The Application of Discrete Event Simulation to Railways

Modelling Neasden Depot

Gabriel Smith

System Performance Integration Manager

Department of Systems Integration
Overview

- Neasden Depot Upgrade
- Why Model the Depot?
- The Modelling Tool
- Development of Neasden Depot Model
- Next Steps
- Conclusions
Neasden Depot Upgrade

- New trains and new signalling
- The S Stock trains have features that are new to London Underground
  - Air conditioning
  - Single unit trains
- Maintenance facilities need to be upgraded
  - Increase in the number of maintenance activities
  - New maintenance activities
- Upgrade needs to be completed whilst maintaining day to day operations
  - A-Stock & S-Stock
New Maintenance Shed Layout

- Cant Rail & Roof Height Access Platform
- HVAC Cleaning
- Level Access Platforms
- Winterisation
- General Purpose Pitted
- Sole Bar Cleaning
- Lifting Roads
- Swimming Pool Roads
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Upgrade Issues

**Affordability**
Budget constraints. Need to better understand what we need and not what we want.

**Migration**
The depot needs to continue to operate whilst demolition and construction works are taking place.

**Physical Constraints**
Flexibility is lost as the S stock is longer than existing stock and cannot be split into smaller units.

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**Modelling will help to provide confidence in all these areas**
- Confirm that performance requirements have been met
- Demonstrate performance during migration
- Identify pinch-points and evaluate solutions
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Neasden Depot Modelling Tool

- Deterministic modelling exercises undertaken
  - Risk based modelling of depot asset failures
  - Modelling of routine depot activities

- These allowed capacity of depot to be assessed but did not provide confidence the depot system would be sufficient to support the enhanced timetables required as part of the Sub-surface upgrade

- A stochastic model of the depot as a system required to gain statistical confidence. This model would include:
  - Planned maintenance activities
  - Unplanned maintenance activities
  - Depot operations (train movements and rules)
  - Reliability of depot assets

- The modelling scope was limited to the depot and its entry and exit roads
The Modelling Tool - ProModel

- ProModel is a new tool within the London Underground environment

- Worked with Production Modelling, who have extensive experience in the use of ProModel

- The tool has been used extensively in the production industry and it was felt there was a synergy between the two environments

- The biggest challenge was to configure ProModel for use in the railway environment
The Modelling Tool - ProModel

Graphical Front End

Probability Distributions

Windows based

Excel Inputs

Programmable
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Development

Locations

Routing

Unplanned Maintenance

Planned Maintenance

Timetable

Trains

Neasden Depot Model

Outputs
Locations & Routing

- **Movement 1**
  - Stabling 1
  - Stabling 2
  - Stabling 3
  - Stabling 4

- **Movement 2**
  - Maintenance 1
  - Maintenance 2

- **Movement 3**
Timetable & Trains

- A timetable is used to:
  - Insert and remove trains from the model area
  - Provide a benchmark against which to assess the performance of depot operations

- The timetable defines:
  - The timing of arrivals and departures
  - An entrance and exit location for each arrival and departure
  - The type of rolling stock used for each arrival and departure

- Trains are individually identified within the model

- Each train keeps a record of the number of days since its last maintenance activity

- When the simulation is started, each train is at a different point in the maintenance cycle
<table>
<thead>
<tr>
<th>Ref.</th>
<th>Maintenance Task</th>
<th>Frequency</th>
<th>Tolerance</th>
<th>Duration</th>
<th>Location Preferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 Day Exam</td>
<td>30 days</td>
<td>-3 days +0 days</td>
<td>7 hours</td>
<td>Pitted roads</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>Swimming Pool road</td>
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<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>37</td>
<td>Wheel Turning</td>
<td>270 days</td>
<td>-40 days +90 days</td>
<td>21 hours</td>
<td>Lathe road</td>
</tr>
<tr>
<td></td>
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<td>...</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>N/A</td>
</tr>
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</table>
# Unplanned Maintenance

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Failure Type</th>
<th>Number of occurrences per train per year</th>
<th>Expected Repair Time</th>
<th>When will the casualty return to the depot?</th>
<th>Location Preferences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Immediately</td>
<td>After peak</td>
</tr>
<tr>
<td>1</td>
<td>Brakes &amp; Air System SAF</td>
<td>0.5441</td>
<td>3 hours</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
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<td></td>
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<td></td>
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<td>...</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Wiper Blade Worn Out</td>
<td>0.1305</td>
<td>0.25 hours</td>
<td>50%</td>
<td>25%</td>
</tr>
</tbody>
</table>
Depots operate successfully due to depot staff skill & experience.

To overcome problems, assumptions had to be made.
Simplifications - Train Movements

Original Plan
Trains reserve entire route through depot

Problem
Route ‘locking’ prevents internal moves

Ideal Solution
Expand scope to automatically plan train routes

Reality
Train movements planned by depot staff.

Actual Solution
Workarounds to ensure timely maintenance
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Next Steps – Neasden model

- Validation of input data and assumptions
- Scenario modelling

- Further iterations of the Neasden model may include
  - Modelling interim depot states
  - Developing train movement logic
  - Adding in manpower constraints

- Further applications of ProModel may include:
  - Modelling of other depot locations
  - Modelling of junctions and complex termini

- Development of a railway focused ProModel training course
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It is possible to model depots as a system bringing together: planned & unplanned maintenance, logistical processes, asset reliability, etc.

Modelling cannot replace the detailed train movement planning undertaken by depot staff but can assist in testing scenarios.

Confidence in the most economic and efficient technical solution demands good quality input data.

Mainline operational data is readily available, depot operational data is harder to find.

This is a modelling capability we want to develop as part of our toolkit.