The Gotthard Base Tunnel – the world’s longest railway tunnel

The Gotthard Base Railway Tunnel in Switzerland is currently under construction. It links Erstfeld in the Uri Valley with Bodio near Biasca in the Canton of Ticino. Following its completion, at 57 km (West Tunnel: 56,798 m, East Tunnel 57,091 m) it will be world’s longest railway tunnel. Including all the transverse and connecting tunnel sections, it will encompass a total tunnel length of 153 km. Each of the two tunnels contains its own continuous track.

Together with the Ceneri Base Tunnel, the Gotthard Base Tunnel is set to cut the journey time for rail passengers travelling from Zurich to Milan by around an hour (from 3 hours 40 minutes to around 2 hours 40 minutes).

A total of 2200 companies are working on the Gotthard Base Tunnel. The project is actually slightly ahead of schedule, with the official opening planned for June 1, 2016. Scheduled services are set to start from December 11, 2016.

The WinCC OA Partner jm systems is involved in the construction of the Gotthard Base Tunnel with an extensive range of services and hardware installations in a variety of facilities. In a total of eleven subprojects, nine redundant master computer systems and fifteen subordinated group computers are used, all of which are based on the SCADA system SIMATIC WinCC Open Architecture (WinCC OA).

The Ethernet network is structured by 400 S602 Scalance routers and 800 XB005/008 Scalance switches, which are used to actuate the ET200S I/O modules. Local tasks are controlled by a SIMATIC S7-300. During the construction phase, the medium-voltage and low-voltage switchboards were monitored by around 200 ET200S modules. In the definitive construction, the connection of low-voltage switchboards, power transfer modules, no-break systems, lighting and escape route signaling was implemented using 400 SIMATIC S7 controllers (ET200S). Hundreds of additional controllers are used to integrate the medium-voltage protection relays with SIPLUS RIC. 2500 interface modules (IM151-3) are used for various remote I/Os.

The system communicates with the Tunnel Control Center (TCC) using OPC UA, with the electric power plant using IEC60870-5-101/104 and with the safety systems on the medium-voltage level using IEC60870-5-103/104. The power transfer modules designed to switch automatically to the back-up grid in the event of a power failure are integrated via SNMP, and the emergency power diesel system via Modbus TCP.
This mega project was broken down into the following subprojects:

- Power supply 50 Hz (LP 44)
- Lifting device (Lot D)
- Rail Technology Building Bodio (HTRB)
- Changeover doors (Lot B3)
- Emergency halt doors (Lot A)
- Cross passage doors (Lot A)
- Closure gates (Lot B7)
- Doors and gates (Lot E)
- Integral ventilation / integral cooling (LP 21)
- Construction power supply (LP 22)
- Service ventilation (Lot C)
- Small hydropower plant Sedrun (Lot K)

End customer
AlpTransit Gotthard AG

AlpTransit Gotthard Ltd is the constructor of the Gotthard axis of the New Rail Link through the Alps with base tunnels through the Gotthard and Ceneri. Founded in 1998, this subsidiary of SBB (Swiss Federal Railways) is now headquartered in Lucerne and at branch offices in Altdorf, Sedrun, Faido and Bellinzona and currently has around 160 employees.

System integrator
jm systems GmbH

jm systems is a WinCC OA Premium Solution Partner in Switzerland. Its main field of business lies in the customer-specific project-oriented planning, programming and commissioning of building and industrial automation systems. These include not only air conditioning control applications but also the integration of third-party systems and facilities enabling standardized operation by the user. Added to these is a range of special applications such as automatic lighting, test stand or access control systems.

Implementation period
2008 – to the present day
Technical data

Complete power supply 50 Hz (LP 44)
The management system comprises a redundant WinCC OA hot-standby server system with over 60,000 data points with two geographically separated master systems and 14 subordinated group systems, as well as a backup group system which guarantees the function of each optional group system without any service interruption.

The PC systems offer a high level of fail safety and availability through the use of redundant power supply units, RAID5 hard disk systems, redundant housing ventilation, redundant network connection/teaming and integration into the central IT system.

The system was developed in conformity with the style guide for the higher-level tunnel management system and the management system standards of the SBB (Swiss Federal Railways). This system is responsible for the normal, event-based, continuous and test operation of all medium and low-voltage switchboards, no-break systems, lighting systems, monitoring and air conditioning of control cabinets and escape route signaling systems.

Connection of the necessary hardware is ensured by over 400 SIMATIC S7 controllers. A further 100 SIMATIC S7 controllers are in charge of connecting the medium-voltage switchboards with SIPLUS RIC, 2500 interface modules for remote I/O, 450 local HMIs, 400 Scalance S602 units and 800 Scalance XB005/008 switches.

Communication:
- Tunnel and rail control system, respective master systems and tunnel reflex support systems linked over OPC UA AC
- Altdorf, Sedrun and AET electrical power plants linked over IEC 60870-5-101/104
- Medium voltage linked over IEC 60870-5-103/104
- Power transfer modules linked over SNMP
- No-break system connected over ModbusTCP
- Distributed I/Os linked over Ethernet-(TCP/IP) and ProfiNet
Integral ventilation / Integral cooling (LP 21)
The management system comprises a redundant WinCC OA master system with two geographically separated server stations and over 40,000 data points.

Linked systems include:
- 8 large fan stations
- 92 air cooling machines whose locations and connections are continuously changed as required
- 2 recooling and cooling water control systems
- 4 large changeover doors
- 4 closure gates
- 374 cross passage doors
- 100 cross passage ventilation systems
- Numerous air locks, air partitions, doors and flaps
- Construction power supply LP 22

Fully automatic control of the ventilation system in the event of an incident (fire) was a mandatory requirement imposed by SUVA for operation of the building site. No matter where in the tunnel an incident occurs, the entire ventilation system is fully automatically controlled by means of the suitable actuation and rotational direction of fans and adjusted positioning of existing gates, doors, air locks and flaps. In this way, individual air pressure regulation in unaffected areas allows the spread of hazardous fumes to be prevented.

Lifting device (Lot D)
In the Sedrun multifunction station there is a monitored lift system through a 800m deep shaft to the surface. This comprises a redundant master system with WinCC OA and around 200 S7 data points, and is connected to the higher-level tunnel control system.

Construction power supply (LP 22)
Integration and visualization of all LP22 power supplies in the LP21 management system as well as monitoring of over 200 SIMATIC ET200S modules for controlling and monitoring all medium voltage and low voltage systems (approx. 200 UPS systems and UV distributors in cross passages and secondary tunnels).
Rail Technology Building Bodio (building service suite in Bodio)
The building technology housed in the Rail Technology Building in Bodio was linked using a redundant head system with WinCC OA and around 200 BACnet data points as a BACnet gateway to the higher-level tunnel control system.

Service ventilation (Lot C) + small hydropower plant Sedrun (Lot K)
For the service ventilation and small hydropower plant in Sedrun, a climate monitoring system for compression-resistant control cabinets was implemented.

Cross passage doors (Lot A)
Each cross passage has two controlled doors which separate the two tunnel tubes with a hermetic seal. If anyone were to open one of the sliding doors at the wrong moment, they would be blasted by air pressure onto the opposite track bed. If a door opens, this immediately stops operation of the train service.

The management system comprises redundant master computers with WinCC OA and around 7000 Modbus TCP data points. The system is connected to the higher-level tunnel control system and temporarily also to the LP21 management system.

Closure gates (Lot B7)
The pressurized closure gates in the side tunnels are also monitored, as they are of relevance for the ventilation targets.

The management system comprises redundant master computers with WinCC OA and around 300 Modbus TCP / S7 data points, and is connected to the higher-level tunnel control system.

Changeover doors (Lot B3)
In the Sedrun and Faido multifunction stations, there are a total of four changeover doors which are controlled by means of eight high-availability redundant SIMATIC S7-400 controllers. One control system is used for each door leaf.

The management system comprises redundant master systems with WinCC OA and around 1000 S7 data points. The system is connected to the higher-level tunnel control system and temporarily to the LP21 management system.

Doors and gates (Lot E)
The doors, gate and air locks are also monitored, as these are of relevance for the ventilation targets.

The management system comprises redundant master systems with WinCC OA and around 1000 Modbus TCP / S7 data points and is linked to the higher-level tunnel control system.

Emergency halt doors (Lot A)
In the multifunction stations there are two emergency halt areas with controlled doors as escape routes and for implementation of the ventilation strategy.
The management system comprises redundant master systems with WinCC OA and around 850 Modbus TCP data points. The system is connected to the higher-level tunnel control system and temporarily to the LP21 management system.

**Special features**
Long before integration of the actual control technology for the tunnel, jm systems implemented a temporary management system for the ventilation and power distribution during the construction phase. The rock at this depth would heat the air to 50°C. Fans and so-called air-cooling machines, large-dimensioned air conditioning systems, are used to cool the air down to around 30°C. By selectively opening or closing gates, air locks or air partitions, air currents can be directed as required.

The entire programming, both of the used PLCs and the management systems, was performed on the basis of a joint database. In other words, the control programs and management systems use a shared source. Using internally developed tools, the necessary program components and objects are generated on an automated basis, both on the PLC and the management system level. This shared data source is also used to generate work instructions and all necessary test specifications and test documentation. The objective here is to achieve the most efficient and trouble-free set-up and commissioning of plants and systems possible.

All lots are always based on the same standard project. Within this standard project, all fundamental technical requirements are implemented. Only the lot-specific requirements are developed separately from the other lots.

Due to a solution developed by jm systems, a combination of single-sign-on and trusted domains, it is possible for defined users from the SBB network to gain access to the GBT systems if required without any additional need for separate legitimization.

Another feature is a solution developed by jm systems for SMS messaging which is closely aligned to the requirements of the operator.

**Advantages / benefits**
The higher-level tunnel control technology and the entire Switzerland-wide monitoring of SBB systems was also implemented using WinCC OA. As SBB will be the subsequent operator of the tunnel, it was logical to select a system familiar to SBB both in terms of look and feel as well as operation across all levels of the control technology. This eliminated the need to engineer different developments and standards for several software products, and jm systems was involved in elaboration of the project-specific style guide, which applies across all the different lots.
Reference Report
Traffic & Transport
Gotthard Base Tunnel

System pictures
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siemens.com/wincc-open-architecture
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Screenshots

System overview LP44

WinCC OA system overview
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Tunnel overview LP44

Tunnel reflex and crossing overview LP44
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Cross passage overview

Cross passage control cabinet
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Control of cooling plant, Amsteg

Escape route in Faido
North section LP44

Low-voltage cross passage

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