# Wheel counting in Vienna

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**Railway track experiences all the climatic extremes the planet can throw at it. It is also subject to heavy loads, vibration, pollution and electromagnetic interference. This is not the ideal environment for an exposed electrical circuit that is a safety-critical element of the signalling system.**

That said, track circuits are generally highly reliable but, when they fail, this is usually due to environmental conditions completing the circuit. As the system fails safe, there is no safety risk but such failures have a high service impact. This is one of the reasons that axle counters are increasingly popular and are now the train detection system of choice for Network Rail.

This much was apparent from the recent 2015 Wheel Detection Forum in Vienna, which was a three-day event attended by over 200 delegates from 34 countries. This was the third such forum, a bi-annual event organised by the Austrian company, Frauscher Sensortechnik GmbH. However, this was not immediately apparent, as its focus was the benefits of axle counters, rather than its own products.

## Keynote speakers

With the exception of Wabtec's Dwayne Allan, the opening keynote speakers said little about axle counters. Dwayne's presentation concerned axle counters in Australia and New Zealand where they were introduced in the 1980s. Their early use was on 'long skinny railways' as, unlike track circuits, there is no restriction on signal section length if axle counters are used. Other advantages of axle counters were the removal of insulated rail joints and the ability to alter signalling functionality during infrastructure upgrades.

Presentations on the project management challenges of installing railway infrastructure in the 57km Gotthard Base Tunnel and the expansion of Turkish railways were fascinating. As far as track circuits were concerned, the Forum learnt that the new Gotthard tunnel used Thales axle counters and that in Turkey there was a mix of detection systems, with track circuits presenting the greatest reliability issue.

Max Schubert of DB Mobility Networks Logistics explained how Fibre Optic Sensing (FOS) detects wheels and anything else along the infrastructure causing ground vibration. This may be quite tiny, for example a human footstep.

FOS measures changes in reflected light from micro deformations in a calibrated fibre that typically can provide a 'microphone' every 10 metres over a 40km length. With fibre cables commonplace along the infrastructure, FOS can make use of spare fibres without the cost of additional infrastructure.

The FOS technique is being evaluated on a 33km section of high-speed line in Germany. This has identified 27 potential applications, one of which is timely


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station announcements of trains approaching at over 160km/h. Initial results indicate that FOS can fulfil this requirement. Although it is not certain whether FOS can be developed to the safety integrity level required by signalling systems, this trial shows its potential for other applications in the near future. In Britain, FOS is now used to detect rocks falling onto the Oban line from the steep slopes of Ben Cruachan.

### Axle counter system

For signalling, the axle counter system consists of the wheel sensor, axle counters and communication with the signalling interlocking. Modern wheel sensors are mounted on the inner face of the rail below flange height. They have two upward facing magnetic coils. Wheels are detected when the voltage of the alternating current in the coils is suppressed as a wheel flange passes over them.

This is not the simple piece of kit it might be thought to be. The coils need to be immune to electromagnetic interference, for which Frauscher has developed the V.Mix technology.

This combines three inductive processes (inductivity, field deflection and eddy current/ hysteresis) to increase the sensor's resistance to electromagnetic interference, linear eddy current brakes and electromagnetic rail brakes. Coils also have to operate consistently between -40°C and 100°C, despite significant changes to the conductivity and permeability of the coils' iron cores over this temperature range.

The axle counter is the electronics that interprets the wheel sensor output. To do this, the counter's evaluation board (EB) converts analogue signals from the wheel sensor coils to a digital pulse. As well as counting the number of axles over the sensor, the EB also detects direction and speed by comparing signals from the two wheel sensor coils. It also has a logic circuit that counts axles in and out of each signal section to determine whether the section is occupied or clear.

The axle counter unit also incorporates a power supply with over-voltage protection. If not directly wired to the interlocking, it also has a communications board to transmit clear/occupied section data and receive requests for resets.

Resets may be required as axle counters, unlike track circuits, do not continuously detect trains. Instead, they use logic to determine whether a section is clear using data from individual wheel sensors. When normal operation is disturbed, for example by equipment failure or engineering work, the normal logic does not apply and a potentially disruptive system reset is required.

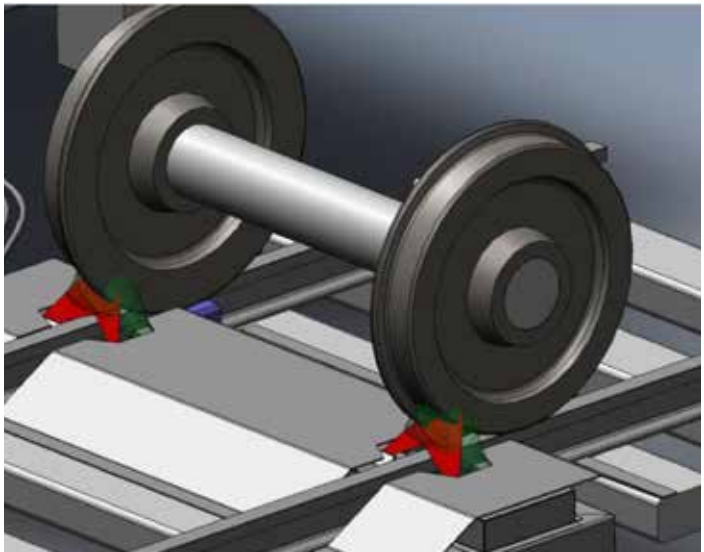
### Automatic reset

The Frauscher FAdC axle counter system has a high availability as it is designed to largely eliminate such disruptive resets without compromising safety. As Phil Blacker of Atkins explained, this approach assumes that trains cannot fly or materialise out of nowhere.

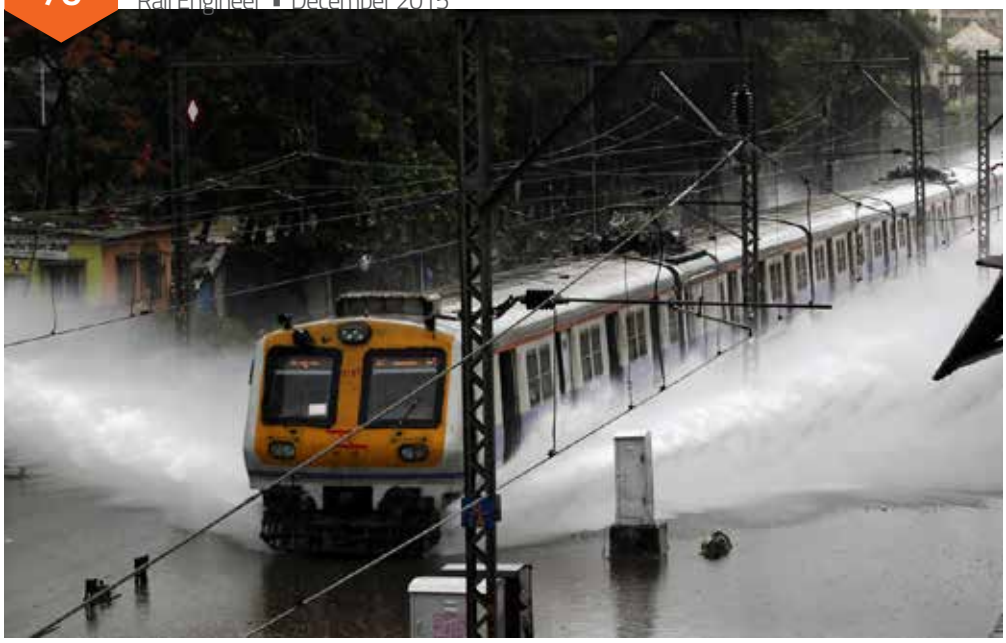
The FAdC system offers two ways of doing this: counting head control or supervisor track sections. The basis of counting head control is that, as the axle counter system knows where trains are, it also knows when a train is approaching a wheel sensor. Hence, it can identify wheel sensor signals that are not trains, for example maintenance trollies.

Supervisor track sections are two adjacent track sections. If there is an abnormal operation of the middle wheel sensor, the sensors at each end of the supervisor section will still count the same number of axles into and out of the larger section. The supervisor track sections overlap so that each track section is part of two of them. If there is a track section fault, the sensor concerned can be automatically reset provided one of its supervisor track sections is clear.

UK standards do not yet allow for axle counter resets using counting head control and supervisor track sections. However, use of these



**Wheel profile camera and laser unit requires exact detection of wheel location.**



**Wheel detectors continue to operate in Bombay's monsoon rains.**

techniques to improve axle counter availability is being actively progressed and has attracted worldwide interest.

## Monsoons, lightning and pythons

The forum heard how monsoon floods, frequent lightning strikes and pythons climbing up overhead line masts affect tropical railways.

Whilst pythons are not a problem for the UK, floods are. Lightning strikes are also not unknown. Anthony Darama Rajan, signalling manager for Kuala Lumpur's 59km airport link, advised that Malaysia has up to 250 thunderstorm days a year. He explained how axle counters had proved resilient to the flooding and made a significant contribution to the air link's 99.83% on-time service performance, once wheel sensor earthing had been modified to prevent wheel sensor damage from frequent lighting strikes.

Flooding is an inevitable consequence of Mumbai's monsoons, as illustrated by Sanjay Singh, S&T general manager of Mumbai Railway. His presentation showed packed trains running whilst water was at rail height as wheel sensors continued to function. With 7.6 million passengers a day on its 319 km suburban network, reliability of Mumbai's signalling equipment is crucial. In 2012, Frauscher provided 1,900 counting heads and 1,400 track sections to upgrade this system.

Sanjay explained that, in addition to the sensor's high environmental resilience, Mumbai's railways achieve high signalling availability by using supervisor track sections, counting head control and redundancy from overlaying axle counters on track circuits.

This arrangement allows combined Counting Head Control and trolley suppression track circuits to avoid resets from use of maintenance trollies. Trolley suppression track circuits do not detect trolleys as they have insulated axles. Using Counting Head Control, the wheel sensor will ignore the two axles of trollies if the adjacent track sections or trolley suppression track circuits are clear. In case the track circuit gets occupied by the passing of another vehicle, the connected wheel sensor gets activated and following sections detect passing trains.

## Ethernet communication

Various speakers mentioned the advantages of a decentralised architecture, made possible by modern transmission technologies. This presents security and reliability issues for which the Frauscher Safe Ethernet protocol has been developed as an option for system integrators who do not have their own protocol.

Providing the required software interface to exchange data between the axle counter and higher-level systems, this protocol also transmits data for diagnostics and centralised remote monitoring.

An example of such decentralised architecture is the modular signalling installed between Crewe and

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Shrewsbury in 2011 by Siemens, the first such system commissioned by Network Rail. This required 79 wheel sensors with the Frauscher FAdC axle counting system installed in 19 external cabinets. Communication between these cabinets and the Westrace interlocking is through an Ethernet connection using duplicated fibre optic cables.

Data transmission between axle counters and signalling interlocking by open Ethernet networks over a radio network also offers significant installation savings by eliminating cable routes. This does, however, present the challenge of providing a power supply for the wheel sensor. It seems this is not an issue for countries like Australia where the sun always shines on the sensor's solar panels.

### Level crossings

Speaking by Skype from India, Petchimuthu Gopalakrishnan advised how India's 40,445 level crossings account for 44% of the country's railway accidents. He referred to the advantages of axle counters for train detection.

In particular, he thought mass violations of level crossing rules by vehicle drivers would reduce if crossings did not have excessive warning times. In this respect, the easy adjustment of wheel sensors location was useful.

In Europe, level crossings account for 29% of all railway fatalities. José Fonseca of the Portuguese company EFACEC and Laurenz Trunner of the Austrian company EBE solutions are both concerned with the manufacture and installation of level crossing systems for which they offered the forum similar insights.

They both considered axle counters to be a more reliable and flexible solution than track circuits or treadles, an important consideration when railways have differing crossing detection requirements. They also noted that axle counters made it easier to optimise crossing warning times. Unlike track circuits, axle counters are not affected by rusty rails at crossings with few rail movements.

Ethernet-based communication reduced installation costs, allowed for remote monitoring of multiple crossings and supported integration with signalling and road traffic systems as required.

José Fonseca noted that EFACEC's previous use of track circuits resulted in, typically, one defect per year per crossing. Since axle counters were introduced there had been virtually no failures.

### Oiling the wheels

Presentations by America's BNSF Railway, Progress Rail, Hegenscheidt and LORAM made it clear that large numbers of wheel sensors are used in non-signalling applications. For such use, Frauscher recently launched a stand-alone wheel sensor with an open analogue interface allowing it to be used with a wide variety of equipment.

Vennie Dyavanapali of LORAM estimated that, in North America, track lubrication systems use an estimated 25,000 wheel sensors


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of which around 90% are in yards with the remainder on the main line. Since 1900, flange lubricators have reduced the coefficient of friction at the gauge-face, typically to 0.05. Top-of-rail lubrication has been used in yards since 1995 and on the main line since 2005. This accommodates wheel speed differences on curves by applying a friction modifier to give a coefficient of friction of typically 0.3.

Wheel sensors ensure the correct amount of lubricant is applied. For top-of-rail lubrication, they also ensure lubricant is not applied until the locomotive has passed.

Axle counters monitor lubricant consumption and are used for billing. In yards, wheel sensors also control wagon speed, determine car location, detect stalled cars and activate wayside equipment such as scales and wheel cleaners.

Vennie noted that, for track maintenance, wheel sensors needed to be installed and calibrated in less than two minutes. They also needed a very low power draw, to be immune from AC interference, and to have wireless capabilities. Frauscher wheel sensors meet these requirements. In particular, with no requirement to drill the rail, sensors can be quickly installed as they are mounted using a rail claw.

## Automated train monitoring

Hark Braren of BNSF provided another North American perspective with his presentation on the use of trackside equipment to prevent wagon derailments. This equipment uses various sensors, generally at common monitoring stations. Bearings are monitored by acoustic sensors and hot bearing monitors that measure surface temperature. A wheel impact detector measures flats and other wheel defects.

Vision Monitoring assesses bogie geometry for worn wheels and poor steering as well as broken springs and friction wedges. It also identifies missing fasteners, broken welds, damaged structural components, defective couplers, low air hoses and wheel tread defects. Accurate wheel detection is an essential part of these monitoring stations, both to trigger the monitoring equipment and specify the location of any train defects.

Progress Rail, Germany, has developed a vehicle monitoring checkpoint for use before tunnels. This detects dragging equipment, out of gauge loads and has hotbox detectors. Throughout Europe, around 1,200 FUES hot box detectors are in use, including 145 in the UK. These monitor external and internal bearings, wheels and brake temperatures. They require accurate wheel sensors to trigger the temperature sensors and provide data on speed and direction.

Wheel lathe company Hegenscheidt has developed its ARGUS II system to monitor wheels using various sensors to detect cracks and measure the diameter, roundness and wheel profile. This is done at up to 15km/h in a depot monitoring station that also identifies the train by, for example, transponders or optical character recognition. The results are stored on a database and used to assess wheel life and time to the next wheel turning. Accurate wheel sensors are an essential part of this system as the monitoring cameras and lasers need to be triggered at exactly the correct point.

Hegenscheidt's Peter Neumann stated that this system is to be developed for main line use at speeds up to 100km/h. For this, the Frauscher wheel sensor triggers when the dip voltage of its two coils is equal. Initial results are that, at speeds between 40 and 60km/h, wheels of 513 and 755 mm diameter can be detected within ranges respectively of 5.2 and 3.2 mm. As this was not sufficiently accurate, further development work is being done.

## Far and wide

The 2015 Wheel Detection Forum certainly offered wide-ranging presentations. Many had travelled far to attend it. No doubt, they found it worth their intercontinental journeys. This worldwide spread of delegates was a reflection of the installation of over 100,000 Frauscher wheel sensors in 70 countries, giving the company a market share of around 40%.

It was clear that axle counters offer significant benefits, so wheel sensors installations are likely to have significantly increased by the next Wheel Detection Forum, in 2017. It will be interesting to see what this next Forum has to offer.