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February 2017

Game changers boost ETCS deployment

TRAIN CONTROL Germany

Avoiding collisions at **low cost**

Top: TrainCAS is now operational on 10 of the Harzer Schmalspurbahnen steam locomotives.

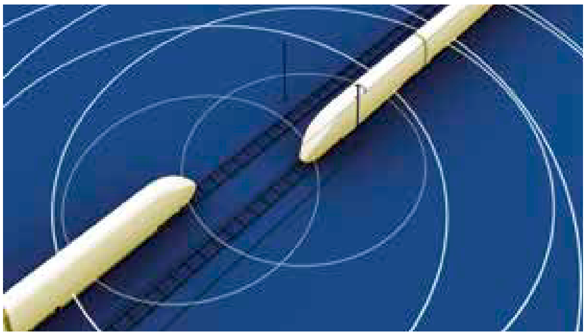
A stand-alone collision avoidance system is currently being rolled out on the metre gauge Harz rail network to improve safety on single-track routes. Using direct radio communication between trains avoids the requirement for fixed equipment.

DR THOMAS STRANG
CEO, Intelligence on Wheels

Last year's fatal head-on collision at Bad Aibling, on DB's single-track Holzkirchen – Rosenheim line in southern Germany, was a salutary reminder that even modern signalling cannot always protect against human error. Inattention by a signaller led to two trains being authorised to enter a single-track section at the same time, using over-ride controls that ironically had been built into the system to minimise any problems of equipment failure. And as the recent collision between two inter-city trains in Iran showed, head-on and rear-end collisions are sadly far from uncommon around the world.

For more than a decade, the German aerospace research centre Deutsches Zentrum für Luft- und Raumfahrt has been working to develop a Railway Collision Avoidance System based on the TCAS/ADS-B technology used in the aviation sector. The result is a low-cost back-up which can be overlaid on any signalling or train control system. This uses radio to enable a continuous train-to-train exchange of information about location, direction and speed without the need for any lineside equipment.

The system is now being marketed as TrainCAS by DLR spin-off company Intelligence on Wheels, which was formed in 2012 specifically for the purpose. The first full-scale implementation is underway on the 140 km Harzer Schmalspurbahnen network, where the equipment was put into regular operation on December 1.



Above: Fig 1. Direct train-to-train radio communications are used to exchange location and speed information.

Function and technology

While based on established aeronautic principles, the TrainCAS equipment has been ruggedised to ensure reliable and robust operation in railway conditions, particularly in terms of protection against vibration and dirt ingress.

Each train has a single onboard unit, which is typically mounted in the driving vehicle, be it a locomotive, railcar or driving trailer. This contains both the train location and communications elements. The OBU determines its approximate location using GPS and refines it with an inertial measuring unit. As the entire network topology — including all tracks and turnouts, gradients, curves and superelevation — is stored onboard, TrainCAS can determine its position to a very high level of precision. Odometry can also be used, but is not essential.

The communications module continually broadcasts the train's location and running parameters, which are picked up by any other trains in the immediate area. In return, it receives information from those trains, and a comparison of the data allows the system to identify emerging potential conflicts. Rather than using GSM-R, which would require lineside base stations, TrainCAS uses a secure frequency in the 400 MHz band. Depending on topography the radio range can reach up to about 40 km.

The OBU has been developed in conjunction with electronics supplier Moxa and its local distributor Sphinx. The heart of the system is a robust Moxa 2426 processor, which has sufficient computing power to perform the necessary calculations. The unit is independent from other on-train systems, simplifying installation and the certification process, while the train-by-train application means the cost is scalable by fleet size rather than route length.

As a driver advisory system, rather than ATP, TrainCAS does not interface with traction or braking controls. Up to five configurable warnings are available to alert the driver to different situations.

Possible collision points are determined on the basis of route and speed, to minimise the risk of false alarms. In this respect, the treatment of turnouts is particularly important. In the case of trailing points, the train's route is clearly defined, and TrainCAS can identify a simultaneous movement on the other track which could threaten a side-on collision. With facing points, the system must check if both tracks are free, as it is independent of any routing logic.

Operators must therefore determine how to treat crossing stations on single lines, in consultation with their safety regulator. The flexibility of the software allows them to set their own alarm parameters. For example, one option might be to issue a 'yellow' alert for 'approach at caution' and only send a danger warning when the IMU detects the train moving on to an occupied track.

Implementation

The Harz installation is being driven by the Ministry for Regional Development & Transport in the *Land* of Sachsen-Anhalt. The ministry called for safety improvements on the metre gauge network in the light of increasing traffic and a couple of recent accidents.

The TrainCAS onboard unit includes a Moxa processor and a driver advisory display, along with a separate battery pack.

When HSB took over the Harz network in 1993, train operations were managed using the former Deutsche Reichsbahn simplified regulations for secondary lines. Dispatchers at Nordhausen Nord, Wernigerode Westerntor and Alexisbad logged line occupancy on the basis of verbal reports and issued movement authorities by radio.

Traffic increased significantly following the reopening of the Brocken branch, and in August 1994 two trains collided when one did not wait for a scheduled crossing at Drängetal. As a result, an electronic interlocking, signals and axle-counters were installed between Wernigerode, Drei Annen Hohne and Brocken in 2000-02. The Nordhausen – Ilfeld section was signalled for the start of tram-train operation in 2004, but the rest of the network still relies on verbal movement authorities.

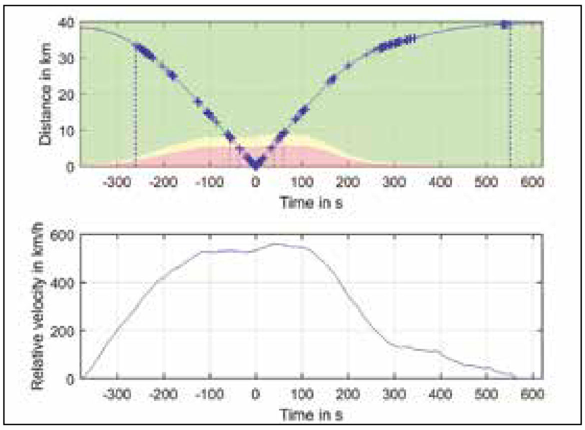
The decision to adopt TrainCAS followed another collision in January 2011, this time on the national network. Freight and passenger trains met head-on at Hordorf on DB's Magdeburg – Halberstadt line, again as a result of a driver over-running a signal. Following that incident the use of PZB intermittent train protection was made mandatory under EBO regulations for all standard gauge lines used by more than one passenger train.

The regulations for narrow gauge railways were not changed, as the Federal Railway Office felt the benefits of PZB would not justify the cost. As an alternative, the *Land* looked at installing TrainCAS on the HSB network. Although this would only cost between 10% and 20% of PZB, a full application would still run into millions of euros. So it was decided in March 2014 to carry out a trial installation on two locomotives.

Local conditions to be tested included the fitting of OBUs on steam locomotives and winter operation on a railway with an altitude difference of more than 1 000 m. It was also necessary to test radio coverage in the mountainous region with woods and tunnels.

While the system successfully detected and warned of impending collisions on single-track lines and at trailing points, the default settings for crossing stations triggered too many warnings. After discussions with the regulator, HSB decided to activate the system only on plain line, once the trains have passed the station limit markers. To minimise false alarms, it was also decided that TrainCAS would only signal the highest level of risk — an imminent collision. If a potential head-on or flank collision is detected, both trains must stop and the drivers request new movement authorities before continuing. In the case of a rear-end collision, only the second train receives an alarm, as halting the leading train could make the situation worse.

Below: High speed trials were in 2016 using a pair of Trenitalia Frecciarossa trainsets operating at up to 300 km/h.



Bottom: Fig 2. Train positioning data was successfully exchanged at a closing speed of 560 km/h.

Funding was secured through the *Länder* of Sachsen-Anhalt and Thüringen for a network-wide roll-out. HSB placed a contract with IoW in early 2015 for the supply and installation of 31 onboard units, as well as five mobile units and five fixed beacons to test the system. So far 10 steam locos and four railcars are using TrainCAS, along with a fixed beacon at Wernigerode depot to test the equipment before each train enters service; the remainder is to be commissioned in the first half of 2017.

On diesel locomotives and railcars, the OBU is powered from the existing electrical supply. Steam locomotives have a separate battery module which can power the equipment for at least 48 h and in practice up to five days.

Future developments

Meanwhile, IoW has introduced a handheld Track Worker Protection App, which can be used to warn staff of approaching trains and vice versa.

Trials have also been undertaken to look at potential applications for higher speeds. In conjunction with Trenitalia, during 2016 DLR tested the RCAS concept on two Frecciarossa high speed trains running at up to 300 km/h.

One test assessed the crossing of two trains on parallel tracks at a closing speed of more than 560 km/h. This demonstrated that RCAS was stable at very high speeds, and could inform the drivers about an approaching train long before it became visible. The requirement for any collision avoidance system is to ensure good contact when the trains are at least twice the emergency braking distance apart, which in the Frecciarossa case was 2 x 3·5 km.

Fig 2 shows the trial results. The lower curve shows the relative speed of the two trains. The upper shows the line-of-sight distance between the antennae, and the blue crosses mark successful SDS data packet reception. The red area indicates the sum of the braking distances at the prevailing speed, while the yellow area adds a margin equivalent to half the braking distance.

Starting more than 40 km apart, both trains accelerated to pass each other at time zero. Around 260 sec before they met, the first communication was established at a distance of 33·6 km, indicated by the left dotted blue line. This is well within the margin needed to initiate emergency braking had they been on the same track. The maximum communication range was achieved after the trains had passed, with the last packet received at a separation of 39·4 km.

So although the collision warning system was primarily designed for low-speed operation, it could be equally applicable for faster routes. ■