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# Optimisation of Wheelset Maintenance using Whole System Cost Modelling

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Steve Mills – Rail Safety & Standards Board

Andy Rhodes, Daniel Ling – Serco

- Background
- Vision of VTISM
- Wheelset Maintenance Strategy
- Damage rates and WPDM
- Wheelset Costs
- Whole System Costs
- Summary
- Acknowledgements

# Background

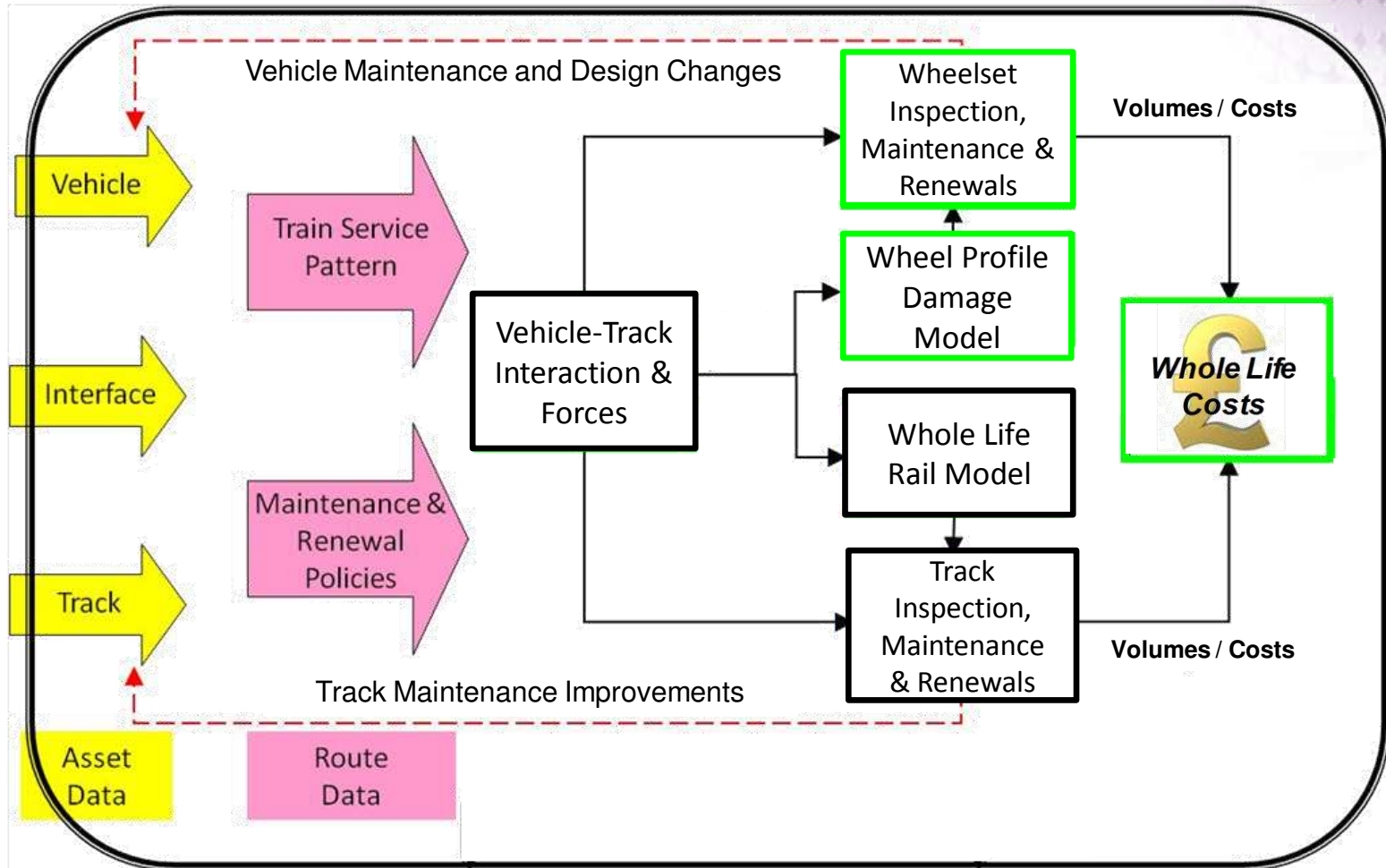
- Wheelset maintenance and renewal activities account for a large proportion of a fleets whole-life costs
- Influenced by a large number of factors:
  - Depot constraints
  - Wheel tread damage
  - Fleet availability
  - Vehicle design
- Optimisation of maintenance and renewal regimes will help to increase wheelset life and reduce costs



- Tools currently exist for prediction of track damage, replacement and maintenance costs
  - Whole Life Rail Model (rail RCF & wear)
  - Track-Ex (NR decision support tool)
  - VTISM (links vehicle-track characteristics to track costs)
- Stage 2 development of VTISM enhanced the rolling stock modelling capabilities
  - Strategic planning of wheelset maintenance and renewal activities
  - Examine benefits and cost impact of a range of different scenarios
  - Optimise wheelset management strategies
- These enhancements go some way to determining the whole life costs for the complete system (vehicle-track)



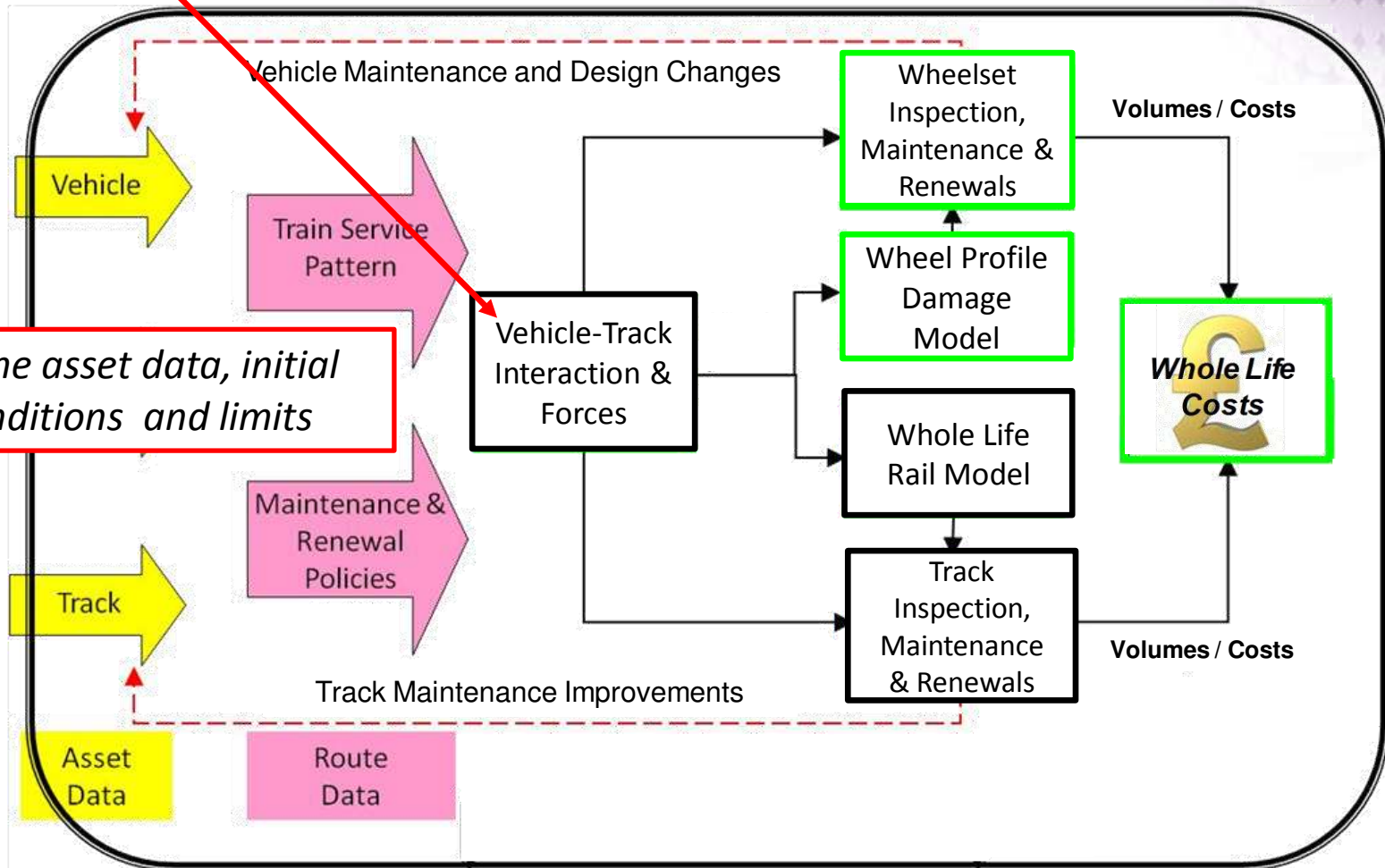
# Vision of VTISM



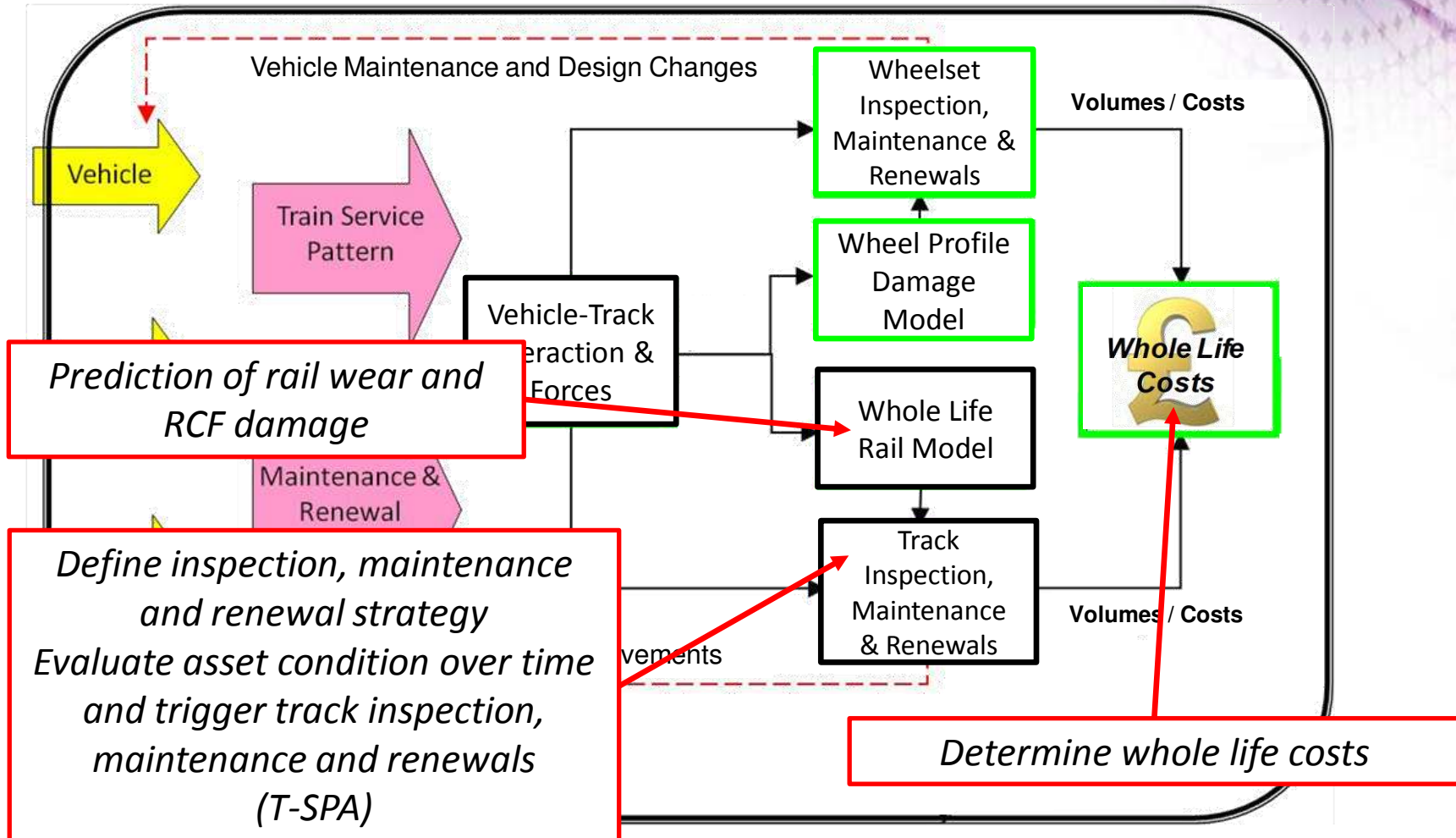
# Vision of VTISM

*Prediction of wheel/rail forces*

*Define asset data, initial conditions and limits*

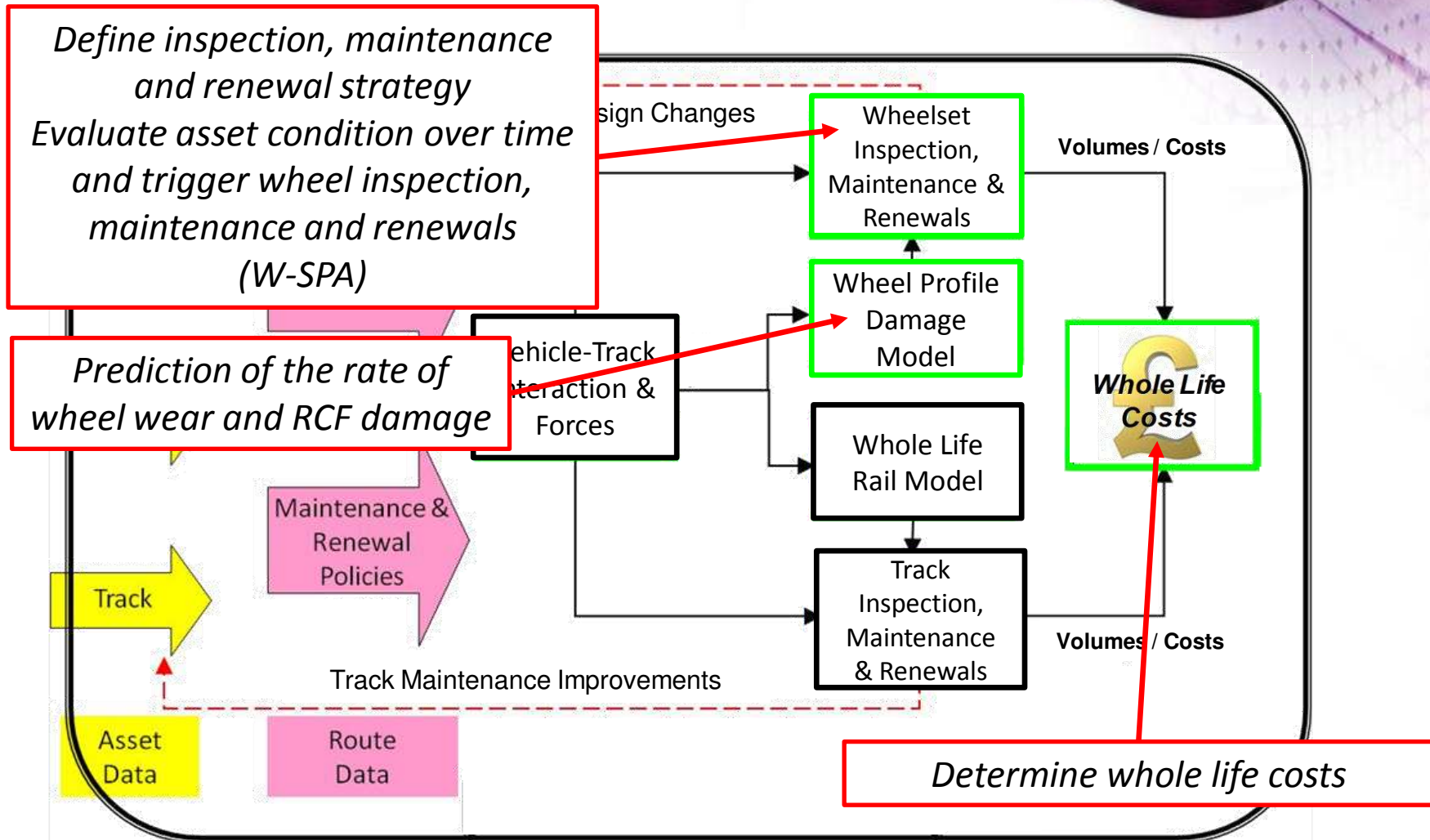


# Vision of VTISM

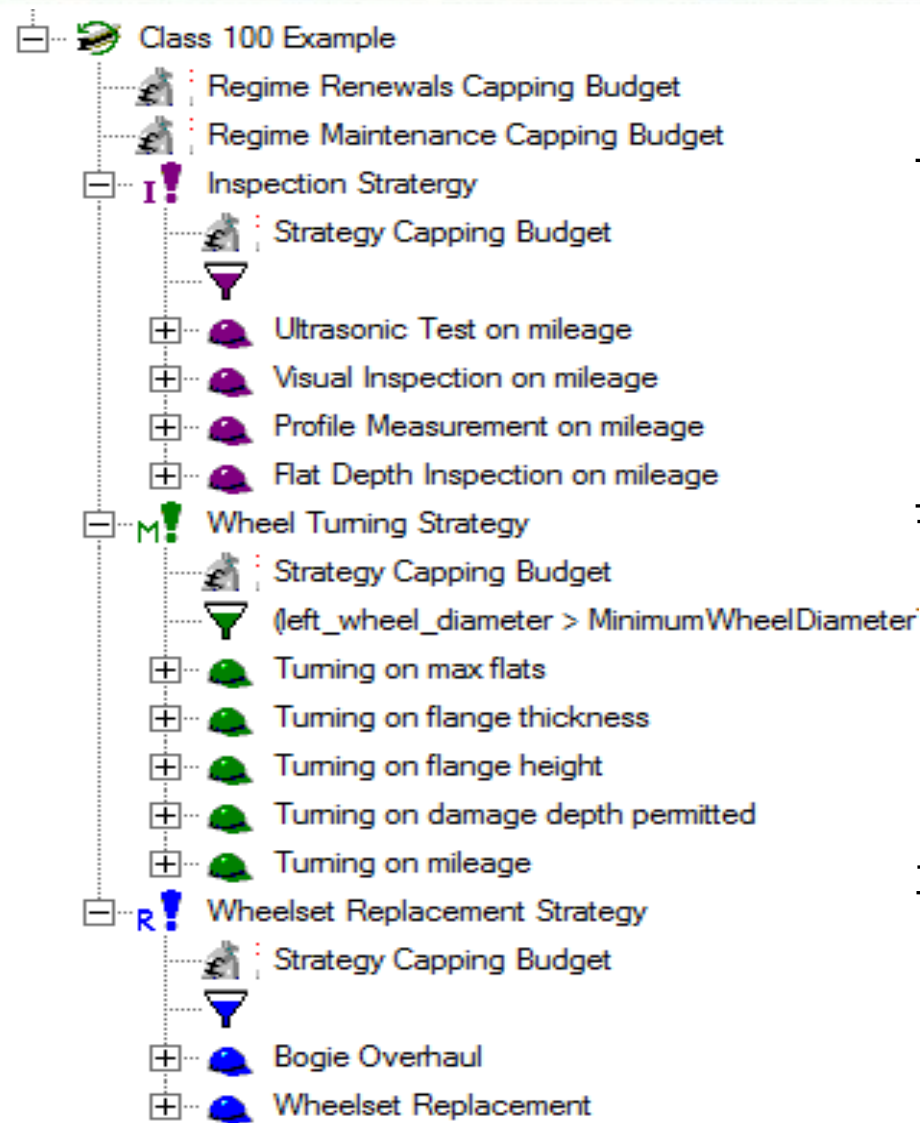




# Vision of VTISM



# Wheelset Maintenance Strategy



## Inspection Strategy

*Applied if mileage since last inspection is greater than the relevant inspection interval*

## Wheel Turning Strategy

*Triggered if condition reaches a pre-defined limit (i.e. flange thickness is less than the minimum permitted flange thickness)*

## Wheelset Replacement Strategy

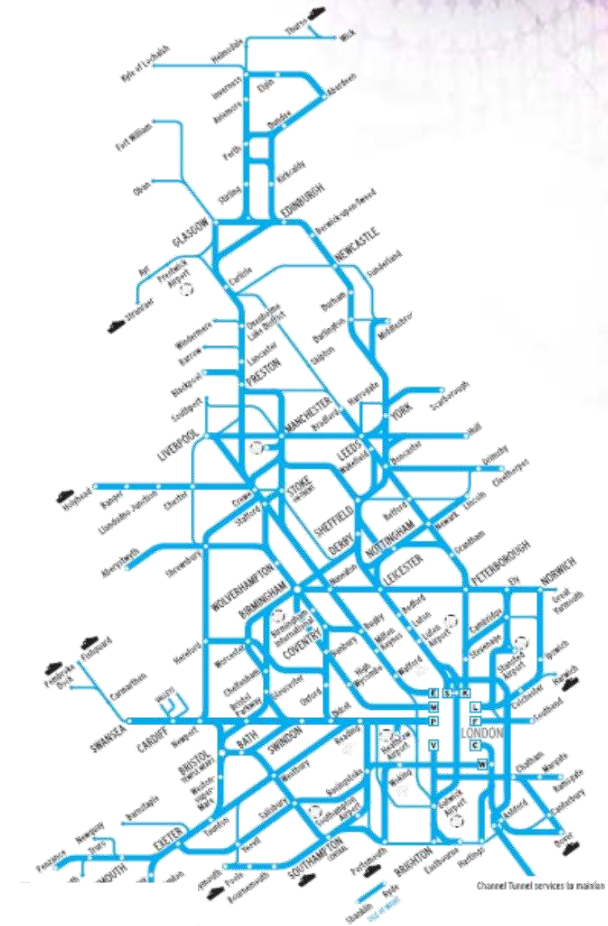
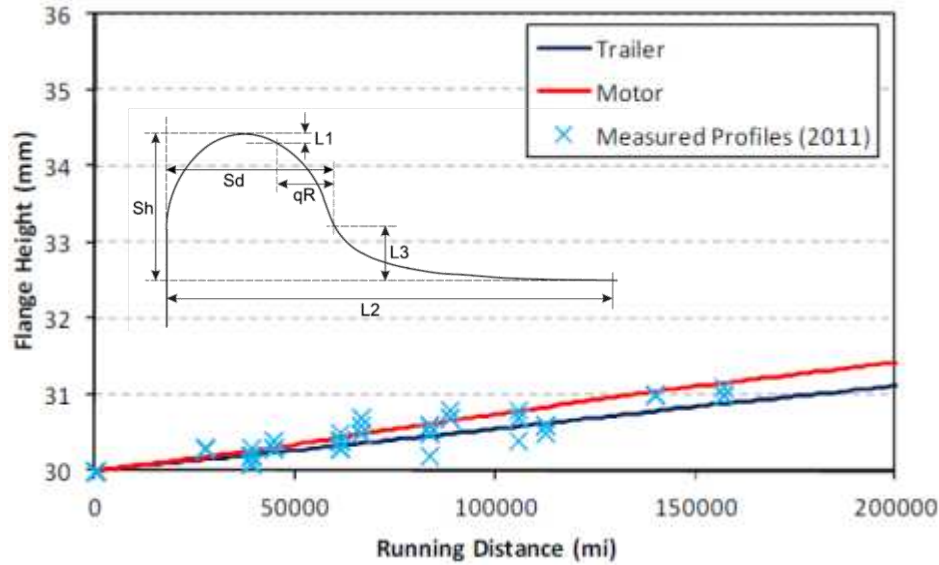
*Triggered if condition reaches a pre-defined limit (i.e. wheel diameter is less than the minimum diameter for running)*

- Rates of damage are included to describe how the attributes of the wheel deteriorate over time
  - Tread/flange wear
  - Change in conicity
  - RCF damage
  - Probability of flats
- Compared with pre-defined limits - trigger maintenance or renewal activity
- This information can be obtained from observation data
- Alternatively, the WPDM can be used to predict the damage rates

- Wheel Profile Damage Model (WPDM) is a standalone tool for the prediction of deterioration rates of the wheel tread
- Uses VAMPIRE vehicle dynamics simulation software to predict wear and RCF damage
- WPDM methodology
  - Characterises a vehicle's route diagram in terms of parameters which influence wheel damage
  - Predicts 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 (Ty-damage model) on the wheel
  - Plot and save the results for use within VTISM and WMM



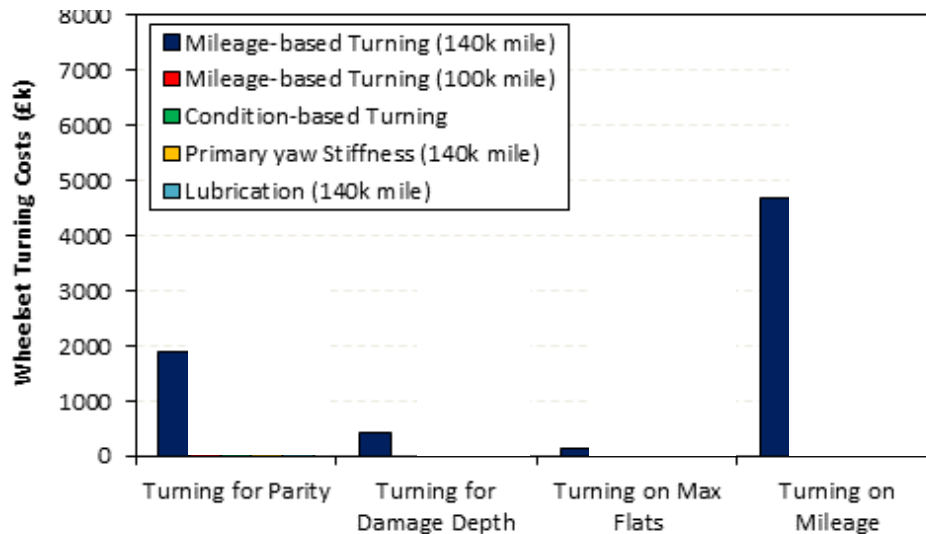
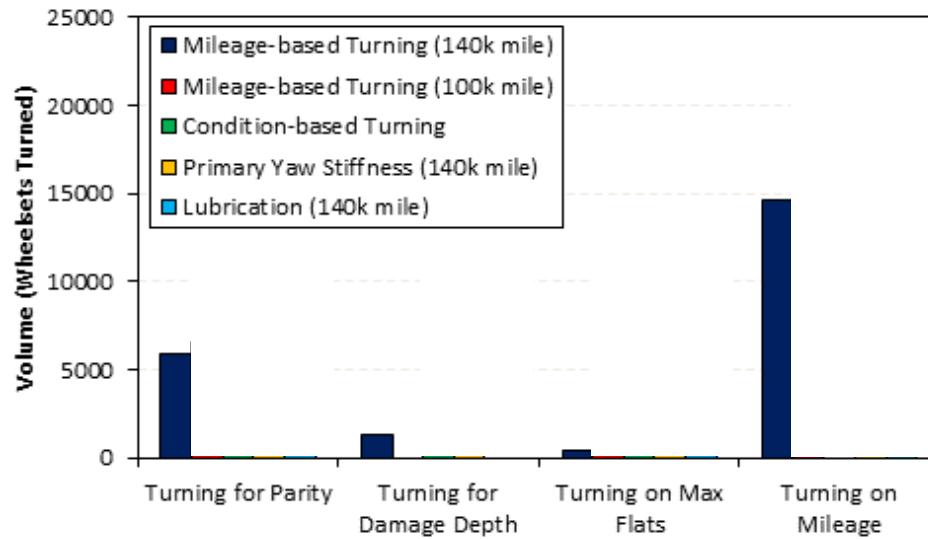
# Predicted Wheel Wear



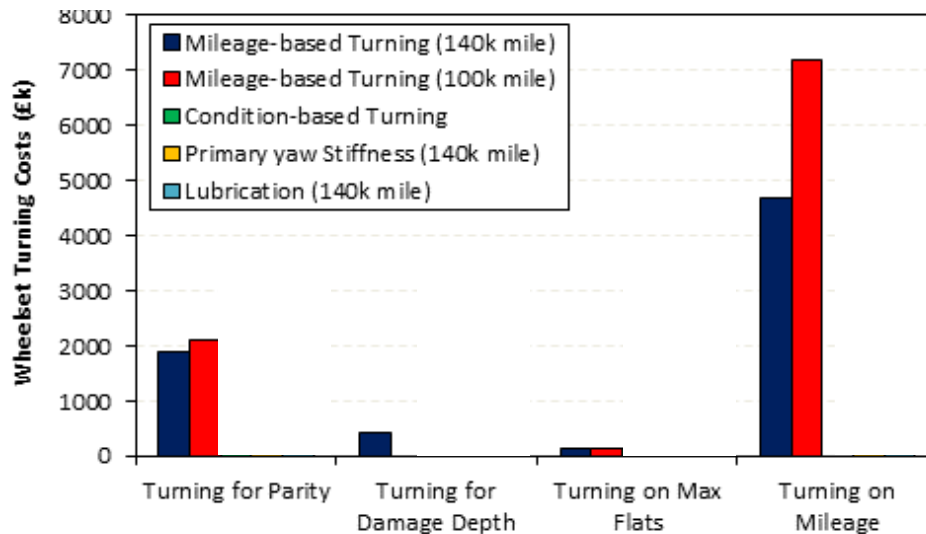
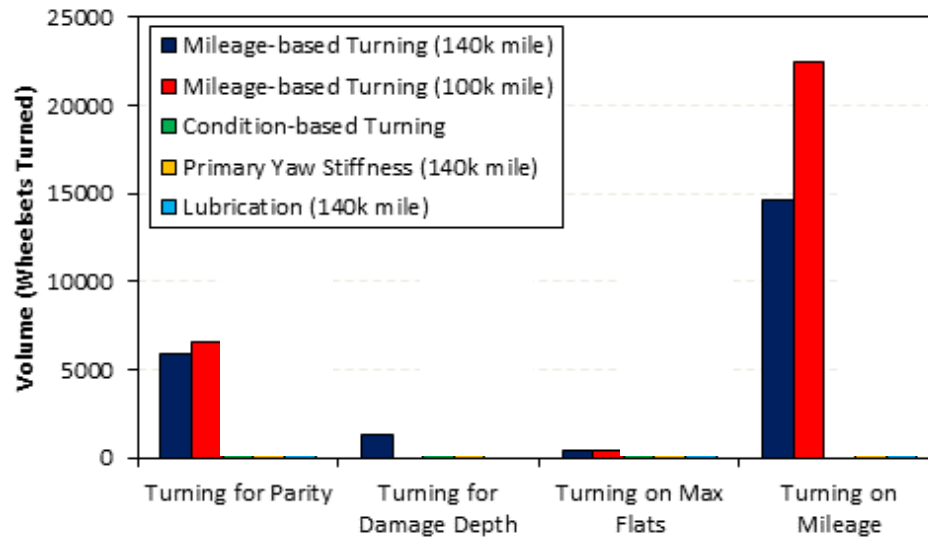


- Mileage-based turning regime (Base Case)
  - Turning interval set to 140,000 miles to represent current practice
- Reduced mileage-based turning interval
  - Turning interval reduced to 100,000 miles to represent a ‘little and often’ turning regime
- Condition-based turning regime
  - Turning triggered by the condition of the wheelset only
- Lubrication strategy
  - Coefficient of friction at the flange contact was reduced to  $\mu=0.1$
  - Inspection and maintenance of the lubrication system included
  - Includes modified wear and RCF damage rates for all wheelset types
- Modified primary yaw stiffness
  - Includes modified wear and RCF damage rates for all wheelset types

# Wheelset Whole Life Costs

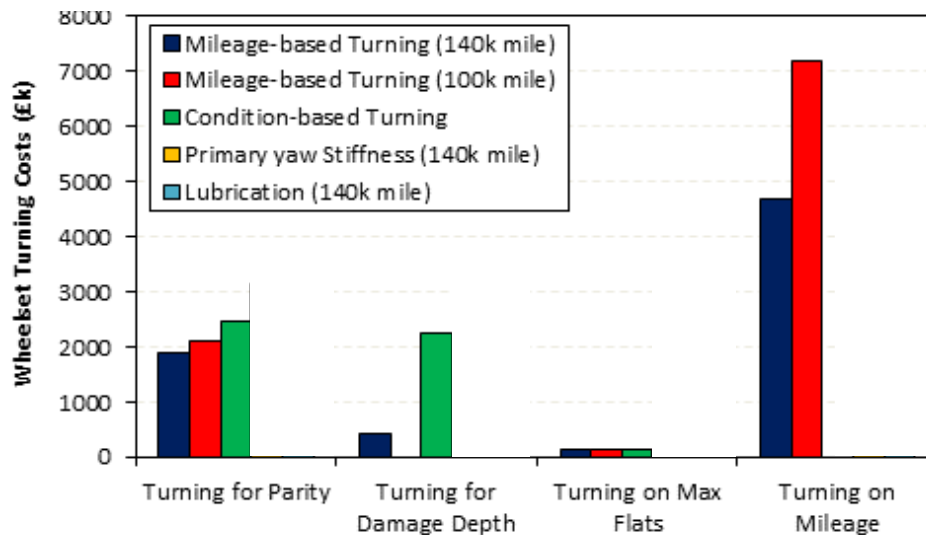
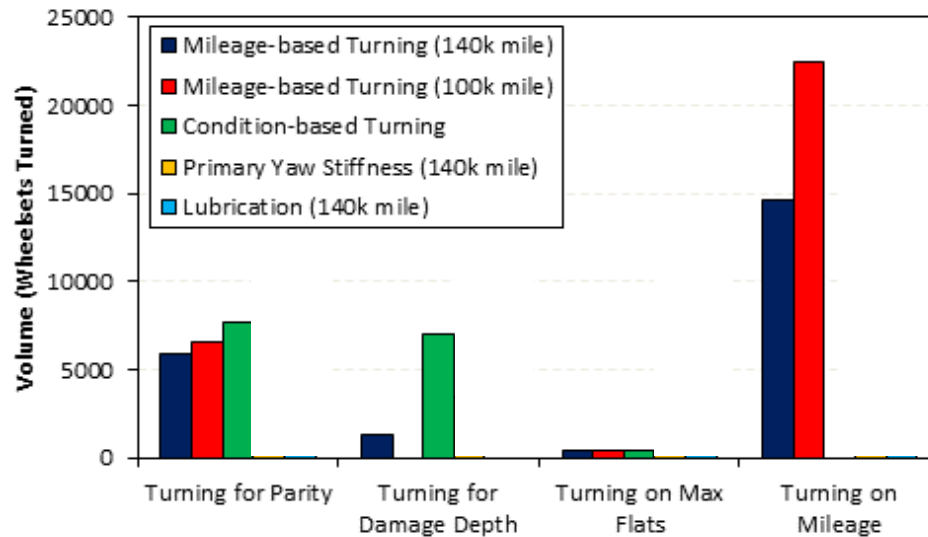


# Wheelset Whole Life Costs



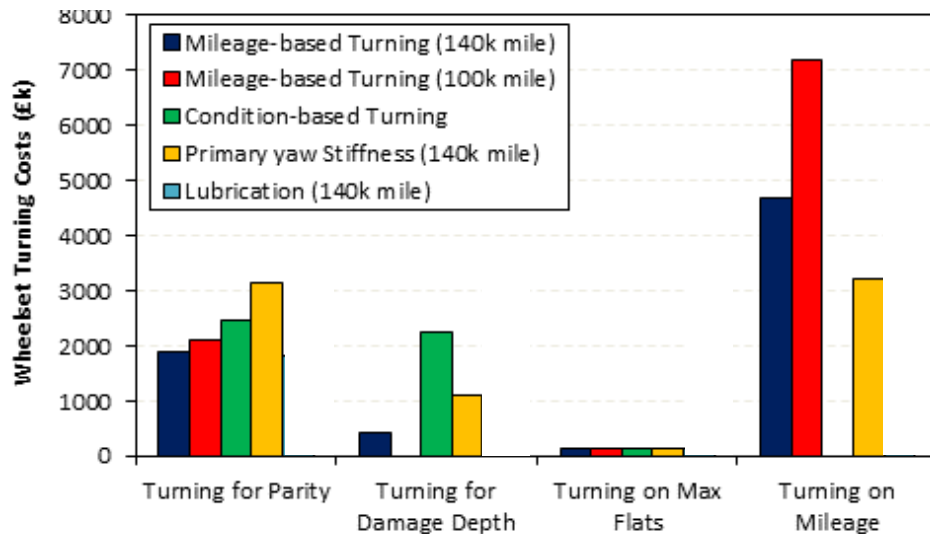
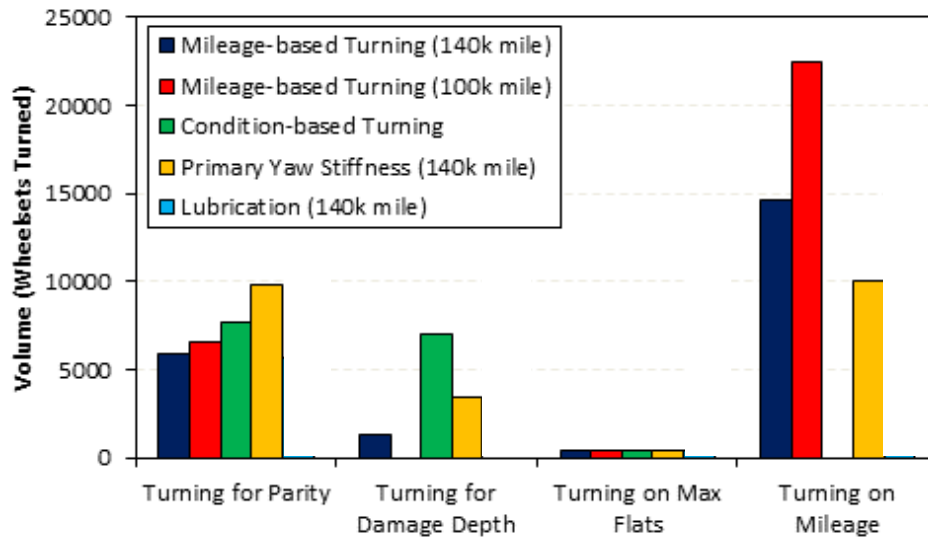
- **Reduced Turning Interval**
  - Increase in mileage-based turning
  - Reduction in turning for damage

# Wheelset Whole Life Costs



- Reduced Turning Interval
  - Increase in mileage-based turning
  - Reduction in turning for damage
- **Condition-based Turning**
  - Increase in turning for damage and parity
  - No mileage-based turning

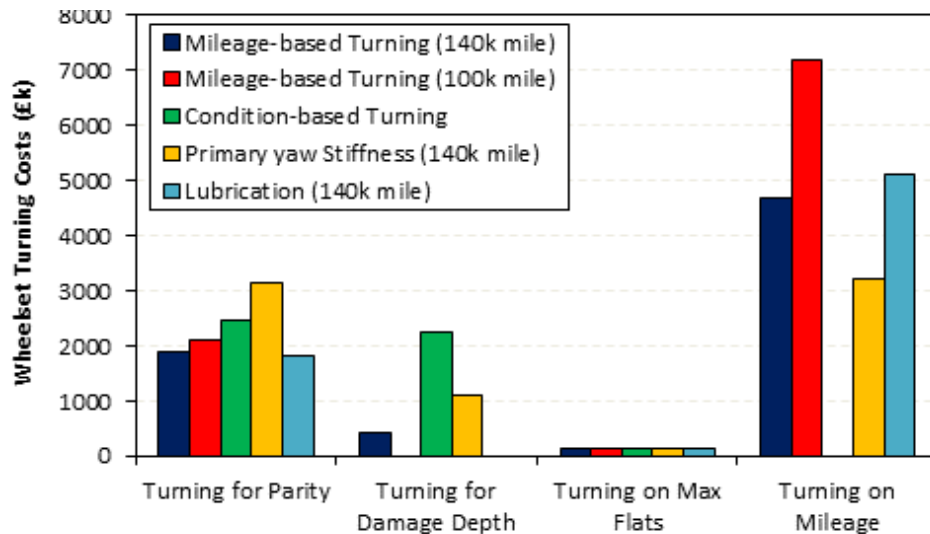
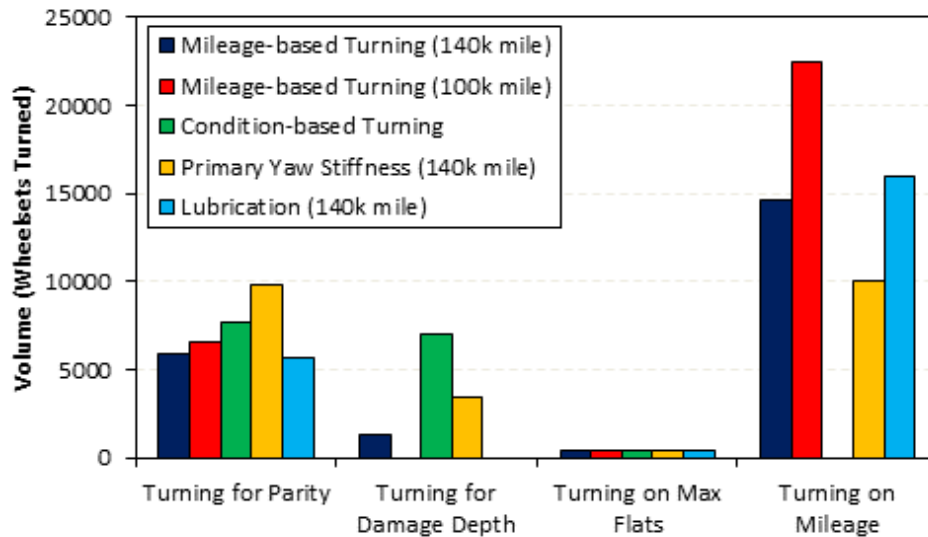
# Wheelset Whole Life Costs



- **Reduced Turning Interval**
  - Increase in mileage-based turning
  - Reduction in turning for damage
- **Condition-based Turning**
  - Increase in turning for damage and parity
  - No mileage-based turning
- **Primary Yaw Stiffness**
  - Increase rates of damage
  - Increase in turning for damage



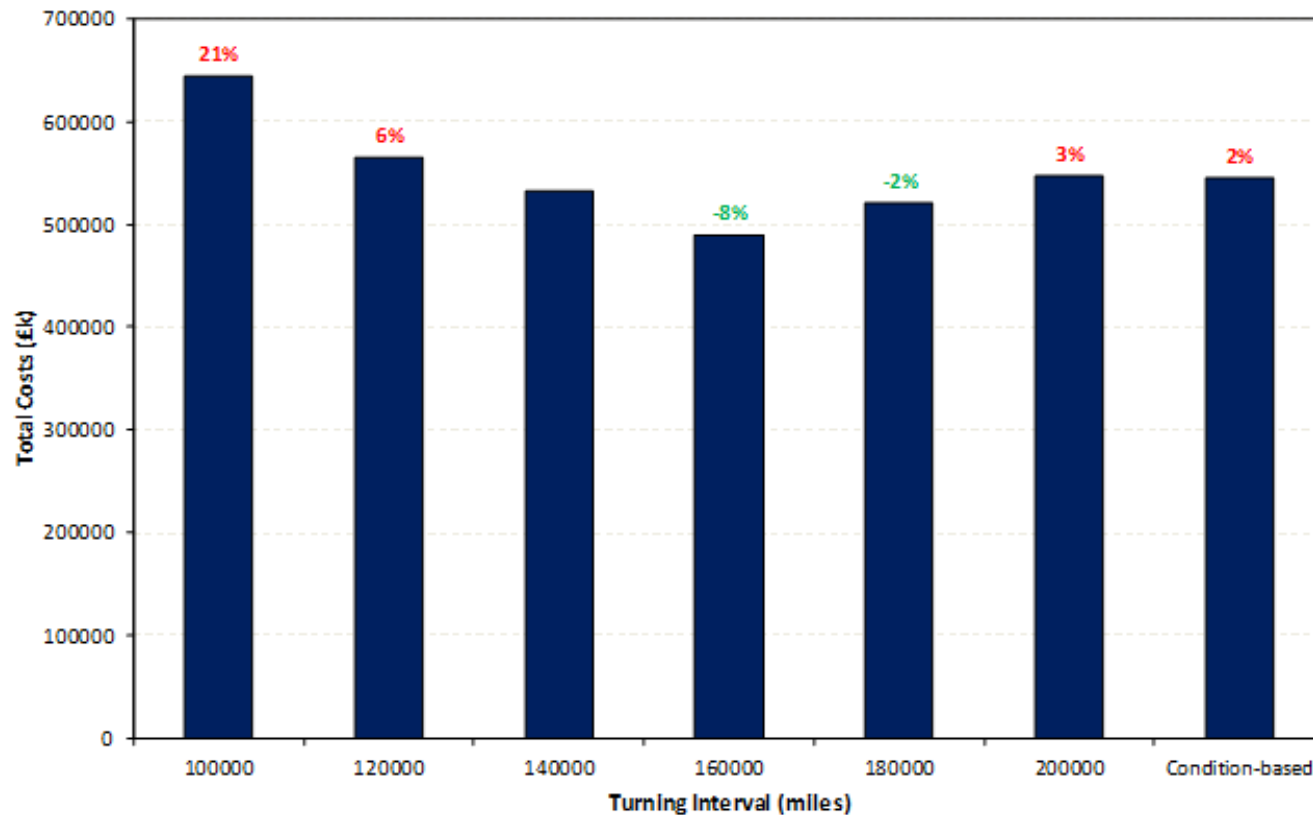
# Wheelset Whole Life Costs



- **Reduced Turning Interval**
  - Increase in mileage-based turning
  - Reduction in turning for damage
- **Condition-based Turning**
  - Increase in turning for damage and parity
  - No mileage-based turning
- **Primary Yaw Stiffness**
  - Increase rates of damage
  - Increase in turning for damage
- **Lubrication**
  - Reduction in damage rates
  - Increase in number of wheelsets achieving mileage-based turning

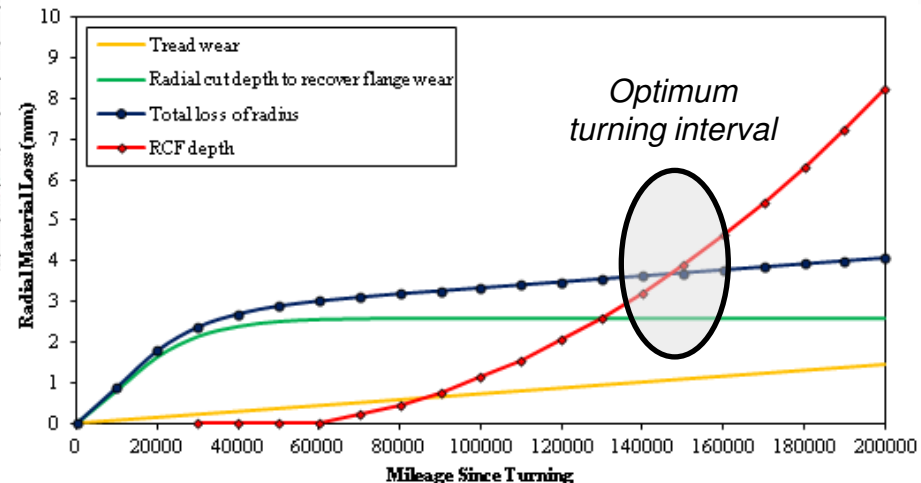
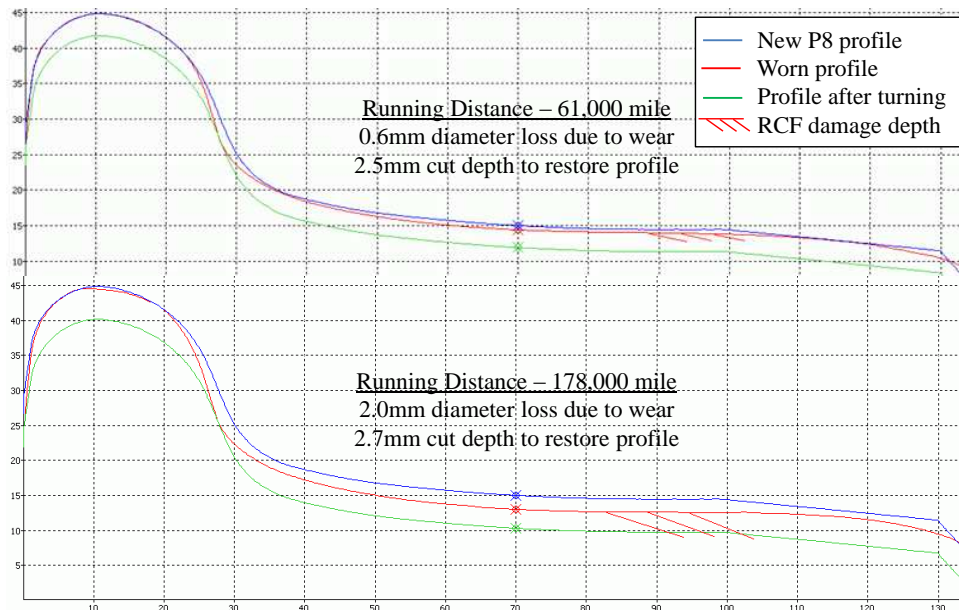
# Optimised Wheel Turning Interval

- Total costs for varying wheel turning interval



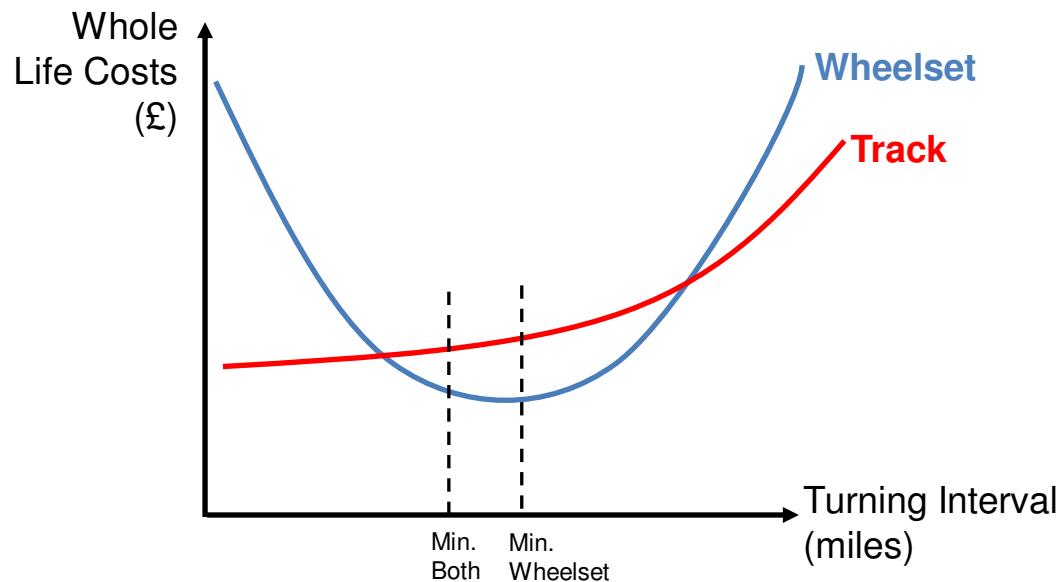
# Material Loss at Turning

- Low mileages – cut depth is governed by the amount of material loss required to restore the profile shape
- Higher mileages – similar cut depth to restore profile, but additional material removed due to RCF damage



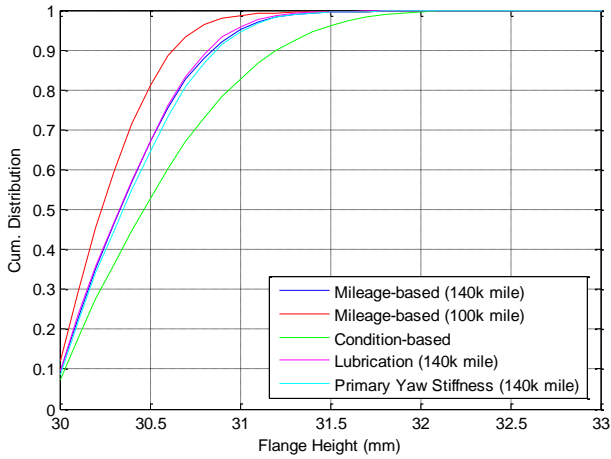
# Whole System Costs

- Increased intervals between wheel turning may result in a cost benefit to vehicle operators/maintainers
- But increases in wheel/rail conformity may result  $\approx$  increasing the probability of RCF damage on the track
- To reduce whole system costs (vehicle-track) it is therefore important to optimise both sides of the interface

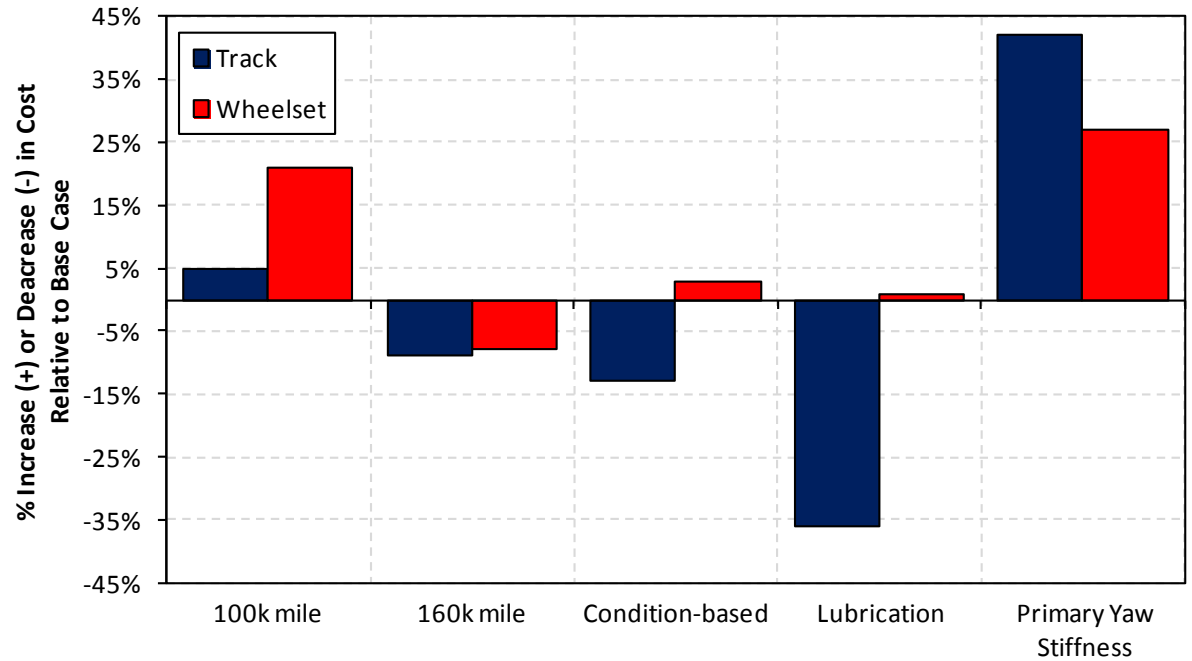
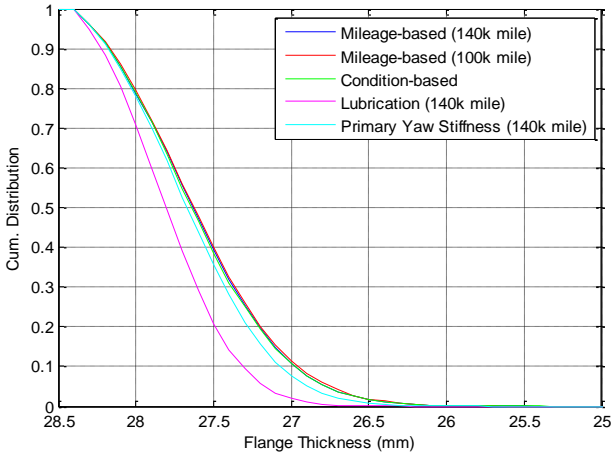


# Track-Wheelset Costs

## Distribution of Flange Height



## Distribution of Flange Thickness





- New tools have been developed which allow users to:
  - Evaluate wheelset whole life costs using fleet asset inventory data, deterioration rates and maintenance regimes
  - Determine annual inspection, maintenance and renewal costs
  - Optimise wheelset maintenance strategy
  - Carry out *'what if'* analysis
- Capabilities of these new tools have been demonstrated by predicting the whole life costs for a typical DMU fleet
  - Cost implications of number of scenarios presented
- Tools can be used to determine the impact of system changes on both vehicle and track costs  $\approx$  potential for reducing whole system costs

# Acknowledgements

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V/T SIC

Vehicle/Track System Interface Committee



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