MULTI-MODAL TRAFFIC DYNAMICS OF CHRISTCHURCH CBD

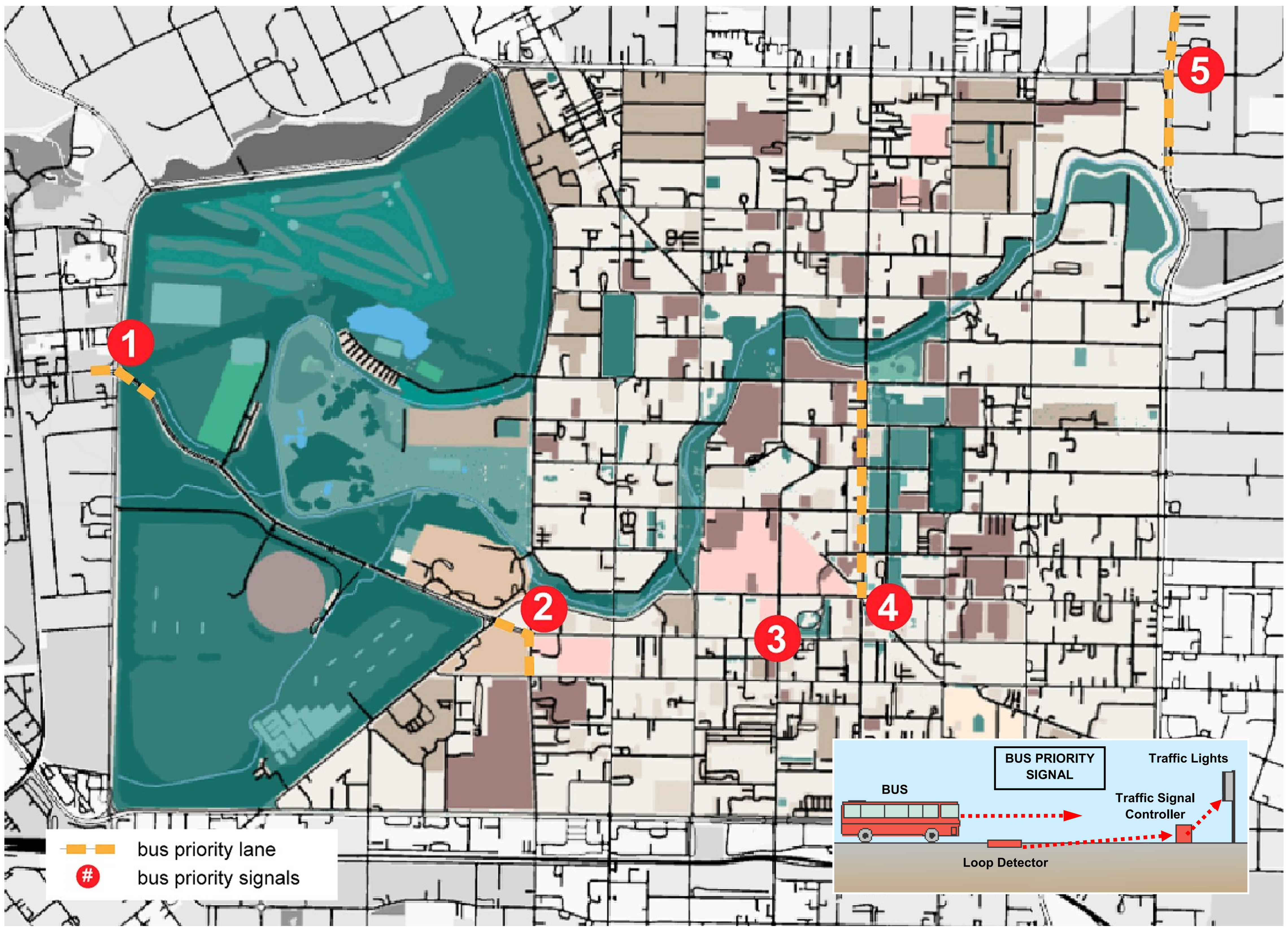

Figure 1. Map of BPS in Christchurch CBD adapted from OpenStreetMap using information gathered from CTOC

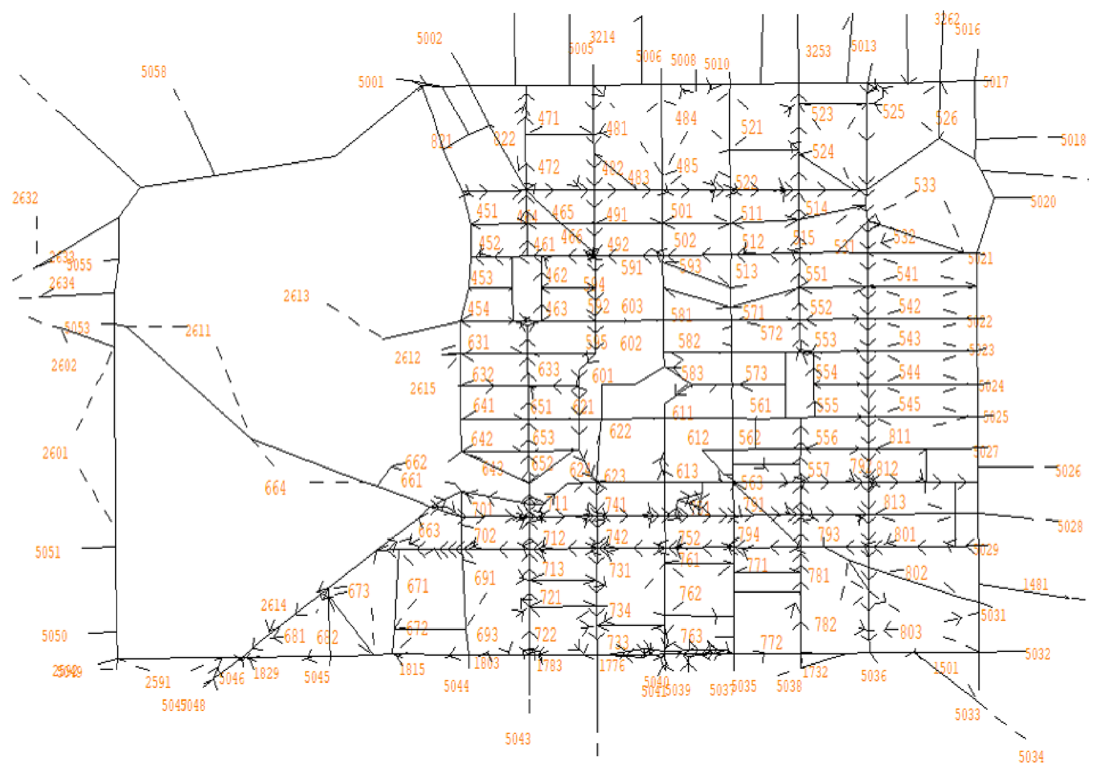

Figure 3. Cordoned 2018 CAST model of CBD in SATURN

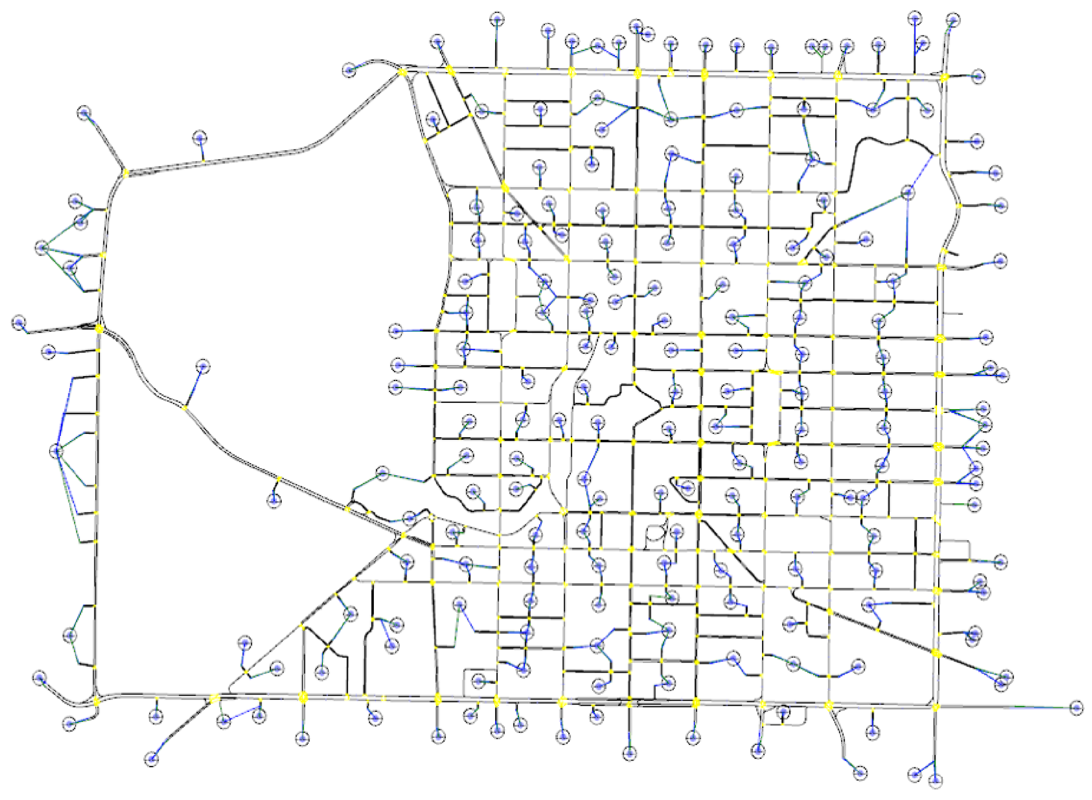

Figure 4. The urban network of CBD created in Aimsun

BACKGROUND

As part of a city-wide strategy to re-establish Christchurch CBD as the primary activity centre for the greater Christchurch region and in the process to improve traffic congestion in the city, An Accessible City (AAC) framework has been prepared. The aim of ACC is to create a people-friendly city centre in Christchurch with an emphasis on accessibility for all people through a variety of different travel modes including walking, cycling, using public transportation, and driving. The project features a new road layout and space allocations with Bus Priority System (BPS). There are currently five locations, where BPS has been implemented in the CBD of Christchurch. Figure 1 shows the locations of the BPS that are installed in the CBD area. The BPS in Christchurch consists of bus priority signals and bus priority lanes.

OBJECTIVES

1. **To investigate the use of Aimsun Next to model and simulate real-life traffic conditions of Christchurch CBD.**
2. **To investigate the effects of the Bus Priority System on the urban network of Christchurch CBD.**

METHODOLOGY

DATA COLLECTION

As demonstrated in Figure 5, the real traffic data was obtained from various organisations in the public sector of Christchurch.

- Christchurch City Council (CCC)
- Christchurch Transport Operation Centre (CTOC)
- Environment Canterbury (ECAN)

NETWORK MODELLING

Geometric Layout
- Geometric layout based on aerial photos from ECAN (5 November 2018)

Origin-Destination (O-D) matrix
- 203 O-D Zones
- Extracted O-D zones from the 2018 Christchurch Assignment and Simulation Traffic (CAST) model

Signal Timing
- 119 traffic signals
- Fixed signal phases based on average time from Sydney Coordinated Adaptive Traffic System (SCATS)

Speed Map
- Speed limits based on the speed limit map from CCC.

Public Transport
- 14 bus routes with 95 bus stops
- Dwelling time of 30 ± 10 seconds for all bus stops

Bus Priority System
- Identified Five locations with BPS from the Controller Information Sheet (CIS)

SIMULATION SETTING

AM traffic demands (2 hours)

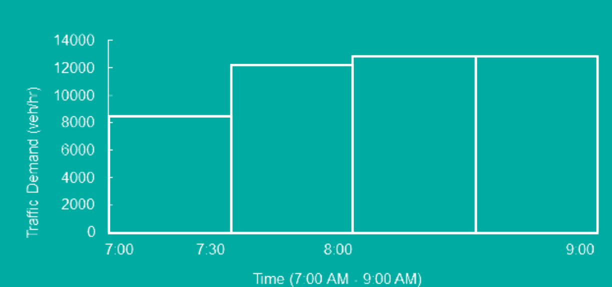

Figure 2. Demand Profile between 7:00 AM—9:00 AM from 2018 CAST model of CBD in SATURN

15 simulation replications (each scenario)
- Random seed
- Same seeds in both Scenario

Dynamic traffic assignment
- C-logit based route choice model
- Stochastic behavior with 90 seconds of cycle time was applied

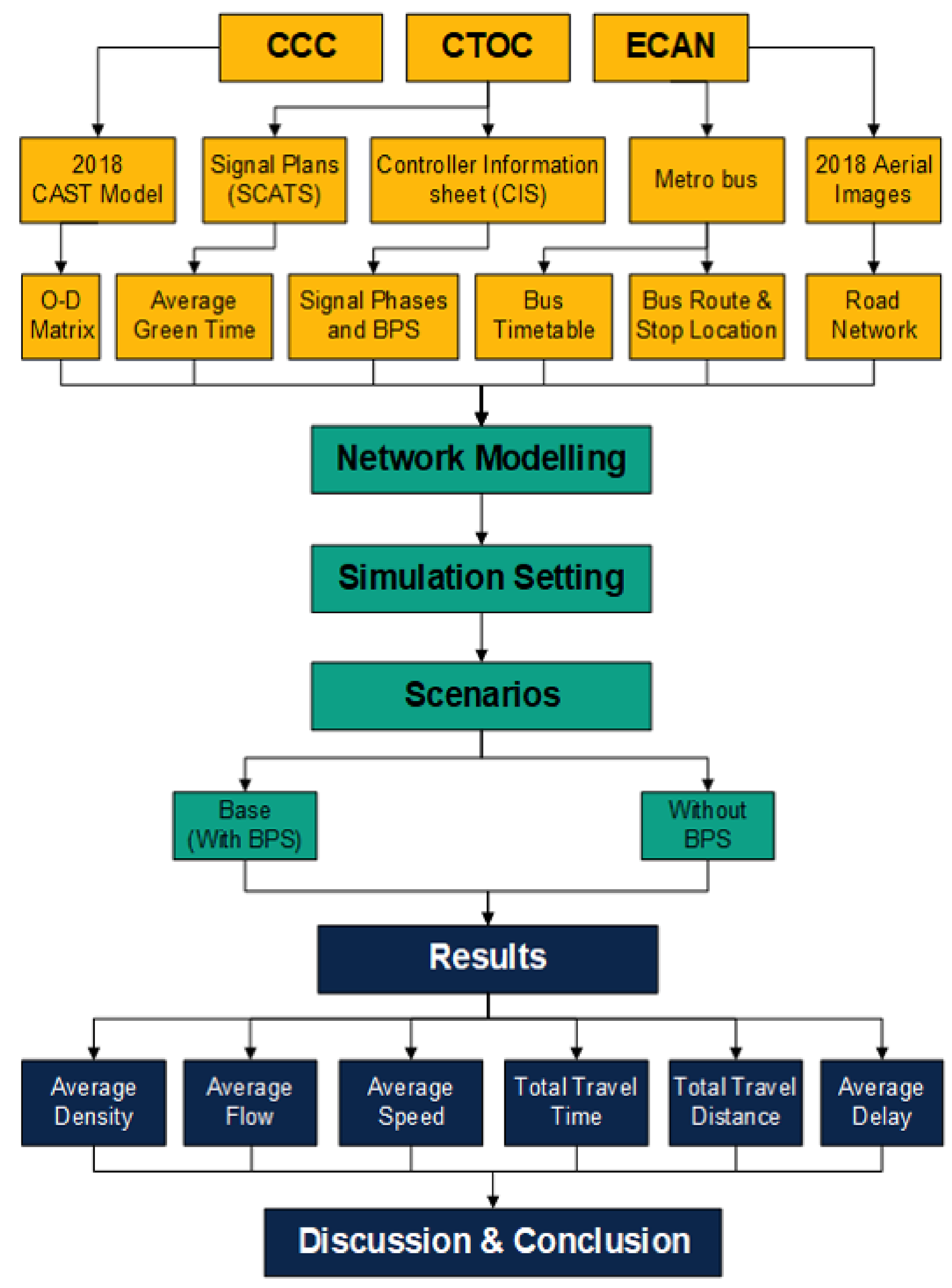

Figure 5. Diagram of research methodology

SCENARIOS

Two simulation scenarios were prepared to compare the effectiveness of the BPS in the network.

1. **With BPS (base condition):** The urban network model of Christchurch CBD. This includes the five locations in the CBD where BPS have been implemented as indicated in Figure 1.
2. **Without BPS:** The urban network model based on the above scenario without any BPS in the network. This model removes all BPS from the base condition including all dedicated bus lanes and bus priority traffic lights in the CBD.

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RESULTS

a) With BPS

b) Without BPS

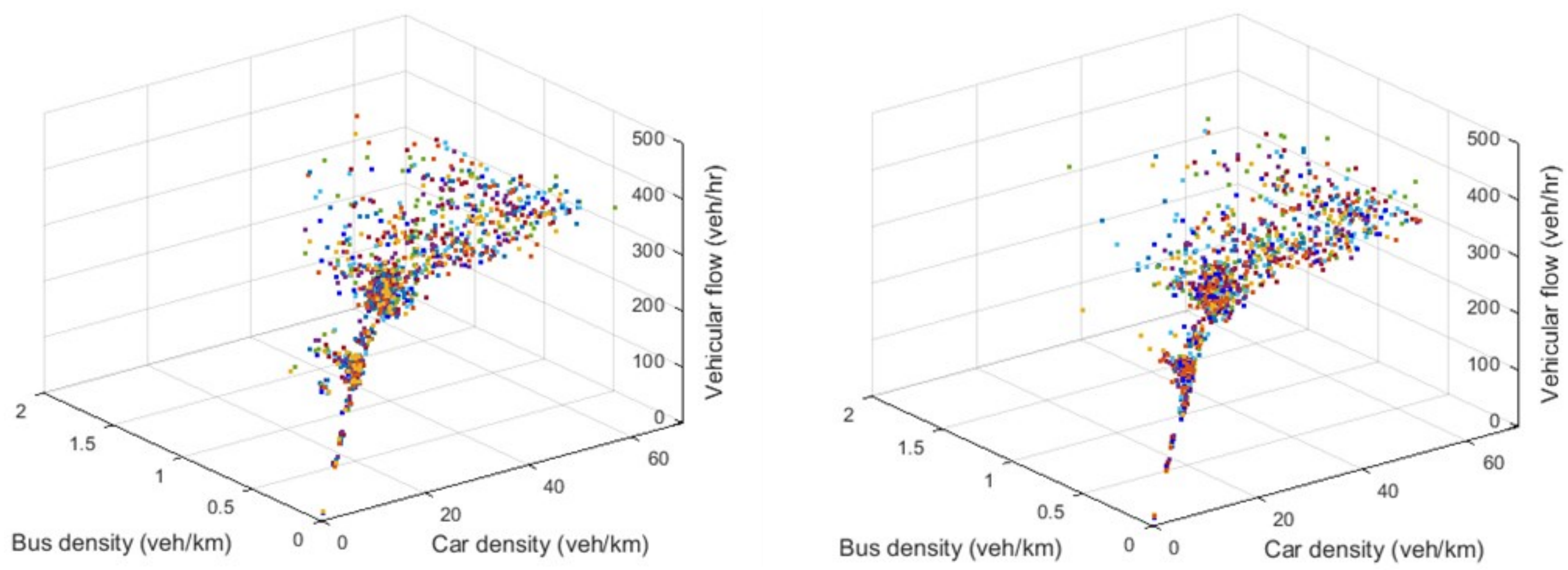

Figure 6. (a) 3D NFD – With BPS (base condition) model, (b) 3D NFD – Without BPS model

a) With BPS

b) Without BPS

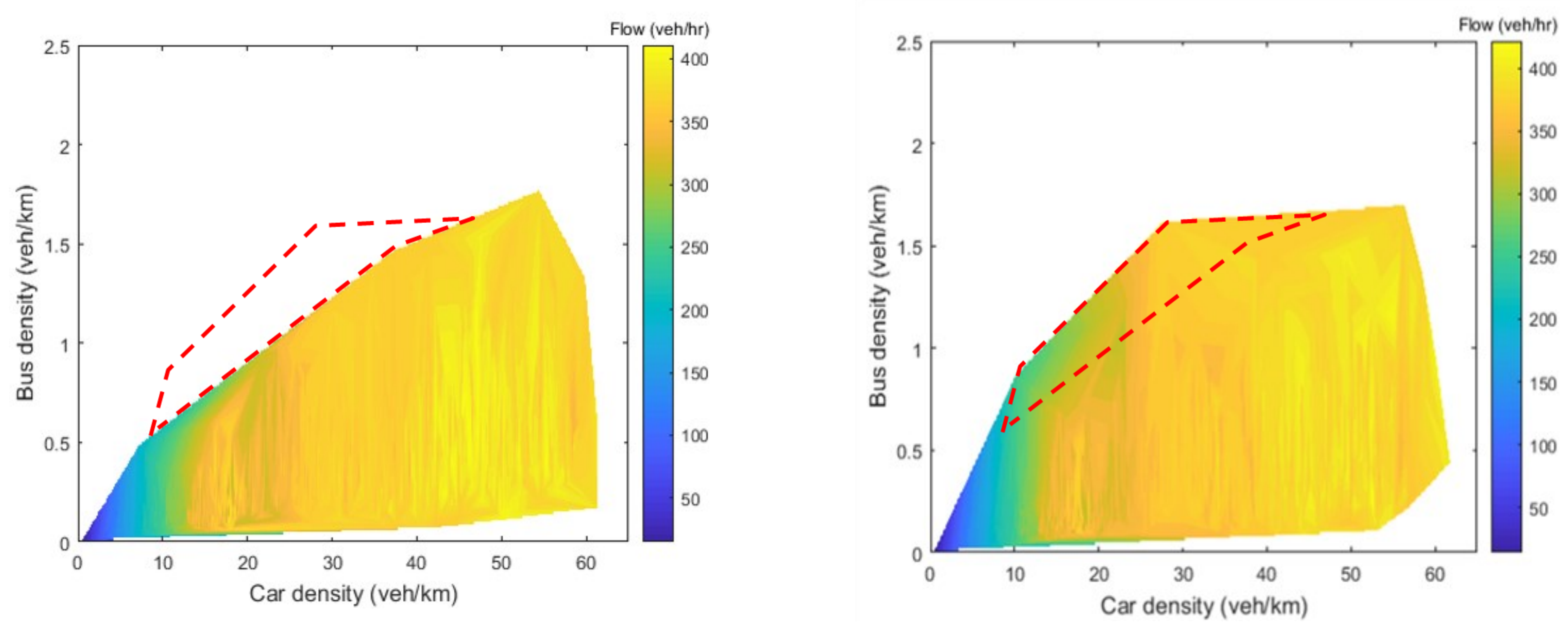

Figure 7. (a) NFD Contour plot – with BPS (Base condition), (b) NFD Contour plot – without BPS

3D NETWORK FUNDAMENTAL DIAGRAM (NFD)

The 3D NFD shows that the relationship between car density and vehicular flow follows an inverted curve shape that is a characteristic of the Fundamental Diagram.

1. **With BPS (base condition):** The critical car density occurred in the range between *40 veh/km* and *50 veh/km* while the network capacity is approximately *410 veh/hr*.
2. **Without BPS:** The critical car density occurred in the range between *40 veh/km* and *50 veh/km* while the network capacity is approximately *430 veh/hr.*

CONTOUR PLOT

The contour plot represents the flow conditions influenced by the movements of buses and cars. The difference in contour plots indicates that network without BPS is more sustainable in its interaction between cars and buses and can serve more buses without the compromise of high capacity.

TRAFFIC DELAYS

a) Bus Delay

b) Car Delay

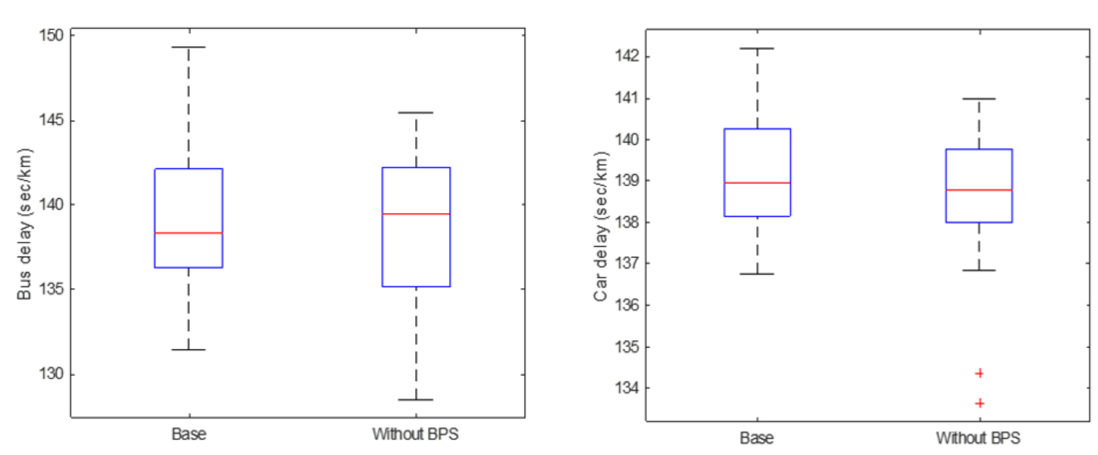

Figure 8. (a) Box plot of average bus delay, (b) Box plot of average car delay (red line showing the median, top and bottom of each box are 75th and 25th percentiles of the samples)

The median car delay of the base model is *139.0 sec/km*, which is slightly higher than the median of the model without BPS of *138.8 sec/km.*

The maximum bus delay in the base network is *149.4 sec/km*, which is also slightly higher than the network without BPS of *145.5 sec/km.*

Table 1. Comparison of the results (median)

	With BPS	Without BPS
Average Car Speed (km/hr)	20.4	20.4
Average Bus Speed (km/hr)	12.4	12.2
Total Travel Time of Car (hr)	4,999.8	5,035.8
Total Travel Time of Bus (hr)	42.1	42.3
Total Travel Distance of Car (km)	84,092.1	85,852.7
Total Travel Distance of Bus (km)	481.8	483.0

The discrepancies between the two scenarios are identified in Table 1. Similar to the box plot comparison, no clear differences can be observed from the results.

LIMITATIONS

Signal Plans
Fixed signal plans were used in the model as opposed to SCATS in real-life.

Pedestrians
The flow of pedestrians has been mostly ignored in the modeling process due to its complexity. The pedestrian dynamics is fundamental in the simulation of the traffic behaviour in the central city due to their priority over vehicles. As more cities adopt city policies towards people-friendly cities, this notion will only continue to grow.

Shared Road
During the simulation, a significant number of vehicles travelled through the shared roads. However, in real-life, vehicles are discouraged from using the shared pathway through various traffic control mechanisms.

Bus Simulation
- Assumed bus dwell time as 30 ± 10 seconds
- In real life, the dwell time will range from zero to a few minutes depending on the bus service

Simulated buses were experiencing difficulty entering the road when in congestion. However, at least in New Zealand, a pseudo-rule exists among the drivers to give way to vehicles that struggle to enter the road.

CONCLUSION

The traffic analysis of the two scenarios ‘with’ and ‘without’ BPS in the CBD network was found to be very similar with negligible differences between the two networks. Therefore, there are minimal effects of Bus Priority System on the performance of the simulated network of Christchurch CBD. However, this is somewhat expected, as the results are based on a relatively large network and any benefits of BPS from such a large model would likely have been masked. This is more likely the case in a network with only five BPS intersections among 119 signalised intersections in the entire CBD network. Therefore, it should be emphasised that the findings do not prove that BPS is ineffective in the system but that its effects were simply not apparent within the larger traffic network analysis at the CBD level. This is the limitation of this research. It is likely that the effects of BPS may have been localised along critical bus routes with BPS, notably Manchester Street. However, further study would be warranted to validate this assumption.

RECOMMENDATIONS

It is recommended to further develop the Aimsun model of Christchurch CBD for the better understanding of multi-modal traffic dynamics of the city, as well as contributing to the future transport planning of Christchurch.

- Apply SCATS (Sydney Coordinated Adaptive Traffic System) in Aimsun.
- Apply pedestrian, cyclist and heavy vehicle dynamics in the Network.
- Apply other traffic dynamics in the Network (on-street parking etc)
- Apply realistic bus dwelling time
- Update to the latest O-D Demand based on 2018 Census
- Perform calibration on the network

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Minimal effects of bus priority system on the performance of the simulated network of Christchurch CBD.
However...

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