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

ENGINEERING
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

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Operational Resilience Assessment of a Rural Road Network

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Disaster Impact

- NZ disaster impact
- EM-DAT The International Disaster Database website
- 2000-2016 natural hazard summary data

Disaster type	Disaster subtype	Events count	Total deaths	Total affected	Total damage ('000 US$)
Drought	Drought	1	0	0	823,000
Earthquake	Ground movement	5	184	615,737	28,450,000
Epidemic	Viral disease	1	0	1	0
Extreme temperature	Heat wave	1	0	0	200,000
Flood	--	4	3	100	104,000
Flood	Flash flood	5	4	7250	320,000
Flood	Riverine flood	2	0	700	171,500
Storm	Convective storm	3	3	557	39,100
Storm	Tropical cyclone	1	0	300	0

2010 Canterbury Earthquake

- **4 September 2010**
- Magnitude 7.1 (M_L)
- Earthquake's epicenter was **40 kilometers west of Christchurch**, near the town of **Darfield**.
- 100 people were injured, no death
- Highway **bridges** generally performed well
- **NZTA retrofit programme** has been very successful
- NZTA had **$6 million** in damage

2011 Canterbury Earthquake

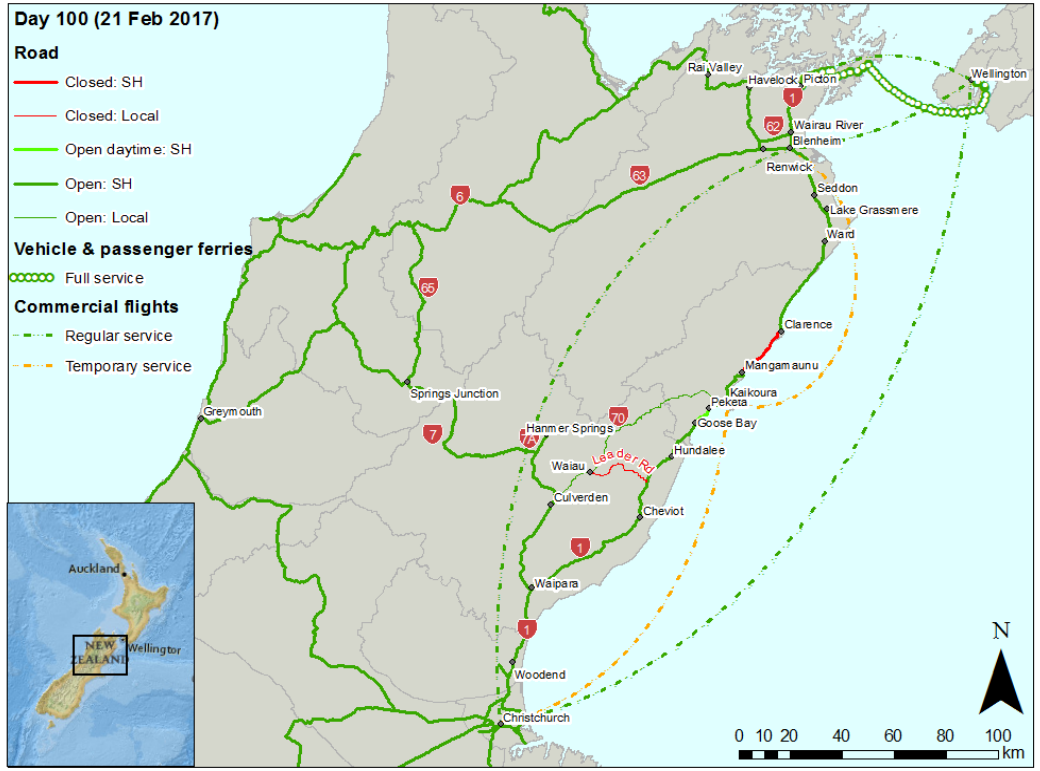
- **Tuesday 22 February 2011**
- Magnitude 6.3 (M_L)
- Killed 182 people
- Economic Impact: $40 billion (~17% NZ GDP)
- **Local roads**: 83 sections of 57 roads were closed.
- **Five of the 6 bridges** crossing the Lower Avon were **closed**, many **weight restriction** (Giovinazzi et al., 2011)
- NZTA had **$40 million** in damage(Eidinger and Tang, 2012)

2016 Kaikoura Earthquake

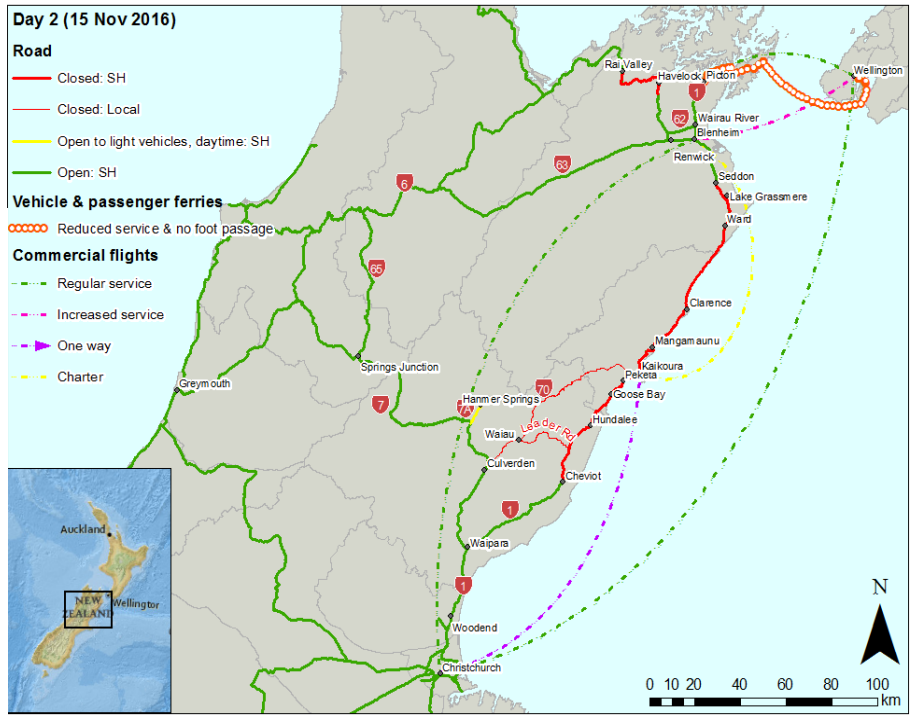
- Midnight on 14 Nov. 2016
- Magnitude 7.8 (MMS, M_W)
- 2 fatalities and 57 injuries
- At least **12 surface faults** ruptured on and offshore
- Initial estimates suggest between 80,000 and 100,000 **landslides**
- **Five landslides** were more than 1,000,000 m^3 in size

2016 Kaikoura Earthquake

- SH1 was by far the **shortest road route between Picton and Christchurch** at around 3 ½ hours, with the closest State Highway alternative route taking around 6 ½ hours.



Level-of-service on Day 100 (21st February 2017) *(Davis, et al, 2017)*.

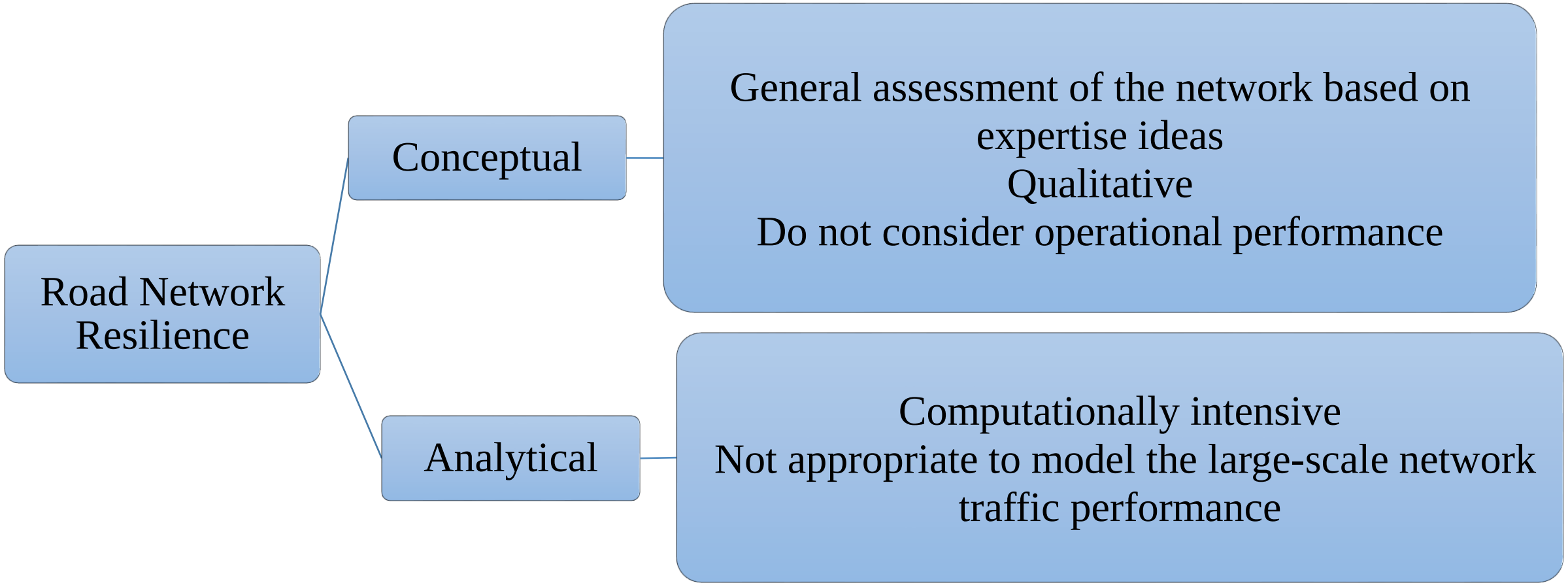


Level-of-service on Day 2 (15th November 2016) (Davis, et al, 2017)

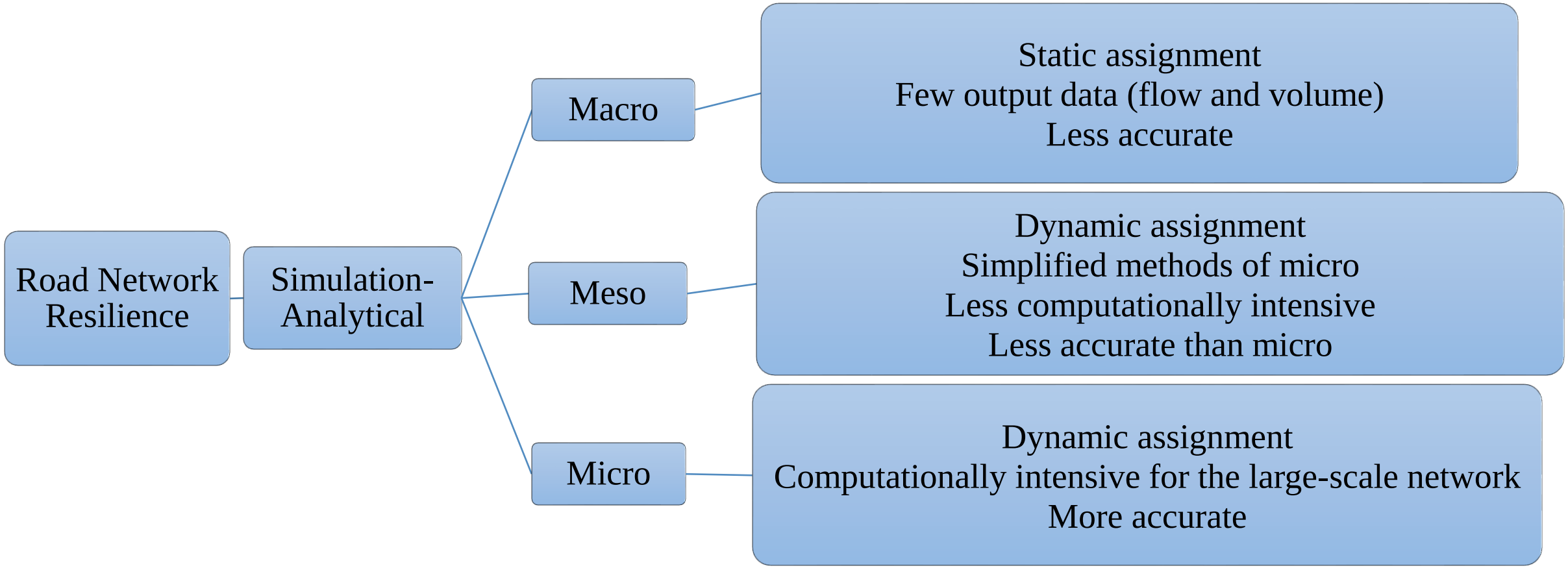
Literature Review

Concept	Definition
Vulnerability	"A susceptibility that can result in considerable reductions in road network serviceability". (Berdica, 2002)
Resilience	Treasury's National infrastructure plan (NIP): The capacity of public, private and civic sectors to **withstand** disruption, **absorb** disturbance, **act** effectively in a crisis, **adapt** to changing conditions, including climate change, and **grow** over time.

Literature Review



Literature Review



Aim and Objectives

- **Main Aim:**
- Assess the **operational resilience** of a **rural road network** in the South Island, New Zealand, in the event of a **major earthquake**.
- **Objectives:**
  - Development of a framework and performance measures to evaluate resilience of rural road network in an event of disasters
  - Development and application of a hybrid simulation approach to model post-disaster transport network performance
  - Evaluation of transport network operational performance for potential earthquake scenarios

Methodology

Supply Data

Study Area

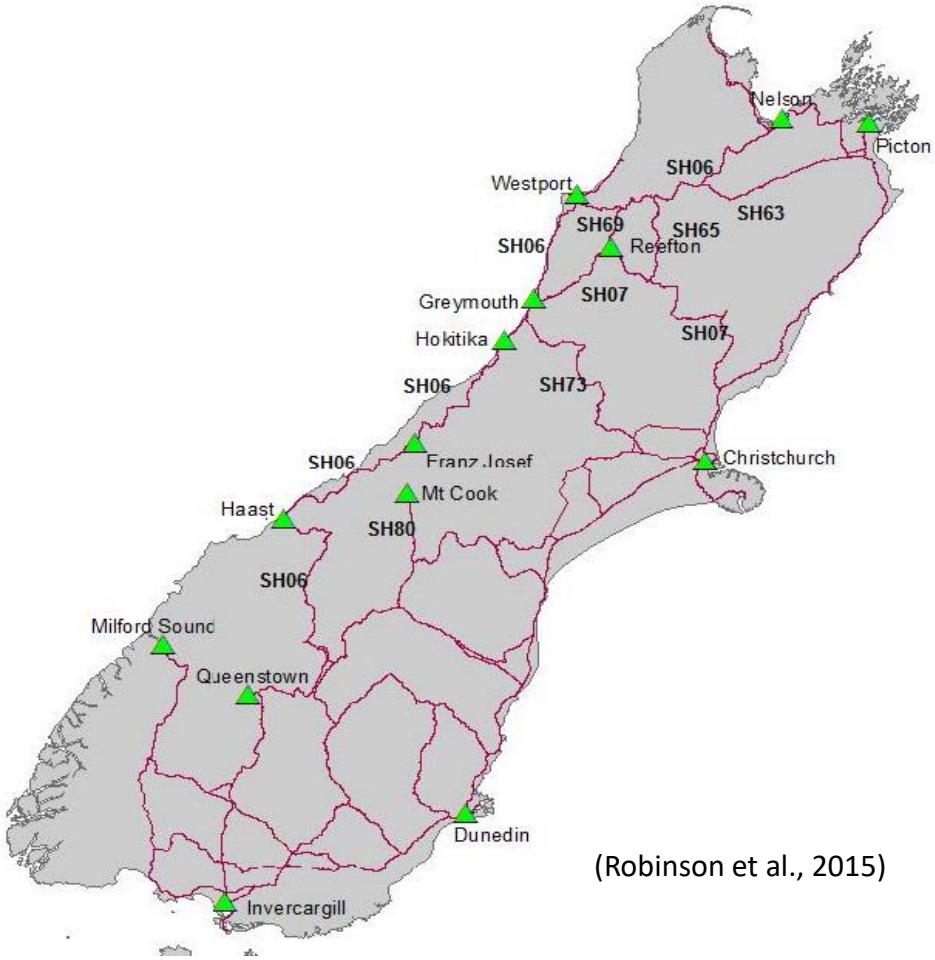
Origin-Destination Data

Study Area

- **Population** of South Island: 1,004,400 (2013 census)
- **Seven regions and 23 Districts** (Canterbury, Otago, Southland, West Coast, Malborough, Nelson, and Tasman)

Road Network

- The South Island State Highway network comprises **long, thin** corridor routes with **little redundancy**; there are **only three routes** that cross the Southern Alps **connecting the east and west** coasts (Robinson et al., 2015).
- **Mining, agriculture, and tourism**

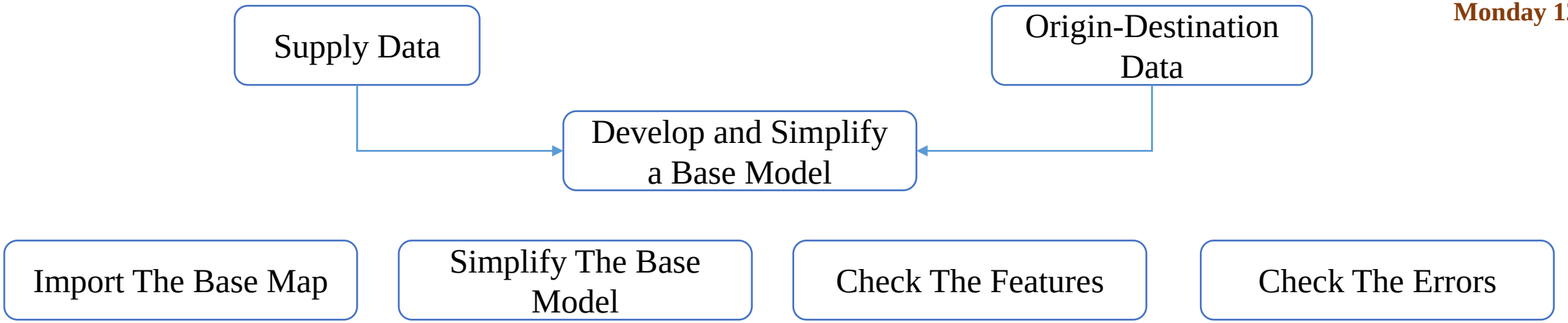


(Robinson et al., 2015)

Required Data

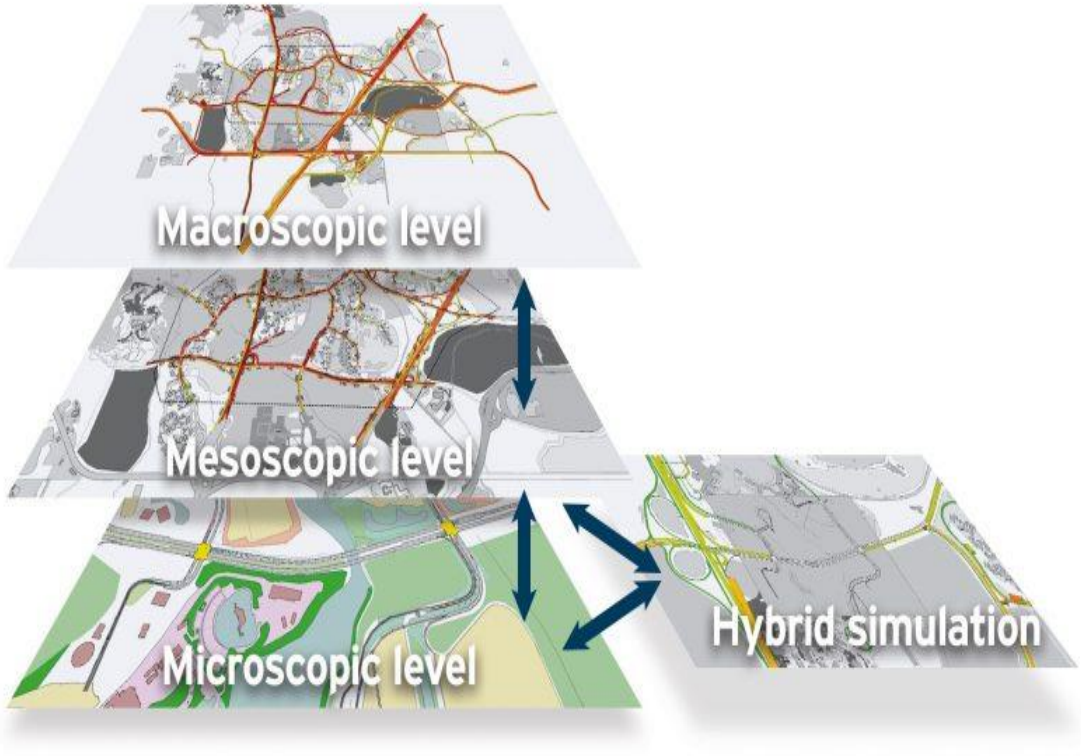
	Modelling Steps	Types of Data
Data Requirements	Development	• Road network map • GIS centreline of road network • RAAM data (# of lanes, grade, speed limit) • Capacity, Jam density • Signal control data • OD matrix • Inter-city travel time profile
	Creating the OD matrix	• Population of cities • Number of tourists • Number of freight • Export and import value • Number of paid employees • Number of business locations • Total households • Traffic count data

Methodology



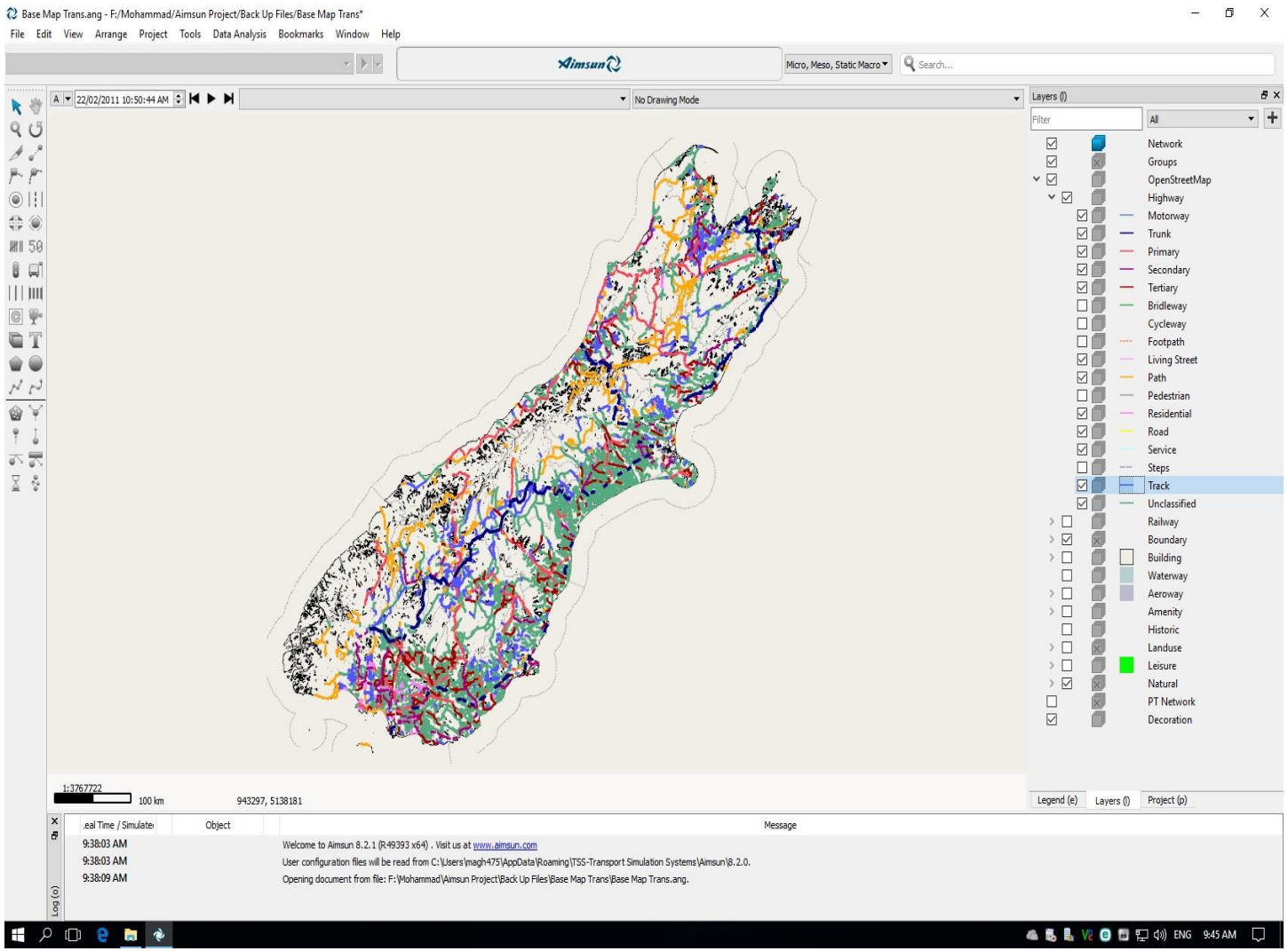
AIMSUN

The AIMSUN hybrid simulator gives **simultaneous microscopic and mesoscopic** simulation, allowing to **model large areas** while zooming in on all areas that require a finer level of detail.



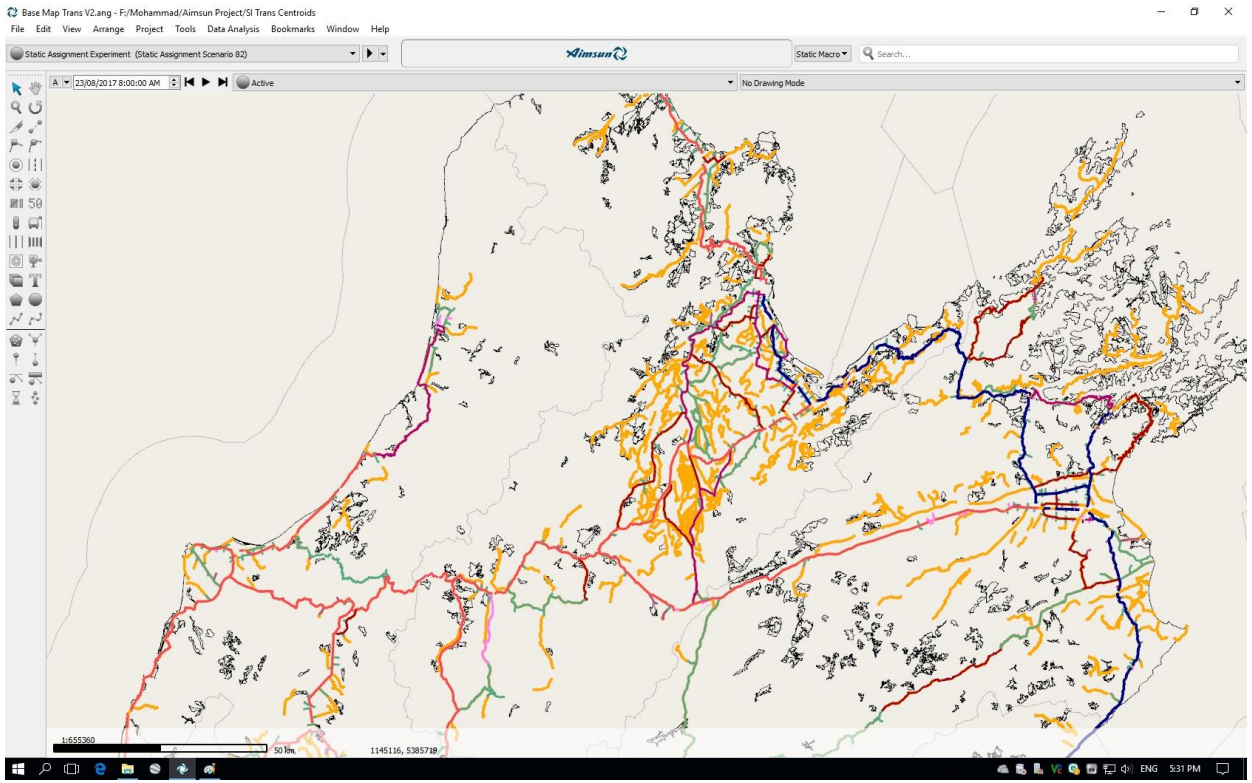
Model Development

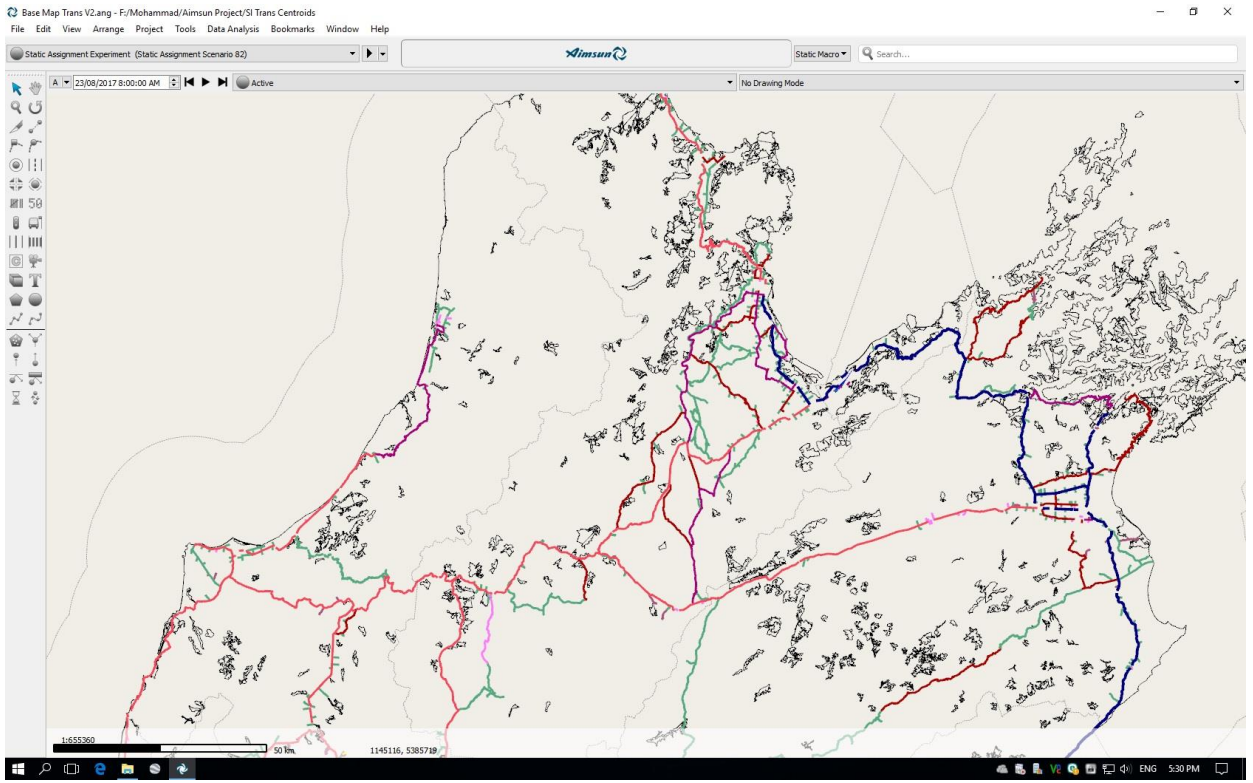
- Open Street Map (OSM) file
- New Zealand road centerline GIS shapefile
- Check the features



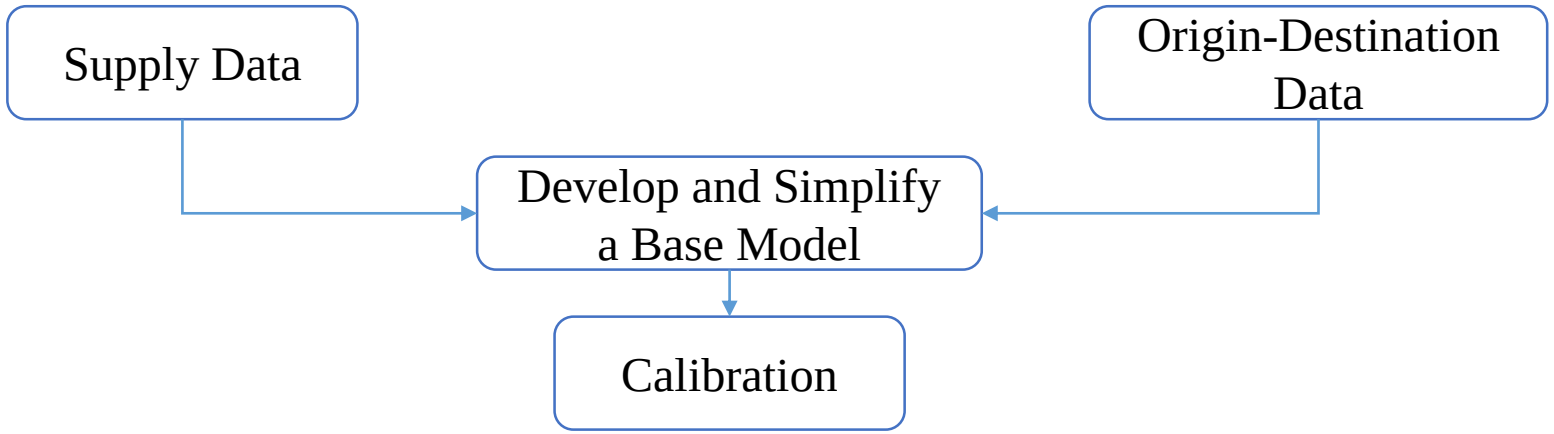
Model Simplification

- Urban/Rural
- NZTA One Network Road Classification (ONRC)
- Google Earth and google Map





Methodology

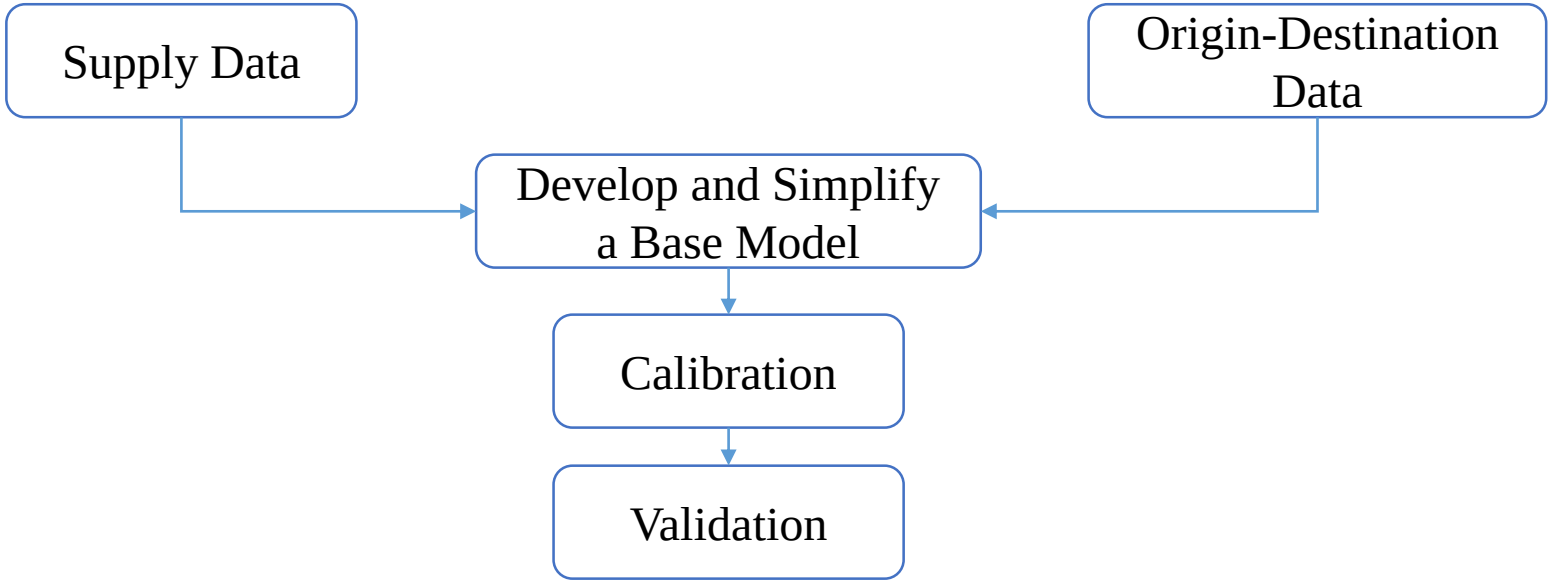


Calibration

- Calibration the network on macroscopic level
- Calibration the network on mesoscopic level
- Calibration the network on hybrid level

- Count data
- Goodness of fit
- NZTA Transport model development guidelines

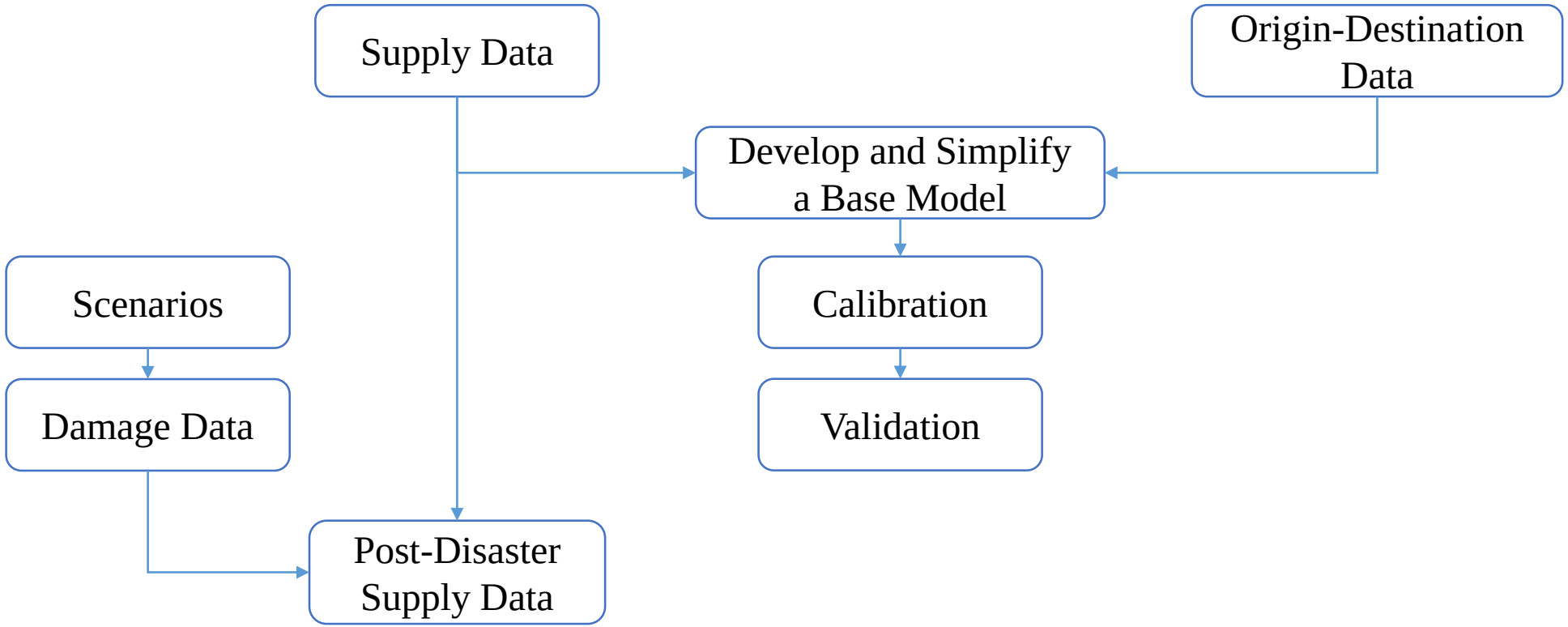
Methodology



Validation

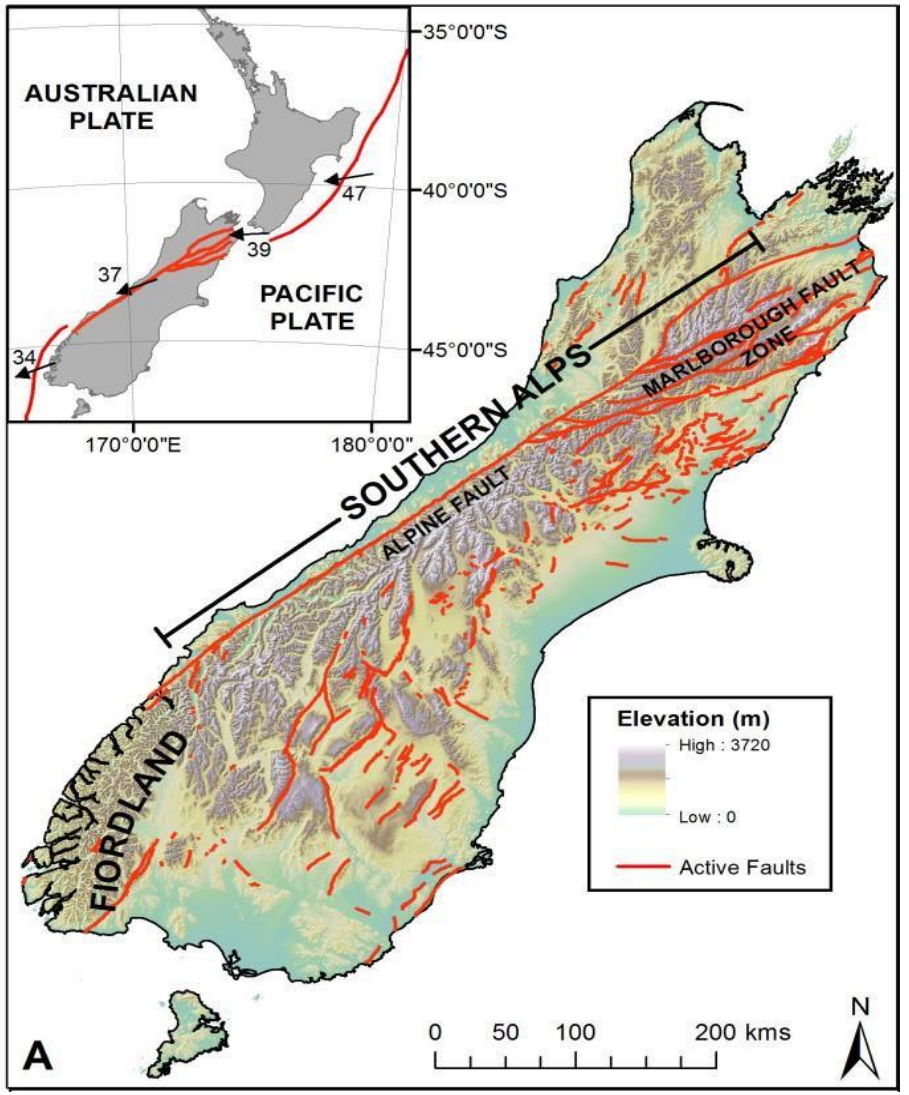
- Validate the network based on **normal conditions**
- Validate the network based on **Kaikoura Earthquake**

Methodology



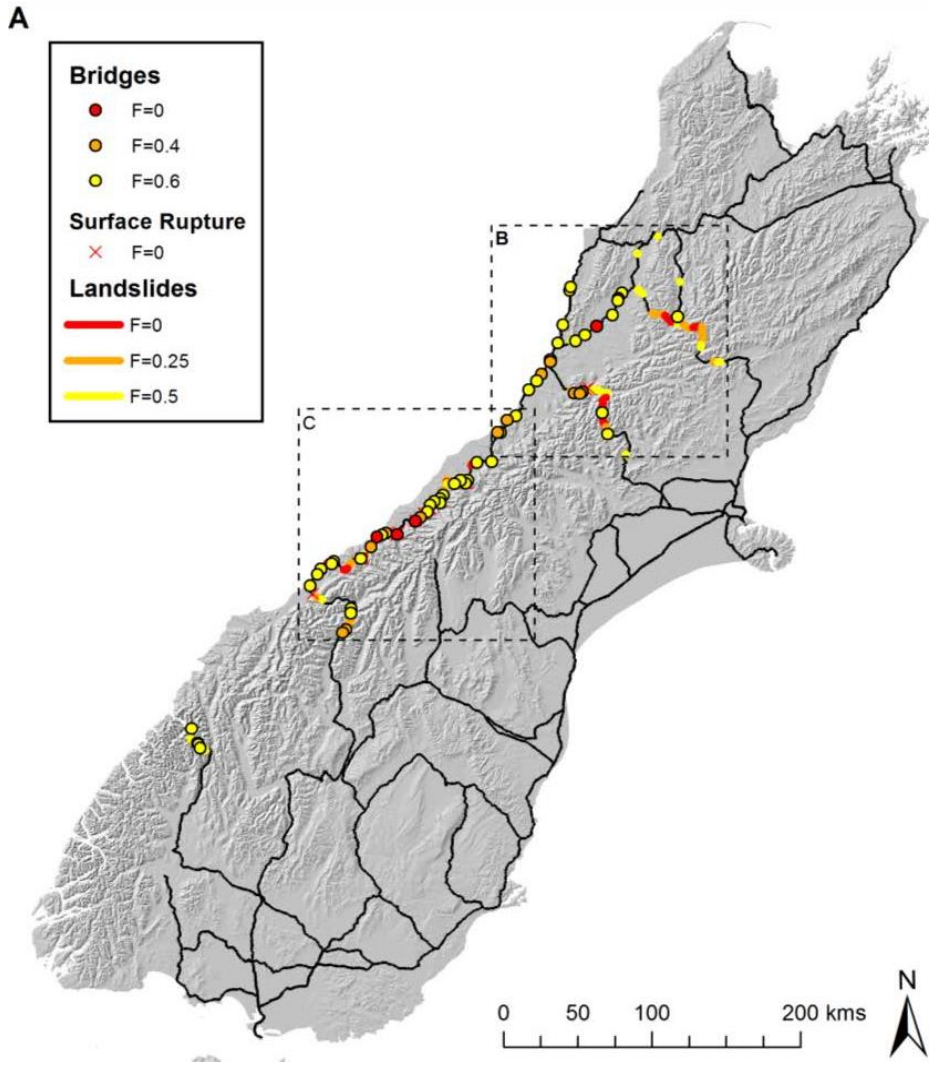
Scenarios

- Alpine Fault M8 Earthquake (AF8)
- The most probable and anticipated earthquakes
- Berryman et al. (2014): the probability of occurrence in the next 50 years as 30% with possibly more than $10 billion economic cost
- Developed by Robinson et al. (2016) or Alistair's PhD outputs



Scenarios

- Different time periods, T=0, 3, 14, 30, and 90 days after the event.
- The performance of bridges, with only 9% catastrophic loss (F=0)
- Minor damage of bridges and imposed weight or speed restrictions (F=0.4)
- Completely blocked locations due to landslides (F=0)



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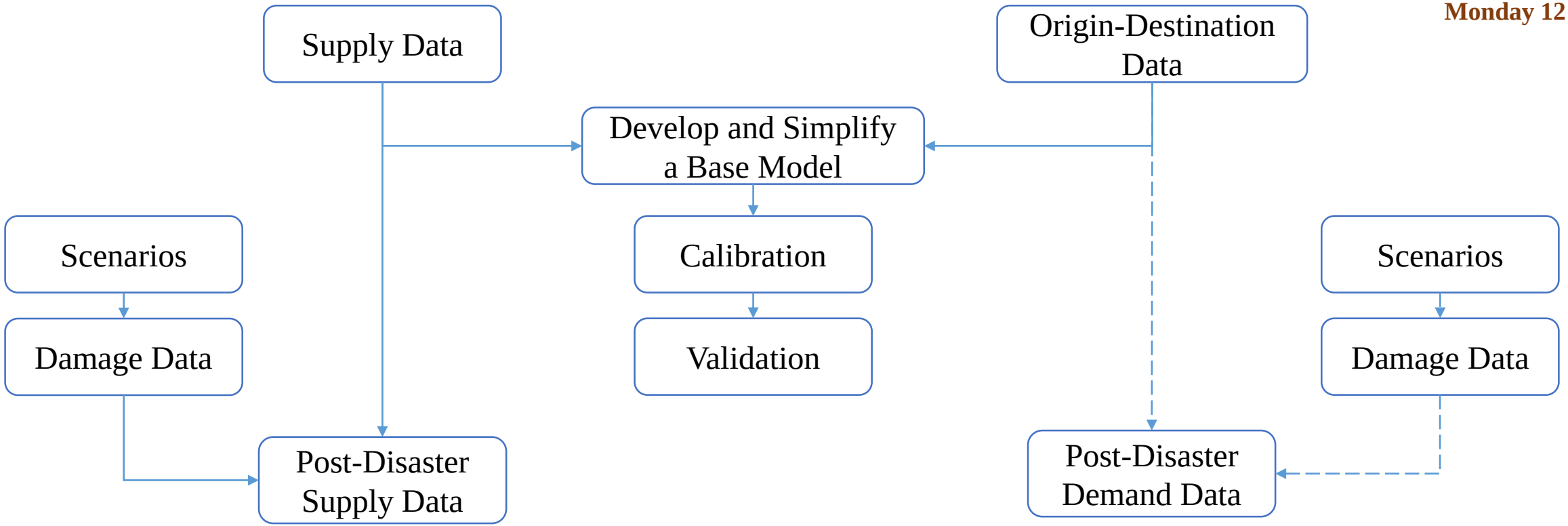

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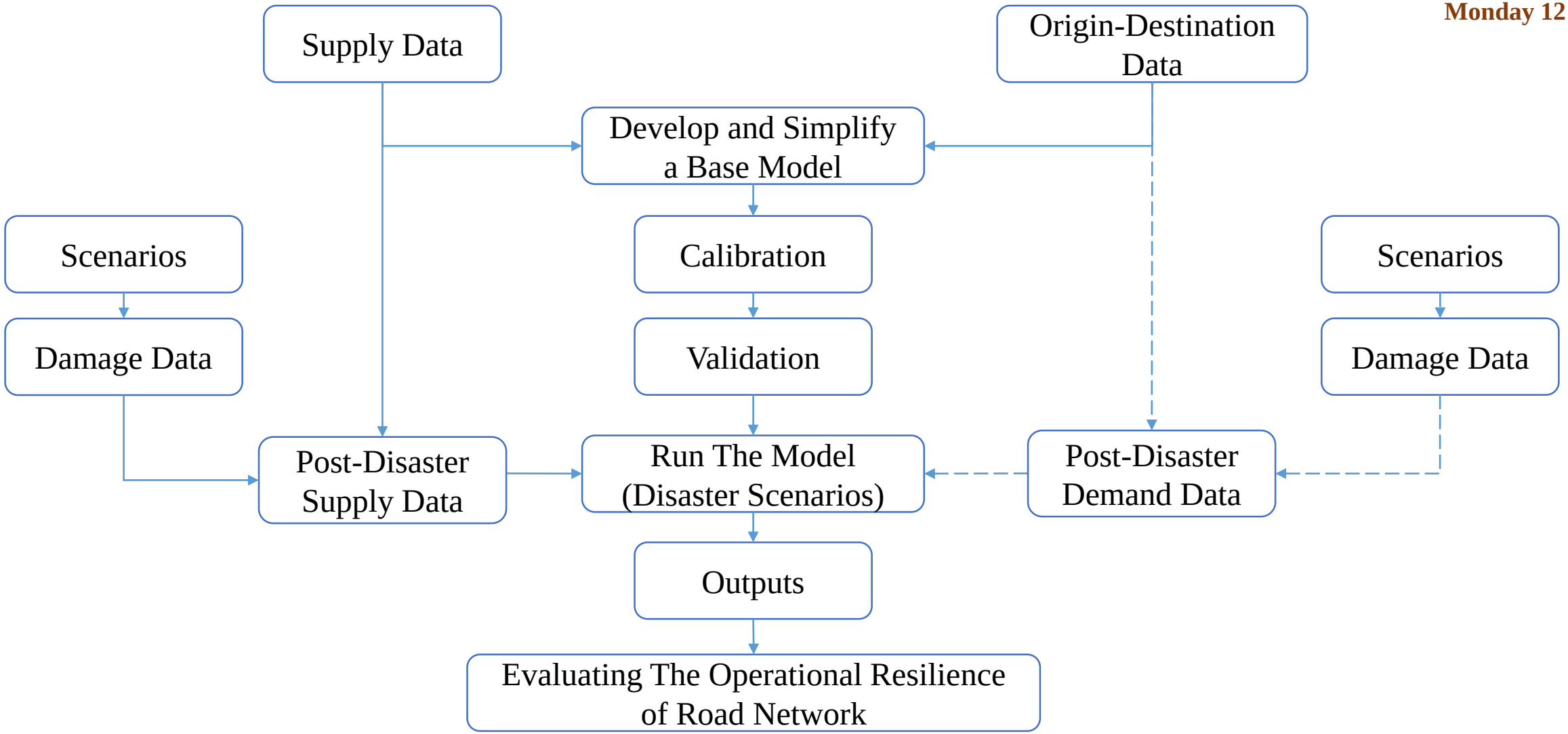

Thank You