Developing digital-twin models for transport systems analysis: challenges and opportunities

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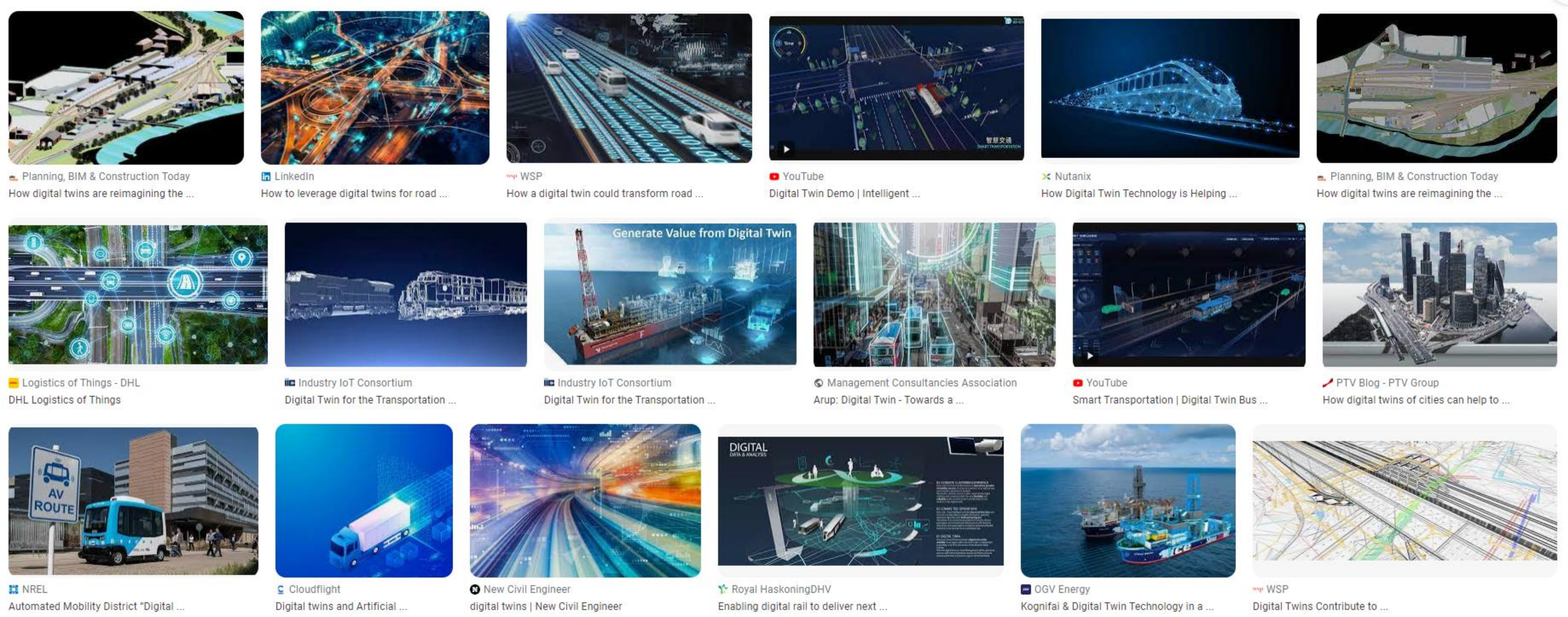
Immense

Realistic 'days in the life' of a place for millions of simulated people

Immense empowers cities, infrastructure and fleet operators to make great decisions about transportation by comparing alternatives

Digital Twins for Transportation...



Opportunity: Making simulation accessible

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Integrated simulation assets with Digital Twin assets reduce time and cost for the end customer to make great decisions by accelerating analyses and providing timely and impactful insights

OLD METHOD

Simulation Software → City Data → Expert Support → End Customer

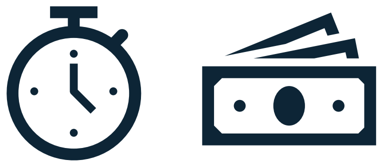
Simulation Software	City Data	Expert Support	End Customer
Specialist tools and consultant lock-in	Multiple providers on a transaction model.	Multiple consultants working on a project level.	Organisation assessing alternative transport solutions
High headcount org with single digit margins	Non-reusable, expensive with high margins	Expensive £/hr with low double digit margins	

NEW METHOD

Integrated Digital Assets and Methods → Expert Support → End Customer

Coupling data with simulation provides consistent on-demand data, software and compute and enables flexible subscription business model and bespoke integrations

Organisation assessing alternative transport solutions



Reduced time and cost per question

Re-usable capability for Infrastructure Planning and Operations: Co-creation with UK public sector

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We have developed our simulation methods with public sector applications to assess infrastructure planning and operational use cases supporting Local, Regional and National customer groups

national highways

Creating a simulation platform suitable for use in control centre environments

- On-the-ground engagement with users to capture requirements
- Creation of productised workflow to generate insights for users
- Deliver and test of pre-production system

Department for Transport

Leveraging real-time data to improve operational decision for traffic management

- Integration of RT data feeds to simulation platform
- Work with proto-client (Oxfordshire) to provide UX insight
- Enable improved traffic management and response strategies

OXFORDSHIRE COUNTY COUNCIL

Deploying a next-generation simulation platform for transport and infrastructure planning

- Simulation of transport and infrastructure for the whole of Oxfordshire
- Used to assess the impact of housing or employment sites and infrastructure
- Vastly improved workflow for fast, iterative transport modelling

TRANSPORT FOR LONDON – EVERY JOURNEY MATTERS

Reinventing roadworks planning, impact analysis and collaboration with the utility industry

- Collaboratively plan roadworks across London
- Increase confidence in decision-making around roadworks planning
- Provide additional simulation tooling to support efforts to improve road safety

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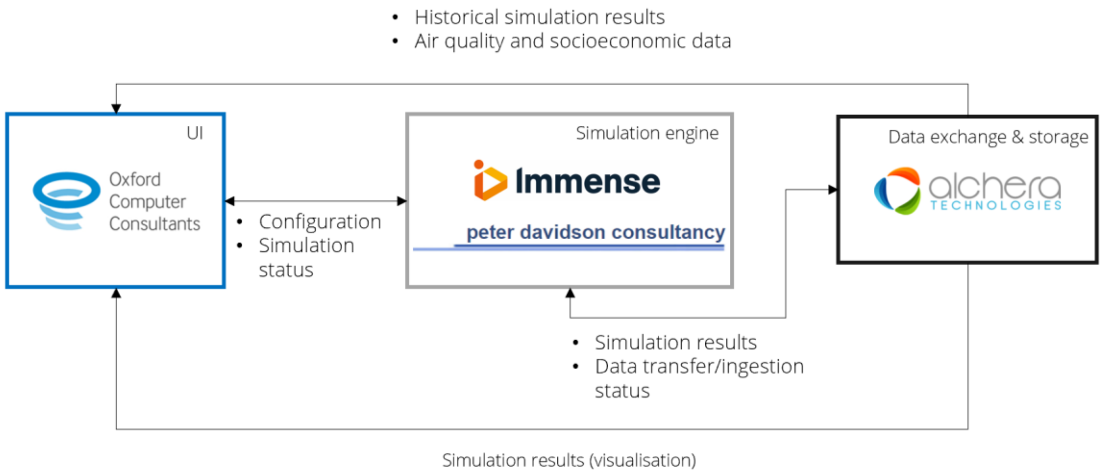
Case study: MIMAS and OMM

MIMAS Immense

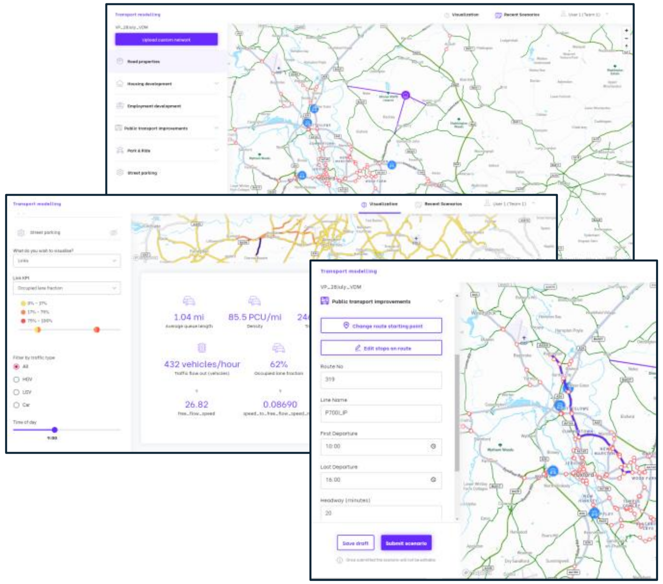


MIMAS “Modelling Infrastructure and Mobility as a Service” is a cloud-based platform built under and Innovation Procurement Partnership:

- an innovative approach to transport modelling;
- scalable data storage enabling other datasets to be integrated;
- intuitive user interface for model inputs and custom visualisations of results;
- a plugin API supporting apps and services.

MIMAS supports a move towards a self-service paradigm for modelling

- The Oxfordshire Mobility Model (OMM) is “MIMAS for Oxfordshire”
- Undergoing final pre-launch validation testing



Case study: OMM facts and figures

***Figure 4**: OMM highway network*

- Model developed with reference to Department for Transport Guidelines (TAG) to enable appraisal use cases (demonstrating fitness-for-purpose and describing capability for specific business cases…)
- Base year of 2019, ~1.5 million activities developed using mobile network data + NTEM + NTS; supply side from mapping, telematics, on-site data.
- Forecast years of 2024 and 2035 do-minimum (TEMPro and committed development sites data); ~100 Highway, ~40 PT and ~3000 Developments
- 24 hr representation with hourly outputs and event-based updates for each agent
- Oxfordshire detail with whole GB zone plan (567 zones in OxCC, 706 in total) incorporateing 25k links, 15k nodes, ~200 signal plans, ~300 count sites

Build: Network Description

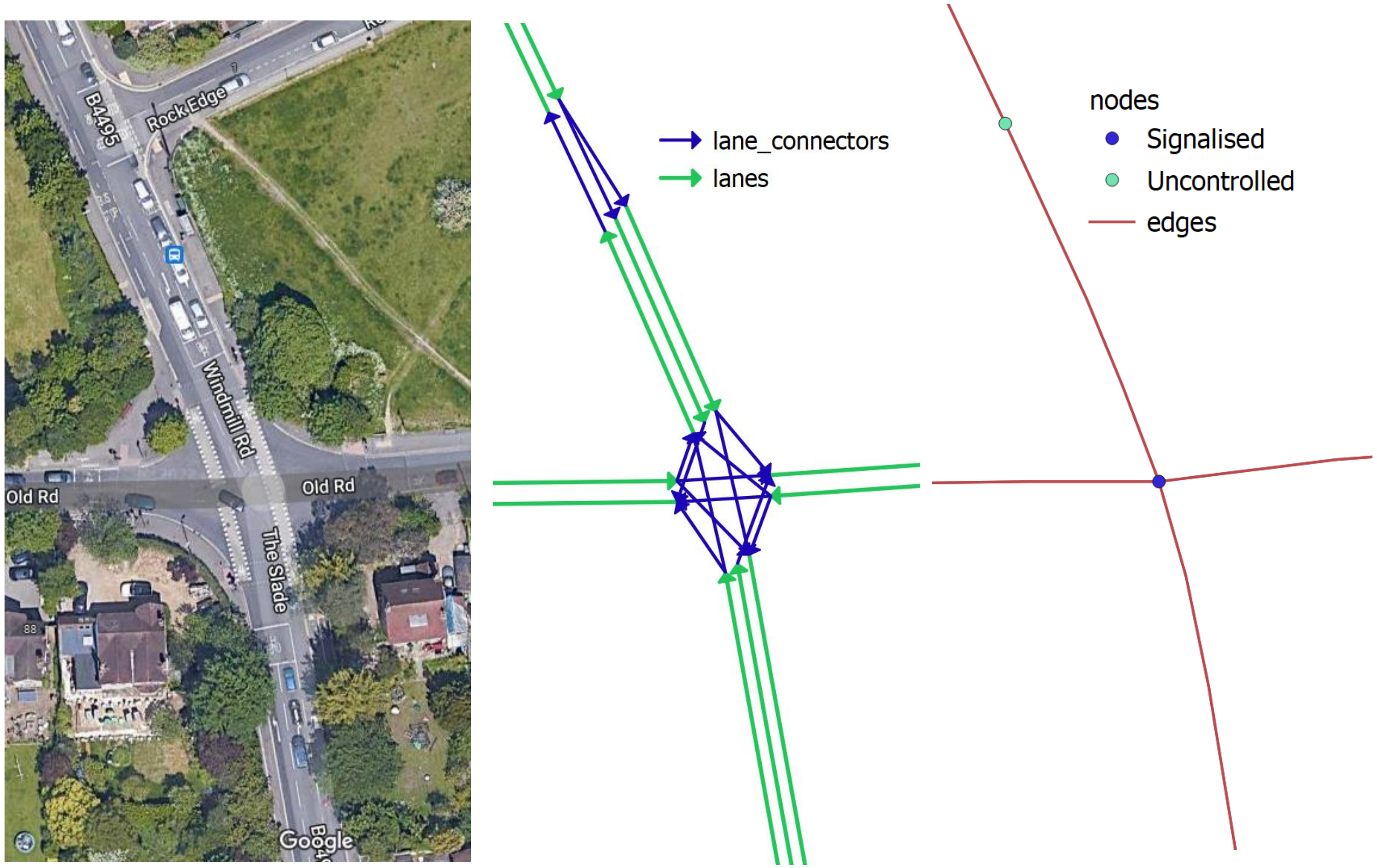


***Figure 6**: Network description: edges, lanes, nodes*

The road traffic network is represented by a graph of lanes and lane connectors. This allows vehicles to be simulated as agents, routing through the network.

Physical constraints of the road, such as number of lanes and speed limits are represented as attributes of the lanes.

Physical constraints at junctions are described by attributes of the lane connectors. For example, turn restrictions by lane, note how the right turn only lane on Windmill Road southbound is represented by lane connectors providing a connection to Old Road westbound only.

Give way behaviour at junctions is represented by a gap acceptance model. Each lane connector has a list of other lane connectors that it must yield to. Traffic may only use a lane connector when there is a sufficiently large (time) gap between vehicles on all lane connectors that it is yielding to. There are typical time gap values derived from empirical data for different junction types and turn types.

The network model includes higher level objects for reporting aggregated results metrics; edges are an aggregation of lanes, and turns are an aggregation of lane connectors

Build: Network Description

Edges and nodes

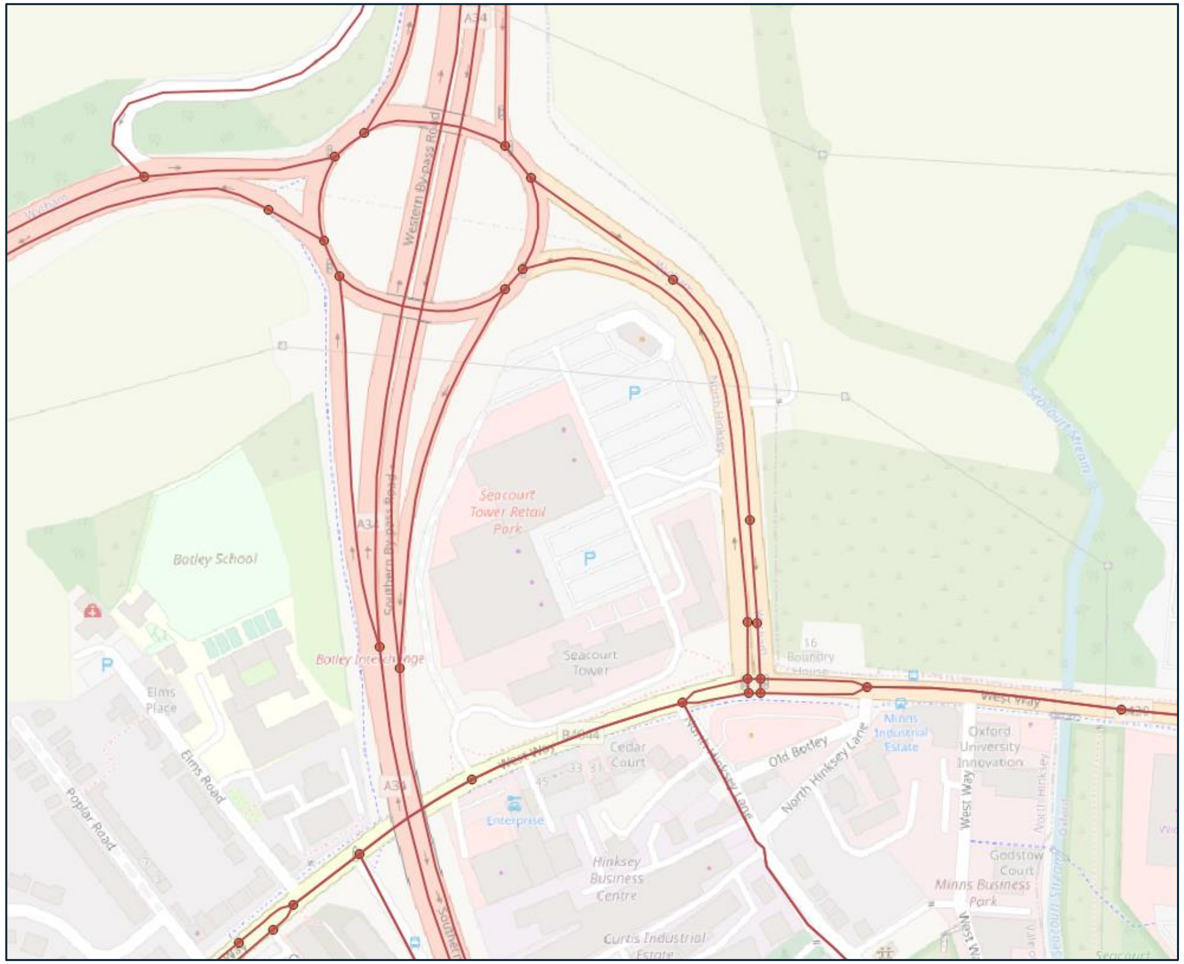


Figure 7: Network description: edges and nodes

Lanes and lane connectors

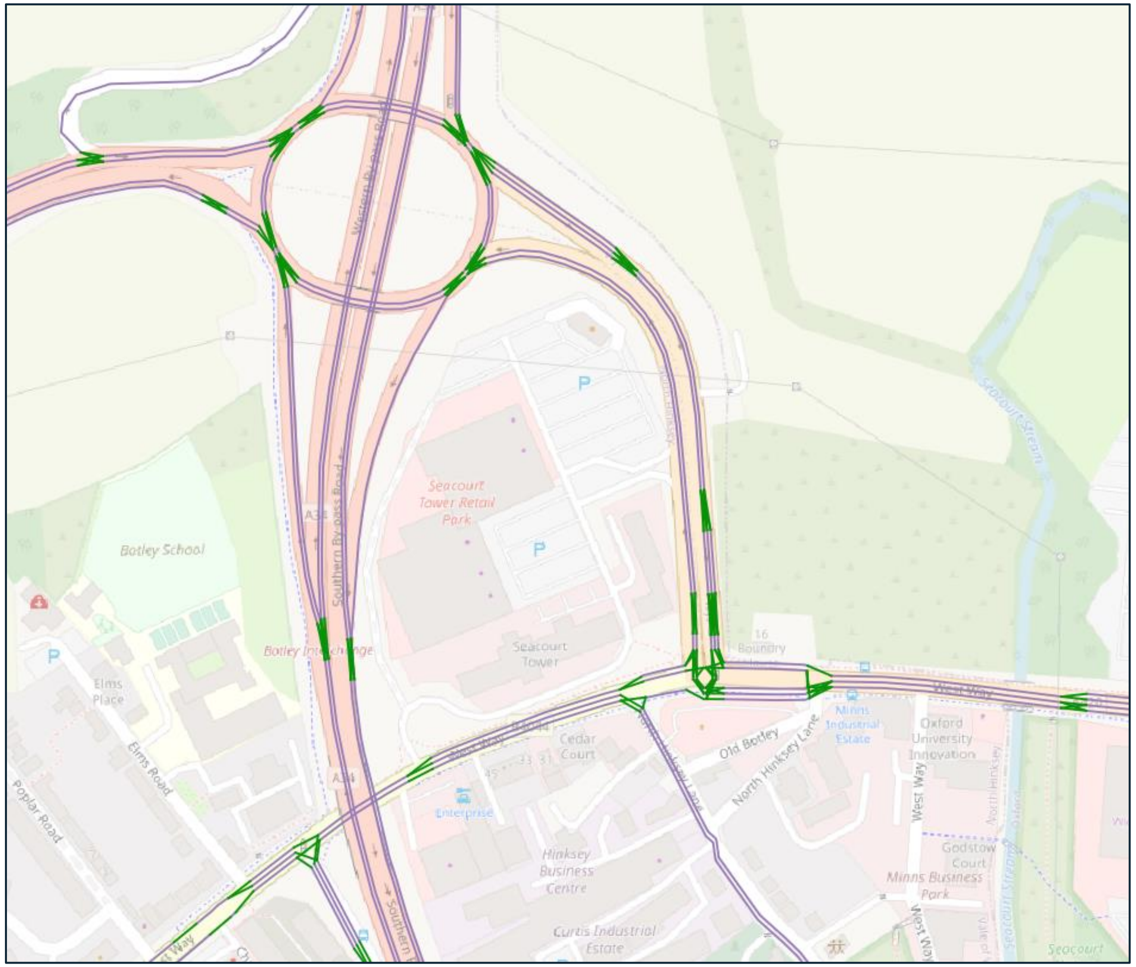
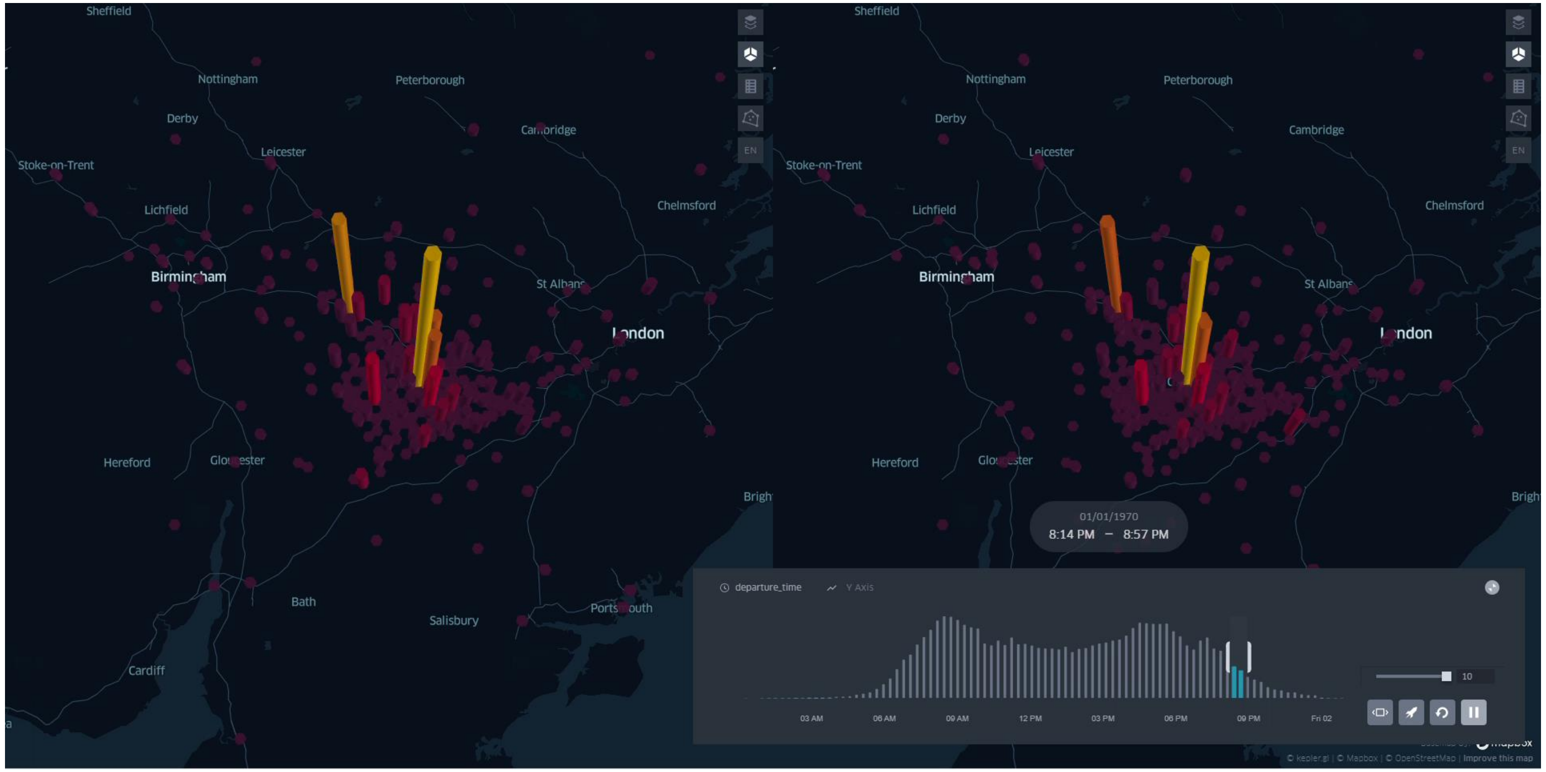


Figure 8: Network description: lanes and lane connectors

Data synthesis: Demand for highway travel

- ~1.6m agent-trips per day
- Synthesis of multiple data sources
  - Mobile Network Activity data
  - Household Census data
  - Land-use information
  - National Travel Survey
  - ..



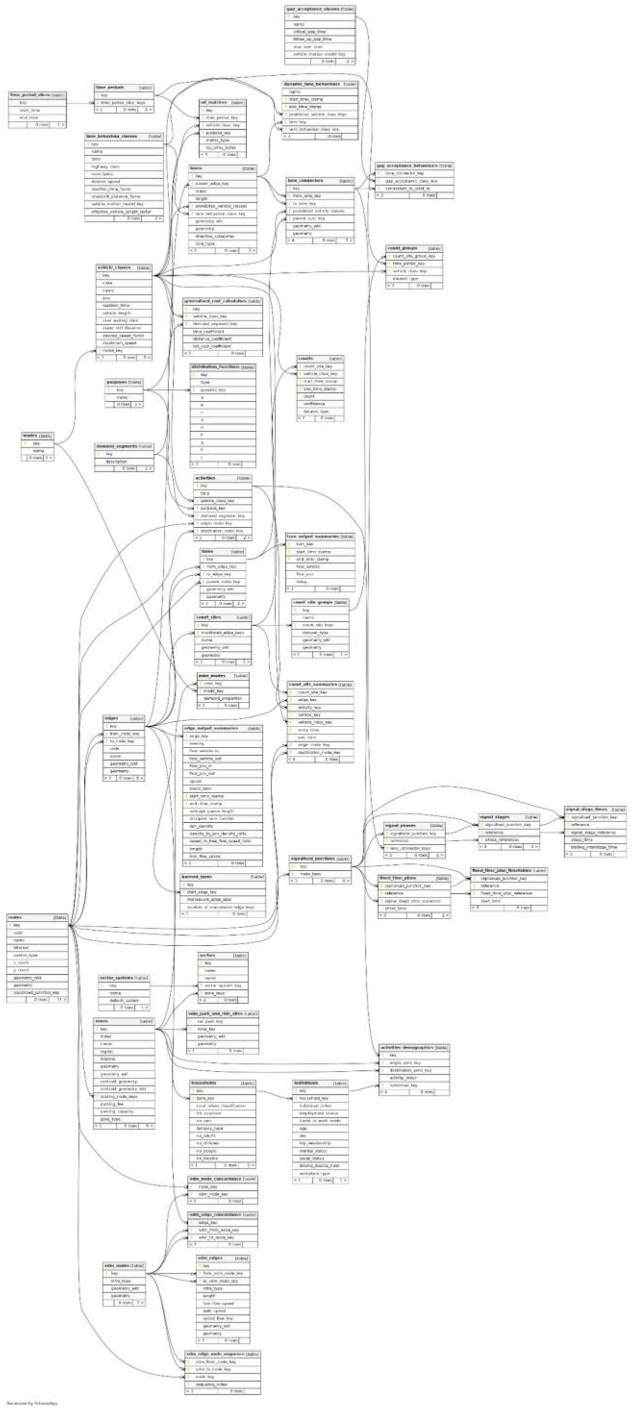
Replicating: A day in the life of…

Highway Assignment simulation. Speed to free-flow speed ratio. 6:00 AM

Google Maps traffic data. Typical Wednesday. 6:00 AM

Availability: a complex model made “simple”

- Real world objects are mapped one-to-one with simulation objects in a comprehensive object model
- Objects relate to one another with referential integrity i.e.
  - Road segments (edges) must have nodes at either end
  - Edges must have one or more lanes
  - Lanes must be connected to upstream and downstream lanes via lane connectors
- Object model easily extensible to incorporate new representations, i.e. bus routes
- “Worlds” generated via automated processes with established data partnerships opportunity to link to additional datasets
- Resilience through established data partnerships



Accessibilty: for humans and machines

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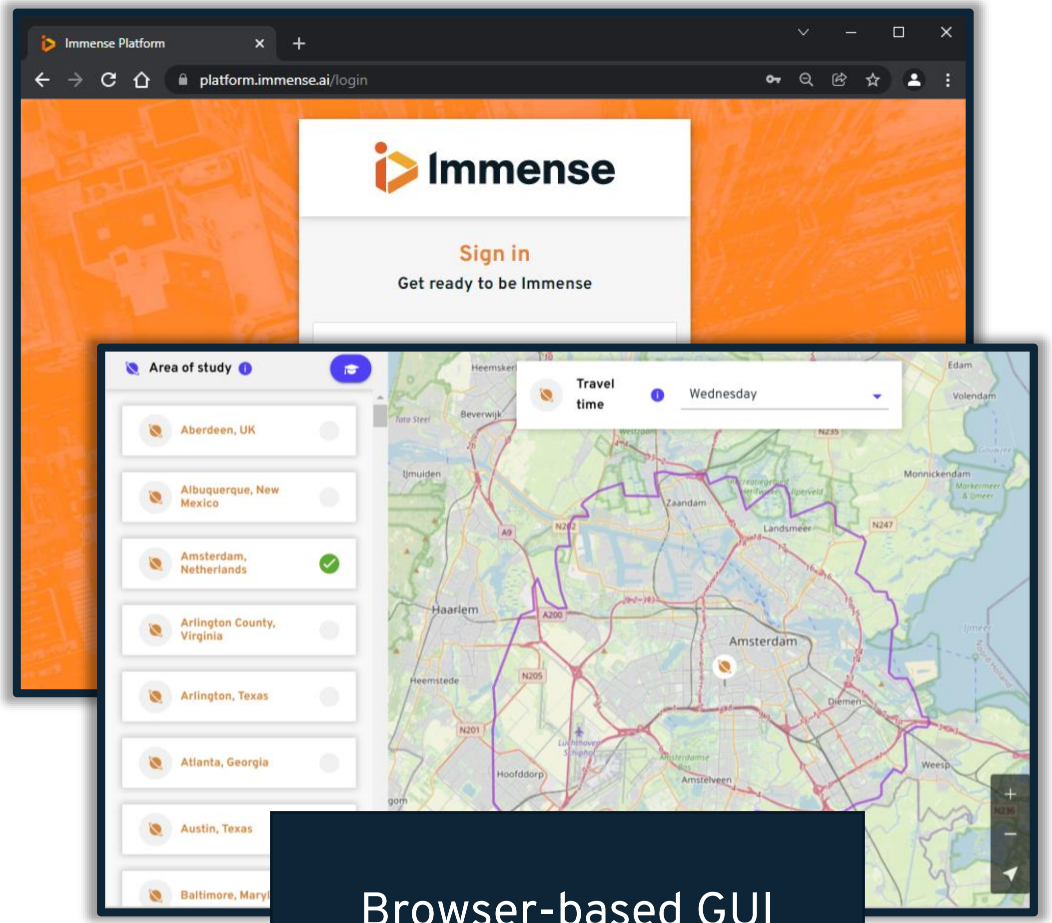
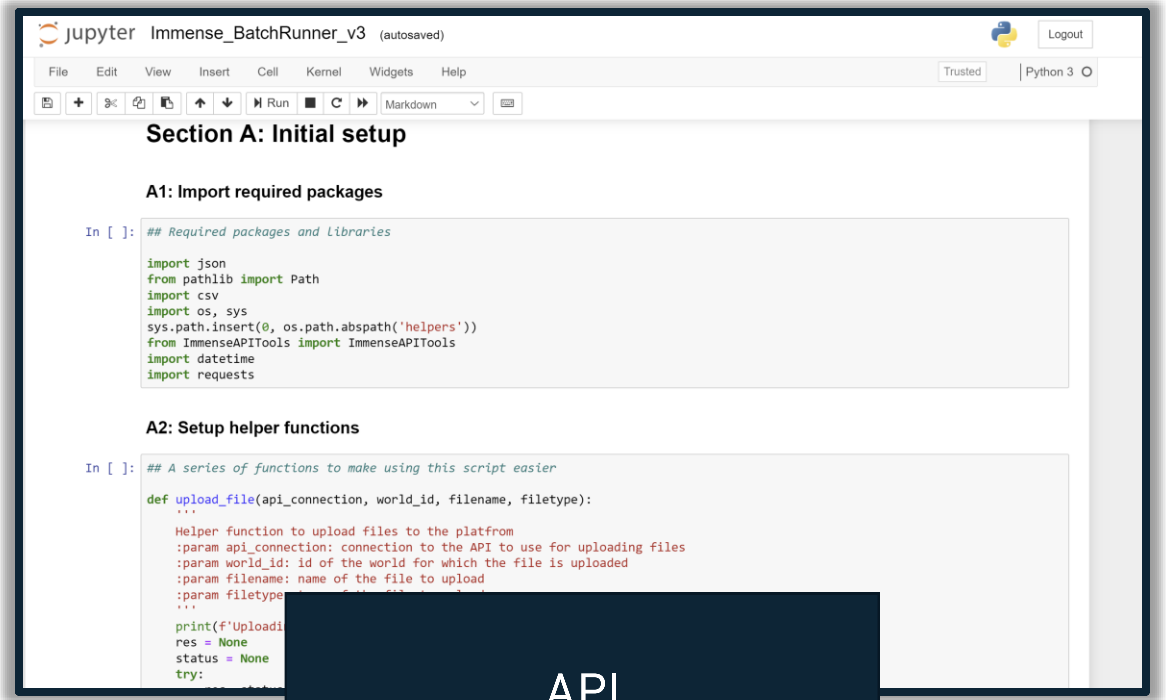


Browser-based GUI



API

Assurance: Calibration and validation criteria (TAG++)

Calibration and validation criteria follow TAG guidelines to enable use across multiple use cases:

- Trip Matrix (screenline flows validation);
- Link Flow and Turning Movement (GEH); *26 cordons/screenlines across 306 sites*
- Journey times; *56 corridors with segment-by-segment comparisons across all time periods*
- Realism tests; *including operational disruption scenarios*

Additional data types enable closer examination of model behaviour and performance.

Criteria	Guideline
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines (i.e. 95%)
Individual flows within 100 veh/h of counts for flows less than 700 veh/h	> 85% of cases
Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	> 85% of cases
Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	> 85% of cases
GEH < 5 for individual flows	> 85% of cases
Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher than 15%)	> 85% of routes

Figure 5-6 Screenlines and cordons in OMM

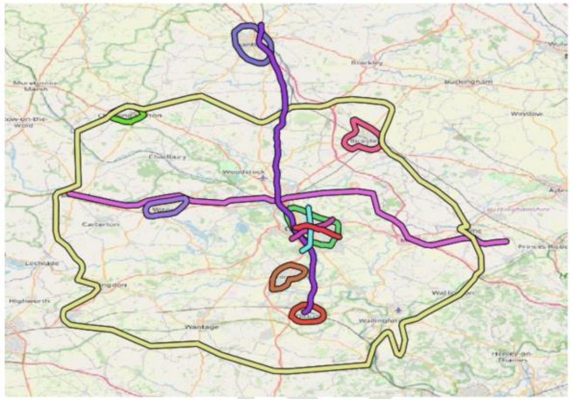
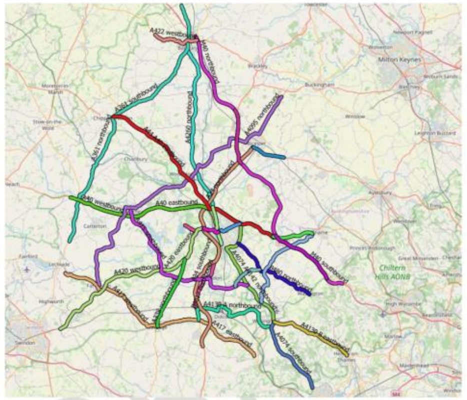


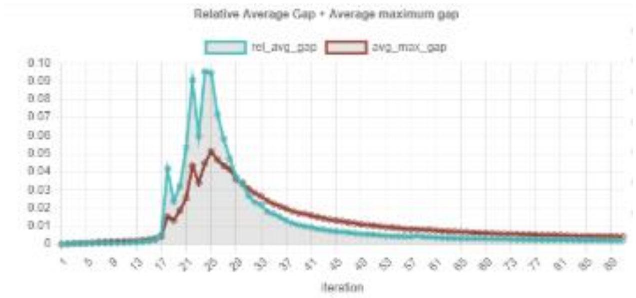
Figure 5-7 Journey Time routes in OMM

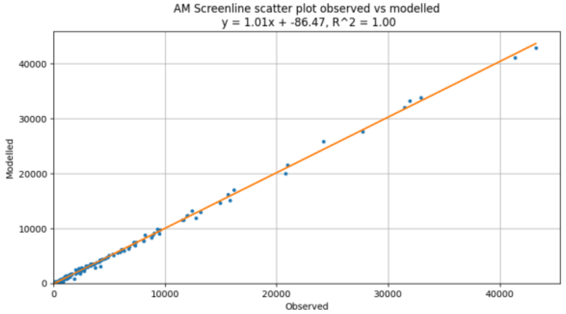


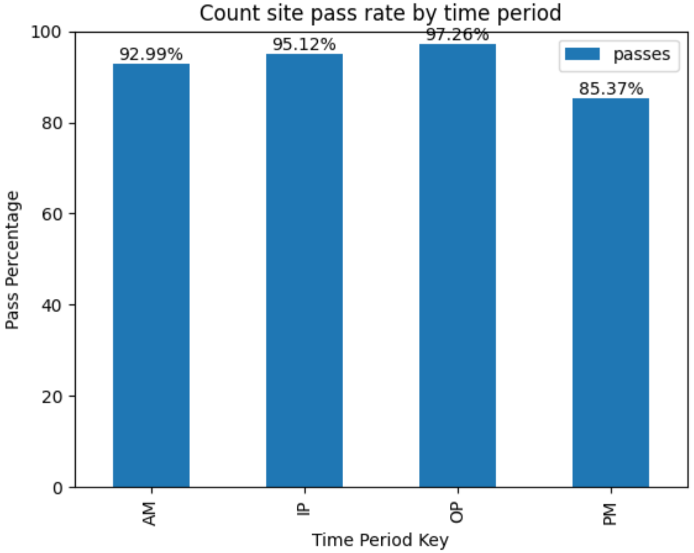
Assurance: Proving the quality of the approach

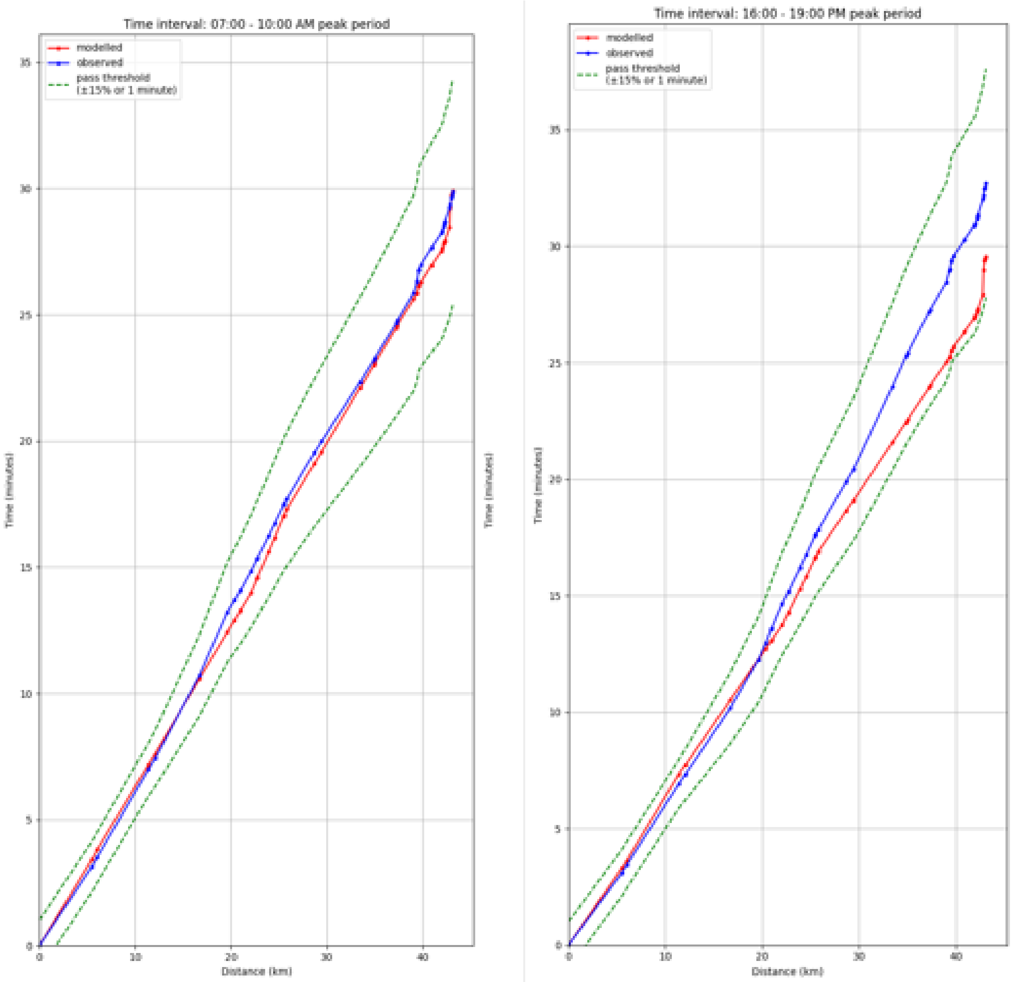
- Baseline models developed in line with Department for Transport Transport Analysis Guidance (TAG) and calibrated against traffic counts and journey times to compare to reference data

- Certified to ISO 27001 for Information Security









Modelled vs observed Journey Times – A34 corridor

Core: What can we do with MIMAS (and OMM) today

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Use-cases include:

- Model the impacts on traffic network of new housing/employment development sites;
- Model the impacts of new road schemes;
- Model the impacts on congestion of modal share changes (e.g., active modes uptake);
- Model PT improvements (e.g., new bus routes);
- Model the impact of new P&R sites, on-street parking spaces;
- Workplaces Parking Levy proposals;
- Zero Emission Zones restrictions;
- Time dependent traffic restrictions;
- Impact on active and non-active modes of highway and public transport schemes.

Concluding thoughts:

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Opportunity to meet multiple stakeholder requirements with reusable digital assets is real;

- Department for Transport infrastructure business case appraisals
- Local Authority Transport and Development Plans
- Development Control impact assessments
- Operational management of the transport network

But challenges remain in streamlining approaches to data and reconciling sources to provide assurance and consistency

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Thank You

Imagine what we could create together.

Dr Robin North, CEO and Co-Founder

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