
UNDERGROUND
London
Underground

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The Application of Discrete Event Simulation to Railways

Modelling Neasden Depot

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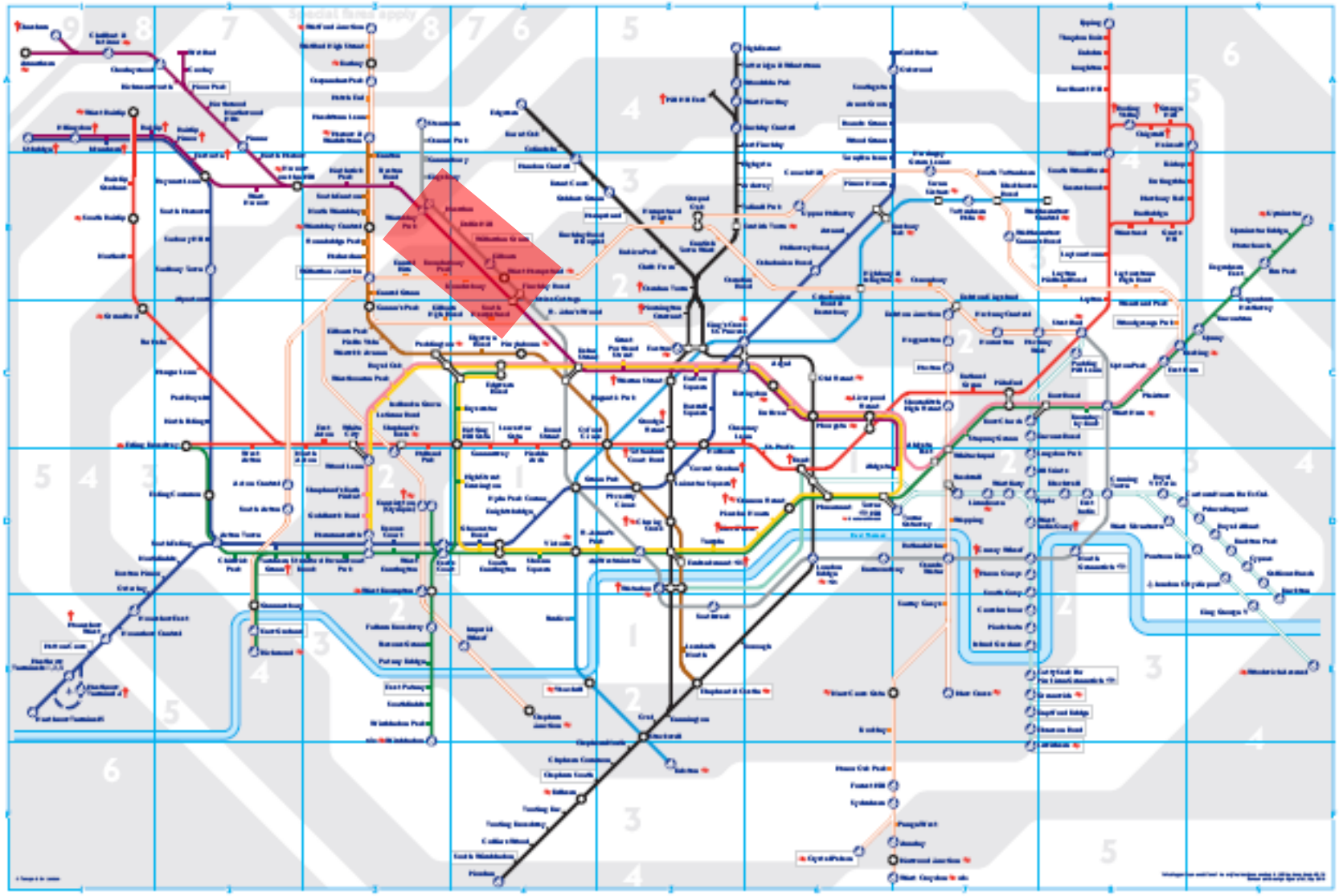
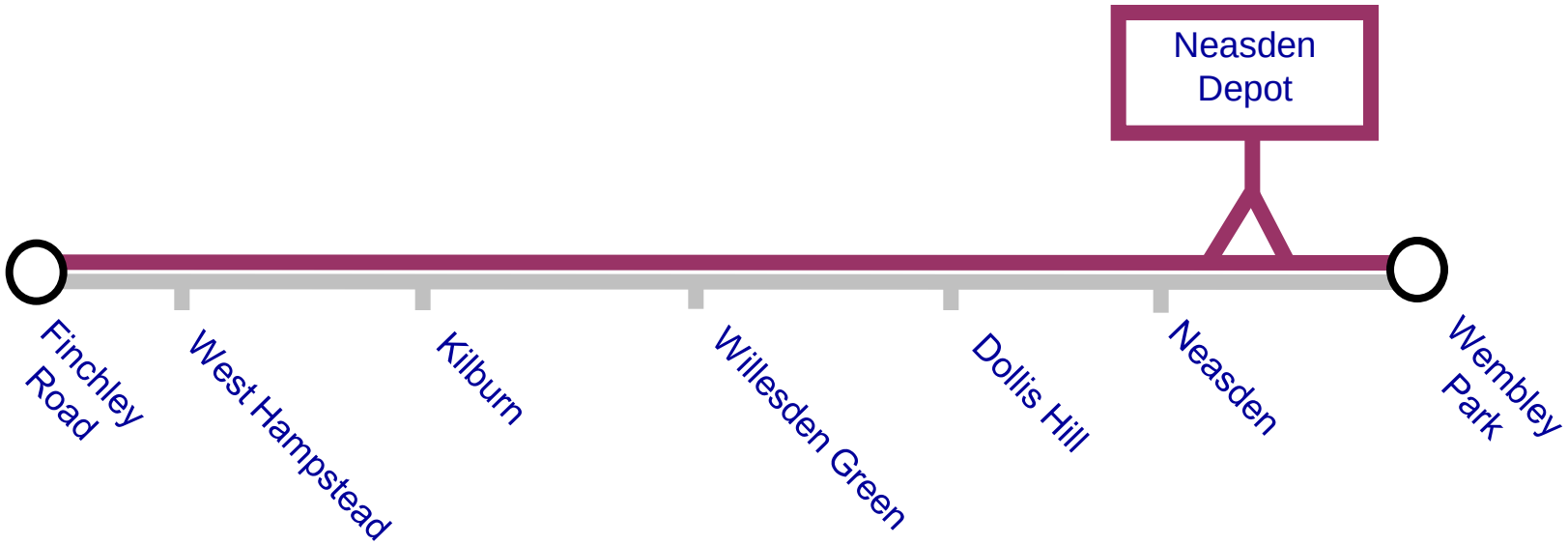
Overview

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




Neasden
Depot
Finchley
Road
West Hampstead
Kilburn
Willesden Green
Dollis Hill
Neasden
Wembley
Park

Metropolitan & Circle line
Neasden Depot

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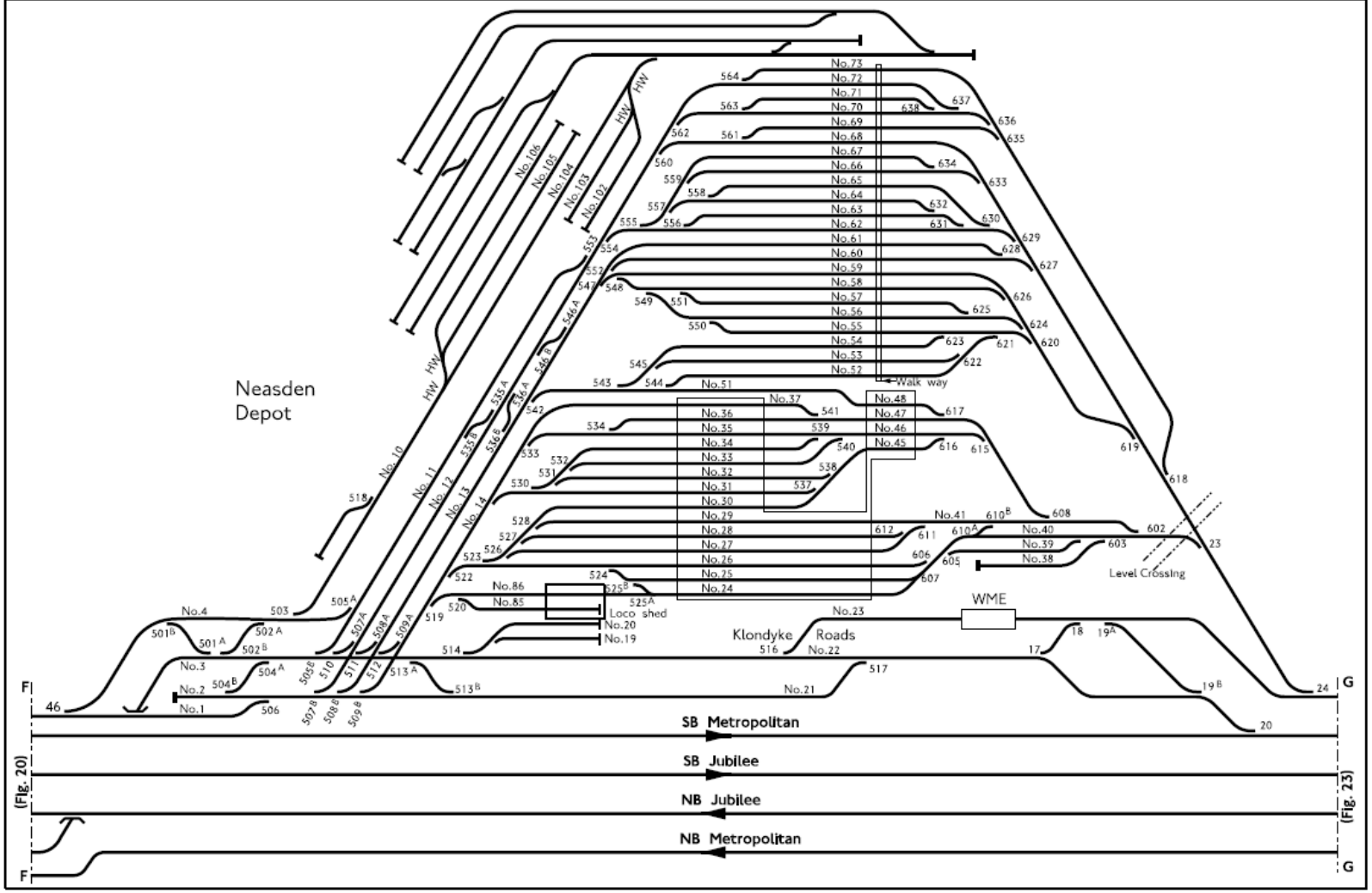
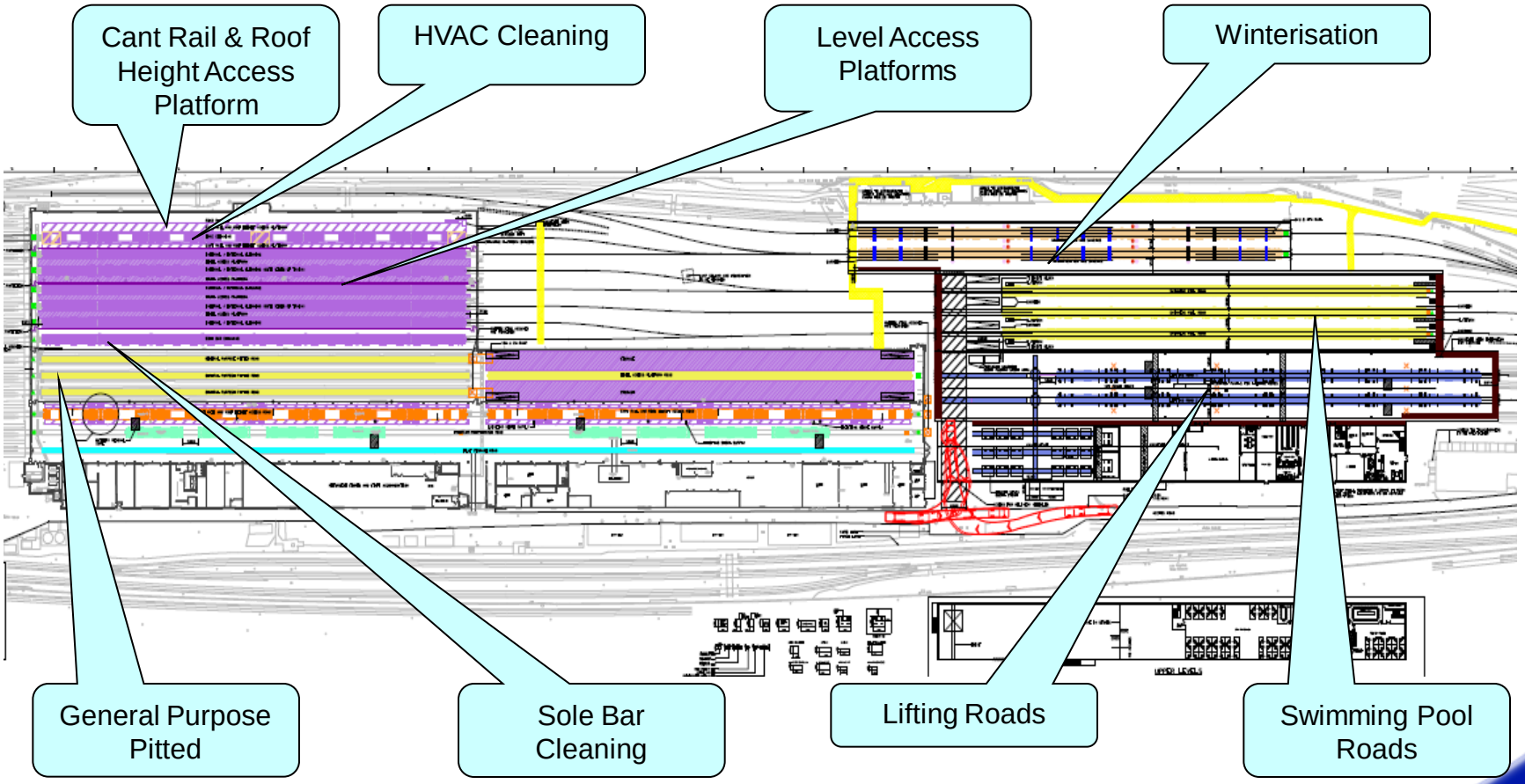
Junction Diagram : Figure 22



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



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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

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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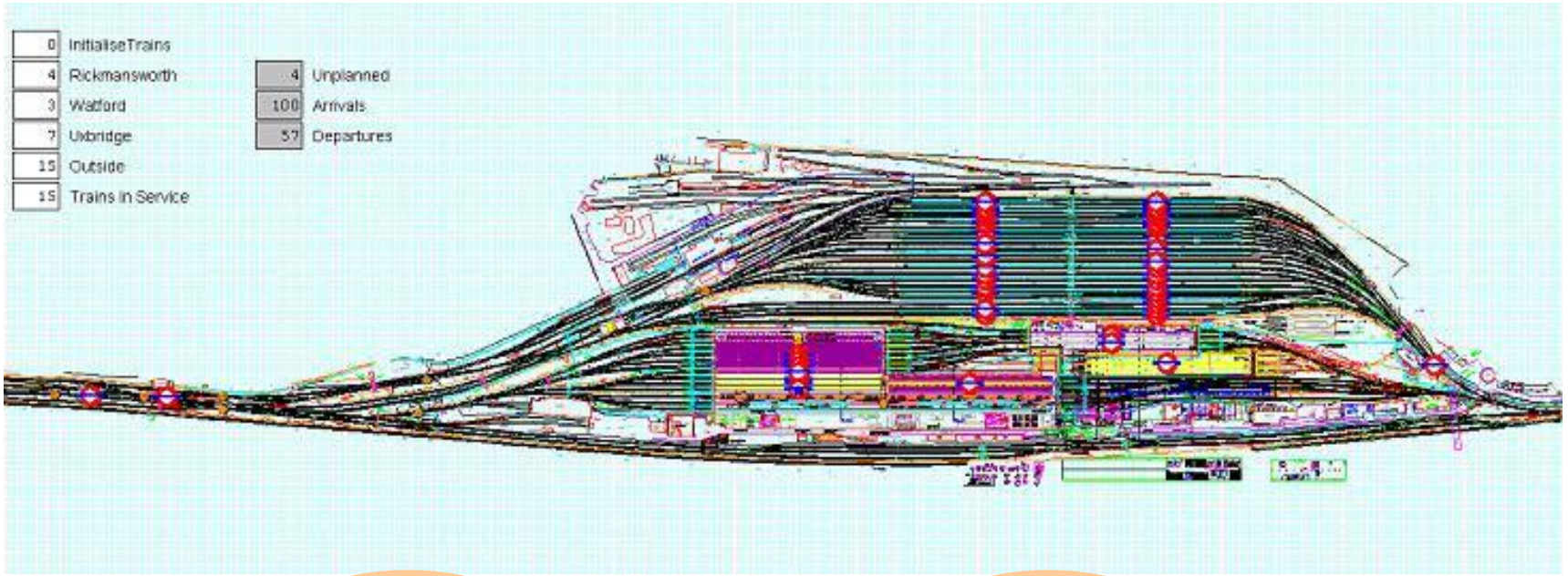
Neasden Depot Modelling Tool

- 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



Probability Distributions

Excel Inputs

Graphical Front End

Windows based

Programmable

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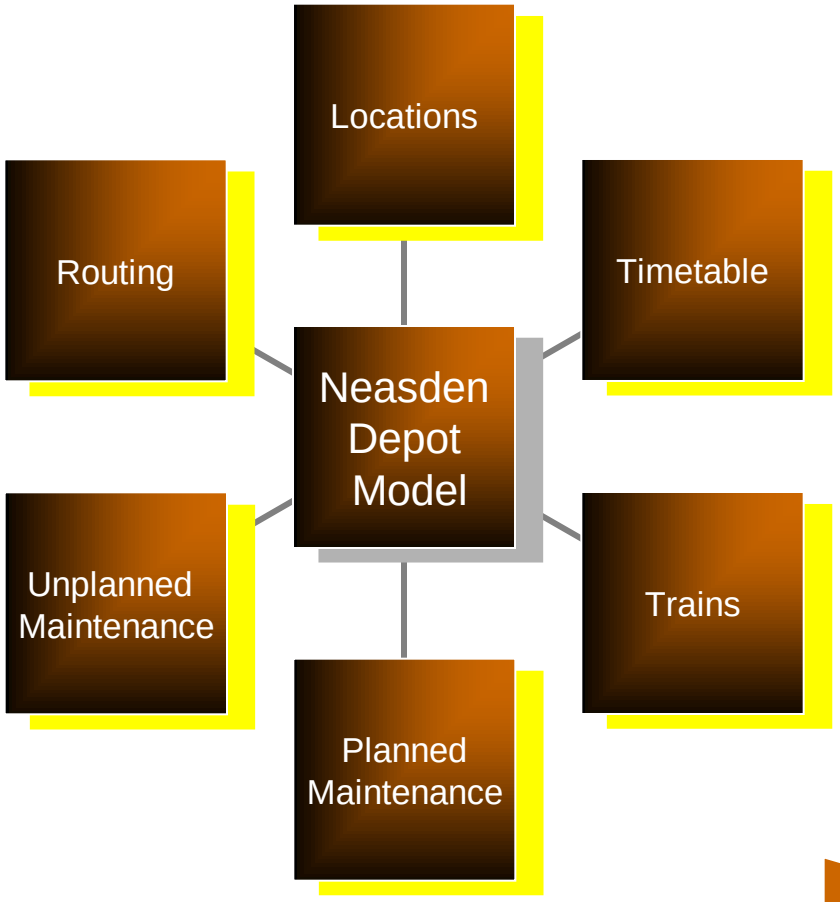
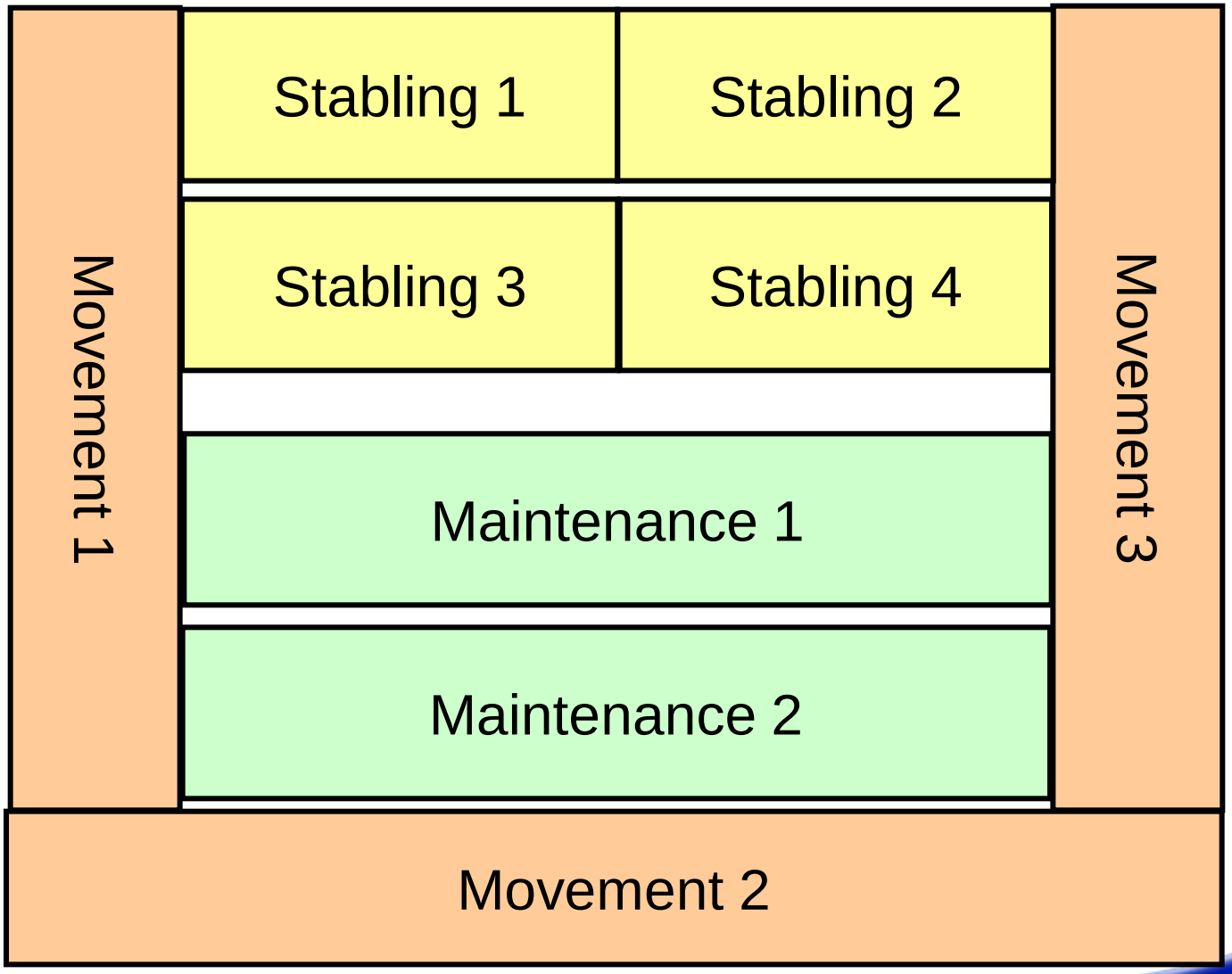
Development



Outputs

Locations & Routing



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

Planned Maintenance

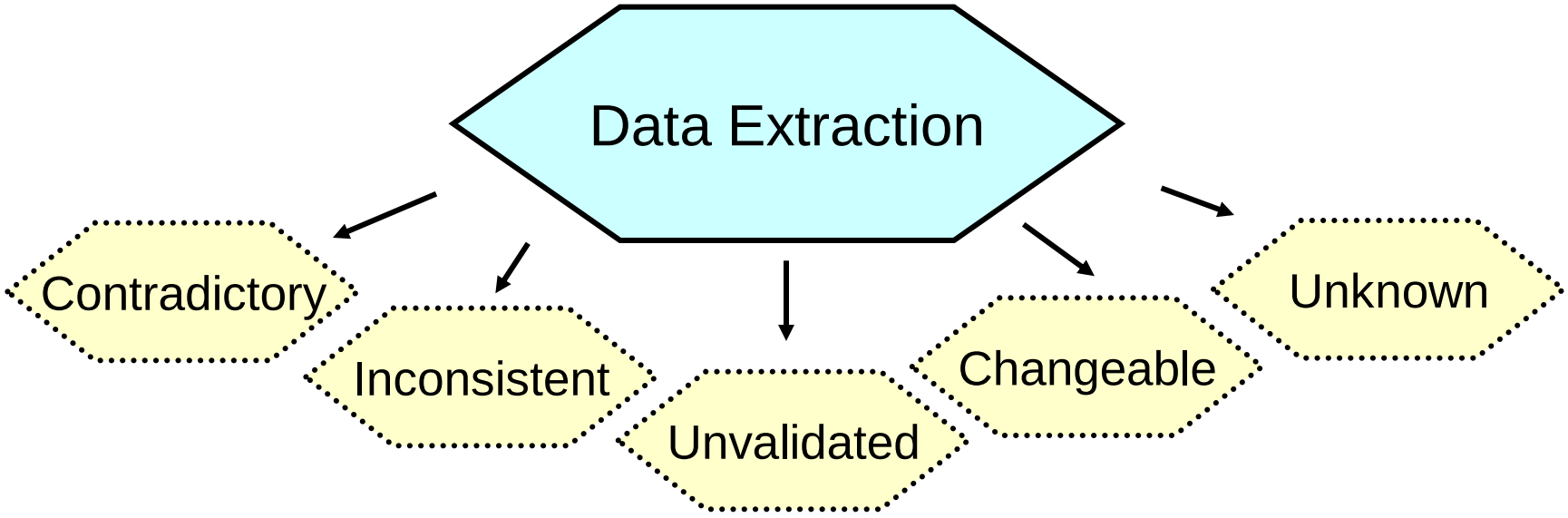
Ref.	Maintenance Task	Frequency	Tolerance	Duration	Location Preferences		
					1st	…	13th
1	30 Day Exam	30 days	-3 days +0 days	7 hours	Pitted roads	…	Swimming Pool road
…	…	…	…	…	…	…	…
37	Wheel Turning	270 days	-40 days +90 days	21 hours	Lathe road	…	N/A

Unplanned Maintenance

Ref.	Failure Type	Number of occurrences per train per year	Expected Repair Time	When will the casualty return to the depot?			Location Preferences		
				Immediately	After peak	As per Schedule	1st	…	13th
1	Brakes & Air System SAF	0.5441	3 hours	100%	0%	0%	Swimming Pool Road	…	Pitted Road
…	…	…	…	…	…	…	…	…	…
60	Wiper Blade Worn Out	0.1305	0.25 hours	50%	25%	25%	Platform Road	…	N/A

Depot Processes

Depots operate successfully due to depot staff skill & experience



To overcome problems, assumptions had to be made

Simplifications - Train Movements

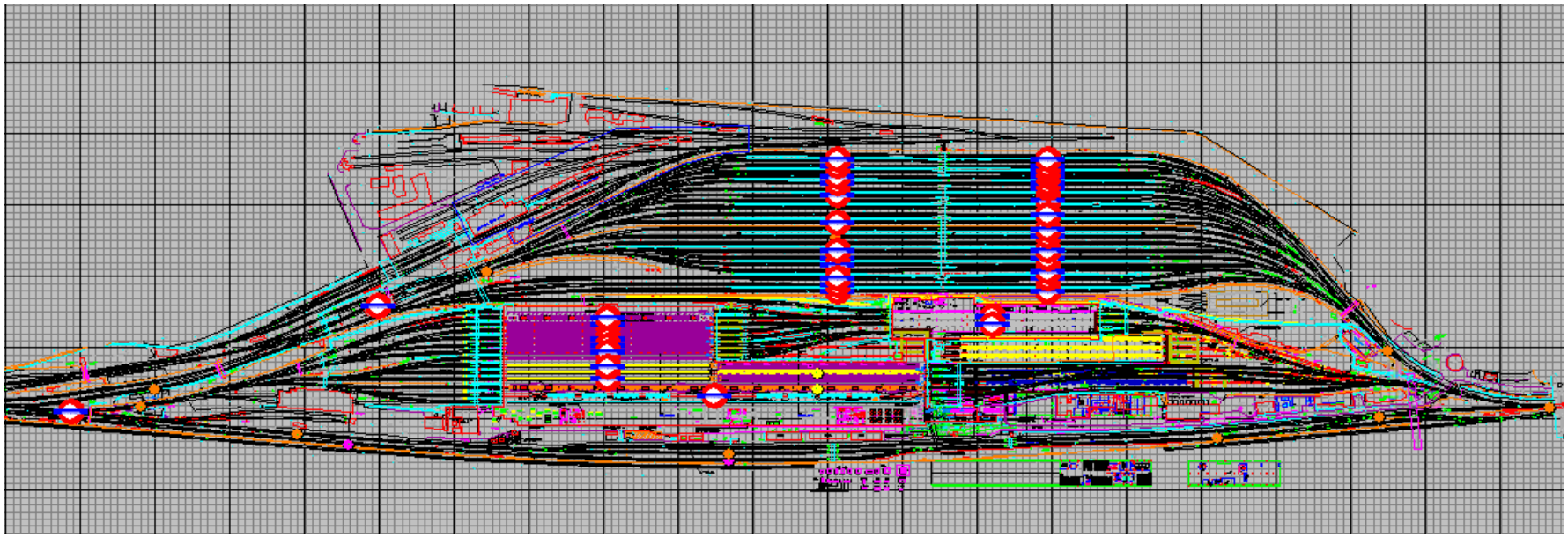
Original Plan
Trains reserve entire route through depot

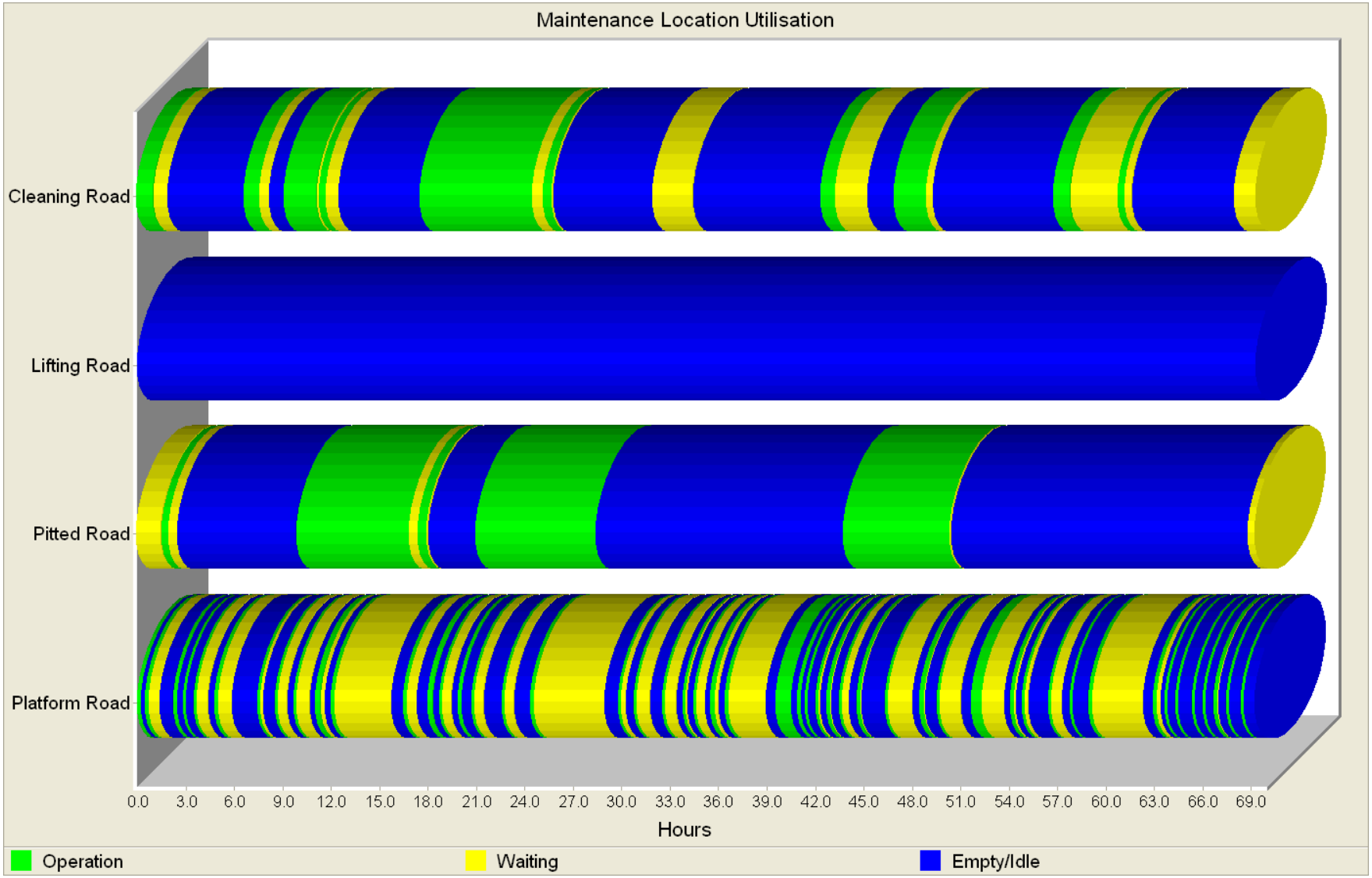
Problem
Route ‘locking’ prevents internal moves

Ideal Solution
Expand scope to automatically plan train routes

Reality
Train movements planned by depot staff.

Actual Solution
Workarounds to ensure timely maintenance




Maintenance Location Utilisation
Cleaning Road
Lifting Road
Pitted Road
Platform Road
0.0 3.0 6.0 9.0 12.0 15.0 18.0 21.0 24.0 27.0 30.0 33.0 36.0 39.0 42.0 45.0 48.0 51.0 54.0 57.0 60.0 63.0 66.0 69.0
Hours
Operation
Waiting
Empty/Idle

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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 out toolkit

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