Institution of MECHANICAL ENGINEERS

Interfaces & Interactions

Interfaces and Interactions

Bridget Eickhoff
Principal Infrastructure Engineer, RSSB

September 2012

Contents of Presentation

- Introduction
- Education & early career
- Some practical projects
- Moving into the wider world
- RSSB (Rail Safety and Standards Board)
- Some technical questions
- Managing interfaces & interactions
- The profession & the IMechE

Introduction

Railways tend to fall flat on their interfaces

Sir Peter Parker
Chairman British Railways Board 1976-1983

- Engineering Interfaces
  - Wheel-rail, pantograph-overhead line, ...
- Organisational Interfaces
  - Chief Mechanical Engineer, Chief Civil Engineer, Chief Signalling Engineer, Chief Operating Officer ...
- Contractual Interfaces
  - Railway Undertaking, Infrastructure Manager, Contractors, Suppliers, ...
- Managed by Interactions between professionals

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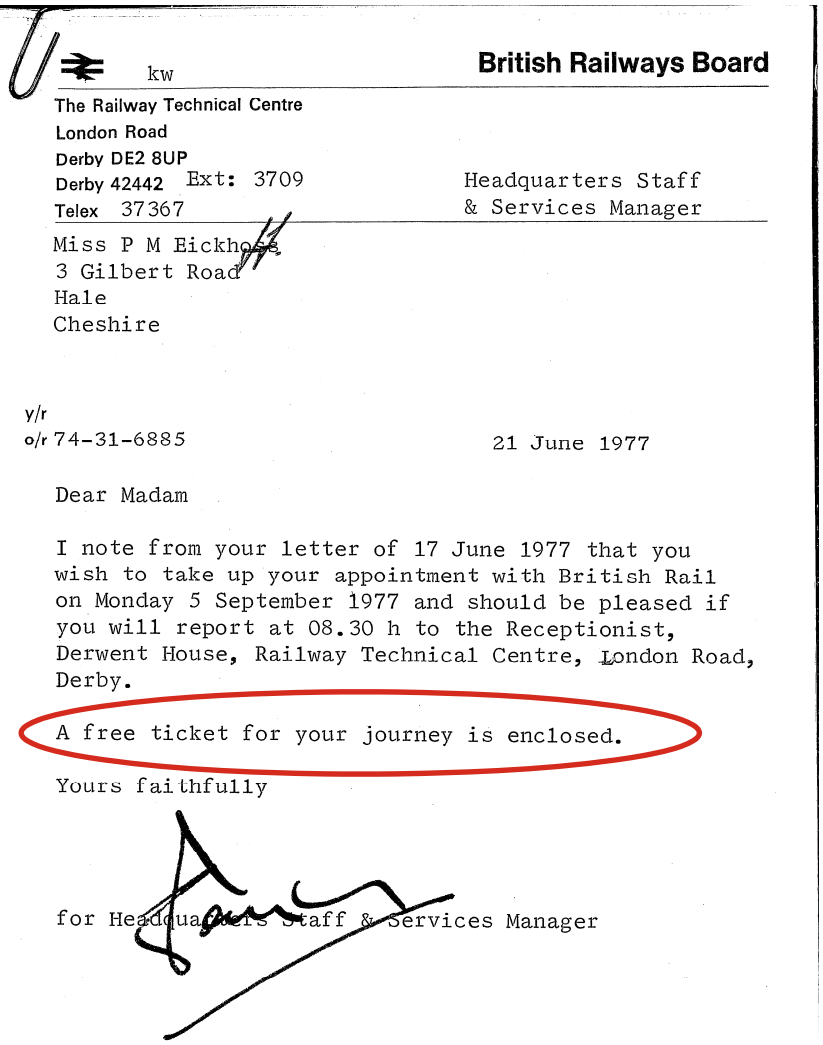
Education & Early Career

Mathematics to Engineering

- A levels in Maths, Further Maths, Physics
- Degree in Mathematics
- Looking for a job in Engineering
  - Would an employer take the risk?
- Interviews at several companies
  - Computing – **Not for me**
  - Statistics – **Not for me**
  - Operational research – **Not for me**
- British Rail Research Department
  - Mathematical modelling – **Not for me**
  - Dynamics – **YES!**

British Rail Research

- Started at RTC Sept 1977
  - Direct entrant
  - No formal graduate training scheme
  - 3 months engineering practical at Loughborough University
  - All other engineering knowledge gained 'on the job'
- Thanks to Tony Hobbs
  - & other members of the interview panel



kw

British Railways Board

The Railway Technical Centre
London Road
Derby DE2 8UP
Derby 42442 Ext: 3709
Telex 37367

Headquarters Staff
& Services Manager

Miss P M Eickhoff
3 Gilbert Road
Hale
Cheshire

y/r
o/r 74-31-6885

21 June 1977

Dear Madam

I note from your letter of 17 June 1977 that you wish to take up your appointment with British Rail on Monday 5 September 1977 and should be pleased if you will report at 08.30 h to the Receptionist, Derwent House, Railway Technical Centre, London Road, Derby.

A free ticket for your journey is enclosed.

Yours faithfully

for Headquarters Staff & Services Manager

Career Progression

- Joined the Vehicle Dynamics Group
- Steady progression through BR Research
  - Vehicle dynamics
  - Track mechanics
  - Vehicle Track Interaction
- Range of projects
  - Experimental and Theoretical
- Early activities:
  - Analysis of Lab 1 curving tests in North Wales
  - Development of Vehicle Dynamic prediction methods
  - Full scale, on-track testing
  - European involvement ORE, ERRI

Some Early Lessons

- Railways may look like 'Heavy' Engineering but small tolerances can have a large impact
- Vehicle dynamic behaviour is complicated
- The wheel-rail interface is very complicated
- Railway engineering has lots of challenges
- Vehicle-Track Interaction is a fascinating area to build a career

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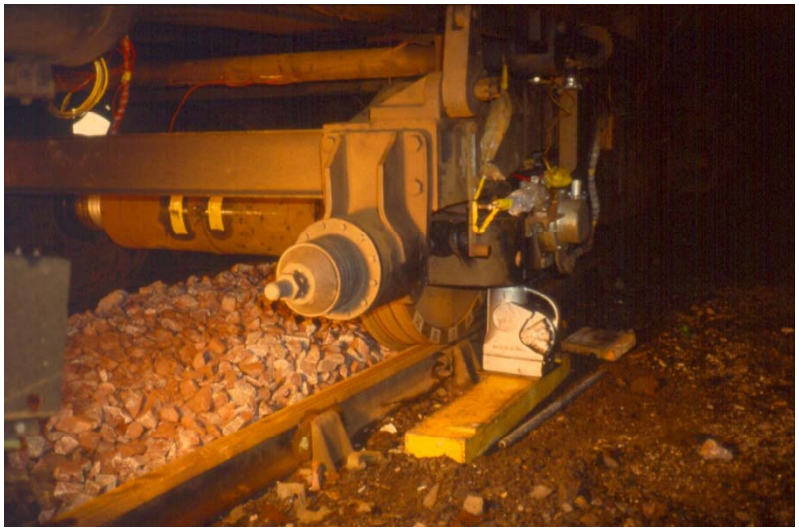
Some Practical Projects

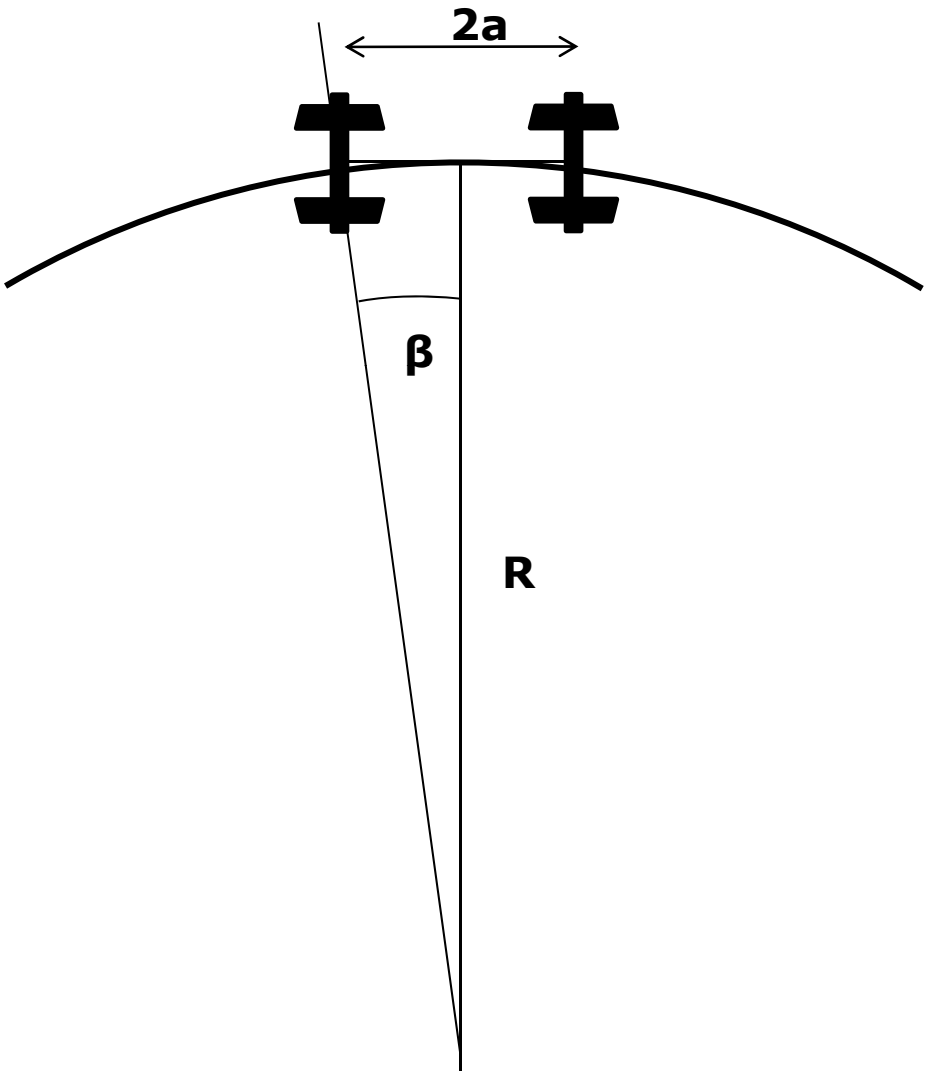
With a small amount of science, some pictures and a few equations

Aspects of On-Track Testing

- Anti social hours
  - Team spirit
  - Lots of mugs of tea
- Instrumentation set-up
  - Load Measuring Wheels (LMWs) need to be zeroed
- Analysis of Lab1 test in North Wales
- High Speed Freight Vehicle (HSFV) 1 in Switches & Crossings
- Lab1 with independently rotating wheels

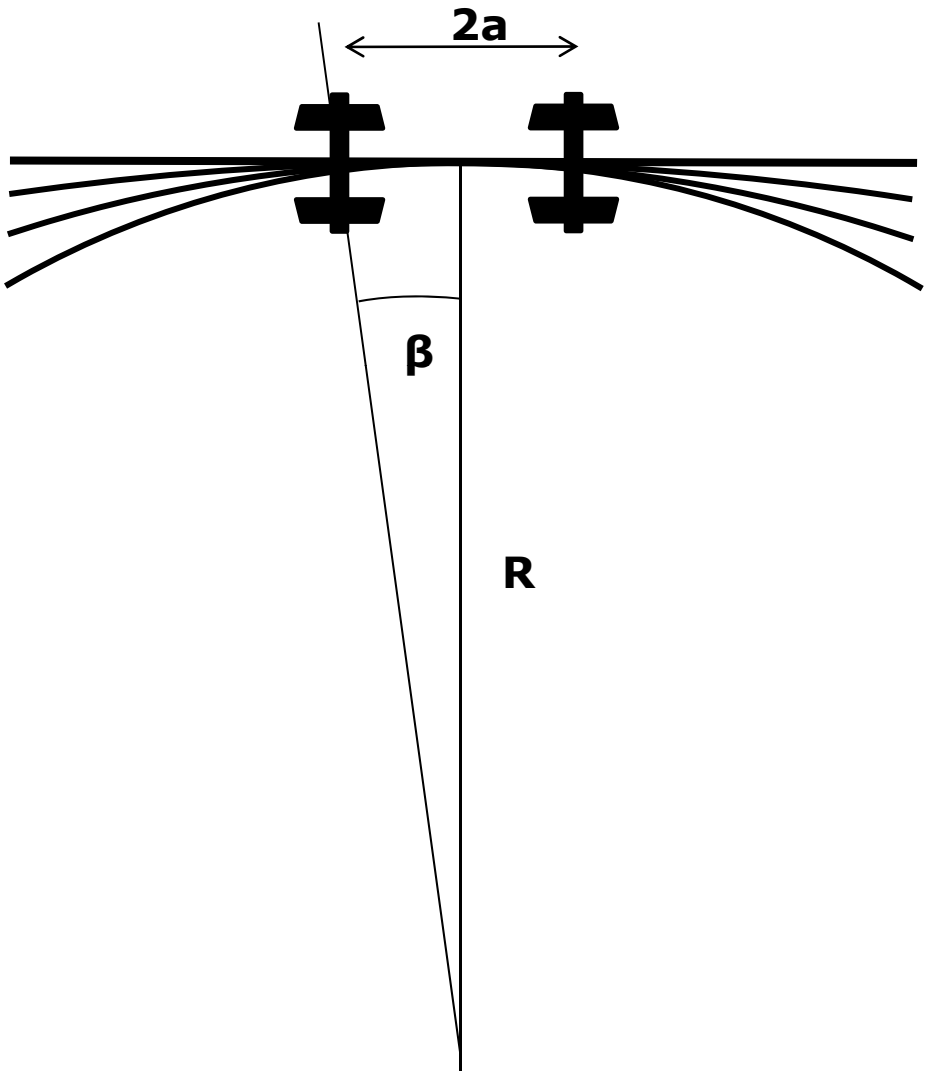


Bogies on Curves & Straights



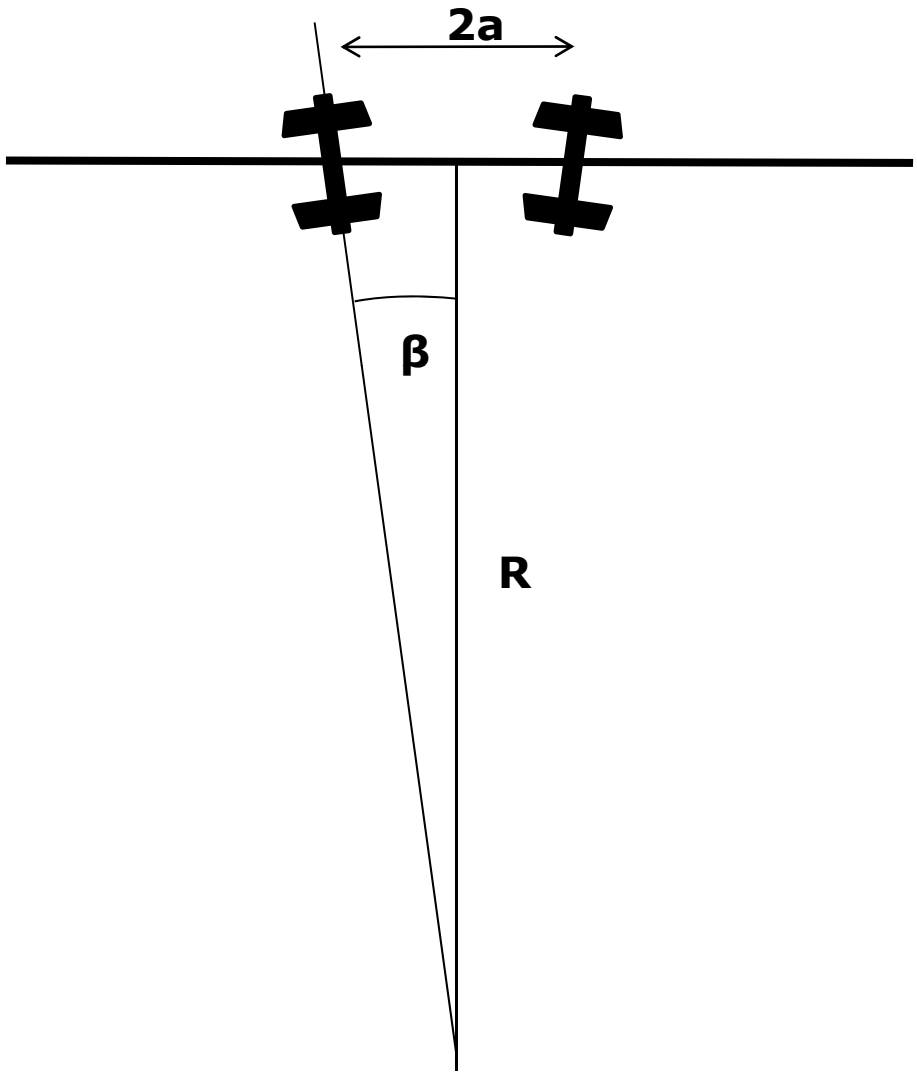
Correctly aligned bogie on a curve
$\beta \approx a/R$

Bogies on Curves & Straights



Correctly aligned bogie on straight track
β = 0

Bogies on Curves & Straights

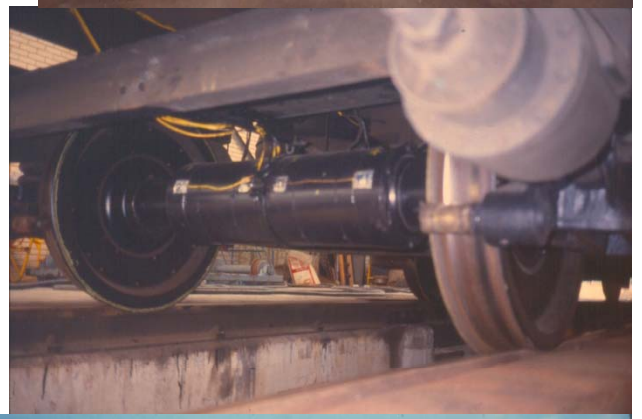


Misaligned bogie on straight track
$\beta \approx a/R$

a= 1.2m, β= 1mrad gives R= 1200m

Independently Rotating Wheels

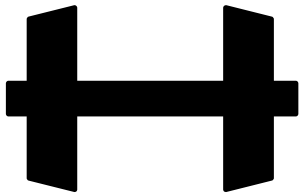
- Literature review
- Theoretical investigations
- On–track tests Lab1 at Old Dalby



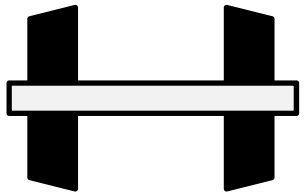
- R&D reports
- Paper for Journal of Rail & Rapid Transit
- The Alfred Rosling Bennett / Charles S Lake Award 1992

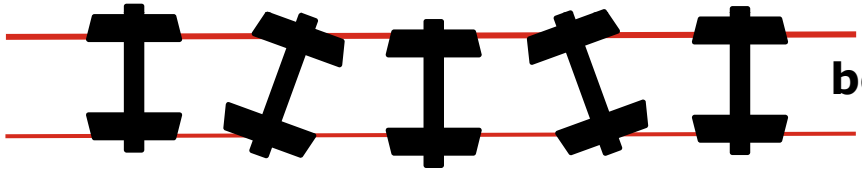
Independently Rotating Wheels

Conventional wheelsets v Independently rotating wheels

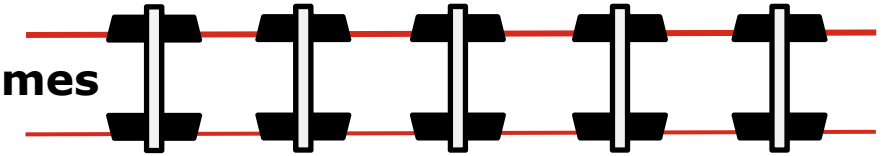


becomes

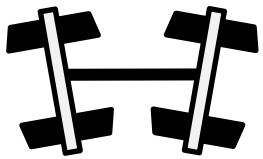




becomes



Misalignment of the axles can 'self correct'

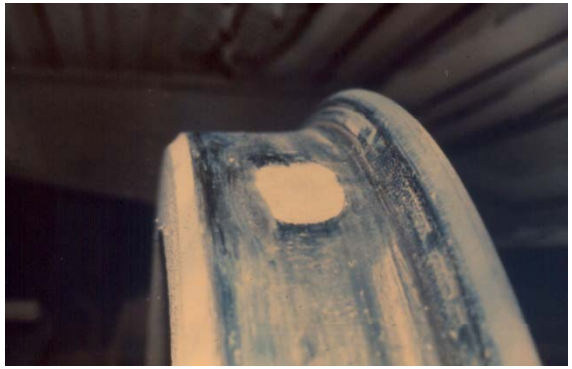


Misalignment of the axles cannot 'self correct' and wheel tends to run against one rail

Removing the axle may remove the problem of instability at high speed on straight track but other issues will need to be considered and forces / wear on curves (and straights) are likely to increase

Wheel Flats and Detection

- Trial of the first wheel impact load detector at Braidwood
  - 12 hour night shifts in a portacabin
  - Fault finding
  - Trans-Atlantic phone calls from a line-side phone
  - Relating measured forces to real wheel defects
  - Identify key factors
- Now a routine inspection tool



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Moving into the Wider World

Changing as the railway changes

Early Cross-Europe Activity

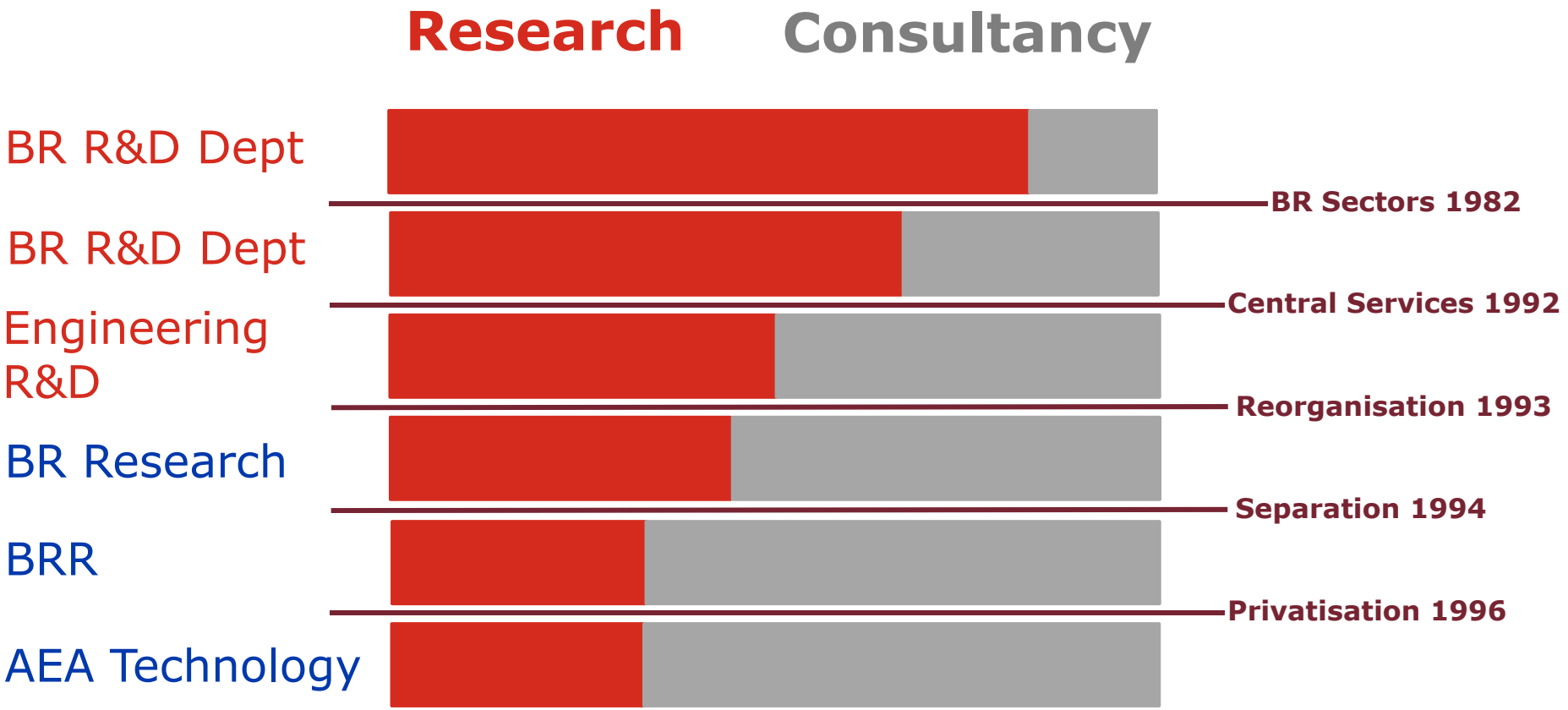
- Scope of involvement
  - ORE committees
    - B176 Development of bogie with 'steered or steering' wheelsets, 1989 - 1993
    - C210 Track geometry description, 1999
  - UIC leaflets, CEN standards
    - Passenger comfort, equivalent conicity, vehicle acceptance testing
- Background / experience in different networks
  - Obvious / 'scientific'
    - 1/20 or 1/40 rail inclination, British loading gauge < UIC
  - Cultural / legal / financial
  - Experience (e.g. learning from accidents)

Business Management Roles

- Management responsibility
  - Financial, commercial, staff, organisational
  - Varying sizes of team from 6 to 60
- Wide range of technical areas including
  - Vehicle Track Interaction
  - Dynamics & Suspensions
  - Aerodynamics
  - Noise & vibration
  - Structural analysis & testing
  - Vehicle approvals (VAB, NoBo)
  - Electrical engineering (briefly, fortunately!)
- Thorough overview of the railway system

Commercialisation & privatisation

- Commercialisation is not a step change
  - Gradual shift of emphasis
  - Largely complete before formal privatisation



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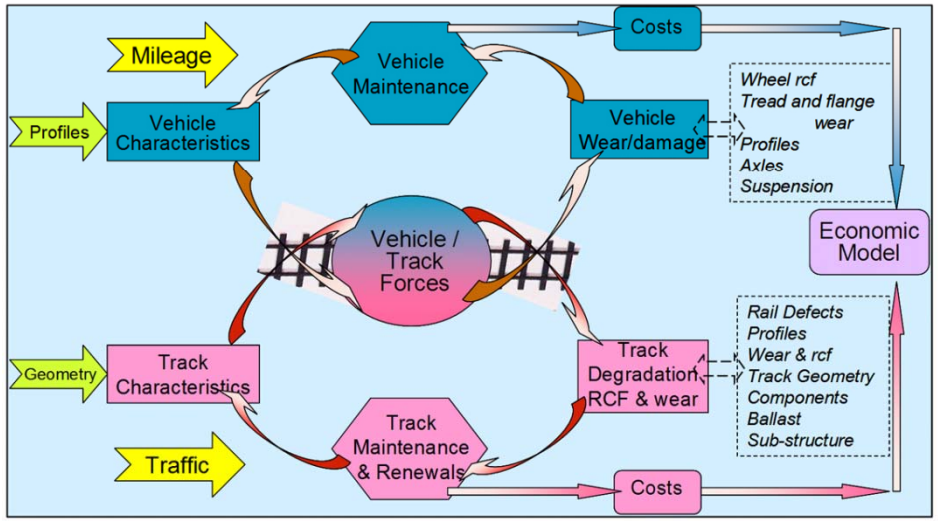
RSSB

Research and standards activities

RSSB (Rail Safety and Standards Board)

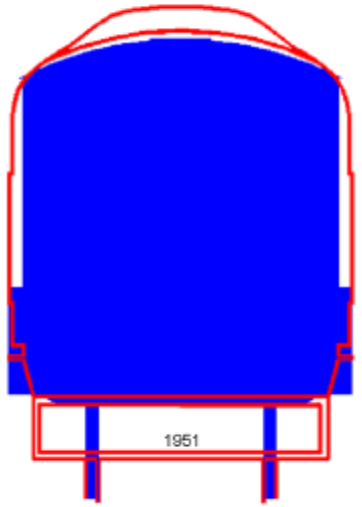
- Joined RSSB in September 2008
  - A not-for-profit company
  - Owned by major industry stakeholders
  - Established in 2003 following Cullen enquiry
- Some current activities
  - Involvement in RSSB managed, DfT funded research
  - Continuing involvement in European standards
  - Increasing involvement in RGS (Railway Group Standards) development
    - Chairman of Infrastructure Standards Committee from 2009
  - Involvement in European (FP7) research project DynoTRAIN

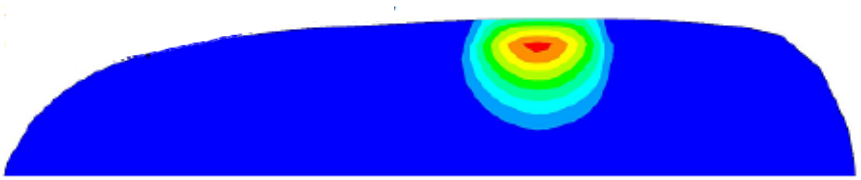
DfT Funded Research Projects



T792 Stage 2 development of VTISM (Vehicle Track Interaction Strategic Model)

T977 Development of revised Lower Sector Gauge
T978 Development of new Suburban passenger vehicle gauge



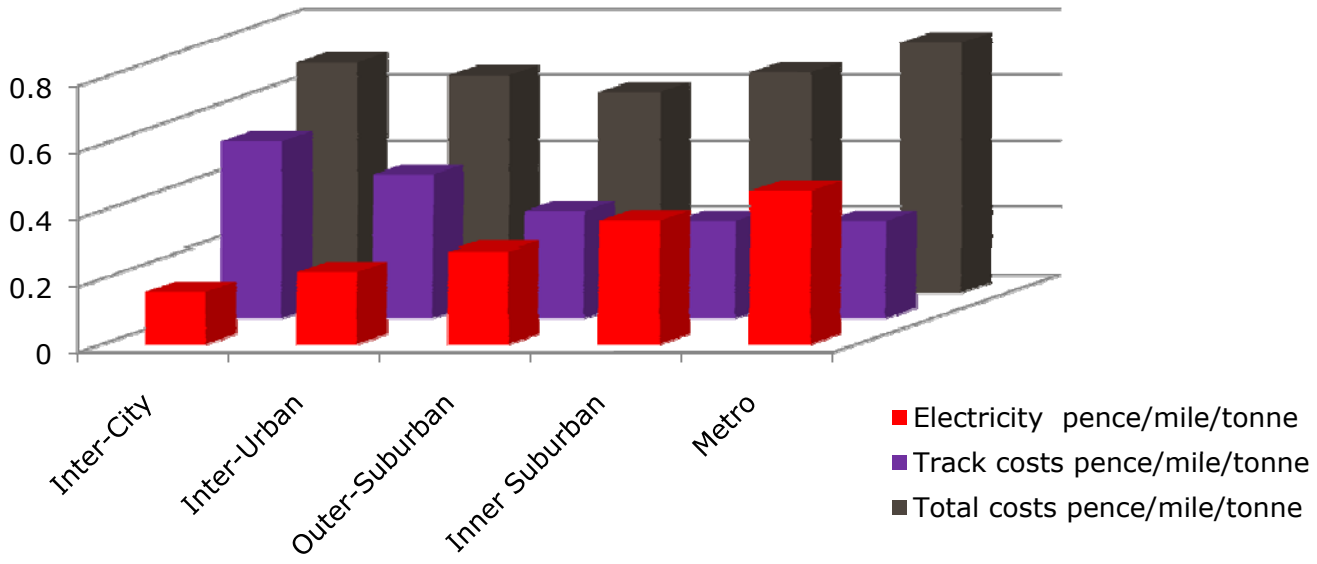


T889 Rail Vertical Contact Stresses (Review and relaxation of Q/D ratio)

T712 Value of Mass

T712 The 'Value of Mass'

- Q: How much is it worth to save 1 tonne of mass on a vehicle?
- A: It depends on the context:

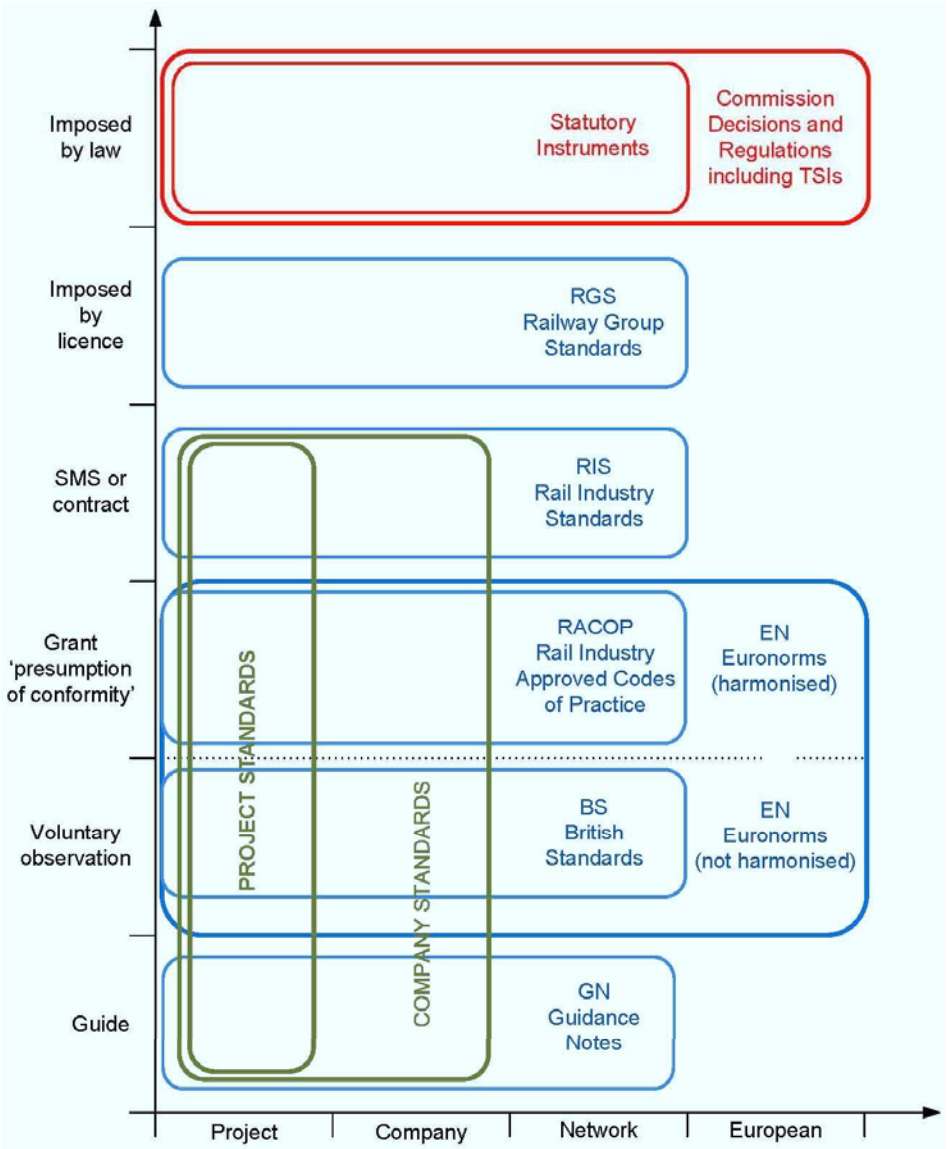


Combined track & energy costs

All at 2010 prices

Approximately 0.6 pence per mile

Overview of Standards



- Wide range of different standards
  - Different legal force
  - Different project scope
  - Different technical scope
  - Different development processes
  - Different timescales
- Need for GB to be involved in most / all of them
  - To ensure fit for purpose
  - Economically acceptable
- No good complaining afterwards

GB Involvement in European Standards

- RSSB
  - Coordinates GB input
  - Acts as focus
  - Provides some representatives
- Scope of personal involvement
  - TSIs (Technical Specifications for Interoperability)
  - CEN standards
  - UIC leaflets,
  - European Research (eg FP7 DynoTRAIN)
- Need to build consensus to make progress
  - Described as 'Absence of sustained opposition'
- Some example issues
  - Wheel-rail contact & track geometry

Wheel-Rail Contact Conditions: Q1

- Q1: How different are the wheel-rail contact conditions in different European networks?
- A1: It depends on the rail inclination:
  - 1/20 in GB, France, Italy, ...
  - 1/40 in Germany, Austria, Switzerland, ...
  - 1/30 in Sweden
- But is it so simple ?
  - This is an interface – so what about the wheels?
- DynoTRAIN WP3 (DfT support for RSSB input)
  - Actual measured rails and wheels from Germany, France, GB
  - Assessment with:
    - 1/40 wheels; design S1002 and measured worn wheels
    - 1/20 wheels; design EPS (P8) and measured worn wheels

Background to T888 DynoTRAIN

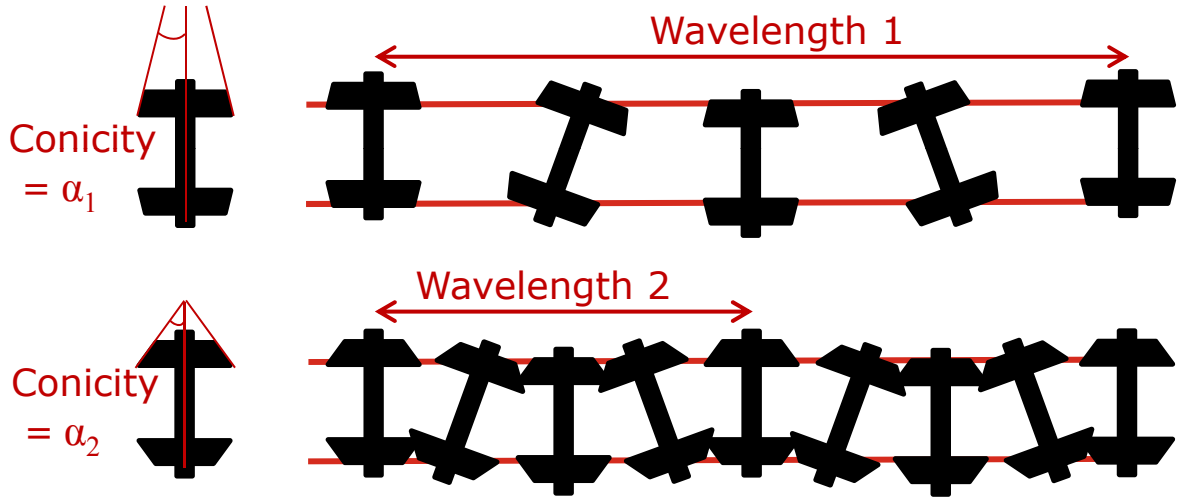
- EU FP7 Research Project (2009 to 2013)
  - Aim to improve efficiency and reduce cost of international vehicle approval
- Major international on-track tests
  - 6 test vehicles, 10 force measuring wheelsets
  - 300 channels of data (wheel-rail forces, vehicle accelerations, suspension displacements, track geometry, rail profiles)
  - 15 days of testing over 4 weeks in 4 countries, 3 TB (10^{12}) of data

Equivalent Conicity

- The cone angle of a railway wheelset permits:
  - Self-centering on straight track
  - Generation of steering forces on curves

For a 1/20 coned wheel
conicity =0.05
For a 1/40 coned wheel
conicity =0.025
etc

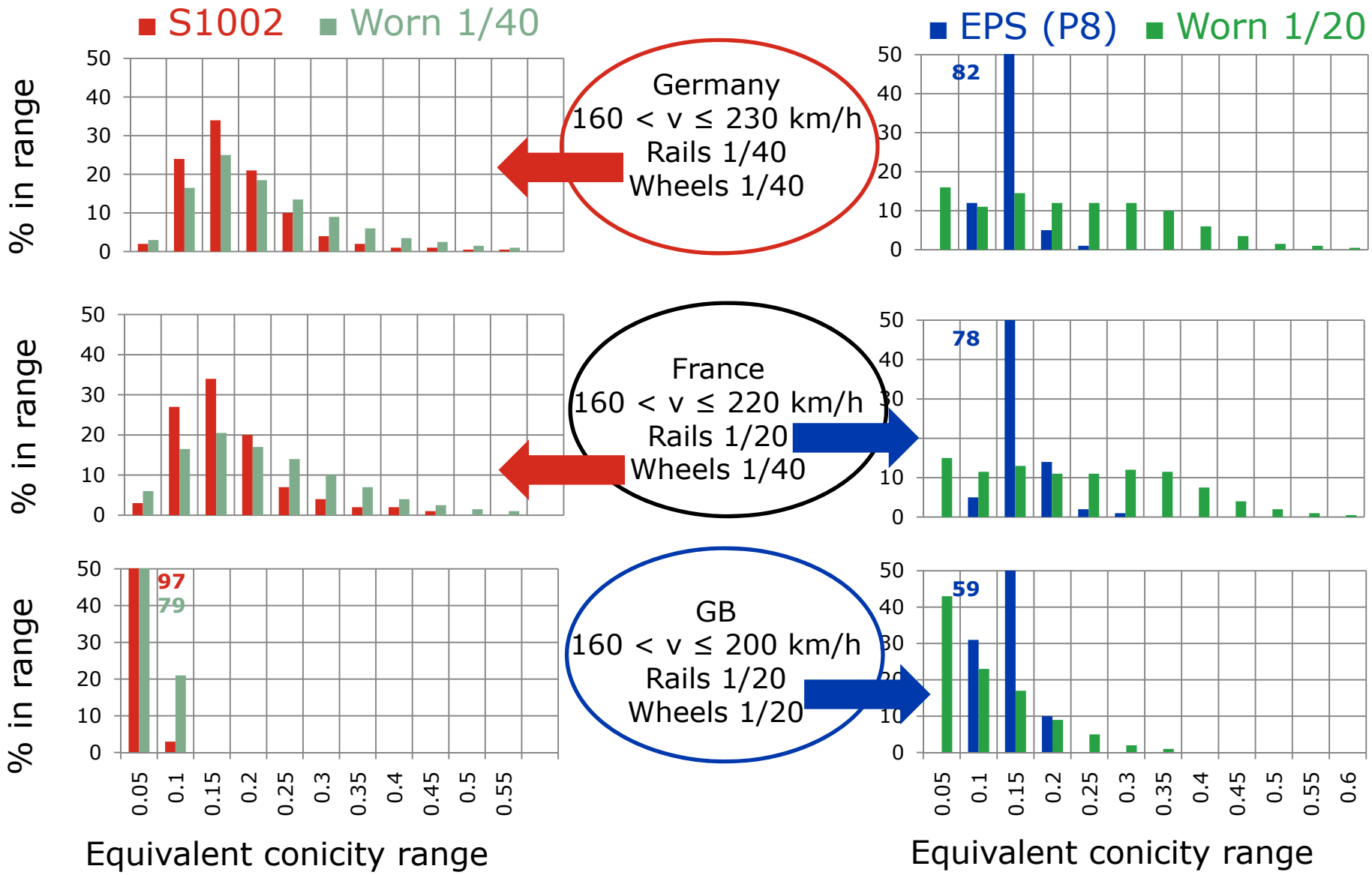
Higher conicity
→ shorter wavelength
→ more energy
→ more risk of instability



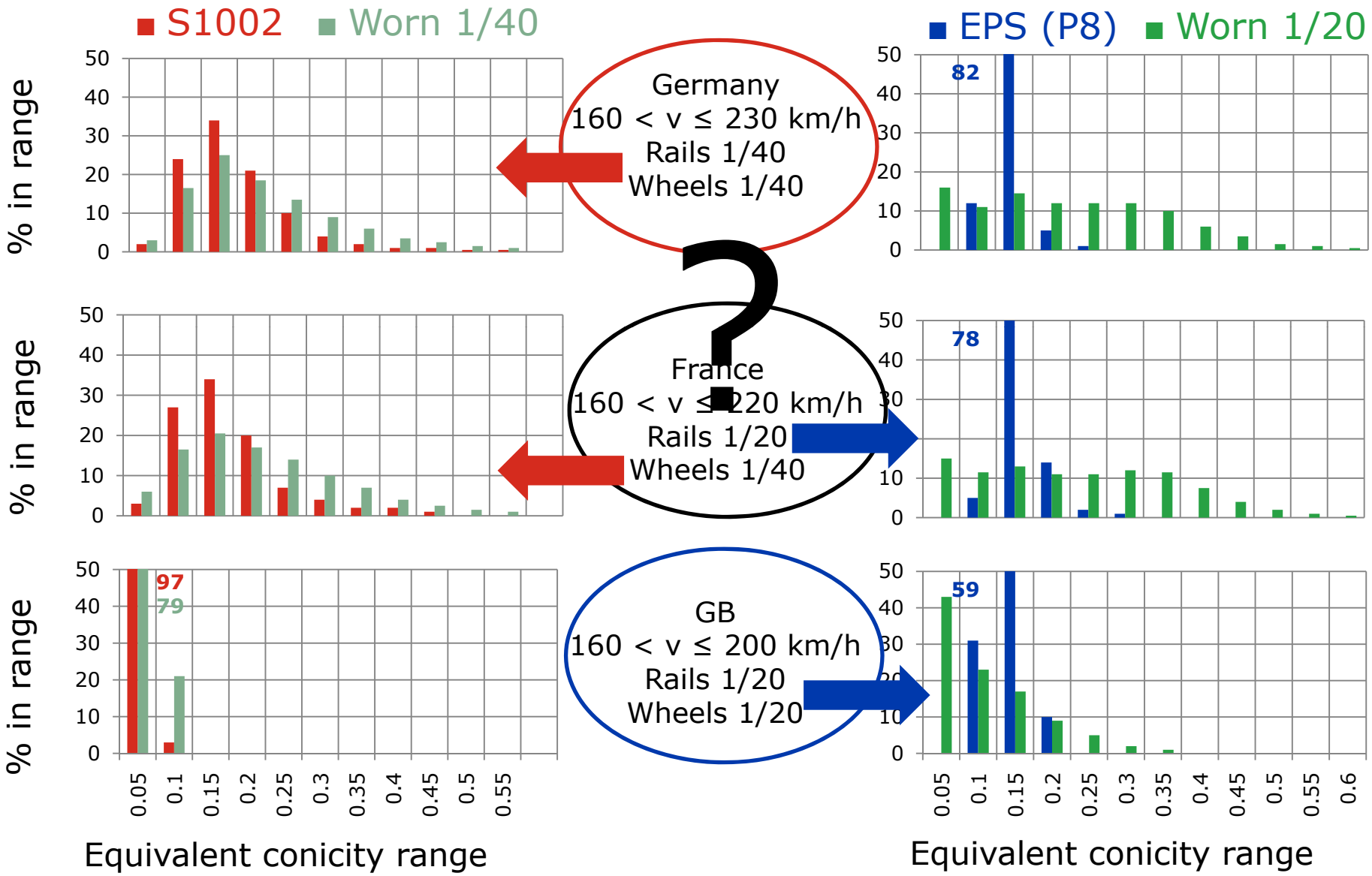
$\alpha_2 > \alpha_1$ and Wavelength 2 < Wavelength 1

- For profiled wheels define 'equivalent conicity'
  - Determine the natural wavelength for the real wheelset / track combination
  - Determine the cone angle that gives the same wavelength

DynoTRAIN Example Conicity Results



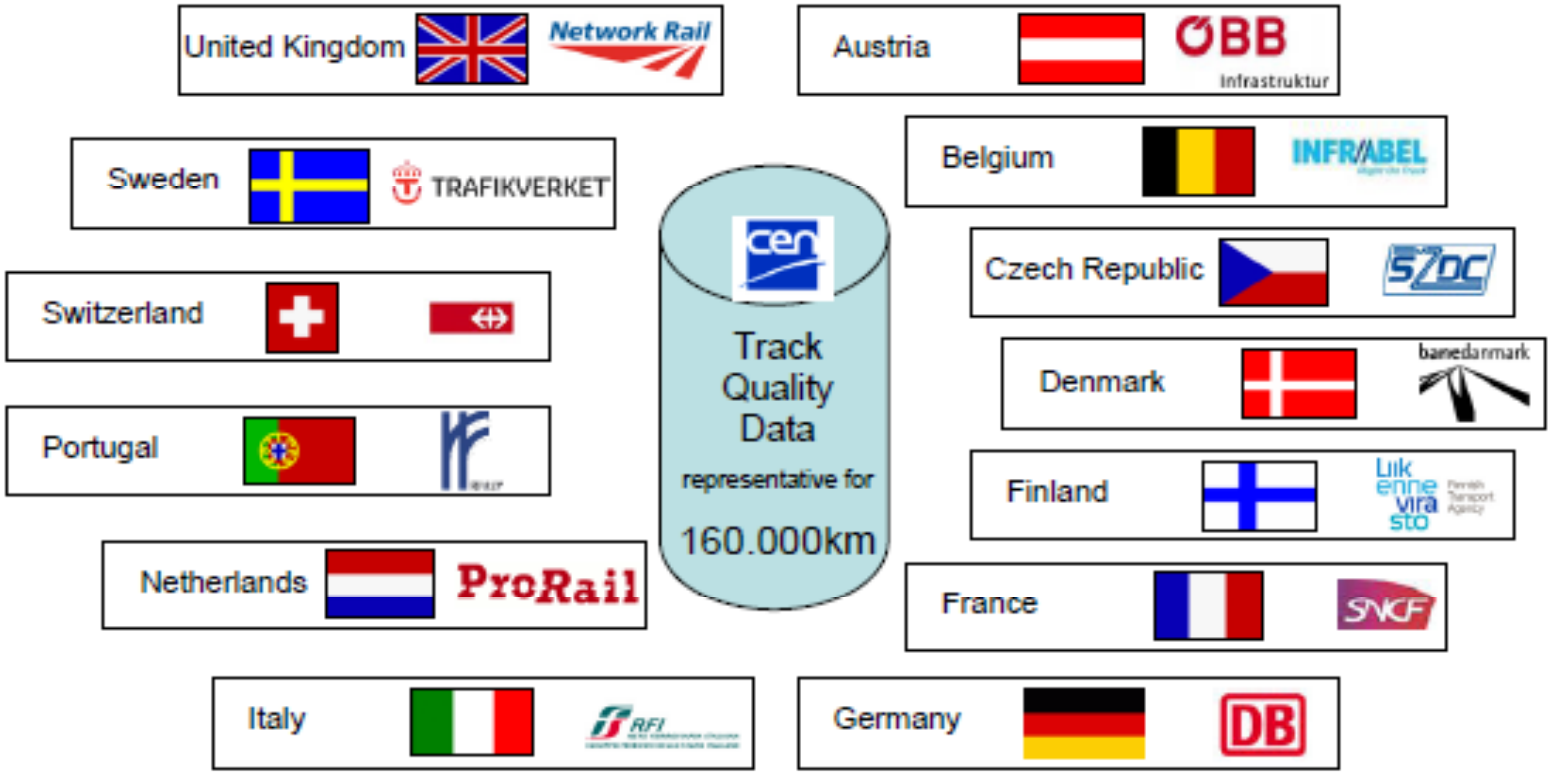
DynoTRAIN Example Conicity Results



Track Geometry Questions

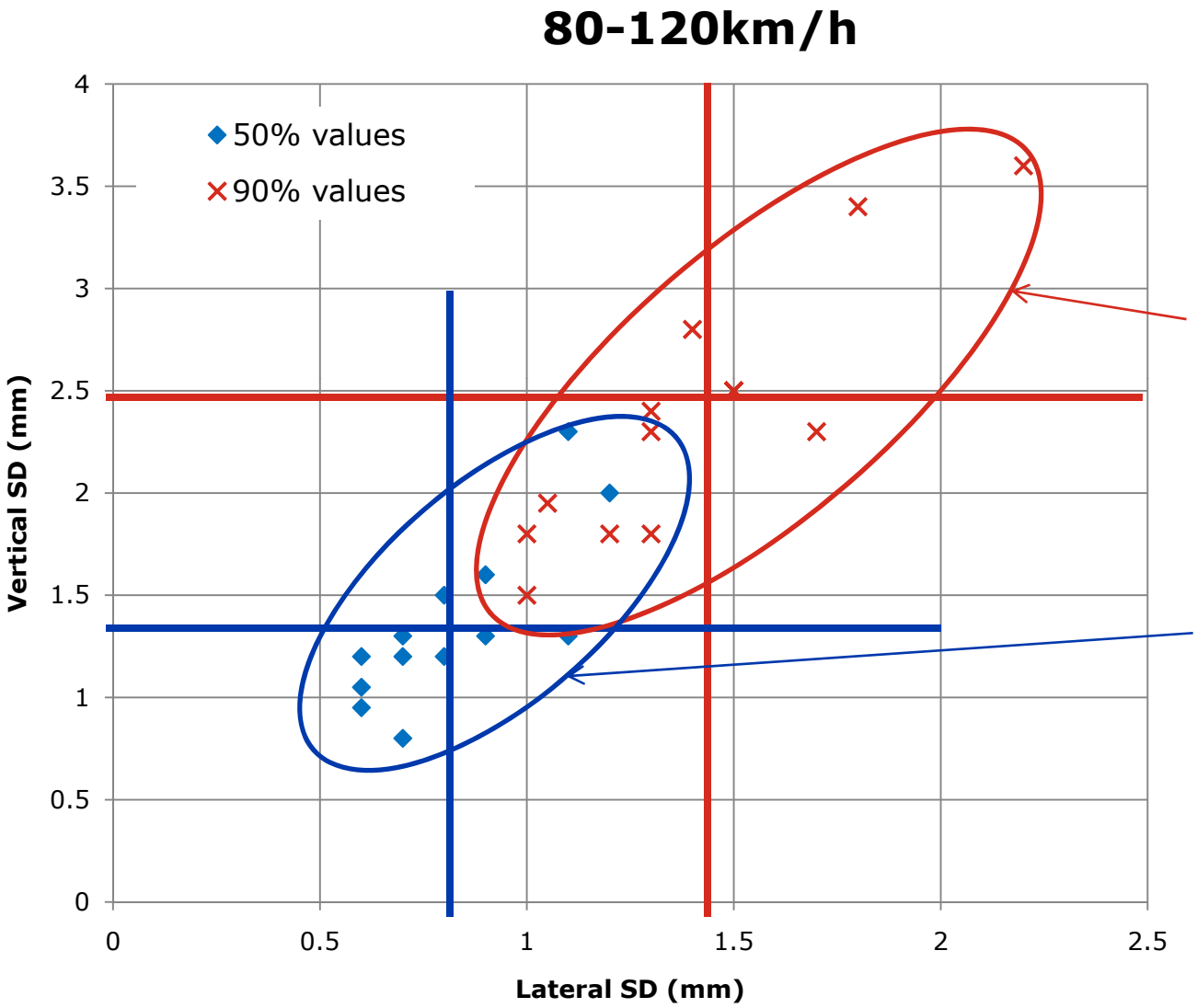
- Q1: How do track geometry conditions compare across Europe?
- Q2: What conditions do we need to include in testing for international approval?
- A: Nobody knows!
- CEN TC256 WG28 survey of representative track geometry over 13 European networks
  - From existing data in each network
  - May be some differences in measuring and analysis methods
  - Better than any previous information

WG28 Track Quality Survey Participants



- All data are Standard Deviations (SD) for 200m track lengths in wavelength range 3m≤ λ ≤ 25m
- Cumulative distributions, select 50% and 90% values
- Lateral and vertical directions

WG28 Track Quality Survey Results



European Average 90% (weighted by network length)

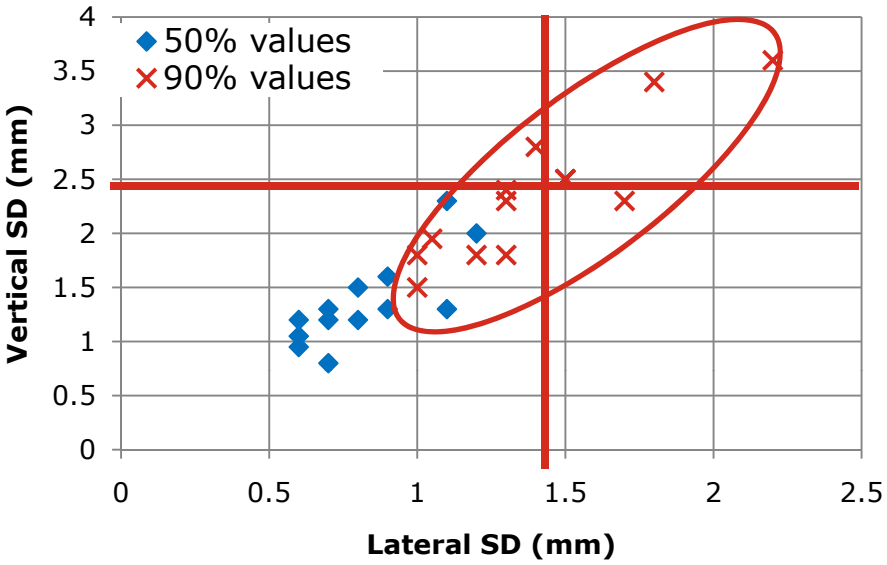
Scatter 90%

Scatter 50%

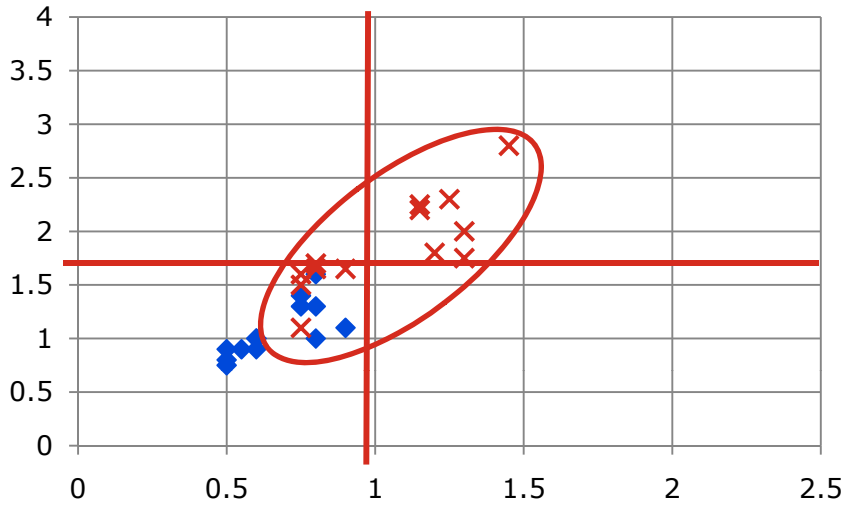
European Average 50% (weighted by network length)

Effect of allowable line speed

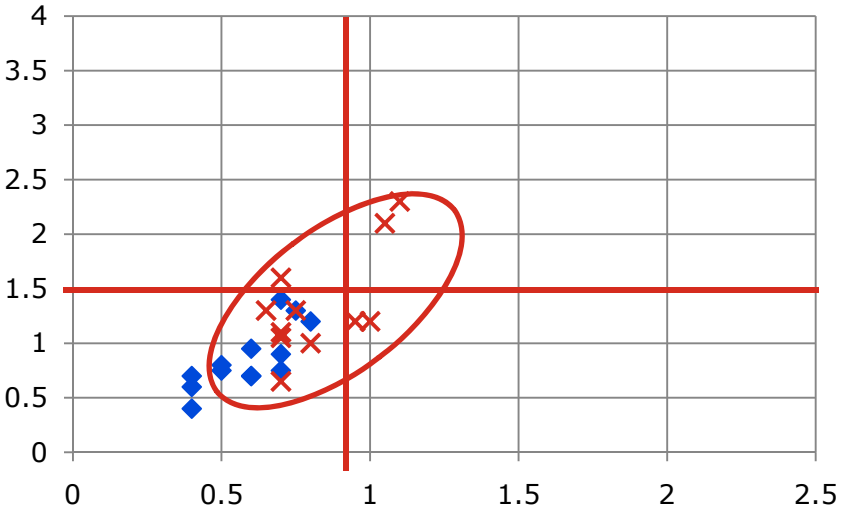
80-120km/h



120-160km/h



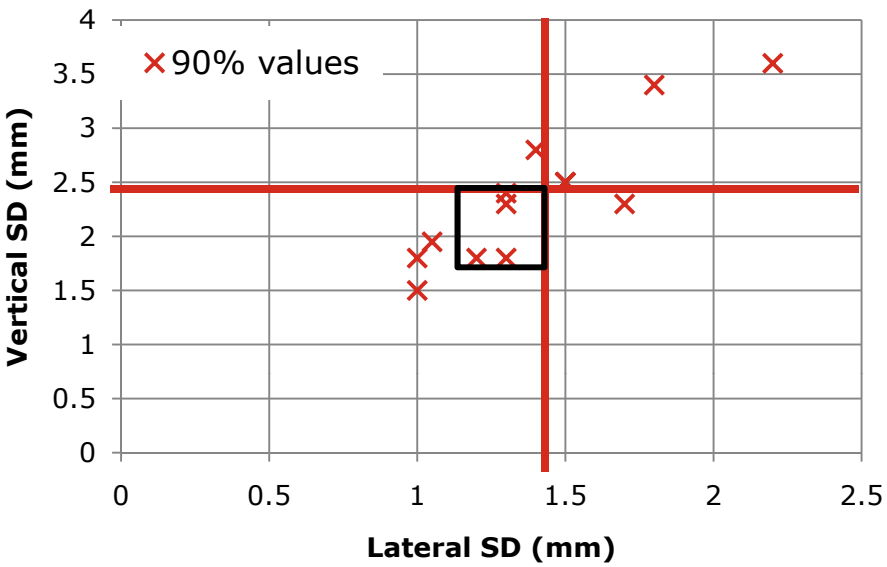
160-230km/h



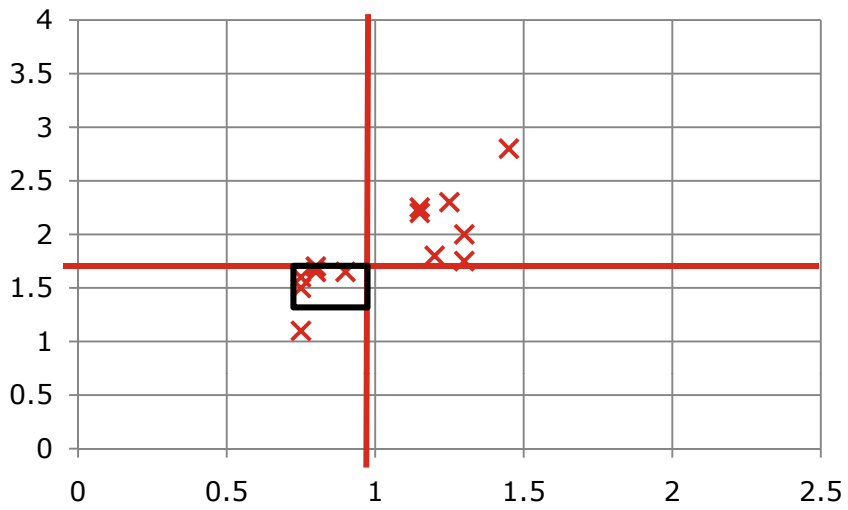
- Smoother track for higher speeds
  - Weighted averages decrease
- Scatter similar proportion of average
  - Lateral: 80% → 70% → 50%
  - Vertical: 80% → 90% → 100%

Track Geometry for Testing

80-120km/h



120-160km/h



- Q2: What conditions do we need to include in testing for international approval?
  - A2a: Concentrate on 90% values
  - A2b: Set target ranges to be achieved

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Managing Interfaces and Interactions

Managing Interfaces

"Maximum efficiency in railway operation can only be attained when the several departments responsible for the various components freely co-operate and try to understand one another's problems. Maximum departmental efficiency may not always coincide with that of the railway as a whole, and no department should gain efficiency at the expense of another"

Harold Holcroft (1928).

(with thanks to Tim Moss, NET)

Engineering Interface Lessons

- Cross industry cooperation is even more vital in today's railway
- Many decisions cannot be made locally or even nationally
- Many railway industry companies are international
- New ideas, research and development are increasingly expensive for national bodies
- International involvement is fundamental to a successful railway

Professional Interactions

- Within GB
  - Standards Committees
  - System Interface Committees
  - Engineering Institutions
  - REF (Railway Engineers Forum)
- Within Europe
  - ERA (European Railway Agency) WGs
  - CEN WGs
  - UIC Committees
- International Conferences
  - World Congress for Railway Research (WCRR)
  - International Association for Vehicle System Dynamics (IAVSD)

Standards Committees

- Act as focus for standards in technical areas
  - Rolling Stock, Infrastructure, Energy, CCS (Control, Command & Signalling), TOM (Traffic, Operations & Management)
- Contain representatives from across industry
  - Network Rail, Train Operators (passenger & freight), ROSCos, Infrastructure Contractors, Suppliers
  - DfT and ORR as observers
- Manage the development and application of Railway Group Standards
- Act as Mirror Group for related European standards
  - TSIs (including GB Specific Cases)
- Consider requests for derogations
  - >90% not withdrawn by applicant are granted
- All decisions by consensus

The Profession and the IMechE

Railway Division Activities

- Centres and HQ
  - 2/3 of activity through Centres
- Seminars, lectures & discussions
  - Space for informed debate
- Visits
  - Learn from experience
- Summer Technical Tour May 2013
  - To NE USA / SE Canada
- Workshops
  - More topics being developed
- Annual lunch
- Stephenson Award
- Railway Challenge
- Membership
  - YM visits to universities

Coordination with:

- NSARE
  - National Skills Academy for Railway Engineering
- REF
  - Railway Engineers Forum
- YRP
  - Young Railway Professionals

Stephenson Award 2012

- Part of National Rail Awards
- Award for the Engineering Innovation with the best potential impact on business performance
- Shortlist of 5 gave presentations on 20 June and answered questions
- Wide variety of topics
- Small and large projects
- Judging panel and audience feedback informed final decision
- Results announced last week (20 September)
- Prepare for next year!

Railway Challenge 2012

- 1 technical specification
  - 3 track based challenges
  - 2 presentation challenges
- 4 teams
  - 4 very different designs
- 1 weekend of trials
  - Stapleford Miniature Railway, Melton Mowbray
- Several engineering innovations
  - Hydrogen powered locomotive
  - Mechanical energy storage
  - Wireless remote control
  - A new locomotive from Derby!
- 2013 competition now open

Broadening Membership

- Railway Division membership ~ 5000
  - Includes CEng, IEng, EngTech
  - But less than 0.3% are EngTech
  - Does not represent spread of skills across industry
- Railway industry started 2000 apprentices in 2011 (NSARE)
- How can RD best support apprentices?
  - Training and development?
  - Visits?
  - Networking?
  - Informal mentoring?
  - Industry information?
- How does this differ from existing activity?
  - Are we intimidating?
- Initial plan to trial company based events
  - Ideas welcome

REF (Railway Engineers Forum)

- Multi-disciplinary body drawn from Professional Institutions with strong railway interests
- Aim to harmonise the various strengths of the constituent Institutions
- Avoid duplication of effort
- Provide conferences, seminars, lectures, training, information services
- Produce publications and statements of policy to Government and other Regulatory Bodies
- Respond to Consultations

Railway Division – Looking forward

- Building on sound foundations
- Developing engineers at all levels
  - 'Apprentice to Fellow'
- Opportunities for informed discussion
  - Across industry
  - With government
  - With society
- Interdisciplinary
- International

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