

# Next steps in train tracking

Combining the emerging technology of Distributed Acoustic Sensing with axle-counter information offers the potential for integrated monitoring of many aspects of railway operations.

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Over the last few years, various railways around the world have been investigating the use of optic fibre acoustic sensing. From the USA to Germany, pilot projects are underway to investigate how such technologies might be used to support more efficient, safer and less costly rail operations (RG 8.16 p67).

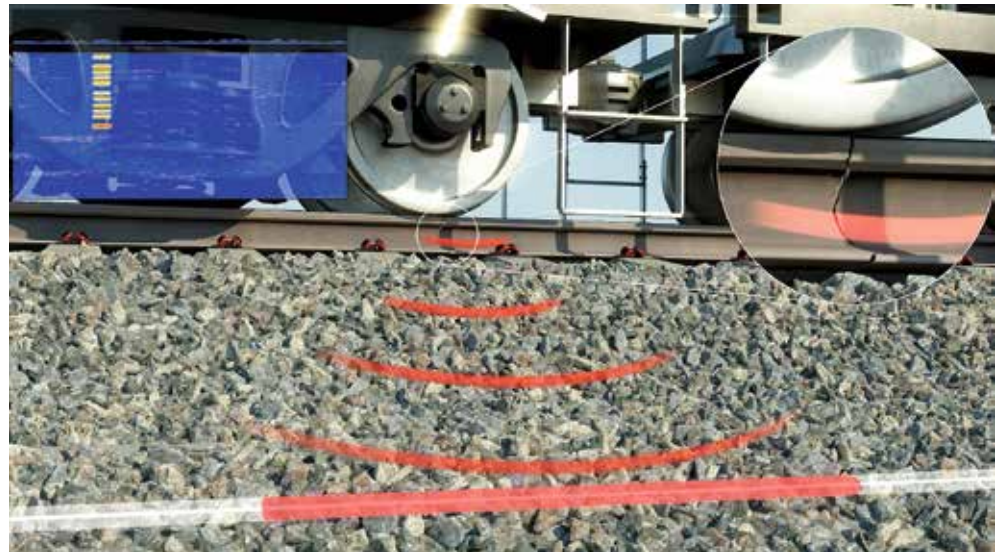
During the InnoTrans fair in Berlin this month, Austrian train detection specialist Frauscher will be unveiling its modular Frauscher Tracking Solutions, which combine Distributed Acoustic Sensing with axle-counter technologies to support a range of detection and monitoring functions. While the systems are still in the early stage of development, we have identified a number of promising applications.

### Optic fibre options

Frauscher has been looking at optic fibre sensing for several years, as one of a number of alternatives to inductive sensors which potentially offer increased reliability in harsh electro-magnetic environments.

One option was Fibre Bragg Gratings, but this approach was not favoured as safe and precise detection of each axle depends on conditions outside the control of the signalling, such as track condition, rolling stock dynamics or axle loading. Furthermore, FBG sensors require intrusive work on the optic fibre cables and the creation of access points at every location which then have to be maintained.

By contrast, DAS offers many more possibilities for rail applications. It can also make use of spare capacity in existing optic fibre cables alongside railway lines, requiring minimal installation work.



**Fig 1. Distributed Acoustic Sensing uses optic fibre cables laid close to the track to detect flat wheels, broken rails and other events with an identifiable noise signature.**

DAS is already being used in other industries, where algorithms have been developed to detect and classify activities that cause measurable vibration signatures, such as the movement of vehicles, footsteps or activities such as manual and mechanical digging. But while the basic concept may be the same, it is not possible to take exactly the same approach in the rail sector. The continuous tracking of trains over long distances is a rail-specific requirement, and railway standards can differ between or even within countries.

### Rail-specific challenges

Current DAS systems do not precisely detect and define the offset distance of an identified impact to the fibre. So it is difficult to determine which track a train is using within multi-track areas. There are some ideas of how this problem might be solved, but as yet fail-safe track identification does not exist.

Whereas DAS provides information about trains, components and activities

all along the fibre, axle-counters are positioned at discrete points. This means that axle-counter information can be assigned uniquely to a detected event. DAS is currently not able to detect the beginning and end of a train or detect individual axles in an accurate, robust or fail-safe manner. Further work will be needed to find a way to meet the CENELEC safety integrity levels, and this could take between five and 10 years. It is not yet clear whether DAS would ever be able to meet the SIL 4 requirements.

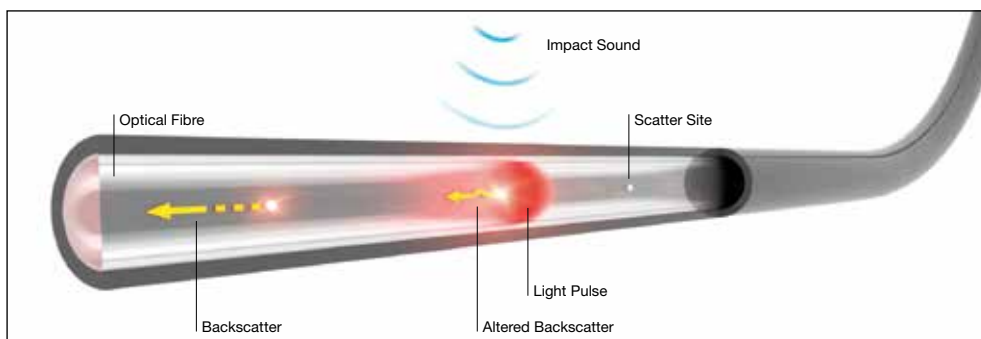
Fail-safe detection of each axle would require a very high DAS sample rate. That increases the costs, as it reduces the length of track that can be monitored by one unit and generates more data to be handled in real time. Frauscher has been looking for the optimum resolution needed for specific applications, as well as the transmission and storage of data. We have been developing algorithms to detect specific events and asset condition such as rail breaks and wheel flats.

### Frauscher Acoustic Sensing

In a parallel study, we have also been looking at the potential integration of DAS with axle-counter and wheel detection information, which may overcome the limitations sooner than developing a SIL-compliant DAS system. And after several years of work, the company is now ready to introduce its first basic applications.

Frauscher Acoustic Sensing consists of three main elements. The optical unit converts the optic fibre cable into

**Fig 2. Passing a pulsed light beam through an optic fibre and measuring the back scatter allows sound and vibration to be identified with a high degree of precision.**



## SPOTLIGHT Train Detection

a distributed sensor, sending laser pulses along the fibre, and measuring the intensity of returned Rayleigh backscatter. It sends signals in real time to the processing unit, which filters and processes the signals from defined sample points to identify any events of interest, sending alarms or notifications to the application unit.

The application unit provides an overview of the system, adding geographical information in the form of location along the route or GPS co-ordinates, and collating the reports into a searchable database. It also monitors the health of the other components, and will also form the base platform for other applications.

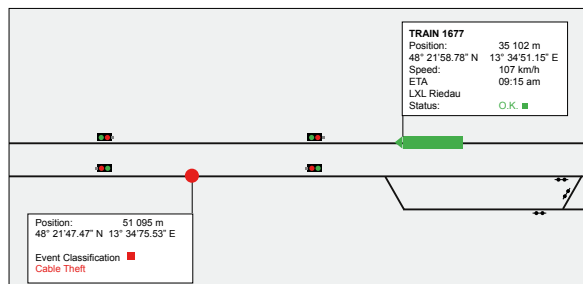
The application unit feeds the newly-developed Human-Machine Interface, which translates specific data into reports and presents status information and alerts in an easily comprehensible format. Alerts can also be sent to other processes or even mobile devices. The system could even trigger the dispatch of a drone to investigate a specific fault if appropriate.

FAS can detect events in 10 m sections along the fibre. Based on the reso-



**Fig 3. DAS can be used to detect people on the track, triggering an alert to warn of trespassing and potential criminal activity.**

**Fig 4. Both train location and unusual events can be indicated on a newly-developed Human-Machine Interface.**



lution, up to 40 km of track can be monitored by an optical unit in one location. It can be used as a stand-alone system for non-vital train tracking, identifying train position, velocity and acceleration, direction of travel and train length. In terms of asset condition monitoring, rail breaks can be detected as well as wheel flats, loose joints or vibrations from a rock fall or landslide. FAS can also be used for security, detecting people working on the line, as well as trespassers, animals or potential criminal activity.

### Higher quality data

Thanks to the modular architecture of Frauscher's products, FAS can be combined with positioning sensors

**Fig 5. Combining data from the acoustic tracking system and existing axle counters offers the possibility of very precise detection.**

such as wheel detection systems to provide higher quality data (below). Signals from an RSR wheel sensor or an AEB axle-counter evaluation board allow very precise detection, so that trains can be assigned to specific tracks and their length determined exactly. Combining the signals with asset condition information from FAS could potentially allow an operator to identify an individual axle with a wheel flat.

The most advanced variant would combine FAS with a modern axle-counter, such as the SIL 4-compliant Frauscher Advanced Counter FAdC. This could monitor trains, assets and personnel on or near all tracks using a single system.

The axle-counter provides fail-safe train detection on block sections of varying length in accordance with the SIL 4 requirements, while the data input from FAS adds more dynamic information such as train location and estimated time of arrival, as well as the asset management and security monitoring functions. Such a combined system has the potential to replace a number of stand-alone applications, offering substantial savings.

### Further development

However, rail-specific DAS is still in its early days, and we expect further progress in developing and enhancing its capabilities. Reducing the componentry noise floor and improved sampling techniques would increase sensitivity, for example. That would provide an ability to detect low-level track and rolling stock defects, while overlaying

wheel sensor data would lift the detection and classification accuracy to another level. Matching the DAS signal with very precise wheel sensor data could facilitate the development of more accurate algorithms, potentially leading to the use of artificial intelligence and self-learning technologies.

Other areas for improvement include the use of dedicated cables and optimal positioning of the fibre along the line. This could include the development of new cables and ways to mount them in defined positions, such as clamping them to the rail foot. That should not affect the potential savings, as the cost of laying extra cables would be offset by the additional functionality.

### Continuous train location

Modern signalling and train control systems rely on timely information on train location to inform traffic management and make best use of available track capacity. Many operators are now looking at moving-block signalling, which requires continuous positioning reports rather than the discrete information available from track circuits or axle-counters.

Current systems for continuous train detection mostly use train-borne equipment to identify position and speed, along with a continuous or quasi-continuous data link using cable loops or radio transmission.

Cable-based systems such as LZB are increasingly being superseded by radio technologies such as ETCS. Research is also underway into the use of satellites for both train positioning and cab signalling, particularly on low-density lines. Further options may be opened up by the 5G mobile telecom and train2x communications standards.

However, all of these technologies require expensive and complex systems on the vehicles. Frauscher Tracking Solutions offers the prospect of trackside continuous train detection, eliminating the problem of unequipped trains, simplifying interoperability, and potentially opening up some new concepts for train control and traffic management. ■

### Combining FAS and axle-counter information

FAS	Axle-counter
Train position, speed, direction, ETA and headway	Section clear/occupied indication, including track identification
Rail breaks, wheel flats, rock fall, trespass, cable theft or vandalism	Number of axles, speed and direction

