Heavy Vehicle Wheel Detachment FERA Seminar

Presented by Martin Dodd

Research Engineer

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Presentation Summary

- **Introduction to TRL**
- **Overview of the project**
- **Phase I**
  - Research Methods
  - Summary of findings
- **Phase II**
  - Objectives
  - Research Methods

TRL – Transport Research Laboratory

- **Established in 1933**
- **Privatised in 1996**
- **550+ staff including many world recognised experts**
- **Head office in Crowthorne, Berkshire**
  - Offices in Scotland, Wales and Australia
  - Project offices overseas

Transport Research Foundation

Parent Company of TRL

- **Vision = *Creating value through the generation and application of knowledge***
- **Created 1st April 1996**
- **Impartial and commercially independent**
- **A company limited by guarantee, with sector members and no shareholders.**
- **Non profit distributing company**
  - TRF re-invests funding within TRL enabling us to undertake Scientific Research

Our Work

Vehicle Safety & Engineering

- Primary and Secondary Safety
- Child Safety
- Biomechanics & Dummy Development
- Pedestrian Safety
- Virtual Testing
- Compatibility

Facilities

- Driving Simulation
- Private Test Track and Road Network
- Impact Testing
- Tyre Road Noise Testing

Facilities

- **3D Laser Scanning**
- **Rapid Response Incident Investigations**
- **Computer Modelling**
- **Structural Testing**
- **Pavement Testing**

Facilities - TruckSIM

- **Real truck cabin mounted on motion platform**
- **Replicates real life driving conditions**
  - Different load types
  - Configurations
- **Simulates different driving conditions**
  - Bad weather
- **Used for driver training**

Facilities - TRL Research Track

- **Central Area**
  - 270m diameter
  - 200m & 120m dia circles
  - Spray bars
- **Long Straight**
  - 550m long
  - 3 x 3m lanes
  - Spray bars
- **Large Loop**
  - 2km long
- **Banked Bend**
- **Small Road System**
  - Urban road conditions
  - 2.5km total length

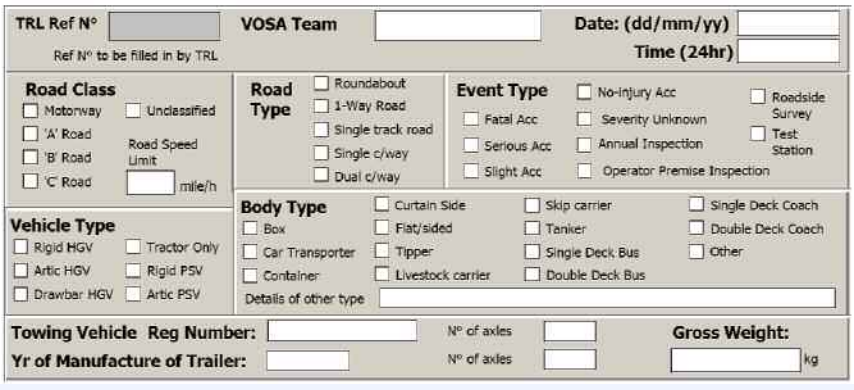
Heavy Vehicle Wheel Detachment

- **Commissioned by UK Department for Transport**
- **Phase I - completed**
  - Quantify current frequency of wheel fixing problems
  - Assess current practices within the industry
  - Identify potential solutions
- **Phase II – started June 2007**
  - Standardisation of best practice for wheel tightening and maintenance
  - Assess effectiveness and durability of identified solutions

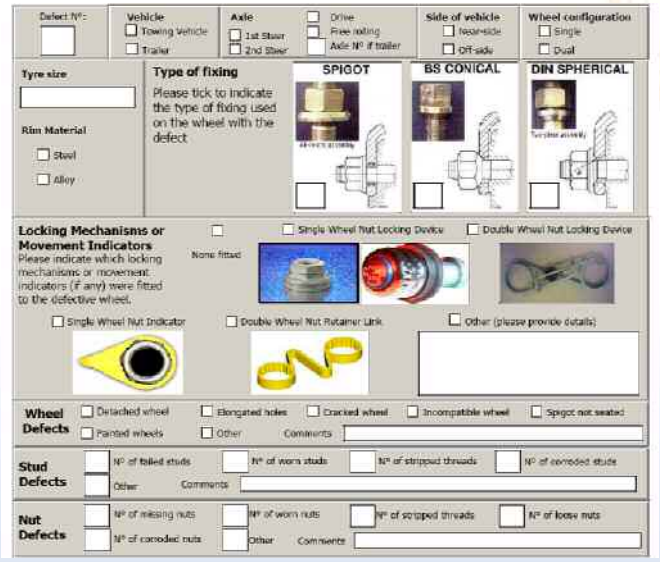
Frequency survey

- **VOSA/ACPO frequency survey**
  - Vehicle and Operator Services Agency (VOSA)
  - Association of Chief Police Officers (ACPO)
- **3 months in duration**
  - VOSA: Nov 2005 – Jan 2006
  - ACPO: Jan 2006 – Mar 2006
- **VOSA**
  - Examinations at operators premises, roadside spot checks and post-collision investigations
- **ACPO**
  - Distributed to officers involved in collision investigation

Survey Form



Survey Form



Analysis of existing data

- **UK data**
  - Institute of Road Transport Engineers (IRTE) survey (1986)
  - VOSA/ACPO survey, 1997
  - VOSA Prohibitions database
  - VOSA collisions database
  - Heavy Vehicle Crash Injury Study (HVCIS) fatals database
- **EU data**
  - Request for information – letter
    - Enforcement authorities
    - CITA
    - Other organisations

Questionnaire surveys

- **Questionnaire surveys**
  - Drivers
  - Operators
  - Manufacturers/component suppliers
- **Information obtained:**
  - Frequency of incidents
  - Maintenance practices
  - Perceptions about the causes, costs and possible solutions

Questionnaire surveys

- **Drivers survey**
  - Interviews at VOSA enforcement sites
  - Interviews at motorway service areas
  - Drivers of TRL's Scottish Truck Simulator (ScotSIM) Received 521 completed questionnaires (Target N°: 500)
- **Operators survey**
  - Range of firms – distance travelled and commodities carried
  - Received 21 replied (Target N°: 30)
- **Manufacturers survey**
  - Majority were involved in design/manufacture of components for solving wheel fixing problems
  - Received 12 replies (Target N°: 30)

Fixing standards and tightening methods

- **Literature review**
  - Design and construction of wheel fixings
  - Tightening procedures used within industry

Frequency of wheel fixing problems in the UK

Information source	Predicted number of incidences per year					
	Wheel nuts loose or missing	Other fixing defects (e.g. stud failures)	Wheel detachment	Damage only collision as a result of detachment	Injury accidents as a result of wheel detachment	Fatal accidents as a result of wheel detachment
VOSA Survey(DETR, 1998)	7,990		175			
ACPO Survey (DETR 1998)			368	140	16	0
VOSA Survey (TRL 2005)	3,886		254			
TRL driver survey (2005)	206,047		4,547			
TRL operator survey (2005)	1,206		132			
VOSA prohibition database (2002-2005)	8,520	2,031	224			
VOSA Collision database				80% of all accidents involving wheel detachment	16% of all accidents involving wheel detachment	4% of all accidents involving wheel detachment
HVCIS fatal database (1988-2001)						4

TRL estimate of wheel fixing problem

- **Typical annual frequency of wheel fixing problems:**
  - 7,500 – 11,000 wheel fixing defects
  - 150 – 400 wheel detachments
  - 50-134 resulting in damage only accidents
  - 10 – 27 resulting in injury accidents
  - 3 – 7 resulting in fatal accidents

Location of defect

- **Previous literature discussed bias towards left side of vehicle**
- **Data from this project showed:**
  - Small bias for loose/missing wheel nuts (56/44)
  - Large bias for wheel detachments (79/21)
- **VOSA survey**
  - Strong bias towards problems on drive axle (46%)
  - Drivers and operators survey agreed (40% and 62%)

Wheel fixing standards & tightening procedures

- **Most procedures agree on main principles**
  - Daily checks must be carried out
  - Periodic check/re-torques required
  - Need for clean mating surfaces
  - Correctly matched parts
  - Trained personnel
- **Some conflicting recommendations identified**
  - Tightening torque: varied between 500Nm – 850Nm
  - Lubrication?
  - Re-torquing
    - After specific distance: 40km – 200km
    - After specific time: 30 minutes
    - Slacken and re-tighten

Wheel fixing standards & tightening procedures

- **Nearly all operators reported having procedures in place for wheel maintenance**
  - **100%** operators reported that drivers should carry out daily visual checks
  - **95%** stated this should include specific check of wheel nut security
  - Only **76%** of drivers reported always carrying out daily checks
  - Only **68%** specifically checked for wheel fixing defects
  - **2%** never carry out daily checks
  - **5%** of operators never check wheel security during routine maintenance
  - **50%** of drivers and **42%** of operators used re-torque procedures not in accordance with best practice guidelines

Potential solutions

- **Prevent problem occurring**
  - Fundamental change to wheel fixing design
  - Wheel nut retention devices
    - Disc-lock
    - Wheelsure
    - Wheel Crown



- **Mitigate consequences of loose wheel nuts**
  - Directionally threaded wheel nuts
  - Movement indicators
    - Ric-clip
    - Wheel-ex
    - Safety-trim
    - Check-link



Proposed Methodology

- **Mathematical analysis of clamp force requirements**
- **Standardisation of best practice for wheel tightening and maintenance**
- **Effectiveness and durability of various countermeasures**

Standardisation of best practice

- **Phase I included a theoretical review**
- **Phase II to include physical testing**
- **Two aspects**
  - Initial tightening procedure
  - Re-torque

Initial tightening

- **Bench tests**
  - Wheel hub and load cell
- **Magnitude and consistency of clamp load**
- **Focused on areas of disagreement**
  - Tightening method – (torque/ angle)
  - Magnitude of torque/angle
  - Lubrication?
  - Material type/ stud size
  - Effect of new/old studs
- **Any other factors to consider?**

Re-torque

- **Agreed it's necessary…but when?**
- **Track tests**
  - 6x4 tipper
- **Monitor clamp load**
  - Time
  - Distance travelled

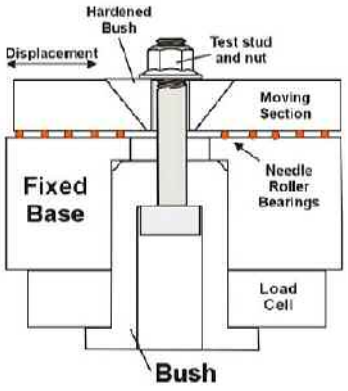
- **Mark positions of wheel nuts**
- **Instrumented wheel studs**
  - Strain gauge and telemetry

Effectiveness and durability

- **Nut loosening or wheel detachment is statistically rare**
- **Phase I: 7,500 – 11,000 incidents per year**
- **One incident every 3.1 - 4.6 million vehicle-km**
- **In-service data**
  - Controlled trial covering 1 billion vehicle-km
  - e.g. 2,000 vehicles covering 250,000km/year for 2 years!
  - Expensive and time consuming
- **Need to simulate the problem in a much shorter timescale**

Junkers test

- Loosen nuts and reduce clamp load in a short space of time
- Stage I – mechanism to allow clamp load to fall
- Stage II – Vibration loosening of nut
- Bearings eliminate friction
- Only assess Stage II
- We need a Junkers machine!!



Effectiveness and durability

- Junkers still considered most cost-effective means of assessing a range of solutions, including:
- Wheel nut indicators
  - Relationship between angle and clamp load
- Disc-lock & Wheelsure
  - Designed to maintain clamp load
  - Potential for stud failure without maintenance
- Ric-clip, Check-link, Safety Trim
  - Prevent nut rotating off
  - Assess amount of clamp load that may be lost
- Other devices considered

Validation trials

- **Above methods not fully representative of behaviour in real service**
- **To validate findings a full scale trial has been proposed**
  - Accelerated wear test on a proving ground
  - Repeated harsh cornering, braking, acceleration
  - Driving over un-even surface – severe vibrations
- **Validation trials expected to last 2 months**

Thank you for your attention

Phase I Report

- **Available from the online store on TRL website:**
- **http://www.trl.co.uk/store/report_detail.asp?srid=5502&pid=108**

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Tel: 01344 770699 Email:mdodd@trl.co.uk