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User Report

Radio and data communication between signal boxes of the Matterhorn Gotthard Railway network.

matterhorn
gotthard bahn

The UMUX 1500 subrack fully equipped with line cards.
(Background: Richleren bridge (Andermatt-Realp),
Source: Matterhorn Gotthard Railway)

Safety all along the Line

The Matterhorn Gotthard Railway controls and monitors radio and data communication between its network's signal boxes with KEYMILE systems technology. A prerequisite for all products used was compliance with all the Swiss Federal Office of Transport's stringent safety stipulations.

The Matterhorn Gotthard Railway's red narrow gauge trains meander their way through Switzerland's mountainous landscape like something out of a picture book. Their journey starts in Zermatt. From Matterhorndorf, the route proceeds through Matter Valley and then the Rhone Valley to Brig, before continuing on through Goms to the Canton of Uri.
The highest point on the route is the Oberalp Pass, 2033 metres above sea level. Disentis is the Matterhorn Gotthard Railway's terminus and offers a direct connection to the Rhaetian Railway. The trains travel a distance of around 144 kilometres, pass through 29 tunnels, 20 alpine galleries and over 60 bridges.

At a glance: the Matterhorn Gotthard Railway's route map.
(Source: Matterhorn Gotthard Railway)

With a service from Visp to Zermatt, the Zermatt narrow gauge railway began its success story at the end of the 19th century, with four locomotives, ten passenger and nine goods carriages. Today's Matterhorn Gotthard Railway was founded in 2003. At the time, BVZ Zermatt-Bahn AG and Furka Oberalp Bahn AG merged to become one single railway company.

Matterhorn Gotthard Railway comprises three companies: Matterhorn Gotthard Verkehrs AG (responsible for all railway operations), Matterhorn Gotthard Infrastruktur AG (track and overhead lines, central control centres, railway property and technical services workshops), as well as Matterhorn Gotthard Managementgesellschaft that employs the entire workforce. Today, the railway company operates services between Zermatt-Brig-Disentis and Andermatt-Göschenen. The trains travel a distance of around 144 kilometres, passing through 29 tunnels, 20 alpine galleries and over 60 bridges. The Matterhorn Gotthard Railway employs around 530 people. Annually, it transports around 6.5 million passengers and 100 000 tonnes of goods in 462 railway vehicles, through 47 stations and stops.

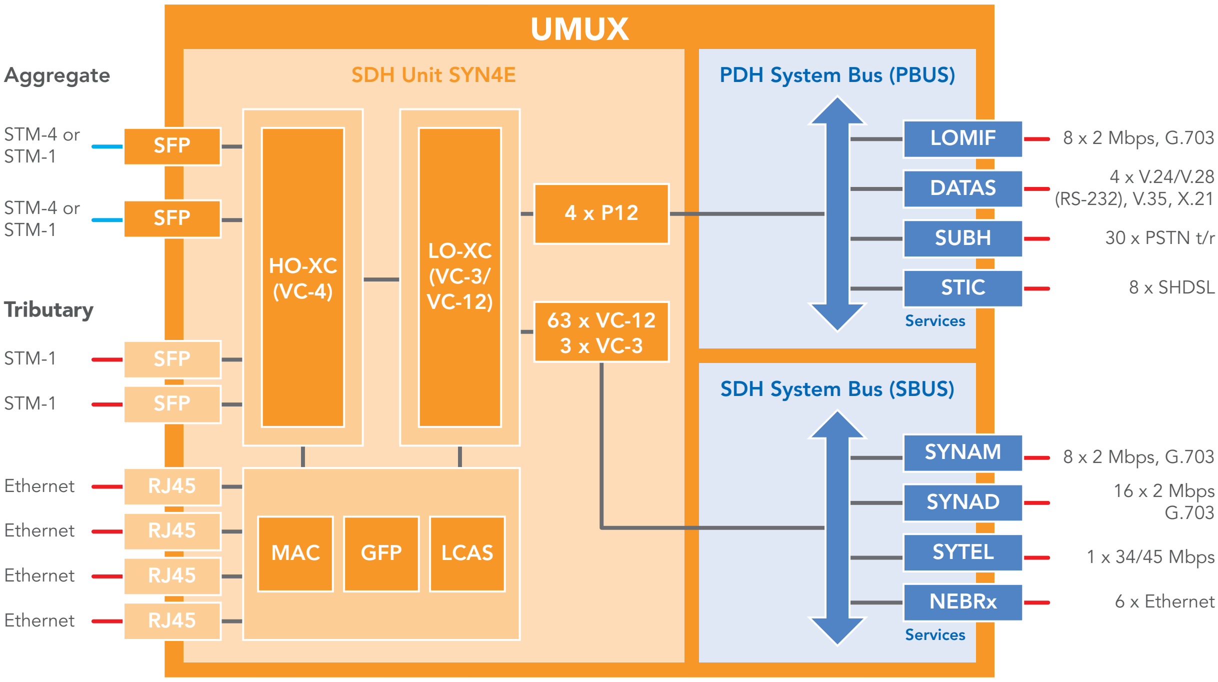
Communications Technology monitors the Railway Network

Thanks to constant optimisation of business processes, Matterhorn Gotthard Railway's demand for automation, and therefore remote control of signal boxes, has increased steadily. For this type of interconnection, data transmission platforms are required that fully comply with the requirements of the regulatory authority. In Switzerland this is the Federal Office for Transport (FOT).

The Matterhorn Gotthard Railway uses KEYMILE's UMUX platform for its telecommunications services. UMUX is a multi-service access system that provides extensive data services. Over 60 of these systems are in use and employed for a wide range of telephony, radio and data connections. A central network management solution proactively monitors all systems used. As a result, any malfunction can be localised immediately, the cause identified and specific steps triggered to rectify the fault. If additional support is required, the Matterhorn Gotthard Railway can rely on KEYMILE's remote support that can access the local network management system should the need arise.

specifications of the control system manufacturer Siemens.

As regards connecting the signal boxes, the ILTIS R40 release is relying on standard IP connections. Each signal box is connected with two 4 Mbps Ethernet connections in point-to-point operation with the central signal box computer in Brig-Glis. These are protected by a redundant path. Should a malfunction occur, for example when fibre optics fail, a switch is made to the second path within milliseconds. For this type of connection, European standard EN 50159-1 closed data transmission network guidelines must be followed. A key issue is the absence of any interference: within the data transmission system, verification must be provided that adjacent data lines have no impact on the ILTIS connections. Due to this



The block diagram of the UMUX SYN4E line card.

Planning fibre optic connection of the first signal boxes began in 2007 with the new R40 release of Siemens' integrated control and information system (ILTIS). The goal was to connect the Andermatt and Göschenen signal boxes with the signal box computer in Brig-Glis. The Matterhorn Gotthard Railway carried out the planning authorisation procedure in close co-operation with the control system supplier. Matterhorn Gotthard Railway chose the UMUX network in accordance with the

measure and error correction mechanisms on higher layers, in the worst case scenario a faulty bit cannot switch a signal from red to green.

KEYMILE implemented this application by employing SDH technology (Synchronous Digital Hierarchy). Using a fixed, circuit-switched mode, paths with 2 x 2 Mbps (2 x VC-12 per connection) are achieved. In the SDH data structure, 2 x VC-12s are allocated and connected virtually with one another, so that a total of 4 Mbps data rates are available.

Matterhorn Gotthard Railway near Nätschen, Andermatt-Oberalppass (Source: Matterhorn Gotthard Railway)

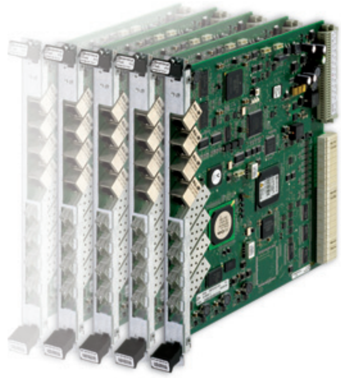
This data rate significantly exceeds the data transmission capacity required for this type of communication, as only low data rates of a maximum of a few 100 kbps are transmitted for the ILTIS application.

ILTIS only occupies a negligible proportion of the 622 Mbps data transmission capacity. EN 50159-1 also permits usage of the remaining transmission capacities for other data connections – regardless of whether these are safety critical or not. In terms of function, time-division technology (PDH, SDH) is viewed as many individual, independent data connections. Railway operators are delighted if such a valuable and precious commodity like fibre optics can be utilised for as many connections as possible. The only alternative would be to apply many fibre optic and copper connections in point-to-point operation.

As a data transmission system, UMUX has another important attribute. From one single system unit and in addition to the transmission interfaces, it also offers all user interfaces, such as analogue radio (2/4-wire with E&M signalling), digital radio systems (GSM-R, Ethernet/IP), data interfaces (all V and X interfaces), bus systems (Ethernet, RS-485), voice interfaces (analogue, ISDN, VoIP) and all other Ethernet/IP-based systems (customer info systems, ticket machines, etc.). Other solutions use three or more systems technologies for the same type of usage: SDH data transmission platform, switch/router IP platform and converters for traditional interfaces (or UMUX too with fewer components for this interface conversion) with appropriately greater complexity for operational activities.

IP Data Transmission on the Path without Routers and Switches

The key element is the data transmission unit SYN4E which was specially developed for this application. Switches/routers were deliberately not integrated in order to demonstrate lack of interference. SYN4E stands for SDH transmission with STM-4 including in-built point-to-point Ethernet interfaces. In addition to the SDH interfaces, this subrack offers some four Ethernet ports (10/100/1000BaseT) which, with Ethernet-over-SDH, are directly mapped to SDH. To change from SDH to Ethernet, the new Generic-Framing Procedure (GFP) and Link-Capacity Adjustment Scheme (LCAS) protocols are used, known on the market as Next Generation SDH.



In addition to the SDH interfaces, the SYN4E subrack offers four electrical Ethernet ports (10/100/1000BaseT) that with Ethernet-over-SDH are directly mapped to SDH.

As a result, efficient mapping of the Ethernet frames is possible. At the same time, during a malfunction, the all-important fast switching times to the redundant SDH technology path can be used. Consequently, on some stretches over 100 km long, the Matterhorn Gotthard Railway needs no routers and switches.

Specifications regarding an absence of interference by other data are also complied with.

An additional challenge for these network connections was the temporary fibre optic bottleneck in the Furka tunnel. The main and second path only had one fibre optic each (not a fibre optic pair). Another problem was that one section of the route is over 40 km long. To bridge this section, STM-4 data transmission was implemented by powerful Small Form-Factor Pluggable (SFP) modules that enable transmitting and receiving via a single fibre optic. These bi-directional SFP's (Bidi-SFPs) only use one fibre optic and transmit/receive data at different wavelengths. For transmitting (Tx) 1310 nm and for receiving (Rx) 1550 nm are used (vice versa in the opposite direction). Years of experience with other networks shows that this Bidi-SFP technology can also be used for this type of high efficiency data communication. As a result, the utilisation of fibre optic resources can be optimised.

The bi-directional SFP's only use one fibre optic and transmit/receive data at different wavelengths.

The current level of implementation has to live with one drawback: the main path and the redundant path have to be accommodated in the same cable duct in one section of the route. An alternative would be to use a fibre optic, or a transparent point-to-point data connection (for example STM-1, 155 Mbps) from another network operator, in order to implement the detour via a fully independent path. However, until this type of alternative can be implemented, the redundant path means the solution concerned has a much higher level of availability than a purely radial connection with a redundant path.

The Matterhorn Gotthard Railway submitted the order for the closed data transmission network in May 2008. After installation in July 2008, the network for implementing the application was handed over to the signal box suppliers and the railway operators in August 2008. The entire signal box connection was finalised in November 2008. The system has now been up and running for about one year and to date no interruption in data transmission has been reported. Matterhorn Gotthard Railway is extremely satisfied with the solution provided. In the next few years, the Matterhorn Gotthard Railway will constantly convert more signal boxes to remote control. Additional stations can be converted with UMUX. And the existing UMUX can be added to and therefore easily integrated into the entire signal box communications.

Publisher

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Matterhorn Gotthard Railway near Oberalpsee (Source: Matterhorn Gotthard Railway)

