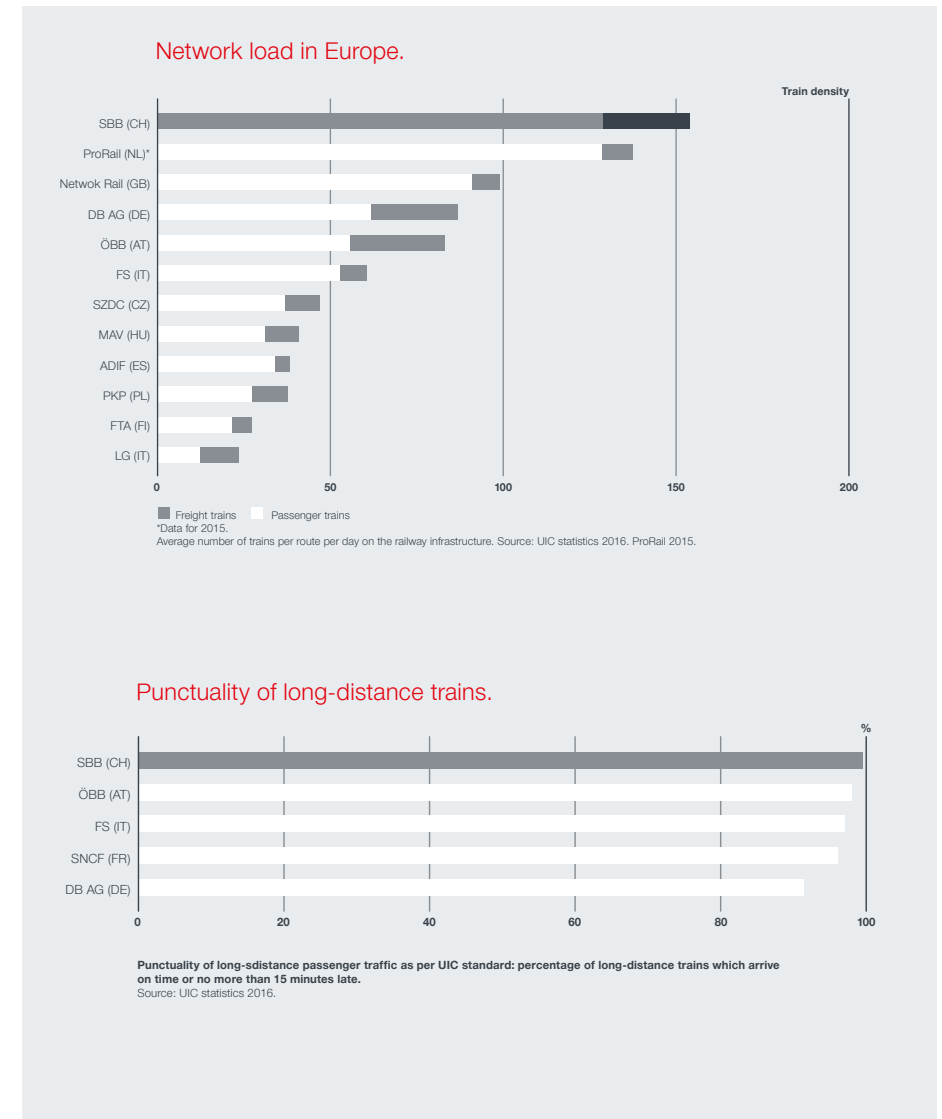
Based on the parameters of intensity of use, service quality and safety, SBB was ranked first in the European Railway Performance Index 2015⁴. In international comparison too, SBB is at the top of the table in terms of rail traffic density and punctuality. With a score of 96.8 %, SBB is Europe’s most punctual railway company⁵. RCS and its modules play a significant part in this success.

Reliable and flexible

Thanks to the redundant system architecture of RCS, any hardware failure can be managed without impacting on service provision or quality. Not even failure of a network router or damage to cables result in the cancellation of services. Moreover, the system allows the hardware to be expanded with ease – and all at a fraction of the costs associated with additional database servers. Thanks to the flexible and open system architecture, the RCS modules can be adapted to the relevant processes. The system can be developed further in various dimensions in line with the customer’s needs.

⁴ European Railway Performance Index 2015

⁵ UIC statistics 2016



Cases:

Resource optimisation and centralisation.

WHEN IT COMES TO CONTROLLING RAILWAY TRAFFIC, SAFETY, PUNCTUALITY AND EFFICIENT USE OF THE INFRASTRUCTURE ARE ALL KEY ISSUES. IT IS ONLY BY INTRODUCING MODERN TOOLS SUCH AS RCS AND THE NEW “INTERLOCKING” CONTROL SYSTEM THAT SIGNAL BOXES CAN BE OPERATED REMOTELY AND EMPLOYEES BROUGHT CLOSER TOGETHER.

Background

With the commissioning of various major projects and the forecast increase in traffic volume, SBB is facing some serious challenges. On a track network which is already very busy, every incident will have an even greater impact on customers. The ability to react quickly in terms of rail traffic control is therefore crucial. Until recently, the control and route setting of rail traffic took place in separate locations. The dispatchers controlled rail traffic across the board at three train-control centres, while the rail traffic controllers, at twelve remote control centres and some 90 signal boxes, set points and signals locally and informed customers. The only consultation between the units was by telephone and the two traffic management systems used were not compatible.

Objectives

- Centralise the monitoring and control of rail traffic
- Modernise the working environment
- Increase traffic capacity
- Guarantee safety
- Improve punctuality

Solution

Since 2010, SBB has been merging the former 100 traffic control and technical operation sites into four train-control centres. The relocation to the train-control centres is being carried out in stages and is scheduled for completion in 2019. There are currently just under 1,300 employees working in the train-control centres.

The specialist tasks cover four key areas:

- Dispatchers: control and monitor rail traffic in their allocated sector
- Rail traffic controllers: monitor rail traffic in their allocated sector and operate the signal boxes using the control systems
- Information specialists: control customer information at the stations
- Technical specialists: monitor the railway installations and traction current



Result

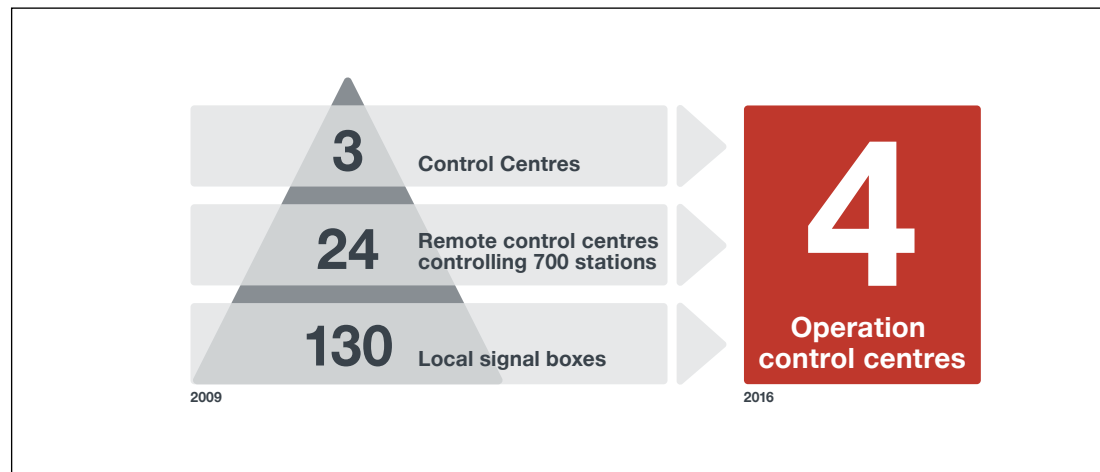
The centralisation makes it possible to align processes, work tools and systems like RCS right across the country. SBB is bringing together all employees involved in traffic control, customer information and technical operations under one roof in the train-control centres, thereby simplifying and improving the cooperation between them. They can take decisions and communicate and implement them more quickly. This all helps to ensure that customers can be offered a safe and punctual railway service, despite the challenges ahead.

SBB has been using the Rail Control System (RCS) to control its rail traffic since 2009. Infrastructure operators BLS and SOB have also been using the system developed by SBB since 2014.

Infrabel (B) is the first non-Swiss infrastructure operator to opt for RCS. The project to introduce RCS was launched in late 2013. SBB drew on its own system and railway experience to support Infrabel as required.

Infrabel successfully completed implementation in mid-November 2016, and the company now uses RCS to manage the 5,000 trains a day that operate across Belgium's rail network. RCS allows busy hubs such as Brussels to be navigated more efficiently.

The German DB network plans to use it from 2020. We are providing both railway companies with support in introducing and developing the system.



Case:

Energy efficiency in rail services.

RCS-ADL MAKES AN IMPORTANT CONTRIBUTION TOWARDS THE ECONOMICAL AND ENVIRONMENTALLY FRIENDLY USE OF RESOURCES IN RAILWAY OPERATIONS. THANKS TO THE INNOVATIVE SYSTEM, SBB HAS IMPROVED ITS ENERGY EFFICIENCY BY SOME 12 PERCENT SINCE 2015. RAILWAY COMPANIES ALL ROUND THE WORLD CAN USE RCS-ADL TO SUSTAINABLY IMPROVE THEIR ECONOMIC EFFICIENCY AND ENVIRONMENTAL IMPACT.

Background

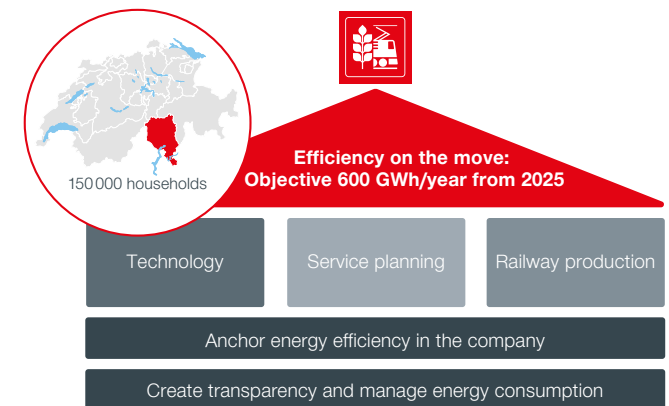
The Swiss federal government's Energy Strategy 2050 is a package of measures designed to secure Switzerland's supply of electrical energy over the long term in light of the decision to withdraw from the use of nuclear energy. The strategy includes measures to increase energy efficiency and to promote the use of renewable energy sources. SBB is also committed to the strategy and is therefore required both to reduce its energy consumption and, at the same time, to boost its efficiency. As the volume of rail traffic rises, however, so too does the amount of energy required, so SBB faces both economic and ecological challenges.

Objectives

- Increase railway productivity
- Reduce energy requirements
- Protect resources
- Improve service quality

Solution

In order to implement an energy strategy successfully, all parts of SBB need to get involved: from planning to production and technical aspects right through to service design.



The implementation of RCS-ADL provides railway production with the foundations for optimisation and for boosting efficiency across various operational functions:

- **Driving profile**

RCS-ADL calculates an energy-optimised driving profile in real time for the entire route. Using this as a basis, the system provides the locomotive crew with automatic speed recommendations. Trains can run smoothly and energy-efficiently, with less wear on materials.

- **Route setting**

RCS-ADL involves two types of route setting: conflict control and efficient driving.

- Conflict control prevents sharp braking or stopping due to a signal by issuing speed recommendations, so that unscheduled stopping or braking before a signal can be avoided.
- Efficient driving means that the system issues a slower speed recommendation to prevent the train from reaching the station earlier than scheduled. The slower speed means lower driving resistance, resulting in traction energy savings.

Result

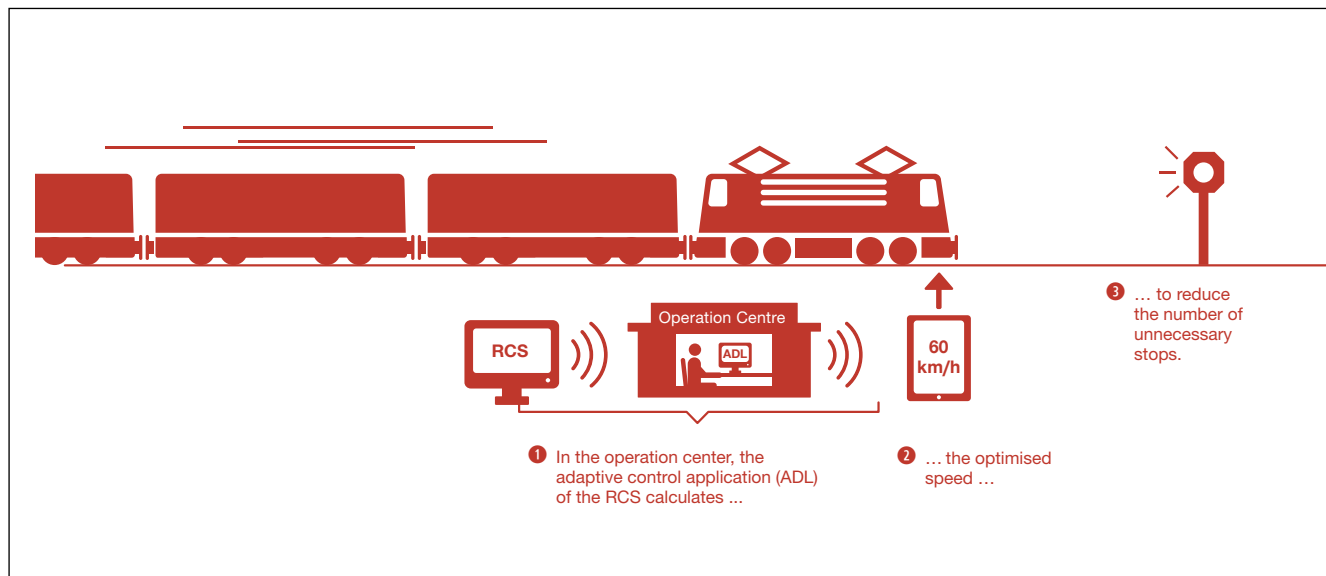
The RCS-ADL system component links up the activity in the train-control centres with operations in the cab and supports the locomotive crew in their everyday work. Thanks to ADL, SBB can maintain its punctuality in spite of the rising volume of traffic and increasing levels of construction and maintenance work. At present, RCS-ADL is used to control more than over 2,000 trains per day, with savings of more than 200,000 kilowatt-hours. Over 635,000 train journeys, SBB reduced its energy consumption in 2017 by some 74

gigawatt-hours, which is the equivalent of the total annual electricity consumption of a small town with 18,500 households. This control system has the greatest impact on energy in the case of heavy freight trains with relatively low levels of energy regeneration.

This reduces wear on materials, boosts precision in railway operations and saves energy. Thanks to RCS-ADL, SBB is making a substantial contribution towards implementing

the federal government's Energy Strategy 2050 and to the sustainable development of mobility in Switzerland.

SBB won the "Watt d'Or" energy prize awarded by the Swiss Federal Office of Energy (SFOE) in the energy-efficient mobility category in recognition of this achievement in early 2016.



Case: Train movement optimisation.

A SMOOTH FLOW OF TRAFFIC, EVEN WITH HIGH TRAIN DENSITY: WITH THE AUTOMATIC TRAIN MOVEMENT OPTIMISATION SYSTEM RCS-HOT (HOT STANDS FOR “HUB OPTIMISATION TECHNOLOGY”), PROBLEMATIC POINTS ON THE SWISS TRACK NETWORK CAN BE NEGOTIATED WITHOUT BRAKING UNNECESSARILY, EVEN AT TIMES OF HIGH TRAFFIC VOLUME. THIS DEVELOPMENT EARNED SBB THE UIC INNOVATION AWARD IN 2016. THE PURPOSE OF THESE AWARDS IS TO ENCOURAGE DEVELOPMENTS THAT WILL ENABLE THE RAILWAY TO STAND UP TO INCREASING COMPETITION, BOTH NOW AND IN THE FUTURE.

Background

The increasing train density on the Swiss track network makes it very difficult to plan and implement an optimal train sequence. At complex hubs in particular, braking by trains in order to wait for a delayed train results in further delays and generally jeopardises the timetable.

Objective

To reduce delays and improve timetable stability, it ought to be possible to optimally calculate the train sequence at busy hubs and thus simplify the management of trains – all without a train having to stop.

Solution

The RCS-HOT module calculates the optimal driving profile for each individual train and signals this information to the locomotive crew via trackside installations. The optimal sequences are also determined and implemented automatically using the control systems to make best possible use of train-path capacity.

- HOT calculates the optimal management of trains based on a complete group (all trains within a certain forecast horizon that are travelling towards a conflict point).
- HOT offers three possible solutions:
 - Speed specifications
 - Changes in sequence (direct impact on the control systems)
 - Changes in route (direct impact on the control systems)
- HOT is integrated into RCS, so it can be used across the entire network.



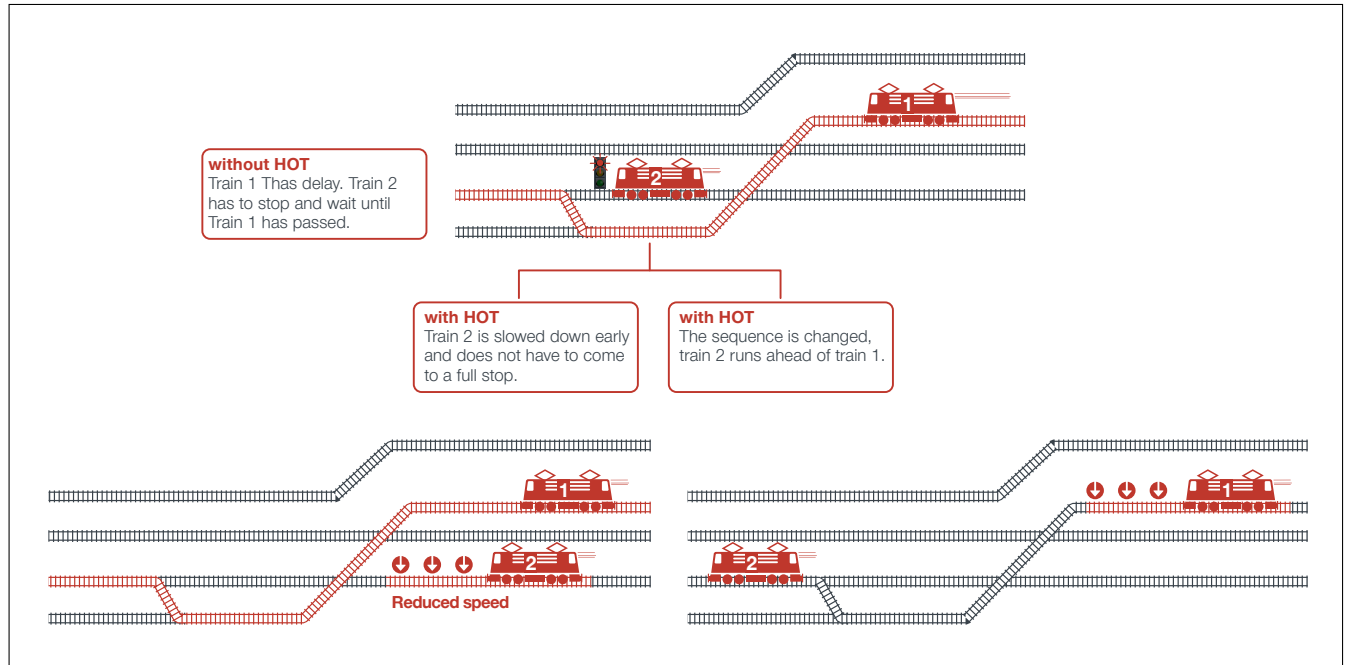
Result

With RCS-HOT, conflict resolutions take place fully automatically at defined hubs, reducing delays.

The precision of the network-wide forecasting and the automatic conflict resolution go further than other control systems.

- Zurich is a highly complex hub in the Swiss railway network, as a number of very busy routes merge there – each month, 2,400 unscheduled stops are prevented on 11,000 journeys between 6 a.m. and 10 p.m. daily, leading to a reduction of 2,000 minutes of train delay. This is the equivalent of 1.4 days.
- This means a savings of 1.2 million minutes of delay for passengers in the Zurich hub each month.
- The system knows around 300 different driving options for each train. In each optimisation cycle, around 10,000 versions of the various driving options are compared.
 - This operation is performed every six seconds on average.
 - The system guides the trains directly via the control systems and trackside signalling.

In addition to other problematic points, HOT is also used in the Gotthard Base Tunnel to keep traffic flowing as smoothly as possible on the new north–south link.



Conclusion.

SUCCESS THAT SPEAKS FOR ITSELF.

With the Rail Control System (RCS), SBB has created a new generation of system components for innovative rail control. As a developer and provider of a comprehensive rail traffic management system in Europe, SBB has first-hand experience of the challenges involved in operating a complex rail system. Switzerland's three railway network operators, SBB, BLS and SOB, are working with RCS. RCS is therefore the central standard platform for controlling active railway traffic on Switzerland's entire railway network. RCS is a mainstay for advanced railway operations: punctual, safe and energy-efficient.

A glimpse into the future

Thanks to digitalisation, the capacity of the Swiss track network – already the most heavily used rail network in the world – can be increased by up to 30 percent. To this end, SBB is furthering the automation of timetable creation, rail operations and train control and is also looking into the possibility of remote-controlled trains. SBB is also designing a new digital signal box. This reduces the quantity and variety of signalling installations, cutting costs substantially.

The railway technology of the future enables the railway system to be used in a more efficient way. From 2025, there will be more trains in use, denser timetables, fewer disruptions, improved radio connection and more precise customer information in the event of a disruption. SBB has launched Group-wide initiatives to achieve this.

In SmartRail 4.0 the RCS Family will expand his functionality over self automated Planing functions up to the secure level of driving the newly developed ETCS Interlockings directly.

The aim is the further automation of processes and operations. Many railway companies still have to contend with process gaps between timetable, operations, customer information, intervention and the allocation of train paths. RCS helps customers to bridge these gaps.

The focus of the further development of RCS will be on the end-to-end automation of all traffic management processes. SBB is pursuing a policy of “complementary division of labour” with a view to implementing these new technologies. This means that the future system will carry out all routine tasks completely automatically and ask the user when entries are relevant to safety or require complex decisions. The future system will therefore be even more intelligent and capable of self-learning. It will support railway operations with autonomous driving. Rather than monitoring trains and lines, the dispatcher's job will involve monitoring the traffic.