EMERGENCY EVACUATION MODELLING FOR AUCKLAND

Prakash Ranjitkar

Senior Lecturer, Department of Civil and Environmental Engineering
Faculty of Engineering, University of Auckland, New Zealand
Email: p.ranjitkar@auckland.ac.nz

Research Contributors: Dr Mohsin Chaudhry, Chris Baker, James Cox, Sze Nga Hung, Zibo Yang, Nirojan Jayananthan and Sithika Jayasinghe

Transport Resilience Workshop, 1st December 2016

National Science Challenges | RESILIENCE TO NATURE'S CHALLENGES | Kia manawaroa – Ngā Ākina o Te Ao Tūroa

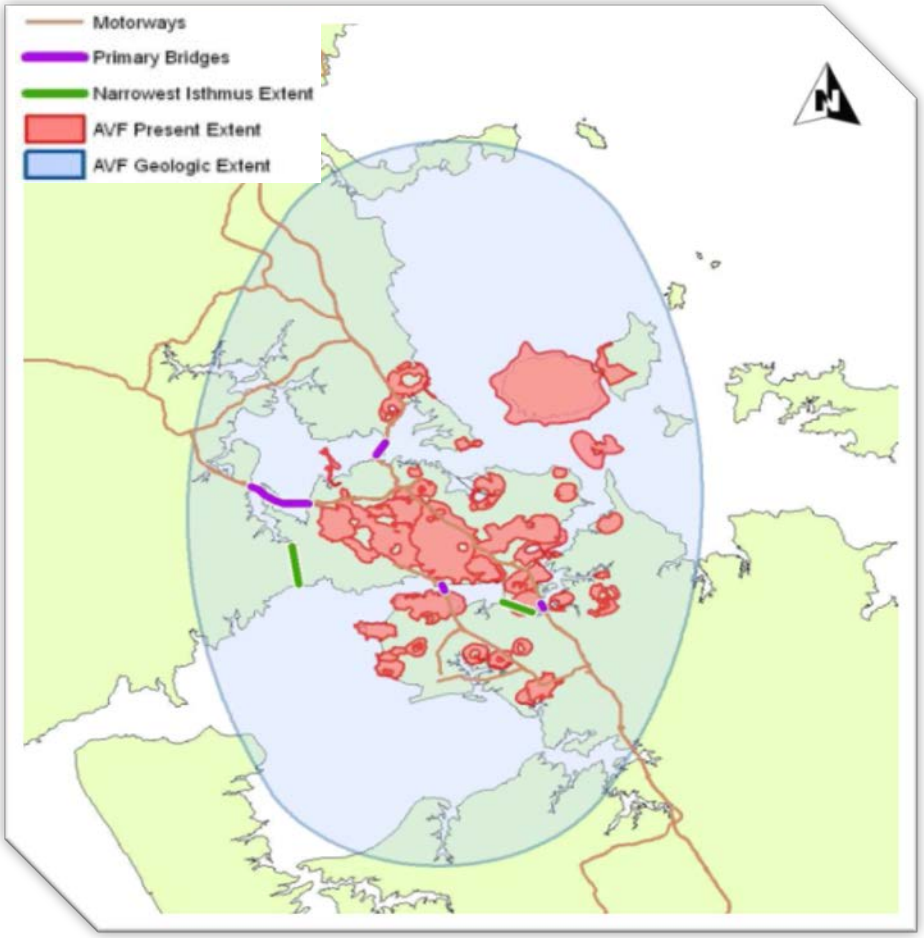
QuakeCoRE NZ Centre for Earthquake Resilience

THE UNIVERSITY OF AUCKLAND Te Whare Wānanga o Tāmaki Makaurau NEW ZEALAND

Need for Auckland's Evacuation Plan

Hazards	Expected number to be displaced	Risk rating	Evacuate
Volcanic Eruption	100,000	High	Yes
Earthquake	10,000	High	Yes
Lifeline Utility Failure	100,000	Very high	No

Source: Civil Defence's Auckland Evacuation Plan (2010)



- Auckland, the largest city of NZ, is located on an active volcanic field - Auckland Volcanic Field (AVF)
- Volcanic eruption is identified as a high risk hazard for Auckland with large scale evacuation needed
- The impact of volcanic eruption can be catastrophic for safety and economy
- Uncertainty in volcano behaviour - estimates on warning time range from a day to a week

Artists impression of a Manurewa volcano

Exercise Ruaumoko '08

- National disaster exercise / public surveys
- Assessment of strategic planning
- 48 hours notice required to evacuate 5 km radius zone (Lindsay et al., 2010) - simply a postulation without reasoned backing

Tomsen's Thesis (2010)

- Strategic level evacuation plan
- GIS based modelling using TransCAD
- Major gridlock experience with infinite clearance time – inconclusive results
- More detailed model required

Research Objectives

Clearance Times

- Time to evacuate

Bottleneck Locations

- Problem areas of the network

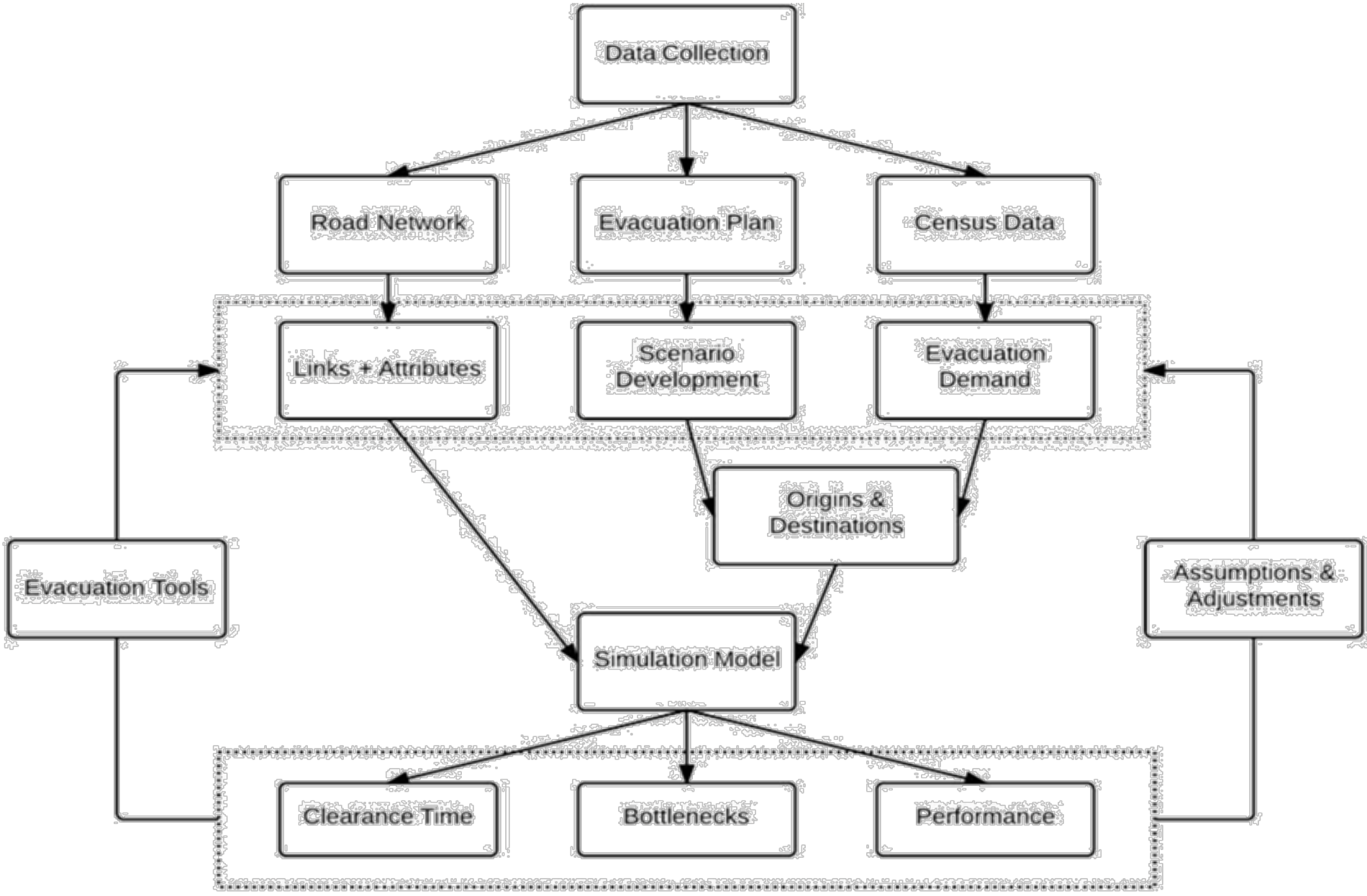
Network Performance

- Capability in evacuation

Evacuation Analysis

- Determine a total clearance time
- Locate bottlenecks and high congestion areas in Auckland road networks during evacuation
- Investigate the effectiveness of traffic control strategies during evacuation
- Investigate selected traffic control measures such as contraflow to reduce clearance time

Methodology

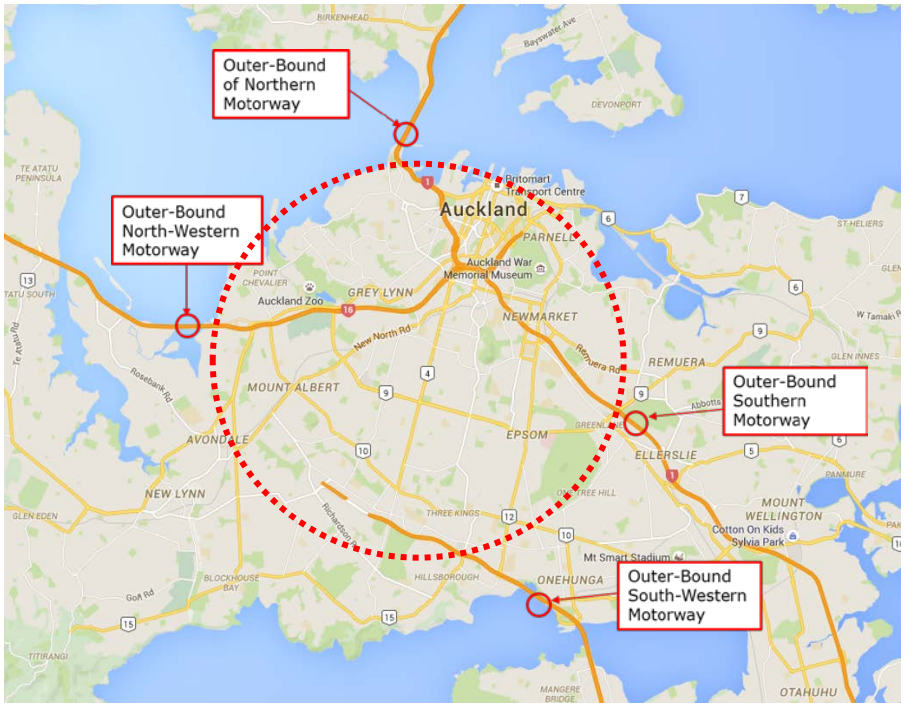


Evacuation Scenarios

Time	Vehicle Number	Assumptions
Night	Single	• Evacuees won't panic (Dombroski and Fischoff, 2006) • Road Rules will be followed • Selection of destinations • No background traffic • 30 people per bus • People with no private vehicles, schools/university population uses buses
	Multiple	
Day	Occupancy based	

Study Area

For the worst situation, the eruption is assumed to be located 1 km south-west of Mt Eden with 5 km radius of the affected area.



Methodology

- Origin and destination
  - Each suburb is considered a zone
  - Auckland contains 411 zones
    - 66 origin zones within the evacuation area
    - 347 destination zones
- Night Time Single Vehicle Scenario

$$\text{Vehicle Demand} = \sum H + \left\{\frac{\left(\frac{L}{H+L}\right)\times P}{30}\right\}$$

- Night Time Multiple Vehicles Scenario

$$\text{Vehicle Demand} = \sum_1^3 (H \times n) + \left\{\frac{\left(\frac{L}{H+L}\right)\times P}{30}\right\}$$

- Day Time Scenario

$$\text{Vehicle demand} = \sum_1^3 (H \times n) + \frac{(W_i - W_o)\times(1-M)}{Oc} + \frac{(W_i - W_o)\times M}{30} + \frac{E}{30} + \frac{\left(\frac{L}{H+L}\right)\times(P-S)}{30}$$

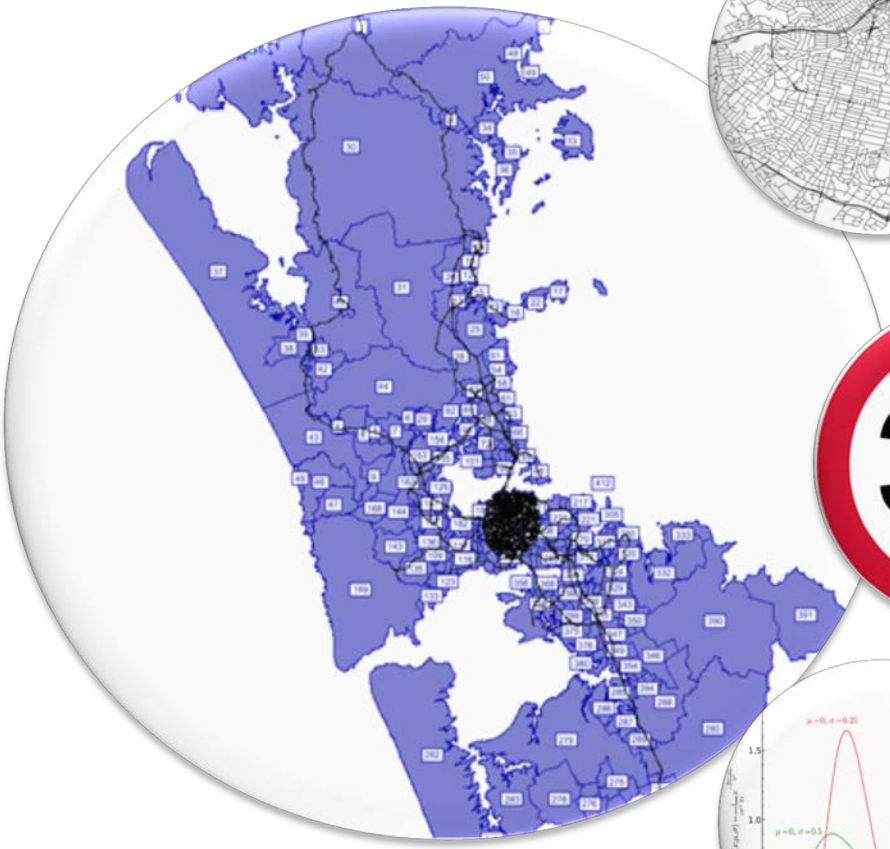
H = number of households with vehicle(s)
n = number of light vehicles
L = number of households with no access to light vehicles
M = mode share of bus
P = total population within affected area
W_i = workers going towards affected area
W_o = workers going out of affected area
O_c = occupancy rate of private vehicles
E = enrolments in affected area
S = students living in affected area

Trips Generated

Scenarios	Trips Generated
Night Time (Single vehicle per household)	76,239
Night Time (Multiple vehicles per household)	130,110
Day Time (Multiple vehicles per household)	169,226

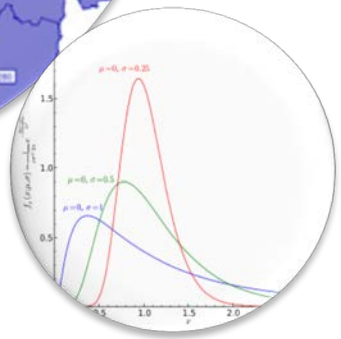
THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

VISSIM, VISUM and AIMSUN



- Import Network

- Define Attributes



- Establish Simulation Parameters

Modelling in VISSIM (2014)

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

Limitations

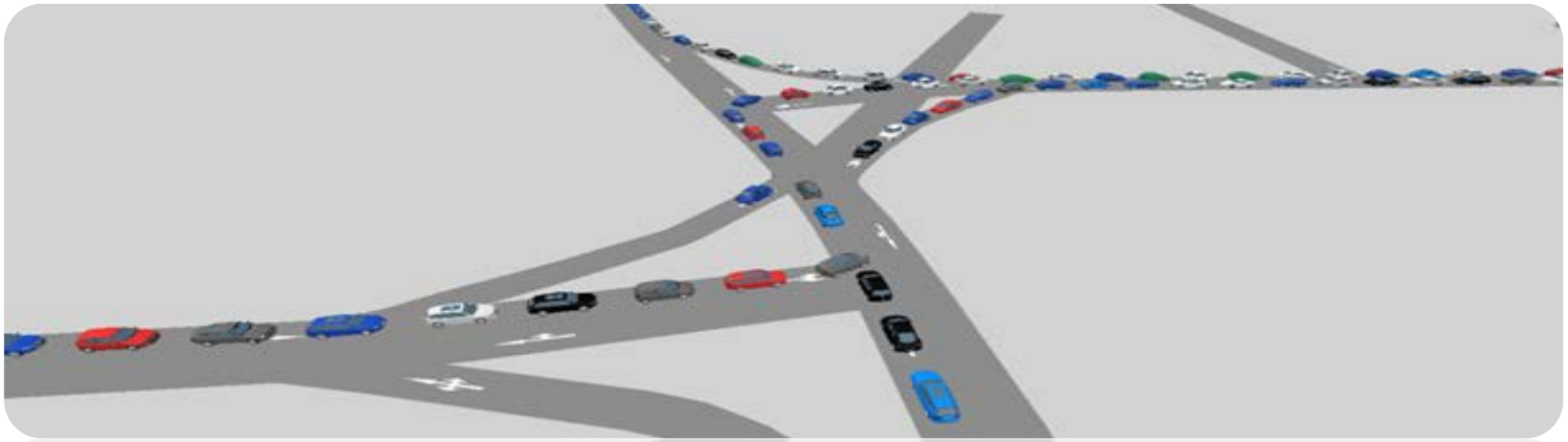
Over 24 hours simulation time

10 simulations required for convergence

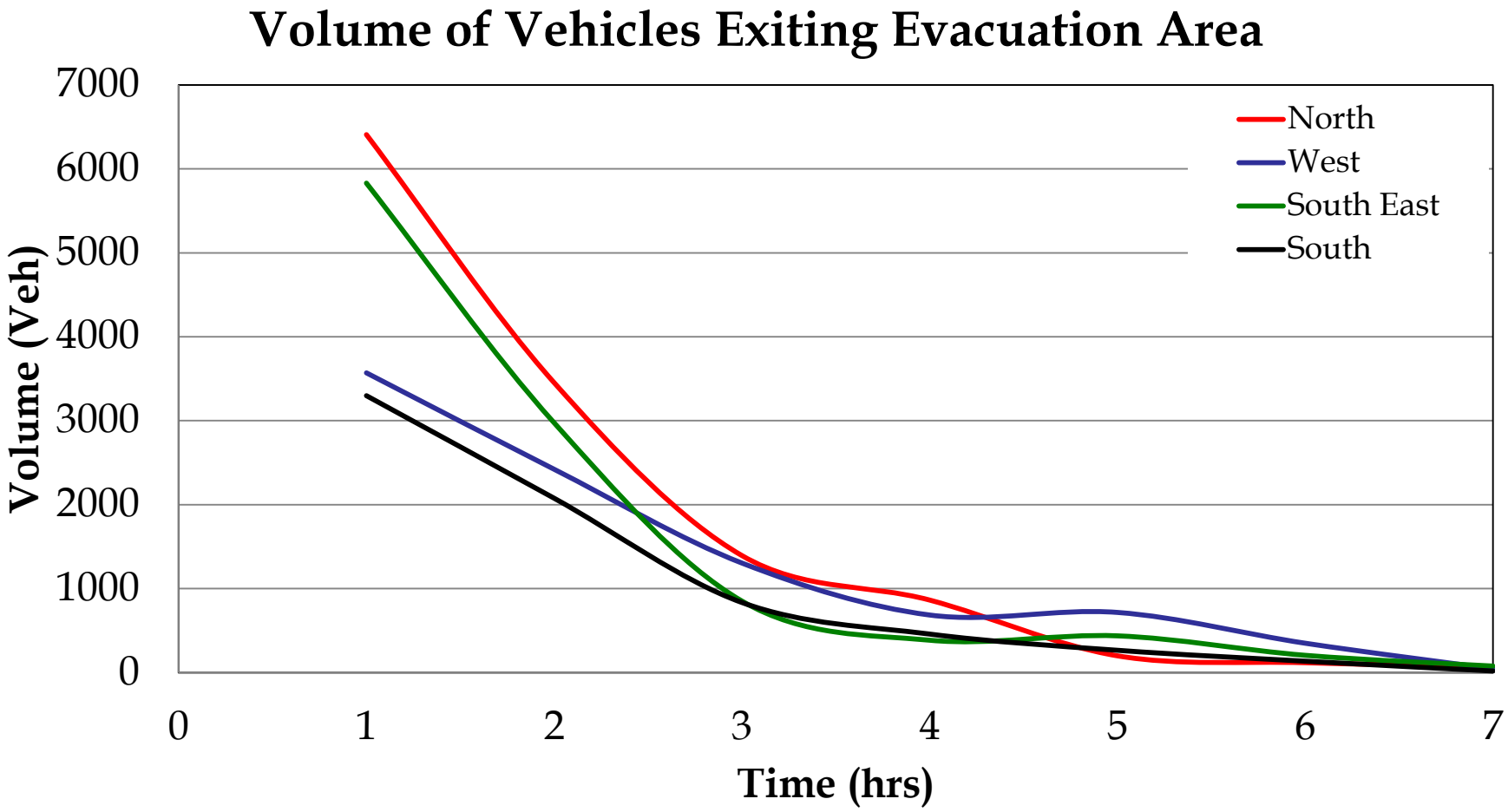
Results

Congestion on connector roads

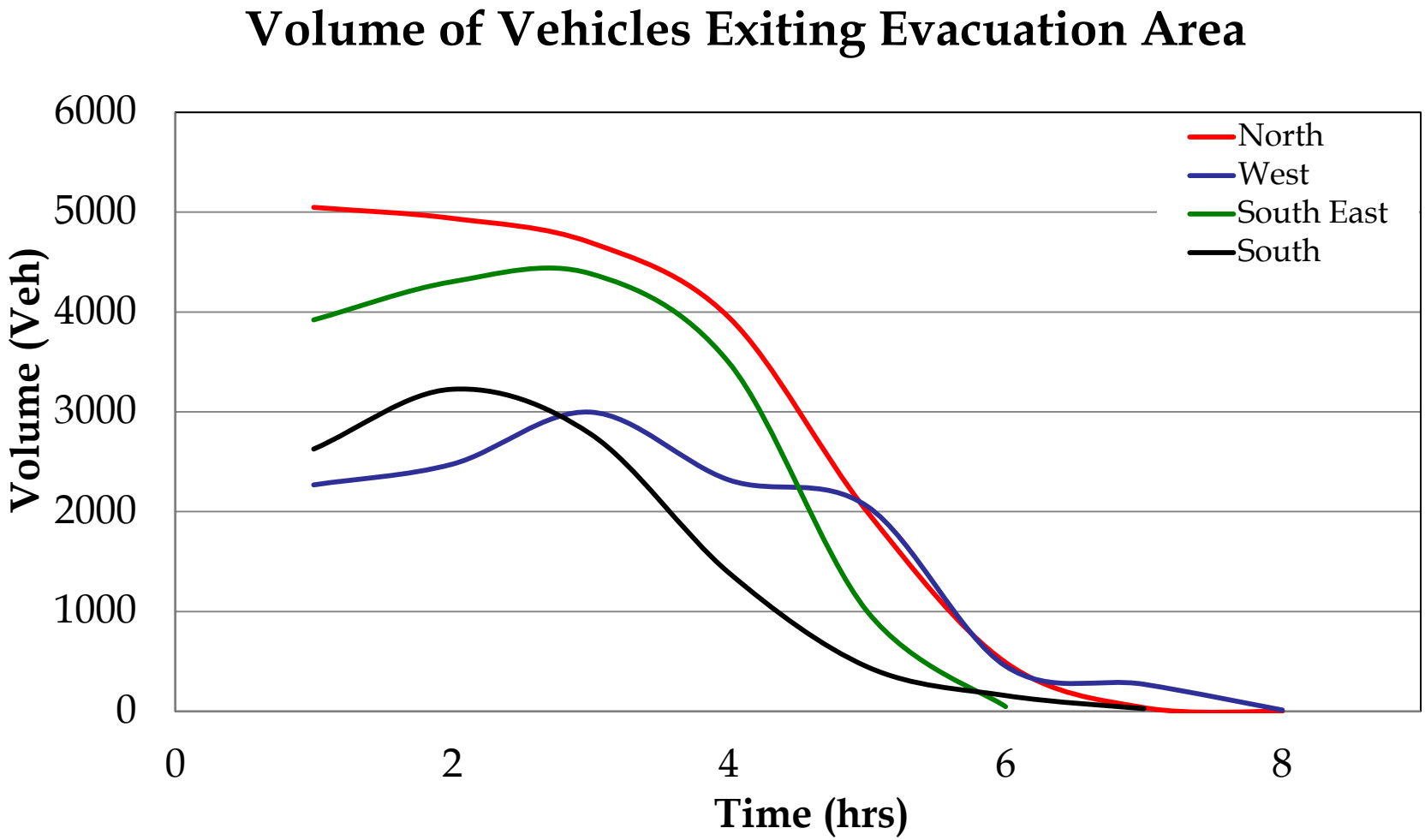
Motorways free flowing



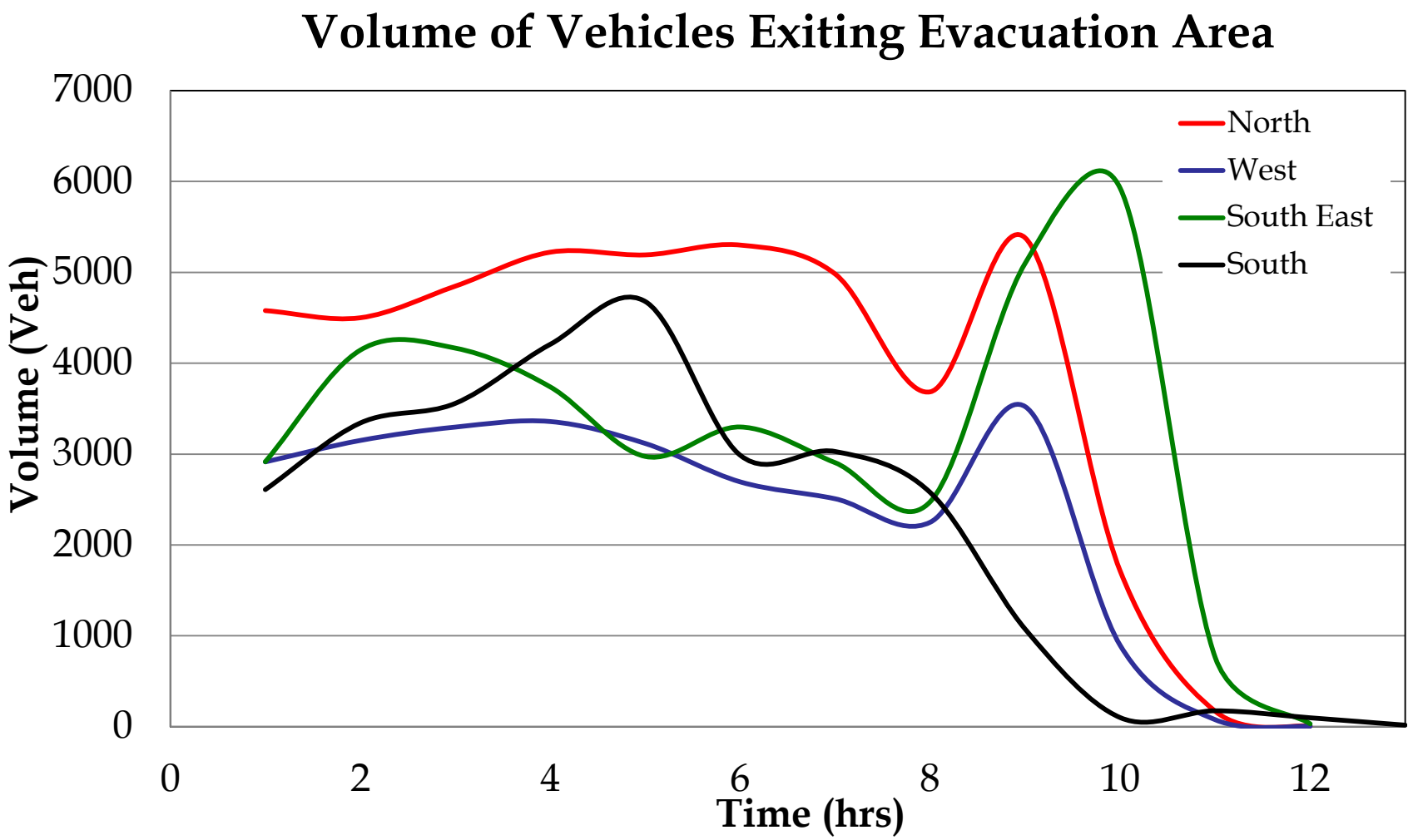
Night Time (Single Car) Scenario



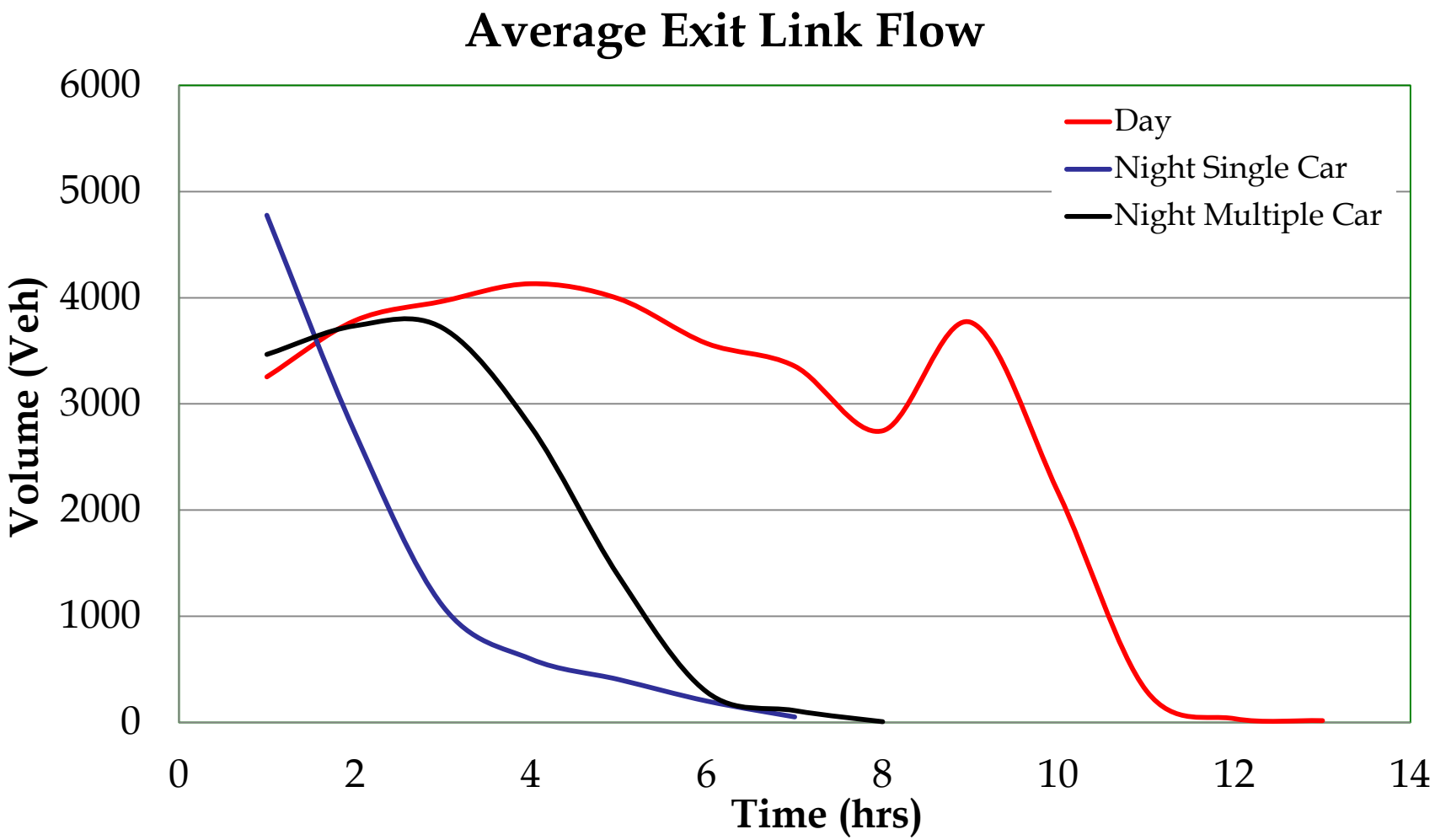
Night Time (Multiple Cars) Scenario



Day Time Scenario



Results using VISUM



Modelling using AIMSUN

- Hybrid simulation tool
- Different platform and overview
- Can import Osm files
- Increasing usage in NZ

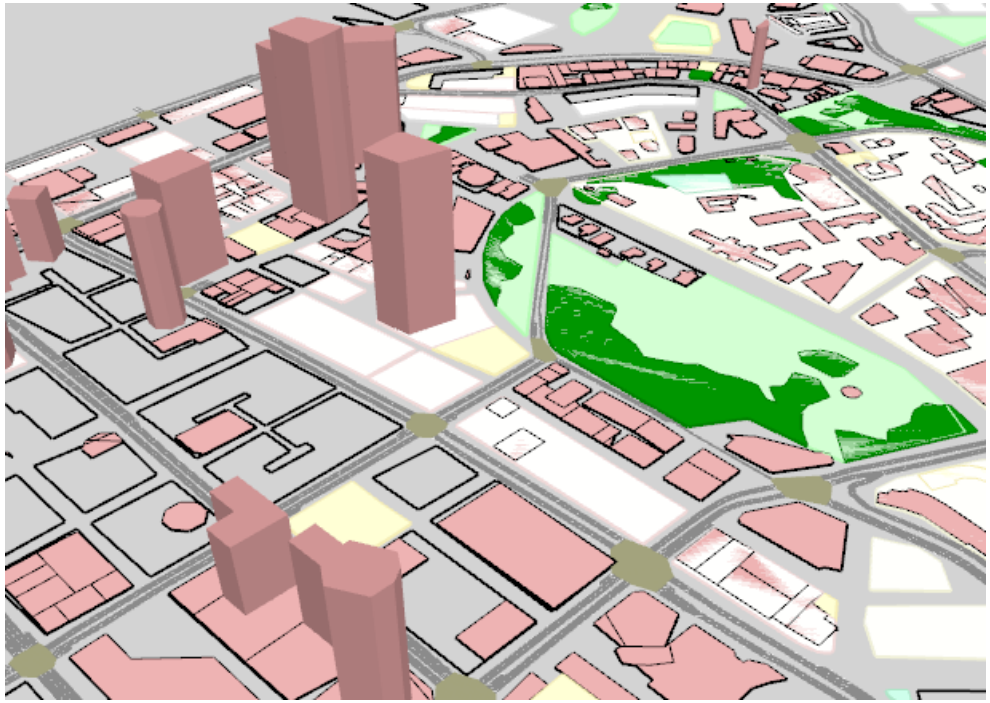
Building The Network

- Importing osm files
- Defining road network

  Arterial and main collector roads
- Lane configuration

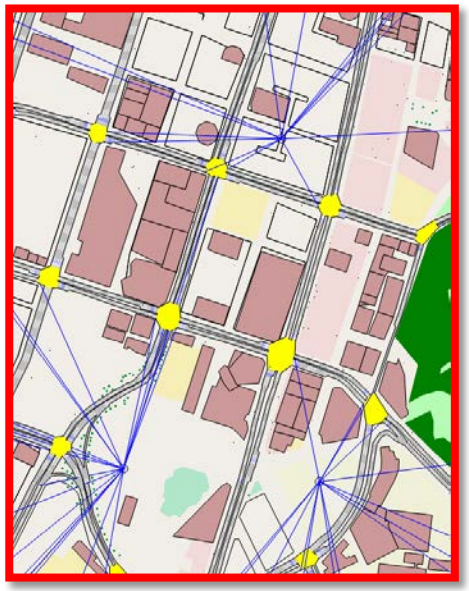
  Number of lanes, turning bays, give-ways
- Road attributes

  Speed, Name and classification
- Actuated signal controls
- Origin – demand matrix



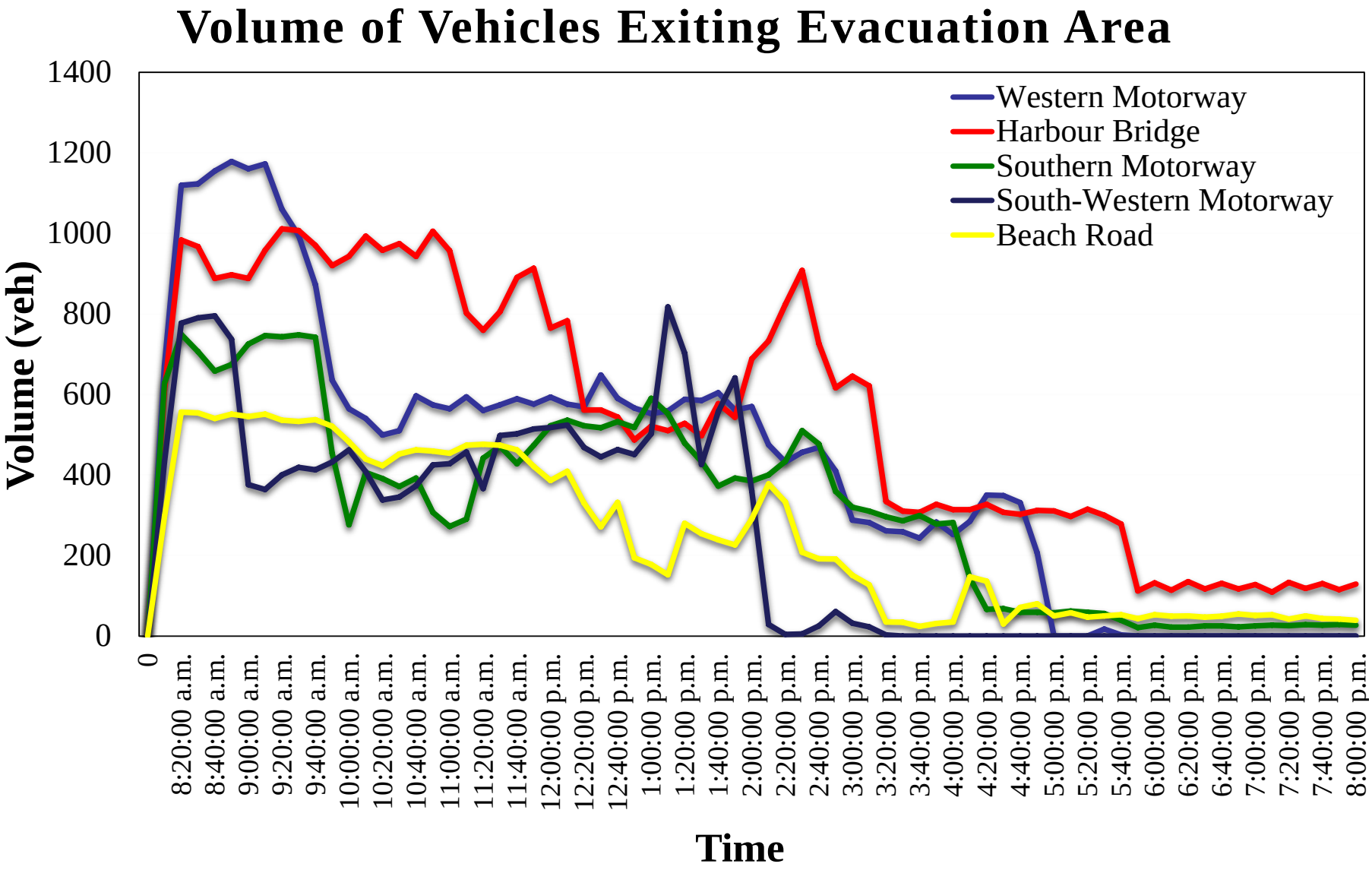
3-D Image of Auckland CBD in AIMSUN

Modelling using AIMSUN



- Dynamic Scenario
- Microscopic Simulation
- As soon as possible (ASAP) vehicle arrival rate
- Stochastic route choice

Day Time Scenario

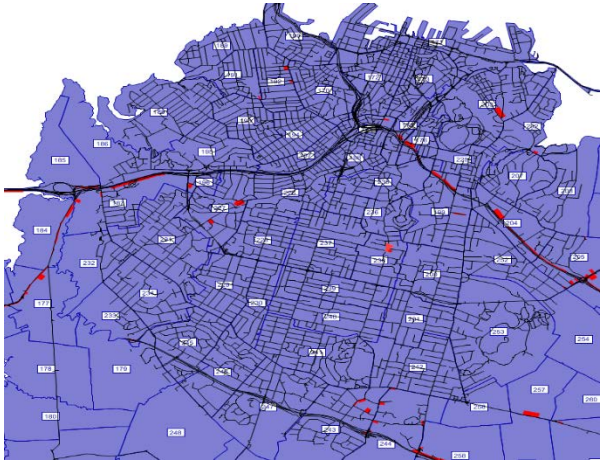


Day Time

Link Speed (First Hour)

Link Speed (Sixth Hour)

Link Speed (Tenth Hour)



Note: Red colour indicates links with speed below 5km/hr

Key Findings

- Total clearance time for worst case scenario (day time) is estimated to be between 10 and 12 hours
- The south-western motorway (#20) is under utilized
- North motorway exit (Harbour bridge) had the greatest demand (30% of all evacuating vehicles)
- Congestion is observed near motorway on-ramps

Future Research Directions

- Locate bottlenecks and high congestion areas in Auckland road networks during evacuation
- Investigate the effectiveness of traffic control strategies during evacuation
- Investigate selected traffic control measures such as contraflow to reduce clearance time