Vehicle/Track Interaction

A guide to RSSB research
RSSB is a not-for-profit company supported by major rail industry stakeholders.

RSSB facilitates the resolution of difficult cross-industry issues and builds consensus.

RSSB delivers a unique mix of products and services to the industry – supplying knowledge, analysis, technical expertise, and information and risk management tools.

RSSB and the rail industry work together to:

- Continually improve the level of safety in the rail industry
- Drive out unnecessary costs
- Improve business performance

The company is limited by guarantee and is governed by its members, a board, and an advisory committee. It is independent of any single railway company and of its commercial interests.
A key part of RSSB’s product range is the research and development (R&D) programme that it manages on behalf of the rail industry. The programme is funded by the Department for Transport (DfT) and aims to assist the industry and its stakeholders in achieving key objectives:

- Improving performance in terms of health and safety, reliability, and punctuality
- Increasing capacity and availability
- Reducing cost
- Integrating all of these to compete effectively with other transport modes (or complement them as appropriate)
- Delivering a sustainable future for the railway

R&D supports industry’s needs in a wide range of areas, from tactical incremental innovations, to long-term step changes in technology. It includes strategic research aimed at helping achieve the industry and government’s long term goals for the railway. The programme addresses:

- Interface issues: engineering and operational interfaces within the railway, and interfaces with other parts of the community and society
- System issues: improving understanding of how the whole railway behaves and the interactions of its constituent parts
- Strategic issues: to support cross-industry planning and the development of the future vision and technical strategy of the railways and assess how that can and should be delivered
- Many other issues that individual companies cannot address on their own, such as identifying good practice
This covers 5 major research subjects, all concerned with reducing risk relating to the infrastructure, the rolling stock, their interaction with each other, and processes that keep the railway moving.

This research brochure focuses on vehicle/track interaction (VTI). The main cross-industry group for this area is the Vehicle/Track Systems Interface Committee (V/T SIC). The aim of this brochure is to:

- Inform you about research that has been done
- Show you where to find the results of the research
- Encourage you to find out more including registering to receive the RSSB R&D e-newsletter
- Encourage you to register on RSSB’s Sharing Portal for Access to Rail Knowledge (SPARK) http://www.sparkrail.org/

The R&D programme has generated substantial knowledge, information and resources – all specifically designed to support the rail industry’s day to day operations, at senior level and on the front line.

This booklet provides only a brief insight into the research projects – the best way to find out more information about each project is to go to the Research and Development section of the RSSB website – www.rssb.co.uk – where you can find more details including links to the research reports and outputs.

Key Contact:
Head of Engineering Research
R&D Programme
RSSB
enquirydesk@rssb.co.uk
The cross-industry groups supporting the research are: the Vehicle/Track System Interface Committee (V/T SIC), the V/T SIC Permanent Project Group (PPG), the V/T SIC Technical Advisory Group (TAG), the RSSB Rolling Stock Standards Committee, the Infrastructure Standards Committee, the Adhesion Working Group (AWG), the Adhesion Research Group (ARG), and the Wheelset Management Group (WMG).

Vehicle/Track Interaction (VTI) covers research into and development of knowledge about the wheel/rail interface; helping to improve the condition, maintenance, and life of wheel and rail assets.

The subject includes adhesion, wheelsets, rail wear, and damage; improving understanding of aspects of the micro-interface such as rolling contact fatigue (RCF), and the macro-interface through fundamental research and modelling.

There is a particular focus on exploring these areas to deliver a more sustainable railway. One of the most ambitious and important projects within the portfolio was the development of the Vehicle Track Interaction Strategic Model (VTISM), which is helping the industry to plan and deliver change more efficiently by adopting a system-wide approach facilitated by interconnected models. Other work also aims to improve efficiency; for instance, development of an adhesion management system and continued research into RCF.
The ability of wheel and rail contaminants to affect the electrical conductivity of the contact patch can affect the integrity of signalling systems; however research that supports this issue is dealt with under the Control, Command & Signalling subject. Research on electric current collection is dealt with under the Energy subject and research on active train protection systems is dealt with under the Command, Control & Signalling subject. Research on injury mitigation that may arise from a VTI effect is dealt with under the Rolling Stock subject.

The key driver for research under the VTI subject is to provide cost-effective reductions in safety risk (and therefore business risk) for the rail industry and its funders, and/or reductions in the cost of operating the railway safely. Vehicle/track interface incidents in particular have a high public profile and are the subject of many inquiry recommendations.

The VTI research encompasses 4 areas:

Area 1 - System modelling to identify the optimum parameters for the vehicle track interface

Research in this area aims to improve understanding of the complex issues involved in the vehicle track interface, and to provide insight on how the system behaves when changes are made taking into consideration conflicting factors and requirements that need to be balanced out. This is done by improving and advancing the modelling methodologies that are applied.

Optimisation of VTI performance requires the consideration of conflicting factors and requirements that need to be balanced for the application in question. For instance: vehicle stability at high speeds can be improved by using a high-
conicity wheel profile and high yaw stiffness, however, this combination can also lead to generation of RCF in rails and wheels. VTISM is a collection of different modules, including databases, calculation software and user definitions of renewal and maintenance policies that has been developed to help users to assess and evaluate strategies to manage VTI performance. It is used to assess the consequences of scenarios based around maintenance or renewal policies or changes to operations. It captures the consequences of these scenarios in economic terms for both the trains and the track allowing cost appraisals to be made. This allows industry to define the optimum parameters for managing the VTI interface and implement through understanding the whole life cost implications on both vehicles and infrastructure. The initial fundamental tools of VTISM were used to study the optimum configuration for HST2 (now progressing under DfT’s Inter-City Express Programme) and the current version was used to support industry submissions for Control Period 5 and more recently by wheelset maintainers.

Area 2 - Research into the operating environment experienced by axles to enhance wheelset design and maintenance practices

Research in this area seeks to build on existing knowledge of the environment experienced by its axles. This is by measuring and analysing the accelerations and axle stresses of wheelsets in normal service conditions to further inform axle design and the associated maintenance and inspection processes. This research also aims to determine what service conditions generate the highest loads on wheelsets to determine if they can be improved. This has a potential benefit for reducing maintenance of existing wheelsets in particular ultrasonic axle tests (UAT).
Area 3 - Research to better understand the nature of adhesion problems to improve management of low adhesion

Research in this area has previously involved working closely with the Adhesion Working Group (AWG), and now with the Adhesion Research Group (ARG) to mitigate problems with adhesion. This is in support of the AWG’s mission to facilitate industry change such that performance (in terms of reliability as well as safety) remains unaffected by the autumn leaf fall period.

A prime objective has been to develop a better understanding of the nature of the low friction contaminant films on the wheel and rail surface that cause adhesion problems.

Area 4 - Research into the optimal management of rolling contact fatigue and vertical track damage to reduce whole life costs

Industry concern over RCF issues is still high, given the profile of the Hatfield enquiry. Knowledge of the initiation and propagation mechanisms of RCF in rails is now sufficiently advanced for the problem to be managed effectively for the continued operation of a safe railway. However, the strategy for RCF management may not be optimal in terms of costs. This area of research is exploiting the Whole Life Rail Model (WLRM) work that established the fundamental causes of RCF damage in rails. It continues work to improve the empirical elements of WLRM and to assist industry in implementing practical measures to reduce the cost of rail RCF.
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### Published Vehicle/Track Interaction Projects

#### T023 Rolling contact fatigue of rail: review of current understanding

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<td>Abstract</td>
<td>In the wake of the Hatfield accident this work contracted Professor Rod Smith of Imperial College to identify the state of rolling contact fatigue (RCF) knowledge at the time. It describes the state of RCF knowledge, identifies gaps in knowledge, and priorities for further research. It argues that the industry should generate a more extensive database of the occurrence of RCF; that existing knowledge should be catalogued, and international exchanges of experience should be encouraged. The effects of lubrication and the need for improved inspection techniques are among the topics identified as requiring further work. A considerable amount of research has been conducted by GB's rail industry since Hatfield, most led by the Wheel/Rail Interface Systems Authority and work continues to be led by the Vehicle/Track Systems Interface Committee. Project T115 supported this work and research project T354 continues to do so.</td>
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<tr>
<td>Published</td>
<td>April 2002</td>
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<tr>
<td>Current</td>
<td>This work has contributed to the development of two models.</td>
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| Position    | 1. RCF risk model – that improves understanding about the different factors and consequences of RCF and allows railway maintainers better capacity to control and manage the risk to the industry.  
2. Rolling Contact Fatigue physical model – this describes the physical processes that lead to the initiation and propagation of RCF cracks and the ability to improve understanding about the likelihood of RCF developing into rail breaks.  
Research projects that developed this work further include: **T060a Feasibility of detecting rail flaws using acoustic equipment fitted to vehicles** and **T060d Survey of wheel/lubrication practices**.  
Associated projects that have developed from this theme include studying the various causes of RCF, effects and mitigation of RCF, taking into consideration wheel/rail lubrication processes, the acoustic monitoring of rail conditions, and wheel impact measurement. |
## T054 Independent review of ‘Laserthor’ railhead cleaner

### Description
This research conducted an independent review of a prototype railhead cleaning system called ‘Laserthor’, which uses lasers to remove railhead contamination and improve adhesion. facilities on board trains safely.

### Abstract
Low adhesion due to the annual leaf fall represents a considerable threat to the railway industry both in terms of operational safety and in terms of the cost of delays and of managing the problem. The adoption of effective novel solutions could therefore have a significant impact on safety and cost. This research project conducted an independent review of a novel technique called ‘Laserthor’ that aims to remove contamination using lasers. This research assessed the system in terms of its effectiveness, impact on infrastructure, and ease of implementation, drawing a comparison with other methods of improving adhesion. The research finds that Laserthor performs well, offering real benefits, but that further development is required particularly with regard to installation on rail vehicles. The research report recommends that further development should continue and, in fact, further assistance was provided in project T144.

### Published
May 2002

### Current Position
Research project T144 Laboratory and on-track testing of ‘Laserthor’ railhead cleaner has followed up the findings from this research.
## T058  Characterising vehicle track interaction (EU project: FOOTPRINT)

**Description**
This pan-European research project determined factors that relate the environmental footprint of a vehicle to infrastructure maintenance costs in order to inform access charging regimes.

**Abstract**
The interaction between vehicle and track results in noise, vibration and deterioration of track and vehicles. This pan-European research project characterises noise and vibration (the environmental ‘footprint’) and relates it to the cost of maintaining the infrastructure. Known as ‘FOOTPRINT’, the research has involved numerous European partners carrying out complementary work in both the rail and road domains, giving the opportunity to share knowledge between the respective industries. The research project consisted of phases covering determination of background knowledge, modelling of vehicle suspensions, weigh-in-motion in-service measurements, and derivation of life cycle costs. The knowledge gained has been used to inform freight vehicle access charging regimes and EU legislation, with the ultimate goal of reducing the environmental footprint of freight transport.

**Published**
June 2007

**Current Position**
This research provided Network Rail with sufficient information for it to implement trials using the Gotcha Quo Vadis systems.

Other related research projects are **T060k Brief review of automatic vehicle identification and location systems** and **T607 Identification of existing and new technologies for wheelset condition monitoring**.
### Description
This research investigated the feasibility of detecting rail flaws and other track faults by acoustically measuring the rolling noise generated by the interaction of the wheel and rail.

### Abstract
This research investigated the feasibility of detecting rail flaws and other track faults by acoustically measuring the rolling noise generated by the interaction of the wheel and rail. Preliminary research collected rolling noise data from a Mark 3 driving van trailer travelling on the West Coast Main Line. The findings from these tests determined that acoustic track monitoring (ATM) does have potential benefits with regard to detecting certain track faults and that the technique may also be capable of identifying track characteristics that are not currently detected by other means. However, further research would be required to establish critical system parameters such as types of track faults that can be reliably detected and the overall accuracy of the system and track features. It would also need to be established if any new ATM system would complement existing track monitoring systems currently used. RSSB is seeking views on the interest in this research before proceeding.

### Published
December 2002

### Current Position
When the research findings were presented to the industry stakeholders, it was considered that ATM was not a priority and further progress was not required. Since this research was completed, flaw detection techniques have moved on and Network Rail uses train mounted eddy current techniques alongside ultrasonic testing.
**T060b Early development of the Whole Life Rail Model**

**Description**
This research developed earlier work led by Railtrack to develop a whole life rail model, which encapsulates the industry’s understanding of rolling contact fatigue.

**Abstract**
Research aimed at understanding rolling contact fatigue (RCF), and thus managing it more effectively, is a key element of the research programme. This project developed Network Rail (at the time Railtrack)’s earlier work to develop a whole life rail model (WLRM), which encapsulates understanding of the initiation and development of RCF in multiple scenarios. At this stage of development the WLRM could predict the probability of RCF initiation for a given site as a function of curve radius, cant deficiency, and rail age. Further work was required to determine the influence that the precise mix of traffic has on RCF initiation. This research determined wear and damage numbers to relate vehicle effects and contact patch position to the probability of RCF initiation and railhead wear rates from VAMPIRE simulations. The research project is documented in two reports and further development of the WLRM was progressed under project T115.

**Published**
July 2002

**Current Position**
The Whole Life Rail Model is used by industry, and from this use further improvements of the model have been identified. These have been taken forward in research projects T115 Development of a Whole Life Rail Model and T775 Further development of the Whole Life Rail Model damage parameter.

The Whole Life Rail Model is owned by RSSB and used by Network Rail and is used widely in research projects. The model is used in the Vehicle Track Interaction Strategic Model (VTISM). Research projects T353 Scoping and development of the Vehicle Track Interaction Strategic Model and T792 Stage 2 of the Vehicle Track Interaction Strategic Model refer to this work.
T060c Review of techniques for rail axle inspection

Description
Inspection techniques have been developed over a number of years to detect the smallest flaw in an axle and thus mitigate the risk of catastrophic failure. This research identifies where further improvements can be made.

Abstract
Various inspection techniques have been developed over a number of years to detect the smallest flaw in an axle and thus mitigate the risk of catastrophic failure in service. This research was commissioned by RSSB to establish the state of current non-destructive testing (NDT) knowledge within the rail industry to identify further actions required to adopt improved inspection techniques. The work questions the value of the far-end scan and suggests that the near and high-angle scan periodicities may be conservative. Rail experience of magnetic particle inspection (MPI) was found to be better than that seen in the offshore industry and other expert judgement. Further validation of MPI is recommended. Various alternative NDT methods are considered and further work is being progressed in a research project entitled Optimising wheelset design and maintenance (T356).

Published
July 2002

Current Position
The findings from this research were used to inform T356 Optimising wheelset design and maintenance, and T607 Identification of existing and new technologies for wheelset condition monitoring. The outputs from these have been used to inform the ongoing T774 Research into effects of human factors in axle inspection inspection.
## T060d Survey of wheel/rail lubrication practices

| Description | Lubrication of the wheel/rail interface is an activity commonly undertaken by rail administrations. This research reviewed international practice in this area and identified potential benefits and disadvantages. |
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T060e Feasibility of reducing the number of standard wheel profile designs

Description
There are nine wheel tread profiles that are accepted for use on Network Rail controlled infrastructure. This research aimed to review the historic and critical features of these profiles and consider the scope for future reduction.

Abstract
There are nine wheel tread profiles that are accepted for use on Network Rail controlled infrastructure. This project aimed to review the historical and critical features of these profiles and consider the scope for future reduction. This research concluded that a single wheel tread profile cannot produce satisfactory performance over the wide range of conditions on Network Rail controlled infrastructure. The research report notes that profiles such as the P1 and P9 will decline in their application, as the vehicles on which they are used become life expired and are withdrawn from service. The P8 profile, which has many desirable features and is used extensively on modern vehicles, will continue to be used for the foreseeable future. It recommends a wheel tread profile assessment process to permit comparative assessment against specified criteria.

Published
August 2002

Current Position
Industry has noted that some of the profiles currently in use will become obsolete as vehicles using them reach the end of their service life and are removed from service. The suggestion for a tread profile assessment process has not been pursued as new tread profiles are very rarely introduced onto the network. New profiles introduced shall comply with requirements set out in the Railway Group Standards and need to ensure they do not have a detrimental effect on the system. Since this research was completed, the P12 profile has been developed and is in use.
<table>
<thead>
<tr>
<th><strong>T060f Possible re-design of P8 wheel profiles</strong></th>
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<tbody>
<tr>
<td><strong>Description</strong></td>
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<tr>
<td><strong>Abstract</strong></td>
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<td><strong>Published</strong></td>
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<td><strong>Current Position</strong></td>
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</tbody>
</table>
T060g Overview of magnetic brakes

**Description**  
Magnetic track brakes, which are used extensively on the continent, are often suggested as a solution to braking in low adhesion. This research conducted a brief investigation into the feasibility of their introduction to Great Britain.

**Abstract**  
Low adhesion due to the annual leaf fall represents a considerable threat to the railway industry both in terms of operational safety and in terms of the cost of delays and of managing the problem. The main threat to safety manifests itself as an inability to stop at signals and buffers. Magnetic track brakes, which are used extensively on the continent, are often suggested as a solution to this. This research conducted a very brief investigation into the feasibility of their introduction to Great Britain. The work finds that magnetic track brakes, which contact the railhead, are also affected by railhead adhesion and offer only limited improvement in braking for low adhesion conditions. However the non-contacting eddy current brake is truly adhesion independent and appears to be an option for GB use in an emergency. Both types of brake are heavy and their effect on track circuits would need to be investigated before progressing further.

**Published**  
May 2002

**Current Position**  
RSSB has developed further research in this area under a rolling stock research project **T860 Benefits of all-electric braking** (this is included in the *RSSB Guide to research in Rolling Stock*) and may draw upon some of the results from this past research project.
Vehicle/Track Interaction – Published projects

T060h Review of vertical dynamic track forces

**Description**  Safe and cost-effective operation of the railway system requires that vehicles do not impart excessive vertical forces to the track. This research examined these forces and the controls in place to limit them, recommending changes as necessary.

**Abstract**  Safe and cost-effective operation of the railway system requires that vehicles do not impart excessive vertical forces to the track. This research examined vertical dynamic track forces imposed by vehicles, the controls that exist to limit such forces, and recommends changes to these limits. The published report details the research and includes a look at current British and European standards, historical evidence, and theoretical issues. Changes are recommended to the permitted track forces imposed by vehicles, mainly to provide a better definition of limits, and some further research is also recommended.

**Published**  August 2002

**Current Position**  The industry considered that setting a maximum dynamic ride force (Q limit) would be beneficial but further research should be undertaken to establish a suitable limit and that the permitted levels as given in Railway Group Standard GM/TT0088 Permissible Track Forces for Railway Vehicles for vertical track stresses should be reviewed.

Research project T889 Controlling rail vertical contact stresses, has assessed the benefit of using the Q/D (maximum static wheel load to wheel tread diameter) ratio as a means of controlling the vertical contact stresses generated within the contact patch. Further details can be found in this research brochure.
**T060j Establishment of vehicle braking trends**

**Description**
The level of adhesion demanded during braking, and the ability of the railway vehicle and infrastructure to provide it, are critical to maintaining safety. This research reviewed whether ‘new’ vehicles demand more adhesion than older vehicles.

**Abstract**
The level of adhesion demanded during braking, and the ability of the railway vehicle and infrastructure to provide it, are critical to maintaining safety. This short piece of research reviewed whether ‘new’ vehicles demand more adhesion from the rail under braking than older vehicles. The research determined deceleration rates and thus adhesion demand during braking, for a variety of types and ages of passenger rolling stock. From this analysis it was determined that there is no evidence to suggest that ‘new’ vehicles demand more or less adhesion than older stock. It was found that the type of brake disc and pad has a greater influence on braking adhesion demand than whether a vehicle is newer or older.

**Published**
May 2002

**Current Position**
The findings from this research were shared with the industry stakeholders and after deliberation; it was considered that no further work was required.
### T060k Brief review of automatic vehicle identification and location systems

<table>
<thead>
<tr>
<th>Description</th>
<th>Automatic vehicle identification (AVI) systems could enhance the value of condition monitoring equipment now employed extensively on the GB railway. This short research project examined three broad technologies used for AVI.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Over recent years there has been a proliferation of data collection and condition monitoring systems on the GB railway. Such systems are gradually being integrated into operating processes and our reliance on them is increasing. In the case of trackside systems that monitor vehicles, enabling them to recognise the vehicles automatically can further enhance their value. This short research project examined three broad technologies used for such automatic vehicle identification (AVI) systems. These are ‘computer vision’ and ‘short-range’ and ‘long-range’ radio systems. The research assessed the costs and benefits of each technology and identified that there remains uncertainty surrounding the best configuration of an AVI system and its cost benefit. The research makes recommendations for further work to reduce that uncertainty.</td>
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<tr>
<td>Published</td>
<td>May 2002</td>
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<tr>
<td>Current Position</td>
<td>Network Rail has developed a strategy for AVI linked to longer term activities around intelligent infrastructure and remote monitoring. Ongoing European Rail Traffic Management System (ERTMS) research is investigating a range of applications. Also, research project T607 Identification of existing and new technologies for wheelset condition monitoring includes considerations for AVI. The Technical Strategy Leadership Group has identified that AVI technology is a key facilitating technology in support of the implementation of long term railway strategies and is considering the most appropriate cross-industry approach to progress further development, supported by the 5 System Interface Committees.</td>
</tr>
</tbody>
</table>
This research investigated the practicalities of using a technique called friction transformation processing to repair shallow micro-cracking on the railhead instead of traditional methods such as grinding or rail renewal.

Traditionally rolling contact fatigue in rails is corrected by renewal or grinding techniques that remove a proportion of the railhead, reducing rail life. As a development of their friction stir welding process, TWI (formerly The Welding Institute) suggested that it might be possible to repair the rail using a spinning disk to plastically deform the railhead locally and repair shallow micro-cracking. This research investigated the practicalities of applying this process. Laboratory trials have concluded that friction transformation processing is capable of removing cracks, however there are problems with the formation of a damaging layer of martensite during the process. A theoretical study to determine the level of rail heating required to prevent the formation of this layer has shown that the power levels required are feasible. However, even if the processing was successful at healing service generated cracks, the need for heat treatment is a serious disadvantage. The process would be limited to slow speed travel (in the order of 0.3 km/hour) to avoid the need for an excessive power requirement.

The findings were reviewed by the industry stakeholders. Consideration was given as to whether the process shows sufficient economic and technical merit for further development. However the review established that the size of investment was too large to continue this research and that current maintenance processes were satisfactory.
### T060n Investigation into the origin and validity of criteria specified in wheelset Railway Group Standards

| **Description** | The criteria against which wheelsets are managed have been established over very many years, some going back 50 years. This research conducted a review of the origin and validity of these criteria to inform future standards. |
| **Abstract** | Wheelsets represent one of the most safety critical components on the railway. The cost of their maintenance and renewal to assure safety is also a significant driver. The criteria against which wheelsets are managed have been established over very many years, some going back 50 years. This research conducted a review of the origin and validity of these criteria to inform future standards. The work found that some criteria are not strictly valid and these were identified. The production of Railway Group Standard GM/RT2466 Railway Wheelsets, has addressed a number of the issues raised in this report. New European Standards may also address other anomalies but some further validation of other criteria is required. This is being considered as part of further research in project T356. |
| **Published** | November 2002 |
| **Current Position** | The findings from this research project were mainly addressed in GM/RT2466 Railway Wheelsets. They are also being used as a reference source for other research projects and further development of Railway Group Standards and European Standards. |
Derailments due to vehicle-track interaction problems remain a significant contributor to risk. This research analysed derailments over a 10-year period as a first stage towards identifying potential mitigation measures.

As a first stage towards identifying potential mitigation measures, RSSB commissioned this research to analyse derailments over a 10-year period. This involved reviewing derailment records and reports to ascertain the cause and to identify whether or not the track, vehicle or both were compliant with Railway Group Standards. Where derailment risks were identified, the research determined whether control measures existed and whether they were adequate. The research included a number of interviews with people from differing roles within the railway industry in order to elicit their views on how current track and vehicle standards could be improved.

The findings from this research suggested that where derailment risks were identified, the wider industry assess the adequacy of existing standards and procedures and make changes as appropriate. This was largely completed and further required research was identified. This was undertaken in research project T357 Cost-effective reduction of derailment risk and a risk model was proposed to be developed under T330 Scoping and feasibility of a track fault risk model.

The output from this research has been used to inform a European Consortium research project that RSSB is engaged in. This is T974 D-RAIL: research into the causes of freight train derailments and mitigation measures. The output was used to inform an early work package providing a summary report and database of derailments incidents.
<table>
<thead>
<tr>
<th><strong>T080  Managing low adhesion risk in the European Rail Traffic Management System</strong></th>
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<tbody>
<tr>
<td><strong>Description</strong></td>
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<td><strong>Current Position</strong></td>
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</table>
T088  Vibration environment for rail vehicle mounted equipment

Description
This research investigated the true vibration loadings to rail vehicle mounted equipment and compared them to the current design requirements. Loadings in excess of those specified were found.

Abstract
Introduction of new train-borne equipment, such as the European Rail Traffic Management System (ERTMS), can lead to equipment being fitted at wheelset, bogie and vehicle level. If this equipment is to operate reliably, it is essential to understand the environment in which it is to operate (experience suggests current design requirements may be inadequate in this area). This work investigated the true vibration loadings seen by rail vehicle mounted equipment and compared them to the current design requirements. Accelerometers were fitted to three vehicles and this data was used to validate dynamic models of suspension components. The models were then used to simulate various degraded conditions to determine realistic vibration levels. The research found loadings in excess of those specified. Recommendations are made for revisions to Group Standards and British Standards specifications.

Published
March 2004

Current Position
The findings from this work have been implemented in standards where practicable. This includes GM/RT2100 Requirements for Railway Vehicle structures.

Research project T923 Axle-end equipment: service accelerations and resonance aims to develop knowledge and understanding about the influences of vehicle- and track-generated forces on axle-end equipment and to establish what rolling stock and track engineers can do to improve the survivability of such components.
### T115 Development of a Whole Life Rail Model (WLRM) to manage Rolling Contact Fatigue (RCF)

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>This research developed earlier work led by Railtrack (now Network Rail) to develop a whole life rail model, which encapsulates the industry’s understanding of rolling contact fatigue.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Research aimed at understanding rolling contact fatigue (RCF), and thus managing it more effectively, is a key element of the research programme. This project developed earlier work led by Network Rail (at the time Railtrack) to develop a whole life rail model (WLRM), which encapsulates understanding of the initiation and development of RCF. In conjunction with work led by the Wheel Rail Interface Systems Authority (WRISA) and now the Vehicle/Track System Interface Committee (V/T SIC), outputs from a site-specific version of the WLRM have been compared with actual RCF initiation and development observed at various sites on FGW and C2C routes. The research found that the model replicates the development of RCF in most but not all scenarios. It is also currently prohibitively data hungry. Working with V/T SIC, further work is being undertaken under separate research projects to address these issues.</td>
</tr>
<tr>
<td><strong>Published</strong></td>
<td>March 2006</td>
</tr>
<tr>
<td><strong>Current Position</strong></td>
<td>The WLRM has been implemented and is in use by industry. It has enabled Network Rail to develop a targeted maintenance strategy for RCF. One of the outcomes was that Network Rail optimised its grinding policy to control and mitigate the onset of RCF. Further research projects T355 Management and understanding of rolling contact fatigue, T549 Development of a wheel wear and rolling contact fatigue mode, T613 Trials of wheel and rail rolling contact fatigue control measures, and T775 Further Development of the Whole Life Rail Model damage parameter also refer.</td>
</tr>
</tbody>
</table>
T144  Laboratory and on-track testing of ‘Laserthor’ railhead cleaner

Description  This research conducted laboratory and on-track testing of ‘Laserthor’, a prototype railhead cleaning system, which uses lasers to remove railhead contamination and improve adhesion.

Abstract  Low adhesion due to the annual leaf fall represents a considerable threat to the railway industry both in terms of operational safety and in terms of the cost of delays and managing the problem. The adoption of effective novel solutions could therefore have a significant impact on safety and cost. This research evaluated the effectiveness of a novel technique called ‘Laserthor’ that aims to remove contamination using lasers. It follows on from earlier research project T054, which conducted an independent review of the concept. On behalf of RSSB, the manufacturers conducted laboratory tests on a test rig specifically designed and built for that purpose. On-track trials using a prototype system followed, along with metallurgical examination of the treated railhead. A report has been published that documents this work and concludes that the concept of using a laser system is feasible, that leaf contaminated railhead can be cleaned at 20 mph, and that the laser does not harm people or animals, or affect signalling circuits.

Published  March 2003

Current Position  Consideration by industry stakeholders was given as to whether the system provided sufficient economic, technical and operational benefit to allow for further development. The review established the financial investment was too significant to continue this work and that the current system used was satisfactory.
## T207 Development of a prototype model for managing derailment risk due to track faults

### Description
By developing a prototype, this research aimed to assess the feasibility of developing a model that would enable Network Rail to manage the risk of derailment due to track faults.

### Abstract
This research aimed to assess the feasibility of developing a risk model capable of describing the complex interactions that create and mitigate the risk of derailment due to track faults. Such a ‘derailment risk model’, would provide a better understanding of derailment risk and the benefits provided by controls. It could assist Network Rail in its management of the risk by conducting ‘what if’ studies to test the impact of proposed changes. This research developed a prototype derailment risk model addressing the risk due to gauge spread to give confidence on whether or not a full model could be developed. A research report describing development of the model has been published. The work continues with project T330, which scopes the model and establishes the feasibility of its development.

### Published
July 2003

### Current Position
Although research project T330 Scoping and feasibility of Track Fault Risk Model would continue the development work for the model, this did not go ahead because Network Rail has existing tools that assess track fault risks. On this basis, it was concluded that the practical impact of the model was unlikely to be sufficient to justify the cost of development and implementation.
Wheel out-of-roundness or ovality aggravates track damage due to the increased vertical track forces. This research investigated whether or not ground wheel lathes are capable of adequately removing out-of-roundness or ovality during re-profiling.

Wheel out-of-roundness or ovality aggravates track damage due to the increased vertical track forces imparted by the eccentricity. This research responded to concern within the industry that ground wheel lathes might not be able to adequately remove ovality during re-profiling, because the wheel can be supported on the tread, rather than entirely at the wheel centre. The research investigated methods of re-profiling and the records subsequently kept. It found that wheels profiled in accordance with the lathe manufacturer’s instructions are effectively turned about the axle centre and the potential for retention of any ovality is negligible. As long as wheels are profiled in accordance with manufacturer’s instructions there does not therefore appear to be any cause for concern.

The outcome of this report has been shared with industry and advice on profiling of wheel treads has been incorporated into the guidance supporting GM/RT2466 Railway Wheelsets.
T330 Scoping and feasibility of the Track Fault Risk Model

Description
Following on from an earlier project (T207), this research investigated the scope, costs and benefits of developing a track fault risk model that could provide the industry with a better understanding of the factors driving derailment risk.

Abstract
The concept of a track fault risk model was first explored in an earlier research project (T207), where it was proposed that such a model would give the industry a better understanding of derailment risk and the benefits provided by controls. It would also enable ‘what if’ studies to be conducted to test the impact of changes in the track asset management regime. Despite development of a simple prototype model, scepticism remained amongst track experts as to how it would enable the industry to manage the issue more effectively. This research was therefore commissioned to establish the costs and benefits of developing a full version of the model. The research included discussion of the requirements for the model with key stakeholders in Network Rail and RSSB to understand its potential use. The research concluded without proving the concept to the satisfaction of the industry.

Published
June 2006

Current Position
Research did not go ahead because Network Rail has existing tools that assesses track fault risks. On this basis, it was concluded that the practical impact of the model was unlikely to be sufficient to justify the cost of development and implementation.
### Description

This research project scoped and developed the Stage 1 Vehicle Track Interaction Strategic Model, a tool that helps the industry to manage changes at the vehicle/track interface, leading to savings from optimised track and vehicle characteristics and maintenance.

### Abstract

This research scoped and delivered Stage 1 of the Vehicle Track Interaction Strategic Model (VTISM). Originally proposed by the Wheel Rail Interface Systems Authority, now the Vehicle Track System Interface Committee, the model links inputs such as track and vehicle characteristics to outputs such as rail and wheel life and maintenance regimes. VTISM aims to help the GB rail industry to manage changes around this interface more effectively, leading to savings through optimised track and vehicle maintenance. Work started with a scoping phase and development of the model architecture in Unified Modelling Language, which was then applied to a pre-Stage 1 feasibility study to determine the best configuration for a fleet of new trains to replace the current High Speed Train. Development of VTISM Stage 1 was then undertaken, and the outputs from the new train fleet study were used to validate the model before release. VTISM Stage 1 has now been released and is available to the GB rail industry, with Stage 2 development now started by the V/T SIC and supported by research project T792.

### Published

August 2004

### Current Position

VTISM is being used by the industry to improve the management of the vehicle/track interface and to influence future vehicle procurement by including system costs. VTISM has been adopted as a new train evaluation tool by the DfT in its procurement of major new passenger rolling stock fleets. The modelling of the long-term system costs associated with new fleet designs during a major bidding process is a novel and world-class approach. It allows a quantitative method of assessing the incremental track maintenance and renewal costs associated with different designs of new trains. Network Rail uses VTISM analysis to inform and optimise its maintenance strategy. Enabling the GB rail industry to manage changes around this interface more effectively, leading to savings through optimised track and vehicle maintenance.

RSSB and Network Rail have completed research project T792 Stage 2 Development of the Vehicle Track Interaction Strategic Model.
The characteristics of railhead leaf contamination

Description

This research sought to improve understanding of the characteristics of rail head leaf contamination, to optimise the management of low adhesion.

Abstract

Low adhesion during the annual leaf fall season results in a significant cost and risk to the industry, including disruption to services, inactivated track circuits, and potential over-runs and collisions. This research aimed to improve understanding of low adhesion so that it can be optimally managed, and thus costs reduced without compromising safety. Research was conducted to enable a better understanding of the effects and characteristics of adhesion, in particular the surface chemistry of the affected rail head and means of modifying the adhesion levels. The objectives were to identify the potential for new or improved treatment or prevention methods for railhead leaf contamination, and to produce guidance notes for low adhesion simulation and measurement.

Published

May 2007

Current Position

The ongoing evaluation of biochemical approaches to managing low adhesion and the use of systems for monitoring slip and slide activity and railhead contamination are considered in research project T540 Scoping and development of the Adhesion Management System.

Guidance Notes for low adhesion simulation and measurement have been published. These are GM/GN2642 Guidance on Wheel/Rail Low Adhesion Measurement and GM/GN2643 Wheel/Rail Low Adhesion Simulation. These were issued in February 2008.
T355  Management and understanding of rolling contact fatigue

Description
This project continued to develop the industry’s knowledge of rolling contact fatigue in rails to facilitate improved control of the mechanisms that cause and propagate it.

Abstract
This research continued to develop the industry’s knowledge of rolling contact fatigue (RCF) in rails to facilitate the optimisation of its management in order to reduce costs without compromising safety. The research complemented the large amount of work that has already been done in this area under project T115, and addressed relevant recommendations from the Hatfield inquiry. The research included investigation of the mechanisms that cause crack formation and development, and developed novel models that can replicate in-service conditions. Outputs from this research project are now being used in the development of predictive tools, such as the Vehicle Track Interaction Strategic Model (project T353), that enable ‘what if’ studies to be carried out to determine vehicle and track features that can potentially be controlled to reduce RCF.

Published
July 2008

Current Position
The findings from this research have been used to inform the development of predictive tools, such as the Vehicle Track Interaction Strategic Model and the Whole Life Rail Model.
**T356 Optimising wheelset design and maintenance**

**Description**
This project aimed to support optimisation of the design and maintenance of wheelsets, and to reduce whole life costs. Wheelset axle stresses and other factors were measured, and the data used to develop design guides for new axles and to optimise testing regimes for existing axles.

**Abstract**
The ‘Optimising wheelset design and maintenance’ project was developed through a consultation process with key industry stakeholders in January 2004. The project aimed to optimise design and maintenance of wheelsets to give the lowest whole life cost. The project also had the potential to reduce maintenance of existing wheelsets, which would see both financial and operational benefits.

Axle design is based upon theoretical load cases; however, statistically significant samples of the loads seen by axles in service were not available. Using on train instrumentation, real loads experienced by wheelsets were recorded and track features identified that give rise to high axle loads. Analysis of the data produced dynamic histograms for representative axle loads. Sensitivity analysis identified important parameters in the generation of high axle loads. The methodology for replicating axle stress histograms was validated using both real and historical test data. The work then examined how maintenance and design standards could be optimised, based upon more accurate knowledge of wheelset loads for a Class 319 trailer axle.

A fundamental objective of this project was to provide data for further focused research projects. Information produced by T356 is already being used in research projects such as T728, Impact of corrosion upon the high cycle fatigue properties of GB axle steel. The recommendations to come out of this project will be taken forward within the Wheelset Management Group’s research programme.

The major benefit of this project was to optimise the design and maintenance of wheelsets to give the lowest whole life cost. This could deliver savings and reduced risk from current wheelsets through less intervention for axle testing in maintenance depots.
Although there is a substantial body of information from axle strain measurements that have been recorded over recent years there are still some vehicle configurations not supported by reliable strain gauge data. In order to support industry in providing mechanisms for understanding the wheelset environment, further data should be obtained for the following vehicles, which the WMG will coordinate as part of the WMG wheelset research programme.

- Freight vehicles, the choice of vehicle, bogie, and suspension type would need to be defined in conjunction with industry stakeholders.
- Locomotives, particularly long-wheelbase, 6-axle vehicles, although there is limited information available for 4-axle vehicles.
- The powered axles of multiple unit vehicles, concentrating on modern drive systems, although axle-hung traction motor systems would be revisited.

Information produced as part of this research project was used in further research projects such as **T728 Impact of corrosion upon high cycle fatigue properties of GB axle steels**. T728 has increased the industry’s knowledge of the effects of damage and corrosion on the fatigue life of axles; which will assist in optimising wheelset whole life costs without adversely affecting safety.

Industry can use the data collected from this research to optimise design and maintenance of wheelsets to give the lowest whole life cost. This could deliver savings and reduce risk from current wheelsets by reducing the amount of intervention for axle testing in maintenance depots.
### T357  Cost-effective reduction of derailment risk

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>Derailments sometimes occur where both vehicle and track appear to comply with standards. This research sought to understand the cause of such derailments and the means of reducing the risk of these occurrences.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Following on from earlier work which analysed derailments over a period of ten years, this research aimed to understand the causes of derailments where both vehicle and track appeared to comply with Railway Group Standards and establish whether changes would be effective in managing the residual risk of such derailments. The research considered derailments when faults act in combination rather than in isolation, by analysing information from a database compiled for the initial study and three other key sources. The study showed that such derailments represented only 2.5% of total derailments, and less than half of these resulted in significant consequential damage. It was concluded that a change to mandatory standards would not be effective, and all of the issues could be more effectively controlled by appropriate operational and management processes.</td>
</tr>
<tr>
<td><strong>Published</strong></td>
<td>January 2006</td>
</tr>
<tr>
<td><strong>Current Position</strong></td>
<td>This research concluded that changes to mandatory standards would not be effective, and that the residual risk of such derailment issues where both vehicle and track appeared to comply with Railway Group Standards could be more effectively controlled by appropriate operational and management processes.</td>
</tr>
</tbody>
</table>
Description

Previous research indicated that high wheelset primary yaw stiffness exacerbates the onset of rolling contact fatigue (RCF) in certain situations. This research project investigated whether a reduction in the yaw stiffness of two classes of rolling stock was feasible and would result in a reduction in their propensity to initiate RCF.

Abstract

One of the important factors in rolling contact fatigue (RCF) in rails is the primary yaw stiffness (PYS), inherent in vehicle suspension design. This was a finding of previous research in collaboration with Network Rail. The research also found that in some cases PYS (also a factor in vehicle stability) may be unnecessarily high. It may be possible to reduce the propensity to initiate RCF by reducing PYS, without compromising vehicle performance, particularly at high speed.

The objective of this research was to establish what changes to the PYS of selected existing vehicles are feasible, and what benefits could be achieved in terms of delivering significant savings in rail damage and wear.

The Class 357 and Mark 4 coach were used for this research. The results showed that potential benefits could be achieved in reducing RCF by revising PYS values to be compatible with the operating speeds and routes. The research also demonstrated positive cost benefits for the GB rail industry from modifying vehicles with reduced PYS, subject to the remaining service life of the vehicle and future operating speeds on the potential routes.

The cost-benefit for the CI357 with a 33% reduction in bush stiffness was particularly robust, as the change to the vehicle required no extra maintenance. The cost benefit calculation suggests possible overall saving to industry of around £60,000 from year 3 onwards for CI357. The possible savings indicated for Mark 4 suggest a possible overall saving to industry between £0.5m to £2.5m from year 3 onwards.

The research provided results that will benefit new rolling stock specifications and for consideration on existing trains where there
**Abstract**

is opportunity to optimise the wheel rail interface. The project also demonstrated the potential financial benefits of maintaining the wheel profile very close to the design profile specification.

**Published**

July 2008

**Current Position**

From this research, a rolling contact fatigue and surface wear component has been included in the Variable Track Access Charge regime from Control Period 4. This provides train operators with the incentive to make savings by reducing track damage and wear on the infrastructure caused by rolling stock. Furthermore, Network Rail has supported the development and trials of new suspension bushes for Mk IV, Class 444, and Class 450 rolling stock. This has demonstrated that there are significant benefits to the industry and that effective savings can be achieved. The benefit of using the new suspension bush continues to be assessed for other rolling stock fleets.
**Description**

This was a laboratory-based feasibility study, to establish whether microwave energy generated super-heated steam could be used to remove contaminants from the surface of rails, using fewer resources than current methods.

**Abstract**

Controlling the effects of low adhesion during the annual leaf fall season results in a significant cost and risk to the rail industry. This includes disruption to services, inactivated track circuits, and potential over-runs and collisions. This research explored the feasibility of using microwave energy generated super-heated steam to remove rail head contaminants such as leaf mulch; the aim being to use significantly less water and power than existing systems.

Laboratory tests used a full-size rail test rig, to allow an estimation of the potential effectiveness and power requirements of a full-size system. The main purpose of the trials was to determine the maximum cleaning speed for a range of contaminant thickness (20 to 60µm). The research showed that a super-heated steam system was capable of cleaning films of artificial leaf contaminant from the rail head up to speeds of 40km/h for average thickness of contaminant film. However, travel speeds had to be reduced to as low as 10 km/h for greater thicknesses of contaminant. The research also highlighted the importance of dispersing the loosened contaminant film before the site is run over by a following wheel. As well as reduced power and water consumption, the railway could also benefit from reduced service delays as a result of improved rail head treatment.

The research was a laboratory test, and the system would require further development to ensure its robust operation on a rail vehicle. There would also need to be an increase in steam output to ensure the removal of a 30µm contaminant film at operating speeds currently used by the rail head treatment trains. Therefore further research was proposed to assess the potential for contaminant film removal at the desired speeds.
T539  Microwave-generated steam cleaning of the railhead  

**Abstract cont.**

V/T SIC has reviewed the project and considers that Network Rail already has a suitable process in place to manage adhesion issues. The industry has a good record of improvement in tackling low adhesion issues in recent years, and the results of the research are so far from the stage of practical implementation that the V/T SIC does not see any benefit in supporting further development at this time.

**Published**

August 2009

**Current Position**

Having considered whether the process shows sufficient economic and technical merit for further development industry stakeholders decided that the size of investment was too large to continue this work and that the current process was satisfactory.
T540 Scoping and development of the Adhesion Management System

Description

This research completed the detailed feasibility studies needed to determine whether an adhesion management system could be successfully implemented on a conventionally signalled railway.

Abstract

Each autumn the effects of low adhesion on the ability of trains to accelerate and brake compromise safety, and incur significant costs because of safety incidents and performance delays. Existing mainline railway adhesion control measures are generally not able to determine and report specific locations of poor rail adhesion in real time. On behalf of the Adhesion Working Group, this research aimed to build on a system that has been successfully deployed on London Underground’s Central Line, with the goal of bringing the benefits to the mainline railway. Research started with an initial cost-benefit analysis (CBA) and development of functional, system, and safety requirement specifications, the data from which was used to produce a revised CBA. The revised CBA also incorporated updated system costs and assessed the alternative modes of implementing an Adhesion Management System (AMS) on the 26 Network Rail business routes. The AMS core system showed a positive NPV on 19 of the routes with ten in excess of £2m. The track-based system showed 16 NPV positive routes with seven in excess of £2m. Whereas the AMS train based system showed six NPV positive routes and only one that was in excess of £2m.

Published

August 2008

Current Position

Further to the completion of the feasibility study, a full scale trial of the Adhesion Management System (AMS) was proposed. Further to a business case evaluation of the benefits of an adhesion management system for the 26 Network Rail business routes, it identified that further development of the train-based display of AMS information could not be supported, and that further development of the project should be based on the Core and Track modes of AMS implementation.
This research investigated whether it was cost effectively possible to use the variations in the level of traction and braking forces, within a train formation, to improve adhesion performance.

Controlling the effects of low adhesion during the annual leaf fall season results in a significant cost and risk to the industry, including disruption to services and potential over-runs and collisions. This research aimed to identify whether improvements to the traction and braking control systems could realise cost savings and reduce risk. It examined the effect of adhesion level and rail conditioning, to calculate the whole life benefits of whole-train, closed-loop traction and braking systems. Cost benefit analyses were then undertaken to assess whether it would be cost effective to modify existing and new vehicle designs to achieve potential improvements that had been identified. The research showed that short trains account for the vast majority of low adhesion delay. It also determined that fitting whole-train, closed-loop traction and braking control systems to existing fleets of trains, to reduce low adhesion delay, is not a cost effective proposition, particularly if the trains are short, and is also unlikely to be so for new fleets.

The key outcome from T545 was that it was not cost-effective to develop a whole train closed-loop braking system, particularly for short train formations like those used in GB. However it did suggest that variable rate sander adhesion control philosophy should be considered for improving performance in low adhesion conditions. It is envisaged that this will form part of the study to be undertaken by research project T797 Performance and installation criteria for sanding systems.
### Description
This research improved the understanding of how train aerodynamics contributes to the deposition of leaves on rails, and developed a code of practice to help train designers to minimise this effect.

### Abstract
Controlling the effects of low adhesion during the annual leaf fall season results in a significant cost and risk to the industry, including disruption to services, inactivated track circuits, and potential over-runs and collisions. An earlier research report, produced as part of low adhesion knowledge research (T354 Work Package 1), concluded that vehicle aerodynamics is a major contributor to the rate of railhead leaf contamination. The objective of this research was to determine the aerodynamic influences of vehicle design on railhead contamination by wind tunnel testing and computational fluid dynamics modelling of existing vehicles that are known to be good and bad in this respect.

The knowledge gained was used to derive guidelines for new train designers on the optimisation of vehicle/train aerodynamic design to reduce leaf deposition on the railhead.

### Published
July 2006

### Current Position
The incorporation of the good practice design guidance into standards has not yet progressed and this activity now falls under the responsibility of the Vehicle/Track Adhesion Research Group, a sub-group of the Vehicle/Track System Interface Committee.
T547  Development of an anti-rolling contact fatigue wheel profile

**Description**
This research determined the service life of a new wheel profile that has been designed to generate less rolling contact fatigue and concluded that in-service evaluation is justified.

**Abstract**
This research sought to further develop an existing wheel profile that reduces the initiation and propagation of rolling contact fatigue (RCF). The WRISA2 wheel profile was developed by the National Research Council of Canada (NRC-CSTT) to provide optimum RCF performance on UK railways, but the likely life of the new wheel profile required determination. With assistance from NRC-CSTT and the Royal Institute of Technology, Stockholm, the Rail Technology Unit at Manchester Metropolitan University developed a novel wheel wear model that allowed the rate of wear of the new profile to be determined, along with its maintenance implications and its effect on vehicle performance. Computer modelling showed that the performance of the WRISA2 profile was comparable to that of the existing P8 and RD9 profiles, and the flange thickness and tread wear of the new profile remained within limits. The research demonstrated that in-service trials of the new profile were justified, and the first of these trials is being undertaken on the Class 444 electric multiple unit under research project T603.

**Published**
April 2006

**Current Position**
Modelling has demonstrated that wear of the WRISA2 profile should be comparable to that of the P8. This information provided justification to proceed with a practical evaluation of the WRISA2 profile as undertaken in research project T603 **Enlarged trial of the WRISA2 anti-rolling contact fatigue wheel profile**. Initial trials demonstrated an acceptable wear life. Following the successful trial V/T SIC recommended adoption of the WRISA2 profile which has been incorporated as a standard profile in the Railway Group Standard GM/RT2466 *Railway Wheelsets*, and is designated as the P12 tread profile.
T549 Development of a wheel wear and rolling contact fatigue model

Description
This research has produced a wheel wear and rolling contact fatigue (RCF) model, by combining the Archard wear model with the RCF damage energy parameter (Ty) from the Whole Life Rail Model.

Abstract
The safe management of the phenomenon of rolling contact fatigue (RCF) continues to cost the industry many millions of pounds a year. A substantial research programme investigating the causes of RCF has been funded and managed by RSSB, with a view to enabling the industry to manage it more cost effectively. This has included development of the Whole Life Rail Model (WLRM) (T115), which can predict the severity of RCF damage in the rail.

This research project has applied the knowledge gained from the research into RCF in wheels and has produced a best practice report to facilitate its management. It has also extended the WLRM to enable it to predict RCF damage in wheels, augmenting it with the Archard wear model. Further research will be undertaken to validate the model against other train fleets and to incorporate it into the Vehicle Track Interaction Strategic Model (T353).

Published
May 2007

Current Position
The knowledge gained from this research project was used to extend the Whole Life Rail Model enabling it to predict RCF damage in wheels. This has been implemented in VTISM. Work is ongoing to validate the model against other train fleets and to improve its calibration through further service monitoring and modelling exercises.

This has been taken forward in subsequent pieces of work including research project T775 Further development of the Whole Life Rail Model damage parameter and T792 Stage 2 development of the Vehicle Track Interaction Strategic Model as part of work package 1 Wheel Profile Damage Module (WPDM) software development. The results from this model have been used for the Wheelset Management Model (a further software development of T792) to help estimate the emerging maintenance costs of wheelsets.
The WPDM calculates the wear and RCF damage rates using a combination of the Archard wear model and the energy dissipated in the contact patch \((Ty)\). The predicted damage rates have been validated using observation data from a number of train fleets. This has resulted in the development of a wheel RCF damage function which generally provides good agreement with the observed damage rates.
## Description

The EU research project WIDEM was set up to provide important new information on wheelset design and non-destructive testing. On behalf of the GB rail industry, RSSB supported several activities that align with GB stakeholders’ interest in the cost, safety, and dependability of axles.

## Abstract

The WIDEM research project planned to exploit a number of new technologies that would allow European stakeholders to re-examine wheelset design, maintenance and inspection. It has involved theoretical modelling, laboratory tests and physical trials and resulted in increased knowledge of NDT techniques and associated human factors issues with probability of detection, the potential for development of wheelsets with reduced mass and the development of a prototype probabilistic crack growth model.

The publicly available results are now being used by the Wheelset Management Group to support parallel research looking at optimising wheelset design and maintenance (T356) and the development of further research projects considering axle corrosion (T728) and the effects of human factors in axle inspection (T774).

WIDEM and other research projects will allow GB stakeholders to optimise the design and maintenance of wheelsets to reduce whole life costs without jeopardising safety.

## Published

December 2008

## Current Position

The validated process from this research has been used for the theoretical calculation of axle loads in research project **T356 Optimising wheelset design and maintenance**. In turn, the Wheelset Management Group commissioned further research to develop the WIDEM prototype model for axle safety (axle failure rate), which will allow a selection of NDT techniques and schedules, to be produced. This will deliver desired levels of safety with minimum cost and disruption to vehicle owners and operators. The model is currently only available to the specialist research community.
### T551  Investigating improvements in defect detection in hollow axles

<table>
<thead>
<tr>
<th>Description</th>
<th>Through experiments, this research demonstrated and verified the effectiveness of a novel technique for detecting shallow surface cracks in hollow railway vehicle axles.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This research investigated a novel method of detecting surface-breaking defects in hollow axles with a view to helping the industry to improve its axle testing regime. Up to the mid-1990s, hollow axles were not commonly fitted to vehicles used in Britain, but the trend is for new designs to be specified with them so that vehicles are more track-friendly. This research undertook experiments to demonstrate and verify improvements in inspection sensitivity obtained when using vertically polarised shear wave transducers. This type of shear wave inspection is particularly useful for thin walled tubes, and as such, is applicable to the testing of hollow railway axles. Whilst the research fully met the overall objectives, it found that there was little benefit to be gained from the general adoption of the technique, however benefits may be gained in exceptional cases.</td>
</tr>
<tr>
<td>Published</td>
<td>April 2008</td>
</tr>
<tr>
<td>Current Position</td>
<td>Whilst the research met the overall objectives of investigating the effectiveness of shallow angle probes, the knowledge gained determined that there is limited benefit from using probes for hollow axles non-destructive testing at present. However benefits may be gained in exceptional cases which can be determined by the wider industry on a case-by-case basis.</td>
</tr>
</tbody>
</table>
### Description

The research is in the area of vehicle/track system optimisation and asset life, and asset whole life cost reduction. The benefit of the research is that the results support the accelerated introduction of measures to reduce the impact of rolling contact fatigue on Britain’s railway.

### Abstract

Over the last few years the R&D programme has conducted a significant proportion of the industry’s research in improving understanding of rolling contact fatigue (RCF). This work has helped the Wheel Rail Interface System Committee (WRISA) and now the Vehicle/Track System Interface Committee (V/T SIC) to develop its strategy on how to reduce the impact of RCF on Britain’s railway. The Permanent Project Group (PPG) is tasked by V/T SIC to enact this strategy.

Through Network Rail, the PPG has recently negotiated a major R&D contract with Transport Technology Centre, Incorporated (TTCI). The research brings unique North American innovation and experience to the GB railway industry. In particular the R&D projects will accelerate the deployment of practical, economic RCF management regimes and bring in valuable US experience in the optimisation of whole life costs.

### Published

March 2009

### Current Position

The findings from this study have been used by the V/T SIC to develop its strategies to reduce the impact of RCF on GB railways. This includes producing business cases for the implementation of solutions to aid and control the mitigation of rail surface damage, especially RCF from the proposed actions identified in this project.
T577  Automatic wheel lathe data acquisition and analysis software

Description
The aim of this project was to provide train operators with greatly improved management information about wheel turning and the impact of wheel turning on service provision. This would allow train operators to make significant cost savings through improved wheel lathe and fleet management.

Abstract
In order to model the wheel/rail interface, and determine best practice in wheelset maintenance, it was recognised that it was important to know the current status of wheel profiles, wear and damage relative to different routes and mileages. ATOC and Network Rail established a collaborative venture to improve the management of wheelsets in GB depots and this project set out to collect data and support the development of a database.

On behalf of the Wheelset Management Group (WMG), a sub-group of the Vehicle/Track System Interface Committee (V/T SIC), phase one of this research involved visits to a number of depots to gather information about wheelset wear, damage and maintenance regimes and obtain wheel profile measurements for wheelsets on different fleets.

Phase two set out to develop the automatic wheel lathe data acquisition and analysis (AWLDAA) software that was intended to provide communications between the wheel lathes and PCs, with analysis tools as defined by the best practice carried out by some of the train operating companies (TOCs). During phase two the project steering group became aware of a much improved software package that was already commercially available, was being used by at least one TOC and was understood to meet the requirements identified for the AWLDAA software development work. Further investigations confirmed that the software met the requirements set out by the project steering group. A recommendation was made not to continue with the phase two development of the AWLDAA software. This was endorsed by the WMG and the V/T SIC as well as agreeing to facilitate the take-up of the commercially available software by other TOCs that have an interest in using it.
The wheelset information, gathered in phase one, will continue to be available for further research and to the industry upon request and to date has been used in further analysis by Network Rail and to help develop the Wheel Profile Damage Model as part of T792 Stage 2 development of the Vehicle Track Interaction Strategic Model.

Published November 2010

In phase 2, the original objective of work package 2 was to build an in-house software product that is able to generate automated wheel lathe data and do the required data analysis. However, it became clear in July 2010 that there was already a commercially available product on the market with greater functionality and sophistication than the product RSSB could develop in the timescales and for budget authorised. The project steering group then recommended that the commercial product should be explored in place of the RSSB software development. This research project was closed further to this recommendation.

Research project T963 Managing the effects of train architecture and operational parameters and influences to reduce wheel damage has reviewed the data acquired by operators and maintainers and has established that many operators have their own, specific data collection, management, and analysis systems to meet their needs.
Enlarged trial of the WRISA2 anti-rolling contact fatigue wheel profile

**Description**
From in-service trials on Class 444 electric multiple units and Class 450 High Capacity units, this project has assessed the potential of the P12 (WRISA2) wheel profile as a control measure on the generation of wheel rolling contact fatigue.

**Abstract**
The P12 (WRISA2) wheel profile was developed as an ‘anti-rolling contact fatigue’ (RCF) wheel profile and provides benefits in terms of reducing the initiation of rail and wheel RCF.

On behalf of the Vehicle/Track System Interface Committee (V/T SIC), in 2007 for the first stage of this research project RSSB oversaw the application and evaluation of a proposed ‘anti-RCF’ wheel profile in limited in-service trials on two Class 444 units operated by South West Trains. As a result of these trials the wheel profile was introduced into the Railway Group Standard GM/RT2466, ‘Railway Wheelsets’ and designated the P12 profile.

To provide greater experience and more detailed evidence of the potential benefits of the P12 profile, an enlarged trial involving fourteen Class 450 High Capacity units and two Class 444 units was completed in 2010. The wheels on the trial fleet were monitored at regular intervals, along with rail head condition at four track sites - Chertsey, Datchet, Farnham, and Vauxhall. Computer simulation undertaken in parallel was used to help understand the causes of the observed damage on wheels and rails.

The research predicted that the P12 profile would provide a benefit by reducing high rail RCF at the expense of an increase in low rail RCF in tight radius curves. These predictions have been observed during the course of the in-service trials and it has been concluded that given there are fewer tight radius curves than moderate radius curves, the reduction in high rail RCF will outweigh the generation of low rail RCF and therefore delivers an overall benefit.
The findings in relation to wheel RCF included the observation that wheel RCF may initially develop towards the middle of the wheel tread on motor car P12 profile wheels but becomes less pronounced as mileage increases as a result of the change in wear patterns. The research also concluded that an effective lubrication regime must be maintained to control flange wear on the P12 wheel profile particularly on curvaceous routes.

Overall, the research has demonstrated the predicted reduction in RCF and provided a lot of information and data. The V/T SIC, through the Permanent Project Group is using these outputs to evaluate changes to the Vehicle Track Access Charge calculation. As a result of this research and potential benefits, RSSB is aware that some train operators and maintainers have taken steps to initiate their own more specific trials to assess the benefits that the P12 wheel profile may have for their individual fleets.

The P12 wheel profile has been included in RGS GM/RT2466 ‘Railway Wheeisets’ further to V/T SIC’s recommendation to the Rolling Stock Standards Committee.

Some train operators have initiated their own trials to assess the benefits that the P12 wheel profile may have for their fleets and progress will be reported to V/T SIC from time- to- time. The Class 380 vehicles operated by ScotRail have the P12 wheel profile as standard.

Train operators and maintainers have taken steps to initiate their own trials to assess the benefits that the P12 wheel profile may have for their individual fleets, as a control measure on the initiation of wheel rolling contact fatigue.

The P12 profile has also been found to extend wheel life on the Class 390 Pendolino fleet and to improve high speed stability on the Class 395 fleet.
Description

This research identified existing and new technologies that can monitor wheelset condition, lessen human intervention in this process, and reduce the potential for errors.

Abstract

On behalf of the Wheelset Management Group, RSSB commissioned this research to identify and evaluate equipment capable of monitoring wheelset condition. The objective was to provide a high-level summary of the state of the market for such systems, to explore their overall advantages and disadvantages, to identify gaps, and to provide recommendations for implementing such systems into a comprehensive monitoring programme. By providing a comprehensive information set, the research supports the implementation of such systems in the GB rail industry, and facilitates the optimisation of wheelset maintenance regimes and economic decisions on vehicle and track maintenance practices.

The research project was organised into five task areas: a literature search, user consultation, equipment evaluation, implementation assessment of the systems, and reporting.

A total of 41 currently available systems, two automatic vehicle identification (AVI) systems, and five emerging technologies were identified. The user consultation then established the highest priority issues with wheelsets to be: wheel flats, out-of-rounds, rolling contact fatigue, bearing failures, and tread defects. The research also identified that hot axle bearing detectors and wheel impact load detectors are the only extensively used trackside automated wheelset condition monitoring systems.

The perceived advantages of a maintenance regime based upon automated wheelset condition monitoring systems included early warning, trend analysis, and a reduction in labour-intensive inspection processes. The main disadvantages were considered to include high up-front costs and increased complexity. Implementation of such automated systems would also require implementation of AVI systems and development of strategies for management of data from automated inspection systems.
Abstract cont. Whilst the current technologies meet most, but not yet all, wheelset inspection requirements, the results of this research will now support the GB rail industry to optimise wheelset maintenance regimes and enhance economic decisions on vehicle and track maintenance regimes.

Published July 2008

Current Position The findings from this research supported the T844 Developing a railway system reliability framework and mapping current remote condition monitoring activities to it research that was commissioned by the Uninterrupted Journey Group, a sub-group of the Technical Strategy Advisory Group.

Completed V/V SIC research project T857 Detailed review of selected remote condition monitoring areas has undertaken a comprehensive review of remote condition monitoring to assist the industry with making informed operational and development decisions for current and future RCM systems. For wheelset monitoring it includes information on axle journal bearings monitoring using trackside systems, Wheel Impact Loads monitoring systems, ride monitoring systems and it provides an overview of the benefits and risks associated with condition monitoring.

Research project T963 Managing the effects of train architecture and operational parameters and influences to reduce wheel damage has reviewed the monitoring technology currently used by fleet operators/maintainers and how the data it records is used to detect wheel damage. It draws on the T607 and T857 research and has noted that there is no change in some of the techniques currently used today. With novel application of the data collected however, some operators/maintainers are starting to benefit from using the data.
<table>
<thead>
<tr>
<th><strong>T608 Development of cost-effective high performance track infrastructure (EC project: INNOTRACK)</strong></th>
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<tr>
<td><strong>Description</strong></td>
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<tr>
<td>The INNOTRACK research project is a joint response from European railways to develop a cost-effective, high-performance track infrastructure, and provide innovative solutions that significantly reduce both infrastructure investment and maintenance costs.</td>
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<tr>
<td><strong>Abstract</strong></td>
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<tr>
<td>One of the greatest challenges for the railways in Europe is to reduce track costs, the major cost component for infrastructure managers (IM). Whilst railway maintenance costs have not significantly decreased in the last 30 years, competing modes of transport have seen a tremendous reduction of life cycle costs (LCC). This narrows the business case for rail transportation.</td>
</tr>
</tbody>
</table>

In addition to costs, noise pollution also has become a crucial issue for railway operations. |

The complete results of the INNOTRACK research project comprise 141 technical deliverables. To improve implementation, 16 deliverables guidelines have been produced. They focus on conclusions and practical application, so the results will be easier to implement. Seven of the deliverables are databases, five of which are to be maintained by UIC. |

The INNOTRACK concluding technical report is the primary deliverable and acts as a comprehensive technical digest of INNOTRACK results and deliverables. |

The technology-driven research focused on track support structure, switches and crossings, rails, and efficiency of logistics for renewal and maintenance, from the point of view of reducing LCC of track structures. The research proposes, validates, and outlines track design solutions that move towards creation of common European standards that respond to the demands for higher traffic volume, higher performance in terms of RAMS (reliability, availability, maintainability and safety) and reduced LCC, without compromising safety.
To further promote dissemination and implementation, several activities were proposed at the last INNOTRACK Steering Committee meeting and carried out by UIC. Five training courses focusing on assisting the implementation of the research project results will be conducted concerning:

- Minimum action rules and maintenance limits
- Sub-grade improvements
- Recommendations on switches & crossings
- Rail grade selection
- Life cycle cost calculations

The results of the INNOTRACK research project will help the railways tackle issues in the important area of track and substructure. This part represents 50-60% of the maintenance and renewal costs of a typical railway, which means that INNOTRACK’s output can have a significant impact on the railways’ overall cost reduction goals.

Network Rail is using and applying the outputs from the INNOTRACK project. This includes building on detection of precursors to switch failure within Intelligent Infrastructure and development of Minimum Action Rules for track maintenance, and performance-based design principles. These are being taken forward through other EC consortium projects such as Sustrail and AutoMAIN. Projects such as INNOTRACK build on the body of knowledge and it is expected that the influence will permeate thinking and technology development.
T613  Trials of wheel and rail rolling contact fatigue control measures

**Description**
This research project has tested the tools and techniques from earlier rolling contact fatigue (RCF) investigations to develop and validate sustainable operational limits that allow the industry to economically manage the wheel/rail interface performance, to mitigate RCF in rails.

**Abstract**
Rolling contact fatigue (RCF) is a problem for the rail industry as premature rail replacement is unplanned, logistically difficult to manage and costly. On behalf of the Vehicle/Track System Interface Committee (V/T SIC), this research project aimed to develop sustainable operational limits (SOL) that could be easily understood by front line maintenance teams, and readily applied to mitigate RCF in rails.

The research involved simulation, analysis, site investigation, and 18 months of site monitoring. The Great Western Main Line and the Trans-Pennine Express routes were chosen for the trials because of their differing infrastructure characteristics and the rolling stock operating across them. The research project was conducted in four stages:

1. Data gathering and initial site selection process
2. Detailed site simulations
3. Conduct remediation measures
4. Monitoring over an 18 month period

SOLs distil a complex body of knowledge into relatively simple guidance, and the aim of this research has been achieved with SOLs developed that address 3 key RCF control measures:

1. Increasing cant deficiency
2. Track alignment
3. Managing degradation of the rail profile (grinding and lubrication)

The knowledge developed by this research will be made available by Network Rail to front line maintenance engineers and will contribute to increased rail asset life and cost savings over the life cycle of the rail asset.
The Network Rail Professional Head of Track fully supported the writing of a new guide to RCF, aimed at track engineers and maintenance support engineers. The guide explains the industry’s understanding of the mechanisms of RCF and what factors can influence it. This is explained in a 'non-technical' way as far as possible. To this end, examples of the different mitigation measured used in T613 were included to provide evidence/examples of implementation of these methods.

The Network Rail Track Design standards have been updated to include some guidance on the benefits of increasing cant deficiency in curves, although it is expected that future revisions of the standard will be able to provide more explicit guidance on cant deficiency.

Track-Ex is currently Network Rail’s main tool to identify and implement RCF mitigation measures, and T613 was useful in validating the models which are incorporated within it. Many maintenance support engineers and rail management engineers currently use Track-Ex, and knowing that some of the predictions of Track-Ex have been verified in the field gives them confidence to use it to analyse and identify RCF control measures at sites of interest to them.

Making this knowledge available to Network Rail front line maintenance engineers is contributing to improved rail asset life and cost savings.
### T614 Investigating a novel method for estimating low adhesion conditions

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>This research investigated a novel method aimed at identifying low adhesion in real-time based upon the concept of model-based estimation.</th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>It is clear that changes in the adhesion conditions will change the behaviour of the rail vehicle, under braking and traction. This research has evaluated whether this same behaviour change can be seen in the 'normal' motion of the vehicle along the track, i.e. before the brakes have been applied.</td>
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<td></td>
<td>On behalf of the Adhesion Working Group this research has developed a computer model for condition monitoring of a bogie’s dynamic response. This has been used to assess the feasibility and range of results that can be obtained from the Kalman Filter application to wheel-rail adhesion simulations.</td>
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<td></td>
<td>This research has established the feasibility of identifying low levels of adhesion from the bogie’s dynamic response during normal running of the train. The approach of estimating the contact forces was considered to be more beneficial than estimating linear terms (creep coefficient) or adding more Kalman Filter model complexity. This is because this offers the most practical solution to estimating low adhesion conditions.</td>
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<td></td>
<td>The output of this research is complementary to a number of other techniques, and provides insight to the overall problem of minimising the impact of low adhesion on railway vehicles, both in terms of reduced operational performance and wheel and rail damage. To validate the findings it would be necessary to undertake some instrumented track testing to confirm that the model produces similar results under life-size test conditions as were produced in Stage 2 of this research.</td>
</tr>
<tr>
<td><strong>Abstract</strong> cont.</td>
<td>The Technical Strategy Advisory Group (TSAG) and the Technical Strategic Support Group (TSSG) have subsequently considered this further research as part of the RSSB-managed Rail Industry Strategic Research Programme and have concluded that TSSG should focus on traffic management systems first (which was the origin of the adhesion research), and drill down to specific issues such as adhesion management when there is a better developed industry strategy in this area. Therefore until this has been clarified, further development of a model is postponed.</td>
</tr>
<tr>
<td><strong>Published</strong></td>
<td>December 2009</td>
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<tr>
<td><strong>Current Position</strong></td>
<td>This research delivered a novel method capable of identifying low adhesion in real-time based upon the concept of model-based estimation. The proposal to validate the findings further was considered by TSAG and TSSG. Further research in this area was progressed by V/T SIC on behalf of the Technical Strategy Leadership Group in research project <strong>T959 Onboard detection of low adhesion</strong>.</td>
</tr>
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</table>
## T641 Cost effective turning of flange worn wheel profiles

### Description
This research investigated whether the tolerance regime for maintaining the wheel profile could be revised to extend wheelset life and reduce maintenance costs without compromising safe train operation.

### Abstract
This research investigated whether it was safely and economically feasible for wheelset life to be increased for wheelsets with flange worn profiles. This would be achieved by revising prescribed wheel profile limits to allow reductions in the depth of material that needs to be removed when turning such wheelsets. Current specifications and practices and the reasons for them were examined and compared with those of other railway administrations to determine best practice for wheelset re-profiling. Potential benefits to the GB rail industry were identified that may be used to help to optimise wheelset maintenance regimes, leading to reduced costs and higher train availability. The research concluded that whilst the use of a profile with a thinner flange is feasible, the benefits of re-profiling to a thinner flange may only be cost effective at the final turning where a full turning may reduce the tyre thickness to below last turning size. Furthermore where flange wear is dominant, wheels should run in service for as long as possible as there is no increased benefit from more frequent re-profiling to offset the removal of natural self-hardened layers.

### Published
July 2007

### Current Position
The main finding for the re-profiling regimes for flange worn wheels was that wheels should run in service for as long as practicable, to delay turning to a new profile for as long as possible. This has been incorporated in *GM/RC2496 Recommendations for Railway Wheelset Maintenance*. 
## Description

This research set out to produce a wheel steels handbook and then to survey and analyse sub-surface cracking, rolling contact fatigue and rim volumetric defects. The expected outcome was for the project to determine design recommendations and control measures for inclusion into Railway Group Standards to manage such defects.

## Abstract

This research set out to understand the effects of metallurgy, design and the manufacturing process on the initiation and propagation rates of sub-surface cracking, rolling contact fatigue (RCF) and rim volumetric defects in wheels. By improving such understanding, design recommendations and control measures for inclusion into Railway Group Standards could be developed to better manage such defects. The expected benefit for doing this was to enable the industry to develop optimal maintenance strategies for wheels hence helping to reduce costs.

The research project was divided into two parts. The first addressed the need for a wheel steels handbook detailing the metallurgical properties. This need was identified by the Vehicle/Track System Interface Committee (V/T SIC) in its ongoing study of wheel rail interaction. The handbook provides metallurgical information on the various types of wheel steels. It categorises them into a format that can identify similar grades or similar properties with an explanation of the relevant characteristics of each of the grade types.

The second part of the research aimed to investigate the development of wheel RCF and rim volumetric defects, to give further understanding of the effects of metallurgy, design, and manufacturing processes on initiation and propagation rates. From this work, control measures were to be developed.
### T672 Wheel rolling contact fatigue and rim defects investigation to further knowledge of RCF causation and to determine control measures *cont.*

#### Abstract *cont.*

After the handbook was completed and published, a review of the requirement and justification for the second part of the research was conducted by the Wheelset Management Group, Vehicle/Track Technical Advisory Group, and V/T SIC. They determined that, in light of the effective wheelset management practices and the rare number of occurrences of such defects, there was limited benefit in carrying out further research into RCF in wheels or of volumetric defects in wheels.

#### Published

June 2008

#### Current Position

The published *Wheel Steels Handbook* provides industry with a valuable reference source that details the metallurgical properties of wheel steels for industry to use when specifying and maintaining wheel steels, and when deviations from the Railway Group Standards are applied for.

The wheel steels handbook has allowed the RCF resistant wheel steel to be incorporated into *BS 5892-3:1992+A2:2009 Railway rolling stock materials. Specification for monobloc wheels for traction and trailing stock.*

Railway Group Standard *GM/RT2466 Railway Wheelsets*, has also been revised to include reference to the RCF resistance wheel material defined in BS 5892. Also, a proposal has been made to CEN for revision of *EN 13262 Railway applications. Wheelsets and bogies. Wheels. Product requirement* to include RCF resistant wheel material.
T728  Impact of corrosion upon the high cycle fatigue properties of GB axle steel

Description
This research project has enhanced the GB rail industry’s knowledge of the effects of corrosion and damage on the fatigue life of axle steels, to help it safely optimise wheelset whole life costs.

Abstract
The rail industry achieves very good safety performance from its wheelsets through rigorous axle maintenance regimes. This does however result in large numbers of axles being rejected at overhaul, at significant cost.

The rail industry requested a review of the axle acceptance criteria to understand whether revised criteria can be developed to optimise axle life. Because an axle is a safety critical component, the rail industry is concerned that by revising the criteria the risk from axle failure could change.

On behalf of the Wheelset Management Group (WMG), this research project aimed to help address this concern, by enhancing the GB rail industry’s knowledge of the effects of damage and corrosion on the fatigue behaviour of its axles. It also aimed to provide a consistent methodology to allow train operators and others to make decisions on optimising wheelset maintenance, using recognised industry safety standards and decision making practices.

The improvement of the scientific understanding of the impact of corrosion upon the high cycle fatigue properties of GB axle steel was approached in 7 stages. These included systematic examination of corrosion affected axles, fatigue crack initiation assessment, and crack propagation testing. It concluded with an independent peer review of the research.

The research has demonstrated that the application of fracture mechanics predictions to safety-related decision support tools is very demanding. The consequence of this was that it was not able to deliver the challenge of producing a support tool to assess the effects of changes in maintenance and inspection processes on the probability of axle failure.

The research findings were reviewed by the WMG, which agreed to consider the recommendations from it and from the peer review in their next update of the WMG wheelset strategy document. This included assessing the industry’s needs for an axle fatigue failure risk model.
## T728 Impact of corrosion upon the high cycle fatigue properties of GB axle steel *cont.*

<table>
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<th>Published</th>
<th>February 2014</th>
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<tr>
<td><strong>Current Position</strong></td>
<td>Some of the outputs on corrosion fatigue have been shared with research project <strong>T920 Euraxles - Minimising the risk of fatigue failure of railway axles: FP7 3rd Call.</strong> Preliminary results were also presented to the representatives of the ESIS TC24 Integrity of Railway Structures Working Group at a workshop hosted by RSSB in March 2011. The WMG is considering the industry’s needs, and has proposed some further work in this area.</td>
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## T775 Further development of the Whole Life Rail Model damage parameter

### Description
This research identified enhancements for the Whole Life Rail Model to improve the accuracy for predictions of rail wear and rolling contact fatigue damage for a broader range of infrastructure types than was previously achievable.

### Abstract
The Whole Life Rail Model (WLRM) is an established world leading tool for predicting rolling contact fatigue (RCF) and wear damage and is used to target maintenance on the rail network, and in the procurement process to assess vehicle performance. It is an essential component of the Vehicle Track Interaction Strategic Model (VTISM). The WLRM damage parameter has been validated on many sites with high levels of rail RCF damage and has given consistently dependable results. In some instances application of the WLRM damage parameter has generated misleading predictions, resulting in either an over- or under-prediction of the observed RCF damage.

On behalf of the Vehicle/Track System Interface Committee (V/T SIC), RSSB has completed further research to improve the accuracy of the WLRM’s RCF prediction and extended the application of the model to other categories of rail damage. Development and integration has involved:

1. Improved calculation methods for \( \gamma \) (Tgamma)
2. Effect of wear in the RCF model
3. Plastic flow in rails
4. Influence of rail metallurgy
5. Wheel and rail profile assessment criteria

The research consisted of both parametric studies and detailed simulations of the damage observed at a range of sites on Network Rail infrastructure. Analysis techniques included the use of vehicle dynamics simulations, finite element analysis, and post-processing and visualisation of the results.
Abstract cont.
The findings from the research have been combined to propose a revised damage parameter in the WLRM for the prediction of RCF and wear, and to develop a new function for the prediction of damage associated with plastic flow. The improvements are particularly applicable to sharper curves and low rail damage mechanisms, and will generally improve the damage predictions in these cases.

The revised damage parameters will be implemented in the VTISM software by RSSB. Network Rail will consider if the new damage parameters should also be included in its Track-Ex software.

Published
October 2011

Current Position
The V/T SIC Permanent Project Group (V/T SIC PPG) is evaluating the application of the new rail damage parameters, for the prediction of RCF and plastic flow in existing and new rail steels. Extensive site monitoring trials have provided a lot of data and the V/T SIC PPG has started the modelling work. This is expected to be completed early in 2015 when decisions can be taken to incorporate the revised damage parameters in VTISM and in Track-Ex.
This research investigated the compatibility between CEN56 S&C, including in service limits, with both the ranges of Technical Specifications for Interoperability compliant wheelsets and Railway Group Standard compliant wheelsets in service in GB, and all permissible wear parameters.

The European Railway Agency (ERA) formally requested the Office of Rail Regulation (ORR) to provide details of the GB-specific cases for the Conventional Rail Infrastructure TSI (CR INF TSI). These address the special provisions in a TSI for part of the rail system because of geographical, topographical or urban environment constraints or those affecting compatibility with the existing system. The specific cases were put forward by Network Rail and RSSB, considered and supported by Infrastructure Standards Committee (INS SC) and recommended to ORR by the Industry Standards Co-ordination Committee. One of those considered provides for the continued use of CEN56 [BR 113A] Vertical design Switches & Crossings (S&C) layouts with nominal track gauge of 1432mm with respect to the CR INF TSI.

The research showed that TSI compliant wheelsets are not significantly different to current RGS compliant wheelsets in respect of their compatibility with S&C. The research provided the basis for supporting the continued use of CEN56 [BR 113A] Vertical design Switches & Crossings (S&C) layouts with nominal track gauge of 1432mm with respect to the CR INF TSI. The study also suggests that a related GB-specific case for wheelsets is not required. RSSB is supporting industry and the ORR in finalising and reaching agreement on the GB specific cases against the CR INF TSI with the ERA.

RSSB has supported the rail industry and the ORR reach agreement with ERA to keep the GB specific case for the CEN 56 S&C design in the combined Conventional Rail and High Speed Infrastructure TSI. This is expected to come into force in January 2015.
T792  Stage 2 development of the Vehicle Track Interaction Strategic Model

**Description**

This research has delivered the Stage 2 enhancements to VTISM. Additional integrated functionality and new models deliver benefits for train operators, owners, manufacturers, and Network Rail.

**Abstract**

On behalf of the Vehicle/Track System Interface Committee, this research project delivered the Stage 2 development of the Vehicle Track Interaction Strategic Model (VTISM). VTISM links inputs such as track and vehicle characteristics to outputs such as rail and wheel life and maintenance regimes. VTISM is already helping the industry to manage changes around this interface more effectively and to realise savings through optimised track and vehicle maintenance.

This latest VTISM development enhances the rolling stock modelling capabilities and improves the user interface of the VTISM tool. These enhancements have included the development of new models: the Wheelset Strategic Planning Application (W-SPA), the Wheelset Management Model (WMM) and the Wheel Profile Damage Model (WPDM).

These new models increase the benefits that VTISM can provide to organisations such as train operating companies, train manufacturers, and rolling stock leasing companies, as well as Network Rail. VTISM and the WPDM and WMM can be used to model vehicle and track maintenance and renewal strategies, without the need for extensive in-service trials.

The benefits provided by this latest version of the VTISM model are:

1. Improved accuracy and confidence in the results, provision of a larger library of routes, and inclusion of scenario examples.

2. Automated New Measurement Train and GEOGIS route matching.

3. Updated equivalent gross tonnage algorithms, giving more accurate differentiation in the track damage costs associated with different vehicles.

4. Provision of a more complete set of predicted track maintenance costs in VTISM.
Abstract cont.

5. The WPDM predicts the rate of wear, conicity, and RCF for each wheelset type within a train fleet. The development work has also extended our knowledge of wheel damage. The outputs are used by the WMM.

6. The WMM provides VTISM with the ability to model wheelset-related costs as well as track costs. It can also be used as a standalone model. For both applications it can help establish the emerging maintenance costs of wheelsets for user-defined scenarios.

7. The usability enhancements reduce the time needed for scenario setup and processing.

VTISM version 2.6.5, compatible with Windows 7 operating system and Office 2007 and 2010, is available for RSSB members under license.

Published

March 2014.

Current Position

RSSB has held product launches to demonstrate the VTISM enhancements to existing and potential new users. It has delivered training sessions to around 60 users and has issued licenses to around 21 organisations.

There is some further work underway for the WPDM, that is being addressed through a PhD funded by Rail Research UK (RRUK) for ‘Development of a Validated Strategic Railway Wheel Damage Model Based on Deterministic Principles’. Research project T963 Managing the effects of train architecture and operational parameters and influences to reduce wheel damage has also provided information to the industry on collecting wheel tread damage data that can be used for WPDM analysis.

RSSB is developing a strategy on behalf of the industry to transition VTISM from the research and development environment to make it a ‘business as usual’ managed tool. RSSB is continuing to provide help desk support and training on behalf of the industry.
### T796 Understanding the current use of sanders on multiple units

**Description**
This research, carried out on behalf of the Adhesion Working Group, aimed to quantify and understand the significance of different interpretations of the Railway Group Standards (RGS) requirements for sanding systems on different rolling stock fleets, and identify best practice in support of future updates to RGS.

**Abstract**
Railway Group Standard GM/RT2461 ‘Sanding Equipment Fitted to Multiple Units and On-Track Machines’ requires sanding systems to be fitted on multiple units. Different interpretations of its requirements have led to different fitting and usage practices on different fleets. In support of the RAIB Autumn Adhesion Report, Part 3, Recommendation 11, this research quantified and highlighted the significance of these interpretations.

The research was carried out for the industry’s Adhesion Working Group and included a review of operational depots that run and maintain units fitted with sanders. It also carried out tests of actual performance against design expectations.

Significant discrepancies between design and performance were found and mitigation measures proposed to ensure that sanders meet the capabilities set out in RGS.

The study generated a record of the installations and performance of existing sander systems on different passenger rolling stock fleets and has produced best practice measures on the design and fitting of sanding systems. Anomalies in performance have also highlighted future requirements for improved sander performance.

The study has provided a greater understanding of the performance levels of sanders in operation throughout Great Britain.

The results are to be used to support future updates to GM/RT2461. The research will support the industry in reducing the levels of low adhesion delay minutes through industry awareness, which currently range between 500,000 and 700,000 minutes each year and equate to over £50million each year.
**T796 Understanding the current use of sanders on multiple units cont.**

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<th>April 2010</th>
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**Current Position**

The findings from the research project were shared with the Adhesion Working Group, ATOC Engineering Council and ATOC Engineering Forum. A strategy to implement these findings has been determined and agreed by these stakeholder groups noting the research will support the industry in reducing the levels of low adhesion delay minutes through industry awareness. This research has also informed research project **T797 Performance and installation criteria for sanding systems.**
**T807  Track quality sensitivity analysis using VTISM**

**Description**
The Vehicle Track Interaction Strategic Model was used to assess whether the GB rail industry could reduce whole-life system costs by maintaining track quality to higher levels than current practice. The results from this work indicated that there is a case for implementation of such techniques and V/T SIC has noted that Network Rail is taking forward the findings of the study.

**Abstract**
This research project was undertaken on behalf of the Vehicle/Track Systems Interface Committee (V/T SIC) to investigate the whole-life costs of ballasted track that is installed and maintained to improved levels of geometric quality.

It is widely accepted that track with good geometry deteriorates more slowly and requires less maintenance than track with poorer geometry. However, there appears to be no quantitative data on the cost differences that are associated with this phenomenon, neither is there any data on the cost of installing track to high or low geometric quality.

The Vehicle Track Interaction Strategic Model (VTISM) was used to investigate how changes to certain track characteristics can affect maintenance and renewal costs. Two routes were used to examine cost changes for rail renewal, due to rolling contact fatigue, wear, and other forms of rail damage, as a consequence of different levels of track alignment quality and, separately, of rail profile. It also estimated the cost changes for maintenance (tamping and stoneblowing) and renewal with different levels of assumed vertical geometric quality.

This determined how whole-life track costs would vary if Great Britain was to increase the geometric quality of its railway to the quality levels implied by current draft EuroNorm (EN) EN13848 'Railway applications. Track. Track geometry quality' and EN13231 'Railway applications. Track. Acceptance of works'.
The research was delivered in two key phases. Phase one involved initial analysis of the magnitude of potential cost savings and improvements to the VTISM track geometry model. Phase two involved analysis of specific track quality improvement methods and techniques.

The findings were consistent with previous research studies, in that track has an inherent quality that is essentially built-in at construction. Trying to drive track quality higher by maintenance, even using more sophisticated methods, is expensive; the cost-effective way is to use techniques that modify the inherent track quality at renewal, which reduces geometry deterioration rate and associated future maintenance and renewals. In particular the research found that there are significant whole life costs saving opportunities available for improving track quality on the GB railway network. From consultation with Network Rail, it is evident that there is potential benefit for extensive use of techniques such as sleeper soffit pads, lime stabilisation and geogrid.

In the short-term, cost savings are obtained from reduced maintenance, and over the longer-term, renewal rates are reduced through extended track life. Priority for implementing such novel track quality improvement techniques should be given to routes where the greatest benefit can be derived from reduced maintenance, which would lead to increased availability (and traffic capacity) and safety.

Consultation with Network Rail Track and Systems Engineering, Asset Management, and Maintenance Strategy teams concluded that there is potential for more widespread use of these techniques that deliver major whole-life cost savings. Network Rail is considering the case for implementation of these techniques and V/T SIC has noted that Network Rail is taking forward the findings of the study.

Network Rail is reviewing the effectiveness and value of the various track quality improvement options and is considering the case for implementation to establish how the potential benefits of this work can be realised in its business plans.
Following completion of the T807 research project, Network Rail’s System Engineering Team has created a Track Stiffness Working Group (TSWG) represented by organisations from the industry with an interest in track stiffness. The aims of the Track Stiffness Working Group are to:

- Share best practice amongst participants
- Solve problem sites
- Review current trials and research
- Define future research and company strategy

Network Rail’s System Engineering Team and the TSWG completed the development of the first generation track formation model in 2012 and the second generation track formation model in 2014.
**Description**

This research led to the production of a wheelset research programme that will now help deliver the knowledge to allow the industry to minimise wheelset whole life cost, without an adverse effect on safety or on the environment.

**Abstract**

The annual expenditure for wheelsets in GB railways is estimated to be in the order of £140m per year and GB railway has become a small customer to a number of very large suppliers. It is therefore increasingly difficult to source relatively small orders for non-standard (in world terms) wheelset designs made of non-standard steels. This research therefore aimed to identify a programme of research projects that would investigate various aspects of the life cycle of a wheelset with a view to reducing costs; maintaining or improving safety in a cost effective manner; and identifying, capturing, retaining, and validating aspects of relevant existing wheelset knowledge.

This research project produced a three-year wheelset research programme that can be owned, monitored, and updated by the Wheelset Management Group (WMG). The programme has been developed over the last 18 months by a sub-group of the WMG and sets out an approach to further research that will help industry to minimise wheelset whole life cost, without an adverse effect on safety or on the environment.

As individual research projects are progressed and completed they will contribute to the ongoing WMG activities that will help the industry to review, simplify, and standardise safety measures applicable to wheelsets, whilst also extending the life of wheelsets. It will also allow the industry to rationalise the number of different wheelset types and help reduce the overhaul rejection rates whilst increasing the understanding of mechanisms that lead to wheelset failure. This work will also allow GB railways to participate with other European railway members to ensure the development of cost effective European standards.

**Published**

June 2009

**Current Position**

This research project has produced the wheelset research programme on behalf of the WMG. Several research ideas were produced by this stakeholder group in support of the proposed programme of work. The WMG is currently reviewing and updating its wheelset research programme.
### T877  GB requirements for wheel slide protection

**Description**
This research project developed draft text for inclusion in a Guidance Note for the performance testing of wheel slide protection for passenger railway vehicles and related braking system functions, using updated simulation methods for mainline GB railway applications.

**Abstract**
Wheel slide protection (WSP) is an electronic system that includes interfaces with braking- and adhesion-related devices, such as dynamic brake control and sander system controls. The intervention of these systems significantly impacts upon the braking performance of the railway vehicle. Developments in braking systems could be enhanced through a more regulated testing strategy; however there is no mechanism to regulate the way in which these systems interact which can negate some of the benefits of a well optimised WSP.

A GB specification for testing WSP systems using simulation methods was developed in 1997. However, the GB specification is not adequately referenced in the GB standards framework and would benefit from being updated to better represent some of the recent changes in WSP and related braking system functions, for example sanding / dynamic braking.

In the near future the Conventional Rail Locomotive and Passenger TSI will be published and include braking requirements for railway vehicles with EN 15595 (WSP) specifying the minimum requirements for WSP systems to maintain interoperability. Whilst this is the mandatory minimum standard for interoperability, for commercial reasons it is advantageous to retain the best practice associated with the simulation methods currently in use in GB.

This research involved a review of WSP testing requirements that are defined in EN 15595 and considered these against the supplementary requirements that would be required for application to the GB mainline railway. This process involved research of these systems, including the WSP, sanding, and dynamic brakes; and included limited simulation
### Abstract

Testing to establish a test strategy and performance limits that are appropriate to these systems.

Introducing a Guidance Note for WSP testing to supplement EN 15595 in Railway Group Standards will help to ensure the consistent application of these better performance requirements by specifiers of new rolling stock, train operators, rolling stock companies, and maintenance contractors, than the minimum performance requirements to be introduced in the near future by the published EN 15595 (WSP).

Benefits to the industry will take the form of avoided costs. As a result of non-compliance such costs will arise from increase to maintenance cycle cost on new EMU wheels. Compliance with the GB specific WSP guidance could lead to cost avoided in the region of £640,000 over the five-year cycle from 2015 to 2020.

### Published

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<th>Published</th>
<th>November 2009</th>
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### Current Position

### Description
RSSB was a member of an EC consortium looking at ways of reducing the costs and time taken to achieve trans-European rail vehicle certification. This research project addressed RSSB’s contribution in the area of vehicle track interaction.

### Abstract
DynoTRAIN was one of three projects within TrioTRAIN (a European FP7 project). DynoTRAIN aimed to transfer rolling stock certification work away from physical testing to simulation. It aimed to develop innovative, software-aided certification methodologies to reduce the amount of physical testing, the overall certification time, the associated costs, and the influence of uncontrolled conditions. RSSB was 75% funded by the European Commission and was a partner in the DynoTRAIN research project valued at around 5.3 million euros. The research was completed in September 2013.

On behalf of the Vehicle/Track and the Vehicle/Vehicle System Interface Committees, RSSB contributed to all seven of the DynoTRAIN work packages.

DynoTRAIN has been considered a success and has delivered the following key benefits:

1. Provision of a method and software tools for creating a track geometry database from measured track geometry data.

2. Recommendations for inclusion of improved ‘plausibility checks’ on measurement of track geometry data in the revision of the EN13848 series of documents.

3. Specification of reference contact conditions in terms of equivalent conicity have been proposed for standards.

4. Identification of good practice for standardisation and cross acceptance of railway rolling stock with respect to track loading, track layout, track design and track maintenance strategies.

5. Evaluated methodologies for the certification process of rolling stock relying on model based predictions to supplement physical test results.
Abstract

6. A framework for handling the uncertainties associated with vehicle dynamic performance assessment.


The main deliverable for this research is a summary report that provides an overview of the project and the research findings.

The research conclusion is that the DynoTRAIN outputs can be included in a requirements framework for standards to enable virtual assessment and simulation for rolling stock certification for the purposes of interoperability.

For the future, proposals have been made to increasingly use simulations instead of tests, and improved application of the statistical techniques for incorporation into the current revision of EN14363 on dynamic approval testing of rolling stock. Recommendations for improvements to track geometry measurement and analysis methods have also been made to the CEN group working in this area.

Published
April 2014

Current Position
ERA is progressing the revisions for the TSIs for locomotives and passenger rolling stock, and infrastructure. It has established a dynamics working party to look at some of the interface issues found between these two documents.

CEN TC256 is working on updating various standards encountered during the project involving DynoTRAIN partners. This includes updating EN 14363.
T889  Controlling rail vertical contact stresses

**Description**  
Assessment of using the Q/D ratio to control the vertical contact stresses generated within the contact patch.

**Abstract**  
On behalf of the Vehicle/Track System Interface Committee, a literature review was completed to establish the background to the Q/D limit (maximum static wheel load to wheel tread diameter). Q/D is used as a means of controlling the vertical contact stresses generated by rolling stock. It is defined in GM/TT0088 Permissible Track Forces for Railway Vehicles issue 1A.

The literature review concluded that there was insufficient evidence to support a relaxation or tightening of the Q/D limit. Notwithstanding this, it provided useful background information to support further research work to:

1) Determine the current contact stress state of the GB rail network.
2) Assess the relative increase in damage that may result from an increase in contact stress or a reduction in wheel diameter.
3) Assess the influence of contact stress on established track damage prediction tools.
4) Determine whether Q/D is an appropriate parameter to limit contact stress; and whether the current standard should be retained or revised to include a standardised method of contact stress calculation.

The findings determined that the worn wheel profile shape has a greater influence on contact stress than the Q/D ratio. A correlation was found between wheel wear and contact stress, with contact stress increasing with higher levels of wheel wear for a range of rail profiles.

The conclusions are that the Q/D ratio is a practical measure to control contact stress and contact stress driven damage; and increasing the Q/D limit would benefit the freight operating community by potentially extending wheel life, and should enable larger freight containers to be introduced.
The outputs from this research have been used to support the drafting of a standards change proposal changing the Q/D limits for consideration by Standards Committees. They have also informed European discussions in this area where normal contact stress is not considered in the current drafts of either CR LOC&PAS TSI (Conventional Rail Locomotives and Passenger rolling stock) or CR WAG TSI (Conventional Rail Freight Wagons).

A proposal for standards change titled: *GM/TT0088 Permissible Track Forces for Railway Vehicles – Change to Q/D Limit* has been submitted for consideration by Standards Committees. The proposal is on hold pending the broader review of the standard that is planned for early 2015. Industry members can use the T889 research output to support a deviation request in advance of the standards change.
**T963 Managing the effects of train architecture and operational parameters and influences to reduce wheel damage**

**Description**

This research has investigated the influence of train architecture and route conditions on wheel tread damage. It has established a common basis for categorising wheel damage and methodologies to manage wheel damage.

**Abstract**

On behalf of the Vehicle/Track System Interface Committee and the Wheelset Management Group this research has investigated, identified and characterised wheel damage problems faced by rolling stock today. The emphasis is on understanding and resolving the current wheel damage issues.

The key input to this research is the data provided by the train operators and maintainers, comprising 90% of the current UK train fleet.

The research was delivered in five phases:

1. Collate and review existing knowledge of wheel damage and wheelset management.
2. Investigate using existing monitoring technology to detect wheel damage.
3. Assess the impact of train architecture parameters and service patterns on wheel damage.
4. Produce a good practice guide for operators and maintainers.
5. Present the results to operators and maintainers at a series of industry workshops.

The research identified the links between wheel life, train configuration, route conditions, and maintenance practices for many existing UK train fleets.

It confirmed that fleets where the wheel condition is closely monitored and analysed have a better wheel life, with benefits outweighing the costs, than fleets where this is not done.
Abstract

Improved data collection and analysis provides valuable information for developing business cases for improvements. It can also be used to assess potential maintenance strategies, in conjunction with the Wheelset Maintenance Model and the Vehicle Track Interaction Strategic Model.

The research also confirmed that using information acquired from existing monitoring technology provides benefits to train operators and maintainers, by enabling:

- Improved planning of wheelset maintenance and a reduction in unplanned maintenance activities
- Improved vehicle availability
- Extended life of vehicle under frame components

The evaluation showed that operating conditions and maintenance practices (or constraints) have a significant impact on wheel life. Train architecture was seen to have less influence on wheel damage.

The main deliverable for RSSB member companies is the Wheel tread damage guide. It provides a common basis for managing wheel tread damage. It can assist fleet operators in the optimisation of wheel life and thus minimise the associated costs. It includes illustrations of the damage types, what causes them, and methodologies for managing the damage.

The Wheelset Management Group supports the continued promotion of the outputs to the wider industry. The group has agreed that an update to the wheel damage questionnaire should be undertaken in the future, to gain further feedback from the industry.

Publication

August 2013

Current Position

The Wheelset Management Group continues to support the ongoing promotion of the outputs from this research project to the wider industry.
### Vehicle/Track Interaction Projects in Progress

**T774 Research investigating the value, reliability and effectiveness of axle inspection techniques**

<table>
<thead>
<tr>
<th>Description</th>
<th>This research project seeks to provide a process that enables train operators to remove or reduce in-service axle inspection.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Effort is invested in inspecting axles using non-destructive testing (NDT) and inspection at overhaul and during routine maintenance. However, there is concern that the present in-service axle inspection processes provides little benefit because of its relative poor reliability and changes in overhaul practices that have introduced more reliable and effective controls of the risks. On behalf of the Wheelset Management Group, a sub-group of the Vehicle/Track System Interface Committee this research project will evaluate the GB rail industry’s approach to axle inspection. The aim is to provide an engineering process that enables train operators to remove or reduce in-service axle inspection. When it is required, the research will provide guidance that the industry can use to support the management of human performance in the ongoing axle inspection processes. This research is delivered in three parts and will draw upon existing RSSB research and additional human factors research to establish what changes can be made to axle inspection processes. The first is completed which was a scoping study to investigate the effects of human factors in axle inspection. The second is the development and delivery of the human factors support tools that the industry can use. The third is the development of the engineering led process to enable train operators to remove or reduce in-service axle NDT. Benefits are expected to come from a reduction in the frequency of in-service testing, which should lead to time and cost savings for operators and maintainers while providing them with the reassurance that by following a robust process they will continue to maintain the high level of safety integrity that exists today.</td>
</tr>
<tr>
<td>Published</td>
<td>Ongoing</td>
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</tbody>
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Vehicle/Track Interaction – Projects in progress
Current Position

The first part of this research project, a scoping study has been completed and was published in 2011. This study considered common NDT techniques, such as ultrasonic testing, magnetic particle inspection and eddy current testing.

The second part of this research project is being delivered as two elements. The first element will provide improved understanding of the human factors issues that can influence the performance of inspection tasks and a good practice guide for non-human factors specialists to assess the effectiveness of human performance in the axle inspection process.

The second element will provide a robust process that can be applied by the industry to determine if in-service axle NDT inspections can be reduced or removed. This has the potential to save the industry time and money.
### T797  Performance and installation criteria for sanding systems

#### Description
Research into sanding system parameters and their operational use to establish if adoption of different sanding strategies and use of modified sanding rates would improve train performance in low adhesion conditions.

#### Abstract
The installation of sanding systems onto multiple units is covered by Railway Group Standard (RGS), GM/RT2461 ‘Sanding Equipment Fitted to Multiple Units and On-Track Machines’. Since this standard was produced, the industry has gained significant operational knowledge from service experience and there have been major developments in modern sanding systems.

On behalf of the Adhesion Research Group, a sub-group of the Vehicle/Track System Interface Committee the research is expected to involve a review of current practices, technology, research, and development. Laboratory tests will be completed possibly followed by validation using track testing on repeatable and simulated GB low adhesion conditions. The validation work will be used to determine the performance of the sanding equipment under normal and emergency operation and the possible trade-off from increased risk of loss of train detection. The results will be used to propose and justify alterations to the sanding criteria in a revision to GM/RT2461 and associated guidance information.

The research and relevant RGS development will enable the industry to exploit the performance benefits demonstrated subject to the scale and cost of an identifiable sanding improvement option.

#### Published
Ongoing

#### Current Position
Initial findings from the research project have been shared with the Adhesion Working Group, ATOC Engineering Council and ATOC Engineering Forum. Proposals to conduct validation using dynamic track testing of optimal sander configuration are being progressed. This is programmed to complete in 2015.
## T920  Euraxles – Minimising the risk of fatigue failure of railway axles: FP7 3rd Call

### Description
The EC Framework Programme 7 project ‘Minimising the risk of fatigue failure of railway axles’ looking at axle design fatigue limits, axle corrosion mitigation and work on non-destructive testing. RSSB is an advisory member and will have access to the results on behalf of the GB rail industry.

### Abstract
The EC Framework Programme 7 project ‘Minimising the risk of fatigue failure of railway axles’ aims to develop further knowledge that will allow the whole life costs of wheelsets to be optimised without affecting safety or the environment.

On behalf of the Wheelset Management Group, a sub-group of the Vehicle/Track System Interface Committee, RSSB has secured membership of the advisory committee for the research project. This will allow previous and ongoing RSSB-managed research to be used to inform this research project as well as drawing upon GB rail experience.

This European research project will support updates to GB and European standards for railway axles and wheelsets that will lead to changes to design validation and inspection technologies and methodologies of the wheel axle. The business benefit from this research will arise from addressing the fundamentals of design for operation and maintenance for axles and will be of long term interest to RoSCos, wheelset suppliers and train operators.

### Publication
Ongoing

### Current Position
RSSB is a member of the Project Advisory Group for this European Consortium project. This project is looking at the operating environment experienced by axles to enhance wheelset design and maintenance practices and specifically looking at minimising the risk of fatigue failure of railway axles. The project kicked-off in November 2010 and is programmed to complete in 2014.
T923 Axle-end equipment: service accelerations and resonance

Description
Developing knowledge and understanding about the influences of vehicle- and track-generated forces on axle-end equipment and establishing what rolling stock and track engineers can do to improve the survivability of such components.

Abstract
On behalf of the Vehicle/Track System Interface Committee this research project aims to further the industry’s knowledge and understanding of the forces experienced by axle-end equipment, the track and vehicle characteristics that contribute to them, and how those effects might be mitigated to minimise axle-end equipment failures.

Rail vehicle manufacturers have to comply with the requirements for the attachment of axle-end equipment set out in the standards such as GM/RT 2100 Structural Requirements for Railway Vehicles and BS EN 61373:2010 Railway applications. Rolling stock equipment: Shock and vibration tests. The standards requirements for equipment attached to the axle-ends are for typical conditions and may be varied with appropriate justification. It can be argued that the design process relies too much on the competence of rolling stock engineers and their knowledge and experience of the environment and conditions within which the rolling stock is to operate.

This has been made evident in the failure of axle-end components (and their associated fastenings) such as lifeguards and speed probes. These have caused significant adverse impact to the reliability and availability of affected fleets.

The research will evaluate the operating environment, to propose changes that help rolling stock engineers and designers optimise the engineering of axle-end components. The research will also identify how the dynamic response of any train varies during service operation, including any resonance frequency inputs that contribute to axle-end equipment failure. Finally, the influence of train characteristics will also be reviewed, to understand how these affect axle-end resonance and resulting equipment failures.
A better understanding of the influence of infrastructure conditions and environment on axle-end components should enable the industry to define the parameters for optimal design of axle-end components. It should also identify which track features have the most significant impact, and how they should be managed by track engineers. Facilitating the understanding and interpretation of vehicle/track data will enable manufacturers to distinguish between the vehicle-ride and track characteristics that cause the exceedences observed in testing. It will also allow designers, testers, and track standards bodies to determine a pragmatic way of managing this issue to reduce fatigue failure of axle-end equipment and therefore the associated cost of repairs.

The research will provide a report that advises on the system effects on axle-end resonance, how these might be addressed, the parameters to which specific axle-end components should be designed and validated, and to advise on changes to standards. Supplementary guidance on the methods for assessing data inputs, such as vehicle response versus track quality, will be provided.

The objectives and scope for this research project have undergone extensive review with V/T SIC and V/T SIC TAG. The outcome was consensus by the industry on what was required to address this issue. The main thrust of this research project will assess correlation methods between track force outputs and their effect on vehicle responses that result in Axle End Equipment component failure. It is planned for this work to complete late Autumn 2015.
Description

This research will develop a system to identify low adhesion conditions from onboard railway vehicles, by measuring and analysing the dynamic response of wheelsets and bogies during normal running.

Abstract

Low adhesion costs the industry significant sums of money each year, not only for various railhead treatments to minimise the occurrence of low adhesion conditions, but also for reduced operational performance and for repair of wheel and rail damage where railhead treatments are not successful. On behalf of the Vehicle/Track Systems Interface Committee and Technical Strategy Leadership Group this research seeks to investigate a novel, conceptually-different method for identifying low adhesion conditions from onboard railway vehicles. Its key feature being that it can operate in real time, while running normally.

The method is a predictive technique based on measuring what is happening dynamically to the wheelsets and bogie during normal running (prior to braking), and using this to deduce information about the level of adhesion available for braking. It relies upon the fact that the force generation mechanism between the wheel and the rail is the same for braking (and traction) forces as it is for guidance forces, and therefore changes in adhesion can be detected by monitoring the movements of the wheelsets and bogie.

Previous RSSB-managed research (T614) showed that, when the level of adhesion starts to fall by more than about 10%, there is a major effect upon the running dynamics of the bogie. The scientific and engineering challenge is to interpret these in terms of adhesion levels. The technique's utility will depend upon how accurately, and at what update rate, the low adhesion detection system can provide information, which is as yet unknown.

The Adhesion Working Group manual 'Managing Low Adhesion' estimates that the annual cost of low adhesion to the GB rail industry as a whole exceeds £50m. It is anticipated that if this research is successful, it can deliver savings of some £23m to the industry in the first 20 years.
### Publication

**Current Position**

Work to develop the on-board detection of low adhesion concept and validation using Vampire simulation has completed. Two key recommendations that have emerged from the research so far:

- The research should move forward to the next step in the validation of the low adhesion detection concept through track testing.
- Further work related to assessment of the processing needs.

The industry decision that was being progressed was to start a final work package of practical track tests. In these an instrumented vehicle would collect data while running at different speeds over track which has artificial and measurable low adhesion sections. This would allow processing algorithms to be further validated offline.

An extensive tendering exercise subsequently failed mainly due to securing industry support in with rolling stock and mitigating the testing risk & liability.

Alternative delivery mechanisms have been explored to no avail resulting in an industry decision to cease further progress.
T996  Categorising the relationship between track condition, line speed, and vehicle forces

Description
Provide the GB rail industry with the means to assess the compatibility of rolling stock at different speeds related to track condition.

Abstract
On behalf of the Vehicle/Track System Interface Committee, this research project is seeking to provide the GB rail industry with the means to assess the compatibility of rolling stock at different speeds related to track condition.

The research is expected to define and examine the parameters that are relevant to track engineers, train specifiers and designers, and rolling stock engineers, and develop a consistent assessment process for both track and vehicles. The research will consider the speed-dependent interfaces, develop and document a categorisation system based on these, define the proposed categories and ‘go anywhere’ values, and ultimately define how this is formalised within the GB rail standards process.

The research project is expected to be delivered in four distinct phases

Phase 1 - will identify, collate, review, analyse and summarise the parameters for vehicle designs and track condition assessment which influence the assessment of train, route and speed compatibility.

Phase 2 – will establish the advantages and limitations of using these parameters to assess train, route and speed compatibility.

Phase 3 – will develop a method to consistently and reliably assess compatibility between rail vehicles and permissible speeds on the infrastructure.

Phase 4 - will develop an implementation strategy that enables the industry to pick-up, use and apply the accepted method promptly and efficiently.

The output from this work will provide a practical “system based method” that can be applied by competent engineers.
Abstract

The implementation activities must ensure that an effective and pragmatic means of determining the relevant line speed is provided for and that the track maintenance implications can be evaluated and managed by the track engineer. The implementation strategy will also provide affirmation to the wider industry that 'state-of-the-art' requirements can be achieved, particularly for the future railway.

The expected benefit from this research is that the GB rail industry will have a straightforward clearly defined and agreed cross industry, up-to-date method that can be applied by the infrastructure manager, the rolling stock owners and operators, and the rolling stock designers and manufacturers, when assessing track condition, introducing new trains, cascading or refurbishing existing trains. This should remove the need to undertake expensive, time consuming and uncertain assessment and analysis processes to demonstrate compatibility.

Publication

Ongoing

Current Position

The work for this research project kicked-off in August 2012 and is planned to complete early Summer 2014.

The research comprises four phases:

1. Identification, collation, review, analysis and summarisation of the parameters for vehicle designs and track condition assessment which influence the assessment of train, route and speed compatibility.

2. Establish the advantages and limitations of using these parameters to assess train, route and speed compatibility.

3. Development of a methodology to assess consistently and reliably compatibility between rail vehicles and permissible speeds on the infrastructure.

4. Delivery of an implementation strategy to help the industry pick-up, use and apply the accepted research outputs promptly and efficiently. This will demonstrate how this can be applied and the benefits to the targeted users.
**T1042 Investigation into the effects of moisture on rail adhesion**

**Description**
This research will draw together existing knowledge of the effects of moisture on rail adhesion, and develop a better understanding of what has come to be known as ‘wet rail’ phenomenon.

**Abstract**
The effect of moisture at the wheel/rail interface, caused by dew and other damp conditions, is not widely understood. It is, however, subject to much debate and supposition. It is also an area where some academic and industrial research has been undertaken, though the results of these studies have not been collated into a single, readily useable body of knowledge on the subject.

On behalf of the Adhesion Research Group this research project aims to review and collate the available knowledge on the subject. From that knowledge it will determine what is robust, and thereby:

- Deliver an overall definition of the ‘Wet Rail’ phenomenon
- Document the tried and tested mitigation that exists
- Provide a better understanding of the subject
- Allow industry to target, prioritise, and co-ordinate further work and investigation

These will be delivered through comprehensive stakeholder engagement, investigation, and analysis.

Moisture-related delays are estimated to cost £3m per year. The objective of the research is to advance cross-industry thinking in this area. In doing so the research could facilitate the reduction of the impact and costs of moisture-related adhesion problems.
The work for this research project kicked-off in October 2013 and is planned to complete early summer 2014. The research comprises 4 elements to:

1. Establish what existing work has been done to quantify current knowledge and perceptions
2. Provide a definition of the problem and establish what has been done by industry.
3. Establish what mitigation exists.
4. Provide an analysis of output looking at the bigger picture
Where can I find research?

Details of all the research projects that have been published since RSSB began its programme can be found using the ‘Research Project Catalogue’:

http://www.rssb.co.uk/research-development-and-innovation/research-and-development/research-project-catalogue

If you know the reference number for the project – eg TXXX – you can use the Search field at the top of the projects list to find it. Alternatively enter a keyword in the Search field to find all the projects with that word in their title.

The previous pages contain listings of the published and current Vehicle/Track Interaction projects – correct at the time of publication.

We hope this helps you find the information that is most relevant to you.
Each project has a research brief that provides a concise summary

Research Brief
Trials of wheel and rail rolling contact fatigue control measures
Stage 4: Post-remediation monitoring and development of the SOLs
T613 - September 2010

Overview

Rolling contact fatigue (RCF) has the potential to reduce rail asset life cycles and is a financial burden for infrastructure companies. However, ongoing research in this field has expanded our knowledge of the conditions that contribute to RCF, and of management techniques to mitigate RCF more effectively. The ongoing RCF investigation programme has been progressed on behalf of the Vehicle/Track System Interface Committee (V/T SIC) and is managed by RSSB in collaboration with the V/T SIC Permanent Project Group (PPG).

This research project focused on testing the tools and techniques developed during previous phases of the ongoing RCF investigation programme; applying the appropriate remediation measures, under controlled conditions, to validate the proposed sustainable operation limits (SOLs), and monitoring the end results. The work included modeling the effects of new trains, on which the suspension had been modified in line with previously recommended enhancements. It is considered that this work can help to support the business case for the wider adoption of SOLs by Network Rail (NR).

The focus was on two routes with different geometrical characteristics:

1. The Trans-Pennine Express (TPE) route. Part of the research offered the opportunity to evaluate the effect of the introduction of the new fleet of Class 185 diesel multiple units (DMUs). The core Manchester to Leeds route contains a variety of track conditions, including lightly curved sections.

2. The Great Western (GW) route. This was a study of contrast, based around a well-established fleet running on a high-speed mainline route, much of which is relatively straight.
Where can I find research?

SPARK provides a way for the rail sector and others to work together and share knowledge more efficiently on-line, with the aim of reducing duplication, speeding up innovation, and maximising value.

Researchers, innovators, and decision makers across the rail community are able to upload and share information via SPARK so other users can find out what is known and who knows it, and this creates opportunities for networking and cooperation.

In partnership with UIC, RSSB is enhancing SPARK to create an even bigger on-line ‘knowledge sharing community’, drawing on the combined wisdom from railway administrations and centres of excellence across the globe.

During this enhancement phase, access to SPARK will continue to be available to RSSB members, knowledge sharing partners and registered researchers in the Rail Research UK Association. From early 2013 new access levels will be available, including that of ‘reader’ which is open to all.

Register for access to SPARK at:
http://www.sparkrail.org
More information

The RSSB R&D e-newsletter is an email bulletin that keeps the industry updated on the latest research projects to be started or published.

To view the most recent edition and to sign up for your own copy, visit:

http://www.rssb.co.uk/research-development-and-innovation/research-and-development/r-d-e-newsletter

If you have enquiries about research RSSB Enquiry Desk – enquirydesk@rssb.co.uk, tel 020 3142 5400