Vehicle Track Interaction Strategic Model VTISM Overview

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Agenda

Welcome

1000 – 1030	1. What is VTISM?
1030 – 1100	2. VTISM Components
1100 – 1130	3. Tutorial Overview and Demonstration

Break

1145 – 1300	4. Technical Basis – Overview of Track Damage Models and Data

Lunch

1330 – 1500	5. Hands-on Session: VTISM Tutorial
1500 – 1515	Discussion

Break

1530 – 1600	6. Use of VTISM in the CP5 VUC Project

Close

Introductions

Serco Rail Technical Services

- Andy Rhodes, Team Leader & Principal Consultant
- Daniel Ling, Senior Project Engineer

Aims

- Familiarisation - VTISM software features and hands-on experience
- To take you through the VTISM workflow
- Overview of track deterioration models
- Update on new Stage 2 developments and Wheelset Management Model

By the end of today, you should feel confident to setup, run and analyse a VTISM scenario

Part 1 - What is VTISM?

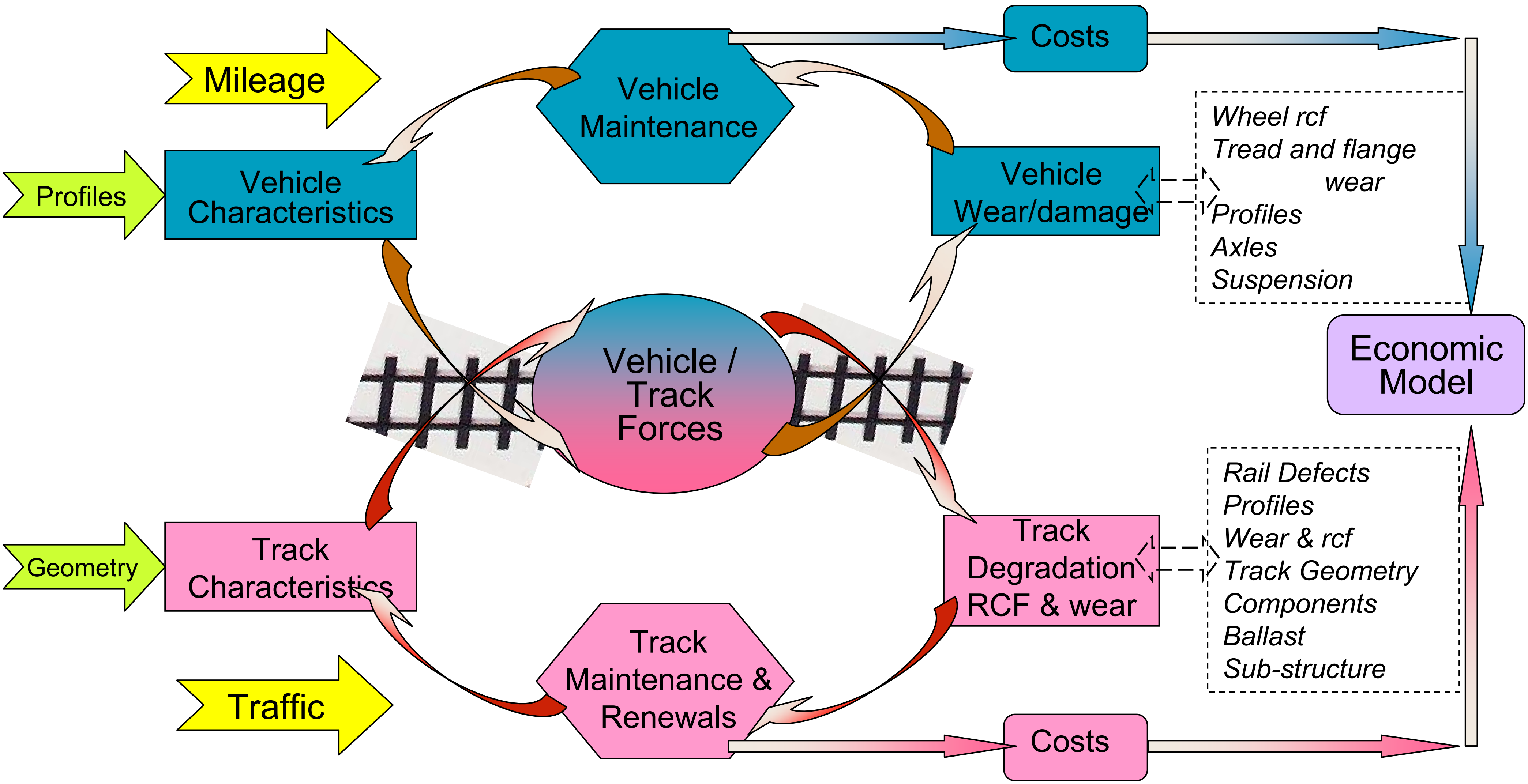
- Objectives
- Modelling framework
- What questions can VTISM answer?
  - What is your focus?
- Stages 1 and 2 development history
- Integrated components
- Benefits to industry
- Summary of key features

What is VTISM? - Objectives

- A whole life cost model for the Vehicle – Track system
- VTISM links inputs:
  - track and vehicle characteristics and maintenance regimes

  to outputs:
  - track asset and wheel lives, replacement and maintenance costs
- VTISM will predict the impact of changes to sub-systems focusing on overall system cost
- VTISM will enable substantial savings by applying a System view to:
  - Challenging and optimising engineering and maintenance standards
  - Improving strategic allocation of maintenance resources
  - Optimising track renewals programme
  - Optimising new vehicle designs
  - Optimising vehicle maintenance and overhaul

What is VTISM? – Modelling framework



What questions can VTISM answer?

- What is the impact of new train designs on track infrastructure?
  - increasing the wheelset primary yaw stiffness
  - adding mass
  - changing the wheel profile
- What is the impact on whole system costs of improving track quality, by better maintenance or renewal?
  - renewal criteria
  - maintenance regime, e.g. ballast stoneblowing
- What is the impact of changing track design?
  - a new grade of rail steel
  - flange lubrication
  - sleeper type / stiffness
  - changing the rail head profile
- What is the impact of increasing traffic?

From the above, do you have any specific questions / issues that you would like us to focus on during the day?

What is VTISM? – Development history

VTISM has been developed for: RSSB, Network Rail and V/T SIC
by: Serco, DeltaRail and UOH

- Based on our past experience:
  - Network Rail – T-SPA
  - Rail industry – Vampire / WLRM / WPDM
- Initial study on replacement HST variants
  - Comparison of each HST variant in terms of impact on track costs
  - Used models that address different aspects of vehicle-track interaction
  - Models were not integrated
- Functional Specification for VTISM Stage 1 (2006)
  - Potential tasks and developments identified and prioritised
  - V/T SIC approval for tasks in Stage 1
  - Additional work carried out for Network Rail that fed into VTISM Stage 1

What is VTISM? – Stage 1 Software integration

- VTISM core module created to link:
  - Track data
  - Traffic data
  - Vehicle Dynamics Simulation
  - RCF/Wear Damage Calculation
  - Vertical Damage Modelling
  - Maintenance and Renewal Planning
- Many components upgraded to improve integration and accuracy:
  - RCF/Wear Damage Calculation
  - Ballast maintenance model
  - Maintenance and renewal criteria
- Validated route data sets (sections of ECML, MML and GWML)
- Comprehensive test and validation programme and super user involvement
- User guide and training course
- VTISM Stage 1 issued to GB Rail users in 2007 and used for DfT's Intercity Express Programme (IEP)

What is VTISM? – Stage 2 Model improvements

- Housekeeping and model improvements (2009-2010)
  - Addition of commuter routes (sections of TPE and SWML)
  - Updated track condition data sets
  - Model improvements
    - Updated Equivalent Gross Tonnage (EGT) algorithm
    - RCF and wear improved via automated location matching between GEOGIS and NMT data;
    - Addition of rail grinding model
  - Addition of generic freight vehicle model
  - Integration of S&C vertical damage module previously developed for Network Rail
  - Addition of track inspection and rail defect (vertical) repair activities and costs
- New release version 2.6 (2010-2011)
  - Wheelset management module
  - Improving the interface, making it easier to use (e.g. ride force coefficient tool, WLRM input convertor tool, batch processing, etc.)

What is VTISM? - Integrated components

- VTISM Core Module
  - Access Database
- Track Data
  - GEOGIS, Trackmaster, NMT Geometry Data, RailFail
- Traffic Data
  - NETRAFF / ACTRAFF
- Vehicle Dynamics Simulation
  - VAMPIRE® or other rail vehicle dynamics software
- RCF/Wear Damage Calculation
  - Whole Life Rail Model (WLRM)
- Track Deterioration Modelling and Maintenance/Renewal Planning
  - T-SPA
- Wheelset Deterioration Modelling and Maintenance/Renewal Planning
  - W-SPA

What is VTISM? - Benefits to industry

- VTISM has been applied by:
  - Network Rail for track assessments in CP4 and CP5 and allocation of variable usage costs
  - DfT and train manufacturers for IEP and Thameslink
  - RSSB on behalf of the industry
    - evaluating whole life costs of track quality improvement methods
    - train mass study
    - whole system costing case study
  - Organisations involved in VTI-related studies
- Licenses issued to several GB railways members (Network Rail, train manufacturers, DfT, TOCs and other research organisations)

What is VTISM? - Summary of key features

- Robust, validated, condition-based models (for UK mainline track)
- Calculates Vertical damage, RCF damage and renewal & maintenance costs (using Network Rail approved unit cost rates)
- Rolling wave approach / multiple asset replacements
  - Asset condition reset on replacement and maintenance, including restoration penalties (e.g. tamping damage)
- Flexible renewal and maintenance criteria can be defined and saved in the scenario
- Library of scenarios / ‘What-ifs’ can be saved – facilitates sensitivity studies
- Budgets and replacement priority
- Maximum granularity via variable length track data segmentation
- It is a complex suite of modules!!! However, the software will guide you via an intuitive workflow, step-by-step through data and scenario setup and calculations
- Trace files allow tracking of through-life asset condition parameters
- Audit trail
- Developed using MS Access, Visual C++ and Fortran which ensures fast processing of scenarios

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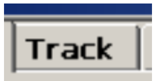
Part 2 - VTISM Components

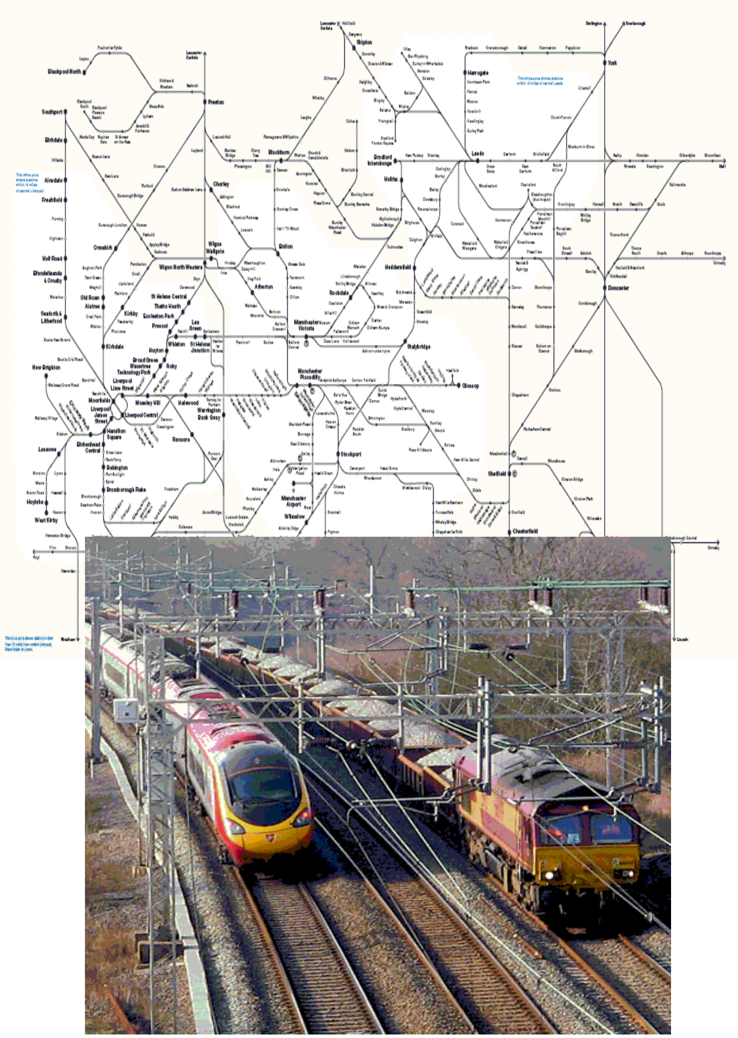
VTISM system overview

- Project 

  - Project name and description
  - A project contains and links inputs and results
- Track 

  - Routes to be considered
  - Re-modelling
- Traffic 

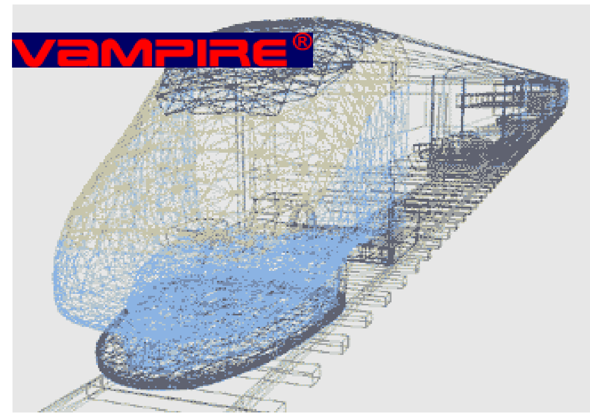
  - Vehicle Types and Traffic levels



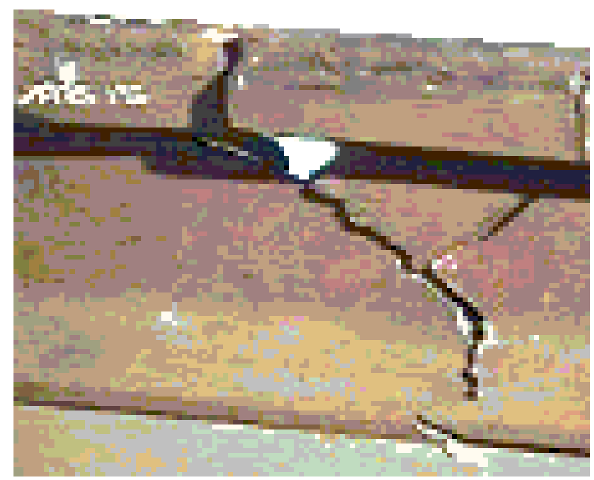
VTISM Components (cont.)

VTISM system overview

- Vampire   Track Forces
  - Analysis results and correlation with vehicle types

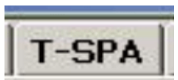


- WLRM   RCF and Wear
  - Analysis results and correlation with track locations

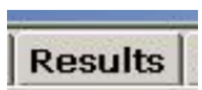


VTISM Components (cont.)

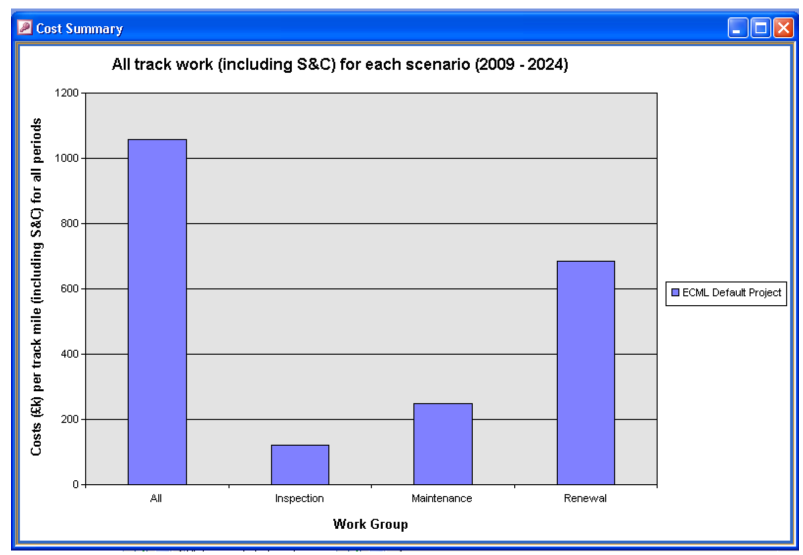
VTISM system overview

- **T-SPA** 

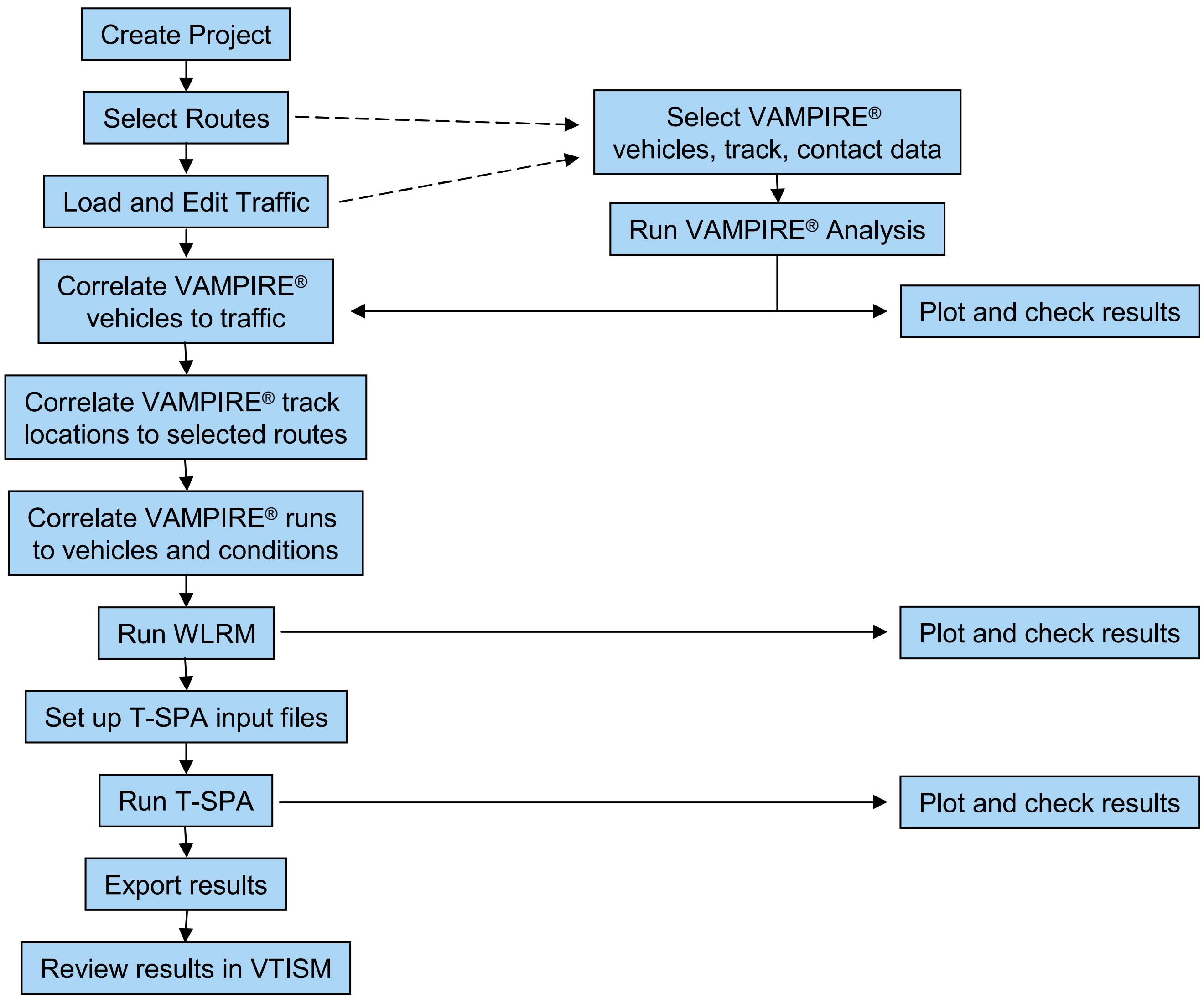
  - T-SPA track standards
  - T-SPA track renewal and maintenance criteria
  - Predicted condition, performance and costs
  - 'Quick review' results

- **Results views** 

  - Plot results exported from T-SPA
  - Compare multiple scenarios



VTISM Components (cont.) - VTISM Flow Chart



VTISM Components (cont.)

Track

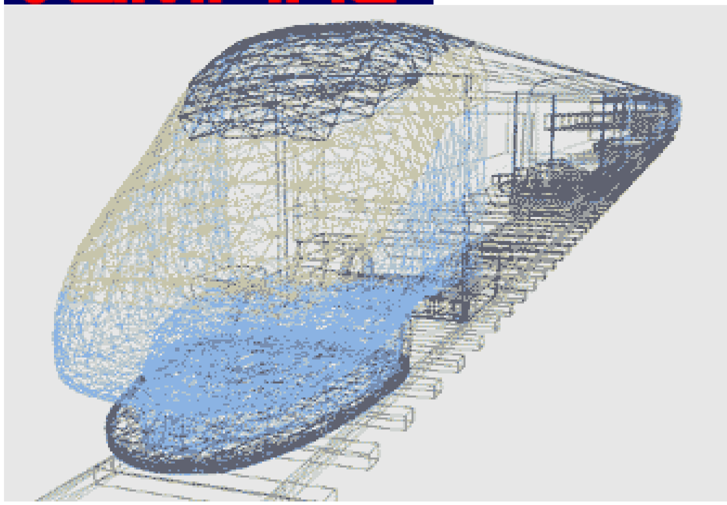
- Amalgam of:
  - Geogis:
    - Rail, sleeper, ballast, S&C installation dates and types
    - Track designation (route, asset territory, strategic route, etc.)
    - Tunnels, stations
  - RailFail: rail defects and breaks
  - TrackMaster: latest geometry and deterioration rates
  - Curvature data
- Track broken down into sections:
  - Uniquely defined by ELR, TID, Start and End mileage
  - Track characteristics (as defined above) are the same for each track section
  - ~600,000 sections making up the 20,000 track miles of track operated by Network Rail
  - Sections between 1 – 125 mMiles (220 yards) long

VTISM Components (cont.)

Traffic

- Vehicle / Axle Database
- Traffic data (NETRAFF / ACTRAFF)
- Change Traffic
  - Alternative vehicle types
  - Change configuration / number of vehicles
  - Traffic growth

VTISM Components (cont.)



Track Forces

- VAMPIRE® analysis:
  - VAMPIRE® run file:
    - Select
    - Edit
    - Vehicle Model from Library
    - Track from Library or NMT
    - Wheel/Rail contact
  - Run VAMPIRE® analysis
  - Plot and review VAMPIRE® results
- Relate VAMPIRE® analysis to previously chosen Route and Traffic
  - Relate VAMPIRE® track file to ELR, TID, Start and End mileage
    - Alignment using curvature matching between GEOGIS and NMT
  - Relate VAMPIRE® vehicles to vehicle types in Traffic data
    - Adjust proportions of vehicles where VAMPIRE® analysis does not provide results for all axles of a vehicle

VTISM Components (cont.)

RCF and Wear

- Create WLRM input file:
  - Define track irregularity file
  - Set RCF Damage and Wear parameters (Tgamma relationship to RCF/ wear damage)
- Run WLRM
  - Established degradation models to predict Rolling Contact Fatigue and Wear
- Plot and review WLRM results
  - RCF
  - Wear

VTISM Components (cont.)

T-SPA

- Inputs:
  - A definition of the current infrastructure and its condition
  - Traffic data
  - Static and dynamic forces associated with different track types
  - RCF/wear
  - Unit costs of work
- User settings
  - Maintenance/renewal/inspection rules and intervention criteria
  - Projection time frame
- Outputs:
  - Track maintenance/renewal volumes and costs, exported and stored in the VTISM project
  - Track section trace data

W-SPA

- Similar to T-SPA but for analysis of wheelset management scenarios

Summary of VTISM Components

- VTISM ‘Project’ file integrates databases associated with:
  - Route / track
  - Traffic
  - Track Forces
  - RCF and Wear
  - T-SPA
  - W-SPA
  - Scenario results

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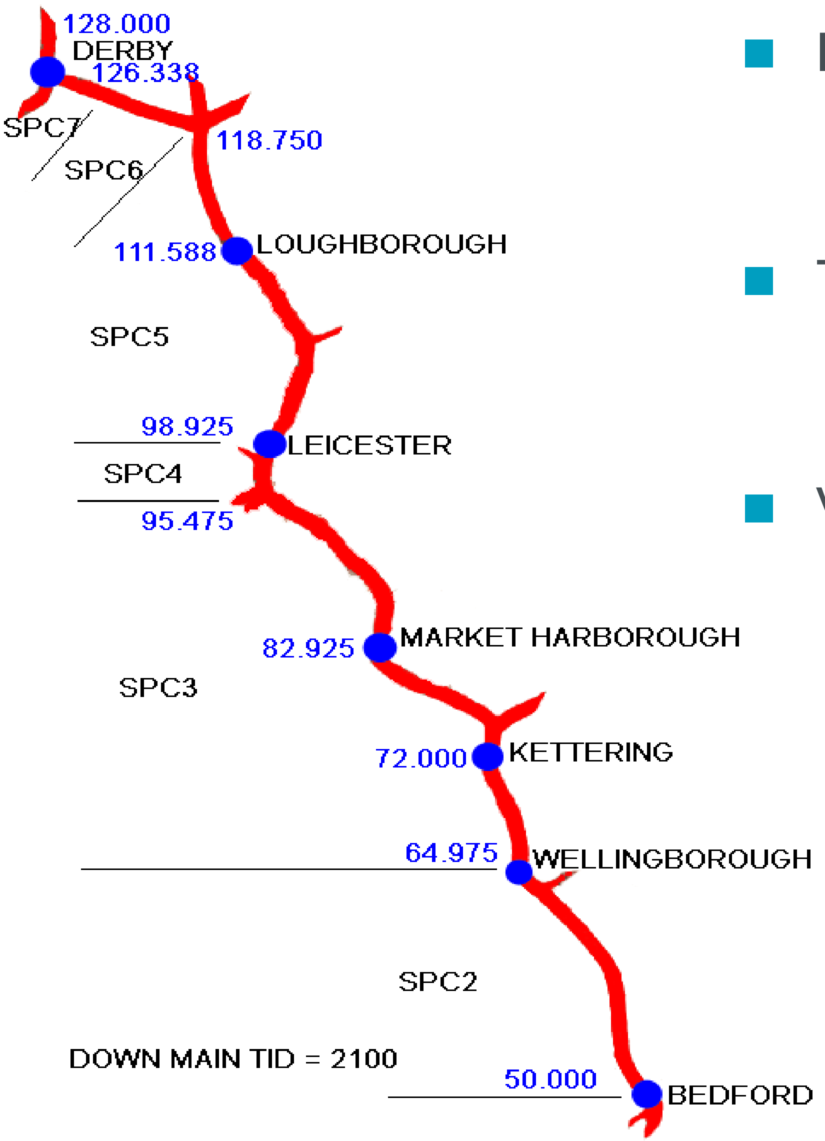
Part 3 - VTISM Tutorial Overview and Demonstration

- We are here today to teach you how to use VTISM
- There is a lot to grasp but it should become clearer once you have started to work through the tutorial
- We welcome your suggestions for improvements; where possible we would prefer to discuss these after the hands-on sessions
- The tutorial is based on part of the HST2 study on the Midland Main Line
- When you have worked through the actions, feel free to try some more variants of the analysis

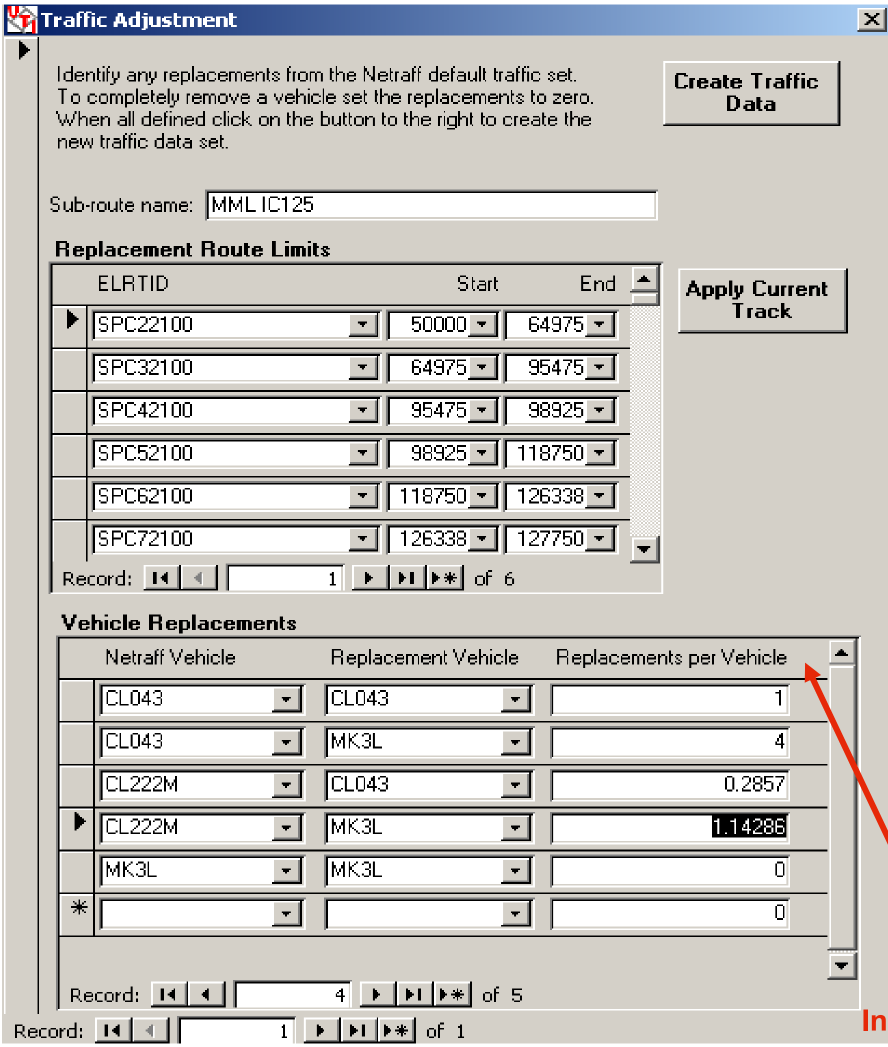
VTISM Tutorial: MML analysis



- Down Main Bedford – Derby:
  - GEOGIS 50.0 – 128.0 miles
  - VAMPIRE® 0.0 – 125184.0 metres
- Traffic:
  - ~60% of tonnage is HSTs
  - No other vehicle over 10%.
- VAMPIRE® runs:

Vehicle	**Run #**
– 26m HST2 car, low PYS:	new PII 001 / worn 002
– 26m HST2 car, medium PYS:	new P8 003 / worn 004
– 26m HST2 car, high PYS:	new P8 005 / worn 006
– 26m HST2 car, light bogie:	new P8 007 / worn 008
– HSTNOW car, light bogie:	new P8 011 / worn 012
– Mk3 Coach:	new P8 013 / worn 014
– HST Power car:	new P8 015 / worn 016
– PGA Hopper:	new P6 017 / worn 018

Vehicle Replacements Example



Input:

- Replace the mixed HST traffic (comprising CL043/MK3L and CL222M) with variant IC125 (CL043/MK3L only)
  - Line 1 – Keeping all the basecase CL043 currently on the route
  - Line 2 – For every CL043 introduce 4 MK3L, i.e. 8/2 = 4
  - Line 3 – For every CL222M (7 vehicles) replace with CL043's (2 vehicles) i.e. 2/7 = 0.2857
  - Line 4 – For every CL222M (7 vehicles) replace with MK3L's (8 vehicles), i.e. 8/7 = 1.14285
  - Line 5 – Existing MK3L's are removed as we introduced them in Line 2.

Replacement Vehicles

Original Netraff vehicles

Vehicle Replacements Example

AS:IS	CL043 8,209	MK3L 32,542	MK3L	MK3L	MK3L	Basecase CL043 / MK3L traffic
	CL222M 83,667					Basecase traffic

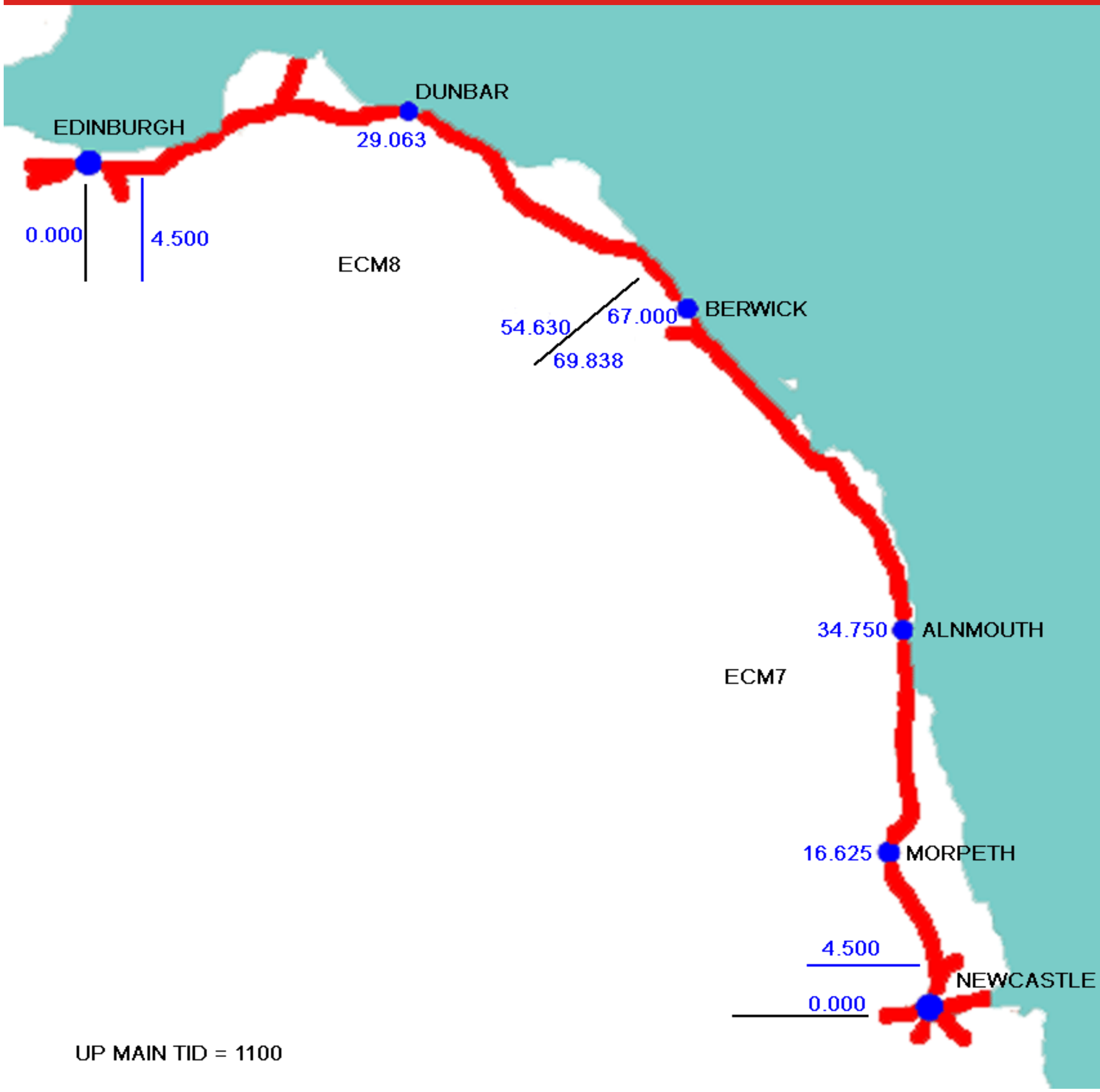
Line 1 & 2 Keep the CL043	CL043 8,209	MK3L 32,542	MK3L	MK3L	MK3L	Basecase MK3L traffic
Introduce MK3L (4xCL043)		MK3L 32,835	MK3L	MK3L	MK3L	Introduction of additional MK3L
	CL222M 83,667					Basecase traffic

Line 3 & 4	CL043 8,209	MK3L 32,542	MK3L	MK3L	MK3L	Basecase CL043 / MK3L traffic
		MK3L 32,835	MK3L	MK3L	MK3L	Introduction of additional MK3L
Replace CL222M with CL043 Replace CL222M with MK3L	CL043 23,904	MK3L 95,620	119,524			Replaced the CL222M trainsets (7 vehicle) with new trainsets (2xCL043, 8 x MK3L) to keep passenger numbers the same.

TO:BE **Line 5** Remove the extra MK3L	CL043 8208.813					Remove basecase MK3L traffic
		MK3L 32,835	MK3L	MK3L	MK3L	
	CL043 23,904	MK3L 95,620	119,524	total		

Totals	CL043 32,113	MK3L 160,997	New totals

VTISM Demonstration: ECML analysis



- Up Main Edinburgh-Newcastle:
  - GEOGIS 4.5 – 54.63 + 69.838 - 4.5 miles
  - VAMPIRE® 0.0 – 194800.0 metres
- Traffic:
  - 39% of tonnage is IC225s
  - 30% is coal trains
  - 14% is Voyagers
- VAMPIRE® runs:
  - **- Refer to vehicle types and proportions in next slide for the setup of data in the Track Forces tab – Vehicles form**

VTISM Demonstration: ECML analysis Vampire runs

File	Vehicles	Proportion
CL66_P8_New CL66_P8_Worn	CL66/0 CL92/0 CL60/0	2
CL91_P8_New CL91_P8_Worn	CL091 CL043	2
CL220_P8_New CL220_P8_Worn	CL220M	2
CL221_P8_New CL221_P8_Worn	CL221L	2
HAA_P6_New HAA_P6_Worn	HAAVL HMAL HDAL HFAL HBAL	1
HTA_P6_New HTA_P6_Worn	HTAAL FCAAL FKAL FIAL FSAL TEAL	1
MK3_P8_New MK3_P8_Worn	MK3L CL156	2
MK4_P8_New MK4_P8_Worn	MK4L DVT4	2

NB: DVT4 has been substituted for CL91/1 in the traffic data.

Close Full Screen

VTISM Demonstration: TPE analysis Overview

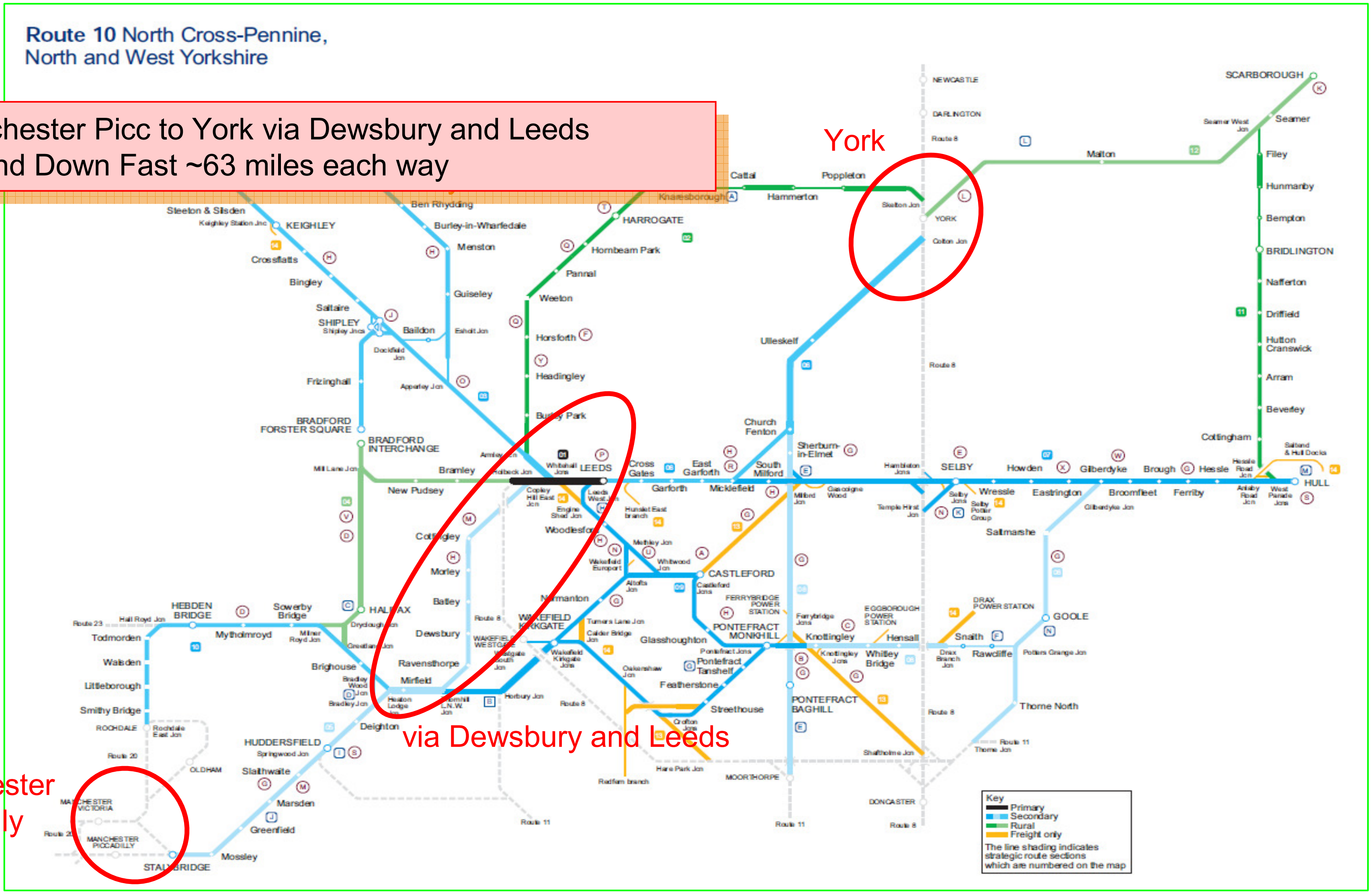
- Aim – To investigate the influence of changes to wheelset maintenance strategy on track costs for a generic DMU on TPE
  - Flange lubrication
  - Changing from a mileage- to a condition-based turning regime
  - Changes to vehicle primary yaw stiffness
- VTISM route is TPE (Manchester – York, Up and Down Lines) (Total 123 miles)
  - Traffic - 49% of tonnage is CL185 DMU 3 cars/unit, remaining traffic is Voyager, Turbostar and freight
  - Vampire
    - NMT data: M-Y 6.832 - 66.766 miles; Y-M 0.142 – 67.651 miles
    - Vampire runs based on generic CL185 vehicle model provided for: light, moderate, worn and heavily worn profiles, lubrication and PYS change

VTISM Demonstration: TPE analysis Scenarios

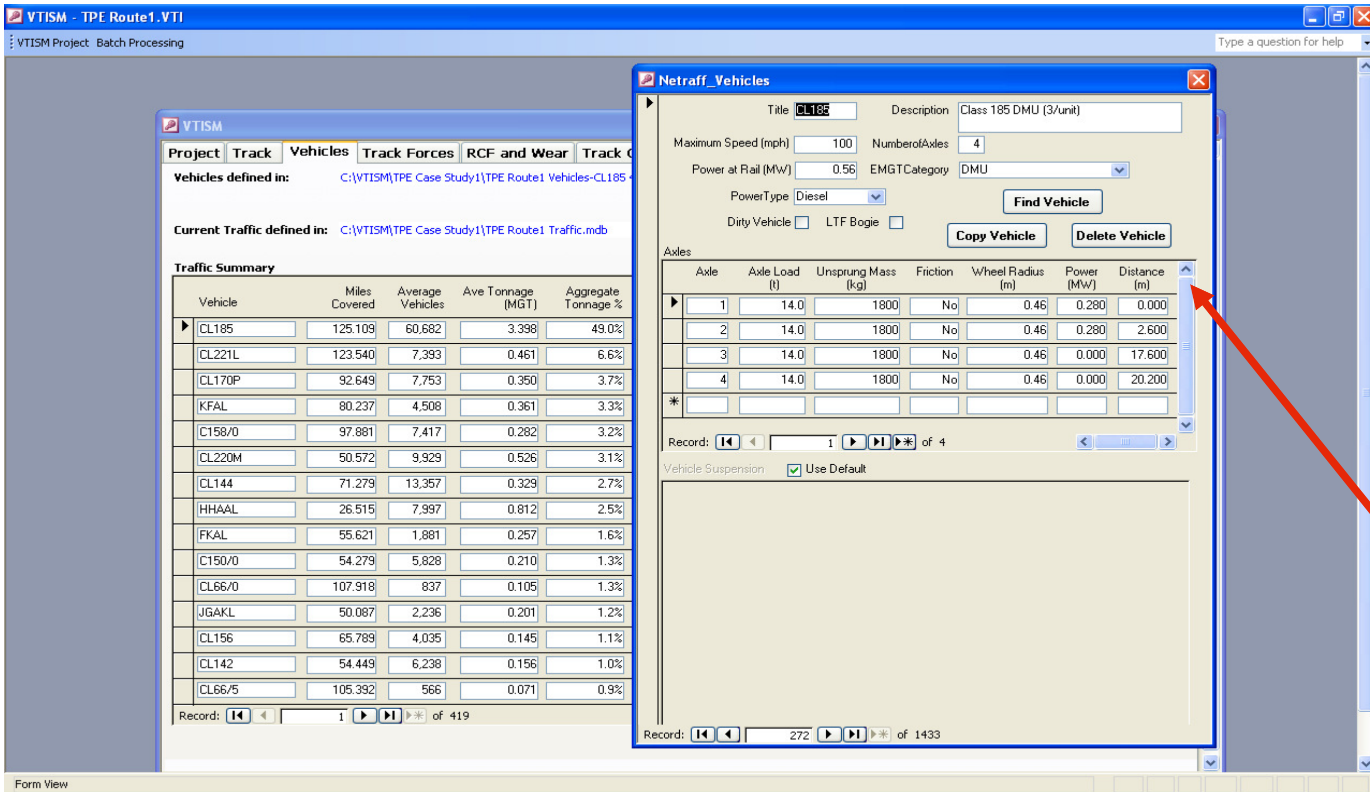
- Scenarios / VTISM runs to be analysed:
  - Step 1. Establish CL185 vertical damage cost (i.e. cost of run 1- cost of run 2):
    - 1. All traffic – No RCF
    - 2. No CL185 – No RCF
  - Step 2. Establish base RCF cost (for other traffic on the route):
    - 3. All traffic – No CL185 RCF (i.e. CL185 RCF excluded from the WLRM analysis)
  - Step 3. Establish RCF/wear cost for each scenario (i.e. cost of run 4,5,6,7 or 8 – cost of run 3)
    - 4. Base case (140k mile turning interval)
    - 5. Variant 1 - Reduced turning interval (100k mile)
    - 6. Variant 2 - Condition-based turning
    - 7. Variant 3 - Lubrication
    - 8. Variant 4 - Primary Yaw Stiffness
  - Results – Add the vertical (constant cost in this case) + RCF cost for each scenario to obtain total track impact cost

VTISM Demonstration: TPE analysis
VTISM standard route

Manchester Picc to York via Dewsbury and Leeds
Up and Down Fast ~63 miles each way

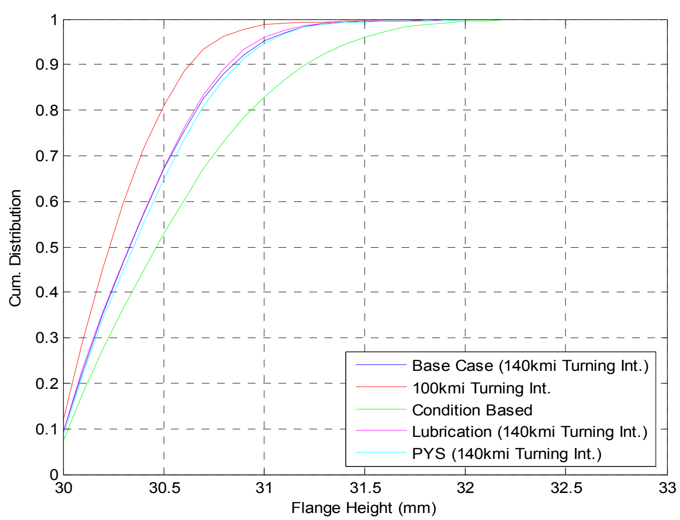


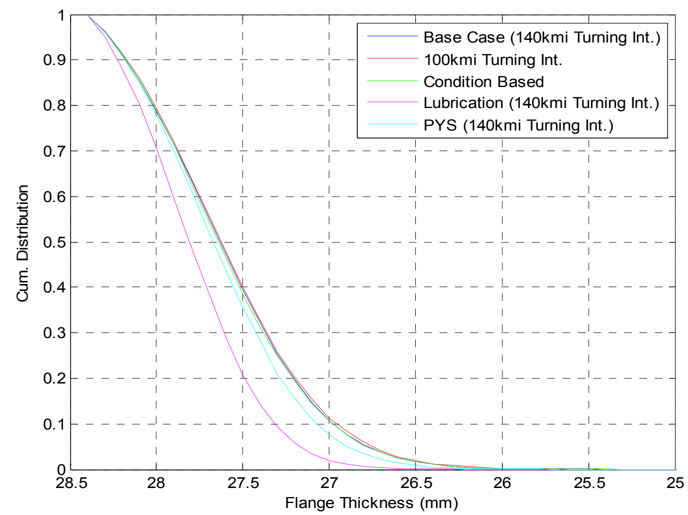
VTISM Demonstration: TPE analysis Class 185 Vehicle data



- Vampire runs output 4 axles
- Distance from the centre of the leading axle to other three axles is 2.6m, 17.6m, 20.2m
  - Enter the CL185 vehicle data – 'Distance' field values as shown

VTISM Demonstration: TPE analysis
Wheel profile distribution





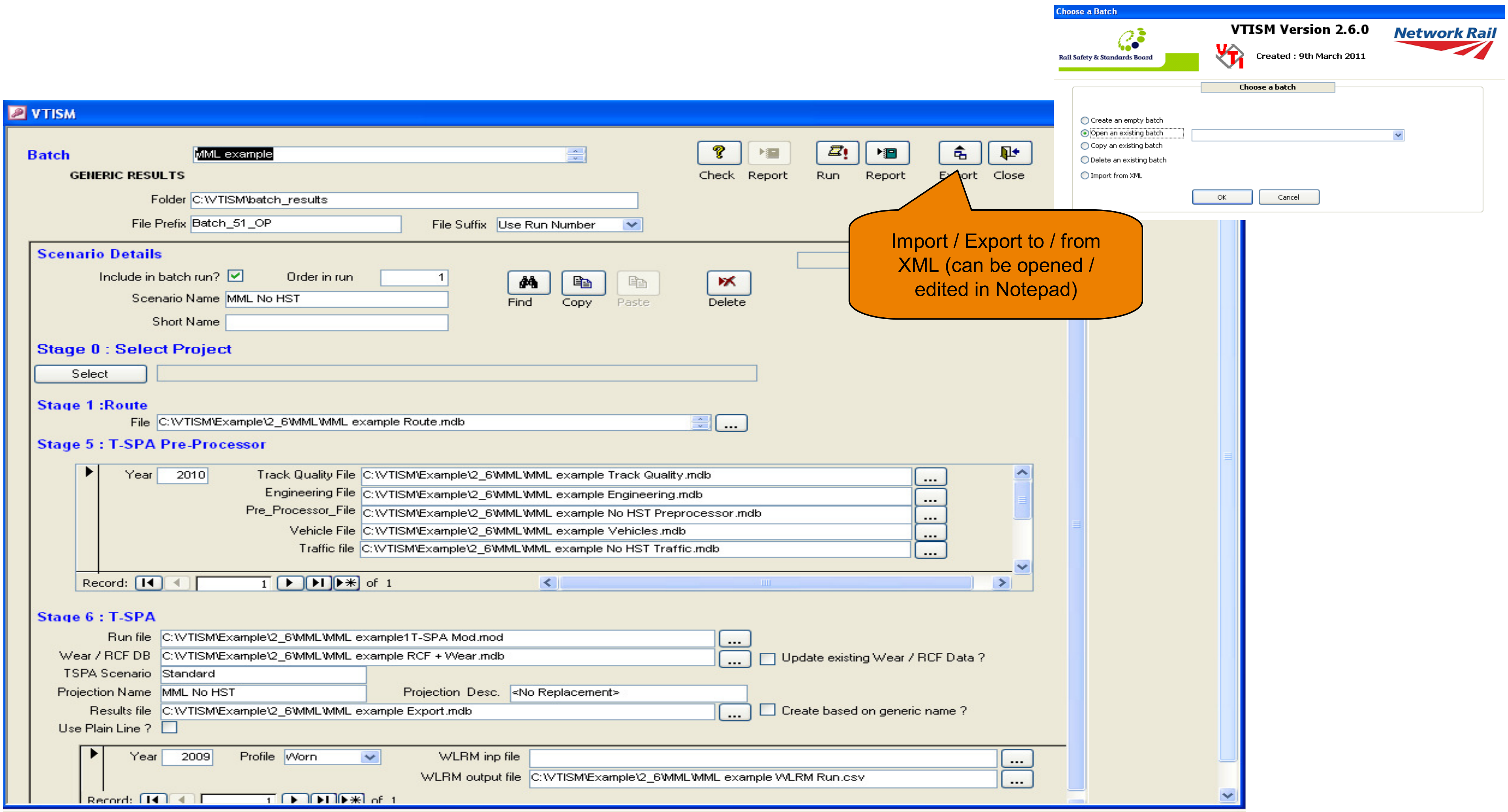
Distribution of Flange Height and Thickness for Different Maintenance Scenarios

Case	Wheel Wear State			
	Light	**Moderate**	**Worn**	**Heavy**
Base case (140k mile turning interval)	0.25	0.5	0.25	0
Reduced turning interval (100k mile)	0.25	0.7	0.05	0
Condition-based turning	0.125	0.125	0.3	0.45
Lubrication	0.25	0.7	0.05	0
Primary Yaw Stiffness	0.25	0.5	0.25	0

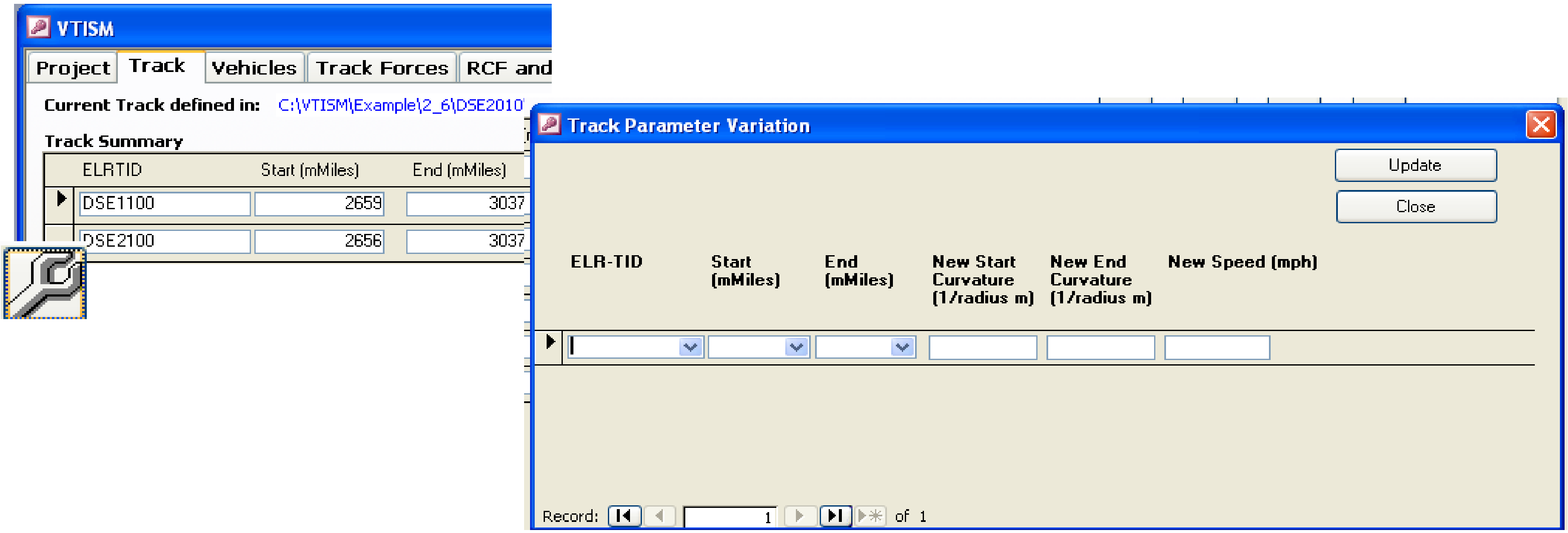
Proportions of Wheel Wear for VTISM Track Analysis

- WMM used to derive wheel profile distribution
- Proportions of each wheel wear state are entered into the Vampire Vehicles tab – ‘Model Proportion’ field

Batch Processing of Track Analysis Scenarios (Refer to User Guide Section 7.2 Page 107)



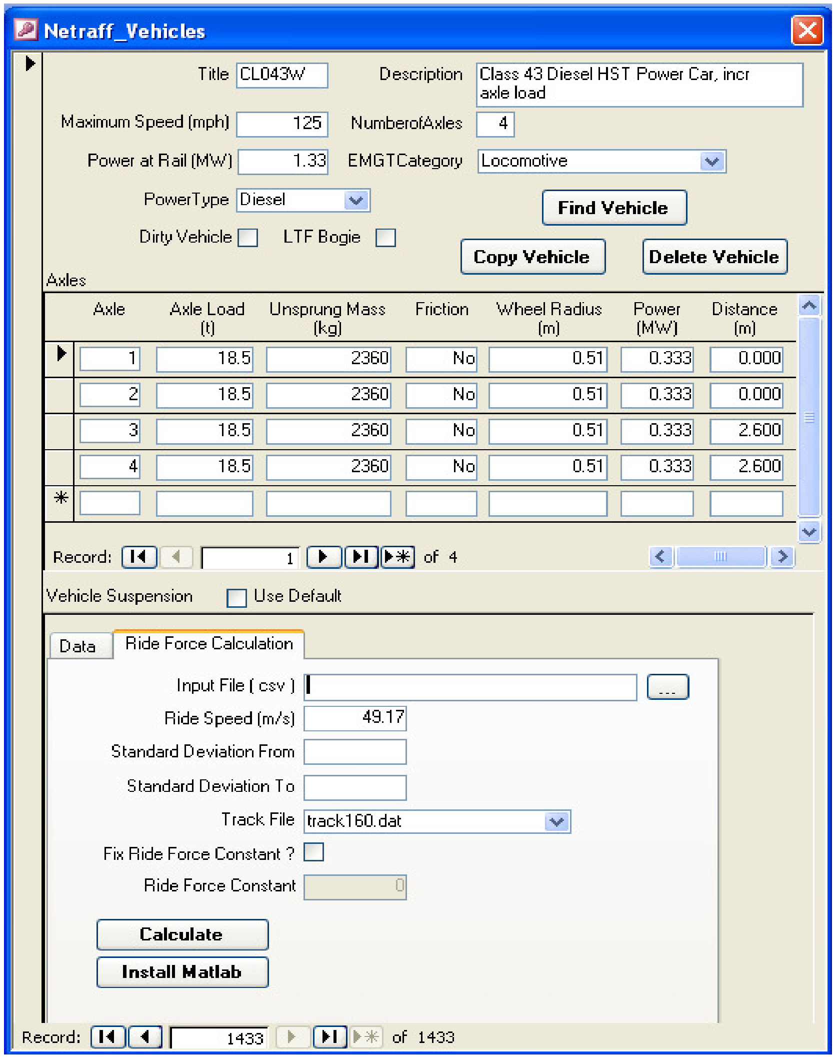
Track Parameter Variation
(Refer to User Guide Section 7.3 Page 113)



- Supports track re-modelling studies by allowing line speed and curvature changes to specific track sections
- Allows impact of changes on costs to be assessed

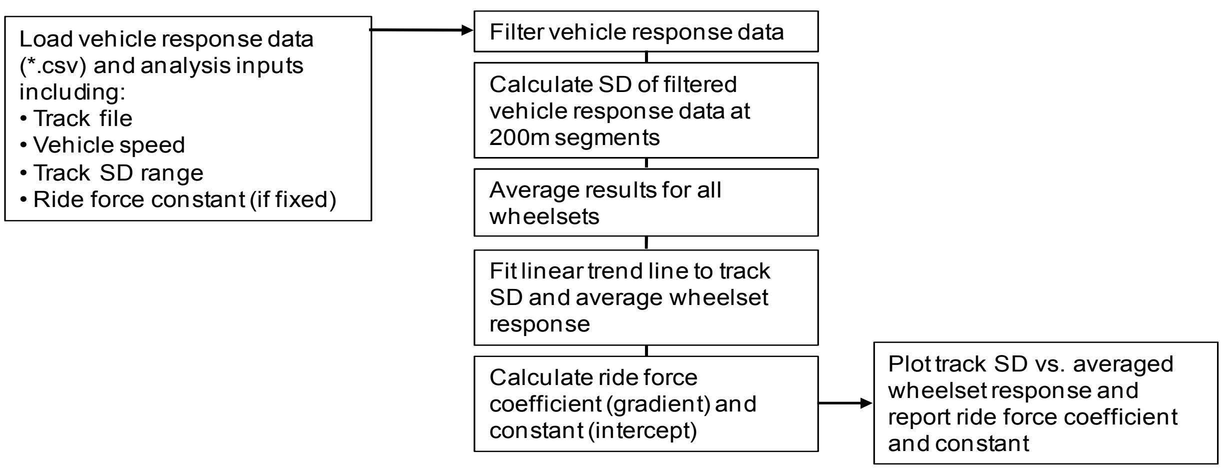
Ride Force Calculation Tool (Refer to User Guide Section 7.4 Page 114)

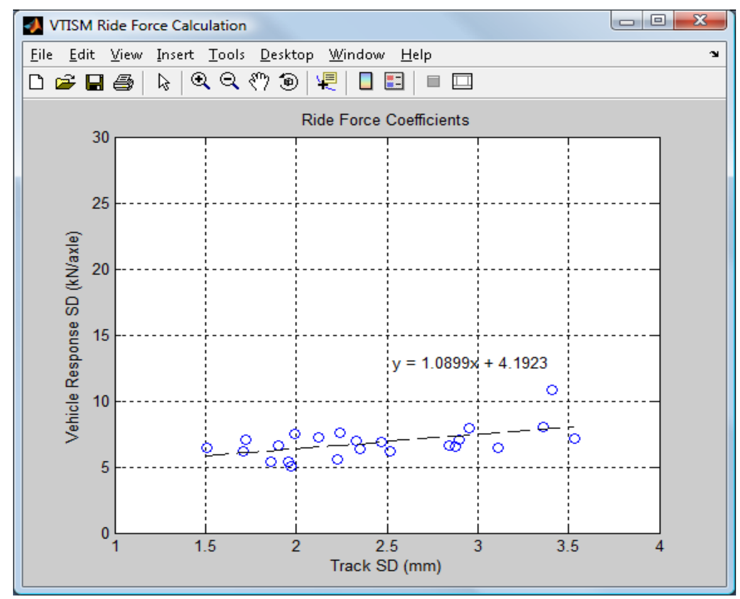
- Matlab application for automatic calculation of ride force coefficient and constant given Vampire outputs (.csv format)



Ride Force Calculation Tool (cont.)

- A tool has been developed to calculate the ride force constant and coefficient from wheel-rail forces derived from vehicle dynamics simulation
  - – tool performs calculation as defined in VTISM User Guide
- The ride force constant and coefficient can then be used within the VTISM software





WLRM Import Utility
(Refer to User Guide Section 7.5 Page 117)

- Tool developed to convert text file (*.csv) of vehicle dynamic simulation outputs into Vampire format (*.run, *.out, *.lis)

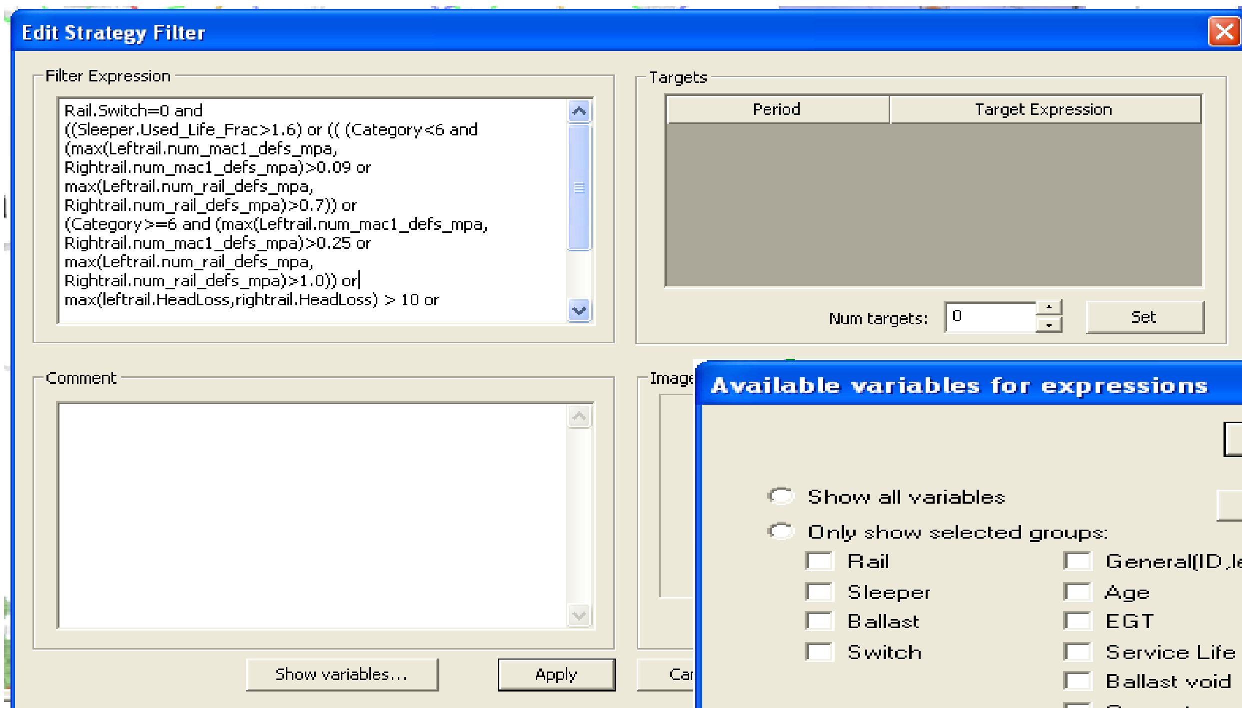
- Text file should contain inputs required for WLRM analysis as detailed in VTISM User Guide (per wheelset, left/right tread and flange):

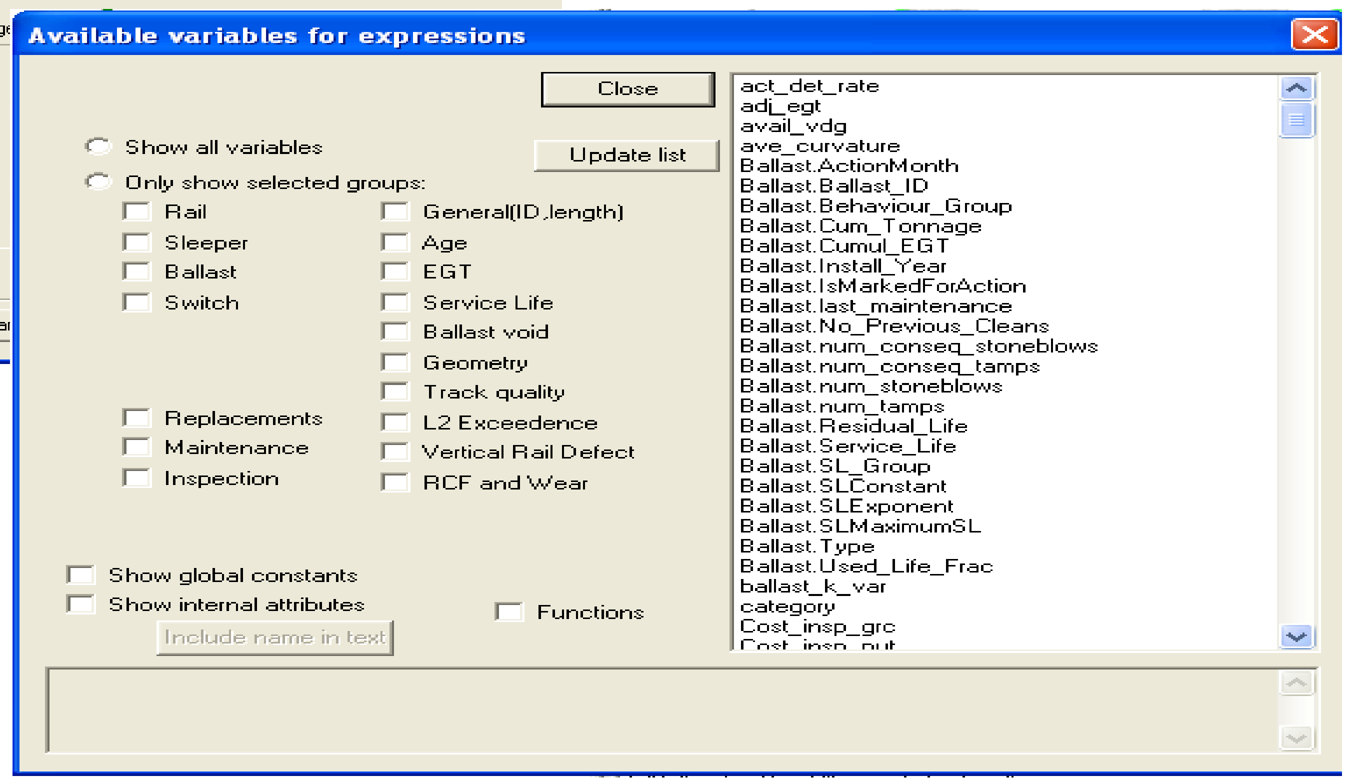
Output Channel	**Units**
Longitudinal creep force	kN
Contact patch area	mm
Contact position	mm
T-gamma	N
Contact patch ellipticity	mm

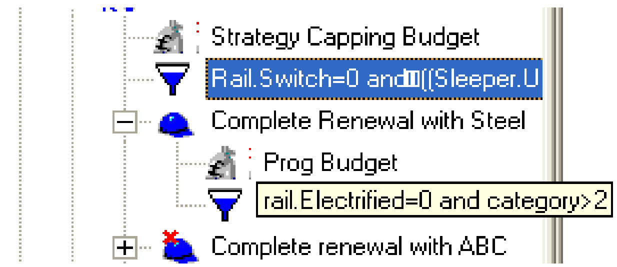
- User will be required to ensure units and sign convention of the inputs match those output from Vampire (guidance given in User Guide)

- Dialog box allows user to navigate to text file that requires converting (multiple files can be converted)

Usability Improvements - Renewal and maintenance criteria expression builder

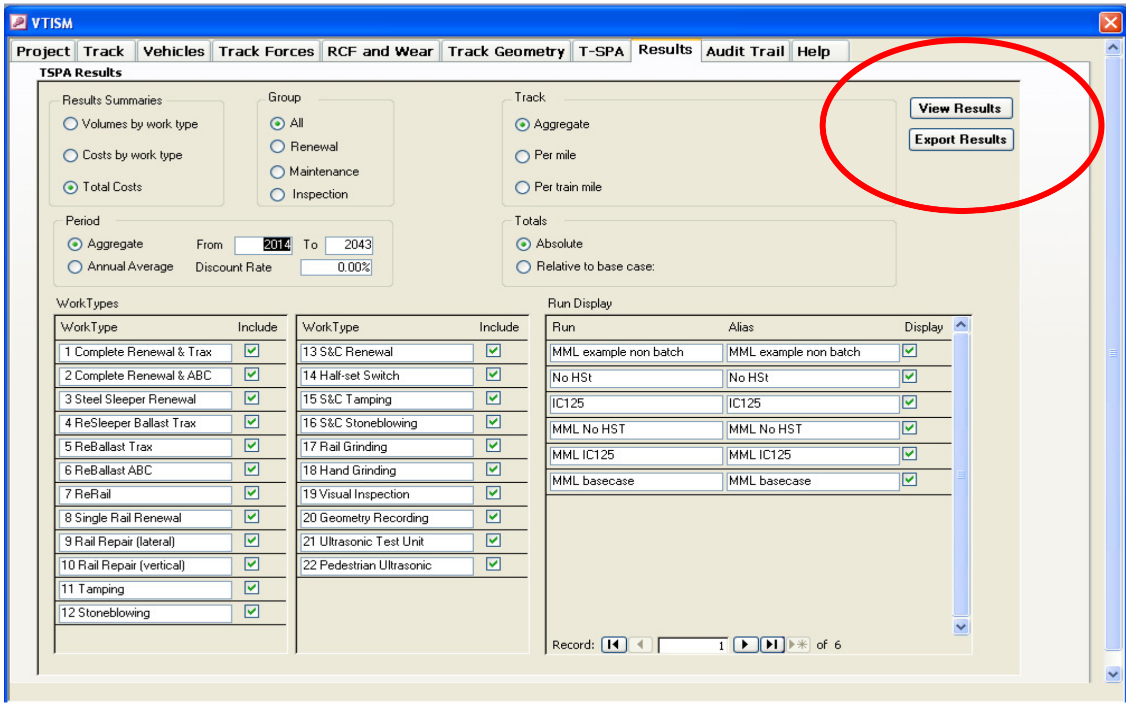






Usability Improvements - User Interface Improvements

- Export Results



Summary of Key Features

- Robust, validated, condition-based models (for UK mainline track)
- Calculates Vertical damage, RCF damage and renewal & maintenance costs (using Network Rail approved unit cost rates)
- Rolling wave approach / multiple asset replacements
  - Asset condition reset on replacement and maintenance, including restoration penalties (e.g. tamping damage)
- Flexible renewal and maintenance criteria can defined and saved in the scenario
- Library of scenarios / ‘What-ifs’ can be saved – facilitates sensitivity studies
- Budgets and replacement priority
- Maximum granularity via variable length track data segmentation
- It is a complex suite of modules!!! However, the software will guide you via an intuitive workflow, step-by-step through data and scenario setup and calculations
- Trace files allow tracking of through-life asset condition parameters
- Audit trail
- Developed using MS Access, Visual C++ and Fortran which ensures fast processing of scenarios

Agenda

Welcome

1000 – 1030	1. What is VTISM?
1030 – 1100	2. VTISM Components
1100 – 1130	3. Tutorial Overview and Demonstration

Break

1145 – 1300	**4. Technical Basis – Overview of Track Damage Models and Data**

Lunch

1330 – 1500	5. Hands-on Session: VTISM Tutorial
1500 – 1515	Discussion

Break

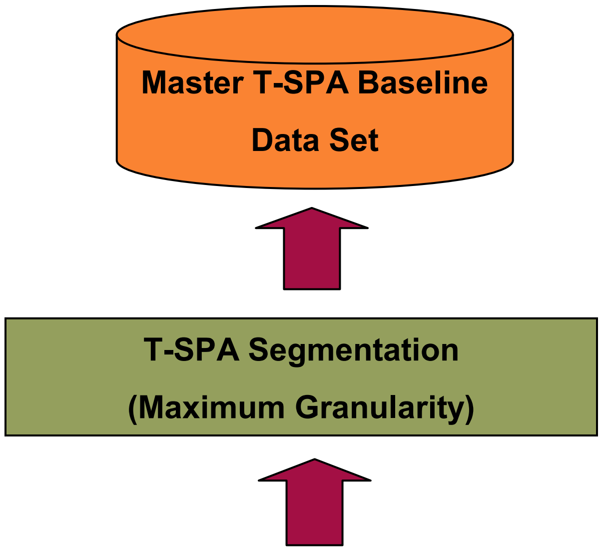
1530 – 1600	6. Use of VTISM in the CP5 VUC Project

Close

Part 4. Overview of Track Damage Models and Data

- Track data and T-SPA databases
- Service live curves
- Track geometry model
- Rail defects model
- T-SPA renewal, maintenance, inspection criteria and unit costs
- Example outputs / applications

Track data - Segmentation



Asset Register	Track Quality and Asset Condition	Traffic and Vehicle Data	Unit Costs
1. GEOGIS (Rail, Sleeper, Ballast and S&C)	1. Track Quality via NMT / TrackMaster	1. Current Train Service Plan (NETRAFF/ ACTRAFFcomposite	1. Track/S&C Track Geometry Maintenance
2. Design Geometry (Curvature/Cant)- National Gauging	2. Rail Defects- RailFail	2. Vehicle / axle / ride force parameters	2. Renewals / defect repair
3. Stations, Tunnels	3. Rail Wear	3. Performance/ Delays	3. Inspection

- Data management procedure for collating several Network Rail corporate databases into unified T-SPA database
- Segmentation program used to segment and integrate data sets, providing maximum granularity
- Quality assurance checks applied and data supplemented, where necessary, for example:
  - Asset type / age data
  - Traffic data
  - Curvature data

VTISM VUC project used snapshot derived in 2012

Track data - T-SPA asset database tables

- ‘TrackSections’ track location, non-asset specific data
  - ELR/TID, Start/End Mileage
  - Track category
  - Route type
  - Traffic segment
  - Latest geometry and deterioration rate
  - Curvature / cant
  - Line speed
  - Stations / tunnels
- ‘RailSections’ left and right rail characteristics
- ‘SleeperSections’ sleeper characteristics
- ‘BallastSections’ ballast characteristics
- ‘Switches’ switches and crossings specific characteristics
- ~600,000 sections making up the 20,000 track miles of track operated by Network Rail; Sections between 1 – 125 mMiles (220 yards) long

  VTISM VUC project selected a random sample of track sections by line speed

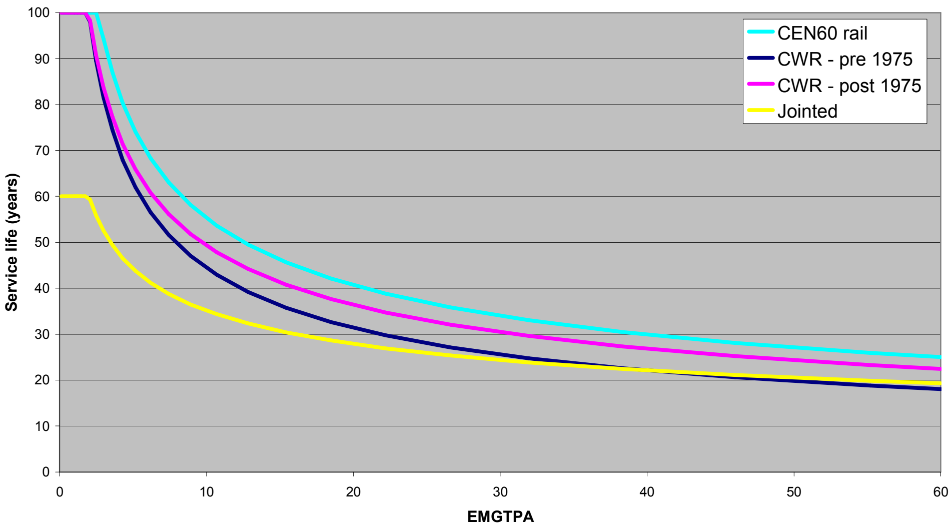
Track data - T-SPA traffic database tables

- ‘AnnualVehicles’
  - Current and historical traffic
  - NETRAFF / ACTRAFF based
  - Historical traffic needed to estimate the cumulative loads on the track assets since their installation
  - Traffic profile includes:
    - traffic segment identifier
    - vehicle types
    - annual number of vehicles passing over the segment
- ‘Vehicles’
  - Vehicle type, max. speed, power at rail, dirty wagon, etc.
- ‘Axles’
  - Axle load, un-sprung mass, power at rail, etc.
- ‘Suspension’
  - Ride force data for generic and specific vehicles

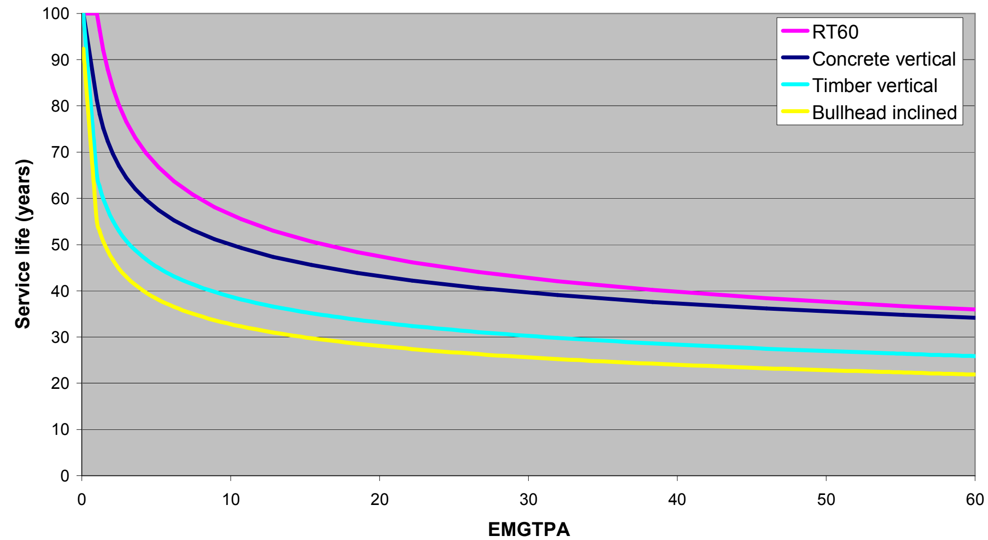
VTISM VUC Project used an artificial vehicle type with varying axle load, un-sprung mass and speed included within the traffic mix. The closest matching vehicle suspension / ride force data was used for the given axle load and speed.

Service lives

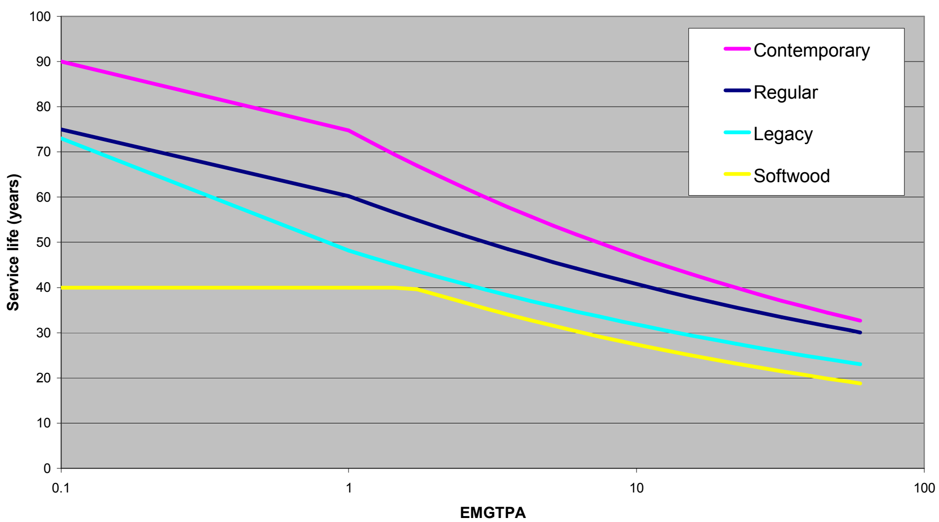
Adjusted plain line rail service lives



Adjusted S&C service lives

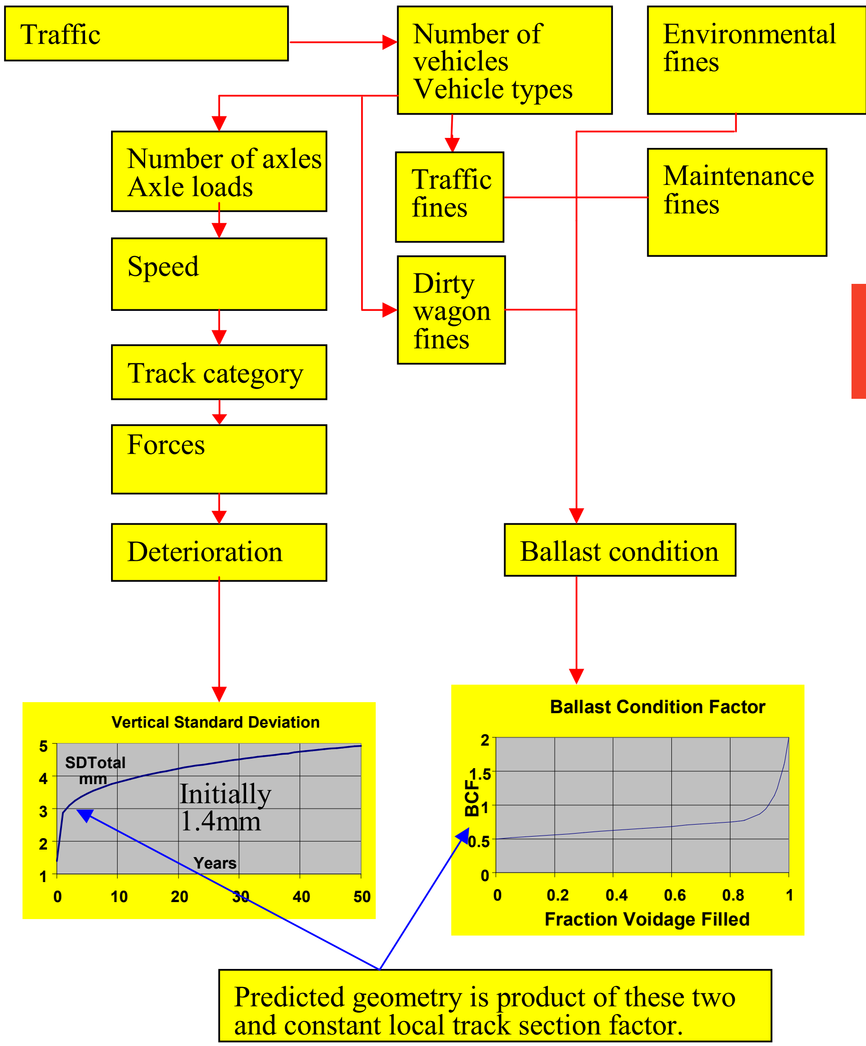


Plain line sleeper service lives by track construction



Band	Plain line
A	Contemporary CWR (CEN60 and CEN56 rail on F40 or later)
B	Regular CWR (CEN56 on F27 or earlier, or on steel sleepers)
C	Legacy CWR (other CWR rail on old concrete or hardwood sleepers, or modern jointed on curved track)
D	Jointed (all other jointed track, usually on softwood sleepers)

Track geometry model - Overview



$$G(t) = LTSF \times BCF \times \exp(at^b)$$

where:

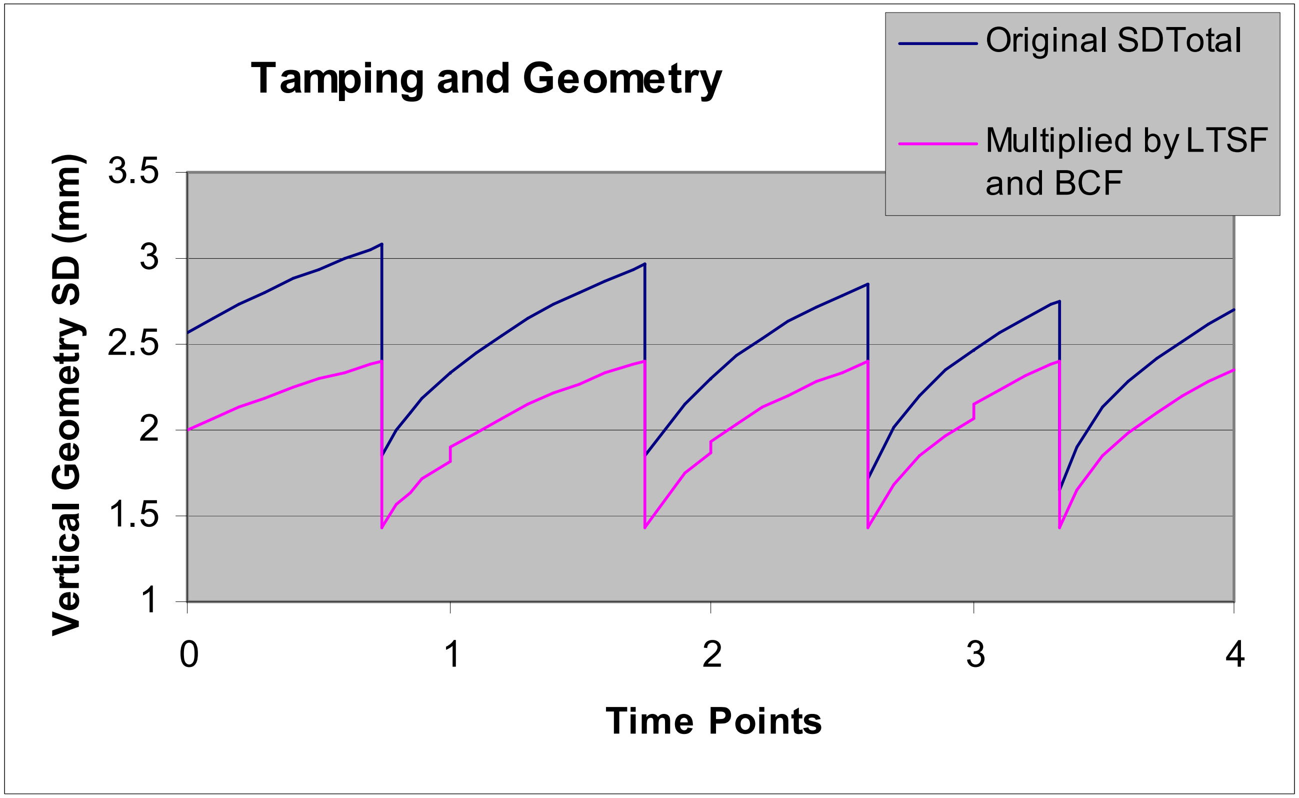
G (t)	**Geometry, i.e. the vertical short-wave (centred 35 m rolling average filter) standard deviation (SD), at time *t*, where *t* is the time after a notional time zero.**
exp(at^b)	Theoretical relationship for geometry at time *t*, based on the track and traffic characteristics.
BCF	Ballast condition factor, a non-linear relationship based on the fraction of the ballast voids filled with fines at any time. The initial fraction is calculated assuming the historical traffic levels and the expected number of historical tamps. *BCF = 1* equates to empty ballast voids, *BCF = 2* for full ballast voids (the notional ballast renewal limit).
LTSF	Local track section factor, calculated by fitting the recently measured geometry and deterioration rate (from TrackMaster) to the theoretical model, accounting for the expected initial *BCF*.

Track geometry model – Vertical SD (1/8th mile)

(1). SDTotal $= \sqrt{\left(SDDipJoints^{2} + SDTotUnsprungMass^{2} + SDTotRideForce^{2}\right)}$

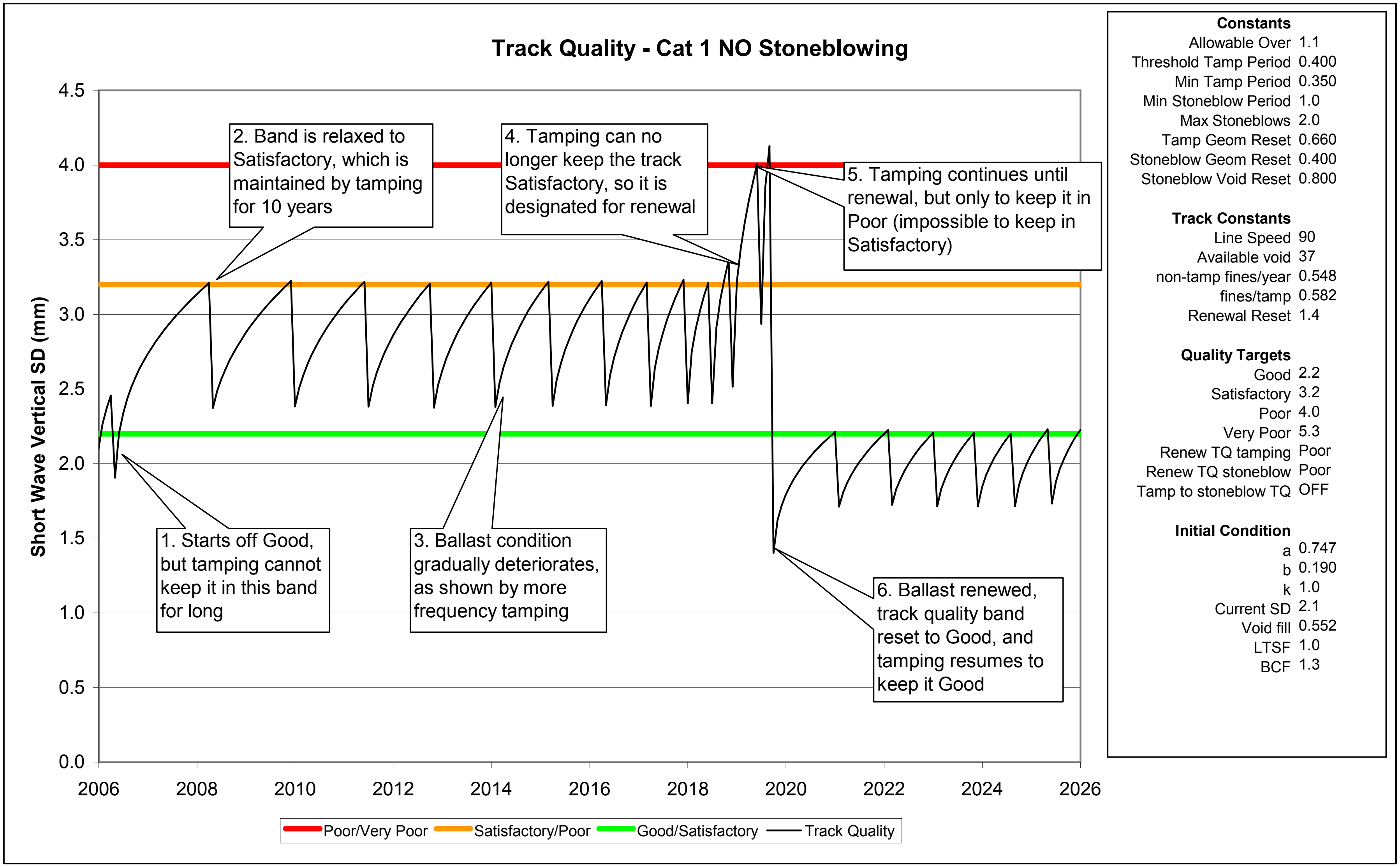
- Vertical SD driven by three component forces:
  - Ride forces - Ride force depends on the average standard deviation for that track section, the speed of the vehicles and their ride characteristics, the impact of previous maintenance operations such as tamping and stoneblowing, and axle load.
  - P2 forces static load and unsprung mass
  - P2 forces at dips (weld and joints)
- Influenced by rail type (CWR, jointed), track bed stiffness and rail shape
- Renewal and maintenance (e.g. tamping and stoneblowing) will modify the SD according to track quality standards and maintenance effectiveness

Track geometry model – Vertical SD simulation and impact of maintenance (tamping)



- T-SPA simulates geometry progression in monthly time-steps

Track geometry model – Impact of renewal



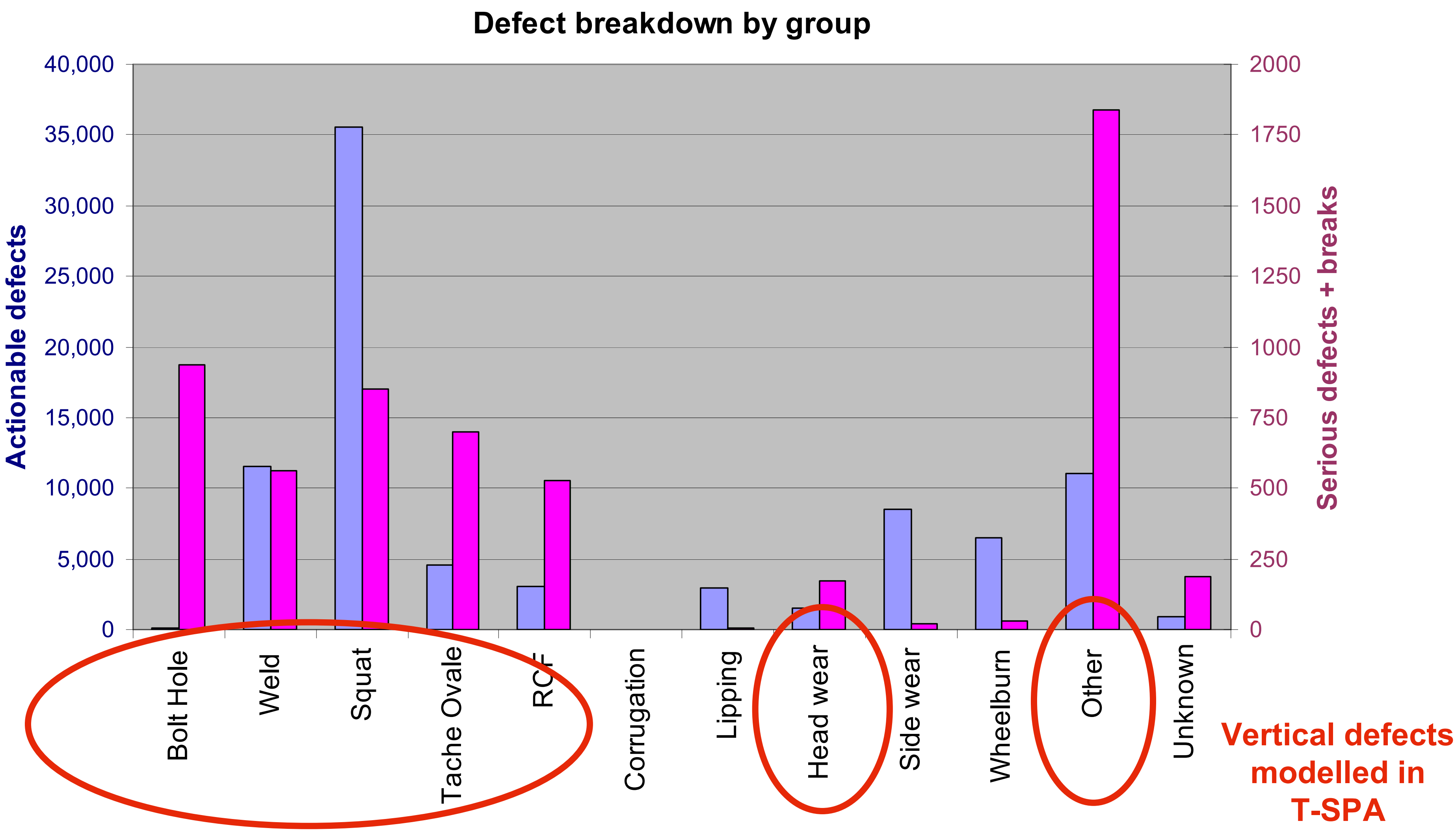
Track geometry model – ‘Approximation’ model

- MS Excel track geometry ‘approximation’ spreadsheet contains main components of the model
- Supports model development and code testing

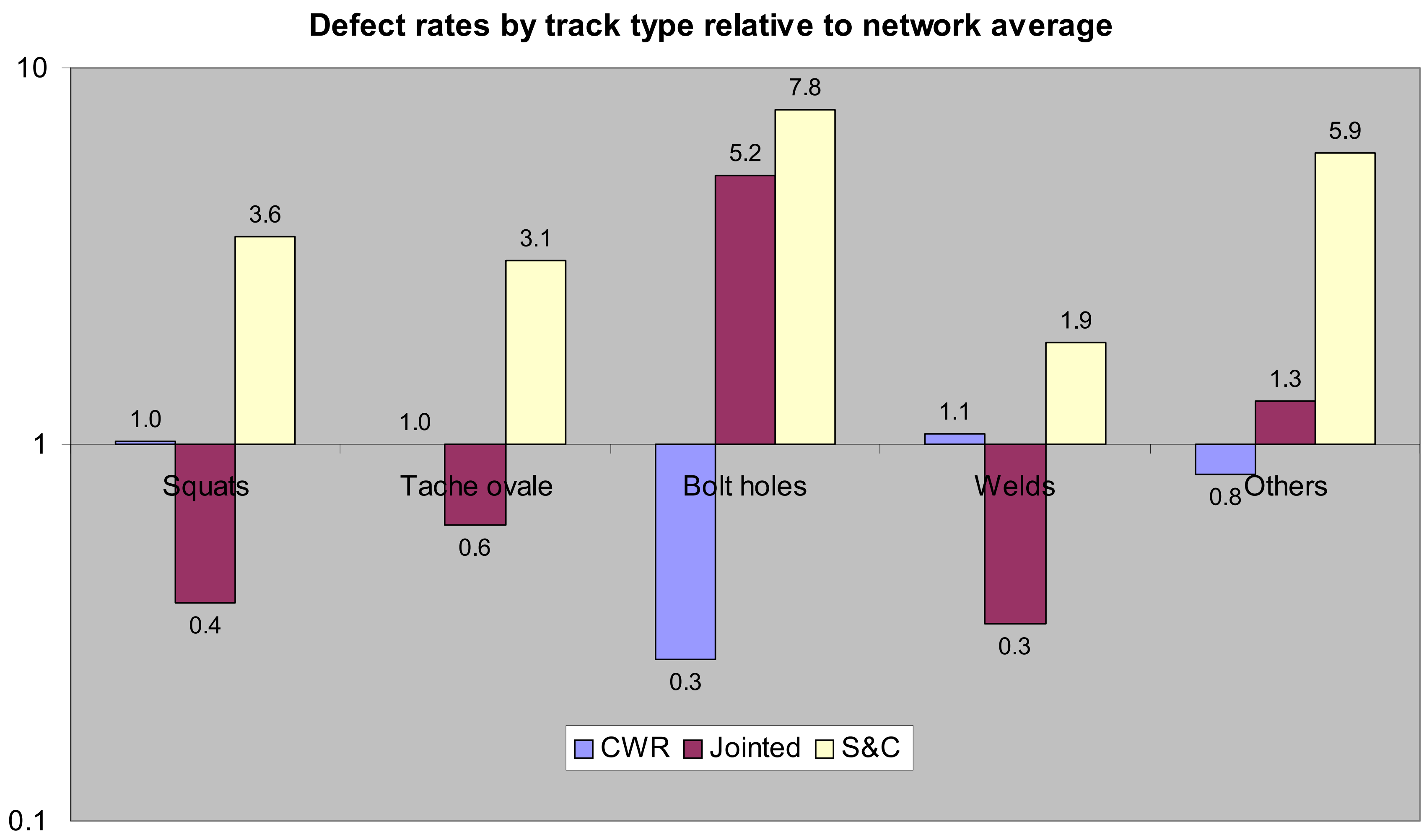
Track geometry model – Engineering database

- T-SPA engineering database contains supporting geometry model parameters and assumptions:
  - Track properties (mass, stiffness, rail and sleeper geometry, etc.)
  - Ballast reset parameters
    - Vertical SD and ballast void fill reset on renewal and maintenance
  - Track quality standards
  - Maintenance intervals

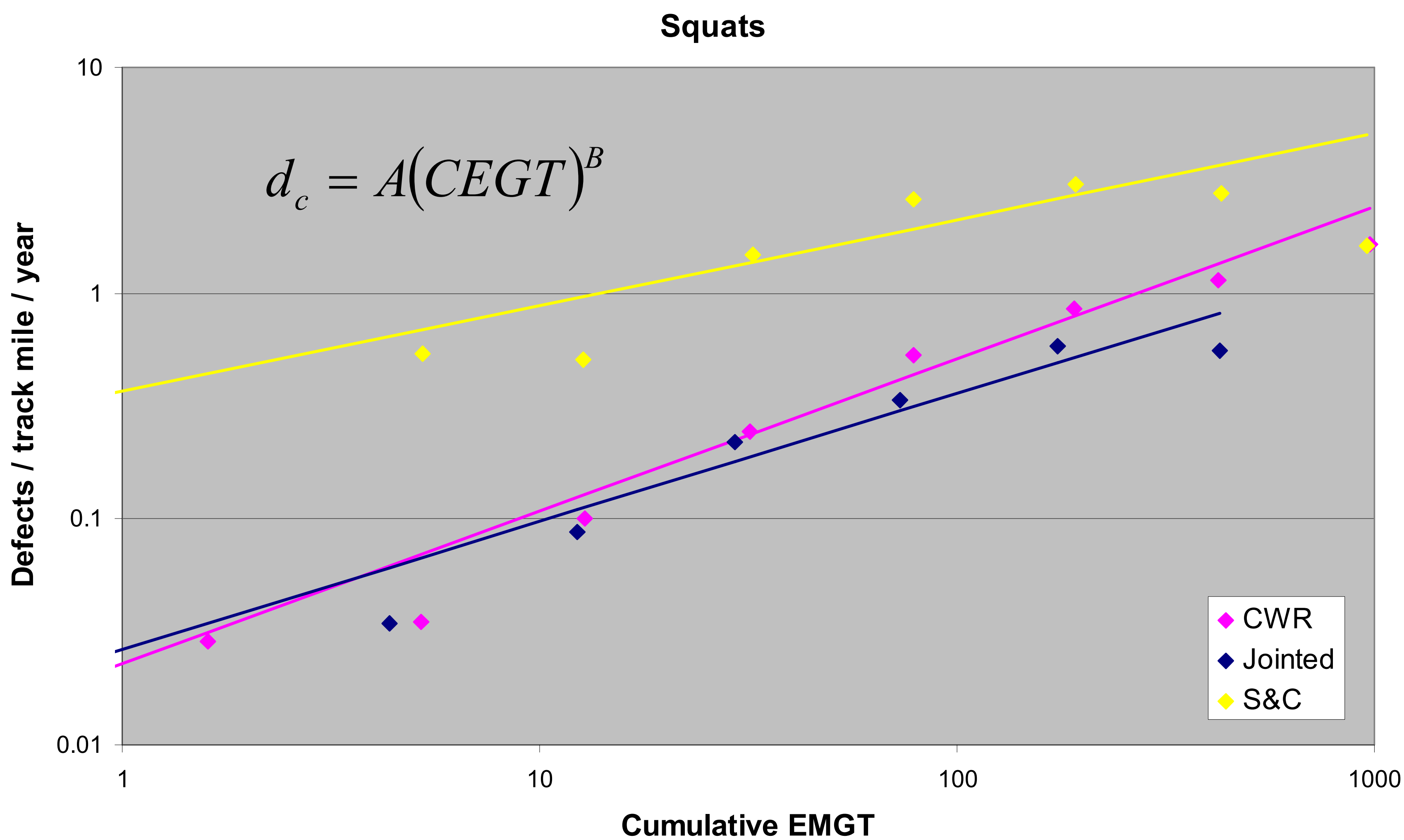
Rail defect model – Recent history by defect group



Rail defect model – Recent history by track type



Rail defect model – Defect analysis



Rail defect model – Formula for actionable defects

$$D_{tr,gr} = \begin{aligned} & d_{tr,gr} \\ & \times E^{p_{tr,gr}} \\ & \times \max\{minG_{tr,gr}, a_{tr,gr} + b_{tr,gr} \times G\} \\ & \times (m_{tr,gr} + n_{tr,gr} \times \min\{maxC_{tr,gr}, |C|\}) \\ & \times r_{rail,tr,gr} \times s_{station,tr,gr} \times t_{tunnel,tr,gr} \end{aligned}$$

$D_{tr,gr}$	Actionable defects per mile per year, for defect group *gr* and track type *tr*
d	Defect constant
E	Cumulative equivalent gross tonnage (EGT)
p	Exponent for EGT
G	Vertical short-wave geometry SD (mm)
$minG$	Minimum vertical short-wave geometry SD (mm)
a, b	Linear relationship for geometry and relative defect rate
C	Average rail curvature in section, i.e. 1 / radius (m^{-1})
$maxC$	Maximum curvature (m^{-1})
m, n	Linear relationship for curvature and relative defect rate
r_{rail}	Multiplier for rail type
$s_{station}$	Multiplier if in a station
t_{tunnel}	Multiplier if in a tunnel

T-SPA renewal, maintenance, inspection criteria and unit costs

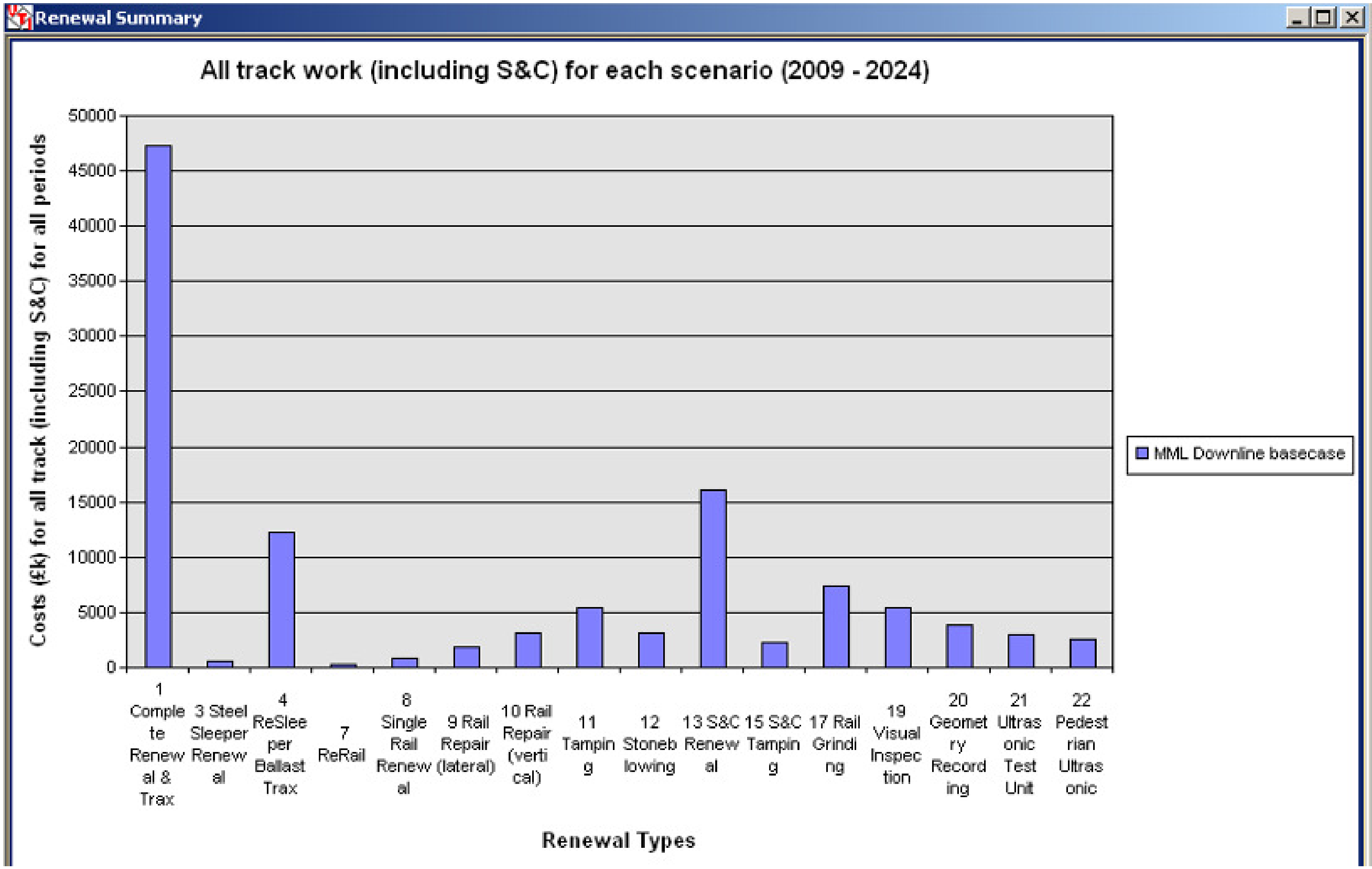
- T-SPA models renewal, maintenance and inspection activities accounting for the majority of track costs:
  - e.g. complete renewal with traxcavation, tamping, stoneblowing, rail renewal, S&C renewal and tamping, manual inspection and ultrasonic testing
- The ‘Standard’ criteria (supplied in VTISM) used to trigger activities is calibrated according to network average levels for:
  - Track quality levels achieved in practice
  - Rail defects rates observed
  - Maintenance and renewal volumes and expenditure
- Can be viewed / edited within the T-SPA regime / strategy / programme structure
- Budget / volume constraints can be applied:
  - Unbudgeted / unconstrained scenario – how much does it cost to achieve a desired condition level?
  - Budgeted / constrained scenario (using work type priority rules if required) – what level of condition can be achieved with the available funds?
- Unit costs for all activities are stored in the engineering database
  - IIP unit costs used for VTISM VUC project

VTISM VUC Project used the standard criteria using unbudgeted runs to determine cost impact from changes to vehicle parameters (axle load, un-sprung mass and vehicle speed)

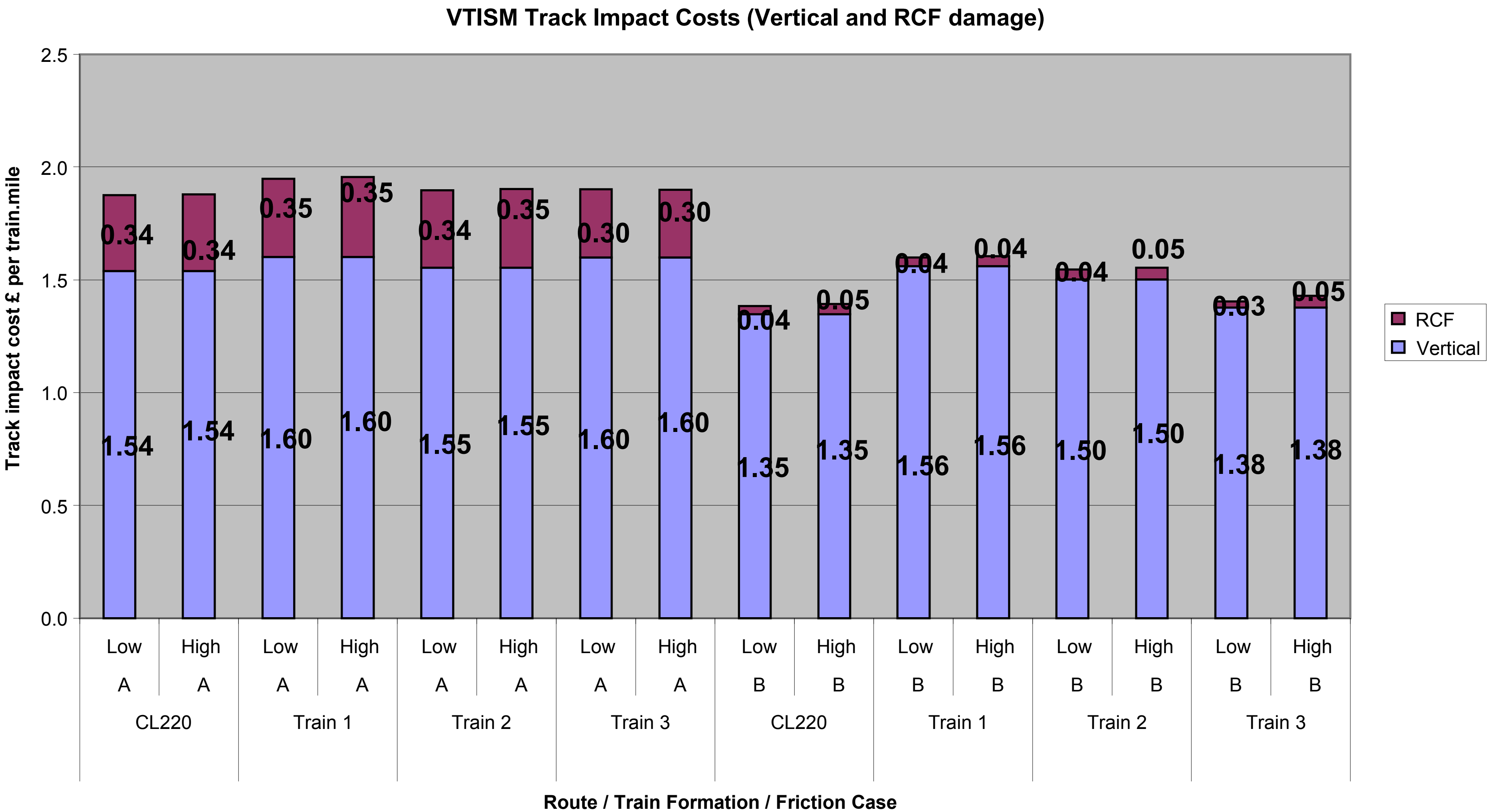
Summary

- VTISM and T-SPA models and databases have been designed to provide the user with flexibility in setting up a range of scenarios
  - Impact of new rolling stock designs or traffic growth via changes to traffic and vehicle databases
  - Track design studies via changes to the engineering database to vary track properties and track quality standards
  - Regulatory investment planning via changes to renewal, maintenance and inspection criteria, budgets and volumes
  - Impact of wheelset management strategies via changes to wheel profile distributions (as part of RCF/wear modelling)

Example cost outputs – MML downline basecase

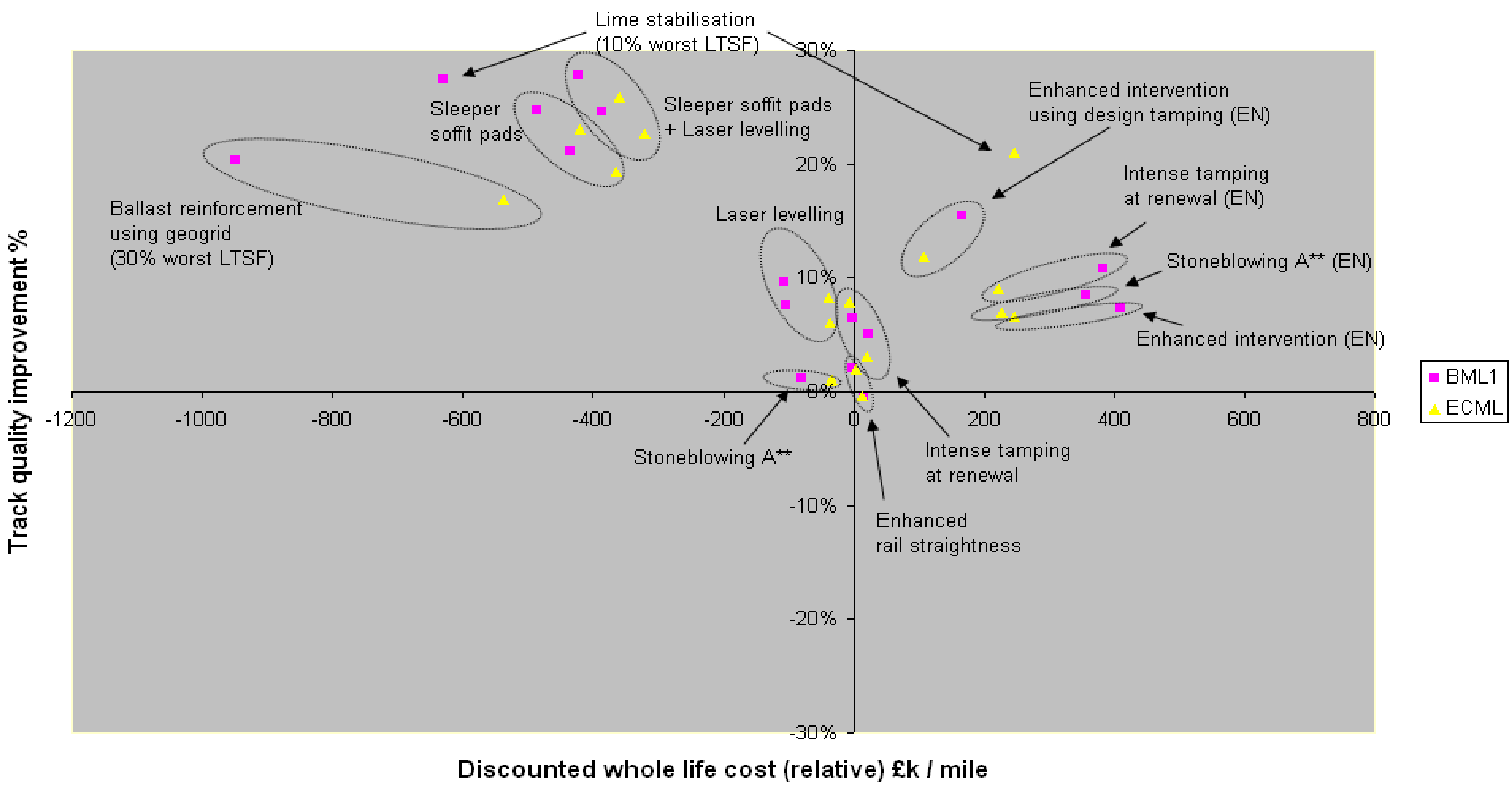


Example application: Using VTISM for analysing train design / configuration

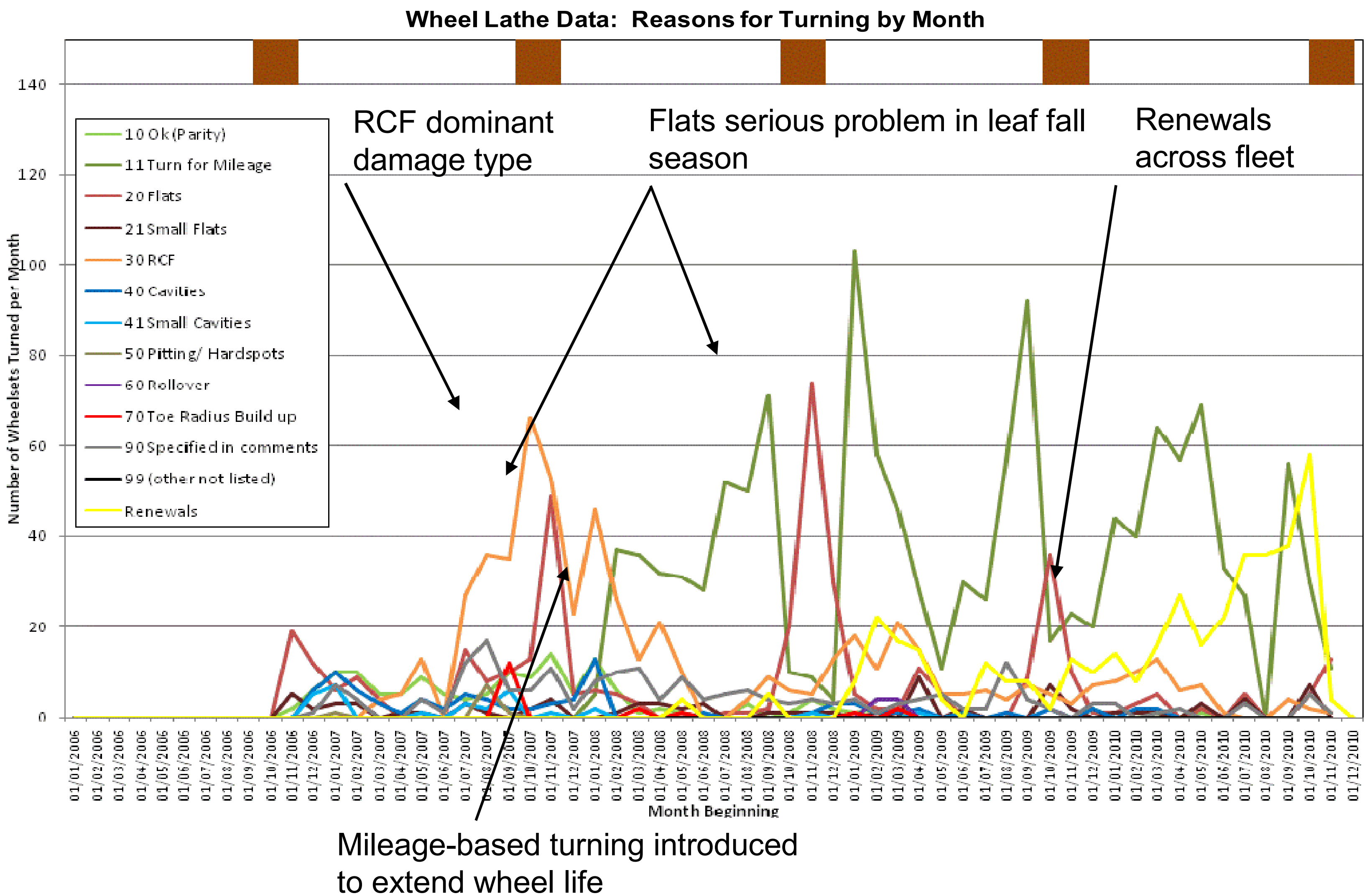


Using VTISM for analysing track
- RSSB/NR T807 track quality improvement techniques

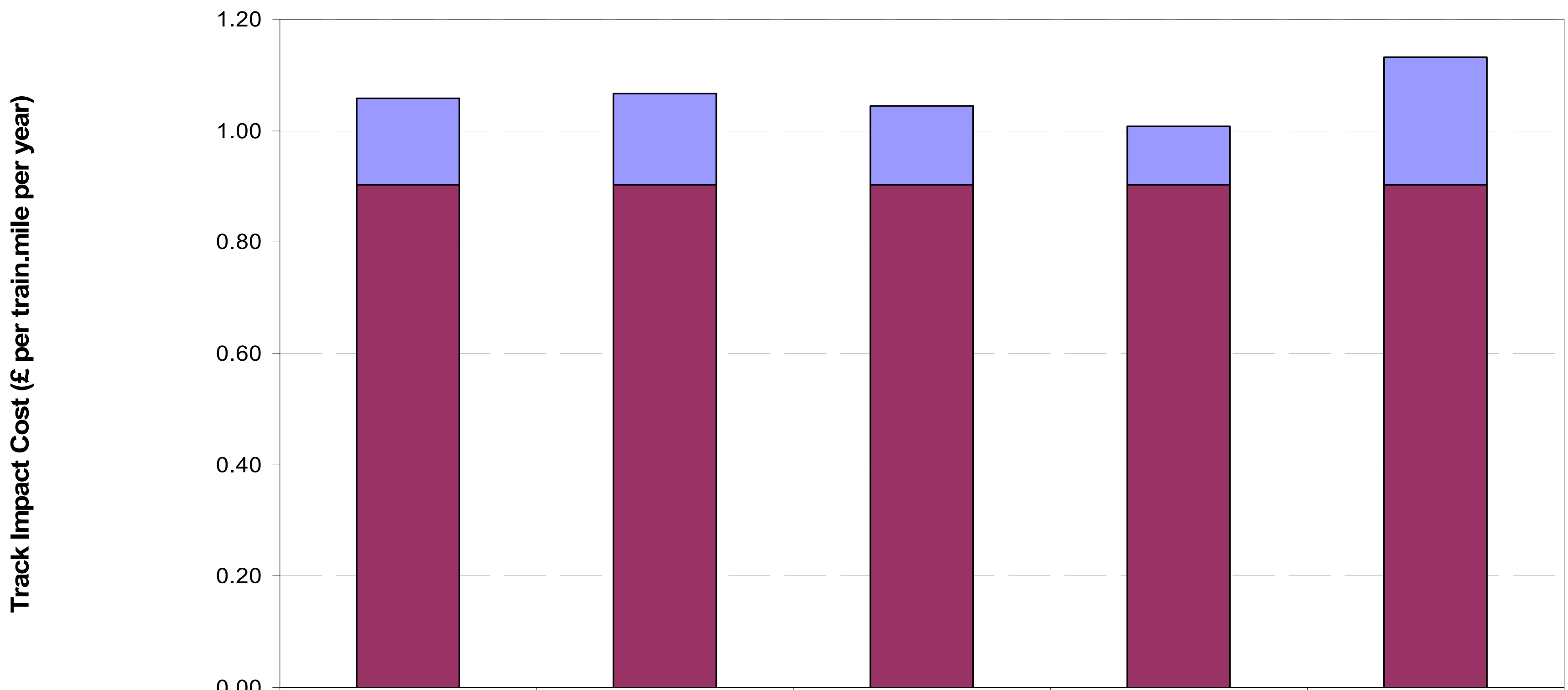
Discounted whole life cost and track quality improvement (relative to appropriate base case)



Using the WMM module in VTISM to analyse fleet wheelset maintenance, renewals and inspection

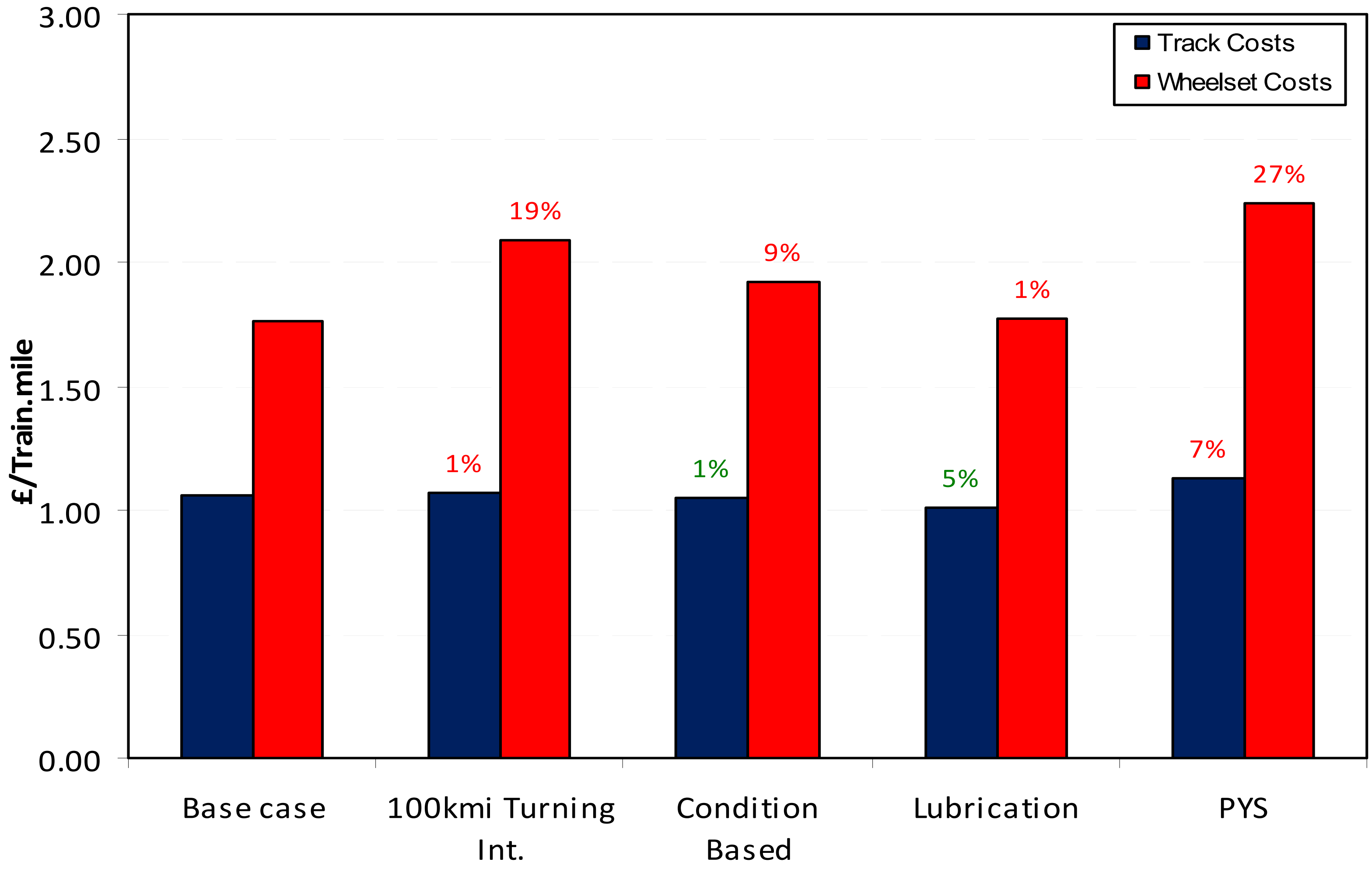


Using VTISM for analysing ‘whole system’ costs - Generic DMU on TPE route – track impact



	Base case (140k mile turning interval)	Reduced turning interval (100k mile)	Condition-based turning	Lubrication	Primary Yaw Stiffness
CL185 RCF / Wear	0.156	0.163	0.142	0.105	0.230
CL185 Vertical	0.90	0.90	0.90	0.90	0.90

Using VTISM for analysing ‘whole system’ costs - Generic DMU on TPE route - wheelset turning optimisation



Further documentation

- VTISM User Guide
- VTISM Stage 1 research brief - http://www.rssb.co.uk/SiteCollectionDocuments/pdf/reports/Research/T353_rb_final.pdf
- VTISM Stage 2 summary report - http://www.rssb.co.uk/SiteCollectionDocuments/pdf/reports/Research/T792_S2_rpt_final.pdf
- VTISM Stage 2 research brief - http://www.rssb.co.uk/SiteCollectionDocuments/pdf/reports/Research/T792_S2_rb_final.pdf
- RSSB VTISM T353 / T792 Stages 1 and 2 Project Documentation
  - Available on SPARK web site for RSSB / GB railways members
- T-SPA Technical Basis Report
- SBP Documentation Pack supplied to ORR
- RSSB Research Studies
  - T807 Track Quality Sensitivity Analysis
  - T792 Stage 2 Whole System Costing Case Study

Review / Discussion

- Any further questions?
- Do you feel confident enough to begin using VTISM?
- Have we covered what you expected?
- What additional information would you find useful? We also offer further courses:
  - T-SPA vertical damage / deterioration models and data requirements (1 day)
  - Using T-SPA for modelling renewals and maintenance (1 day)
  - VAMPIRE analysis (3 days)
- Don’t forget further help information:
  - VTISM User’s Guide
  - Help-desk support