



TP TransPosition

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TransPosition

A NEW APPROACH TO TRANSPORT MODELLING – THE 4S MODEL

Background

- ⊙ Probably few modellers here, but many make use of models
- ⊙ Worked for 30 years as a modeller, 25 doing four-step models
- ⊙ Frustrated with inadequacies of current approaches
- ⊙ Came to a forefront when reviewing failure of toll road models in Australia
- ⊙ Not convinced by activity based models (ABM)
- ⊙ Developed a new model structure – the 4S model
- ⊙ Not enough time to describe here – see paper
- ⊙ This presentation is to give you a broad view on how it is different, and gives you an encouragement to read the paper

**CONVENTIONAL WISDOM: MODELS TAKE A LOT
OF EFFORT AND COST TO DEVELOP**



Why are models are models hard? Lots to do:

- ⦿ Build network (Choose links, code attributes)
- ⦿ Establish zoning system (boundaries, centroids, centroid connectors)
- ⦿ Collate demographics (bring to common zoning system, may need splits)
- ⦿ Collect data
- ⦿ Determine mode choice structure and time periods
- ⦿ Calibrate sub-models (may need to be done iteratively)
- ⦿ Scripting
- ⦿ Add optional bits – bolt on toll choice, time of day, induced demand etc
- ⦿ Validate model

What if models were much easier to develop?

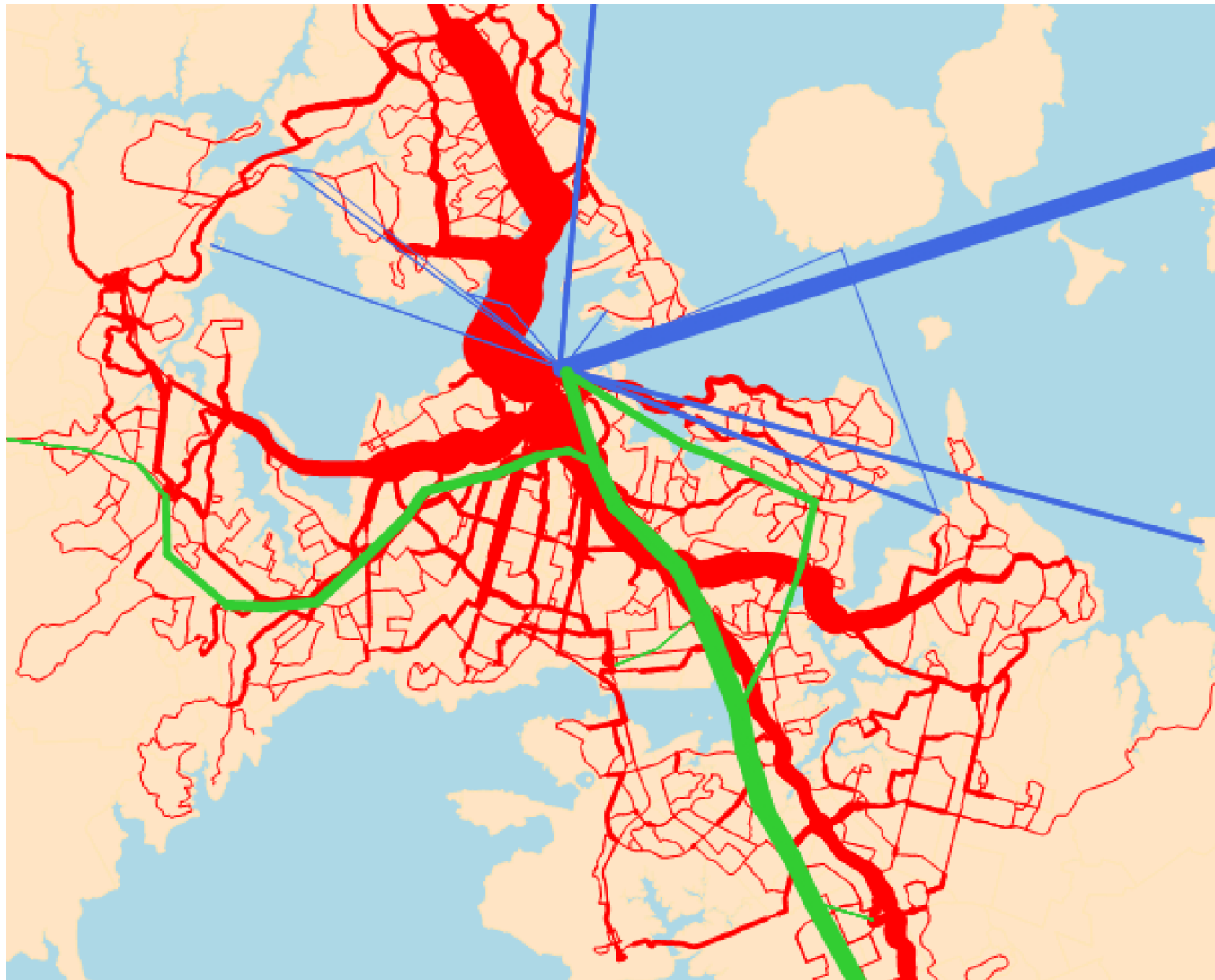
- ◎ What if we did not use zones?
 - ◎ No need for coding centroid connectors
- ◎ What if we included all roads?
 - ◎ No need to spend time choosing which to include
- ◎ What if we could build off common data?
 - ◎ Put things together quickly, update easily
- ◎ What if we could reuse model parameters?
 - ◎ Less need for local data, less effort in development
- ◎ What if the model did not need multiple steps?
 - ◎ Simplify calibration, no need for bolt-ons

- © Usually takes a couple of years for new model (less for refresh)
- © Here's a model that I put together in 2 days (including the time to source the data)...

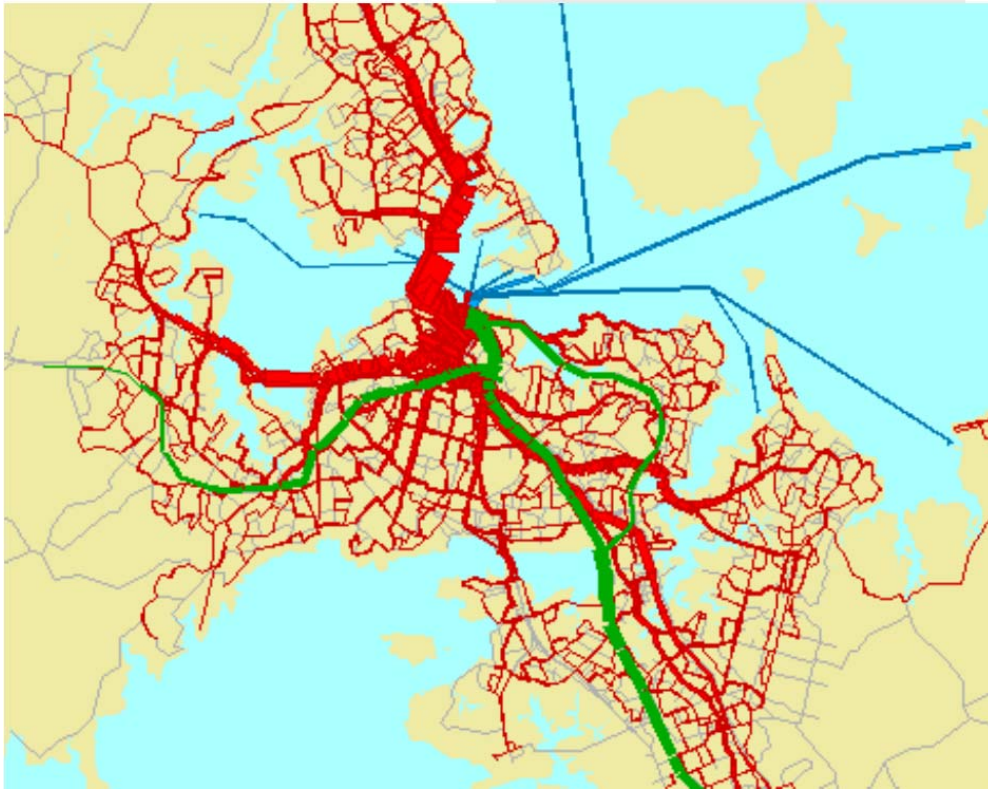
Modelled traffic volumes in Auckland



Public transport results - Auckland

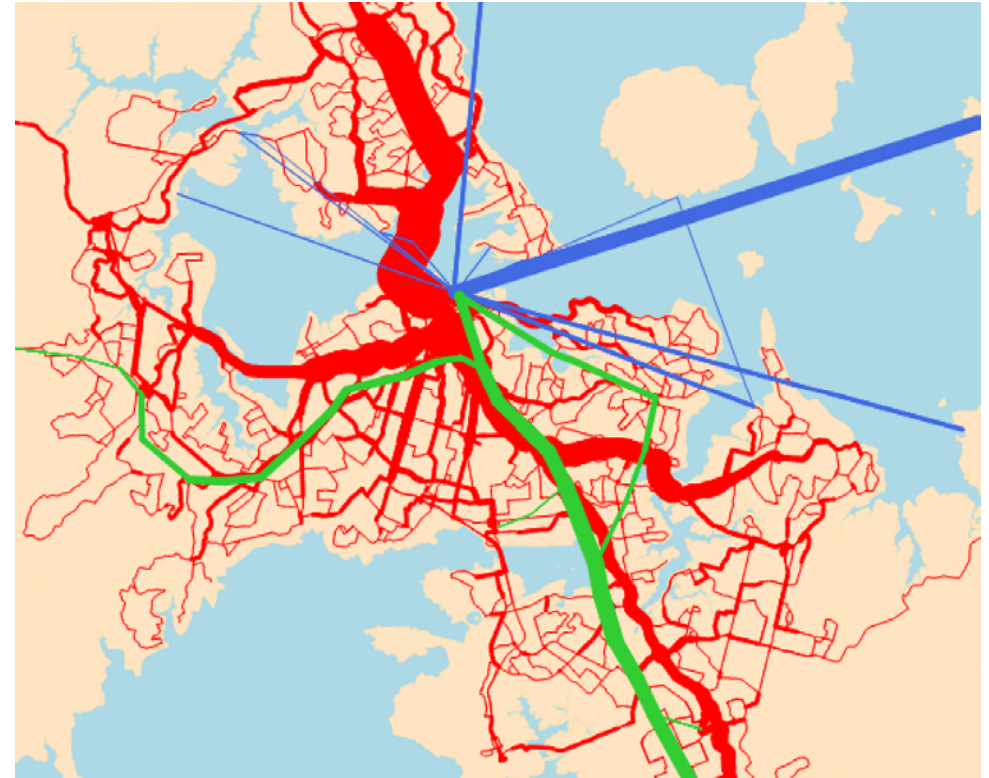


Comparison with Auckland (APT) model



Auckland Passenger Transport Model (2009)

Source: Davies, J et al, The Auckland Transport Models Project
– Overview and Use to Date, ATRF 2009



TransPosition's 4S Model (2017)

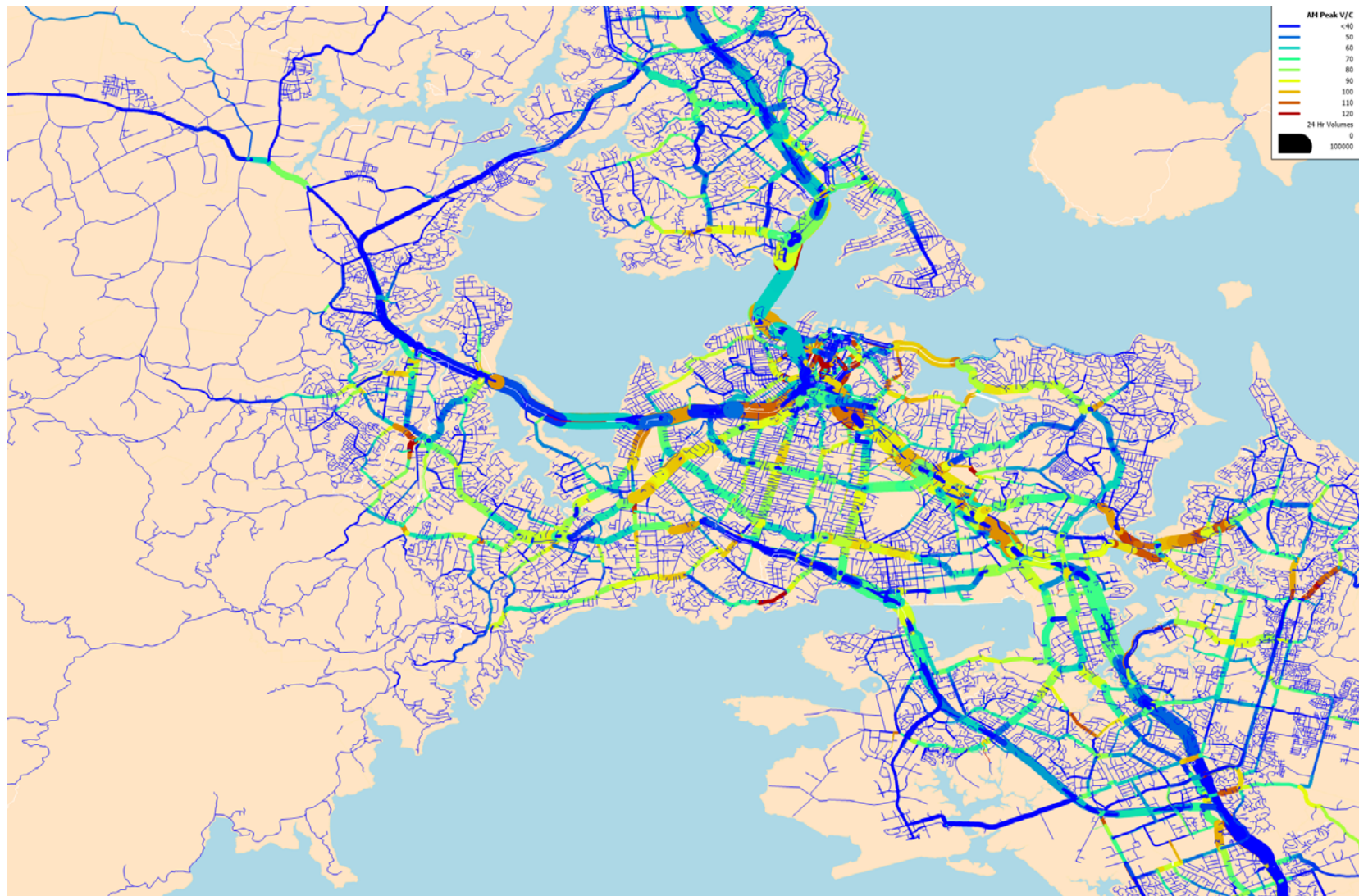
**CONVENTIONAL WISDOM: MUST HAVE A
HIERARCHY OF MODELS – STRATEGIC MODEL
HAS A STRATEGIC ROAD NETWORK**



Spatial Detail in Auckland

- ◎ Auckland Regional Transport Model (ART3)
 - ◎ Strategic road network
 - ◎ 512 zones
 - ◎ More detail in smaller area models (SATURN, Microsim)
- ◎ BUT 4S model for Auckland
 - ◎ Includes every road and intersection
 - ◎ All demographics are distributed to nodes
 - ◎ Population taken from 11,768 mesh blocks
 - ◎ Travel is node to node (38,919 nodes)

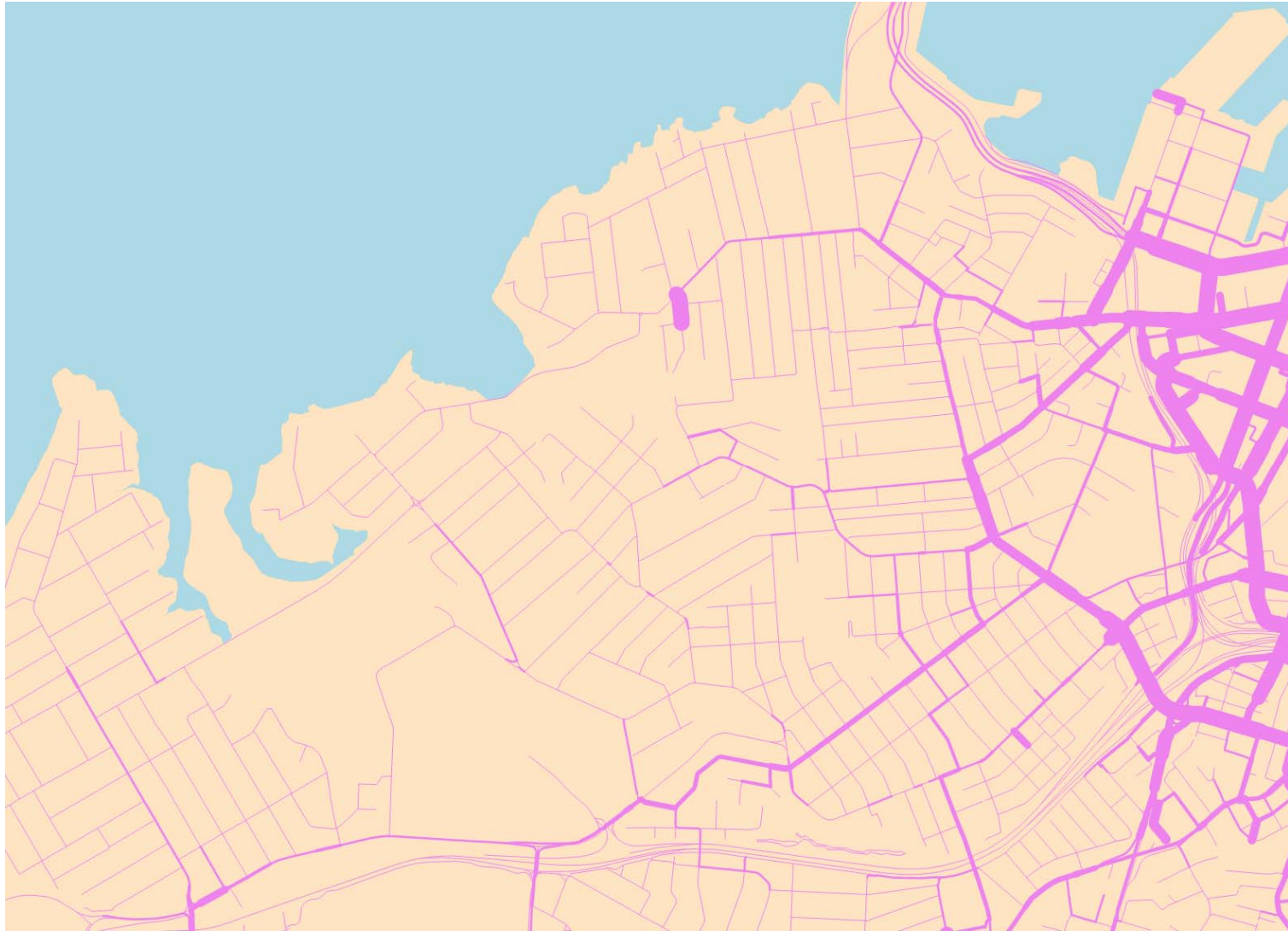
24Hr Traffic volumes and AM peak V/C ratio



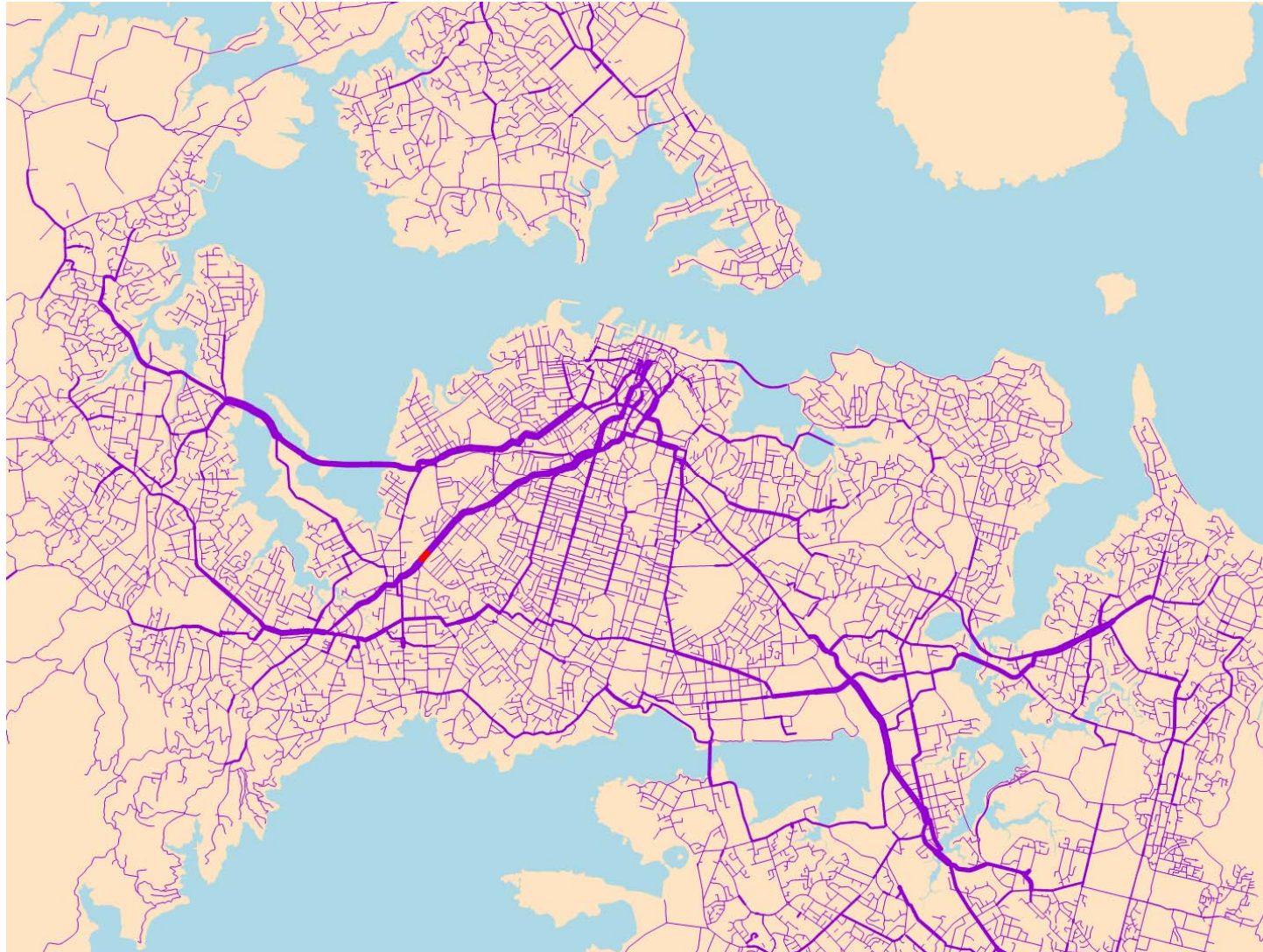
Detail of central Auckland



Walking volumes



Cycling volumes



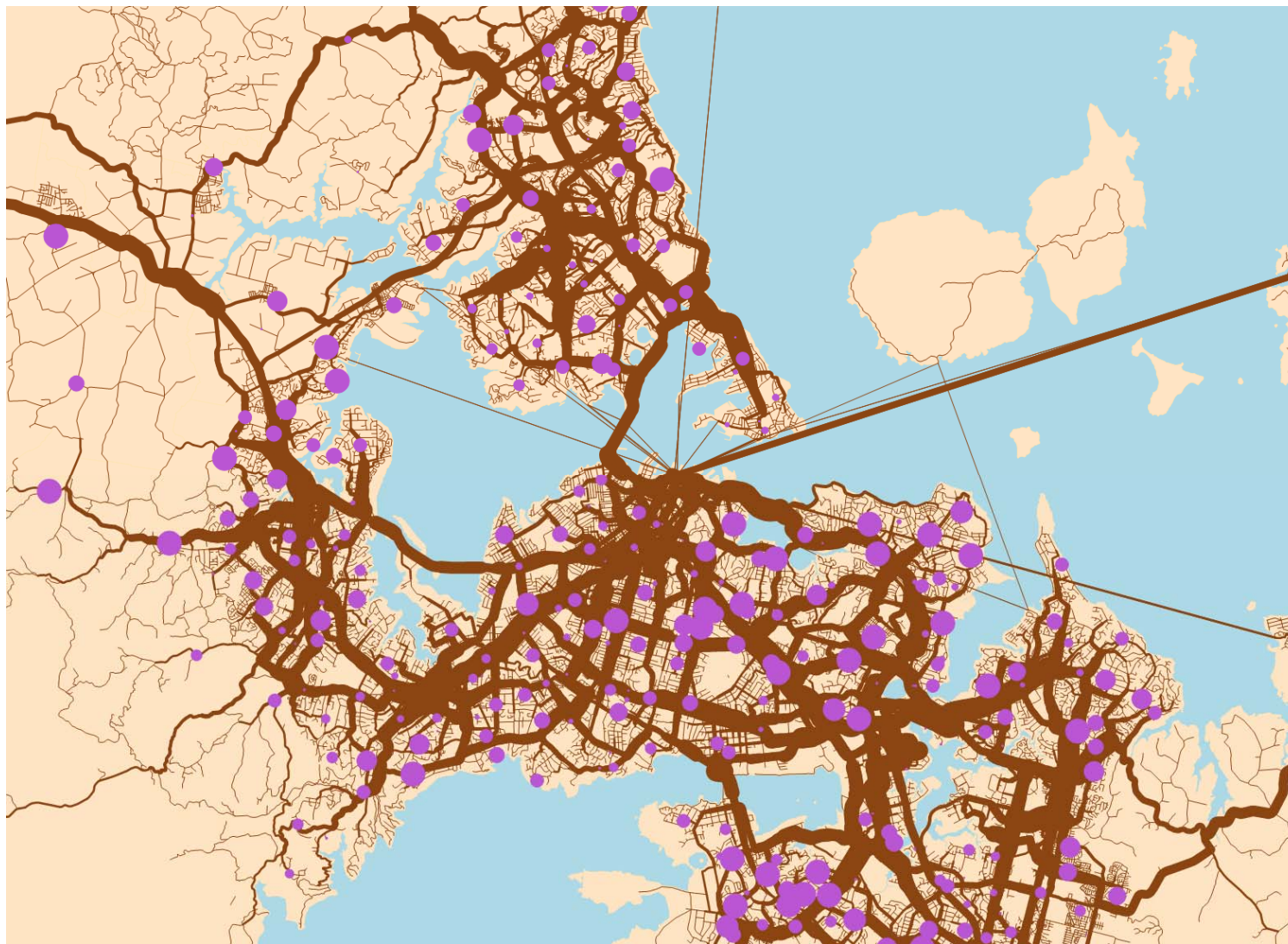
Strategic model with high level of detail

- ◎ Every single road
- ◎ Intersection delays
- ◎ Timetabled public transport
- ◎ Cycle paths, walking paths
- ◎ Can have parking supply (not included in this one)
- ◎ Full time of day (model uses continuous time)

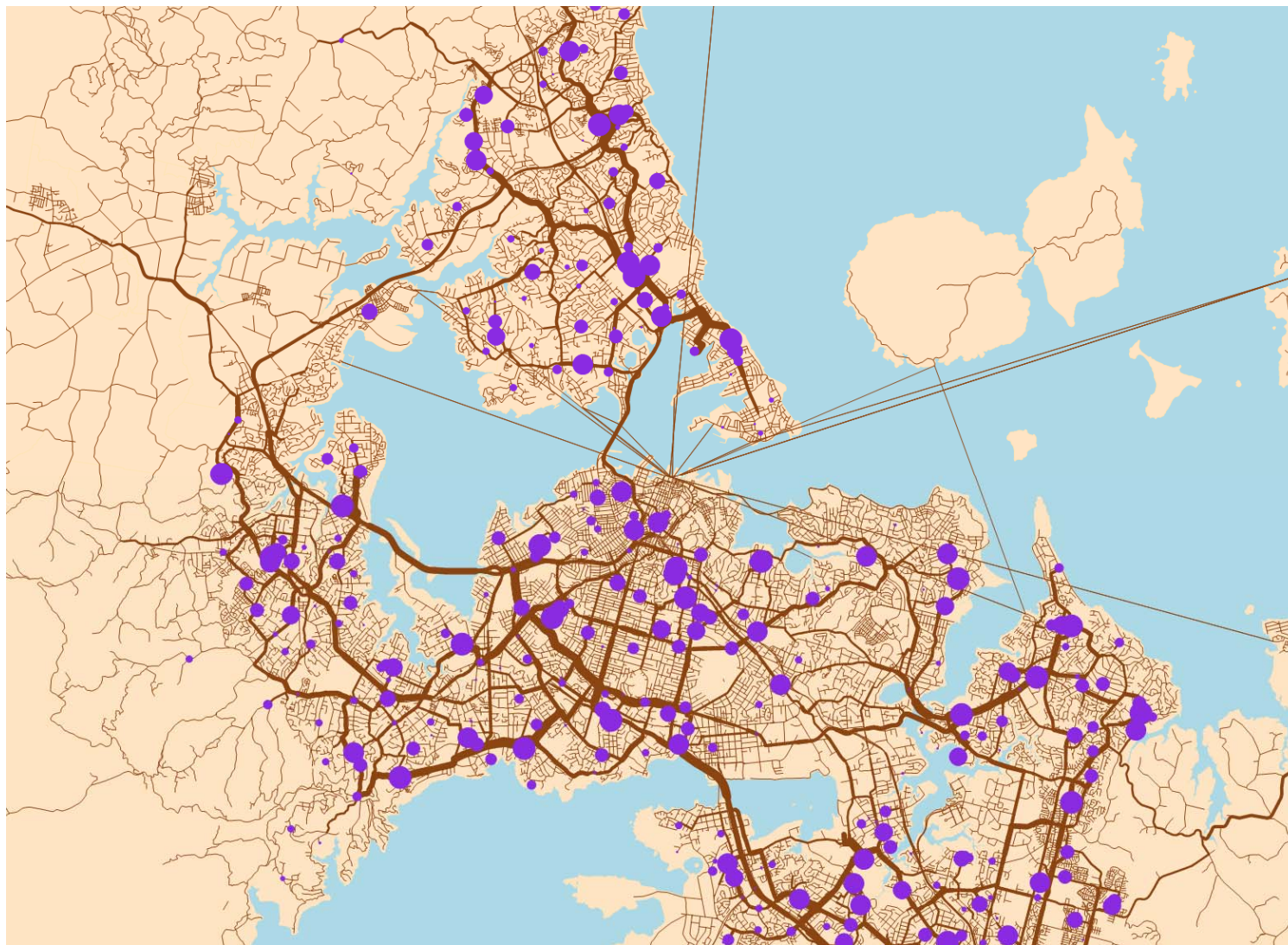
**CONVENTIONAL WISDOM: MODELS ARE A
“BLACK BOX” – DIFFICULT TO UNDERSTAND
WHY THEY GIVE THE RESULTS THEY DO**



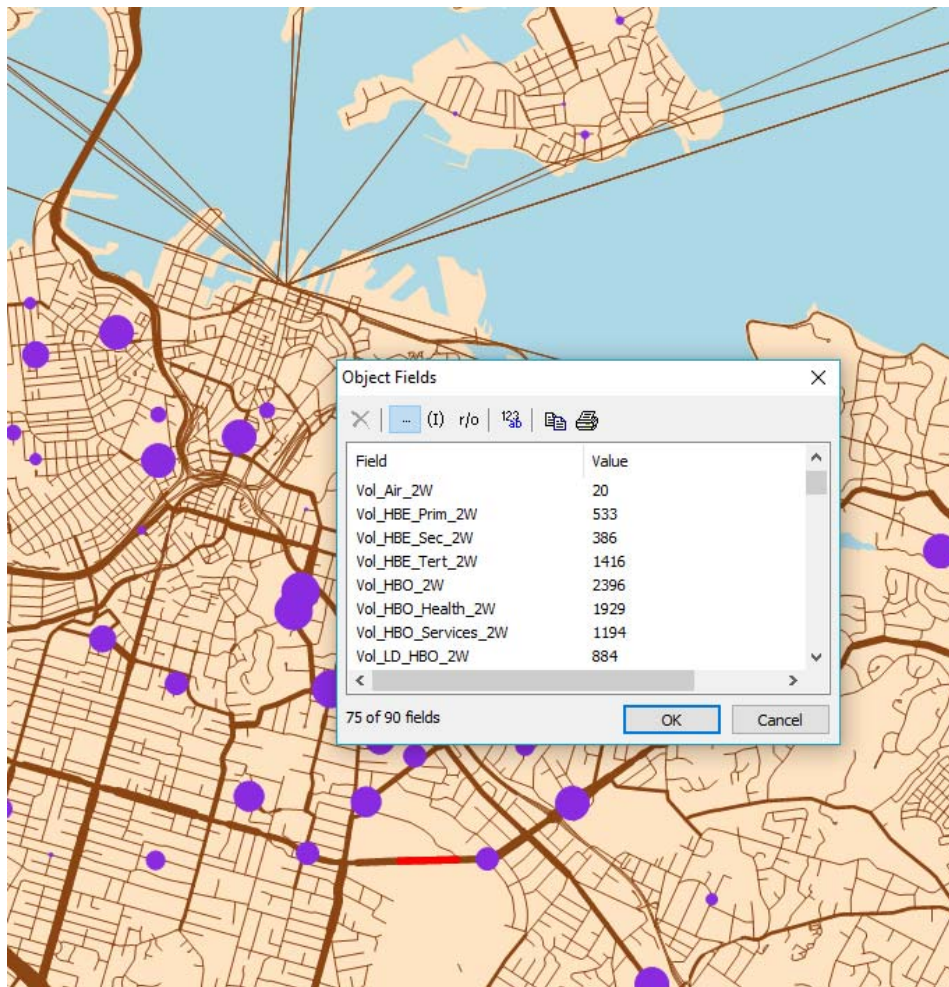
School locations and HBE_Primary demand



Secondary Schools and HBE_Sec



Detailed purpose breakdown in volumes



Personal Travel

- ⊙ Air_Private
- ⊙ Air_Work
- ⊙ HBE_Prim
- ⊙ HBE_Sec
- ⊙ HBE_Tert
- ⊙ HBO
- ⊙ HBO_Health
- ⊙ HBO_Services
- ⊙ HBO_LD
- ⊙ HBR_Commercial
- ⊙ HBR_Social
- ⊙ HBS
- ⊙ HBW_Blue_LD
- ⊙ HBW_White_LD
- ⊙ HBW_Blue
- ⊙ HBW_White
- ⊙ OBO
- ⊙ SBS
- ⊙ WBO
- ⊙ WBO_SP
- ⊙ WBS
- ⊙ WBW

Freight Travel

- ⊙ HV_Agric_Export
- ⊙ HV_Agric_Manufact
- ⊙ HV_Agric_Wholesale
- ⊙ HV_Manufact_Manufact
- ⊙ HV_Manufact_Retail
- ⊙ HV_Manufact_Wholesale
- ⊙ HV_Mining_Manufact
- ⊙ HV_Mining_Wholesale
- ⊙ HV_Transport_Blue
- ⊙ HV_Wholesale_Manufact
- ⊙ HV_Wholesale_Retail
- ⊙ HV_Wholesale_Wholesale
- ⊙ PORT_HV_Export
- ⊙ PORT_HV_Import
- ⊙ PORT_HV_ImportDistribution
- ⊙ MV_B2B
- ⊙ MV_B2H
- ⊙ MV_Manufact_Manufact
- ⊙ MV_Manufact_Retail
- ⊙ MV_Manufact_Wholesale
- ⊙ MV_Transport_Blue
- ⊙ MV_Wholesale_Manufact
- ⊙ MV_Wholesale_Retail
- ⊙ MV_Wholesale_Wholesale
- ⊙ PORT_MV_ImportDistribution

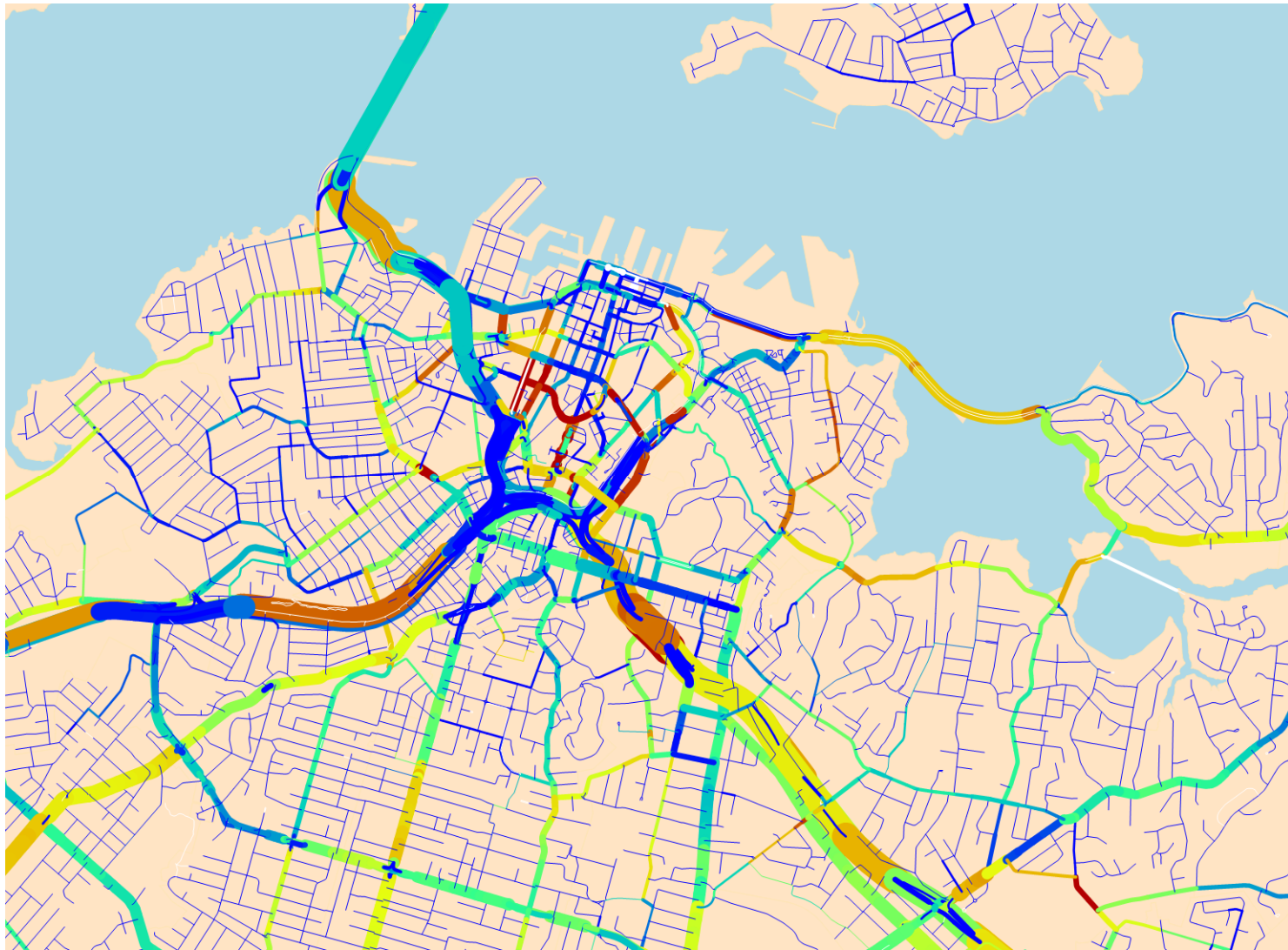
- ◎ No sequential steps
- ◎ No hierarchical logit models
- ◎ No need for destination choice model, or toll choice model, or time of day model etc.
- ◎ All travel is described by a single utility function
- ◎ **Net utility of travel = utility of destination – cost of travel**

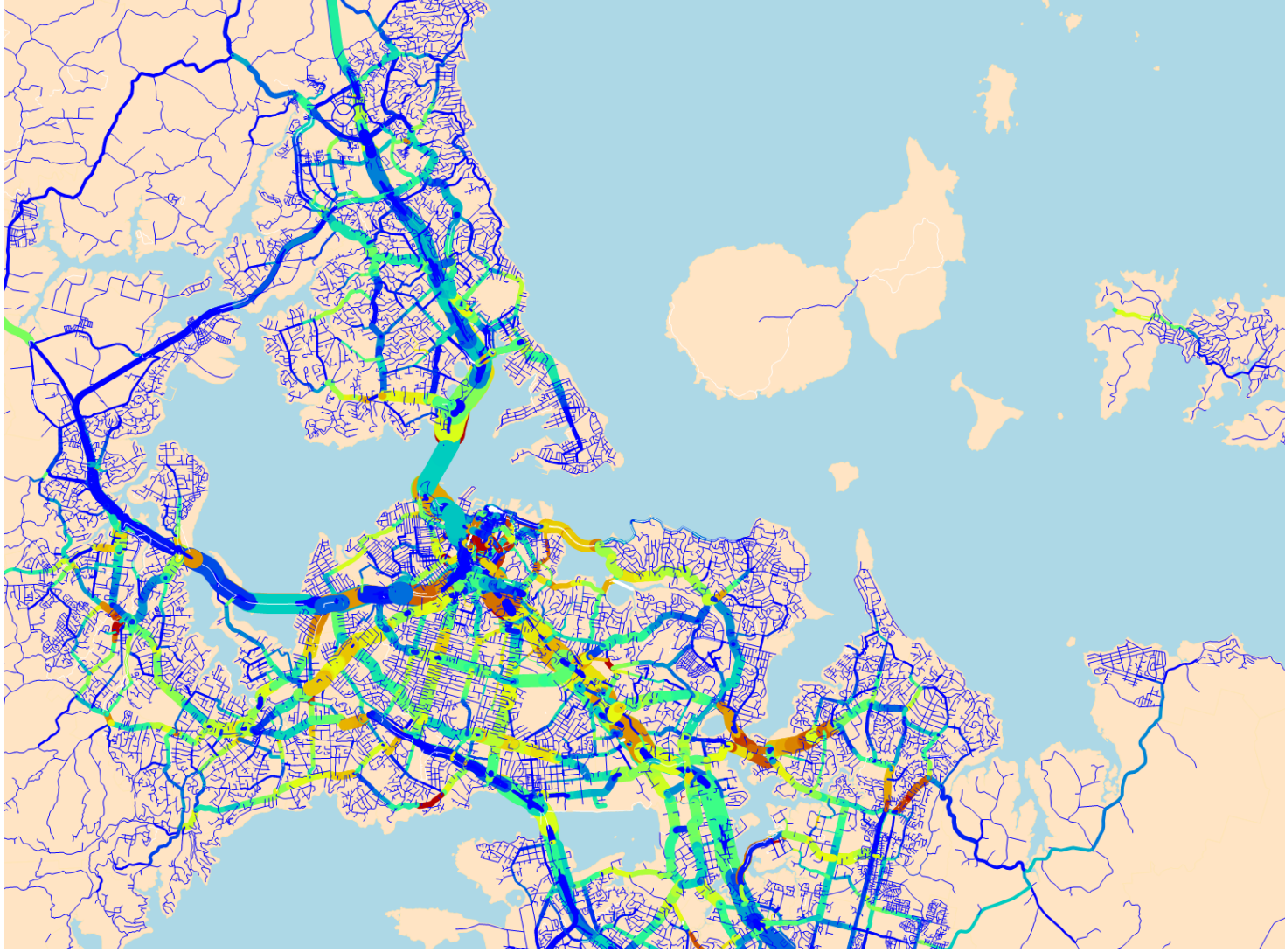
- ◎ Model uses Monte Carlo sampling to efficiently find the optimal choice for different markets of travellers throughout the day
 - ◎ Whether to travel
 - ◎ Destination
 - ◎ Mode
 - ◎ Route
- ◎ All work done by separate choice models (destination choice, mode choice, toll choice etc) is done by random variable in utility function

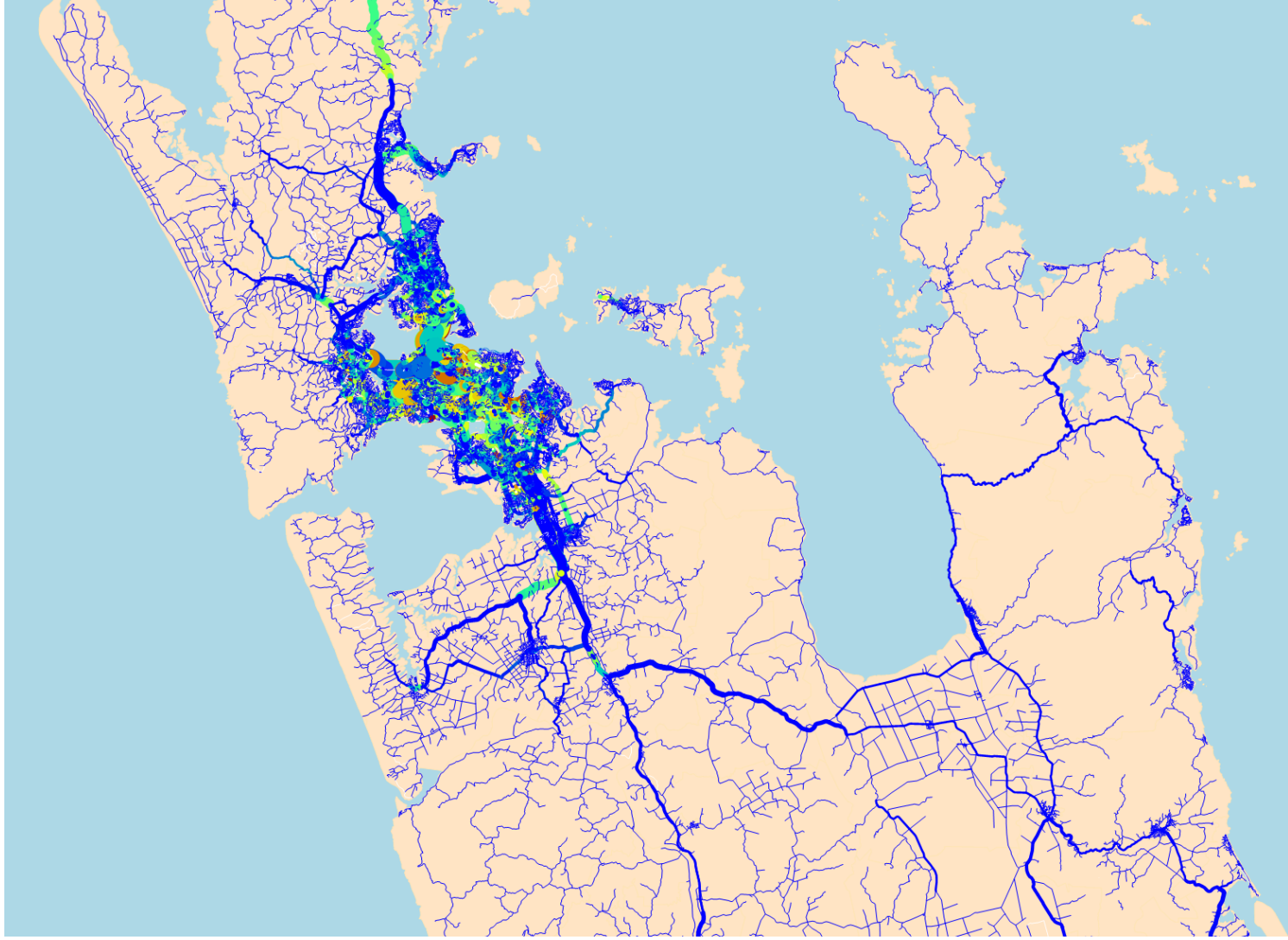
**CONVENTIONAL WISDOM: TRADE OFF
BETWEEN DETAIL AND SCOPE – LARGE MODELS
ARE COARSE AND SLOW**

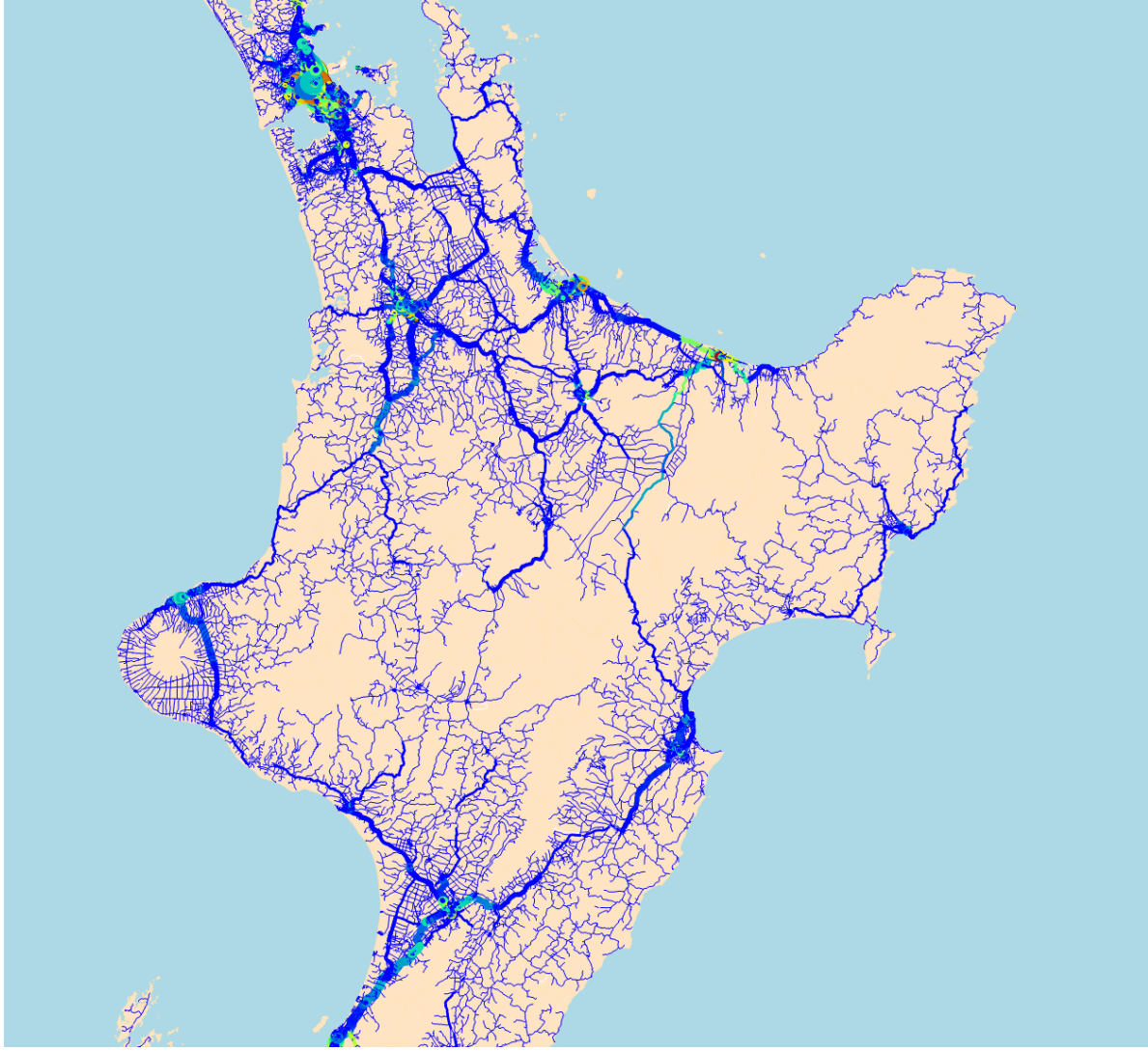


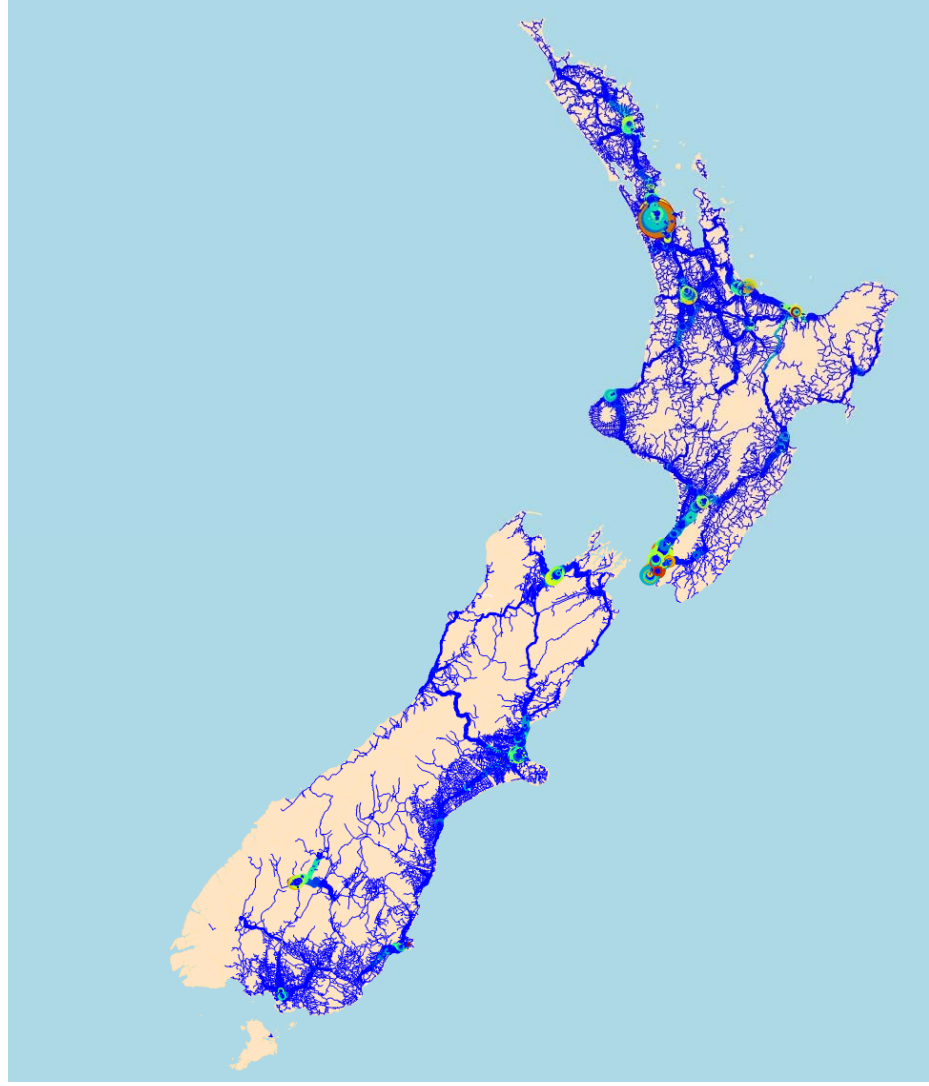
Not just a model of Auckland



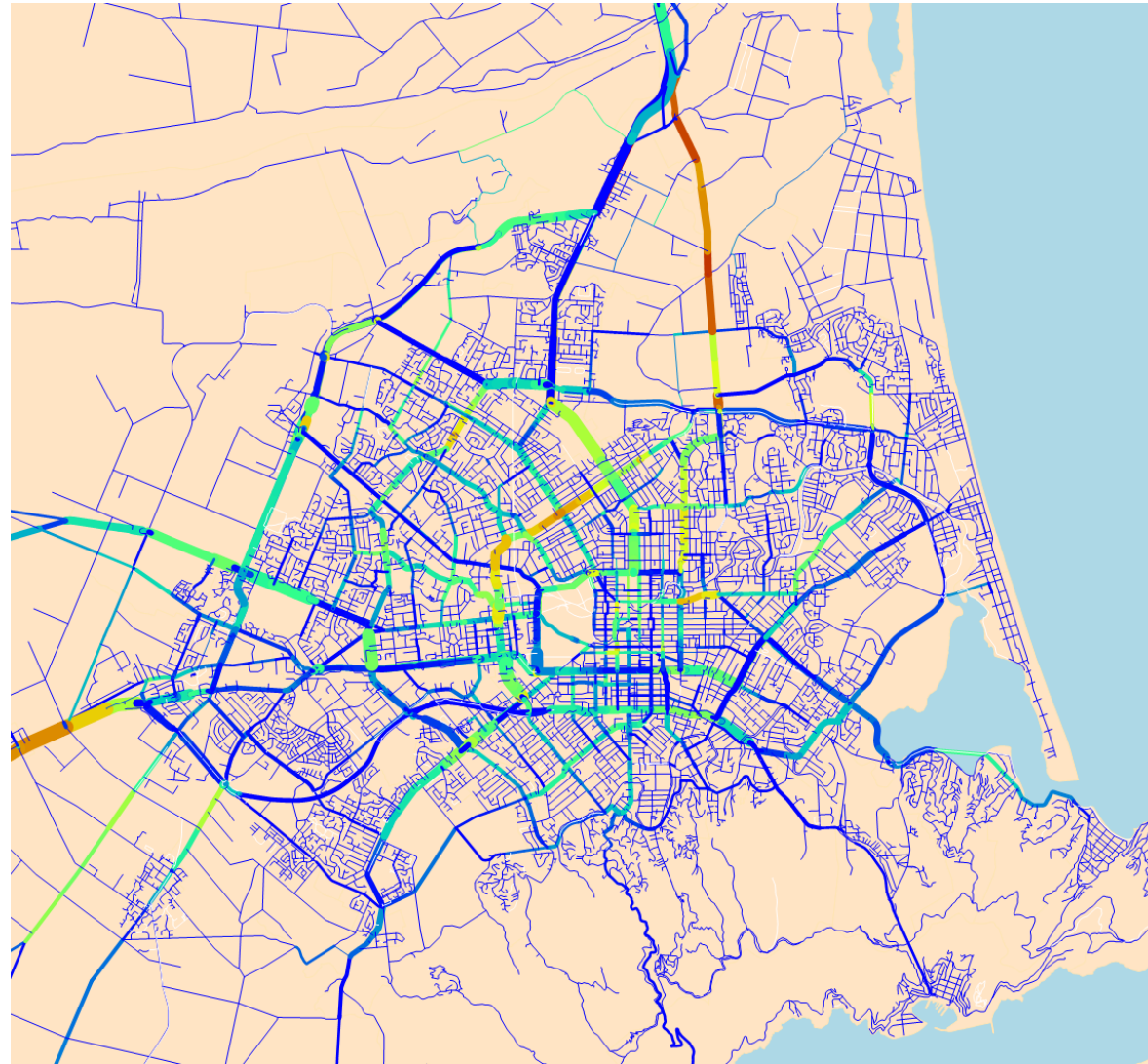




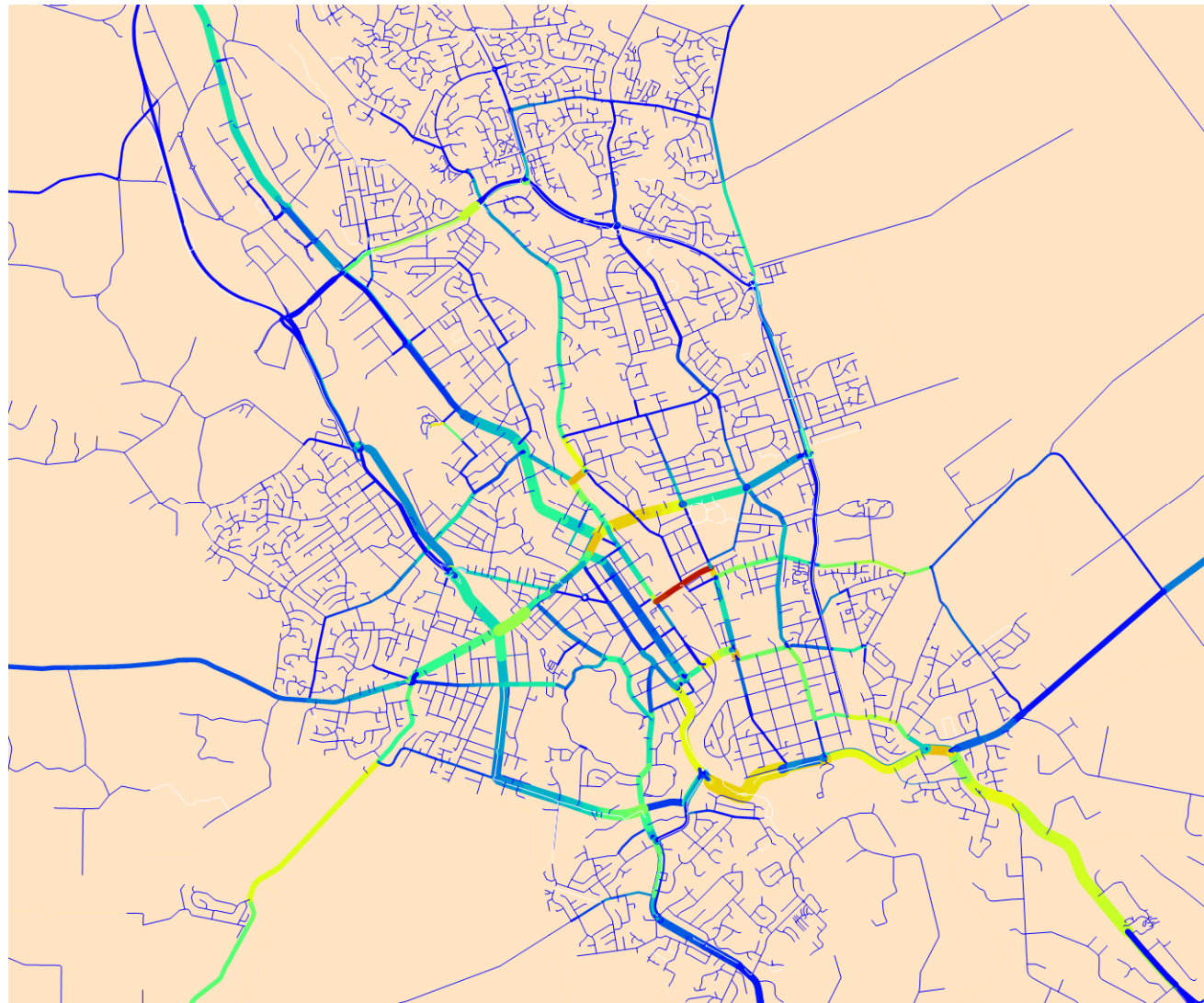




Everything we
saw for Auckland
we also have for
Christchurch

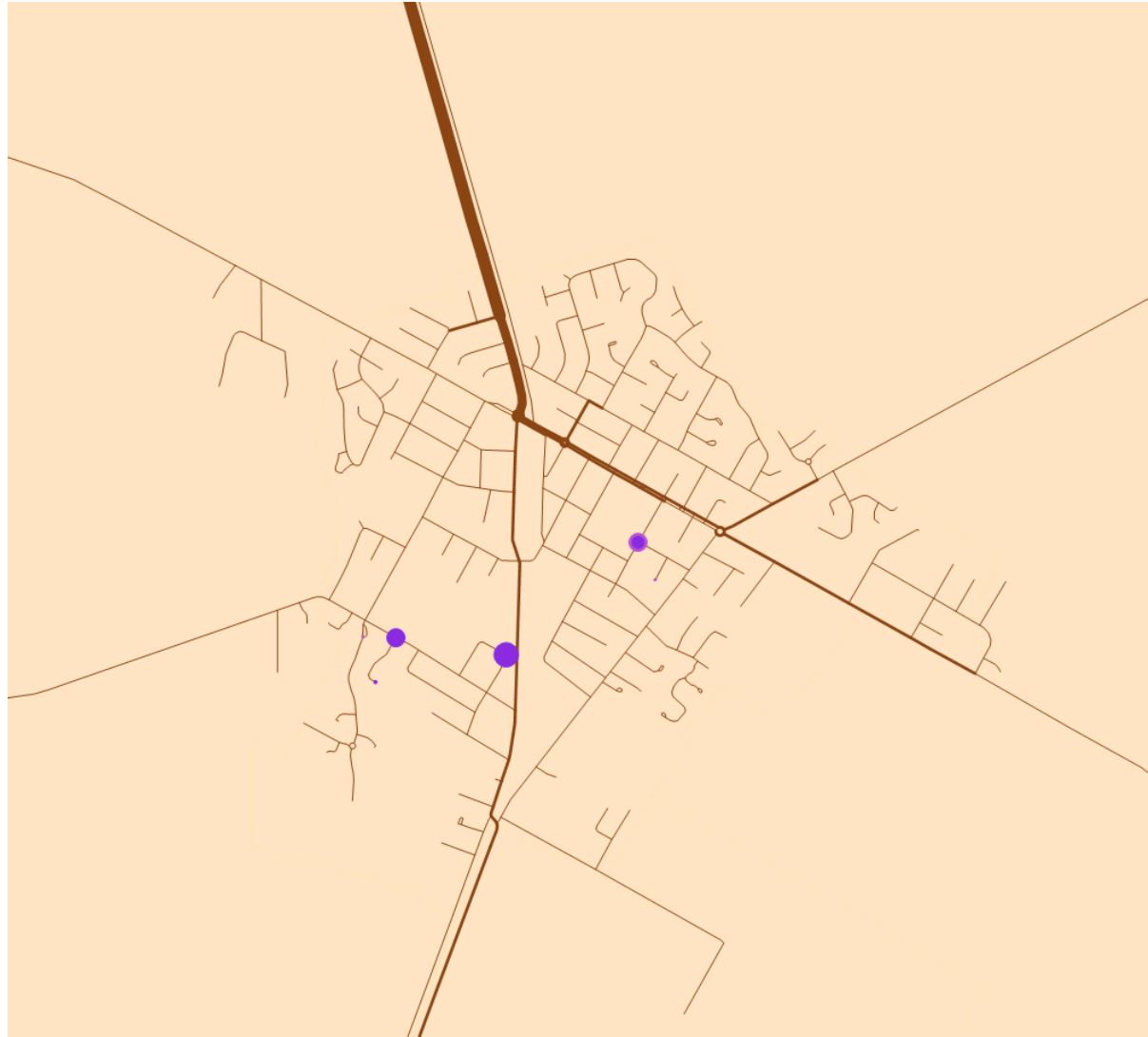


.. Or Hamilton

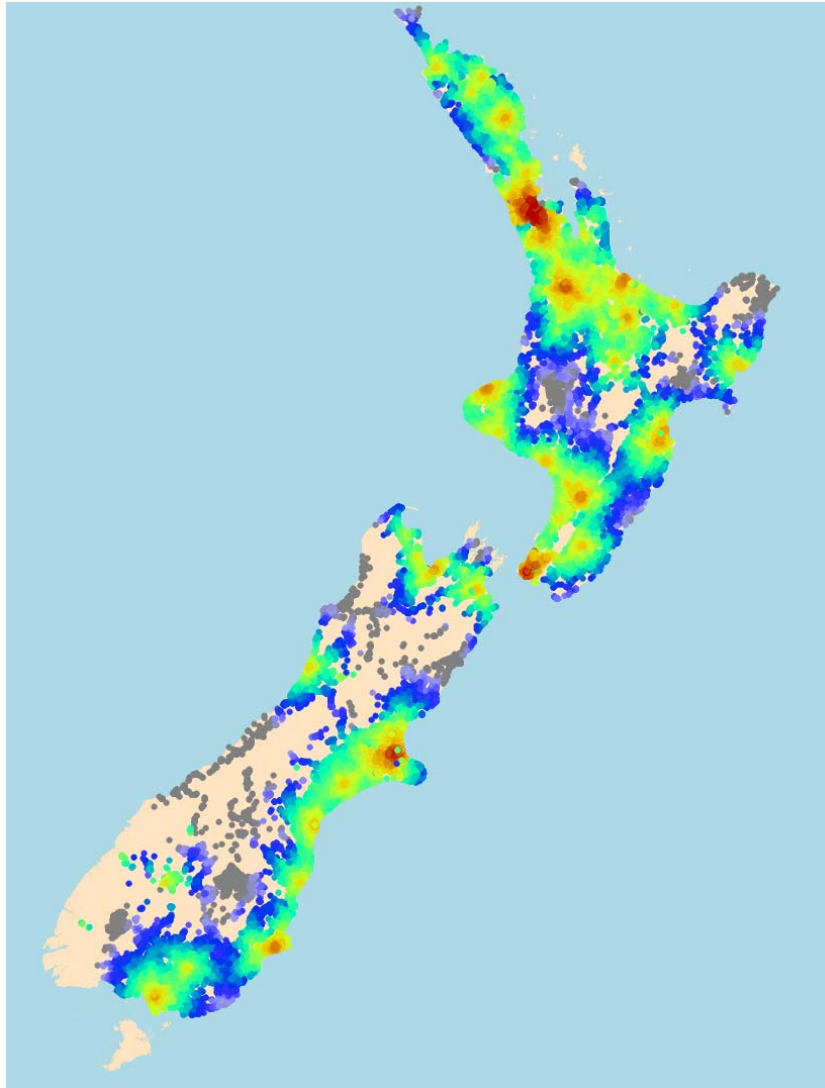


Or smaller areas – like Matamata

Primary
and
secondary
schools
and HBE
demand



Accessibility Map of New Zealand



IS THIS A REAL MODEL?



New Zealand 4S Model

- ⊙ Developed for this conference
- ⊙ Spent 2-3 days, including gathering data
- ⊙ Roads and paths based on OpenStreetMap – lanes, speed, hierarchy used where available (good coverage), estimates based on surrounds and hierarchy used elsewhere
- ⊙ Intersection details also from OpenStreetMap and surrounds

- ◎ PT from GTFS feed (only Auckland included due to time, but also available for Christchurch and Wellington)
- ◎ Demographics from NZ Census (Pop by Meshblock, Emp by Area Unit)
- ◎ Other government data - school enrolments, airport demand
- ◎ Other activities taken from OpenStreetMap (ports, airports, universities)

- ◎ Set up data and model: 2-3 days
- ◎ Build model (when source data changes): 5 minutes
- ◎ Run time: 60 minutes (average of 6 runs multi threaded on a single machine)
- ◎ Nodes: 163,850
- ◎ Two-way links: 227,145
- ◎ One way links (including mode variants): 1,643,133

Problems

- ⊙ Still a demonstration model
- ⊙ Behavioural data taken from South East Queensland model
- ⊙ Made some assumptions for missing data (blue collar/white collar splits)
- ⊙ No checking of network
- ⊙ Validation – not great
- ⊙ Likely issues
 - ⊙ Different behaviour of rural NZ
 - ⊙ Blue collar/white collar (assumed fixed %)
 - ⊙ Possible network errors
 - ⊙ Missing PT outside of Auckland

GEH	Percentage of Links (based on 1,372 counts)
0-5	31%
0-10	58%
0-15	76%
>15	24%

Other applications

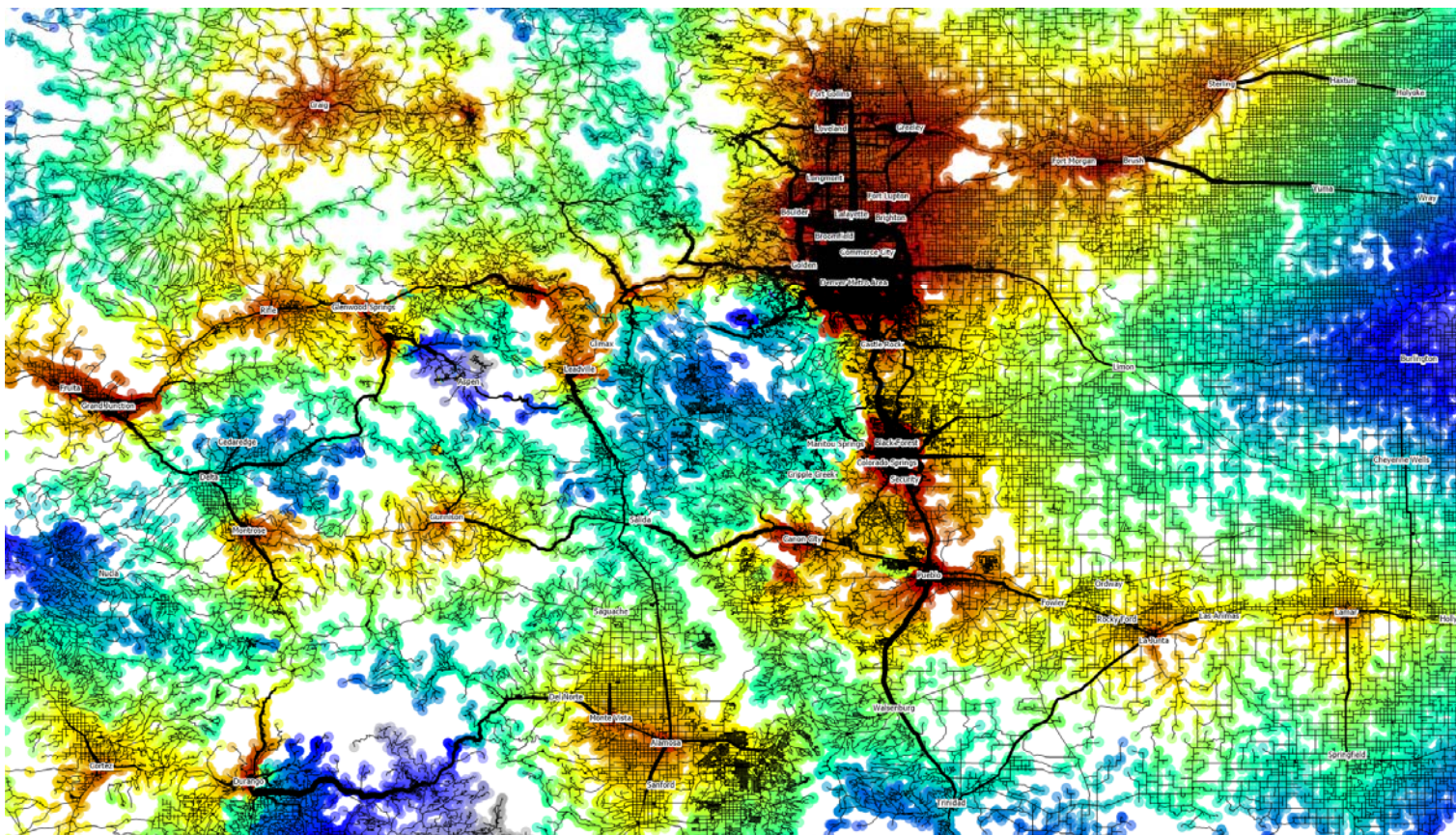
- ◎ Model in South East Queensland used for 7 years
- ◎ Over \$9b in investment decisions
 - ◎ Toowoomba Second Range Crossing Business Case (\$1.6b)
 - ◎ Demand advice to bidders in sale of Queensland Motorways Limited (\$7b)
 - ◎ Demand advice to determine post-receivership valuation of Airport Link (\$1.9b) and Clem 7 (\$618m)
- ◎ Peer reviewed and subject to due diligence review

Other applications

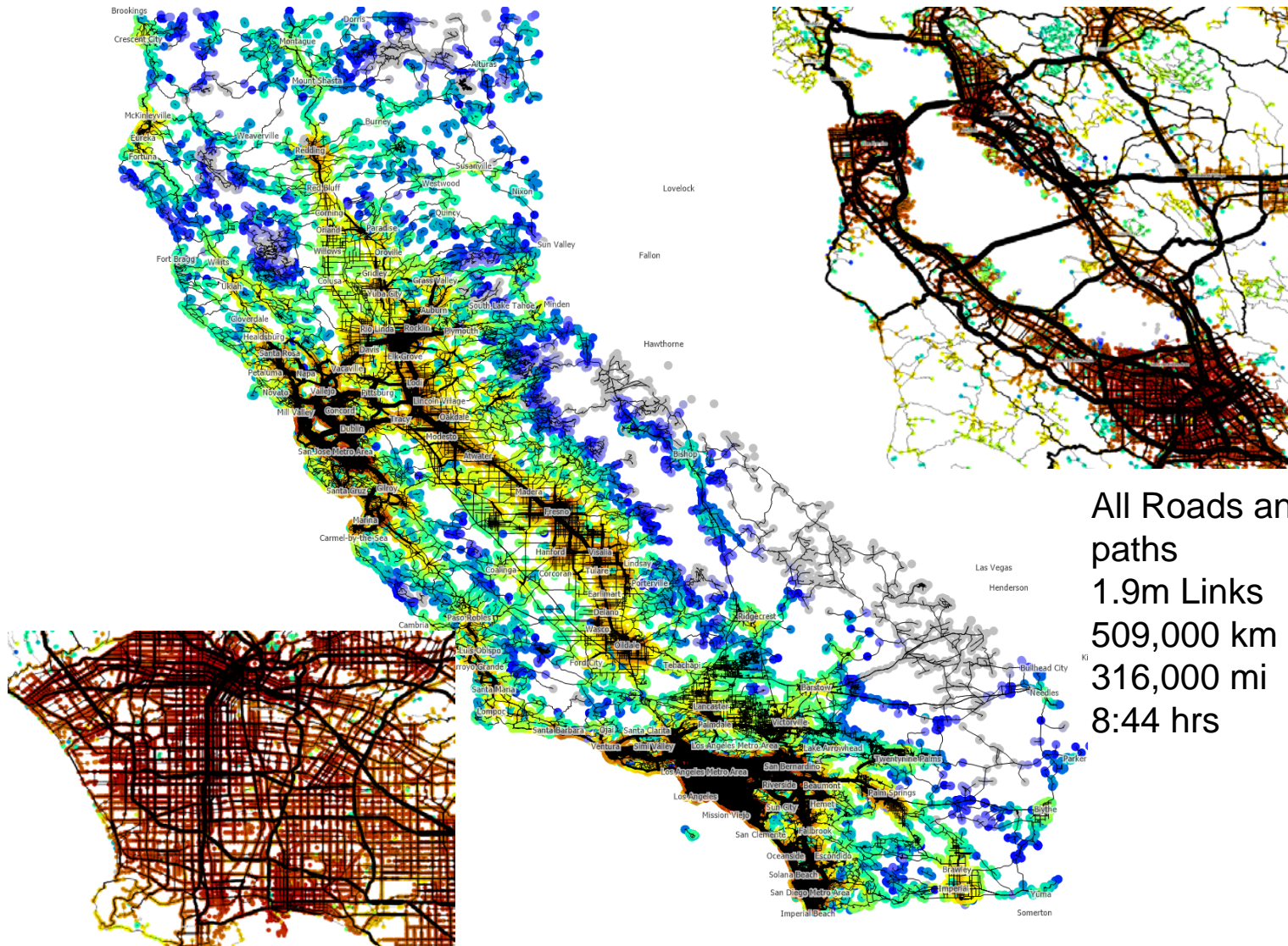
- ◎ Testing scenarios and policy development for Autonomous Vehicles
- ◎ Accessibility analysis and Land Use Transport Integration (LUTI)
- ◎ Transport planning (local, metropolitan and state-wide)

Colorado

All roads 480k links, Run time: 1.5 hr

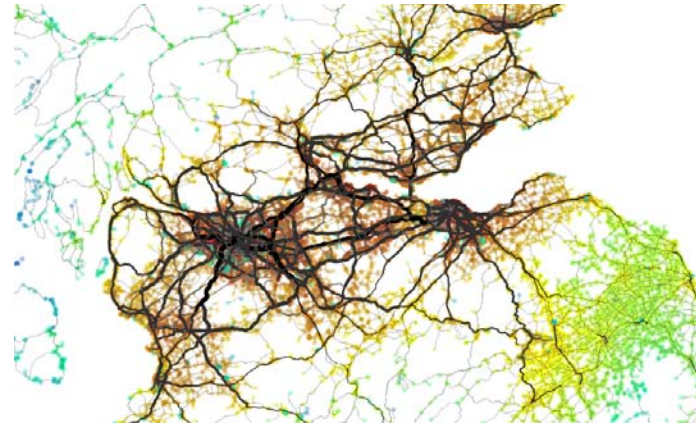
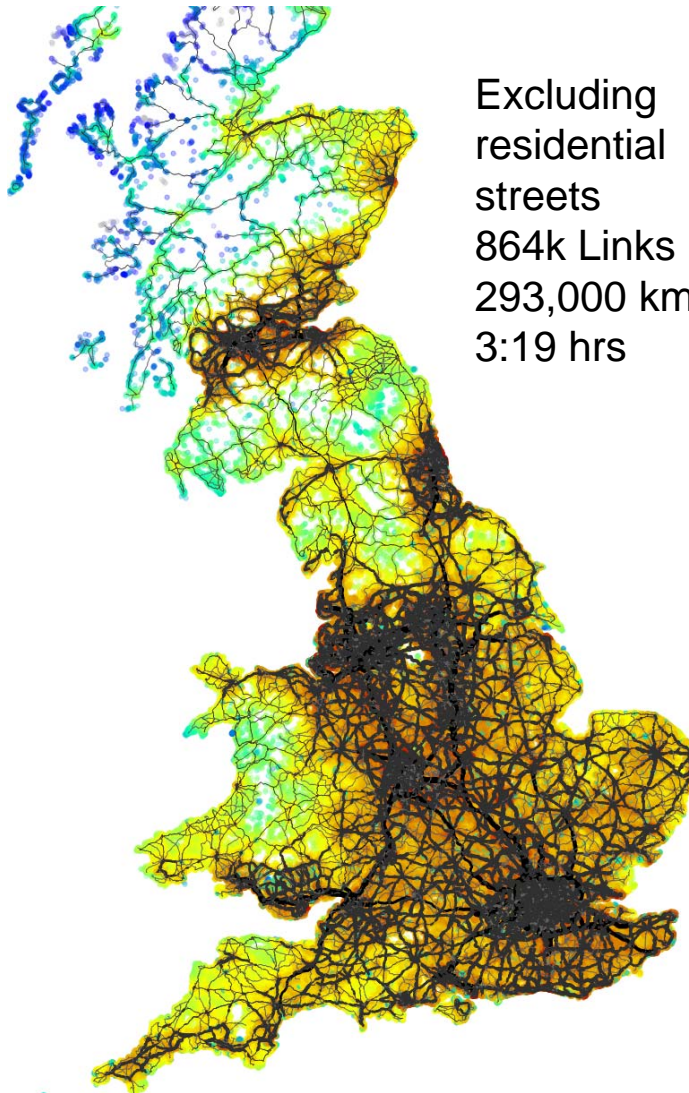


California



All Roads and
paths
1.9m Links
509,000 km
316,000 mi
8:44 hrs

Great Britain



HOW IS THIS POSSIBLE?



4S Model is different

- ◎ Single, integrated utility fn with random variables
 - ◎ Variability in behaviour from variation in taste (value of time etc)
- ◎ Not implicit aggregate equations, all factors are individual and explicit
 - ◎ Easy to incorporate external behavioural knowledge
 - ◎ Parameters are more easily transferred
 - ◎ Can estimate likely values, and test behavioural changes
 - ◎ Less reliant on data (more is better, but never enough, don't use as a crutch or replacement for judgement)

4S Model is different

- ◎ Sampling not full enumeration – don't fill every cell of matrix
- ◎ No zones and no matrices – all travel is point to point
 - ◎ eliminate lots of work (centroid connectors etc)
 - ◎ no need for consistent boundaries for demographics
 - ◎ escape problem of N^2 increase, which allows large models
- ◎ Traditional models are hugely inefficient
 - ◎ spend most time solving irrelevant problems (paths for O-D pairs by mode that get rejected)
- ◎ Improve efficiency
 - ◎ can include all links and modes
 - ◎ reduce coding effort

Different approach to data

- ◎ When transport models were first developed, we were the only ones with the data – we were the data creators and owners
- ◎ That is no longer true – we are curators + aggregators
- ◎ Do not build a model as a standalone artifact
- ◎ Instead build an automatic process – as source data changes can seamlessly rebuild model
- ◎ Some complexities – addressed in a paper presented at AITPM Conference 2016 “**MANAGING MODELS IN THE AGE OF OPEN DATA**”

Segmented:

- Comprehensive breakdown of travel markets (20 private + 40 CV + 40 AV)
- Behavioural parameters vary by market segment

EXPLICIT RANDOM UTILITY

Slice:

- Slices of the travel market
 - across model area
 - through probability distributions
- Very efficient – detailed networks, large models

Stochastic:

- Monte Carlo to draw values from probability distributions
- Random variable parameters
- Number of slices can be varied
 - choose runtime

SIMULTANEOUS

Simulation:

- State-machine
- Sim all aspects of travel choice
- Complex public transport
- Multimodal freight
- Easily extended

4S



THANK YOU

Questions and Discussion