The quiet revolution in noise abatement

As the European Parliment prepares to vote on the latest Noise TSI, **David Burroughs** looks at why noise is an issue worth fixing and what is being done to increase customer satisfaction.

TALK to most people who live beside a railway and they are bound to mention at some point the rumbling noise and perhaps even the shaking of their house. According to the 2014 Eurobarometer survey, 29% of EU citizens are often or very often disturbed by traffic noise, which is defined as sound that causes annoyance. Of those, 13% are affected by rail noise. The latest data reported by the European Environment Agency (EEA) member countries shows that around 19 million people in the European Union (EU) are exposed to rail noise above 55dB.

World Health Organisation (WHO) noise guidelines for Europe released on October 10 strongly recommend reducing noise levels produced by railway traffic below a daytime, evening and night average of 54dB. Noise above this level is associated with adverse health effects including annoyance, sleep disturbance, cardiovascular disease and impairment of cognitive performance in children. The WHO also recommends reducing nocturnal rail noise levels to below 44dB, as night-time railway noise above this level is associated with adverse effects on sleep.

While the majority of railway operating activities generate noise, the European Union Agency for Railways identifies the root problem of rail noise as the braking technology used, which affects the wheels' surface and increases its roughness, resulting in more rolling noise. Freight wagons equipped with cast iron brake blocks, which currently represent about 75% of the European freight wagon fleet, are the biggest contributor to noise and a major focus of mitigation efforts.

According to the Environmental Noise Directive (END), the railway noise problem in the European Union (EU) is mainly concentrated in central Europe, where the majority of the affected citizens live, and the volume of rail freight is highest. This occurs primarily in Germany, Italy and Switzerland, but traffic density is also high in Poland, Austria, the Netherlands and France, while noise mapping indicates that a significant number of people are also affected in Belgium and Luxembourg.

Although the costs of tackling railway noise are similar across the EU, public resources available to combat the problem are limited, due to both different economic pressures and policy variations between EU member states.

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The new Technical Specification for Interoperability for Noise (NOI TSI), developed by the Agency, is aiming to reduce noise levels by targeting the use of cast iron brakes, as well as facilitating the creation of silent lines.

Past iterations of the NOI TSI, published in 2006 and revised in 2011 and 2014, imposed rolling noise limits for new, upgraded and renewed freight wagons which in most cases required fitting composite brake blocks in the braking system. However, the Agency says the freight wagon fleet has been renewed at the rate of less than 1.5% per year since 2010 with only 68,000 vehicles retrofitted by 2017.

To accelerate the change, the Agency has decided to go further with the latest NOI TSI which will likely require operators to retrofit most existing wagons with composite brakes. The TSI has been sent to the European Commission, which is due to put the proposal to a vote by member states on November 9. If accepted, it will come into force in 2019, with operators having until the end of 2024 to make the required changes. The European Commission (EC), through the Connecting Europe Fund, will support the proposal by providing grants to cover up to 20% of the initial cost of retrofitting.

Exceptions have also been written into the TSI for wagons that meet certain conditions and are too expensive to retrofit. Mr Oscar Martos, a project officer with the Agency's railway systems and one of the officials responsible for writing the TSIs, says up to 100,000 wagons could come under the exemptions, but they will likely be older vehicles that are due for replacement. However, the exemptions will not apply to lines used by more than 12 trains a night.

Benefits versus costs

Despite a common framework introduced by the Environmental Noise Directive (END), the level of attention given to railway noise by government and rail infrastructure managers is likely to continue to vary. Despite these differences, operators, network managers and fleet owners are researching and developing unique and innovative ways to tackle the challenge of producing quieter, more efficient railways.

Inevitably, these efforts are a balancing act between protecting the public immediately effected by noise and

Photo: DB/ Oliver Lana

Trackside noise barriers have been used by railways for many years, but now some European infrastructure managers are experimenting with alternatives, including 75cm-high barriers.

vibration and ensuring rail remains a cost effective and attractive method of moving freight and passengers. Retrofitting existing wagons with silent brake blocks provides an immediate direct benefit, but also brings considerable costs to a low-margin sector of the rail industry. For example, the Agency found that replacing brake blocks and wheel reprofiling results in a rolling noise reduction of 8dB, but also results in additional estimated life cycle costs of almost €1000 a year, increasing the operational costs of rail freight transport by around 2%.

Some operators and fleet managers are concerned by such costs as they will need to either be absorbed internally or passed onto customers, potentially causing a modal shift back to transporting more freight by road.

"We can't forget that we talk about a business that, due to competition from road transport, is very cost-sensitive," say the technical director of wagon-leasing company Touax, Mr Michal Kowalski, and chief commercial and marketing officer, Mr Louis Pastré. "The more goods go on the road, the more noise, pollution and safety risks arise somewhere else."

As the Touax fleet is relatively young, only about 25% requires retrofitting and the company is initially targeting the wagons used in areas that are especially prone to noise.

"In addition to the obvious environmental impacts, we are future-proofing our wagons," Pastre says. "For us, as a freight wagon lessor, the pressure is coming indirectly from our customers and lawmakers and in several areas of Europe, like the Rhine Valley, it comes directly from the population."

For standard new-build freight wagons, equipped with K composite blocks, the biggest barrier to improving noise reduction is the cost incurred by the increased rate of wheelset wear. The situation is more complicated for existing wagons, as the wear of the wheelsets is even more significant when the more common retrofit method of fitting LL blocks is applied.

"Ultimately wagons not fulfilling low noise requirements will not be able to be used on large sections of the European infrastructure, and therefore there is no way back," Pastre says. "As an ultimate objective, we all fight for a modal shift from road to rail, a greener and hopefully more silent transportation mode."

Cost-effective

Research is currently underway to find new and innovative methods of reducing noise in a cost-effective manner. Among the objectives for the Shift2Rail (S2R) Joint Undertaking (JU) is a requirement to incorporate research into the wider projects undertaken by the JU. The noise project is charged with fulfilling that requirement - Future Improvement for Energy and Noise (Fine 1) - was launched on September 1 2016 with a three-year timeframe and more than €3m in funding.

The project is looking to develop practical methods for predicting noise and vibration at a system level, according to Ms Siv Leth, coordinator of the Fine 1 project, and Mr Giorgio Travaini, head of research and innovation at S2R. Instead of waiting until after a system has been developed and installed to research various ways of reducing the noise, by which time it is often too late or too difficult to implement the required changes, the project is collaborating with a range of other S2R projects to develop noise abatement solutions which are incorporated into the designs and developments produced by other S2R schemes.

The Fine 1 project is largely focused on modelling interior noise, although it does cover a wide range of other elements, while Fine 2, which will build on the Fine 1 research, is expected to focus on modelling and reducing exterior noise.

The project aims to develop practical methods for predicting noise and vibration performance at a system level including for rolling stock, infrastructure and the environment, as well as predicting interior vehicle noise and providing source modelling for interior and exterior noise. An accurate characterisation of each contributing source will make it possible to optimise cost benefit scenarios while also taking exposure and comfort into account.

The Fine 1 project, which involves Bombardier, German Rail (DB), Alstom, CAF, Talgo, German Aerospace Center (DLR), Siemens and Trafikverket, is complemented by the Destinate project, which involves non-S2R members that are providing external input into the programme.

Destinate aims to reduce the operational costs of railways by cutting rail's energy use and noise. Coordinated by Berlin Technical University, the project is attempting to characterise structure-borne and airborne sound sources accurately in order to create valid input for sound prediction simulation models. The calculated interior and exterior noise can then be auralised and visualised in a studio to evaluate the sound quality and sound comfort of potential mitigation measures in the vehicle design process.

S2R has also developed a tool that uses the modelling of noise along a line to demonstrate to members of the public how they will potentially be affected. Using headphones and virtual reality glasses, the tool, which was displayed at InnoTrans in Berlin in September, gives people an accurate and important idea of what they can expect.

"You can hear, look and see what it will be like if you go to the line," Leth says. "It's very, very important to have this conversation with the people who are annoyed by noise. As soon as you build a new line and it's noisy, people will go out and protest. They do like railways but they say 'they're too noisy so if you build here you have to make it quiet'."

The busy Rotterdam - Genoa Corridor, which forms part of the Trans-European Transport Network (TEN-T) and is used for a range of passenger and freight services, has been used to create a baseline to evaluate the different noise mitigation effects of the various technologies. A long-term vision for prospective traffic increases and the impacts of different scenarios will also be developed on the corridor.

Fine 1 is also developing definitions of typical scenarios for parked-train and stabled modes to identify ways to minimise or eliminate noise from trains idling overnight or parked in a yard.

Quieter infrastructure

While the TSI is set to throw down the gauntlet to operators, infrastructure managers are also investigating ways they can create networks to both reduce and contain noise. Noise barriers, under-track and under-sleeper pads, and passive soundproofing installed on neighbouring structures are all in use to reduce noise and ground vibrations to varying degrees.

One company that is taking a hard line on noise is DB, which has set itself the goal of halving its 2000 noise levels by 2020. On average, rail noise will be reduced by 10dB, which to human perception corresponds to halving the volume.

As both an operator and infrastructure manager, DB has control over all of the major factors influencing noise emissions. The company's overarching concept is fundamentally based on two pillars: fixed noise protection on the infrastructure and fleet-based noise reduction measures.

Stationary measures primarily include sound-insulation walls and equipment such as low-noise barriers, rail dampers or rail lubrication equipment directly installed on or near the track as part of the Federal Voluntary Noise Abatement Programme, which is focusing on 3700km of lines considered to be particularly noisy. The programme was launched in 1999, and by the end of 2017 had installed noise abatement measures on nearly 1700km of track.

The second pillar focuses primarily on noise reduction at the source. Almost two thirds of DB Cargo's freight wagon fleet in Germany has been retrofitted with composite brakes, with the goal of converting the entire fleet by 2020.

As well as the traditional methods of noise and vibration reduction, DB is researching other innovative techniques that could become mainstream if they prove effective. At Grünstadt and Freinsheim stations near Mannheim in the state of Rhineland-Palatinate, DB is testing three technologies designed to reduce wheel squeal through curves, including two rail lubrication systems from different manufacturers and a rail damper.

Before these technologies were installed, extensive measurements were taken in order to determine the baseline sound emissions. The lubrication systems are designed to reduce friction on the rails, while the dampers alter the vibrational behaviour of the rails. Another extensive measurement phase is now underway to test the effectiveness of the processes in order to obtain objective and reproducible data. This will be followed by extensive evaluation of the data, with initial results expected at the end of the year. A second round of testing is planned in 2020 to assess the effectiveness of the techniques after a longer period, with a decision on their suitability expected then.

Dutch infrastructure manager Prorail is also testing noise abatement innovations, such as the application of low-height noise barriers as a means of protecting the 2 million residents who live within 300m of its network. Prorail says the application of the 75cm high barriers is another step closer after two successful trials in Hilversum and Susteren, where in both cases they decreased noise by approximately 5dB.

While the public is often receptive of most measures to reduce noise, there are often calls for implementation without adverse environmental effects such as the visual intrusion often created by standard full-height noise barriers. In Hilversum, Prorail is testing so-called "mini-screens," low noise barriers which are placed very close to the track, and have so far produced positive results. The infrastructure manager is now undertaking further research into the suitability of the screens with regard to daily maintenance and safety considerations such as escape routes.

In addition, experiments have been carried out at Susteren in Limburg Province with a sound diffractor, a 1m-wide steel container with 25 slots of increasing depth which deflect the sound waves upwards, achieving a 5dB reduction.

While the new screens do not yet offer the same benefits as standard high screens, which can reduce noise by up to 15dB, ProRail says the 5dB reduction provided by the low screens is sufficient in some circumstances. Further discussion is planned with the Ministry of Infrastructure and the Environment and the National Institute for Public Health and the Environment to determine whether the screens can be included as a measure in existing legislation and regulations.

Efforts to reduce the effects of vibration go further than just track. Prorail has also sent hundreds of letters to municipalities, urging them to improve building regulations. The infrastructure manager argues that it is more effective to build vibration protection into new homes than it is to install vibration reduction measures afterwards.

In the Leidsche Rijn district of Utrecht, houses alongside the railway must be built on piles which use rubber as a damper. Residents here experience minimal vibrations while complaints from a neighbouring area, which still uses traditional building methods, are commonplace.

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As demand for rail continues to grow and the frequency of both passenger and freight services increases, operators, infrastructure managers and fleet owners will come under increasing pressure to operate those services with as little disruption as possible. More work is required to deliver quieter networks, but that work is well underway. **IRJ**