Swiss Section

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Filling a missing link among COTS components

Report by Patrick Sonderegger and George Raymond

Many railway signalling suppliers are shifting away from proprietary systems and towards the integration of Commercial Off-The-Shelf (COTS) components. But the transition to COTS can be easier to preach than to practice. This is especially true, for example, when designing a safe interface between an interlocking and the signals and points it controls.

On 6 March 2020, 21 members and six guests of the IRSE Swiss Section visited an interlocking in the town of Châtel-Saint-Denis that incorporates a new solution for the interface between COTS components in an interlocking and those in the field. The interlocking's maker had to design the interface from scratch, but now hopes it can take a place on the shelf of COTS components available to other system integrators. Swiss Section member Patrick Sonderegger organised the event with Christoph Lerch and project manager Marc-Oliver Pellaton of the interlocking's builder, Swiss company Bär Bahnsicherung.

Collaboration across two language zones

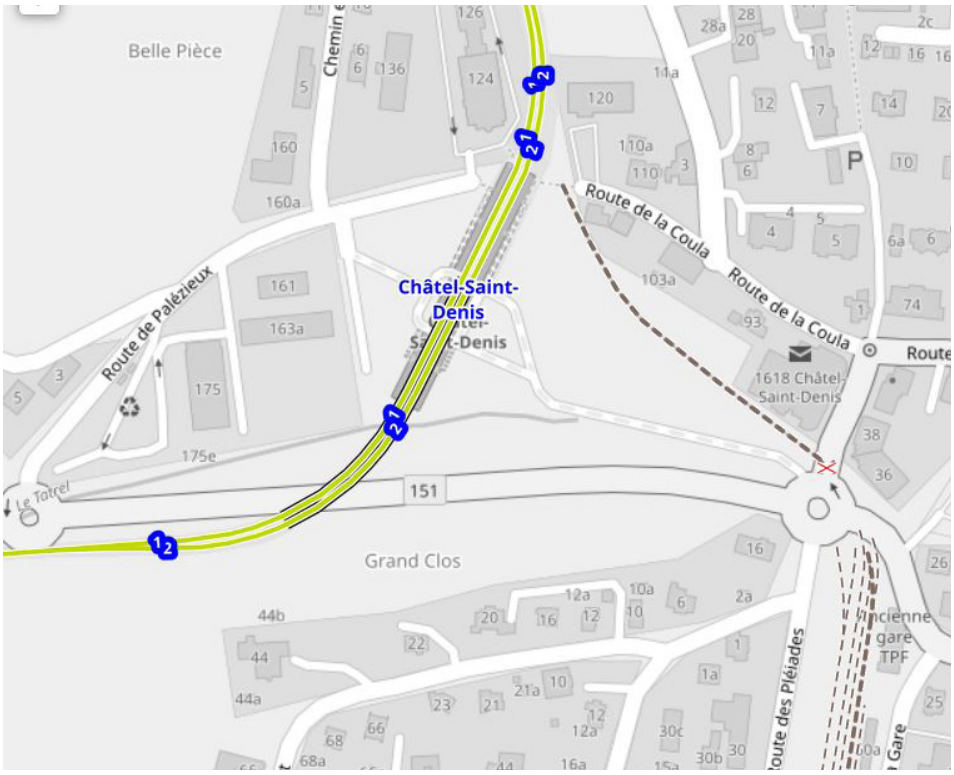
Châtel-Saint-Denis is in French-speaking Switzerland, about 15km north of Montreux. The company's main development centre is in German-speaking Olten. This has meant collaboration across two language zones. This is rarely a problem in Switzerland. Châtel-Saint-Denis is on the 43km metre-gauge Palézieux-Bulle-Montbovon line of Fribourg Public Transport (TPF), who graciously facilitated our visit.

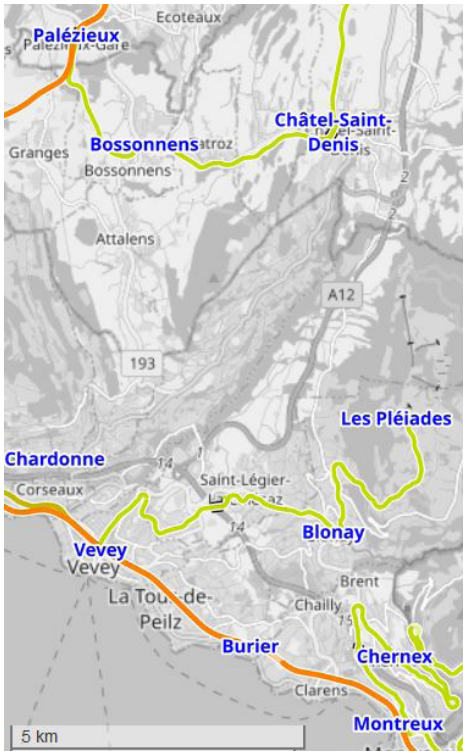
Following two years of tests, the interlocking in Châtel-Saint-Denis had entered commercial service in December 2019 along with two others at adjacent Bossonnens and Palézieux.

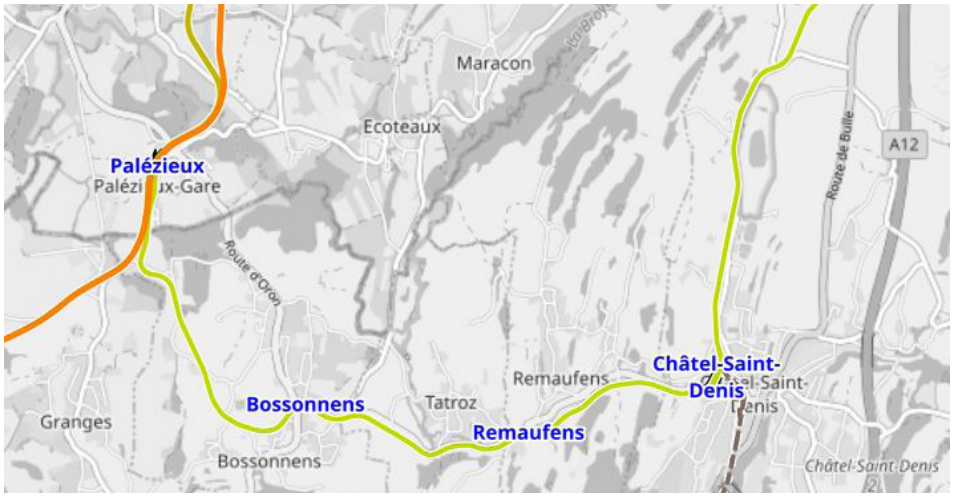
Advantages of COTS components

For proponents of COTS components, their advantages over proprietary systems

Châtel-St-Denis station on 6 March 2020. Some construction was still under way. *All photos Daniel Pixley except as noted.*







Top left: The line from Châtel-Saint-Denis south to Lake Geneva is unusual for Switzerland in having been lifted, in 1969. The resulting stub station in Châtel-Saint-Denis has now been rebuilt into a through station. This has shortened trips by three minutes. Trains call in each direction every half hour.

Left: Châtel-Saint-Denis is on the west end of TPF's single-track, metre-gauge Palézieux-Bulle-Montbovon line.

Above: Châtel-Saint-Denis, north of Lake Geneva.

Source: OpenRailwayMap/OpenStreetMap and contributors.

in industrial control have long been clear. These pluses include open interfaces, manufacturer-independent standards, the opportunity to have dialogue with several suppliers during project development, faster development, greater availability, flexibility when adapting to customer-specific requirements, and lower initial and maintenance costs.

Makers of railway interlocking systems have been seeking to enjoy these advantages. In railway signalling, another advantage of COTS is the potential for harmonisation among different interlocking systems and their components.

With three decades' experience building relay interlockings in Switzerland, in early 2015 Bär decided to develop a new electronic interlocking it called Eurolocking together with the Dutch company Movares, which markets an interlocking bearing the same name. Both companies used the same Programmable Logic Controller (PLC) and faced similar challenges.

Users of COTS components benefit from a network of existing users and can have dialogue with suppliers about improvements. This speeded development and enabled a medium-sized Swiss company with 130 employees to develop its own interlocking within three years. The new interlocking first entered commercial service at Bellevue (La Chaux-de-Fonds) on the Swiss metre-gauge Jura Railway in September 2018.

Key requirements for the new interlocking were:

- CENELEC SIL 4 conformity.
- A safe and secure network for communication among components.
- Compactness to fit in the limited space typical of urban settings.
- Concentration of processing within the interlocking so as to simplify connections with outdoor elements and neighbouring interlockings.
- Ease of configuration.
- Maintenance-free, hot-swappable components that quicken the system's return to operation.
- Moderate training requirements for maintenance technicians.
- Minimal spare-parts inventory.
- Cost optimisation thanks to all these features.

The new interlocking's components and functions

The new electronic interlocking in Châtel-Saint-Denis sets each train's route by assembling a series of elements, notably signals, points and track sections. A programmable logic controller (PLC) hosts the interlocking's 1-out-of-3 architecture. Axle counters prove track

vacancy. SIL4 interface cards connect the interlocking to point machines, derailers, signals, axle counters and adjacent interlockings. Each of these devices transmits its state to the interlocking via two redundant ethernet channels. Faced with any fault, the interlocking ensures that the system enters a safe state.

Indoor boards of a single basic design control both shunting signals and line signals. The indoor boards also feed power to signal lamps and point machines.

Signals

An advantage of designing a new interlocking from scratch was that old functions and signal types, such as signals with moving parts, could be ignored. This made for fewer interface types.

The interlocking controls LED signal lamps meeting current life-cycle standards. The indoor boards supply each signal with 100V AC at night or 150V AC during the day, no matter how far away. At each signal, a converter transforms this into 8V AC (night) or 12V AC (day) for the LED signals. The interlocking's logic tells the indoor board the appropriate aspect; the outdoor signal controller then lights the corresponding lamps. The design of the signal control is fail-safe. For railways with blinking (flashing) signals, blinking and its frequency can be set in each indoor signal board.

Some suppliers of COTS components

At the time of the new interlocking's design, the PLC, axle counters, uninterruptible power supply, LED signal lamps and point machines were each available on a COTS basis from several suppliers. The German maker Paul Hildebrandt supplied the PLC.

Frauscher supplied the axle counters and ethernet protocol, Benning an uninterruptible power supply and Zelisko the LED signal lamps. The customer railway, TPF, specified Siemens KCA point machines. An electronic block interface from maker Mauerhofer-Zuber links the Châtel-Saint-Denis interlocking with the one at Semsales, 6km to the north. This allows the interlockings to request tracks and exchange information on track occupancy.

On 29 November 2020, a remote station that is part of Châtel-Saint-Denis' interlocking went online at Vuadens, 16km to the northeast.

The missing link: object controllers

All these components qualify as COTS. A missing link remained, however. No COTS Object Controllers (OCs) were available to control and monitor point machines and signals. Proprietary OCs were not an option because their makers neither designed nor intended them for use outside their own systems. And no open, non-proprietary network protocol was available for SIL 4 communication between the COTS components. The proposed interfaces of EULYNX, the European initiative of 13 railway infrastructure managers to standardise signalling interfaces, were not yet mature enough.

This meant that building the new interlocking would not just involve integrating COTS components. The interlocking's designers would also have to design their own OCs for the point machines and signal lamps.

Besides meeting the general requirements for the interlocking, the OCs for the points and signals also had to:

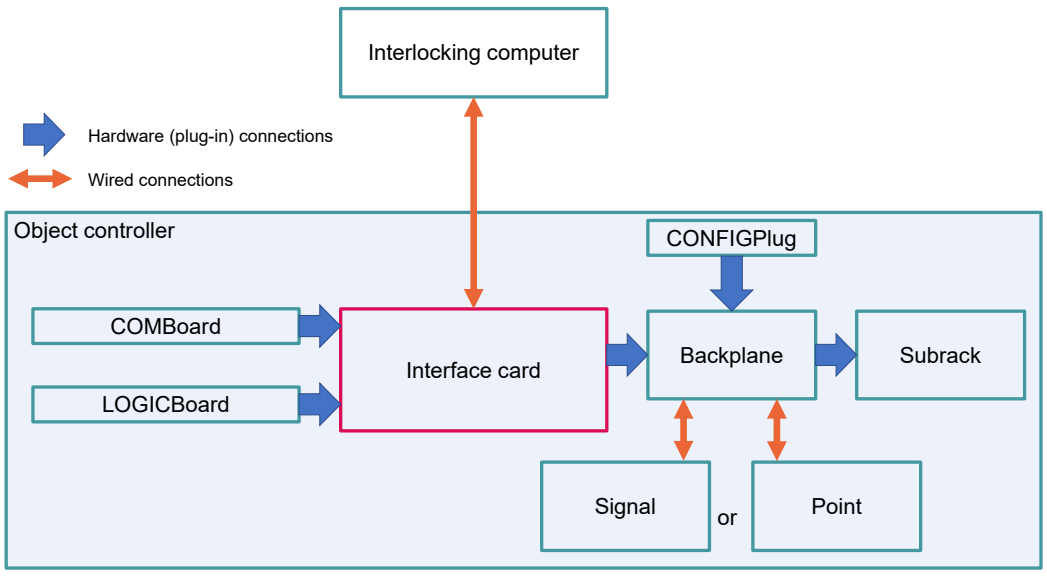
- Provide a digital (not relay) connection between the COTS components.
- All be of the same, small size.
- Be easy for small supplier companies to produce in small batches.

In line with their experience as system integrators, designers divided the OC into functional components, then evaluated different COTS solutions for each. This resulted in one OC design for point machines and another for signal lamps, each consisting of a sub rack, a backplane and an interface card.

Communication between the interlocking computer, the OC and the outdoor elements required a secure network protocol. At the time, the Rail Safe Transport Application (RaSTA) protocol was still an industry pre-standard. The risk of applying RaSTA too early was considered too great and its implementation in the PLC too time-consuming. Based on their experience with the integration of components from different COTS manufacturers, designers opted for Frauscher's Safe Ethernet (FSE). An expert had already certified that FSE was at SIL 4. And the designers had already implemented FSE within the PLC environment to connect it with the axle counters.

Within the OC, a separate component for each function

To ease future adoption of protocols like RaSTA, the designers implemented the OC's communication on a separate, pluggable circuit board called the COMBoard. It plugs into the OC's interface card. Modifying the communication protocol requires replacing the COMBoard, but not the interface card. After a software update, a removed COMBoard is ready for reuse. In

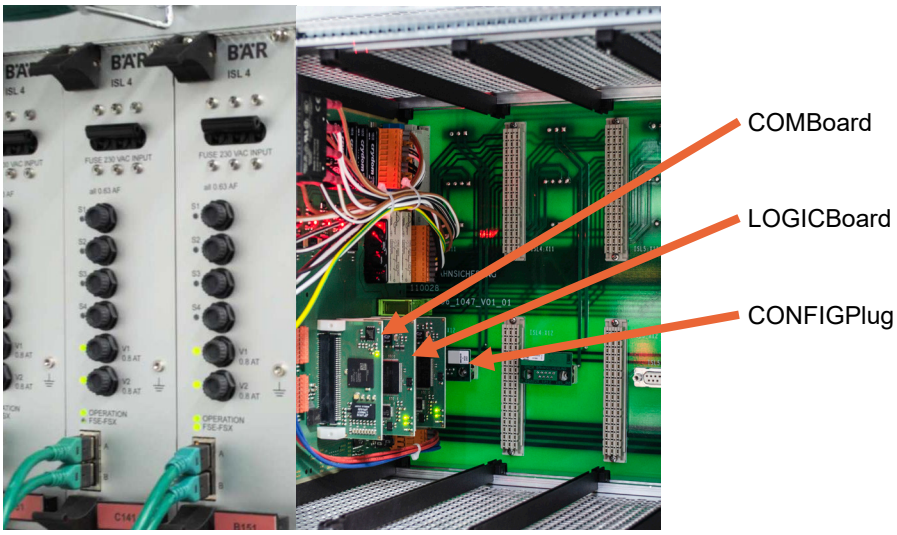


Components surrounding the interface card of the object controller for signals and points. *Diagram Christoph Lerch and George Raymond.*

Right: Interface cards for object controllers, including plug-in boards for communication, logic and configuration.
Photo Bär.

Below: Part of the indoor installations at Châtel-Saint-Denis including the new interlocking, relay interfaces to adjacent blocks, level crossing controls and cables to outdoor equipment.

Below right: Interface cards of the object controllers for points.



the future, this will ease implementation of the standardised EULYNX interface specifications for outdoor elements.

Another component, the LOGICBoard, also plugs into the OC's interface card and stores its basic generic functions, such as continuous end-position monitoring of the point machine. Extension and reuse of the LOGICBoard with more such functions is possible.

Configuration means telling each OC's interface card the functions that its field element must perform. For a signal, this includes signal type, lamp arrangement and fail-safe states. To ease configuration of new and modified installations, configuration data resides on a separate element, the CONFIGPlug. A maintenance technician can use a laptop to prepare and test the CONFIGPlug before installing it. This feature greatly reduces the number and variety of required spare parts.

The components of the signal and point OCs are reusable. Both plug into the same subrack and accept the same COMBoard and CONFIGPlug. The only difference between the two OCs is the backplane, the OC interface card and the LOGICBoard plugged into it.

Designers worked with TÜV Süd Rail to ensure SIL 4 conformity of the system.

Minimising downtime

The customer railway, TPF, has a round-the-clock service to handle interlocking problems. For fault analysis, a diagnosis system is usable remotely. A separate system can diagnose the axle counters.

The CONFIGPlug does not plug into the OC interface card, but rather into the backplane. This means that a technician can immediately replace a faulty interface card with another of the same type. The interlocking then reads the CONFIGPlug and restores the configuration in less than a second. Not requiring the maintenance technician to configure a new interface card

Left: A line signal and shunting signal and the connection box for both.

Above: 6 March 2020, a few days before the first lockdown, Swiss Section members including former IRSE president Markus Montigel (left) gathered in Châtel-Saint-Denis. *Photo Patrick Sonderegger.*

before installing it reduces interlocking downtime, technician training costs and misconfiguration risk.

Within the interlocking, different cable colours provide an easy overview if a cable needs replacing. For example, fibre-optic connections are yellow and connections to the PLC are blue.

The interlocking has two independent 230V AC 50Hz power supplies, as is customary in Switzerland. Batteries allow the interlocking to run up to six hours without mains power. An uninterruptible power supply provides DC power at 24V for the interface boards and the interlocking, and also 60V for the links, supplied by Kummler+Matter, to level crossings and the blocks leading to adjacent stations.

Fabricating the OCs

As a system integrator, Bär asked specialised suppliers to fabricate the relatively small number of OCs needed. For each OC component, the production process required intensive dialogue with the supplier and early planning and procurement. As always, quality control was central, especially for SIL 4 certification.

The company says that the new OCs were the last piece of a puzzle that has yielded a complete, modern electronic interlocking system consisting of industrial components that is on a par with current proprietary systems in terms of functionality, safety, reliability and availability.

Five years after the start of development, four of the new interlockings were in commercial operation by August 2020. Their OCs control a total of 104 signals and 17 sets of points.

The open and adaptable design of the interlocking's OCs means that they can take their place on the shelf among COTS components available to other system integrators in the railway signalling field. The OCs' developers can support such companies in integrating the OCs within their system architecture.

Remote control and automatic train protection outside SIL 4

Regulators at a control centre at Givisiez, 43km to the northeast next to Fribourg, control the Châtel-Saint-Denis interlocking. A Kummler+Matter system links Givisiez with Châtel-Saint-Denis and with K+M and relay interlockings at other stations on TPF routes. One feature is automatic route setting. The Châtel-Saint-Denis interlocking also implements the ZSI-127 automatic train protection system that is largely standard on Swiss metre-gauge lines. Both route setting and ATP are independent of the interlocking's SIL 4 functions.

Tour of Châtel-Saint-Denis station

After the presentation in the interlocking room, our IRSE group toured the installations at Châtel-Saint-Denis station, where we watched the signals and points in action and inspected the links between the interlocking and the field.

AGM – and a last dinner together before the lockdown

We then rode a TPF train about 20km northeast to Bulle for the Swiss Section's annual general meeting. We dined on specialties of the Fribourg region. Some of us stayed overnight before returning to German-speaking Switzerland. We would later recall that the first lockdown was only a few days away.

This article is based on the IRSE's visit to Châtel-Saint-Denis and on Christoph Lerch's article in Signal + Draht (112) 9/2020.