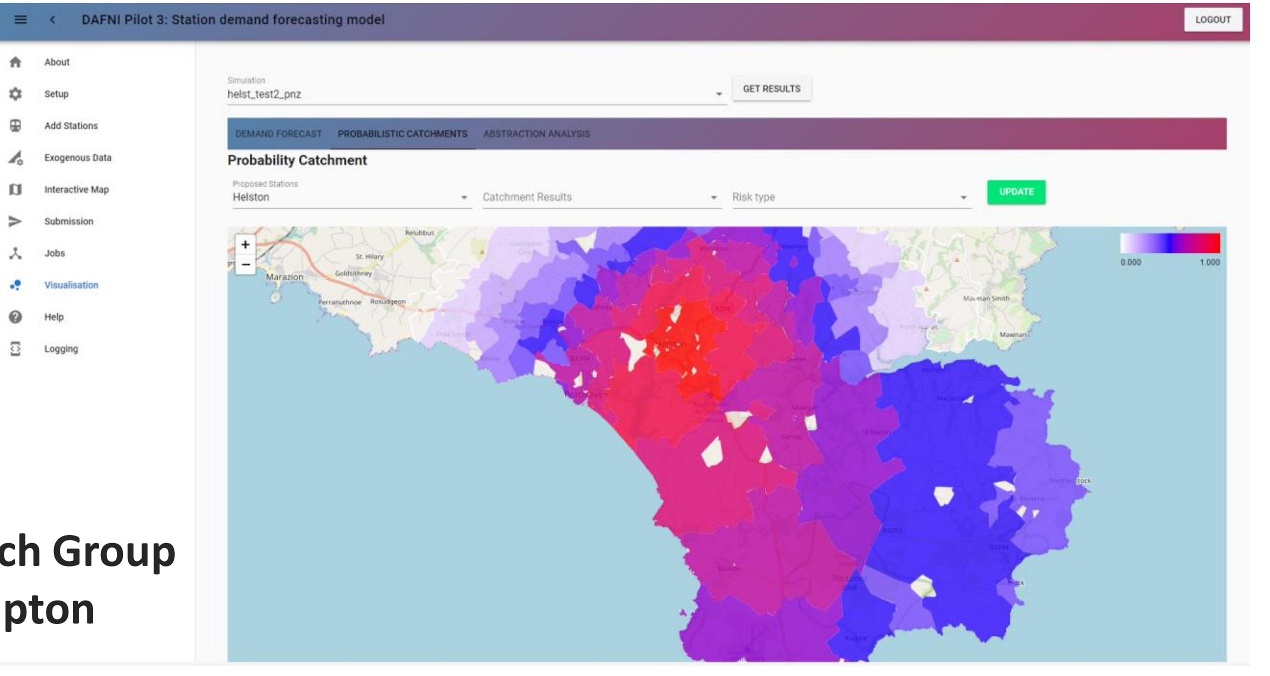
An automated online tool to forecast demand for new railway stations



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10 July 2019

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DAFNI

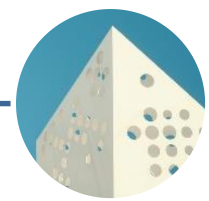
EPSRC Engineering and Physical Sciences Research Council

What does the tool do?

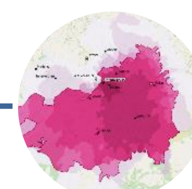
Forecasts demand for new local railway stations

Individual station(s)

New line



Abstraction analysis



Catchment visualisation

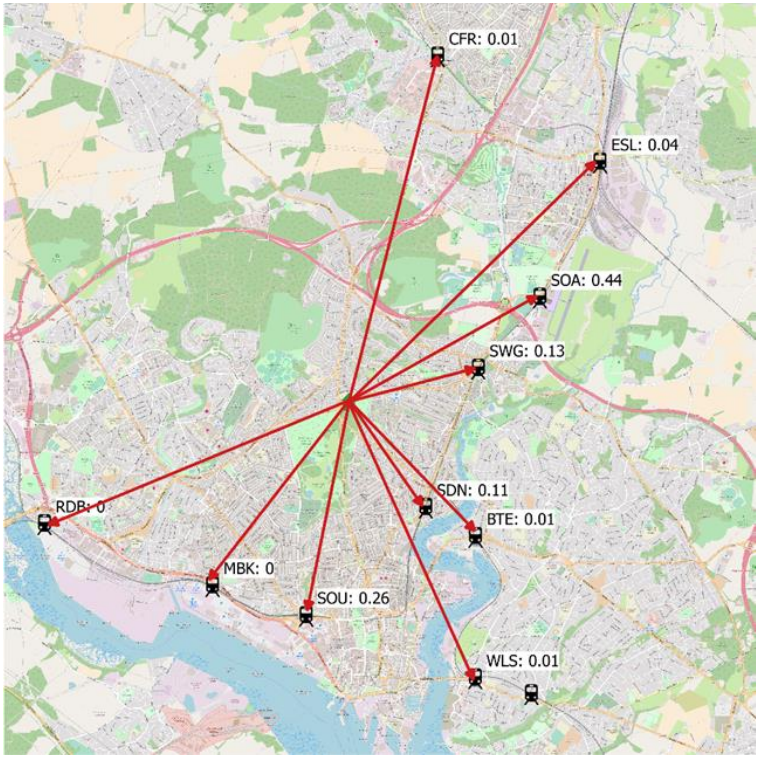
Theoretical basis - a national trip end model incorporating probability-based catchments

$$\ln \hat{V}_i = \alpha + \beta \overbrace{\boxed{\left(\ln \sum_{z}^{Z} Pr_{zi} P_z w_{zi}\right)}}^{\text{catchment}} + \overbrace{\boxed{\gamma \ln F_i + \delta \ln J_{it} + \epsilon \ln Pk_i + \zeta Te_i + \eta El_i + \theta B_i}}^{\text{other predictor variables}}$$

V - annual trips

Pr - probability of station being chosen
P - population
w - decay function
Z - postcodes with station *i* in choice set
z - postcode

F - *service frequency*
J - *jobs (within approx. 0.5 mile)*
Pk - *parking spaces*
B - *travelcard boundary (y/n)*
Te - *terminus station (y/n)*
El - *served by electric trains (y/n)*

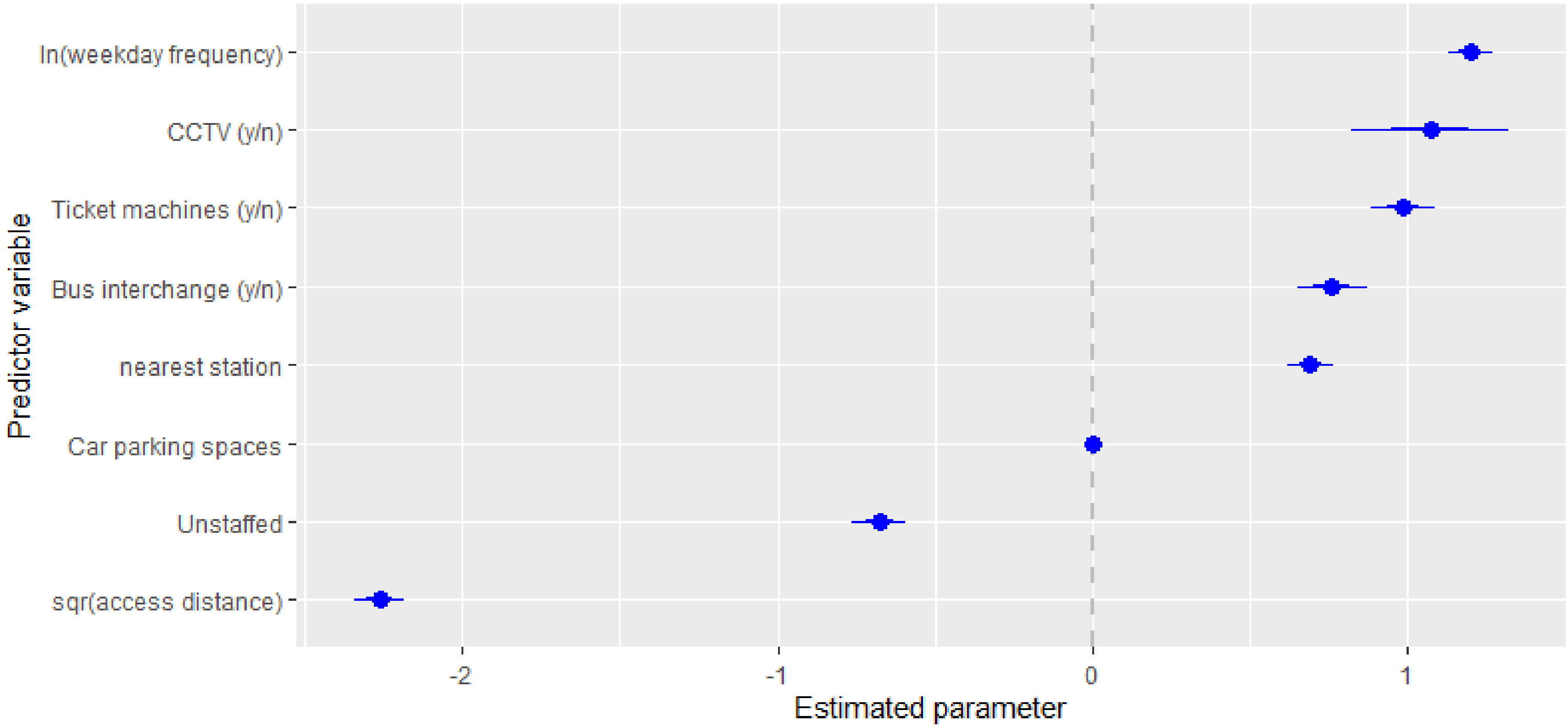


A station choice model calibrated using ~15,000 observations from on-train passenger surveys

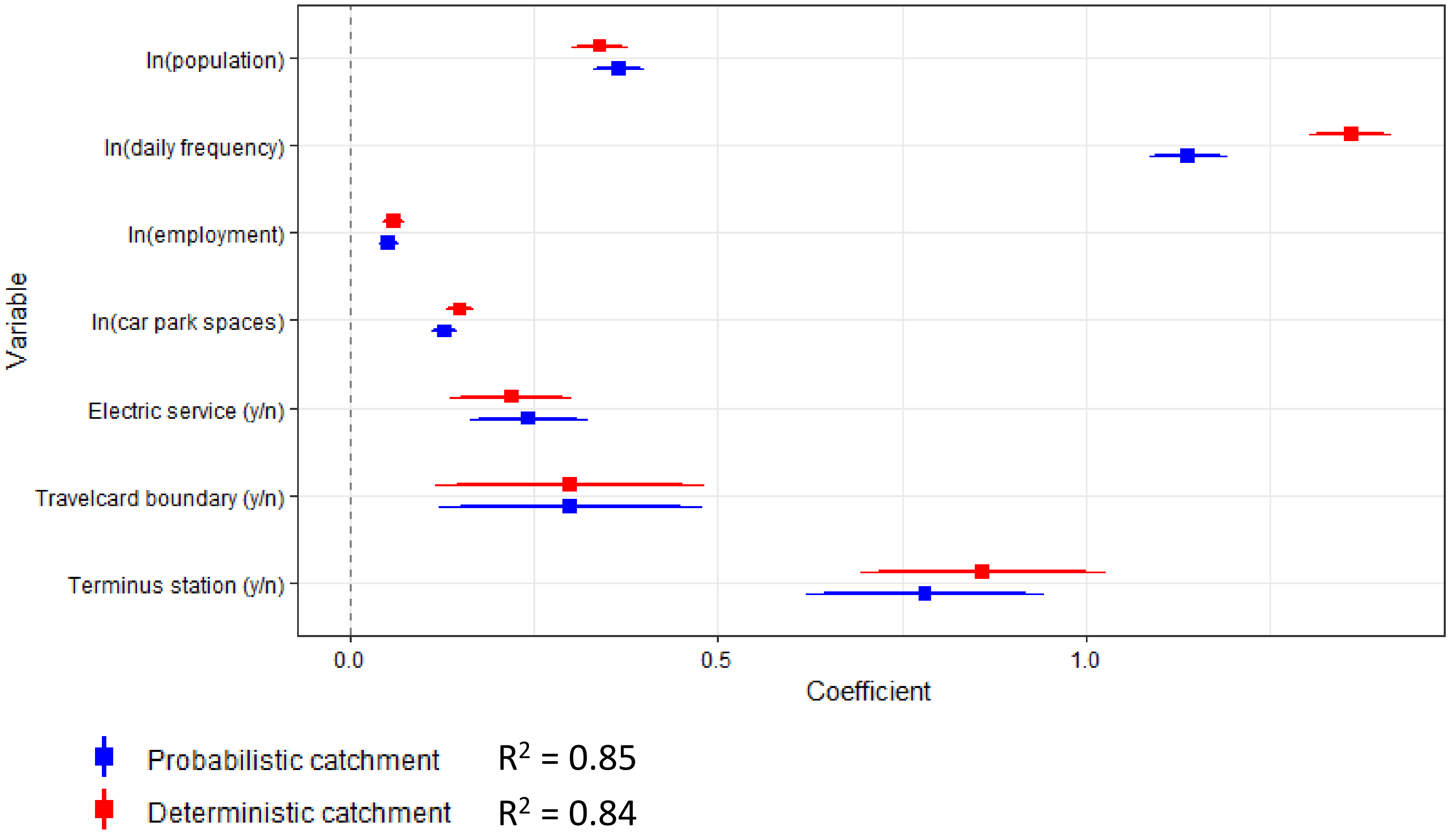
$$Pr_{nik} = \frac{\exp\left(\beta N_k + \gamma\sqrt{D_{ik}} + \delta U_k + \epsilon \ln F_k + \zeta C_k + \eta Ps_k + \theta T_k + \iota B_k\right)}{\sum_{k=1}^{K} \exp\left(\beta N_k + \gamma\sqrt{D_{ik}} + \delta U_k + \epsilon \ln F_k + \zeta C_k + \eta Ps_k + \theta T_k + \iota B_k\right)}$$

K = 10 nearest stations to each postcode

Pseudo R^2 = 0.71



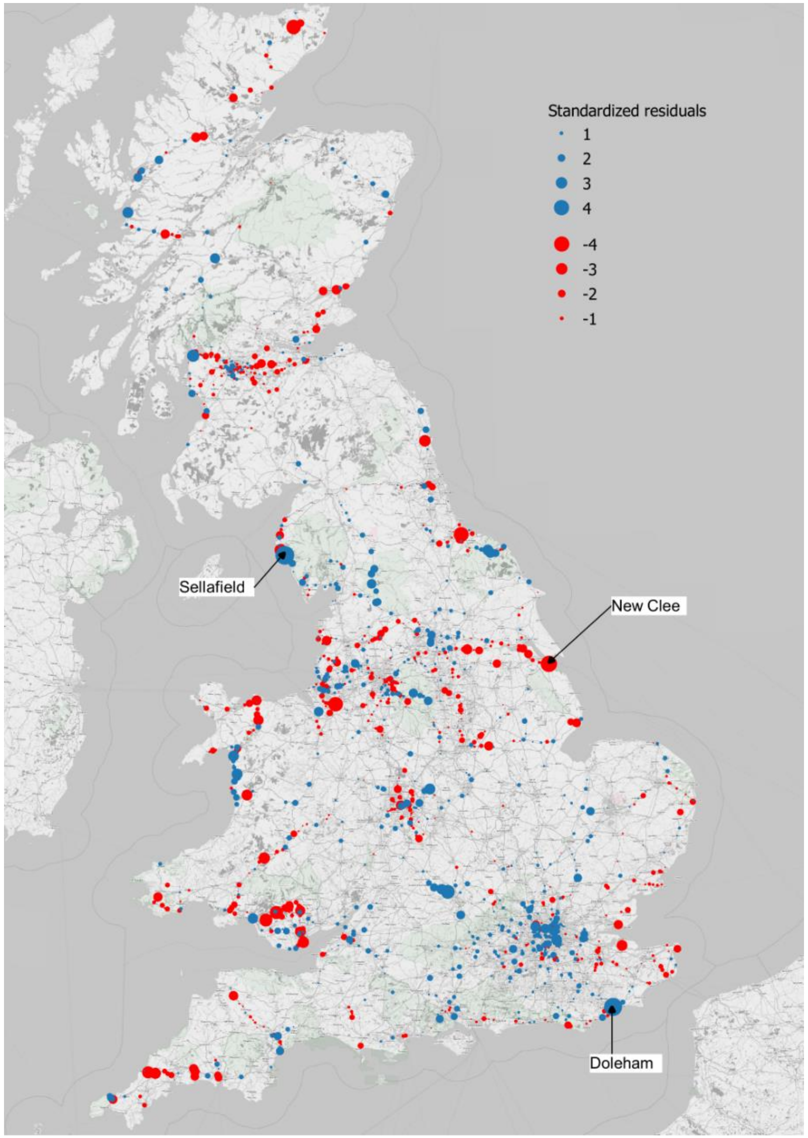
The trip end model was calibrated using Category E and F stations in mainland GB



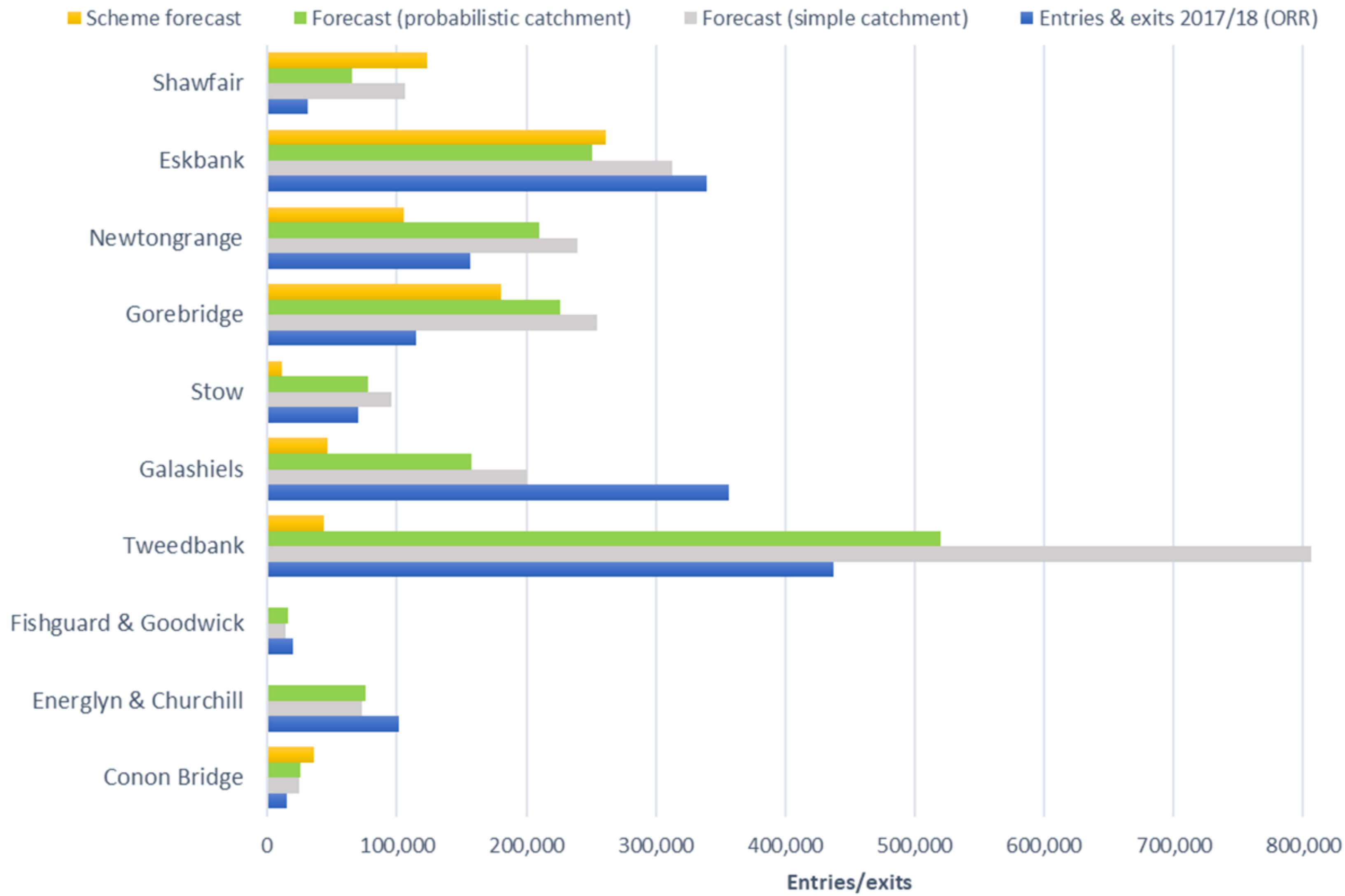
$R^2 = 0.85$

$R^2 = 0.84$

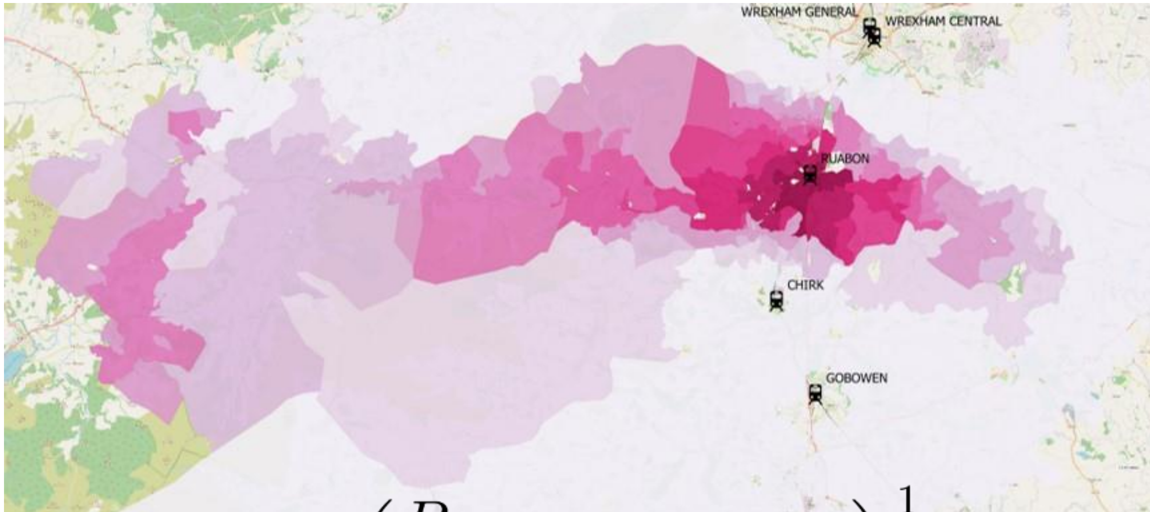
Standardised residuals show that the model performs fairly consistently across the country



The model generally produces better forecasts than the scheme appraisal for 10 recently opened stations

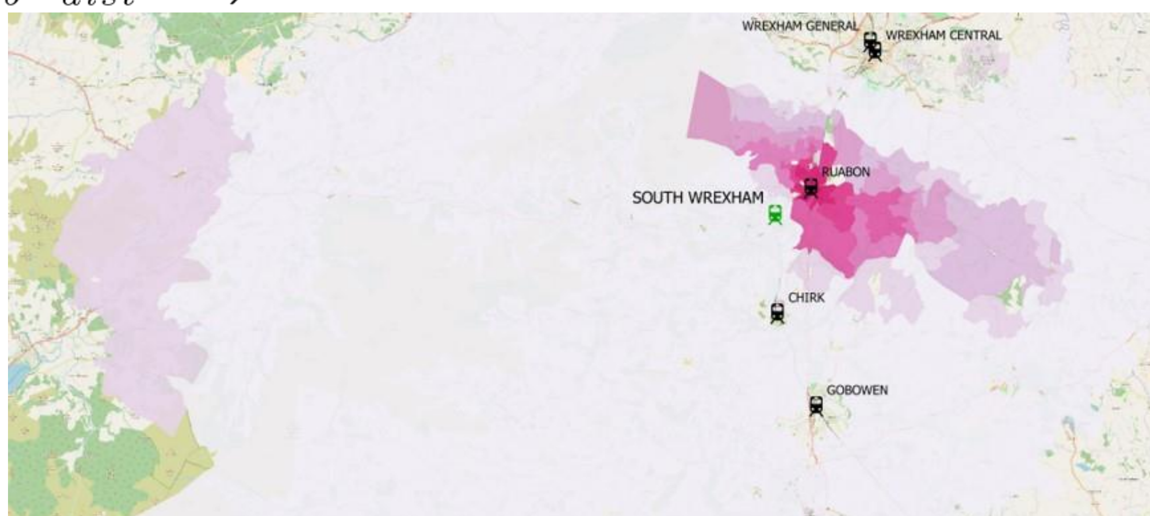


Abstraction analysis is based on expected change in an existing station's probabilistic catchment



Probabilistic catchment for Ruabon station

$$Trips_{old} \times \left(\frac{Pop_{w_{prob} w_{dist} new}}{Pop_{w_{prob} w_{dist} old}} \right)^{1} = Trips_{new}$$



Ruabon catchment after new station

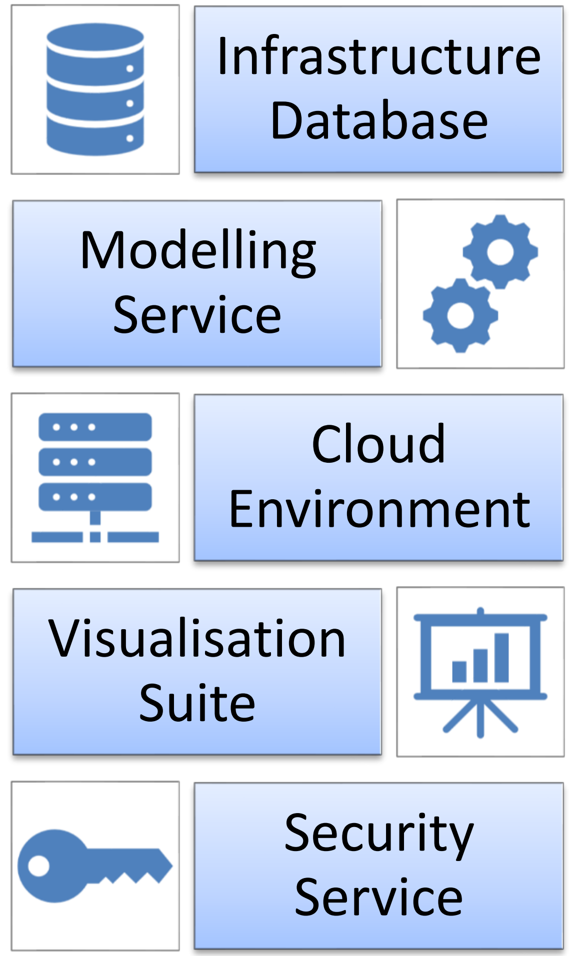
The tool has been implemented on the Data and Analytics Facility for National Infrastructure (DAFNI)

DAFNI

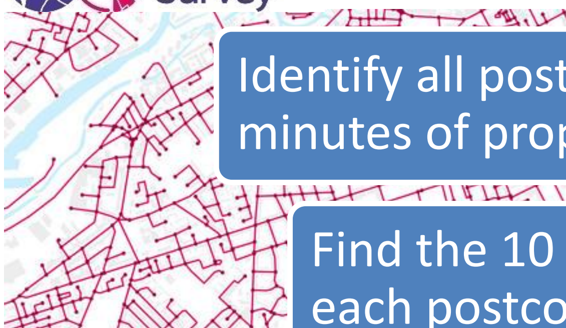
EPSRC
Engineering and Physical Sciences Research Council

Science & Technology Facilities Council

One of four initial pilot projects

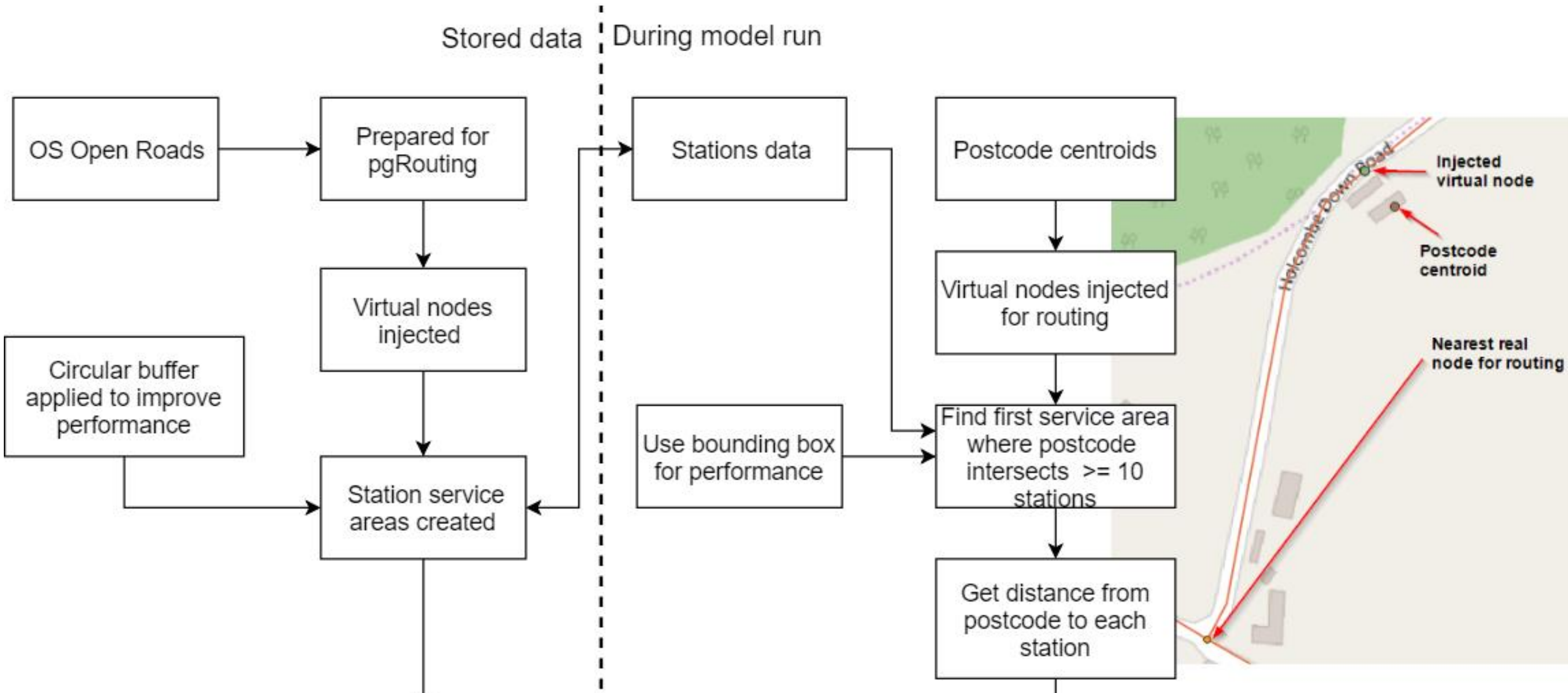


The tool is built using open source tools and data



1. Identify all postcodes within 60 minutes of proposed station
2. Find the 10 nearest stations to each postcode
3. Calculate probabilities using station choice model
4. Run trip end model to generate forecast
5. Run abstraction analysis (if needed)

Generating choice sets is computationally intensive



Service areas for Plymouth station

Message | Result 1

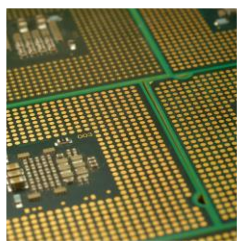
name	crscode	distance
PAIGNTON	PGN	659
TORQUAY	TQY	3846
TORRE	TRR	5172
TOTNES	TOT	9804
NEWTON ABBOT	NTA	12585
TEIGNMOUTH	TGM	16487
DAWLISH	DWL	21040
DAWLISH WARREN	DWW	23988
IVYBRIDGE	IVY	27024
STARCROSS	SCS	27545

Query time: 0.215s | Record 1 of 10

DAFNI provides step-change in run times

Parallel processing employed in R

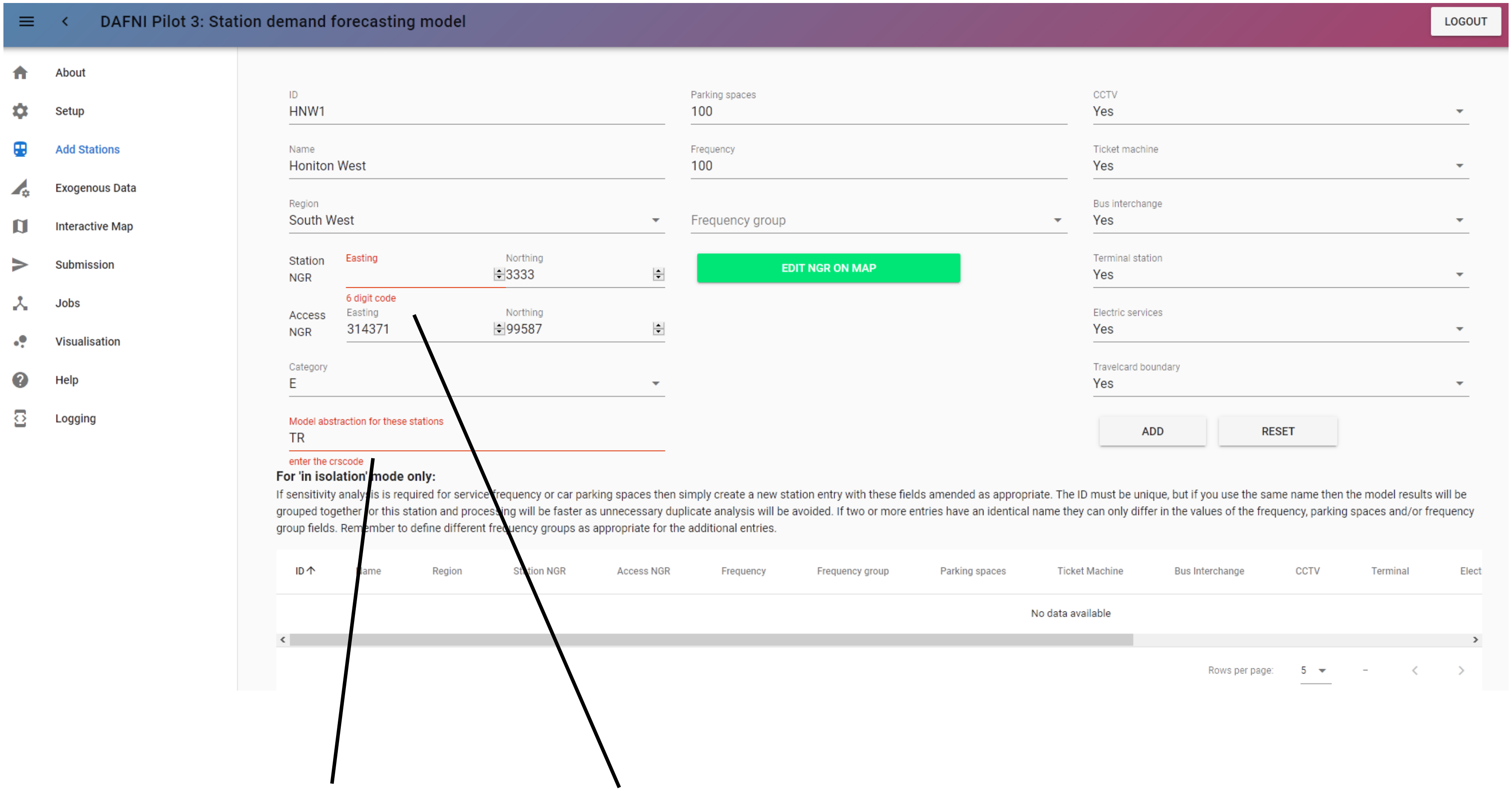
Each job runs in a separate container (virtualised OS)



Up to 30 cores per container

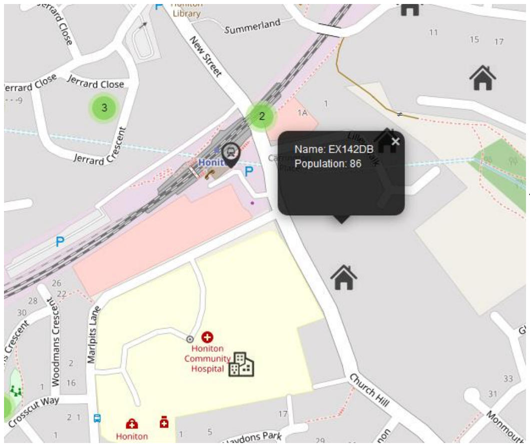
< 5 minutes for a single station forecast

The tool has a user friendly web interface

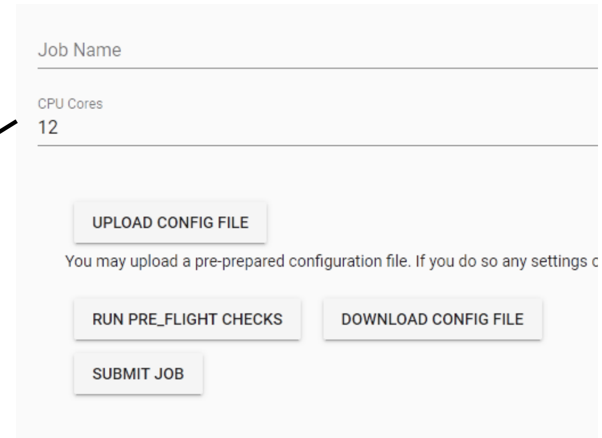


Includes input verification

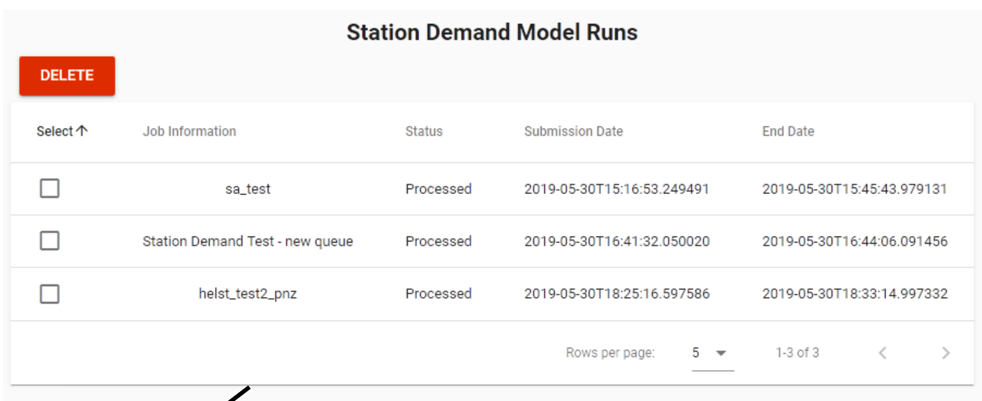
Advanced front-end functionality is provided



Interactive map



Job submission

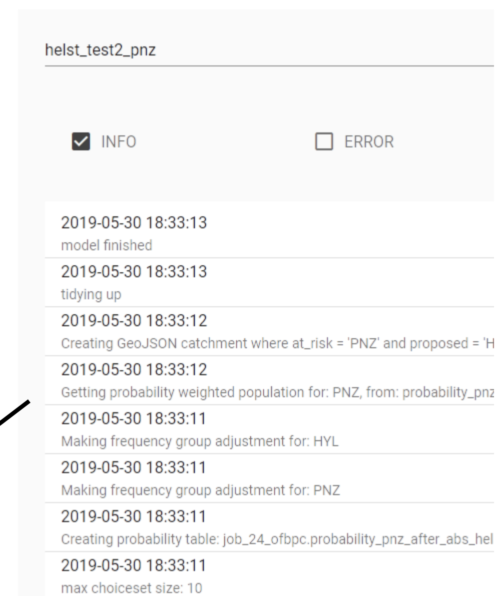

Station Demand Model Runs

DELETE

Select ↑	Job Information	Status	Submission Date	End Date
☐	sa_test	Processed	2019-05-30T15:16:53.249491	2019-05-30T15:45:43.979131
☐	Station Demand Test - new queue	Processed	2019-05-30T16:41:32.050020	2019-05-30T16:44:06.091456
☐	helst_test2_pnz	Processed	2019-05-30T18:25:16.597586	2019-05-30T18:33:14.997332

Rows per page: 5 1-3 of 3

Job management



Logging

Demonstration – configuring and running a job

DAFNI Pilot 3: Station demand forecasting model

LOGOUT

- About
- Setup
- Add Stations
- Exogenous Data
- Interactive Map
- Submission
- Jobs
- Visualisation
- Help
- Logging

About the model

This DAFNI-hosted service generates a demand forecast (predicted trips per year) for one or more proposed local railway stations. If required it can also produce an analysis of potential abstraction of journeys from existing stations, enabling the net impact of a new station on rail use to be estimated. Forecasts for multiple stations can be accommodated as part of the same job. These can be treated independently (alternative station locations are to be assessed) or concurrently (the proposed stations will coexist).

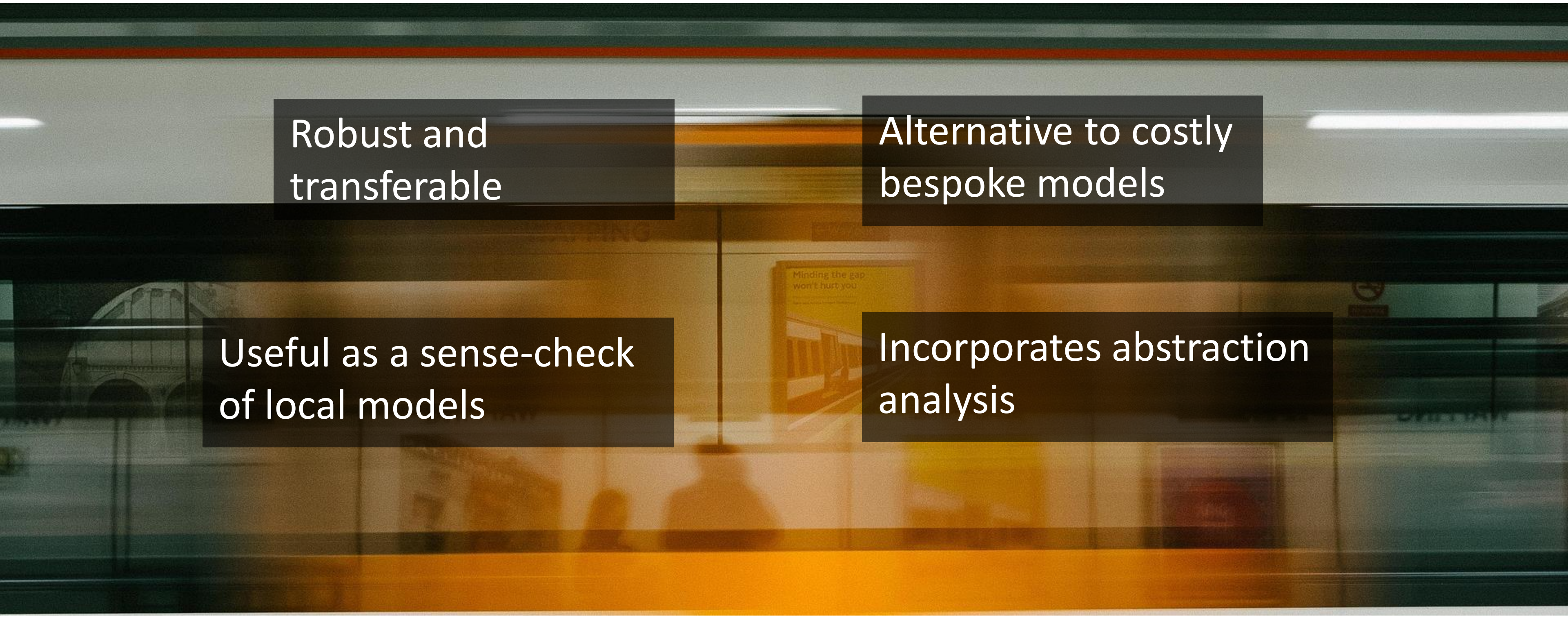
The underlying model is based on research by the University of Southampton's Transportation Research Group. At its core is a trip end model which has been calibrated on the smaller stations in Great Britain. In such a model the number of trips is a function of the population in a station's catchment and a range of other variables, such as service frequency and number of jobs nearby. A novel aspect of this model is that probability-based catchments are defined using a station choice model. Rather than assuming everyone will use their nearest station, this provides a more realistic representation of behaviour and allows competition to occur between stations.

Generating a demand forecast involves a series of data processing and spatial analysis steps with a high computational requirement. As the model has been coded to take advantage of parallelisation, DAFNI provides an ideal environment, enabling it to run across multiple processor cores. This has delivered a step-change in performance, reducing the time to model a single station from around 60 minutes on a high-end workstation to some __ minutes. Time savings will be substantially higher for larger and more complex model scenarios.

The DAFNI development team has provided a professional web interface that enables the user to interact with the model, delivers visualisation of outputs, and handles job management. DAFNI has enabled what could otherwise have become a siloed model to be rapidly made accessible to other researchers and transport practitioners, thus maximising knowledge exchange and research impact.

https://pilots-station-demand-forecasting-ui.platform.dafni.rl.ac.uk

In conclusion, the tool enables rapid review of scheme options for individual stations or new lines.



- Robust and transferable
- Alternative to costly bespoke models
- Useful as a sense-check of local models
- Incorporates abstraction analysis

Any Questions?

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