Institution: University of Southampton

Unit of Assessment: 15 General Engineering

Title of case study: 15-01 Sustainable expansion of rail networks through noise reduction

1. Summary of the impact

Research by the University of Southampton into reducing railway noise has a created new technology that has allowed railway networks in Europe and Australia to be expanded, while preserving citizens' quality of life. Under a licence agreement with Tata Steel, patented rail dampers have been fitted on around 155 km of track in 16 countries and proved critical to a new route in New South Wales. They have enabled operators to save tens of millions of pounds that would have been spent on expensive noise barriers, and earned Tata Steel significant amounts in sales and the University in royalties [exact figures removed for publication]. Follow-on research funding of £2M from EU and EPSRC.

2. Underpinning research

A rise in noise pollution and public awareness is restraining the development of railways around Europe as countries seek to expand sustainable public transport networks and increase passenger capacity. Public opposition to new rail projects is widespread – objections by local communities to the UK's proposed high-speed line HS2 are a case in point – which means that increased rail volume can only be achieved through the implementation of cost-effective noise mitigation measures.

Conventional solutions centre on the installation of noise barriers or the construction of deeper rail cuttings or even tunnels but the costs are prohibitive and high barriers can blight the landscape, obscure the view and reduce light in people's homes. Since 1996, research at the Institute of Sound and Vibration Research (ISVR) at the University of Southampton has sought to design a new, economically viable solution to combat the noise emitted by the vibration of rails. David Thompson, Professor of Railway Noise and Vibration, has led this research since 1996; his team includes Christopher Jones, Reader in Railway Noise and Vibration (1997-2011), Timothy Waters, Senior Lecturer (2000-), Neil Ferguson, Senior Lecturer in Structural Dynamics (1986-) and Mohammed Hussein, Senior Lecturer in Rail Dynamics (2013-).

The ISVR was a key partner in two EU-funded projects between 1996 and 1999: Silent Freight and Silent Track. ISVR academics developed theoretical models to predict more accurately levels of railway rolling noise: the sound caused by the rolling of steel wheels on steel rails. This led to the creation of the software program TWINS (Track Wheel Interaction Noise Software), which analyses the effect of wheel and track design changes on the noise produced, and modifies designs to control railway noise at source [3.1].

The concept of a rail damper was the most successful outcome of Silent Track [3.1, 3.2] and stemmed from the realisation that noise is emitted by both wheels and rails. Whereas several solutions existed for wheel noise, there was no practical way of reducing noise emanating from the track. The rail damper, consisting of various steel masses embedded in a high-damping rubber, is attached to the rail and reduces the noise by attenuating the vibrations transmitted along the rail. It was devised by ISVR in collaboration with British Steel, later Corus, now Tata Steel, and led to a joint patent application in 1998 [3.3]. It was developed using modelling techniques to achieve a good damping performance in the required frequency range. The key to its success was the development of a suitable damping material, which had both a high damping performance and the requisite stiffness.

Several prototypes were tested in the ISVR laboratory and a lengthy process of experimental work determined the optimal configuration. Field tests in 1999 demonstrated a substantial noise reduction of 6 dB [3.4]. Studies into how rail damping could be employed to slow the rate of development of roughness on the surface of rails were part of further collaborative work with Corus within the Silence (2005-7) and Innotrack (2006-9) EU projects [3.5]. The damper development is part of a wider body of work on railway noise and vibration at the ISVR, worth £2 million in total

funding to the University since 1996 from EPSRC, EU and industry leaders in Europe, that culminated in a definitive book on the subject in 2008 [3.6].

3. References to the research (the best 3 are starred)

3.1. D.J. Thompson, C.J.C. Jones, 2000, Using theoretical models to design low noise wheels and track. Transportation Research Record, Journal of the Transportation Research Board, 1702, 51-56.

3.2*. D.J. Thompson and P.E. Gautier, 2006, A review of research into wheel/rail rolling noise reduction, Proceedings of the Institution of Mechanical Engineers, Part F Journal of Rail and Rapid Transit, 220(F4), 385-408.

3.3. Patent: Rail Fixings, applicants: British Steel plc and University of Southampton. Inventors: Hodgson, W.H., Clarke, J.B., Farrington, D., Thompson, D., Jones, C.J.C., International Patent Application filed 18-9-1998, no PCT/GB98/02767. World, European, US, Australian and other patents held.

3.4*. D.J. Thompson, C.J.C. Jones, T.P. Waters and D. Farrington, 2007, A tuned damping device for reducing noise from railway track, Applied Acoustics, 68(1), 43-57.

3.5. B.E. Croft, C.J.C. Jones and D.J. Thompson, 2009, Modelling the effect of rail dampers on wheel-rail interaction forces and rail roughness growth rates, Journal of Sound and Vibration, 323(1-2), 17-32.

3.6*. D.J. Thompson, 2008, Railway noise and vibration: mechanisms, modelling and means of control. Elsevier: Oxford.

Examples of Related Grants

EU: Silent Freight (1996-99), University PI: Walker, value to UoS £135k

EU: Silent Track (1997-99), University PI: Ferguson, value to UoS £129k

EU: SILENCE (2005-7), University PI: Jones, value to UoS £110k

EU: Innotrack (2006-8), University PI: Jones, value to UoS £55k

EU: RIVAS (2011-13), University PI: Thompson, value to UoS £200k

EU: Acoutrain (2011-14), University PI: Thompson, value to UoS £200k

EPSRC: Non-linear effects at the wheel/rail interface (GR/M82455), PI: Thompson, 1999-2002, £187k

EPSRC: Rail Research UK (GR/S12784/01, 2003-6), grant PI: Powrie, subprojects A3 and A4, lead: Thompson, Jones and Iwnicki (MMU), value of subprojects to UoS: £210k

EPSRC: Track21 (EP/H044949/1), grant PI: Powrie, Work Area 3 lead: Thompson, value of WA3 to UoS: £248k

EPSRC: MOTIV (EP/K006002/1), PI: Thompson, Hussein and Hunt (U. Cambridge), UoS £560k

Deufrako: Stardamp (2010-12), University PI: Thompson, value to UoS £100k

4. Details of the impact

Total sales of the ISVR-invented rail dampers, marketed as SilentTrack®, amount to [exact figure removed for publication] as of the end of FY 2012/3, evidence of significant financial benefit to Tata Steel. Royalty income to the University from Tata Steel is also significant [exact figure removed for publication]. The Project Manager of Tata Steel writes: “Following the development work based on ISVR's research, the subsequent sales of the SilentTrack rail damper has given Tata Steel a valuable new income stream which is independent of our traditional manufacturing activity, whilst remaining integral to our core product, the rail. The input of ISVR to the initial prototypes and their on-going support during our product development phase has been vital to the successful commercialisation of this product” [5.7].

The successful commercialisation of the ISVR/Tata Steel rail damper has facilitated the expansion of rail services in Europe and Australia over the last five years. Capable of delivering noise reductions of up to 5-7 dB, it is the only technology, barring the use of high-cost and visually intrusive noise barriers, to deliver this level of noise reduction at source [5.1].

The benefit-cost ratio of rail dampers is twice that of noise barriers [5.2, 5.10], which cost on average £1 million per km depending on the height [5.3]. In Germany 362 km of noise barriers have been constructed along existing railway lines and in Switzerland they cover 144 km of track [5.4]. The Betuwelijn, a new freight route in the Netherlands that opened in 2007, has 160 km of noise barriers along its 160-km-long route. In contrast ISVR/Tata Steel rail dampers manufactured and sold by Tata Steel have been installed in 16 countries since 2001. Despite reluctance in the rail industry generally to adopt new technology, approximately 155 km of track have been fitted with these dampers, with the majority (130 km) installed from 2008 onwards [5.7].

In the Netherlands, the number of passenger trains has doubled on some lines in recent years. The introduction of noise emission ceilings means that an increase in passenger trains can reduce the permitted number of freight trains [5.3]. In response, Dutch rail infrastructure owner ProRail has installed rail dampers on over 90 km of line in order to comply with the new laws. The resulting 3 dB reduction has allowed a doubling of traffic at a significantly lower cost than installing noise barriers [5.3].

In Australia, the ISVR/Tata Steel rail dampers were used in 2009 to resolve severe noise issues on the controversial 16 km Epping to Chatswood Rail Line (ECRL) in the northern suburbs of Sydney [5.5]. After a series of delays to the line, which resulted in intense media scrutiny, RailCorp discovered that noise levels were akin to the landing of a Boeing 737. Any further delays would have incurred hefty fines for the operator of the £2.3 bn service, which was already significantly over budget. Tata Steel supplied the rail dampers on time and the line's successful opening allowed the New South Wales government in February 2010 to announce a new $2.1bn North West Rail Link to connect with the ECRL.

Network Rail's £6bn Thameslink Programme, which is upgrading the north-south route through central London, marked the first installation of rail dampers in the UK. ISVR/Tata Steel rail dampers were fitted on 1.5 km of track at Blackfriars Station in 2012. The installation was featured in The Engineer in 2012 [5.6]. Network Rail is now considering the use of rail dampers on a national scale as part of the Action Plans required to comply with the EU's Environmental Noise Directive (2002) [5.8]. German and French railways also consider rail dampers as potential candidates for Action Plans required by the Directive [5.9, 5.10].

In each case the main beneficiary is the railway infrastructure authority, who would otherwise need to implement a more expensive solution. As a result of rail dampers, the height of noise barriers can be reduced or even eliminated to achieve the same level of noise reduction [5.3]. Estimated savings in noise barrier costs amount to at least £16 million, according to cost-benefit analyses [5.2], with the potential for future savings of several hundred million pounds based on expected future quantities of noise barriers.

More generally the research has led to improved quality of life for people living near railway lines where the rail dampers are installed and ultimately highlighted the potential for a sustainable modal shift to railways away from a more carbon-intensive means of transport.

The TWINS software developed by Prof Thompson has become the de facto software standard for the rail industry for the design of wheels for new rolling stock. A European standard for wheel design (EN13979-1), published in 2004, explicitly recommends using TWINS to ensure designs conform to regulations.

ISVR's published research has led to further EU grants from 2010 to 2013 totalling more than £500,000 to work with leading European rail companies such as SNCF, Deutsche Bahn, Alstom and Bombardier, to advance damping technologies. This includes £200,000 awarded to ISVR in 2011 to contribute its expertise to Acoutrain, an FP7 project coordinated by UNIFE – the Association of the European Rail Industry, which aims to speed up acoustic authorisation of new

railway stock to encourage innovation and cut costs.

A recent German-French project STARDAMP has developed standardised methods to assess rail and wheel damping treatments. Due to the ISVR's expertise in this area, the consortium considered it essential to the success of the project that they should be included and, as they were not eligible for German-French funding, the 9 partners subcontracted ISVR to develop test methods and software for the assessment of dampers [5.9, 5.10].

In 2008 Prof. Thompson was invited to join the international reference group for the €30M Noise Innovation Programme (IPG) in the Netherlands which included field tests of rail dampers and in 2011 began advising Swiss Railways on rail damper field tests, with a view to installing them on tracks in Switzerland.

5. Sources to corroborate the impact

5.1. B. Asmussen et al, Reducing the noise emission by increasing the damping of the rail: results of a field test. In: *Noise and Vibration Mitigation for Rail Transportation Systems*, ed B. Schulte-Werning et al, Springer, 2008.

5.2. J. Oertli, The STAIRRS project, work package 1: a cost-effectiveness analysis of railway noise reduction on a European scale, Journal of Sound and Vibration 267, 431-438, 2003. http://dx.doi.org/10.1016/S0022-460X(03)00705-3

5.3. P.H. van den Dool, Rail dampers, rail infrastructure gets quiet, Proc. Internoise 2007, Istanbul, Turkey, August 2007.

5.4. E. Wiebe et al, ERRAC Roadmap - WP 01 - The Greening of Surface Transport "Towards 2030 – Noise and Vibrations Roadmap for the European Railway Sector", UIC, version 6.0, December 2011. Available at: http://www.errac.org/IMG/pdf/errac_wp01_roadmap_noise_and_vibration_v06.pdf

5.5. C.M. Weber et al, In-car noise control for Epping to Chatswood Rail Link, In: *Noise and Vibration Mitigation for Rail Transportation Systems*, ed T. Maeda et al, Springer, 2012.

5.6. A. Czyzewski, Thameslink set to get noise dampening on rail tracks, The Engineer, May 2012. Available at: http://www.theengineer.co.uk/sectors/rail-and-marine/news/thameslink-set-to-get-noise-dampening-on-rail-tracks/1012656.article#ixzz2AQQNnKyc

Users/beneficiaries:

5.7 David Benton, Tata Steel, Business Development Manager, SilentTrack, Website: http://www.tatasteeleurope.com/en/products_and_services/products/long/rail/silent/

User of the technology who can confirm sales figures and importance to Tata Steel's business.

5.8 Nick Craven, Senior Technology Engineer (Acoustics), Network Rail.

Approval for use in the UK, installation on Blackfriars viaduct, potential for use on a national scale as part of the Action Plans required to comply with the EU's Environmental Noise Directive.

5.9 Bernd Asmussen, DB Systemtechnik (German Railways Research Department).

Can confirm application of dampers in Germany; EU projects Silence, Innotrack, Acoutrain, RIVAS, and Stardamp project.

5.10 Florence Margiocchi, SNCF INFRA (French Railways Infrastructure Department).

Can confirm installation of dampers in France; EU projects Silent Track, Silent Freight, STAIRRS, Silence, and Stardamp project.