V/T SIC

Vehicle / Track System Interface Committee

Vehicle Track Interaction Strategic Model (VTISM) Overview for ICRI Project (Apr-2016)

Andy Rhodes, Serco
Adam Bevan, University of Huddersfield

Overview

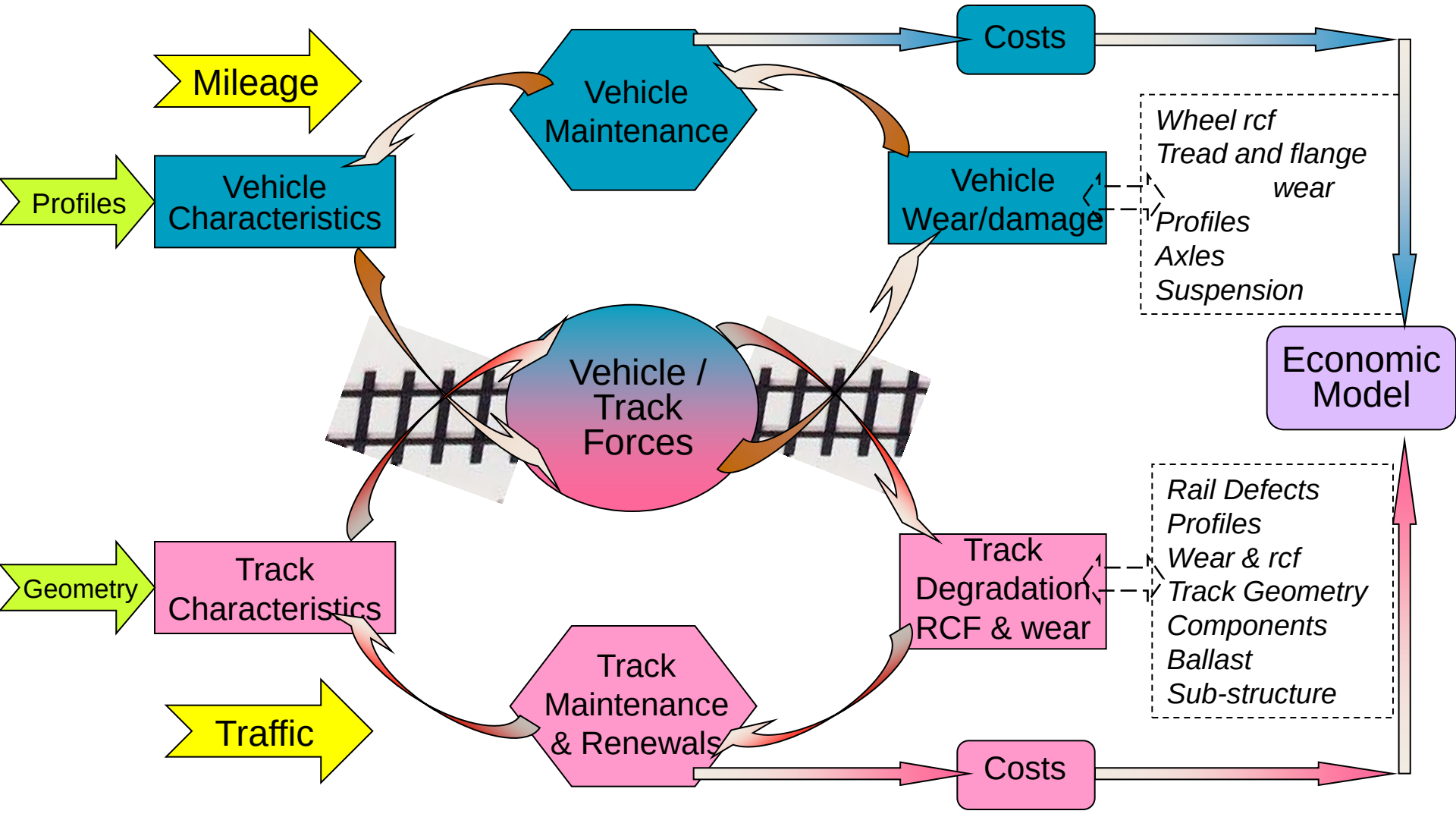
- What is VTISM?
  - Objectives
  - Modelling framework
  - What questions can VTISM answer?
  - Stage 1 and 2 development history
  - Integrated components
  - Benefits to industry
  - Summary of key features
- VTISM Components
  - Track Strategic Planning Application (T-SPA)
  - Whole Life Rail Model (WLRM)
- VTISM Flow Chart
- Wheelset Management Model (WMM)

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?
  - changing the rail head profile
  - a new grade of rail steel
  - flange lubrication
  - sleeper types
- What is the impact of increasing traffic?

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 – Track Strategic Planning Application (T-SPA)
  - Rail industry – Vehicle dynamic simulation (Vampire), Whole Life Rail Model (WLRM), Wheel Profile Damage Model (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 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 issue 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
- Vehicle Dynamics Simulation
  - VAMPIRE® or other rail vehicle dynamics software (via the converter)
- 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

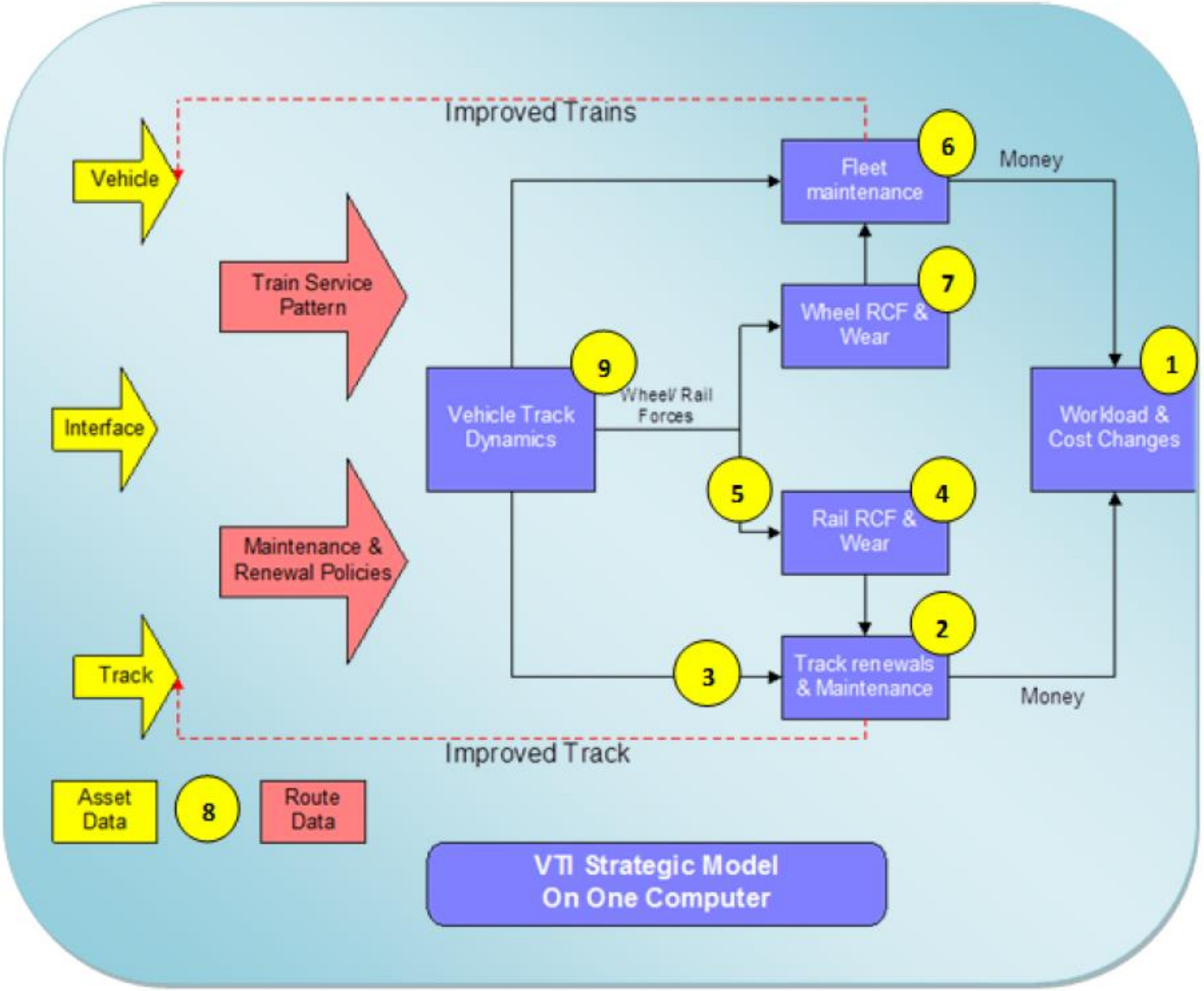
What is VTISM? – Benefits to Industry

- VTISM has been applied by:
  - Network Rail
    - Optimising track maintenance and renewal strategies
  - Office of Rail Regulation
    - Development of track access charges
  - DfT and train manufacturers
    - New rolling stock procurement evaluation
    - Evaluating different train configurations
  - Vehicle maintainers
    - Optimising wheelset maintenance and renewal strategies
  - 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)

Summary of Key Features

- Robust, validated, condition-based models (for GB 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

VTISM Components



VTISM Components

Item	Module	Function
1	VTISM Core Module	VTISM interface providing the GUI for setting up and analysing scenarios and the link between all the calculation modules and data.
2	Track Strategic Planning Application (T-SPA)	Network Rail's decision support tool. Track degradation, inspection, maintenance and renewals simulation.
3	Ride Force Calculator (RFC)	Tool for processing vehicle dynamic simulation outputs to generate ride force parameters for input to the track degradation modelling. Ride forces are the vertical forces associated with dynamics of a vehicles sprung mass.
4	Whole Life Rail Model (WLRM)	Model to predict rail RCF and wear based on vehicle dynamics simulation outputs.
5	WLRM Import Convertor	Tool for converting output files from different vehicle dynamic simulation software packages into the format required for import to the WLRM.
6	Wheelset Management Model (WMM)	Fleet maintenance simulation, currently for wheelsets (wheel inspection, maintenance and renewals) only. Generated during VTISM stage 2 developments.
7	Wheel Profile Damage Model (WPDM)	Model to predict wheel RCF and wear based on vehicle dynamics simulation outputs.
8	VTISM data libraries / databases	Input databases containing information on track assets, traffic (vehicle types, axles, and suspension), routes, engineering data and rail and wheel profiles.
9	Vehicle-Track Dynamics Simulation Software (such as VAMPIRE®)	Vehicle-track dynamics route simulations to provide wheel-rail force outputs for inclusion in RFC (3), WLRM (4) and WPDM (7).

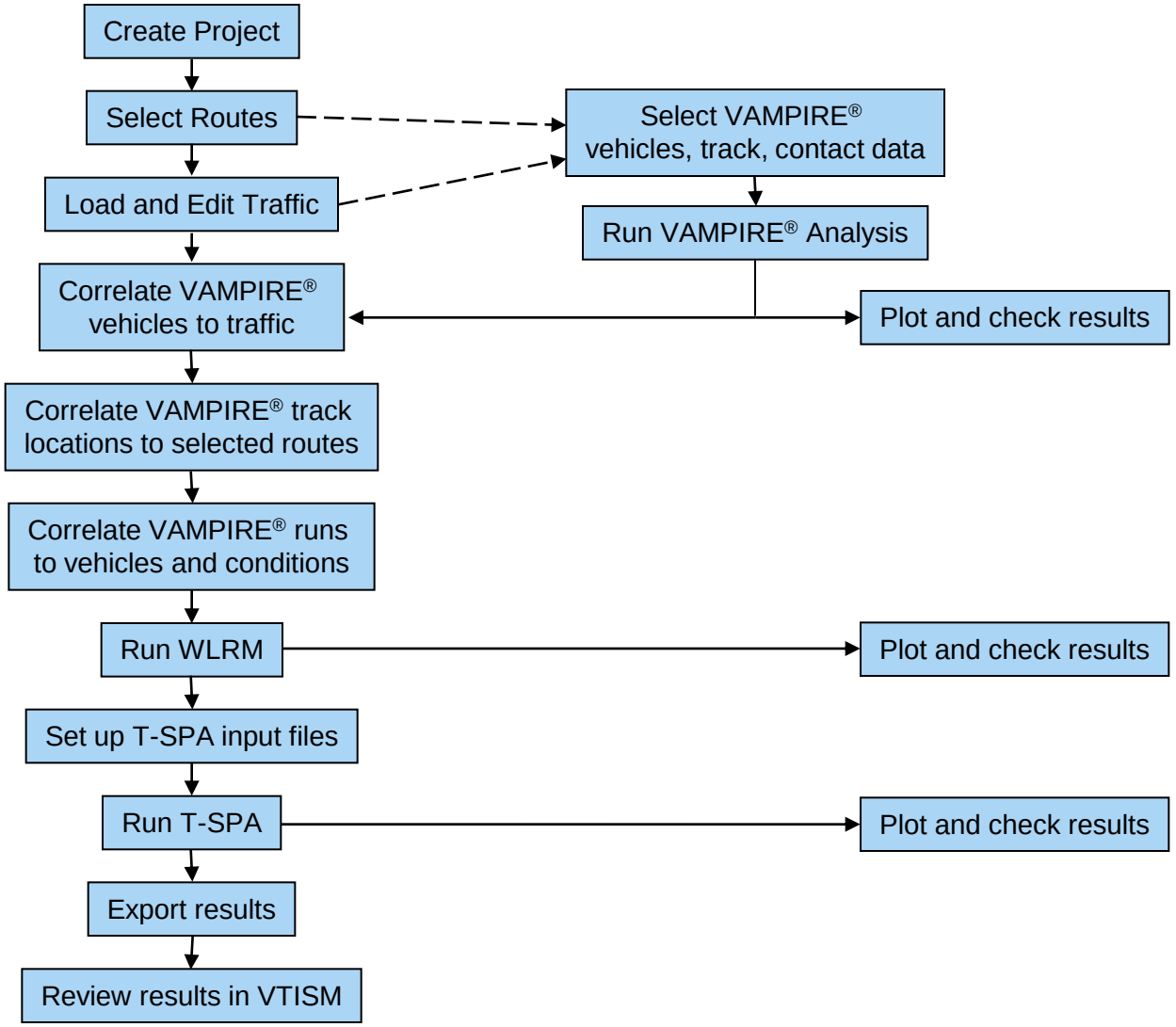
VTISM Components

- T-SPA
  - Function
    - Prediction of track degradation (ballast settlement and deterioration of track geometry) based on current ballast degradation rates and maintenance history, rail defects history under current traffic
  - Inputs
    - Vehicle characteristics (e.g. axle load, unsprung mass)
    - Track asset inventory, condition and traffic
    - Maintenance, renewal and inspection policy and invention criteria (user settings)
    - WLRM outputs (maximum, mean rail wear and RCF damage)
    - Unit costs of work
  - Outputs
    - Measures of asset age, residual life, condition and performance
    - Work volumes and costs

VTISM Components

- RCF and Wear (WLRM)
  - Function
    - Prediction of rail life in terms of wear and RCF damage using functions which relate the contact patch energy (Tγ) to damage
  - Inputs
    - Vehicle dynamic route simulation outputs (e.g. Tγ, creep forces, contact positions etc.)
    - Wear and RCF damage functions
    - Proportions (weightings) for simulations (e.g. new and worn wheels etc.)
  - Outputs
    - Maximum and mean rail wear and RCF damage rates

VTISM Flow Chart



Wheelset Management Model (WMM)

- Stage 2 development has enhanced VTISM's rolling stock modelling capability
  - Strategic planning of wheelset maintenance and renewal activities
  - Examine benefits and cost impact of a range of different scenarios
  - Optimise wheelset management strategies
- What questions can WMM answer:
  - What is the annual and total cost of supply, inspection, maintenance, and disposal of the wheelsets in a fleet over its lifetime?
  - What is the impact on whole system costs of changes to wheelset maintenance and renewal criteria?
  - What is the impact of changes to vehicle design, wheel profiles and routes operated?
  - What are the indicative damage rates of the wheels in the fleet?
  - What are the impacts of system changes to wheelset maintenance and renewals?

WMM – Key Features

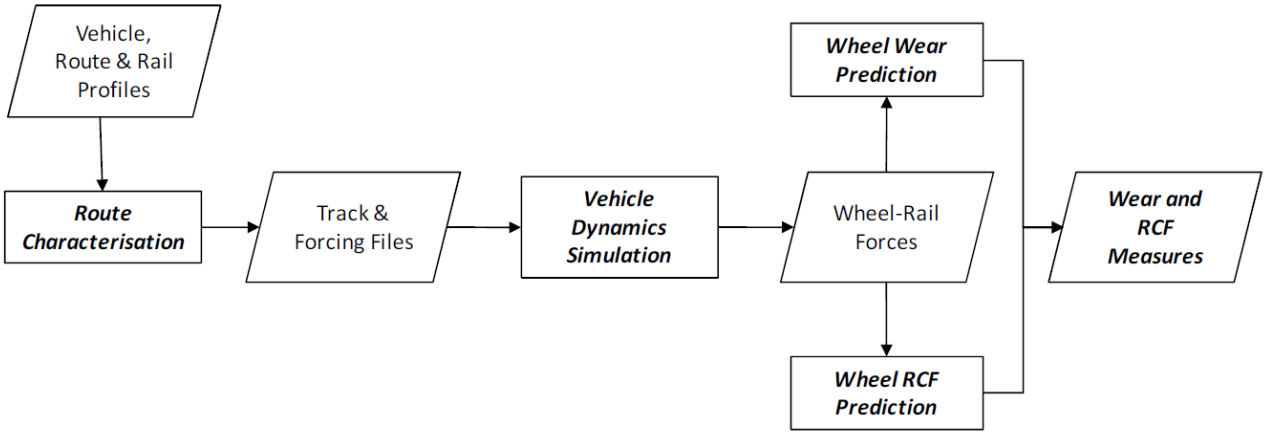
- WMM developed which combines
  - Damage rates predicted by WPDM (or supplied by the user)
  - Fleet data (supplied by the user)
  - W-SPA (wheelset strategic planning application)
- Available as a standalone tool or integrated in to VTISM using the user interface
- Calculates damage rates, renewal and maintenances activities and costs (using representative cost data)
- Alternative renewal and maintenance criteria can be defined by the user
- Asset condition can be tracked though its life using trace files
- Results can be exported for comparison in VTISM

WMM – Wheel Profile Damage Model (WPDM)

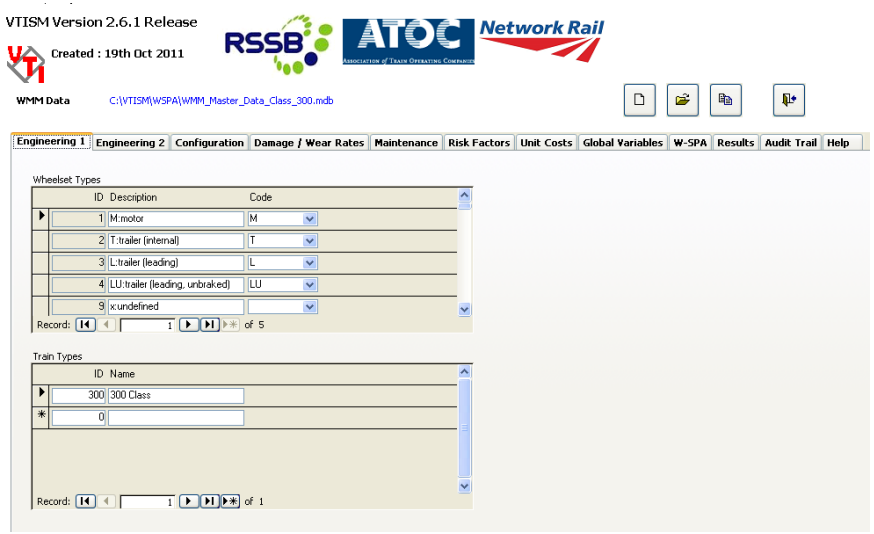
- WPDM
  - Function
    - WPDM developed to predict damage rates for each wheelset type within a vehicle fleet
    - When damage rates are not known by the user
  - Inputs
    - Vampire vehicle dynamics model
    - Track geometry data for each route section of a fleet's service diagram
    - Archard wear map
    - RCF-Tγ damage function
  - Outputs from WPDM provide inputs into the WMM
    - Wear rates (mm/mile, flange height, flange thickness, conicity)
    - Wheel RCF damage index (damage depth)
    - Change of conicity
  - These values are used by WMM to track the life of the wheelset
    - Changes in the wheelset attributes (diameter, wear, flats, RCF damage)
    - Comparison with attribute limits
    - Trigger maintenance or renewal activity

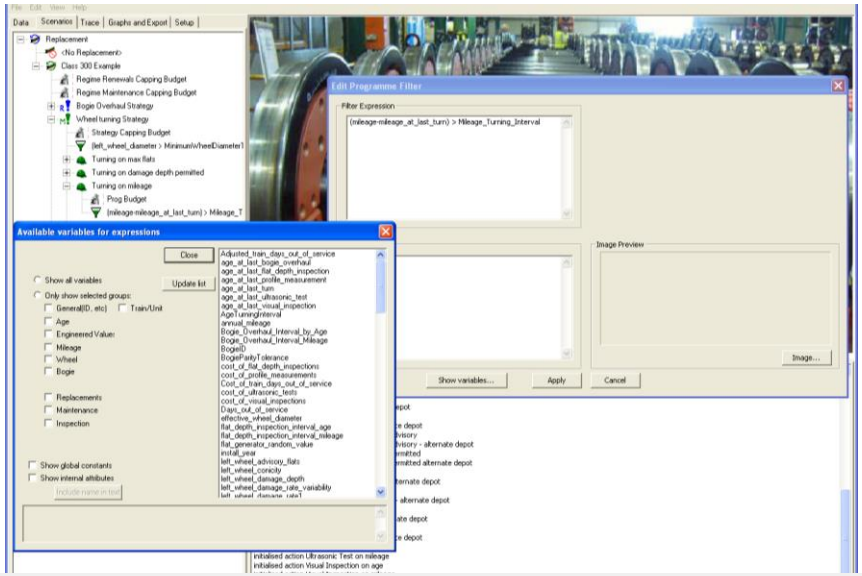
WMM – Wheel Profile Damage Model (WPDM)

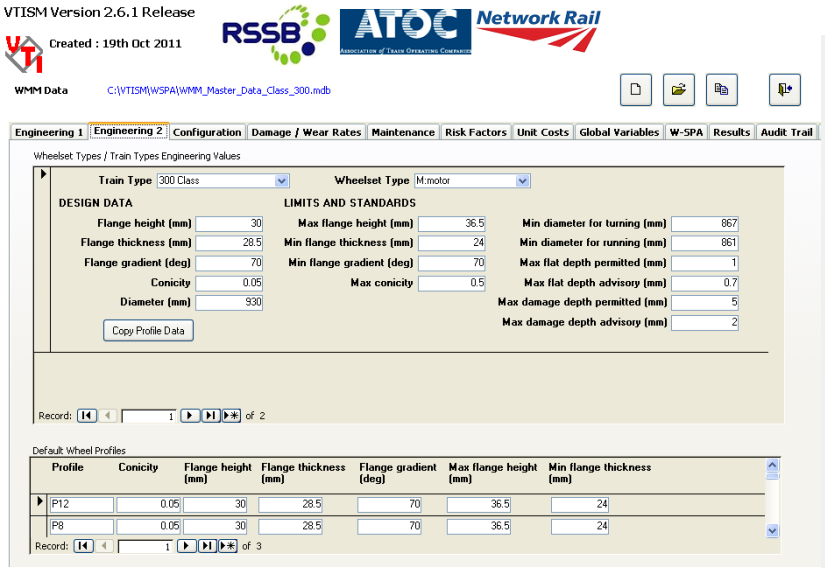
- Characterise a vehicle's route diagram in terms of parameters which influence wheel damage
- Predict wheel-rail forces for the chosen route conditions using vehicle dynamics simulations
- Post-process the calculated wheel-rail forces to predict the formation of wear (Archard model) and RCF (T-damage model) on the wheel
- Plot and save the results for use within VTISM and WMM

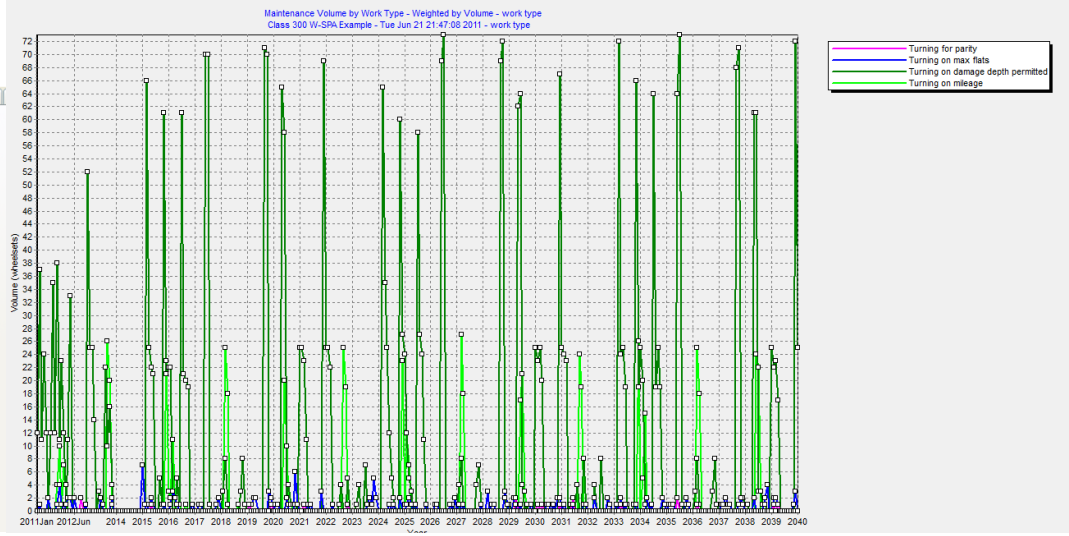


WMM – Screenshots









Contact Details

- Adam Bevan: a.j.bevan@hud.ac.uk
- Andy Rhodes: andy.rhodes@serco.com