SAFERAIL – An EU FP7 Research Project
Providing Innovation in Railway Wheelset Inspection and Wayside Monitoring

Today, rail networks across Europe are getting busier with trains travelling at higher speeds and carrying more passengers and heavier axle loads than ever before. The combination of these factors has put considerable pressure on the existing infrastructure, leading to increased demands in inspection and maintenance of rail assets. The immediate key challenges faced by the rail industry are: a) the improvement in the safety of the railway systems of European Member States, b) the development of new railways to accommodate the continued growth in demand, and c) contributing to a more sustainable railway, in both environmental and financial terms, by delivering further efficiencies and exploiting technological innovation.

To maximise safety efficiency in rail travel, the rail industry has applied a pro-active maintenance policy for wheelsets, combining on-line monitoring and inspections during production and maintenance. Minimising wheelset failures also helps reduce maintenance costs, and is a consideration for both train and light rail vehicle operators.

Existing wayside detection monitors can check rolling stock for poorly performing axle bearings, inefficiencies in the braking system, skidded or spalled wheels, and transient lateral motion, otherwise known as 'hunting'. However, the output of existing on-line detectors is not fully reliable and can lead to misinterpretation of the data acquired. Furthermore, available detectors may frequently miss significant defects and so they do not substitute for maintenance inspections. Most of the wayside detection systems can be connected to a railway's computer network (Knowledge and Information System) to provide the information they require on wheelset performance.

Currently, there are several methods that have been developed for wheelset monitoring of moving rolling stock, including standard wheel impact, strain-based wheel impact, accelerometer-based wheel impact, mechanical profile monitors, hot box, sliding wheel, acoustic bearing defect, wheel profile and cracked wheel detectors, and Automated Optical Inspection (AOI) systems.

The main purpose of the currently available on-line systems is to detect severe wheelset defects just before they result in a catastrophic failure. The most classic example for this is the hot box detector, which can detect the heat emitted by the bearing and report its imminent failure. However, wheelset bearings can heat up and seize extremely rapidly causing derailment, before the train passes over a hot box detector and triggers an alarm in time to receive a warning to stop.

Rolling stock with wheels that contain skid flats and spalling (see Figure 1) can cause derailment or damage to infrastructure. Although wheel impact monitors, which measure the impact loads from the wheels of passing rolling stock on rails, can reliably detect defective train wheels that are out-of-round due to flat spots, chipped-off tread surface, or spalling they cannot provide any information with regards to tight surface breaking cracking or internal defects that may be present on the wheel. As a direct consequence, any severe surface-breaking or deep internal defect will be missed by such systems and will remain undetected until the defective wheelset is taken out of service for inspection and maintenance. Nonetheless, failing to detect severe defects in time between maintenance intervals may subsequently lead to severe structural degradation of the wheel and derailment.

Figure 1 Damage on a wheel due to breaking

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In general, the most immediate objective of existing wayside detection systems is to ensure that rolling stock does not cause such damage and the railway can continue to operate. However, due to the fact that the performance of existing wayside systems is not totally reliable, in most cases their operation is limited to finding rolling stock which requires maintenance or inspection before it leaves the yard. Although the technology for determining the magnitude of wheel impact is more well-established, its applicability is limited since the defect needs to be severe before triggering an alarm.

Main inspection of rail wheelsets takes place during their production and maintenance by using classical Non-Destructive Evaluation (NDE) tools such as standard ultrasonic testing (UT), Magnetic Particle Inspection (MPI) and eddy current probes. Inspection of wheelsets with such NDE tools is time-consuming and prone to human error (some time severe defects can be missed). The fact that these techniques have been in use by the rail industry for the past 50 years means that they are not only regarded as traditional solutions to the inspection problem, but also as undoubted standards. Nonetheless, the remarkable increase of damaged wheelsets due to modified operating conditions, such as higher speeds, higher traffic density and heavier axle loads has led the rail industry to reconsider the inspection methodologies employed during the last few years. Although extensive technological advances were made in the wayside monitoring of rolling stock, development of novel NDE systems for inspection of wheelsets during production and maintenance has been relatively limited, focusing on ultrasonic phased array equipment only. Despite the fact that ultrasonic phased arrays are much more reliable and faster than traditionally used NDE equipment, they can still miss surface-breaking defects, which means that wheelsets also need to be inspected using either eddy current probes or more commonly MPI.

The rail industry has widely recognised the need for measurable and valid innovation, especially in inspection and maintenance procedures of rail assets in order to improve existing safety standards and reduce maintenance costs for rail infrastructure and rolling stock. This has also been stimulated by the reforms that the industry has been requested to undergo according to the new European Commission Directives. Therefore, the development of novel inspection and wayside condition monitoring systems and procedures is timely. Current inspection methodology for wheelsets fails to implement the reliability and efficiency targets set by the rail industry.

SAFERAIL aims to address this problem by developing: a) a novel on-line inspection system for the accurate and reliable wayside monitoring of wheelsets, and b) a powerful NDE technique that will combine ultrasonic phased arrays with ACFM sensors for the faster and more accurate inspection of wheelsets during production and maintenance. The successful implementation of the SAFERAIL systems intends to practically eliminate the likelihood of wheelset failures and derailments caused by them, as well as minimise the damage to the rail infrastructure and rolling stock due to wheel flats and shelling.

The project aims to improve existing wayside monitoring capability by developing an integrated on-line system which will combine vibration analysis, acoustic emission and thermography techniques. Each of these techniques complements the other and therefore increases the versatility of the overall integrated on-line system. The three sensing modules will be integrated via an intelligent control unit which will incorporate software for the automated analysis of the signals obtained. The integrated system will be capable of being connected to the railway's computer network in order to provide feedback on passing rolling stock to signaling engineers. The system will also allow connection with existing wayside detectors, such as strain-based wheel impact monitors, giving it increased accuracy and versatility.

Good progress has already been made by partners APT and DeLijn for light railway application. A first prototype online monitoring system, using vibration analysis, was installed by APT and its up and running at De Lijn in Antwerp, Belgium. All sensors were embedded in the track as shown in figure 2. Figure 3 shows an actual picture from the systems camera activated as the tram runs over the sensors. Live updates of the online system are accessible through a password protected web address. The next stage will be to improve and optimise the defect detection and recognition algorithms.

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Figure 2 ***Embedding the sensors into the track***

Figure 3 ***CCT image generated when tram runs over the sensors***

The SAFERAIL consortium has already carried several field tests with the support of De Lijn, EMEF (see figure 4), VTG and SNCF under effectively actual operational conditions with very encouraging results.

The SAFERAIL consortium will also develop a novel manual non-destructive evaluation technique, for inspection of wheelsets during production and maintenance, by combining ultrasonic phased arrays with Alternating Current Field Measurement (ACFM) sensors. Ultrasonic phased arrays have the capability of emitting ultrasonic shear waves under different angles by steering the ultrasound beam. It is also possible to obtain a C-scan image of the component being evaluated and phased arrays can inspect larger areas faster than conventional UT probes. However, ultrasonic phased arrays are not very sensitive to surface-breaking defects, which mean that another NDE technique is needed to complement its operation. ACFM is an electromagnetic inspection method capable of both detecting and sizing (length and depth) surface breaking cracks in metals. The basis of the technique is that an alternating current can be induced to flow in a thin skin near the surface of any conductor. By introducing a remote uniform current into an area of the component under test when there are no defects present, the electrical current will be undisturbed. If a crack is present the uniform current is disturbed and the current flows around the ends and down the faces of the crack, thus allowing its detection and sizing.

The aim of the combined UT-ACFM system is to be capable of inspecting wheelsets for both deeply buried and surface-breaking defects simultaneously, without the need for complementary inspection using eddy current probes or MPI.

Figure 4 ***EMEF train on test track in Porto***

The successful implementation of the SAFERAIL deliverables will offer to the rail industry several technical advantages which will increase the reliability of rolling stock operations and will help towards the optimisation of operational cost efficiency. The partners believe that the full commercialisation of the SAFERAIL technology is feasible as soon as the project concludes in September 2011.

More information can be found at www.saferail.net

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