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

ENGINEERING
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Development and Calibration of NZ South Island Regional Road Network

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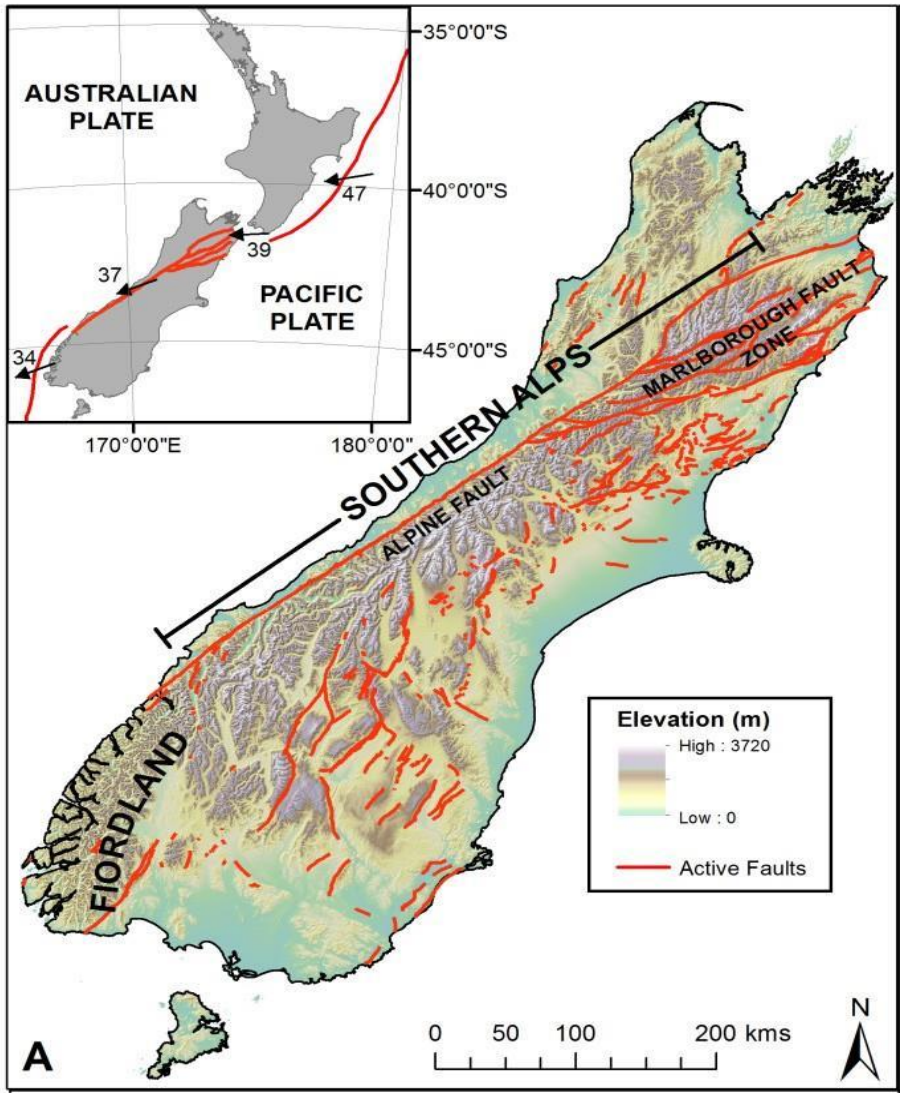
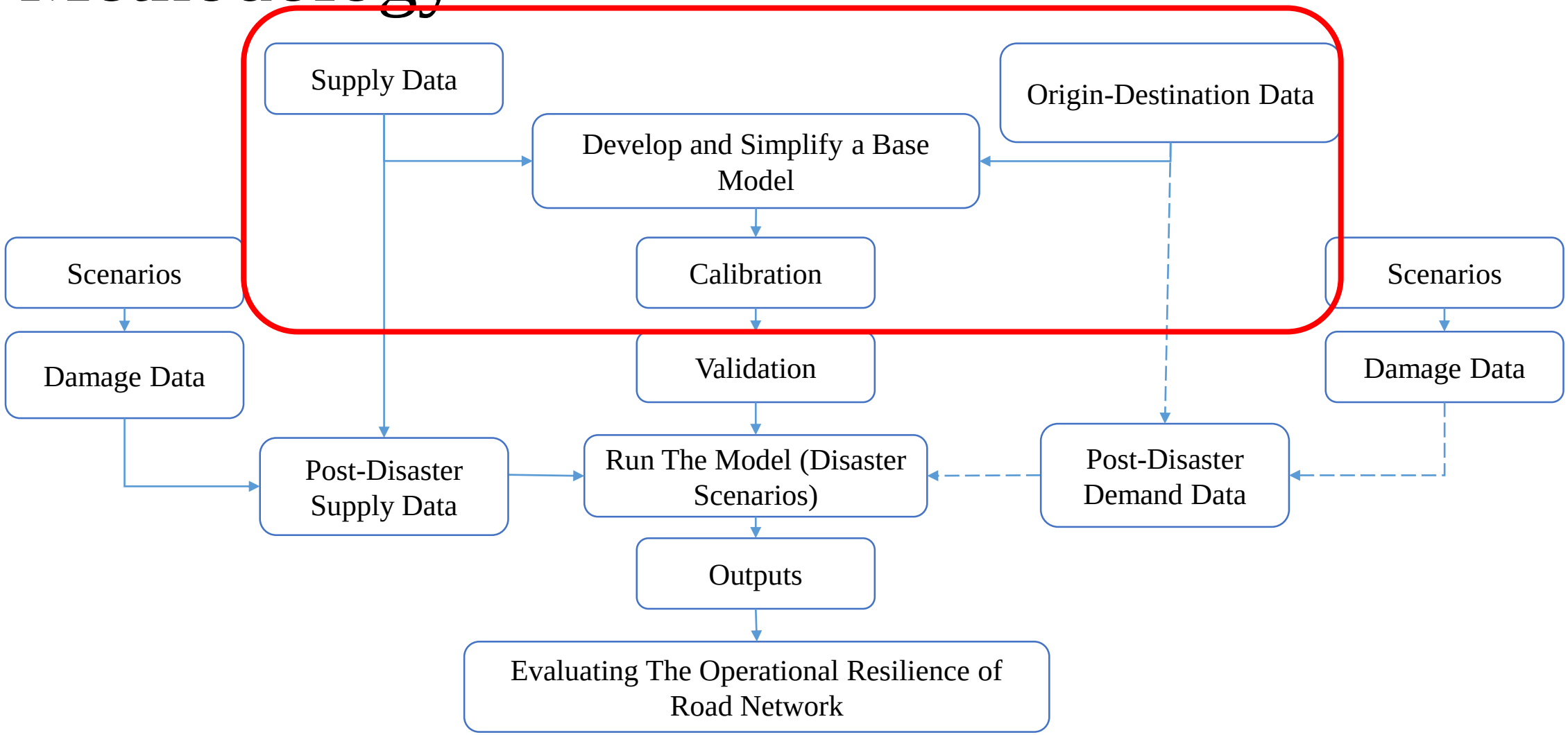
Background

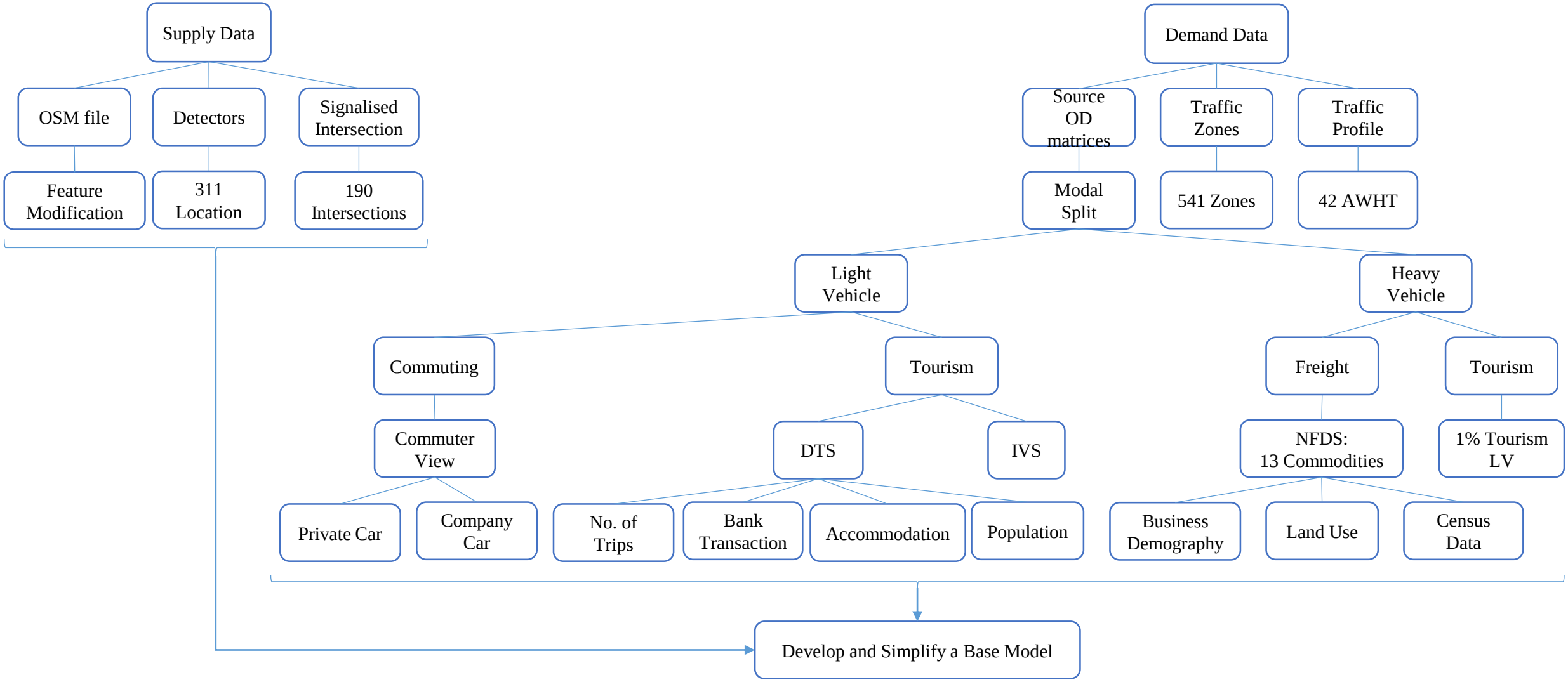
- The main title:
  - "**Operational Resilience Assessment of a Rural Road Network**"

- The main aim:
  - Assess the **operational resilience** of a **rural road network** in the South Island, New Zealand, in the event of a **major earthquake**.



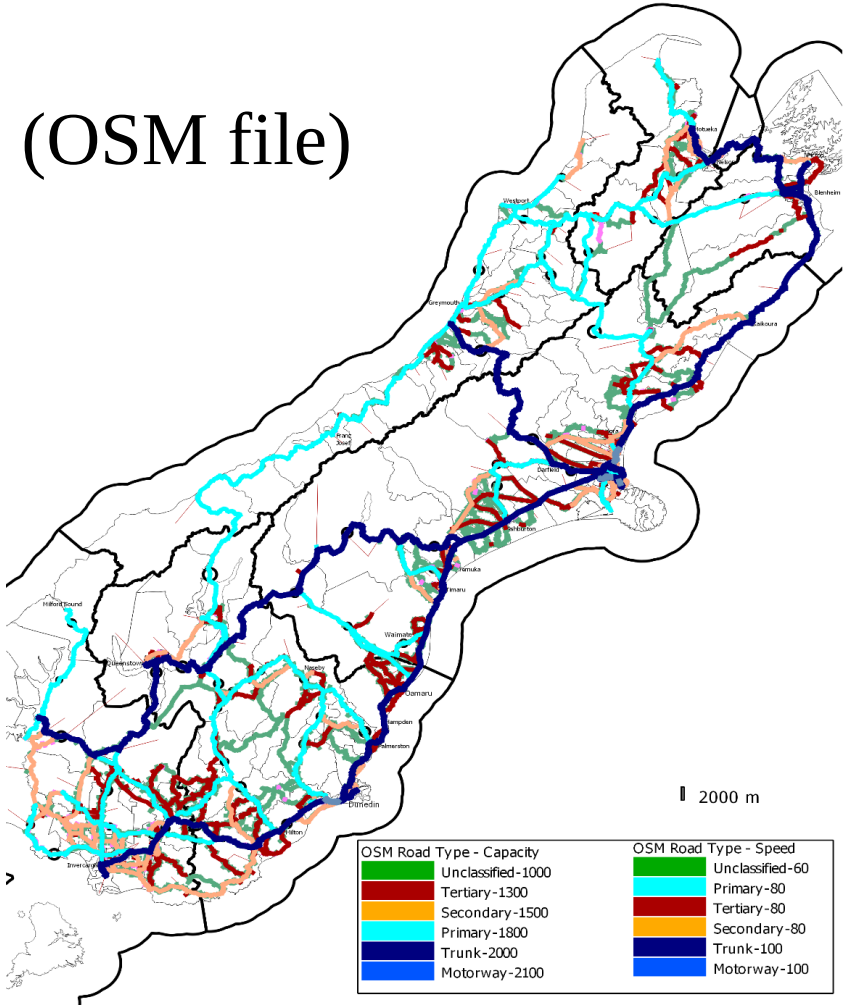
Methodology




Supply Data
OSM file
Detectors
Signalised Intersection
Feature Modification
311 Location
190 Intersections
Demand Data
Source OD matrices
Traffic Zones
Traffic Profile
Modal Split
541 Zones
42 AWHT
Light Vehicle
Heavy Vehicle
Commuting
Tourism
Freight
Tourism
Commuter View
DTS
IVS
NFDS: 13 Commodities
1% Tourism LV
Private Car
Company Car
No. of Trips
Bank Transaction
Accommodation
Population
Business Demography
Land Use
Census Data
Develop and Simplify a Base Model

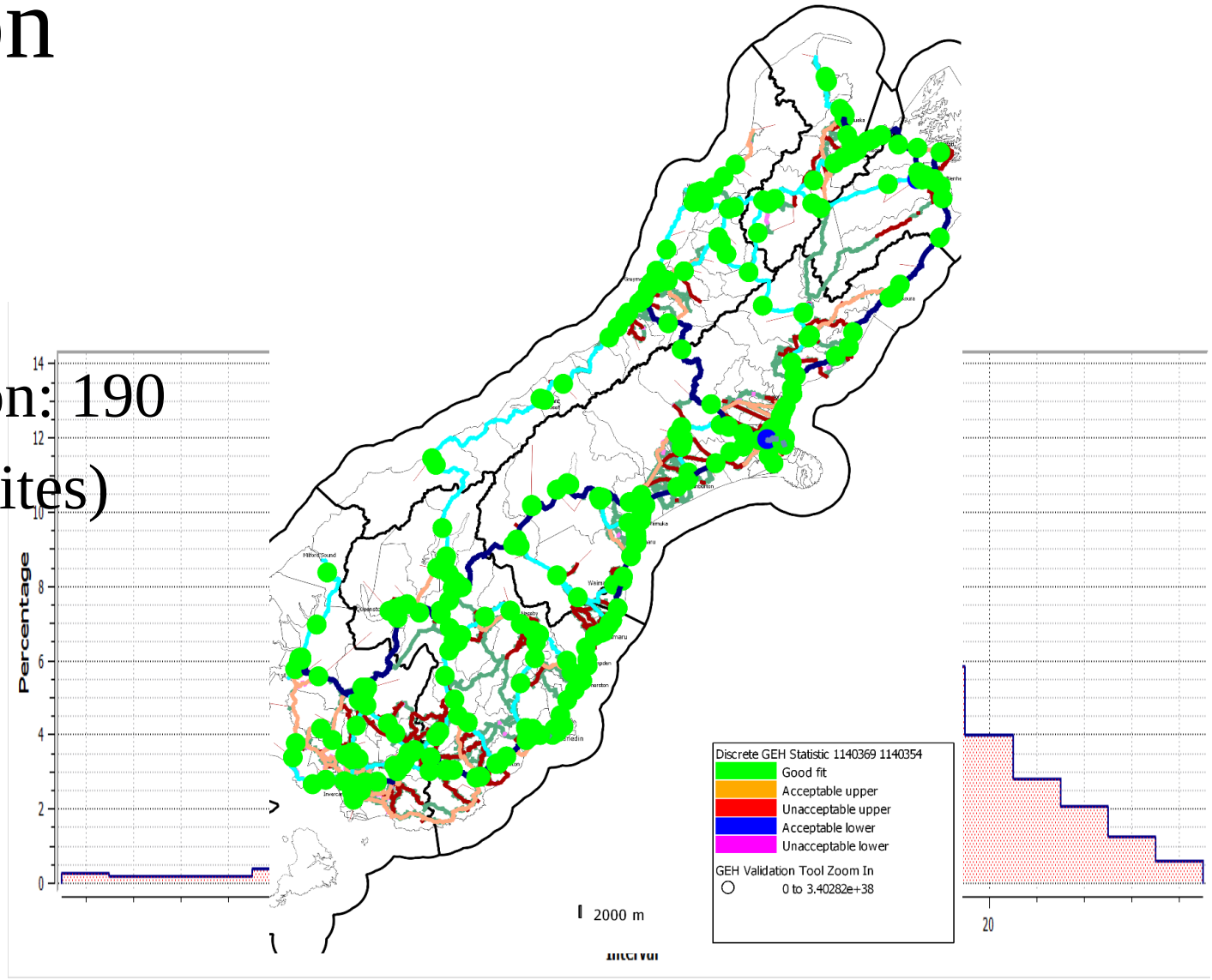
Development of Regional Road Network

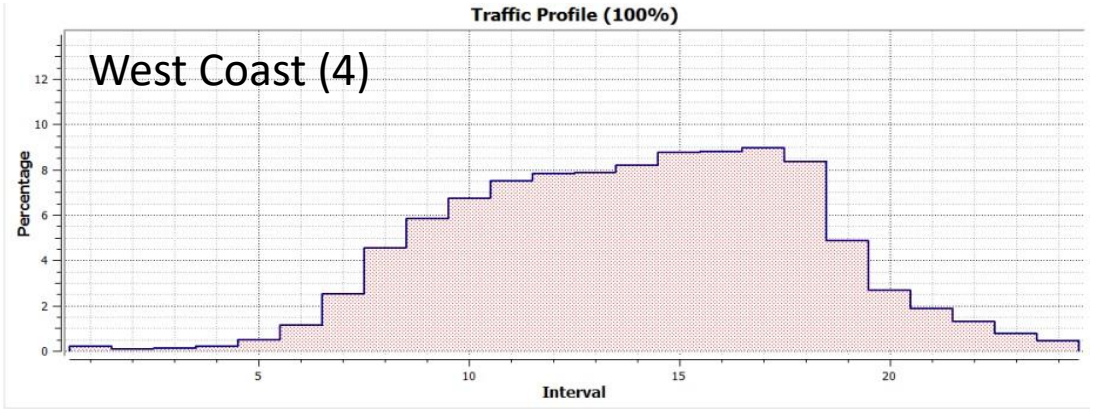
- Import Road Network from Open Street Map (OSM file)
- Default Features including:
  - Speed
  - Capacity
  - Road Hierarchy
  - Nodes
- Modify the default features

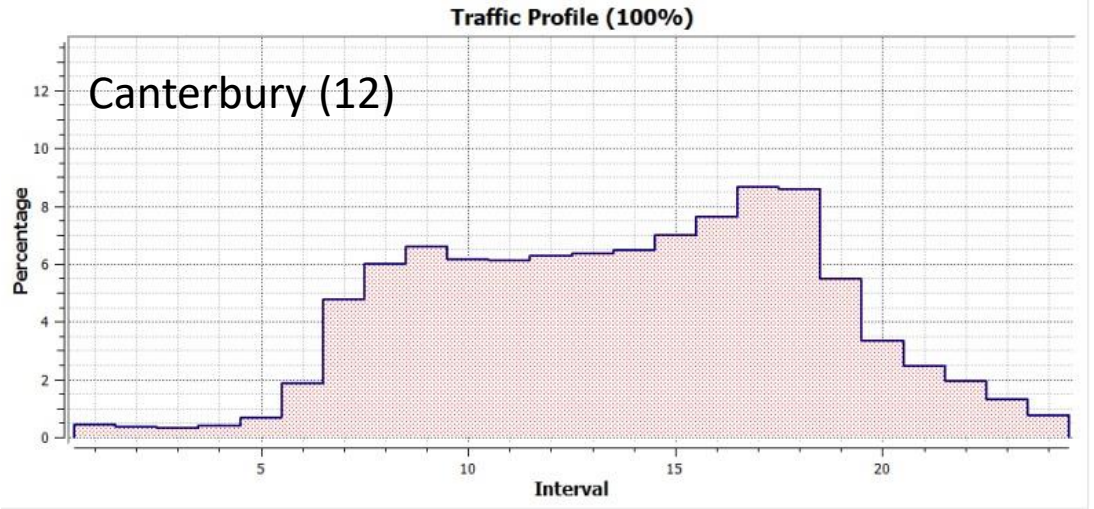


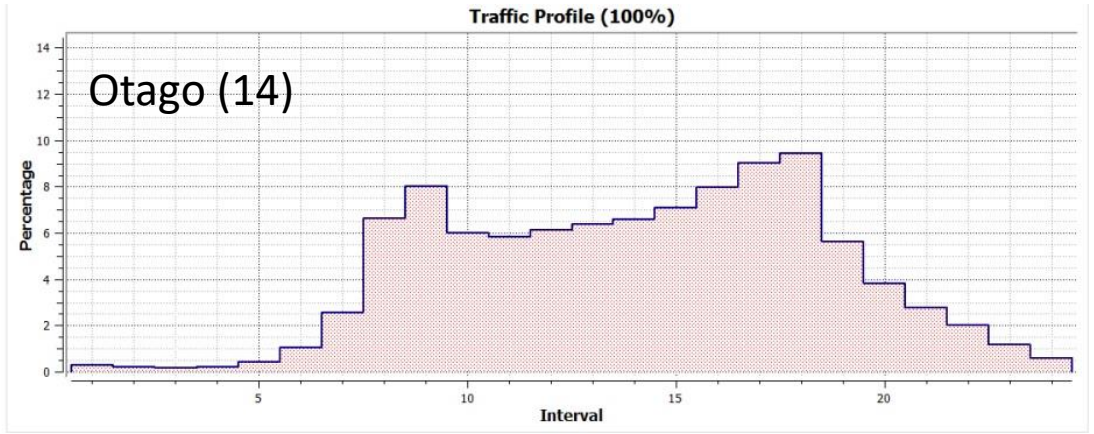
General Information

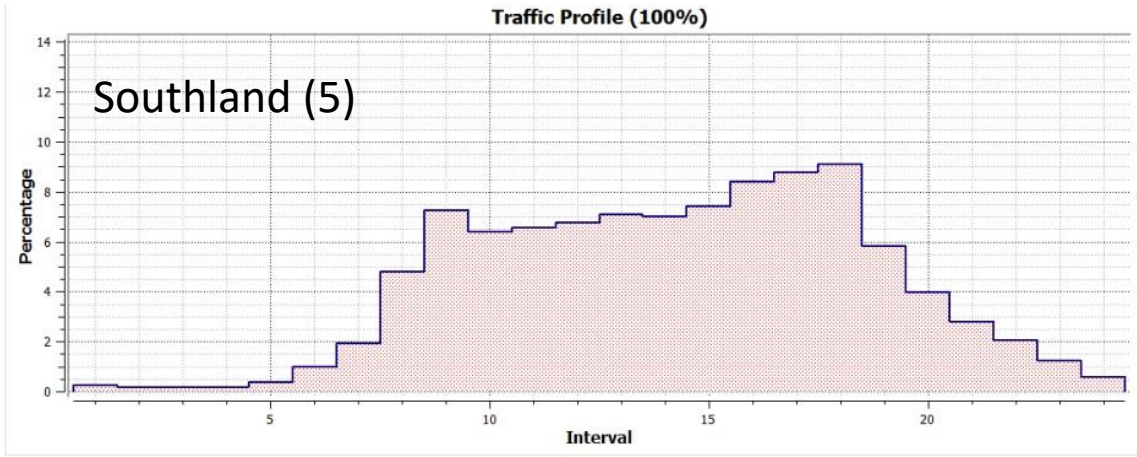
- Base Year: 2013
- 541 Unit Areas (Centroids)
- No. of Signalised Intersection: 190
- No. of Detectors: 622 (311 sites)
- 24 Hours period
- General Traffic Profile
  42 sites (AWHT)

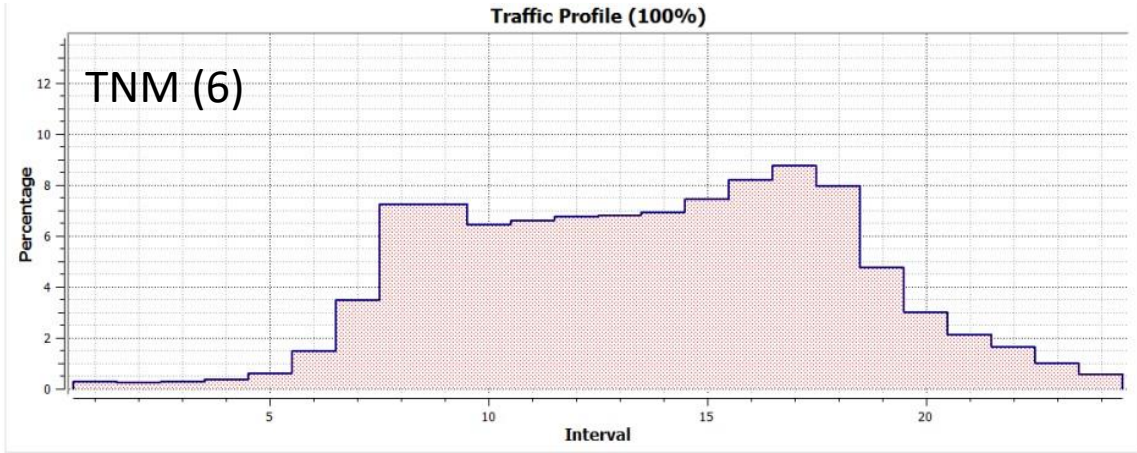



Traffic Profile (100%)
West Coast (4)
Percentage
Interval


Traffic Profile (100%)
Canterbury (12)
Percentage
Interval


Traffic Profile (100%)
Otago (14)
Percentage
Interval


Traffic Profile (100%)
Southland (5)
Percentage
Interval


Traffic Profile (100%)
TNM (6)
Percentage
Interval

Travel Demand Modelling

- Three purposes:
  - Commuting
  - Tourism
  - Freight

Commuter Trips

- Commuter view website (NZ statistics)
  - Based on unit areas
  - **Commute in:** number of employed people who gave a workplace address in this area unit, but who did not usually reside in this area unit.
  - **Commute out:** number of employed people who usually resided in this area unit, but gave a workplace address outside this area unit.
  - Private car
  - Company car

Tourism Trips

- NZ.Stat (census data) and MBIE website, tourism section
  - **Domestic Travel Survey (DTS)**
  - International Visitor Survey (IVS)
- Data used:
  - **Number of trips** (day, overnight, total) for each RTO
  - **Bank transaction** (BNZ card holders (20%))
    - Total No. of transactions between seven region (O) and 14 RTO (D)
- Destination: Tourism Attracted Locations **(No. of accommodations)**
  - Regional Tourism Organisations (RTO)
- Origin: All Unit Areas **(Population)**
- Same behaviour for International Visitors

Heavy Vehicle Trips

- "National Freight Demand Study"; MOT 2014
- Total movements of 19 commodities in million tonnes
- Exports; Imports; Domestic movements
- Origin or Destination was unknown

Heavy Vehicle Trips

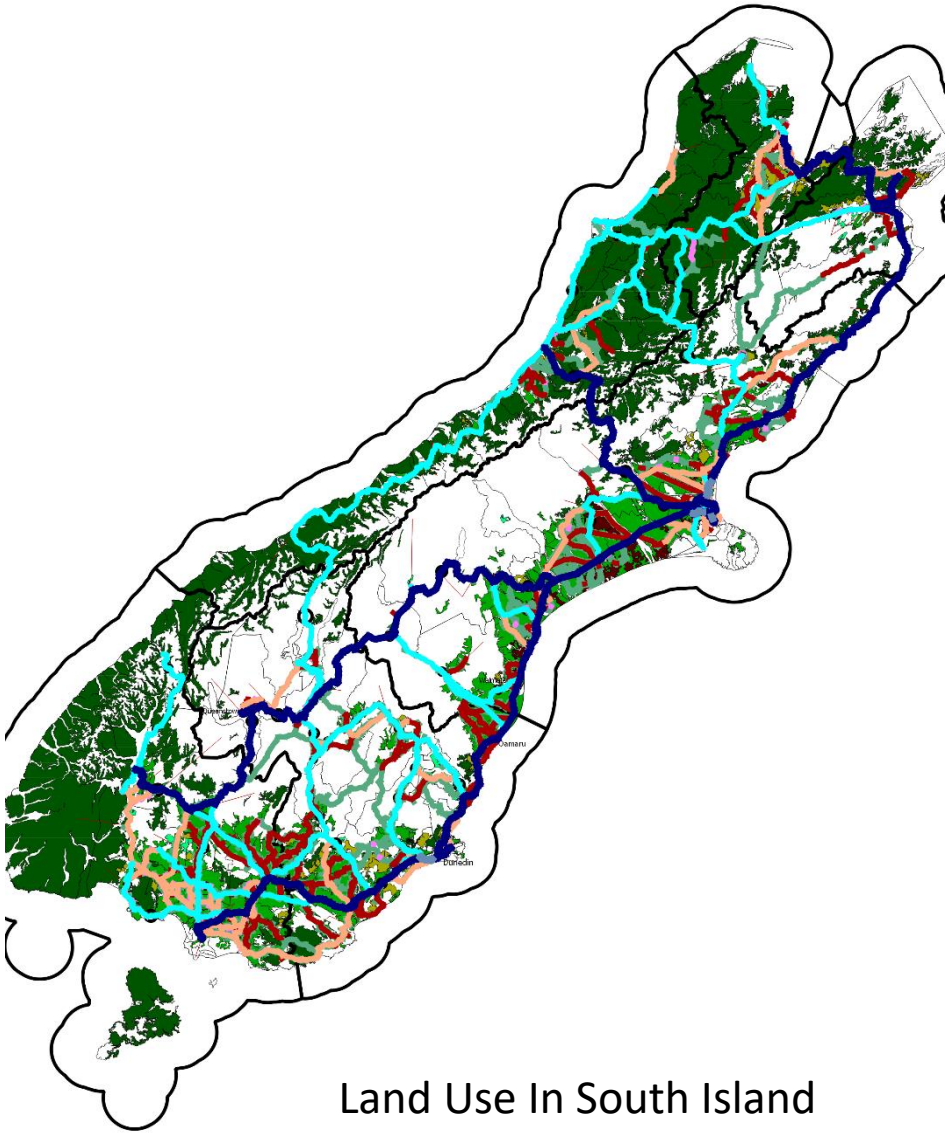
Total movements of 19 commodities in million tonnes

- Liquid Milk (1)
- Manufactured Dairy (2)
- Logs (1)
- Timber Products (2)
- Waste (1)
- Wool
- Fish (2)
- Livestock (1)
- Meat and meat byproducts (1)
- Horticulture and other agriculture (2)
- Coal (1)
- Petroleum
- Limestone, cement, fertilisers (2)
- Aggregates (1)
- Steel and aluminium
- Other minerals
- Manufacturing, retails, and general freight (2)

Heavy Vehicle Trips

- Utilised Data:
  - Geographic units or business location
  - Employee count
  - Population
  - NZ Land Use GIS Shapefile (Grassland, cropland, landfills, forests, quarries, coal, …)

- Tourism Trips (HV) 1% of Tourism Trips (LV)



Land Use In South Island

Source	Organisation	Details	Description
Land Use and Carbon Analysis System (LUCAS) Land Use Map (LUM)	Ministry of Environment	Natural forest	Areas since 1 January 1990
		Pre-1990 planted forest	Areas on 1 January 1990
		Post-1989 forest	Includes post-1989 planted forest
		Grassland – high producing	grassland with high-quality pasture species
		Cropland – perennial	all orchards and vineyards
		Cropland – annual	• all annual crops • all cultivated bare ground
Business Demography Tables	NZ Stat	A014 Sheep, Beef Cattle and Grain Farming	Liquid milk movements
		A03 Forestry and Logging	Log movements
		C141 timber dressing	Timber Movements
		C149 Other Wood Products	Timber Movements
		C111 Meat and Meat Product Manufacturing	Meat and Meat Product movements
		C114 Fruit and Vegetable Processing	Horticulture and other agriculture
		A020 Aquaculture	Fish Movements
		C112 Seafood Processing	Fish Movements
		C203 Cement, Lime, Plaster and Concrete Product Manufacturing	Limestone, cement and fertiliser movements
Land Information New Zealand (LINZ)	LINZ	NZ Topo50 land cover data	NZ Landfill Polygons (Topo, 1:50k)
			NZ Mine Polygons (Topo, 1:50k)
			NZ Quarry Polygons (Topo, 1:50k)
National Freight Demand Study	MOT	19 different commodities	Movements in million tonnes between regions
Livestock Movements	MOT	Number of movements of livestock between territorial local authorities (TLAs)	

Commodity	Data for Generation	Data for Attraction
Liquid Milk movements	(A014 Sheep, Beef Cattle and Grain Farming) and (Grassland – high producing)	Processors
Milk and Dairy Products	Processors	Population or ports
Log, Timber and Wood Products Movements	C141 timber dressing	(C149 Other Wood Products) or (Ports)
	Forest Areas	Ports
Livestock Movements	(A014 Sheep, Beef Cattle and Grain Farming) and (Grassland – high producing)	(A014 Sheep, Beef Cattle and Grain Farming) and (Grassland – high producing)
Meat and Meat Products Movements	C111 Meat and Meat Product Manufacturing	Ports
Horticulture and other agriculture Movements	Croplands	(C114 Fruit and Vegetable Processing) or (Ports)
Fish Movements	C112 Seafood Processing	Ports
	A020 Aquaculture	C112 Seafood Processing
Coal Movements	No. of Mines	Ports
Movements of Aggregate	No. of Quarry	Population
Movements of Limestone, Cement, Fertiliser	ports	C203 Cement, Lime, Plaster and Concrete Product Manufacturing
	C203 Cement, Lime, Plaster and Concrete Product Manufacturing	Population
Waste Movements	Landfills	Population
Total Manufacturing and Retail Movements	Population and business units	Population and business units

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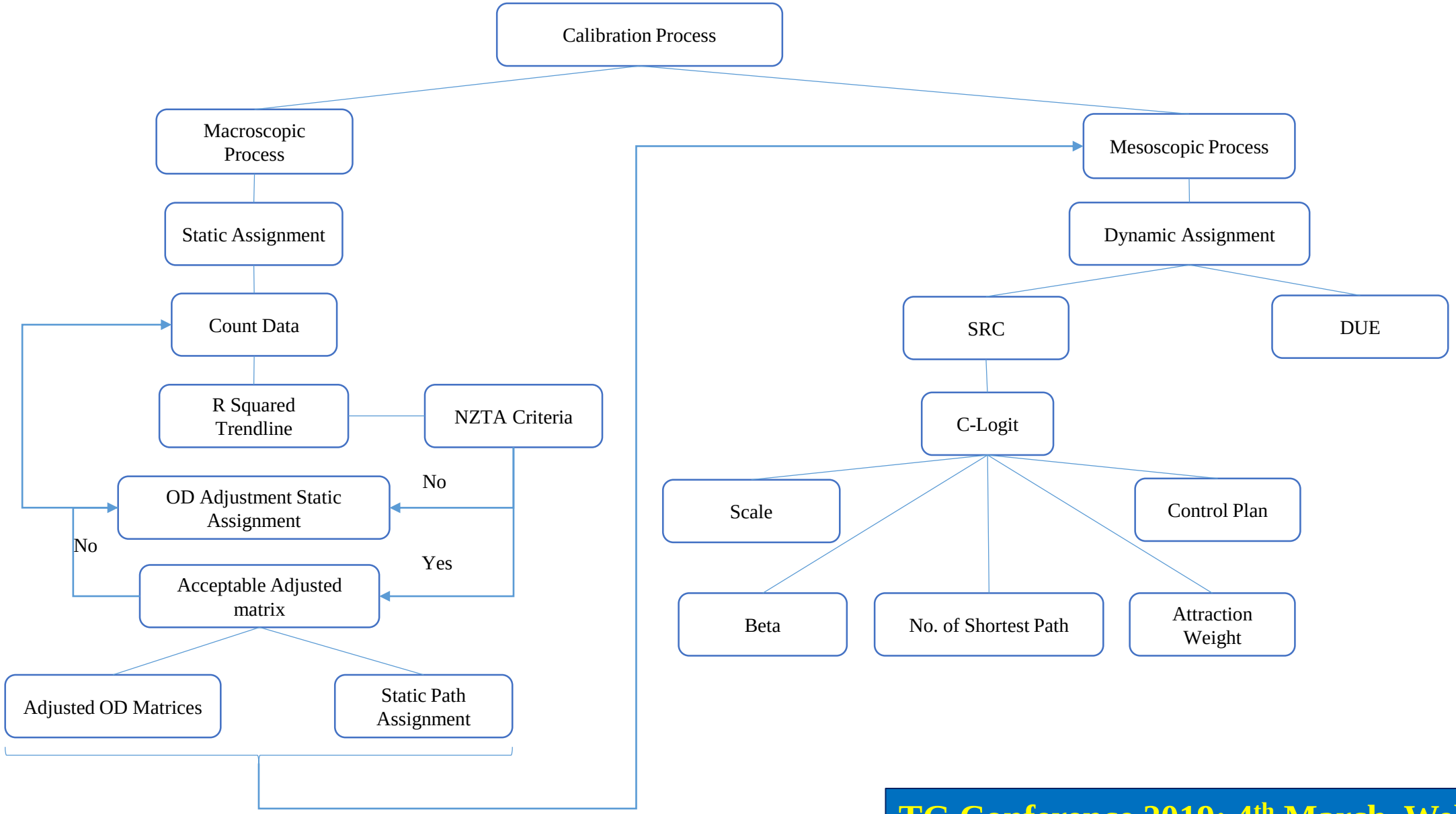
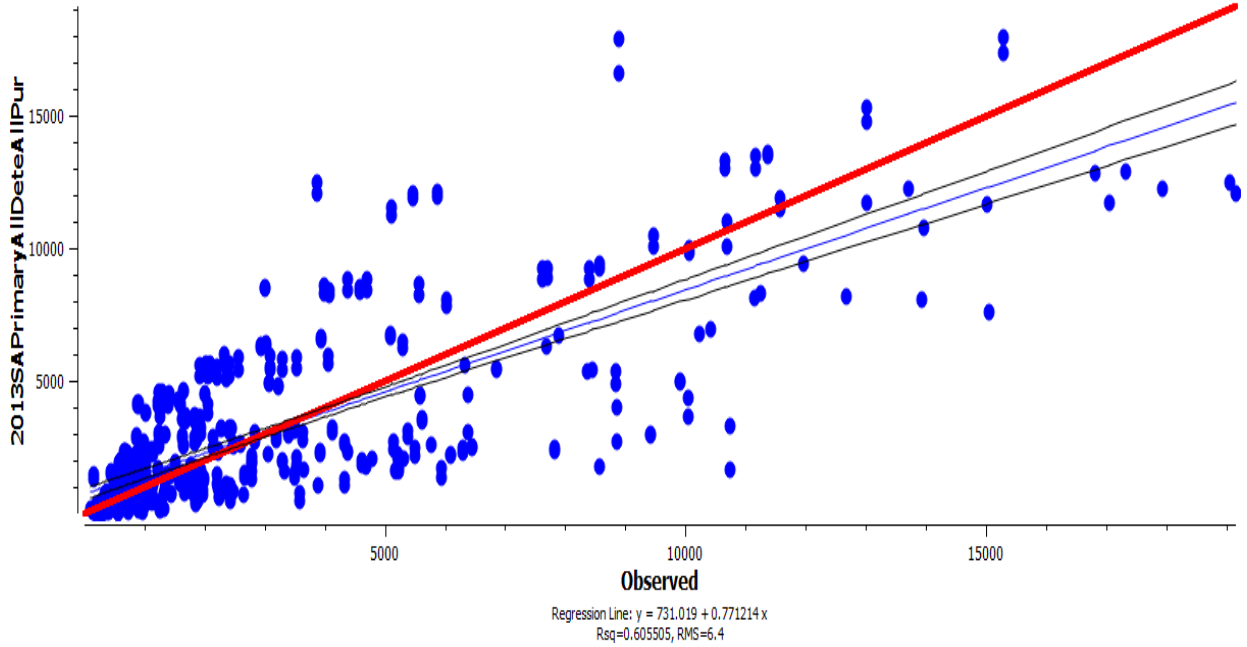
19 Freight Matrices and One Tourism Matrix


Calibration Process
Macroscopic Process
Static Assignment
Count Data
R Squared Trendline
NZTA Criteria
No
OD Adjustment Static Assignment
No
Yes
Acceptable Adjusted matrix
Adjusted OD Matrices
Static Path Assignment
Mesoscopic Process
Dynamic Assignment
SRC
DUE
C-Logit
Scale
Control Plan
Beta
No. of Shortest Path
Attraction Weight

Static Assignment (Source Matrix) 2013

- Total Commuter Trips: 323,484
- Total Tourism Trips: 68,097
- Total Freight Trips (Heavy Vehicles): 16,778
- All Detectors (622)
- Frank and Wolfe Assignment
- Speed Reduction at Urban Areas
- R Square: 60.5%



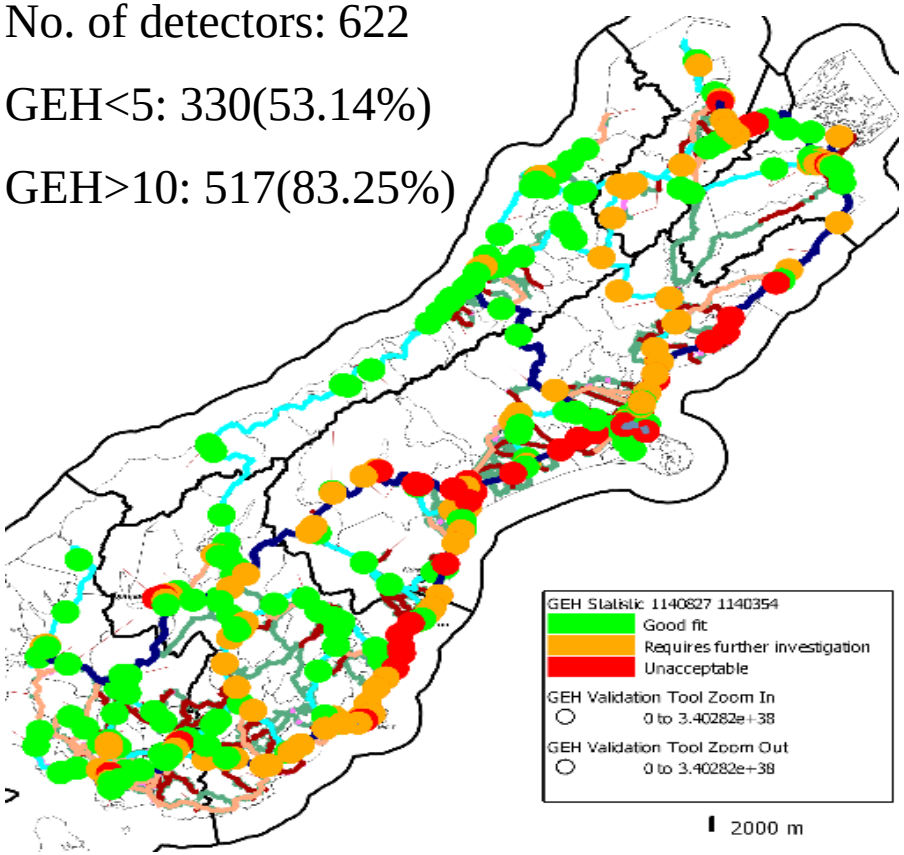
Static Assignment (Source OD)

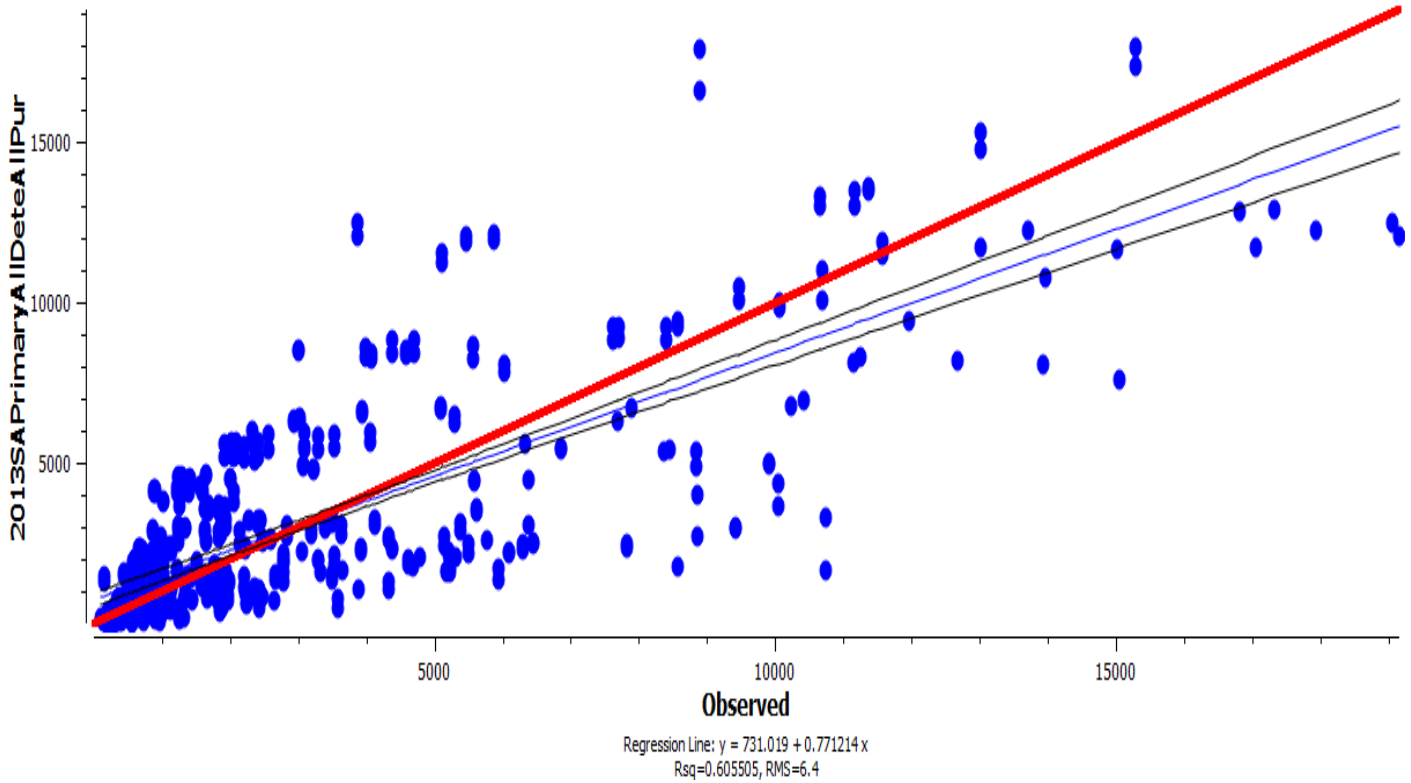
Static Assignment (Source Matrix) 2013

No. of detectors: 622

GEH<5: 330(53.14%)

GEH>10: 517(83.25%)

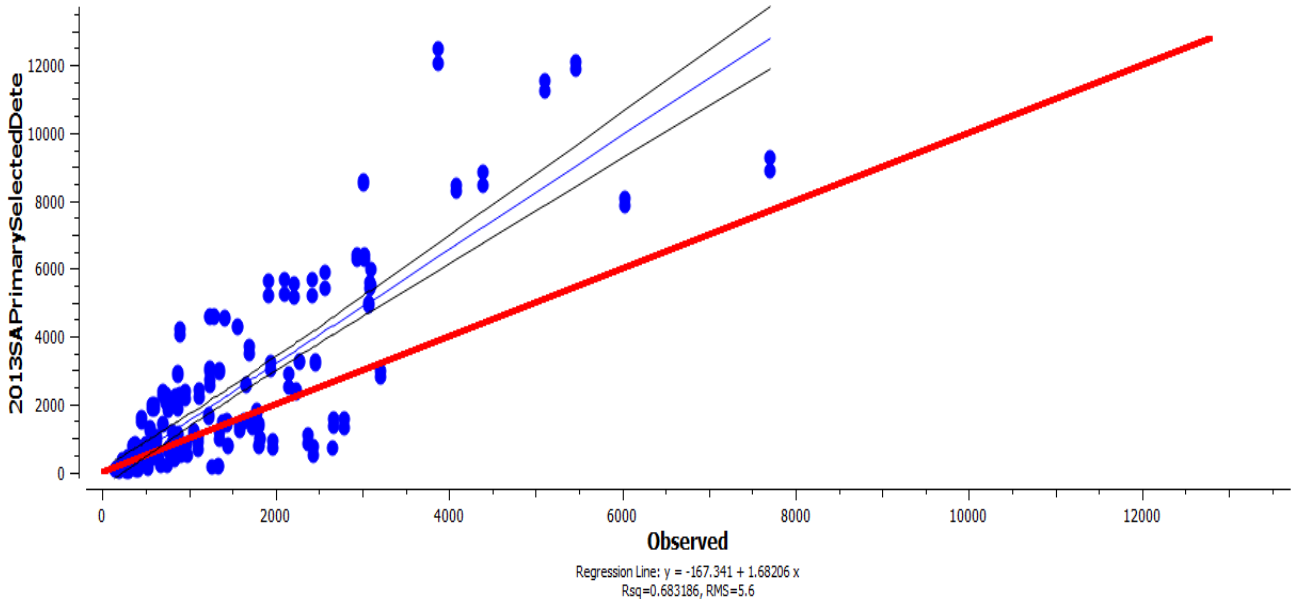




Static Assignment (Source OD)

Static Assignment (Source Matrix) 2013

- Total Commuter Trips: 323,484
- Total Tourism Trips: 68,097
- Total Freight Trips (Heavy Vehicles): 16,778
- Selected Detectors (250)
- Frank and Wolfe Assignment
- Speed Reduction at Urban Areas
- R Square: 68.3%



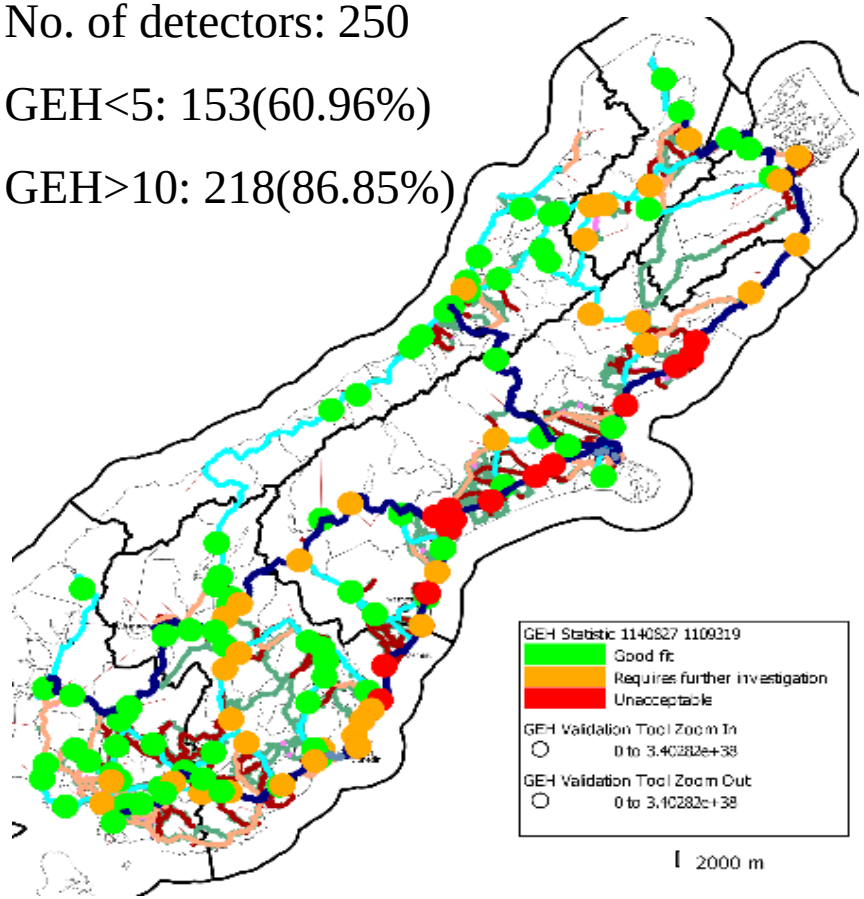
Static Assignment (Source OD)

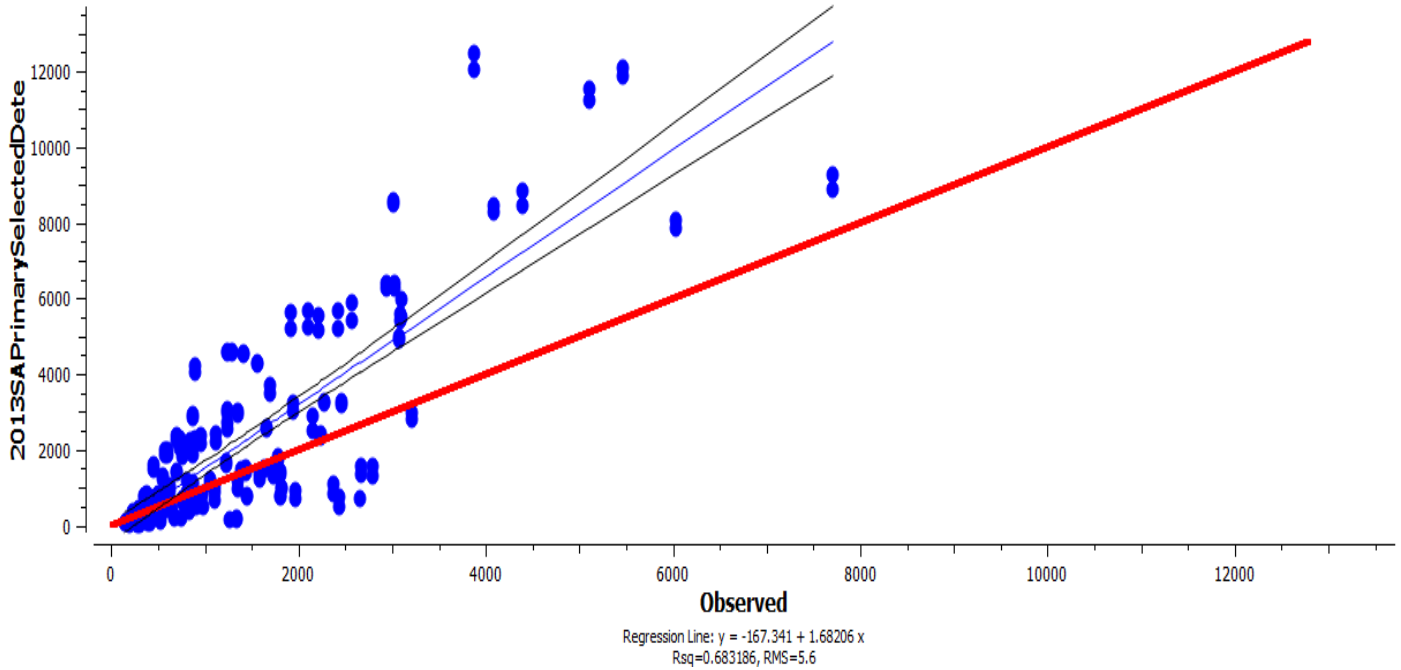
Static Assignment (Source Matrix) 2013

No. of detectors: 250

GEH<5: 153(60.96%)

GEH>10: 218(86.85%)

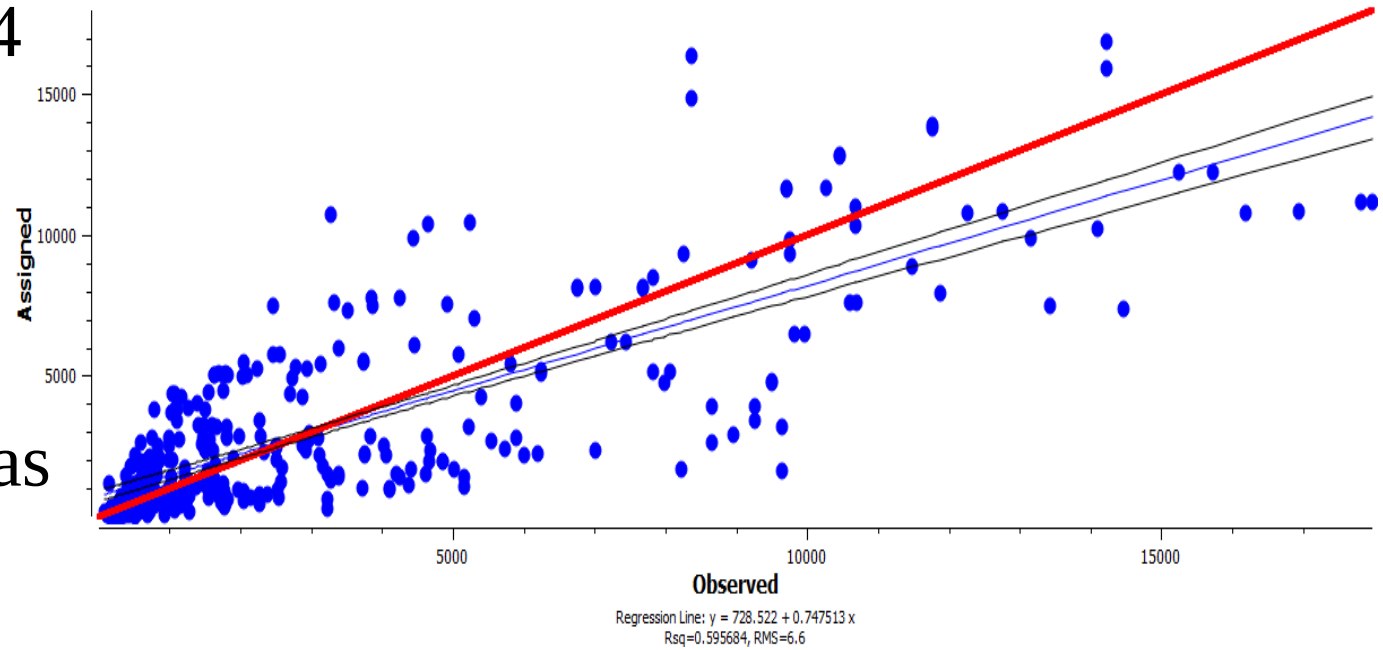




Static Assignment (Source OD)

Static Assignment (LV Source OD) 2013

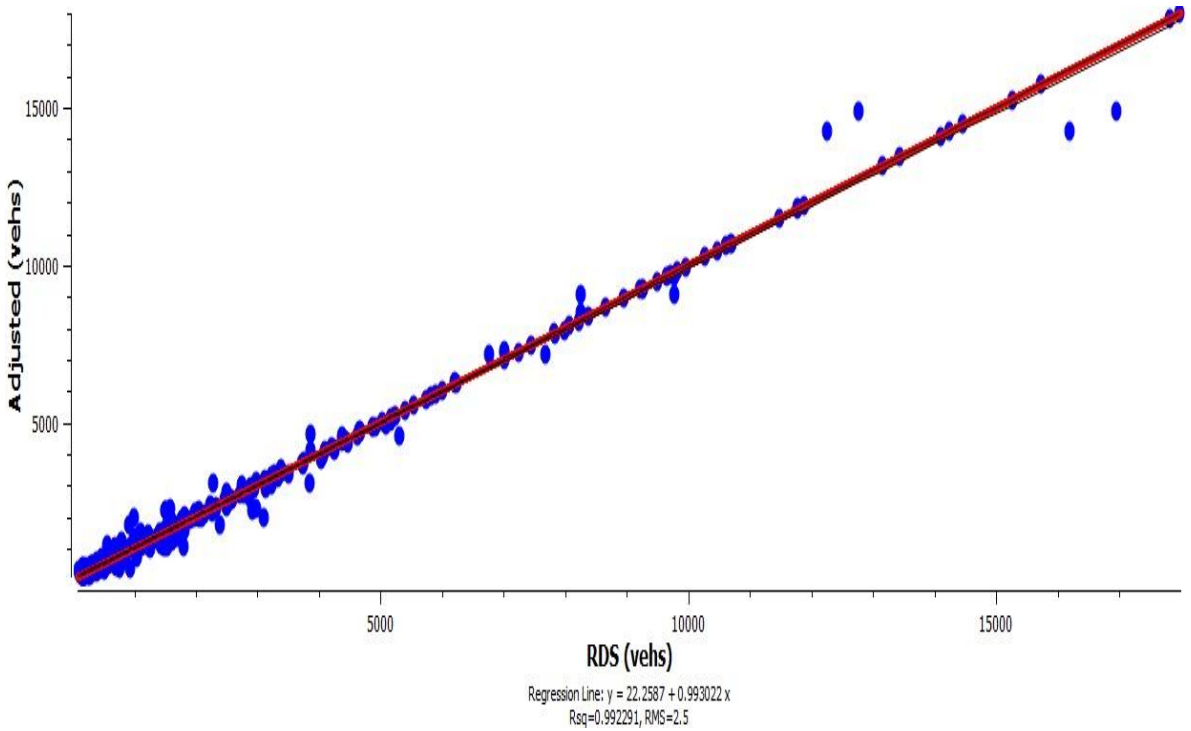
- Total Commuter Trips: 323,484
- Total Tourism Trips: 68,097
- Source OD matrix
- Frank and Wolfe Assignment
- Speed Reduction at Urban Areas
- R Square: 59.6%



Static Assignment (LV: Tourism; Commuters)

Static Assignment (LV Adjusted OD) 2013

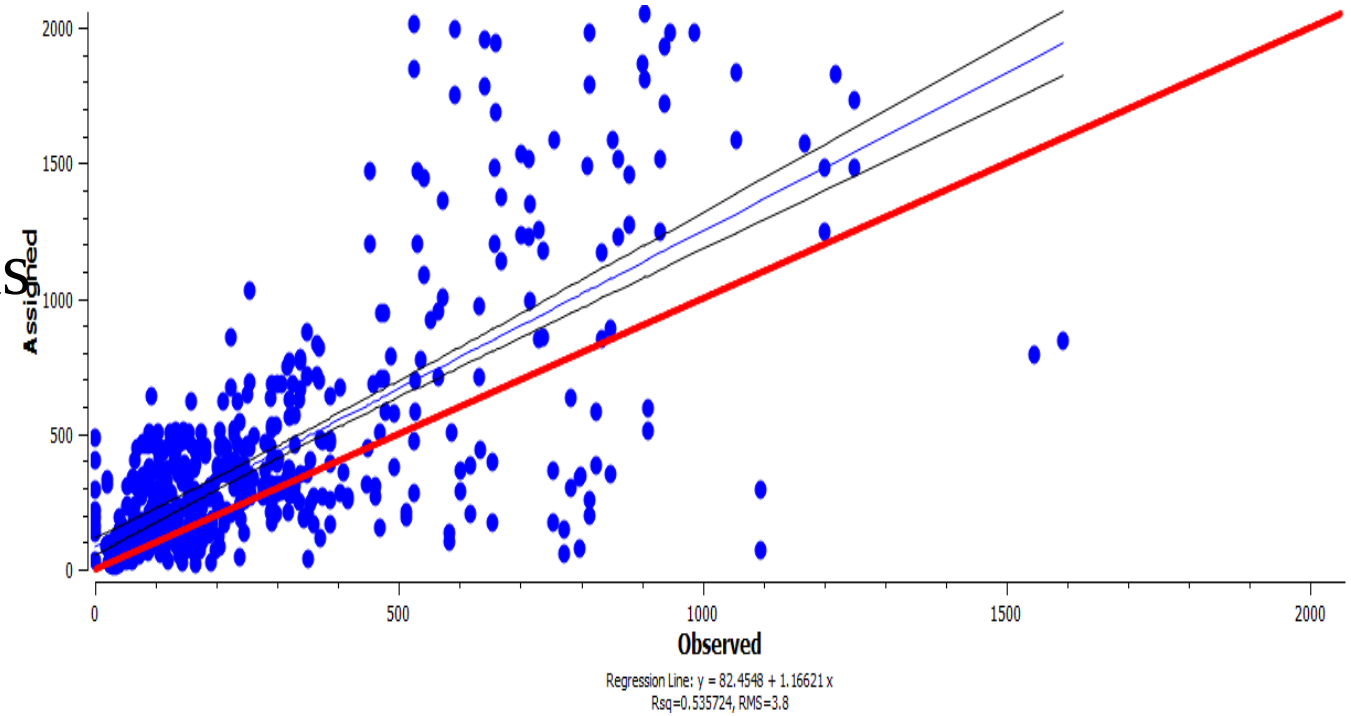
- Adjusted OD matrix
- Frank and Wolfe Assignment
- Speed Reduction at Urban Areas
- Total Commuter Trips: 521,837
- Total Tourism Trips: 64,178
- R Square: 99.2%



Static Assignment (LV: Tourism; Commuters)

Static Assignment (HV Source OD) 2013

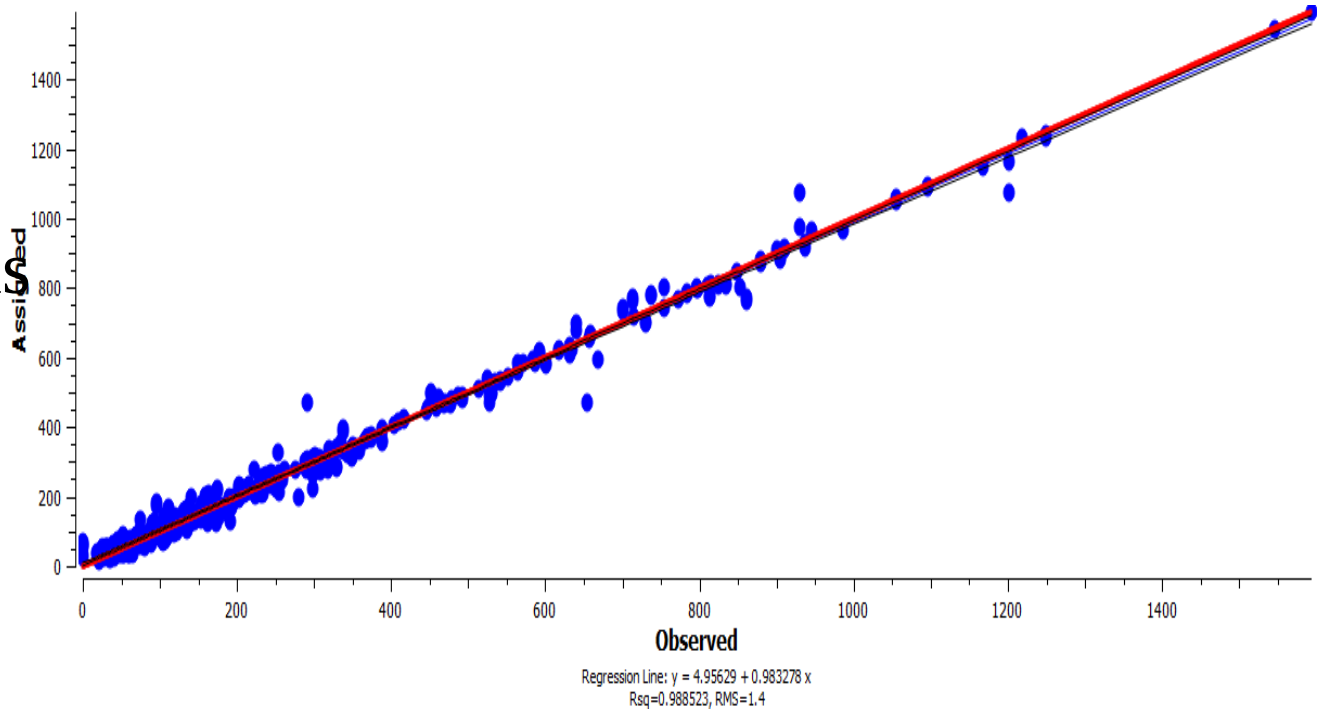
- Source OD matrix
- Frank and Wolfe Assignment
- Speed Reduction at Urban Areas
- Total Freight Trips (Heavy Vehicles): 16,778
- R Square: 53,6%



Static Assignment (HV: Freight, Tourism)

Static Assignment (HV Adjusted OD) 2013

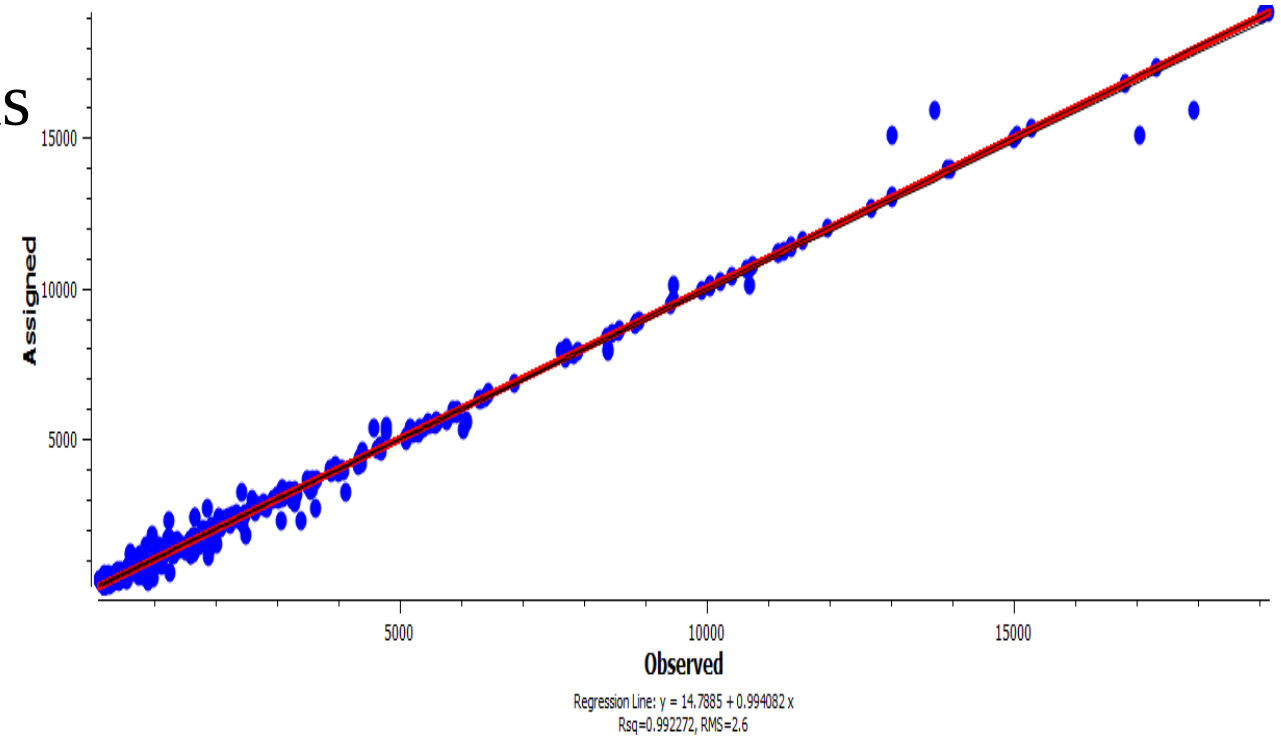
- Adjusted OD matrix
- Frank and Wolfe Assignment
- Speed Reduction at Urban Areas
- Total Freight Trips (Heavy Vehicles): 28,207
- R Square: 98.8%



Static Assignment (HV: Freight, Tourism)

Static Assignment (All Purposes Adj.) 2013

- Frank and Wolfe Assignment
- Speed Reduction at Urban Areas
- Total Commuter Trips: 52,1837
- Total Tourism Trips: 64,178
- Total Freight Trips (Heavy Vehicles): 28,207
- R Square: 99.2%



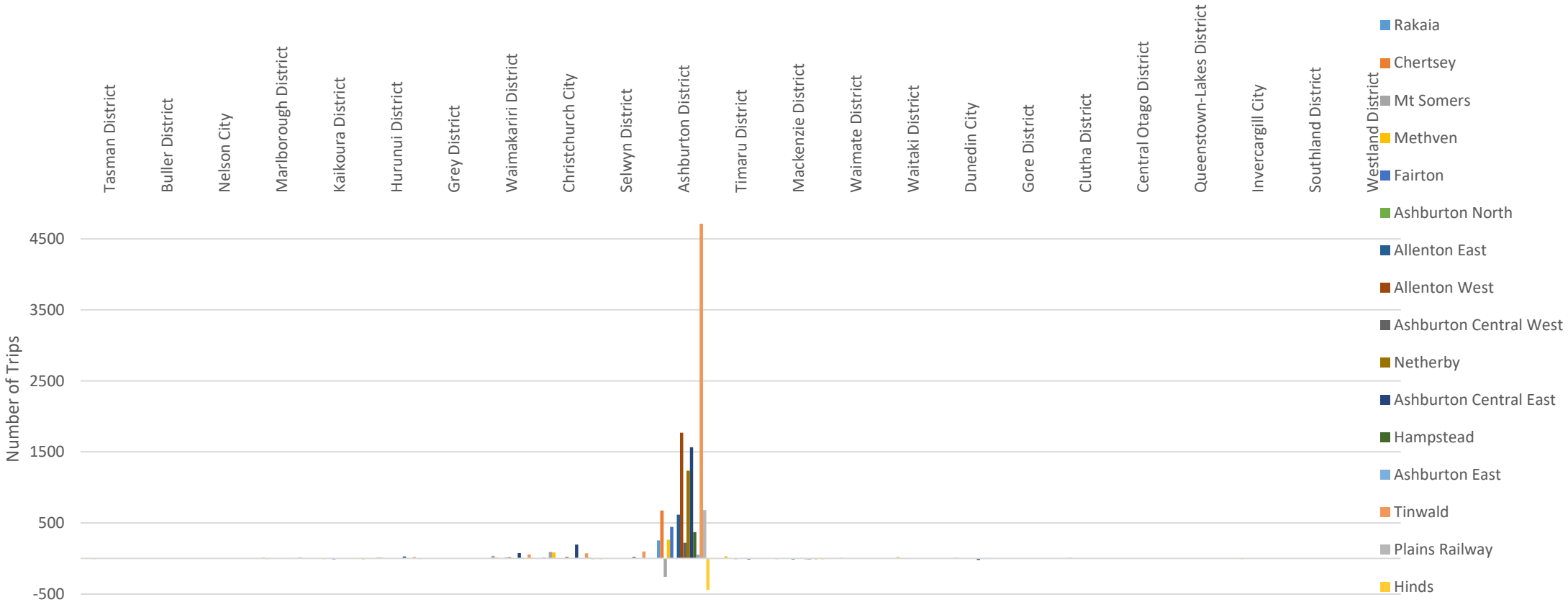
Static Assignment (All Purposes)

Summary of Static OD Adjustment

Purpose	Source Trips	Adjusted Trips	R2 source	R2 Adjusted	Explanation	
Commuting	323,484	516,217	59.6	99.2	59.6%	47.2%
Tourism	68,097	65,082			-4.4%	-0.7%
Freight	16,779	25,790	53.6	98.8	53.7%	2.2%
Total	408,360	607,089	-	-	48.7%	48.7%
R2	60.5	99.2	NA	NA	622 Detector	
R2	68.3	NA	NA	NA	250 Detector	

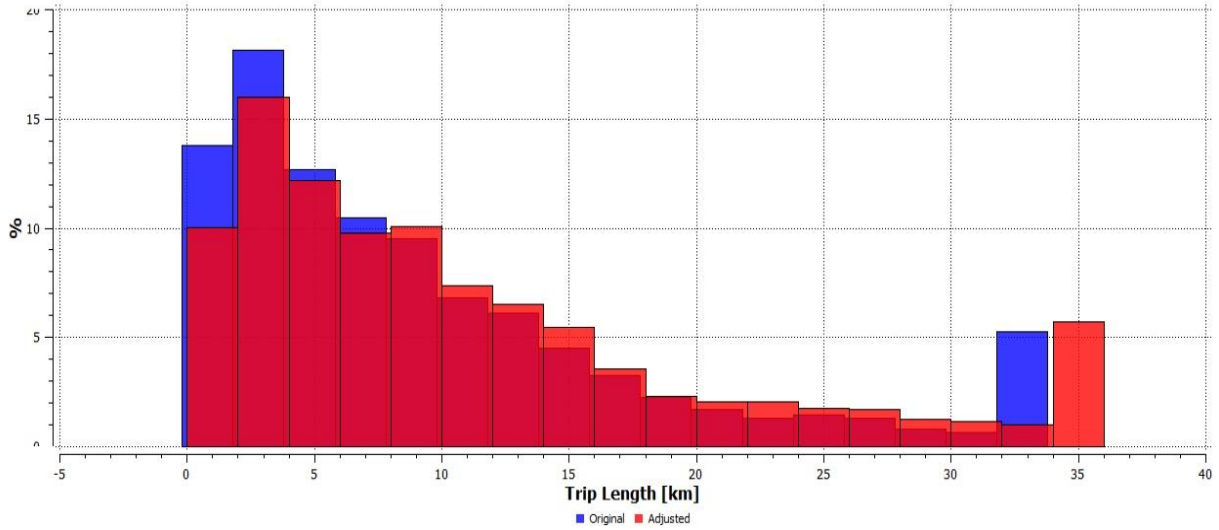
LV OD Adjustment

Variation of Source and Adjusted OD matrix for Ashburton District on LV Movements

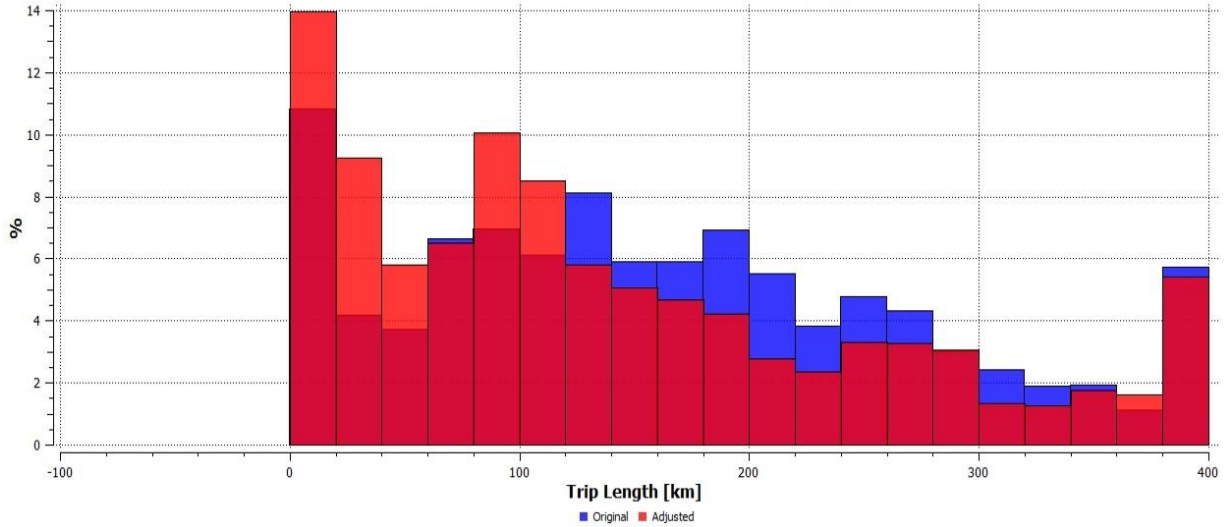


Trip Length Distribution

Commuting Trip Length Distribution

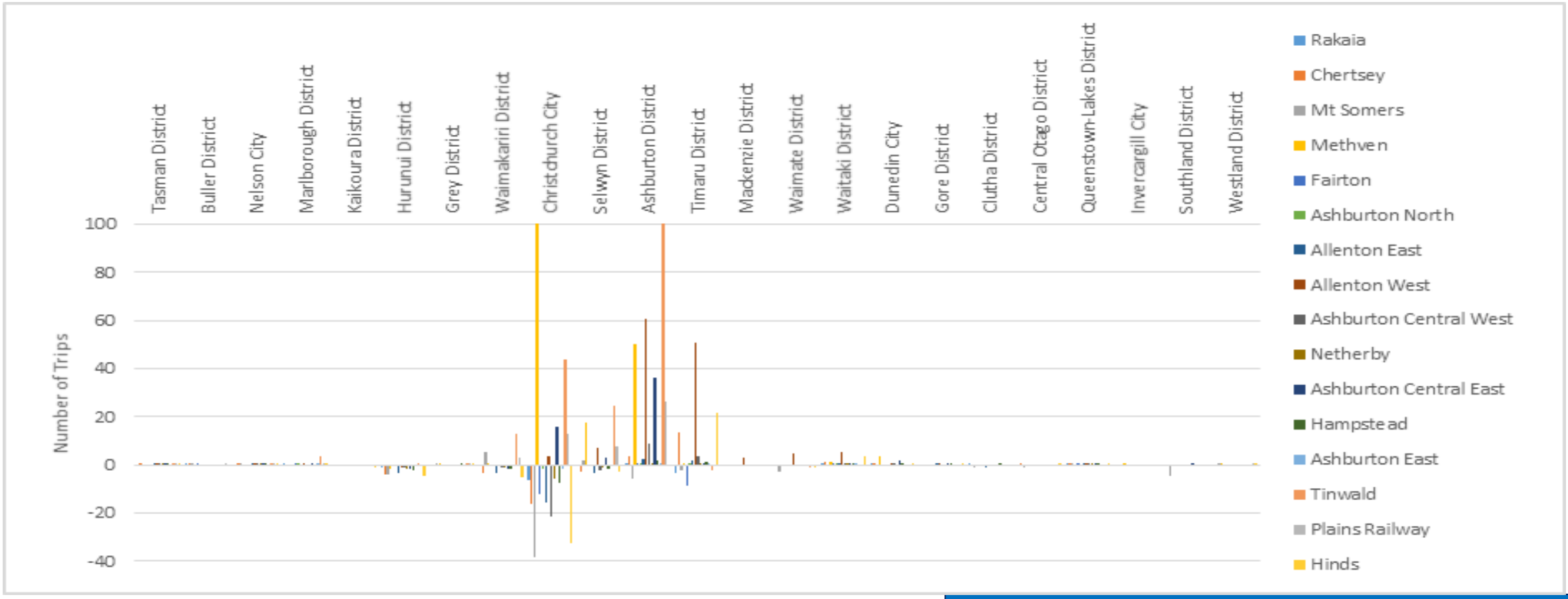


Tourism Trip Length Distribution



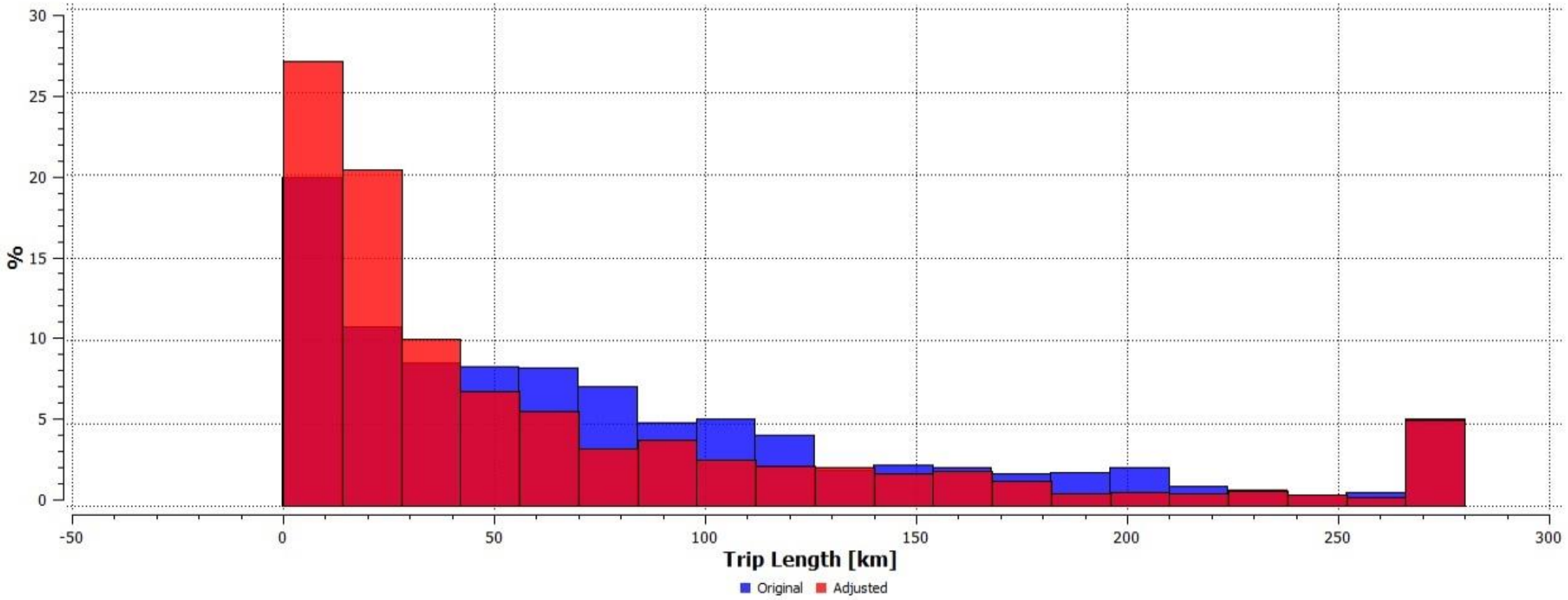
HV OD Adjustment

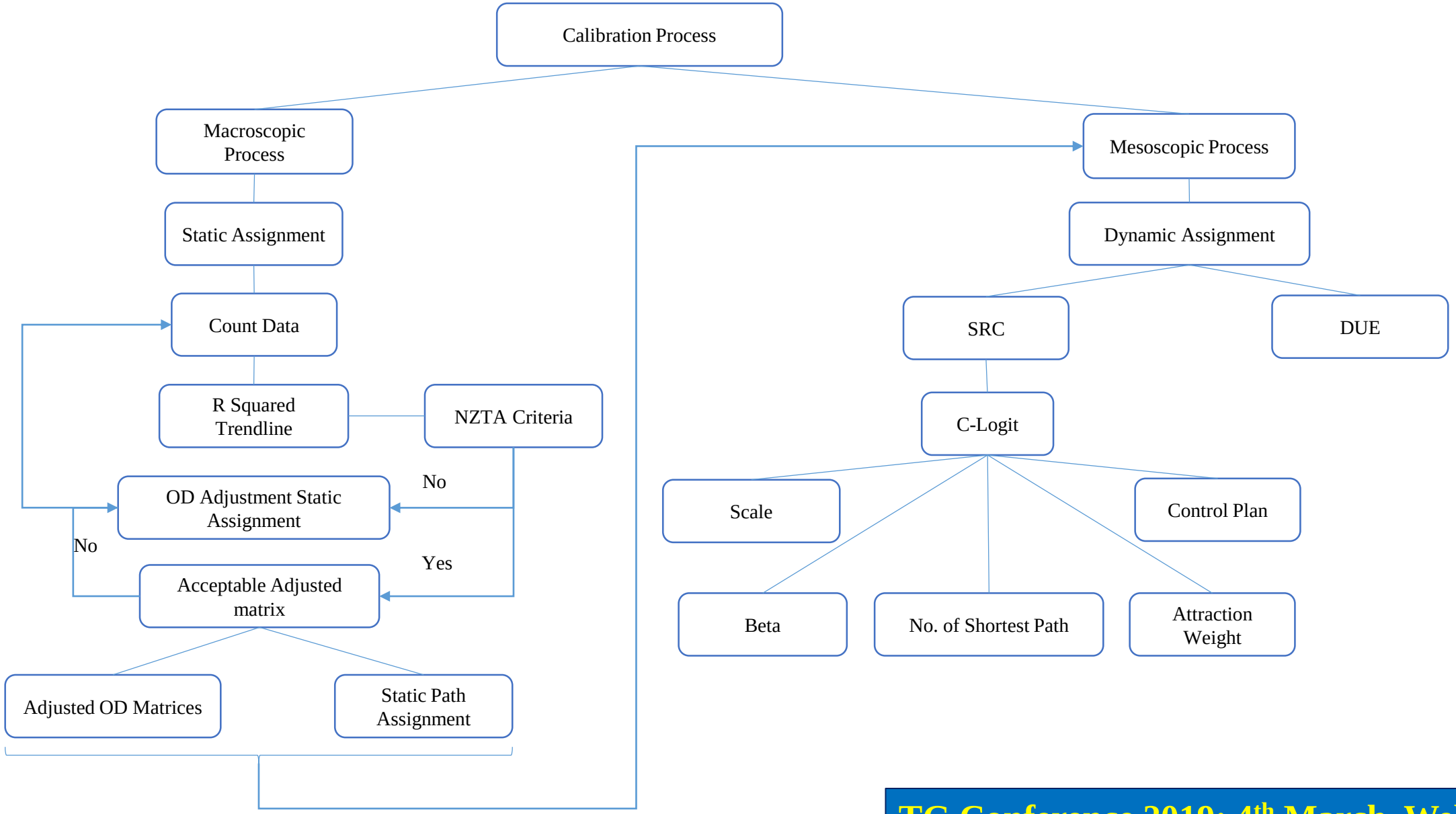
Variation of Source and Adjusted OD matrix for Ashburton District on HV Movements



Trip Length Distribution

Heavy Vehicle Trip Length Distribution




Calibration Process
Macroscopic Process
Static Assignment
Count Data
R Squared Trendline
NZTA Criteria
No
OD Adjustment Static Assignment
No
Yes
Acceptable Adjusted matrix
Adjusted OD Matrices
Static Path Assignment
Mesoscopic Process
Dynamic Assignment
SRC
DUE
C-Logit
Scale
Control Plan
Beta
No. of Shortest Path
Attraction Weight

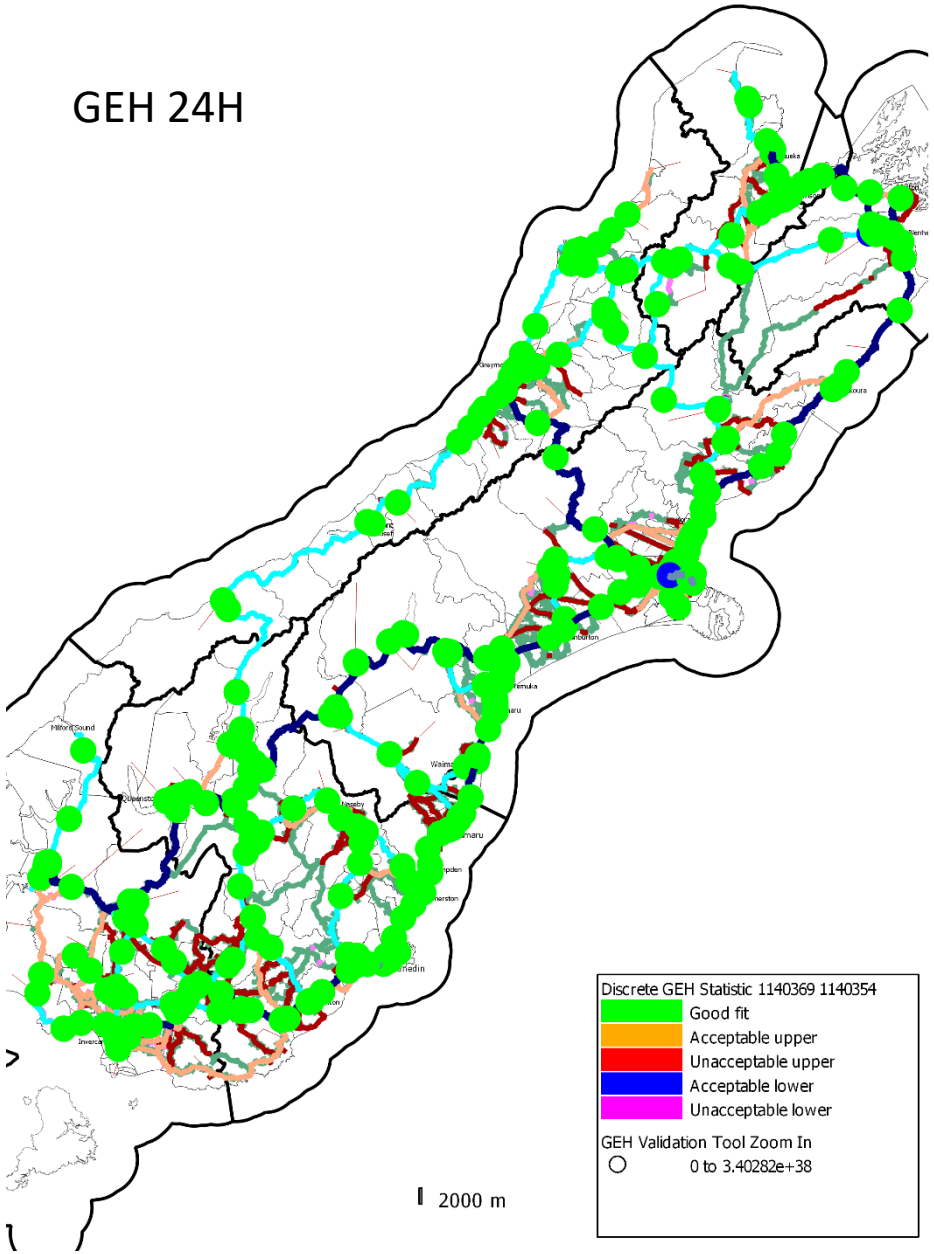
Meso Calibration Issue

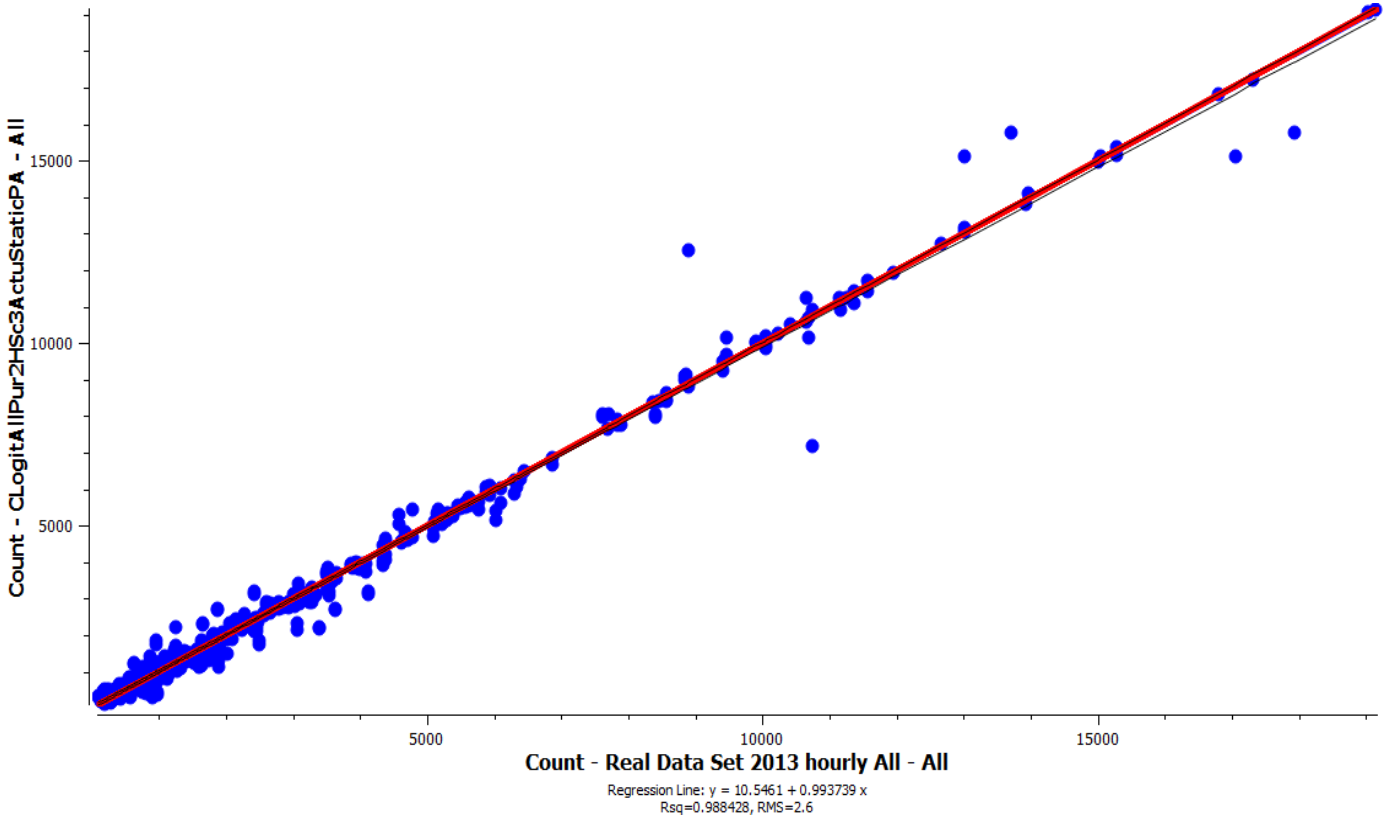
- Issues:
  - Waiting vehicles to enter to the network
  - Mean virtual queue
- Solution:
  - Coding to find centroids with long virtual queue
  - Changing centroid connections
  - Route choice option

Meso Scenario (2013)

- warm-up for 2H,
- Path assignment of static assignment for main path
- Using C-Logit model for SRC assignment, enroute after virtual queue
- Number of Short Path (K-SP) = 2
- Scale = 3
- Attractiveness Weight = 0
- One hour costs cycle
- Arrival: Exponential

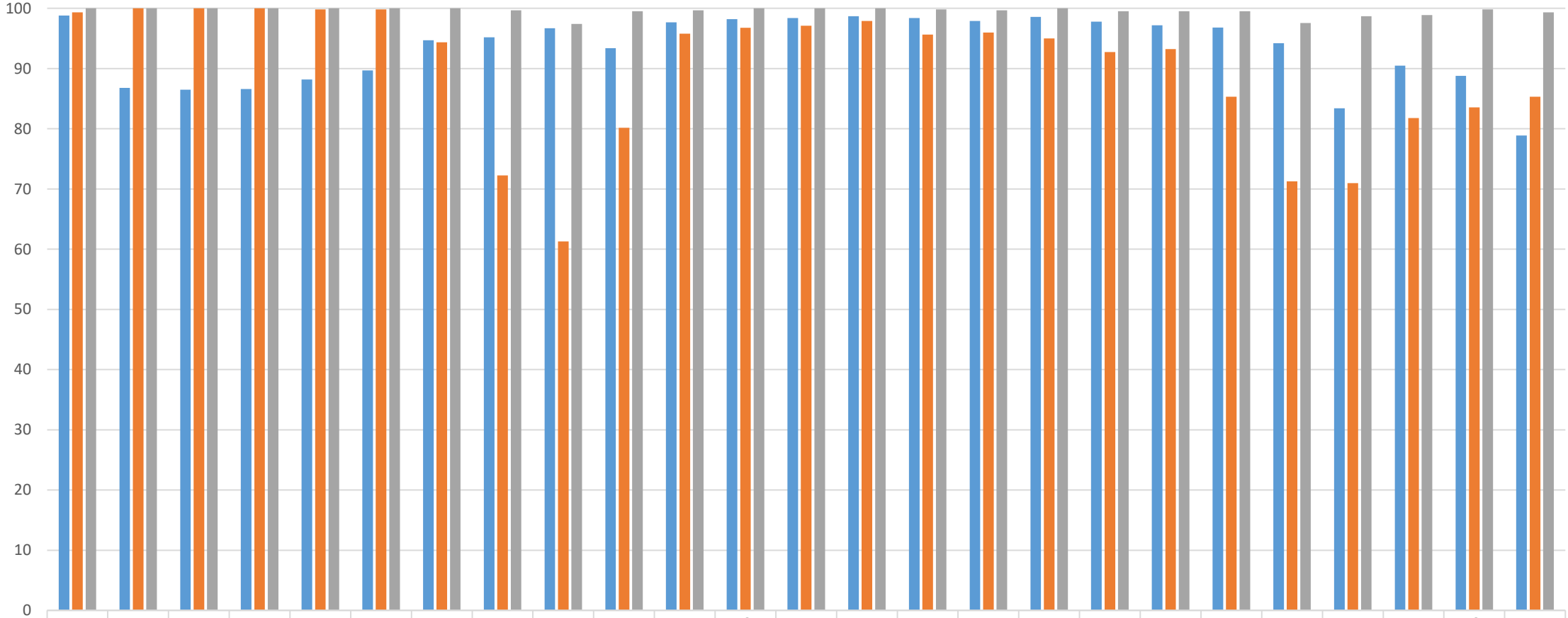
GEH 24H





R Square: 98.8%
GEH < 5: 99.52% (617)
GEH < 10: 100%

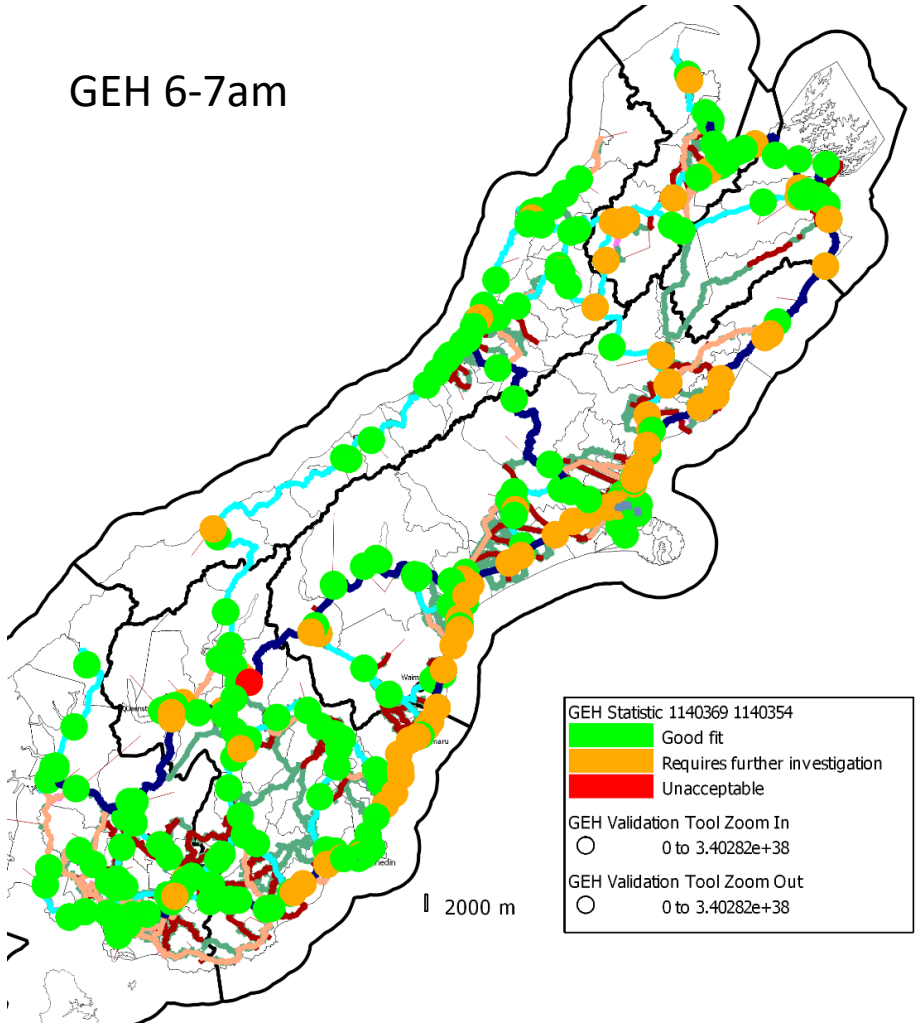
GEH Hourly 2013



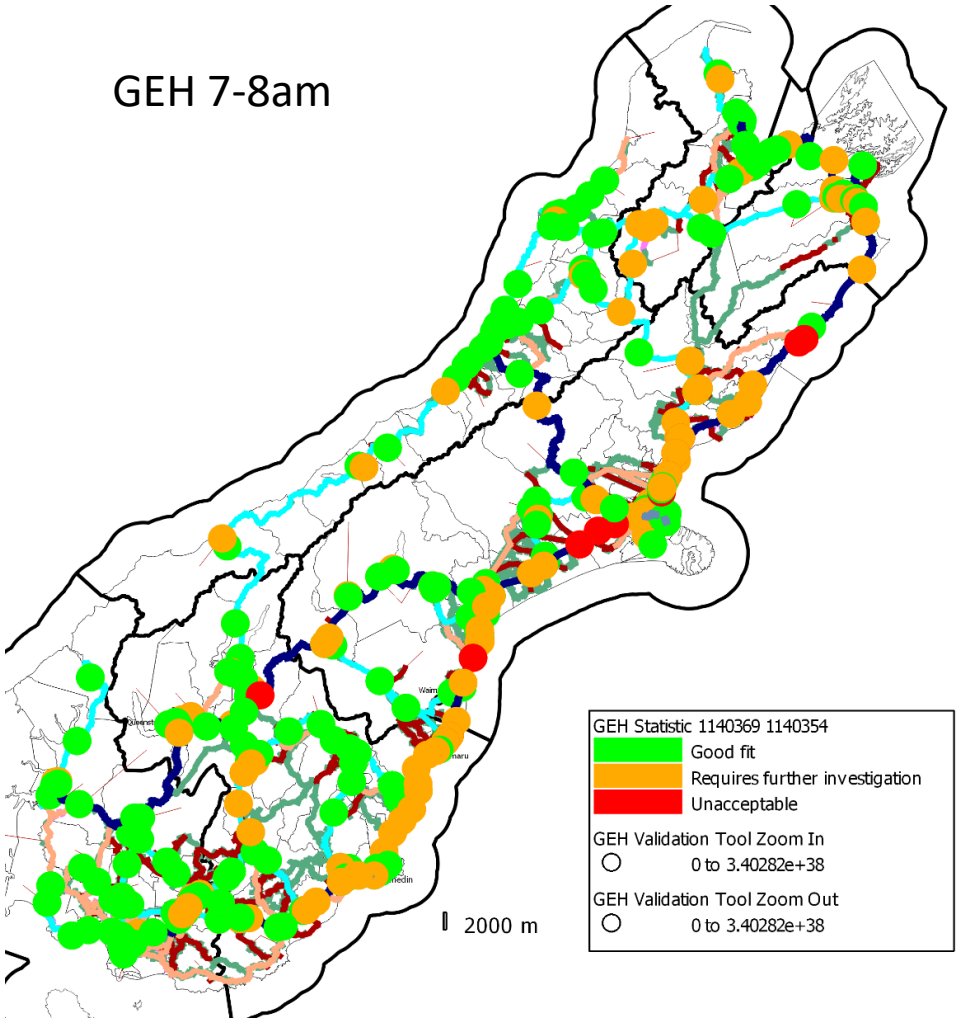
	24H	12-1am	1-2am	2-3am	3-4am	4-5am	5-6am	6-7am	7-8am	8-9am	9-10am	10-11Am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	6-7pm	7-8pm	8-9pm	9-10pm	10-11pm	11-12am
R Square	98.8	86.8	86.5	86.6	88.2	89.7	94.7	95.2	96.7	93.4	97.7	98.2	98.4	98.7	98.4	97.9	98.6	97.8	97.2	96.8	94.2	83.4	90.5	88.8	78.9
GEH<5	99.35	100.00	100	100	99.84	99.84	94.35	72.26	61.29	80.16	95.81	96.77	97.1	97.9	95.65	95.97	95	92.74	93.23	85.32	71.29	70.97	81.77	83.55	85.32
GEH<10	100	100	100	100	100	100	100	99.68	97.42	99.52	99.68	100	100	100	99.84	99.68	100	99.52	99.52	99.52	97.58	98.71	98.87	99.84	99.35

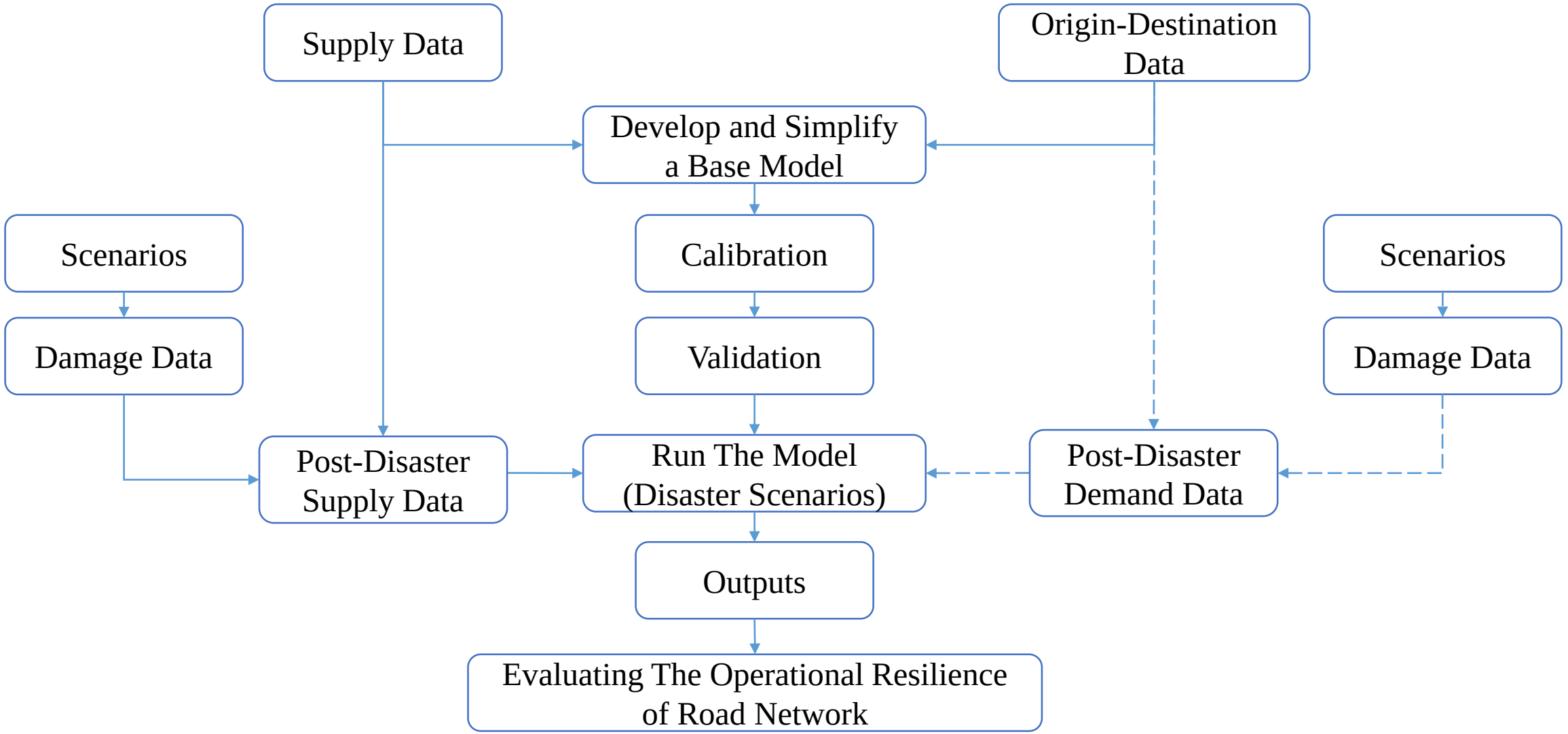
GEH Hourly 2013

GEH 6-7am



GEH 7-8am




Supply Data
Origin-Destination Data
Develop and Simplify a Base Model
Scenarios
Calibration
Scenarios
Damage Data
Validation
Damage Data
Post-Disaster Supply Data
Run The Model (Disaster Scenarios)
Post-Disaster Demand Data
Outputs
Evaluating The Operational Resilience of Road Network

Thank You
Comments
Questions?

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