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Reducing Rail RCF through Better Wheel Shapes

ICRI Conference, Vancouver, 2016

Paul Molyneux-Berry

University of Huddersfield Institute of Railway Research

In partnership with the Rail Safety and Standards Board

Inspiring tomorrow's professionals

Contents

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Influence of Wheel Shape on Rail RCF

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- Higher conicity wheel/rail combinations have greater RRD and generate greater steering forces
  - More likely to cause RCF
- We should be able to reduce RCF by reducing conicity
  - But there may be a penalty in wear damage
  - Changes to reduce damage on one curve radius may cause more damage on other curve radii
- How to reduce conicity?
  - Change rail profile
    - Grinding, can be done to different profile depending on curve radius
  - Change design wheel profile
  - Change wheelset maintenance
    - more frequent reprofiling to prevent conicity rising due to wear

Δr_1 as a measure of RRD

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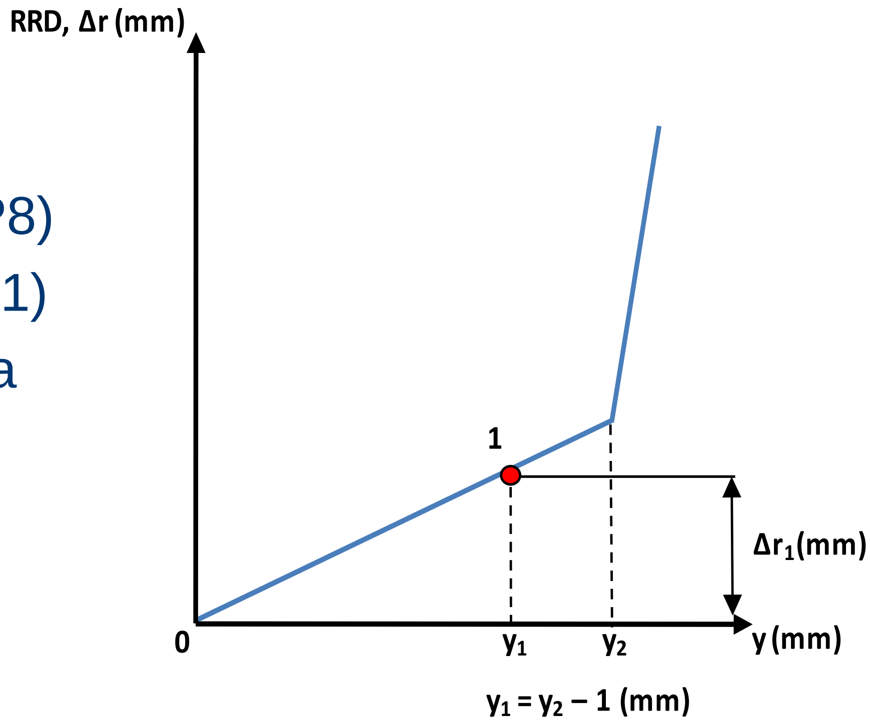
- To generate significant RRD, contact must occur between the wheel and rail on the gauge shoulder of the rail
- Δr_1 is the rolling radius difference 1mm before flange contact
- Wheel/rail pairs with:
  - High Δr_1 are prone to RCF (e.g. P8)
  - Low Δr_1 are prone to wear (e.g. P1)
  - Wheel profiles with low Δr_1 have a substantial gap or relief between flange root of the wheel and the gauge shoulder of the rail



Example from c2c

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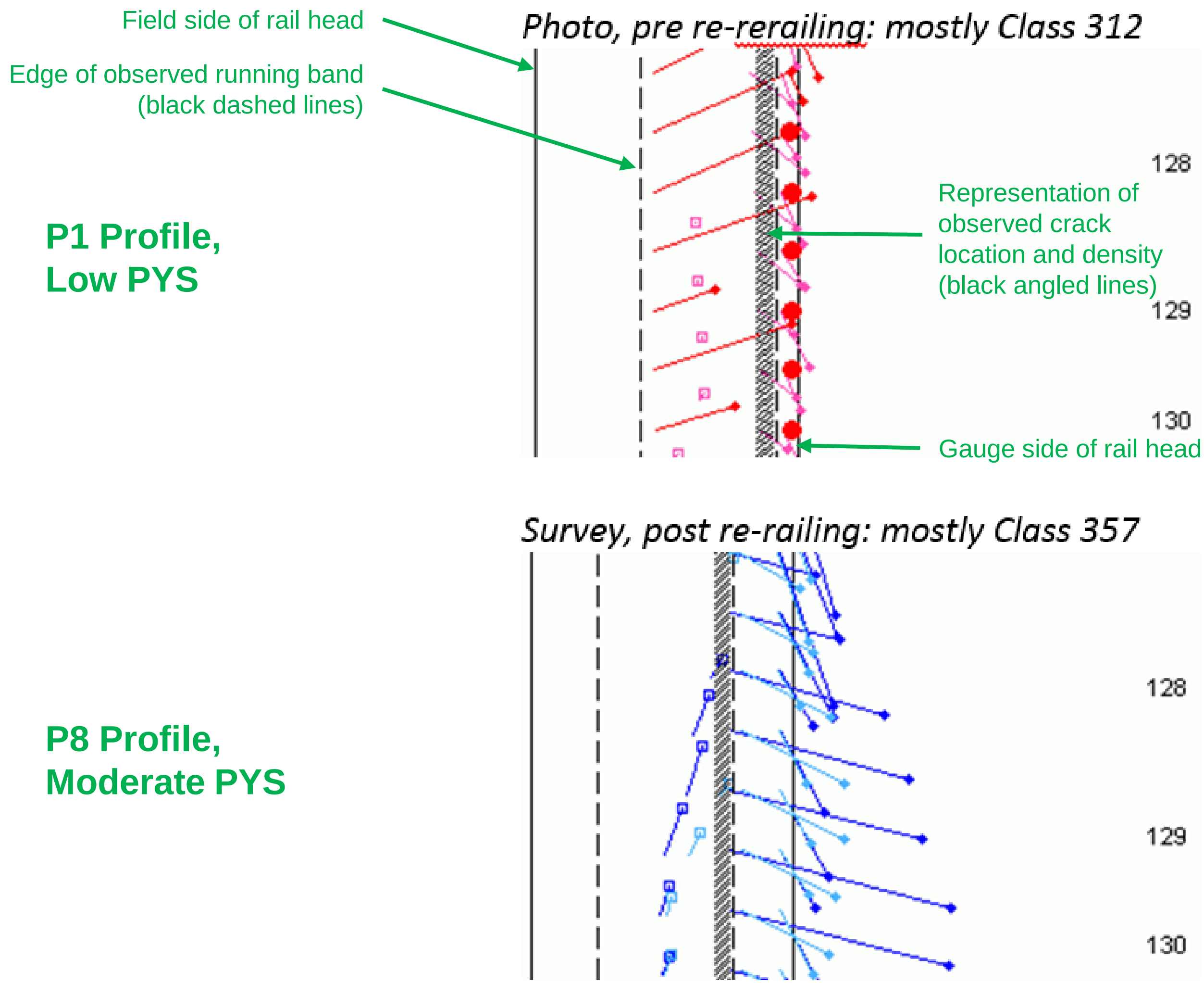
Location:
High Rail (Left)
East Ham Depot
Sleeper 128

Damage Types:
Photo (pre-rerailing)
H1 Sidewear
H2 Classic RCF
Survey (post-rerailing)
H2 Classic RCF

Causes:
H1: Class 312 leading
H2: CL312&CL357 ldg

Plotted Examples:
♦T775_EHD_312MWS9_mod
▫T775_EHD_312MWS10_mod
♦T775_EHD_312MWS9_holo
▫T775_EHD_312MWS10_holo

♦T775_EHD_357TWS1_mod
▫T775_EHD_357TWS2_mod
♦T775_EHD_357TWS1_worn
▫T775_EHD_357TWS2_worn



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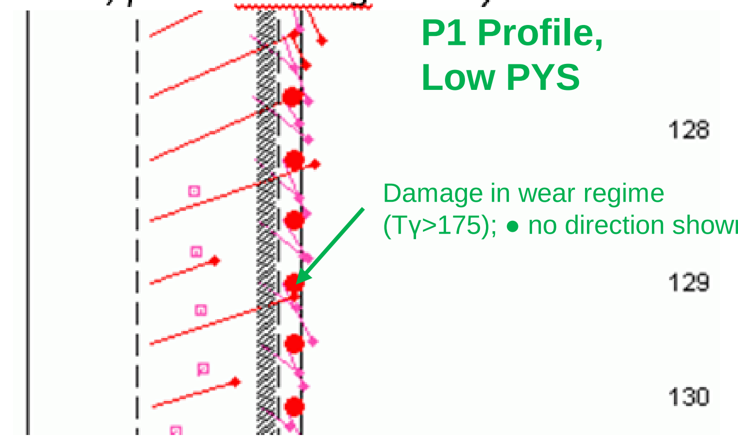
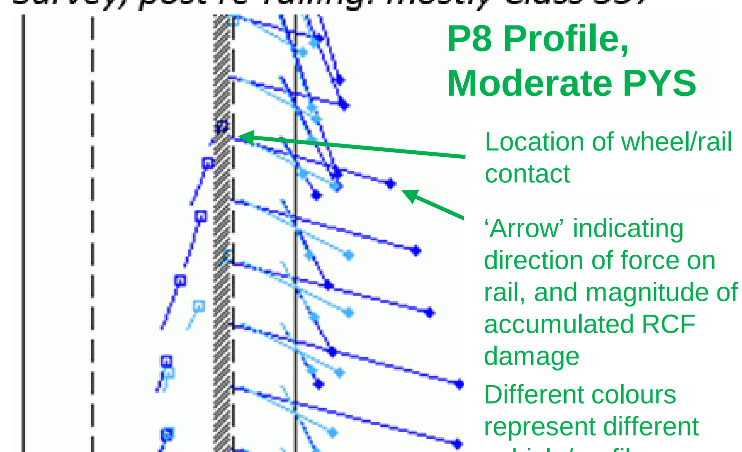
♦T775_EHD_357TWS1_mod
□T775_EHD_357TWS2_mod
♦T775_EHD_357TWS1_worn
□T775_EHD_357TWS2_worn

Photo, pre re-rerailing: mostly Class 312



Survey, post re-railing: mostly Class 357



Different colours represent different vehicle/profile cases
♦ = leading wheelset
□ = trailing wheelset

Example from c2c

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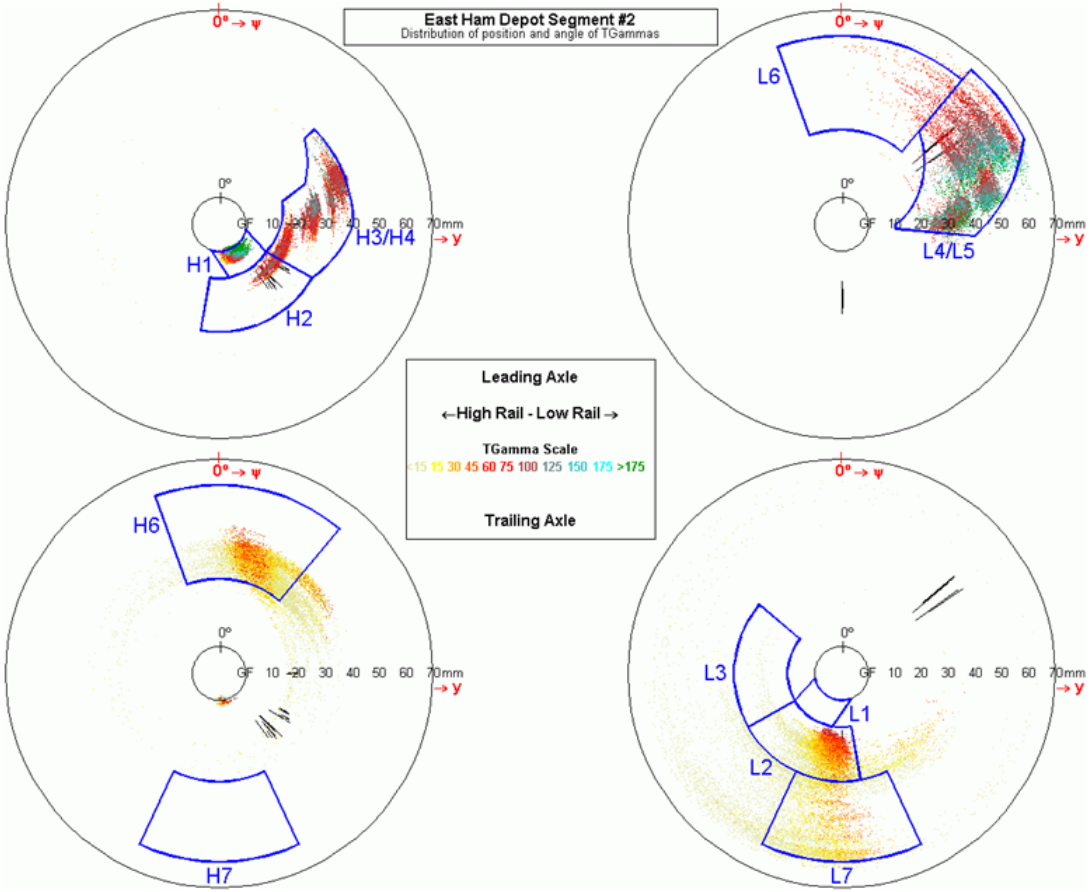
The different types and locations of rail damage can also be shown on a 'circle plot'

Damage tends to form in distinct 'clusters' on these plots which can be associated with each damage mechanism



H1	High Rail Sidewear	L1	Low Rail Sidewear
H2	Classic High Rail RCF	L2	Classic Low Rail RCF
H3	Plastic Flow to Gauge Side	L3	Plastic Flow to Gauge Side
H4	Longitudinal Cracks/Spalling	L4	Field Side Cracks
		L5	Plastic Flow to Field Side
H6	Longitudinal Flow With Traffic	L6	Longitudinal Flow With Traffic
H7	Longitudinal Flow Against Traffic	L7	Longitudinal Flow Against Traffic

The P12 Wheel Profile

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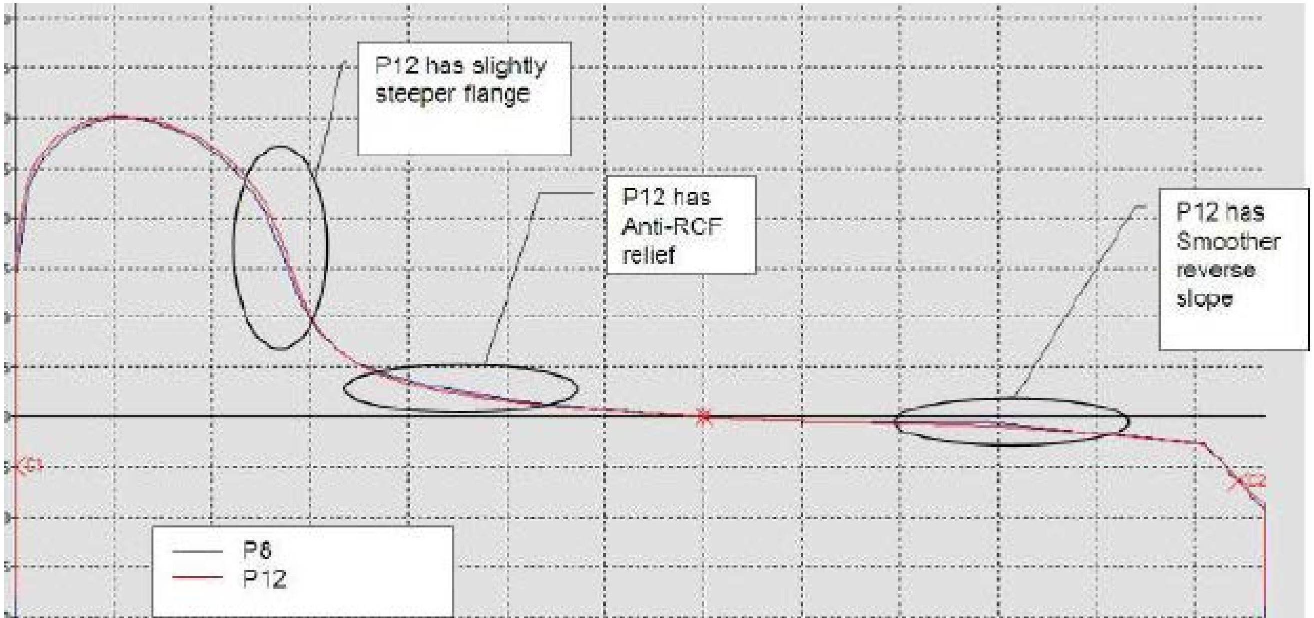
- Developed by NRC Canada in 2004 for RSSB WRISA committee
- Very similar to P8, the most common wheel profile on UK passenger vehicles
- Subtle changes made to 3 areas of the profile:



Δr_1 for P12 and P8

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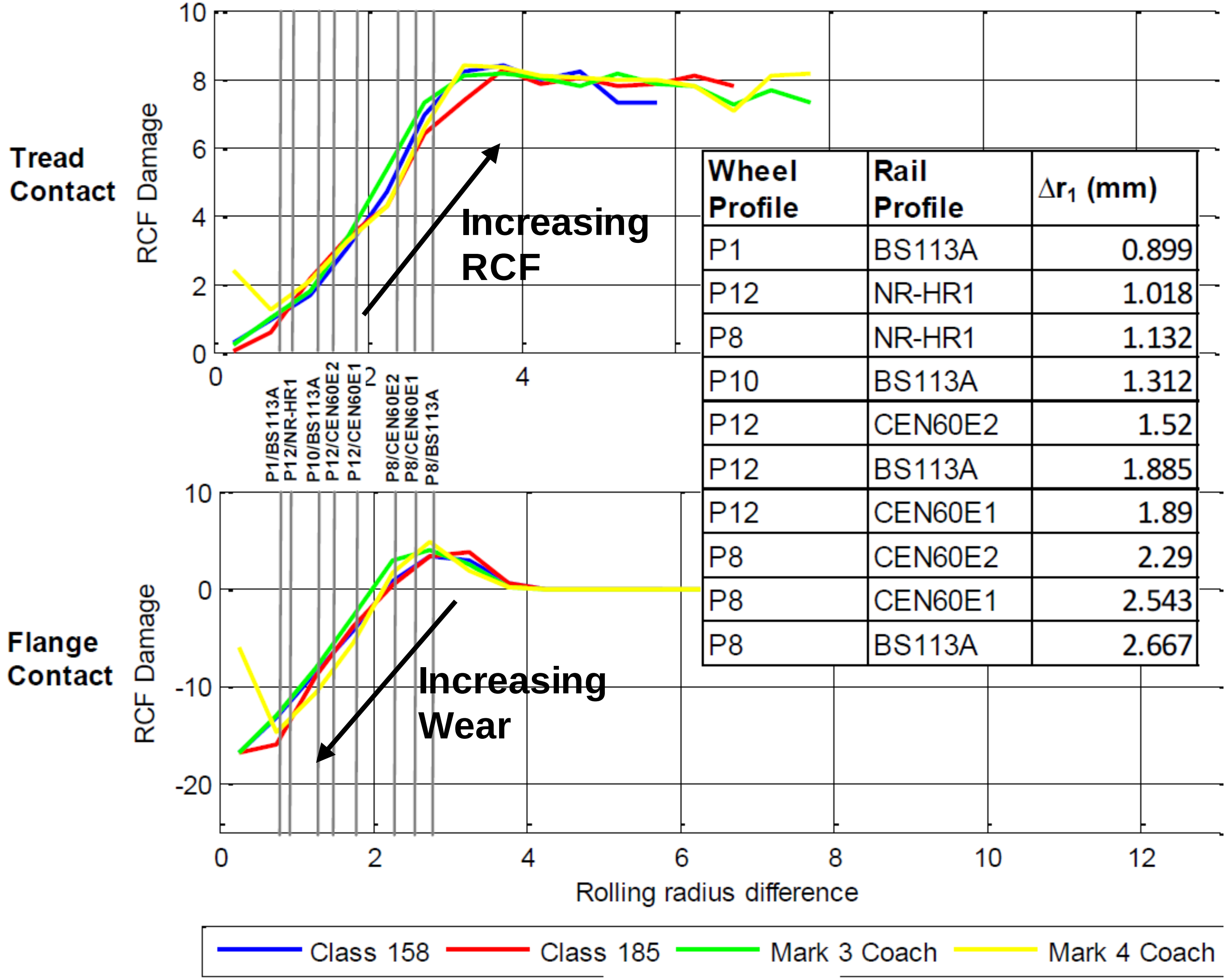

Wheel Profile	Rail Profile	Δr_1 (mm)
P1	BS113A	0.899
P12	NR-HR1	1.018
P8	NR-HR1	1.132
P10	BS113A	1.312
P12	CEN60E2	1.52
P12	BS113A	1.885
P12	CEN60E1	1.89
P8	CEN60E2	2.29
P8	CEN60E1	2.543
P8	BS113A	2.667

Trials and Implementation

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- P12 wheel profiles have been applied to six train types:
  - Class 68 Diesel Locomotive
  - Class 380 EMU
  - Class 390 EMU
  - Class 395 EMU
  - Class 444 EMU
  - Class 450 EMU
- I'll consider each application over the next few slides

UK Light (Class 68) Locomotive

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- Vossloh ‘UK Light’ Mixed-Traffic Diesel Loco
- Bo-Bo, 3800hp, 80 tonnes, 100mph, disc braked
- Small fleet – 25 in service, 7 more on order
- Delivered from 2013, fitted with P12 from new
  - P12 chosen to extend wheel life and reduce track forces
  - New, small and widespread fleet unlikely to have a measurable effect on rail RCF
  - Wheel life is extended: P12 maintains lower conicity, lower RCF and wear compared to similar locos with P8 profile
  - Ride also remains excellent

Thanks to Andy Martlew at DRS

Class 380 EMU

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- Siemens ‘Desiro’ EMU for ScotRail
- Glasgow outer suburban services, max speed 100mph
- Fleet comprises 130 vehicles in 3 & 4 car sets
- Delivered from 2010, fitted with P12 from new
- Operate among other EMU fleets with P8 profiles
  - Some routes dominated by 380s
  - Initial wear problems apparent but have now settled down?

Class 390 EMU

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- Alstom ‘Pendolino’ ICEMU for West Coast Main Line
- Max speed 125mph, tilting train (high cant deficiency)
- Fleet comprises 583 vehicles in 9 & 11 car sets
- Dominate traffic on some parts of WCML
- Delivered from 2002, P12 trialled from 2010 and rolled out fleet-wide from 2012
  - Main purpose was to reduce conicity and extend wheel reprofiling intervals
  - Very successful in achieving these goals, wheel wear and RCF also reduced

Thanks to John Williams at Alstom and Mark Burstow at Network Rail

Class 395 EMU

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- Hitachi 'Javelin' EMU for London outer suburban trains
- Runs partly on High Speed Line (to EU standards) and partly on conventional routes
- Max speed 140mph
- Fleet of 174 vehicles in 6 car sets, delivered in 2009
- P12 successfully trialled and rolled out fleet-wide
  - Stability problems resolved
  - No increase in wheel wear
  - Reprofiling periodicity doubled
  - Dynamic behaviour through switches has improved

Class 444 and 450 EMU

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- Siemens ‘Desiro’ EMUs for South West Trains
- London inner and outer suburban services, max 100mph
- Fleet of 733 vehicles, 4 & 5 car sets, delivered from 2004
- P12 trialled on selected vehicles in 2007 and 2009/10
  - Wheel & rail RCF monitored
  - Rail RCF damage findings were inconclusive
  - Wheels suffered from more RCF and wear, reducing life
  - Other influences hampered trial including wheel diameter
  - P12 not adopted: HALL Bush used instead (VTAC benefit too)

Thanks to Mark Burstow and Keith Hutchins

Challenges: Experimental Conditions

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- Impossible to have consistent, robust experimental conditions on an operating railway/fleet
  - 444/450 trial influenced by wheel diameter/age
  - Mixed traffic on routes influences rail RCF
  - Lack of control experiments
  - Difficult to prevent trial sites being maintained (e.g. ground)
- Trial timescales often too short to quantify benefits
- Network Rail initiatives since Hatfield have had a bigger impact on rail RCF than the limited application of P12s
  - These crucial developments support the operational railway
  - But have made assessment of the benefit of P12s on the infrastructure almost impossible to quantify

Challenges:
Experimental Conditions

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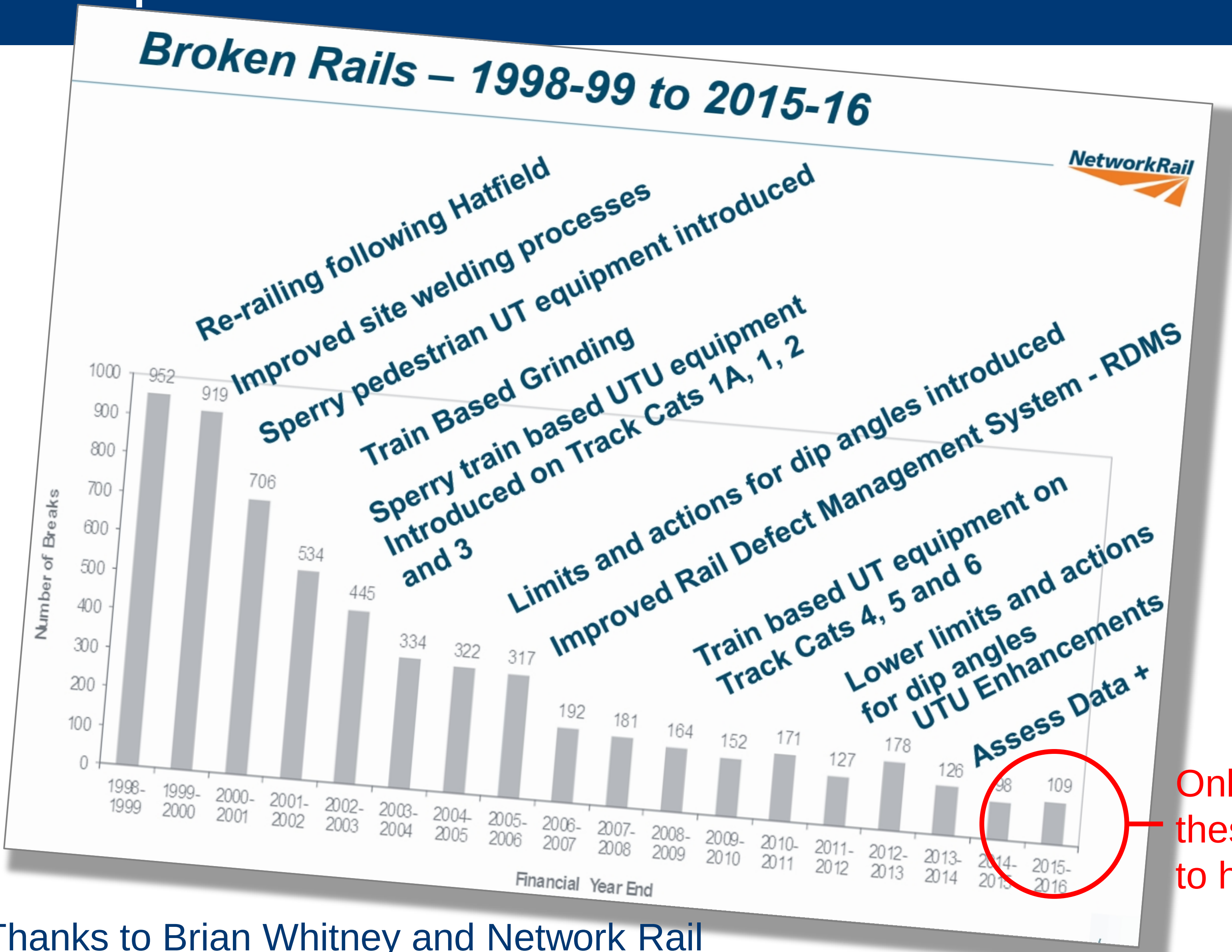

Only 10% of these are related to head defects

Thanks to Brian Whitney and Network Rail

Challenges:
Quantification of Benefits

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- Simulations suggest that the P12 should reduce rail RCF
  - But also indicate an increase in wear
  - There is no benefit in overall track damage cost using models such as VTISM and VTAC
  - No quantifiable evidence of a real benefit on-track either
  - Little incentive for operators to use the P12 profile
- The P12 profile has shown a benefit to wheel life
  - Improved stability and extended turning interval on fleets where conicity is critical
  - But benefits for wheel RCF and wear are unclear or inconsistent
- How to quantify benefits and incentivise use?

Quantification of Benefits: VTISM Simulation of Class 390

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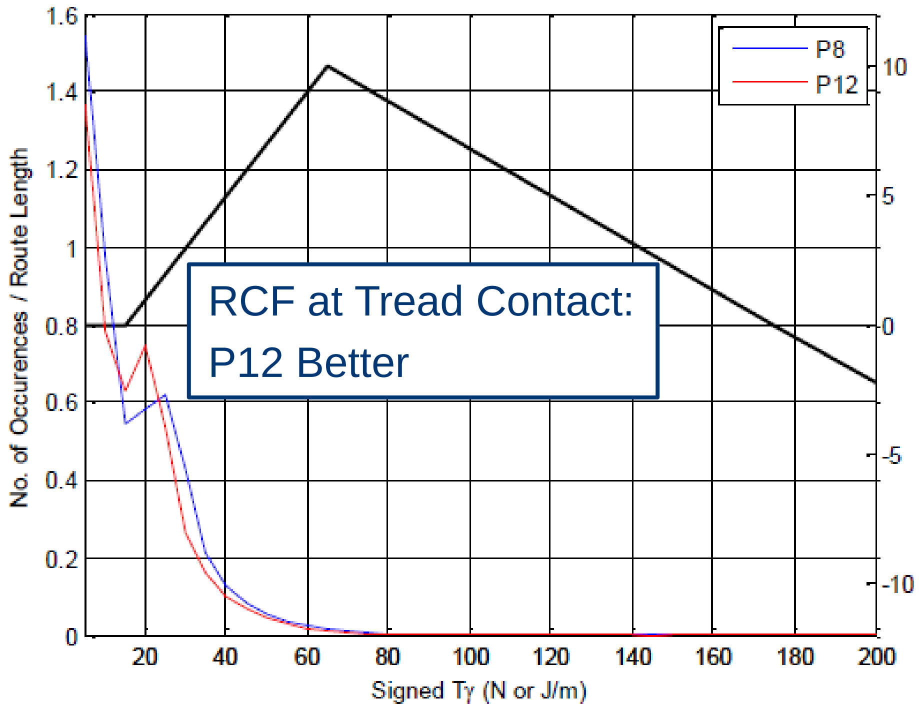

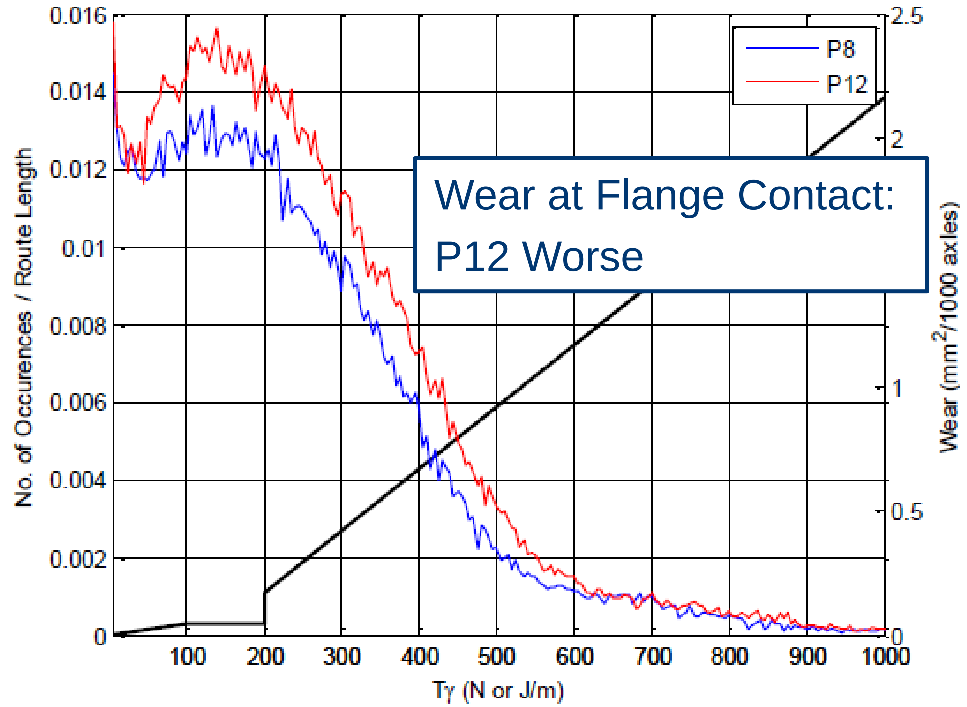

Profile	Rail RCF & Wear Cost	Vertical Damage Cost
P8	0.93	1.07
P12	0.94	1.07
Negligible difference in track damage: P12 shows no benefit		

More Frequent Wheel Reprofiling and Whole System Costing

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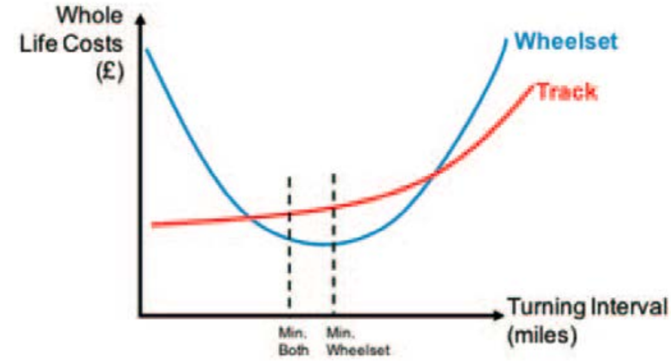
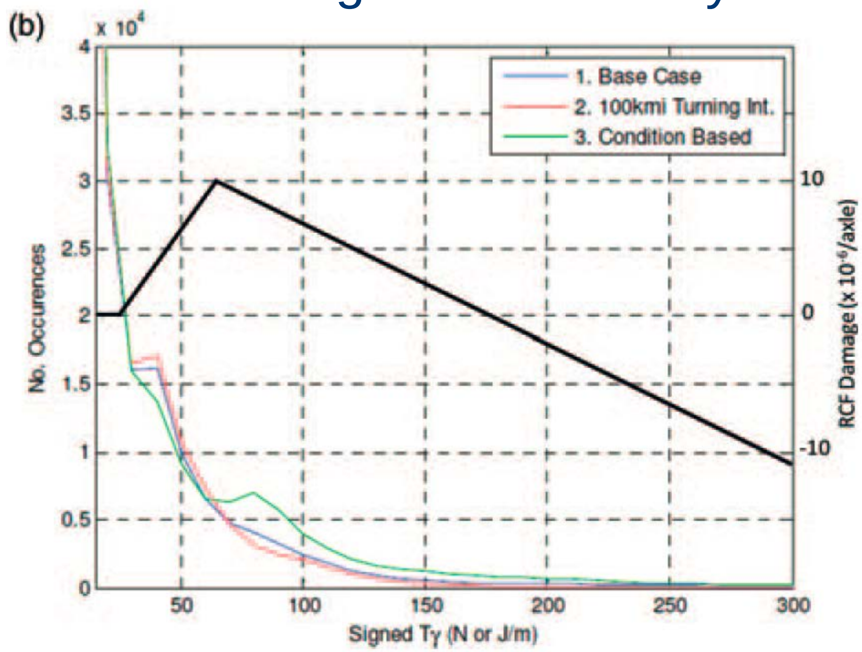
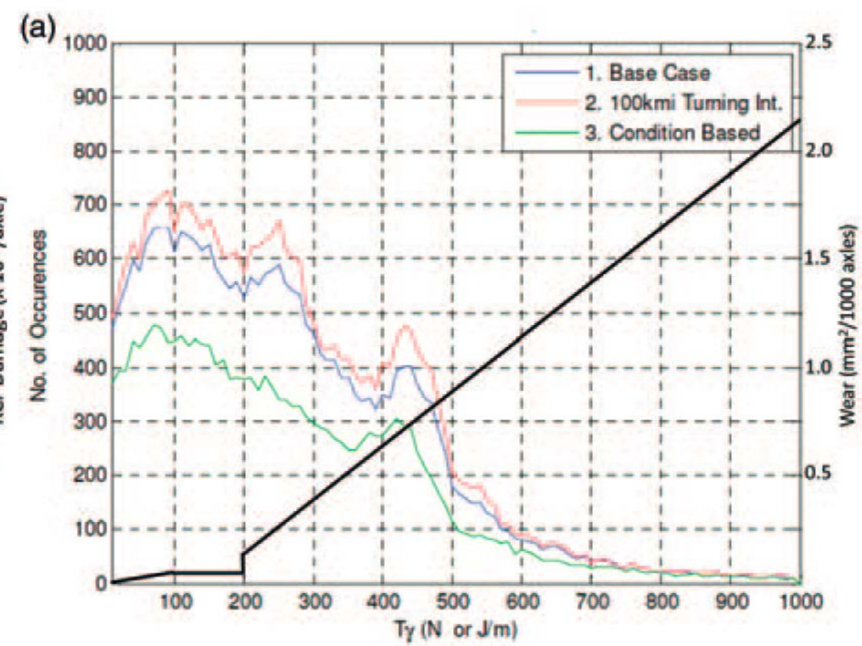
- Wheelset Management Model used to predict effect of wheel turning policy on both wheel and track damage
- Optimum turning interval for system was different to that for the vehicles alone
- High-mileage wheels cause more RCF
- Incentivising this is not easy either!







What Have We Learnt?

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- ‘Low RCF’ wheel profiles can be designed or achieved by better wheelset maintenance
- Simulations can demonstrate their RCF benefits, but there is often an increase in wear
- Track damage is influenced by too many other factors to provide clear experimental evidence of a benefit
- Other technologies (rail grinding, HALL bush) provide clearer benefits, and an impression of ‘problem solved’
- Difficult to incentivise the use of P12 wheel profiles
- Successful applications have mostly been higher-speed vehicles where conicity is a limiting factor