### Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Subject</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30</td>
<td>Aims of workshop</td>
<td>NR</td>
</tr>
<tr>
<td>10:45</td>
<td>RFCpro (introduction and background)</td>
<td>University of Huddersfield</td>
</tr>
<tr>
<td>11:30</td>
<td>Break</td>
<td></td>
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<tr>
<td>11:40</td>
<td>RFCpro (software demonstration)</td>
<td>University of Huddersfield</td>
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<tr>
<td>12:25</td>
<td>Questions and discussion</td>
<td></td>
</tr>
<tr>
<td>12:50</td>
<td>Next steps</td>
<td>NR</td>
</tr>
<tr>
<td>13:00</td>
<td>Lunch and close</td>
<td></td>
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</tbody>
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Aims of workshop
Introduction

• A significant quantity of work carried out over the past two years to review suspension factors used in freight variable usage charges

• Stakeholder meetings/workshops throughout the process

• NR submitted final proposal to ORR in August 2012 - approved today
  
  – All new vehicles in CP5 to use RFCpro to calculate suspension factor

  – Existing vehicles can be reassessed using RFC approach before February 2013 in time for start of CP5
Aims of workshop

• To explain:
  – RFC metric
  – RFCpro software

• To demonstrate:
  – RFCpro
    – Methods available to calculate RFC (specific v generic)

• to address questions / comments on the RFCpro software
Calculation of Suspension Factors for Freight Vehicles using RFCpro

Paul Allen & David Crosbee
Institute of Railway Research, University of Huddersfield
29th October 2012
The ORR required “a revised suspension banding method that can be used as criteria for deciding the appropriate level of discount that should apply to new suspension types as these are designed through CP4 and CP5”. ORR specifically requested the following key points:

- a *quantitative* measure of the mid-point of each suspension factor band
- a *quantitative* measure of the boundary between each band
- consideration of whether it is appropriate to introduce tangential (wear and RCF) effects into the suspension bandings table
The proposed new approach is based upon the magnitude of a vehicle’s dynamic *ride forces* – a measure of a vehicle’s suspension performance.

The ride forces are processed to provide a ‘Ride Force Count’ (RFC) metric; the RFC is calculated separately for tare and laden conditions.

The RFC has been related to the level of Suspension Discount Factor based on vehicle dynamic analysis of a wide range of freight vehicle types (60 vehicle dynamic models).

The level of track access ‘discount’ available has been fixed at the current levels (+9.7 to -14.2%). Allocation of bands removed and replaced by continuous function.

The process required to generate and submit an RFC based assessment has been fully developed and is defined within the RFCpro user guide.
Stage 1 – Determine the Ride Force Constants and Coefficients (RFCC) using vehicle dynamic simulation over the control Track for Banding file (TfB)

TfB file represents lower quality lines, more typical of freight vehicle operation. (Based on 1000 km of TRV data)

RFCC values with high correlation coefficient are achieved using TfB
E.g. \( \text{RFCC} = 2.36 \text{kN/mm} + 0.29 \text{kN} \)

For a track SD of 0-1mm, No. of Occurrences = 1
therefore \( \text{RFC} = (0 \text{mm} \times 2.36 + 0.29) \times 1 = 0.29 \)

For a track SD of 1-2mm, No. of Occurrences = 16
therefore \( \text{RFC} = (1 \text{mm} \times 2.36 + 0.29) \times 16 = 42.4 \)

For a track SD of 2-3mm, No. of Occurrences = 26
therefore \( \text{RFC} = (2 \text{mm} \times 2.36 + 0.29) \times 26 = 130.26 \)

…….and so on. These values are summed to obtain the RFC value for the complete TfG file SD set:-

\[ \text{i.e. } 2.65 + 42.4 + 130.26 + \ldots + n_7 + n_8 \ldots \text{ RFC } = 713 \]
Stage 3 – Evaluate the Suspension Discount Factor using RFC Discount Curve

RFC Discount Curves for both Tare and Laden Vehicles (Tare shown)

RFC= 713 Suspension Discount Factor = +5.71%
For reference, equivalent to old Suspension Band 2 (Discount Factor = +5.8%)

<table>
<thead>
<tr>
<th>Suspension Band</th>
<th>Tare RFC Range</th>
<th>Laden RFC Range</th>
<th>Suspension Discount Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RFC &gt; 715</td>
<td>RFC &gt; 1650</td>
<td>1.098</td>
</tr>
<tr>
<td>2</td>
<td>680 – 715</td>
<td>1545 – 1650</td>
<td>1.058</td>
</tr>
<tr>
<td>3</td>
<td>640 – 679</td>
<td>1450 – 1544</td>
<td>1.018</td>
</tr>
<tr>
<td>4</td>
<td>605 – 639</td>
<td>1350 – 1449</td>
<td>0.978</td>
</tr>
<tr>
<td>5</td>
<td>565 – 604</td>
<td>1255 – 1349</td>
<td>0.938</td>
</tr>
<tr>
<td>6</td>
<td>465 – 564</td>
<td>925 – 1254</td>
<td>0.898</td>
</tr>
<tr>
<td>7</td>
<td>RFC &lt; 465</td>
<td>RFC &lt; 925</td>
<td>0.858</td>
</tr>
</tbody>
</table>
RFCpro Software
RFCpro is a piece of software used to calculate Suspension Factors

Suspension Factors are used in determining the Track Access Charge for freight vehicles
RFC Pro Software

Integrates the RFC and Suspension Factor calculation into a user friendly Graphical User Interface

Provides the user with the option of Specific Vehicle and Generic Vehicle methods

Outputs results to a Log File for submission to Network Rail
Calculation Methods

Specific Vehicle Method
- Assessment of a single wagon type of known properties
- 1 Tare and 1 Laden simulation required

Generic Vehicle Method
- Assessment of a bogie or suspension type for a range of generic body parameters
- Up to 7 Tare and 6 Laden simulations required
- Can be used in the tendering process
Vampire Simulations

- Predefined Vampire simulations are to be carried out for the freight vehicle under assessment
- For the Generic Vehicle method the parameters for the different cases are generated using RFC pro
- The user builds the Vampire models in the usual way using either actual or generic body parameters
- Standard template Run File for all simulations
- Simulations to be carried out using Vampire directly
Template Vampire Run File:

Ride Force Calculation for freight banding: Tare Vehicle 1
UNITS VAMPIRE
C:\\VampirePro\\Freight_banding_11\\Param_study\\Vehicles\\Vehicle_1
*TRANSIENT
   20000.0  0.0005  0.010  0.00
SPEED   33.53
C:\\.....\\track\\TfB_Vampire_20km_final_v1
*CREEP
   0.32000  0.32000  8.00000  0.32000  0.32000  0.32000  0.32000
NON-LINEAR PROFILE  C:\\.....\\profiles\\NR_Freightbanding_P10
**************************************************************************
*OUTPUT
**************************************************************************
Vertical axle load (w’set 1)   kN
FW01Z
Vertical axle load (w’set 2)   kN
FW02Z
Vertical axle load (w’set 3)   kN
FW03Z
Vertical axle load (w’set 4)   kN
FW04Z
*

Values in Red are fixed and should not be altered.
Values in Blue are varied by the user as appropriate.
Specify Name and Location of RFCpro Log File
RFCpro – Specific Vehicle Method

RFCpro: Import Vampire Results

- Import Tare Results
- Import Laden Results

Selected Tare Vehicle File
No files selected

Selected Laden Vehicle File
No files selected

View Log File
Run RFC Processor
RFCpro – Specific Vehicle Method

RFCpro: Import Vampire Results

- Import Tare Results
- Import Laden Results

Selected Tare Vehicle File:
No files selected

Selected Laden Vehicle File:
No files selected

- View Log File
- Run RFC Processor
RFCpro – Specific Vehicle Method

[Image of a software interface for RFCpro, showing files and folder options]

File name: Freight_4ax_tare.002.xls

Open

View Log File
Run RFC Processor
Signals highlight the verification status of the imported files.

‘Run RFC Processor’ button is enabled once all selected files are verified.
Results are automatically written to the Log File

Click here to start a new assessment
RFCpro – Generic Vehicle Method

Choose Processing Method
See help menu for further details
RFCpro – Generic Vehicle Method

Parameters can be selected and copied using Ctrl+C.
Specify Name and Location of RFCpro Log File
RFCpro – Generic Vehicle Method

Make multiple selections by:
• Dragging a box round with the mouse OR
• Hold Ctrl+Click
‘Run RFC Processor’ button is enabled once all selected files are verified.
RFCpro – Generic Vehicle Method

RFCpro: RFC Results

Tare RFC Results
Ride Force Count: 657
Suspension Factor: 0.997

Laden RFC Results
Ride Force Count: 1400
Suspension Factor: 0.959

View Log File
Start New Assessment

Test.log
Imported Vampire Results Verification:

- Checks for existence of .lis, .log & .out files
- Checks that simulation was a Transient analysis and that it has executed correctly
- Checks the log file for Vampire Warnings
- Checks input axleloads match generic body details and do not exceed 25.5t
- Checks Run file parameters
  - Speed, Integration Timestep, Simulation Length
  - Correct Track Irregularity file has been used
- Output equations are correct
Software Demonstration
IRR will provide support for RFCpro until end of April 2013
NR beyond this point

Any problems should be directed to:

- Paul Allen
  p.d.allen@hud.ac.uk
- David Crosbee
  d.crosbee@hud.ac.uk
Any Questions?
Next steps
Next steps

• Software to be made available for use (subject to any substantial comments)

• Technical queries to Mark.Burstow@networkrail.co.uk

• Policy/charging queries to Ekta.Sareen@networkrail.co.uk