PENANG SMART MOBILITY MICRO-SIMULATION MODEL DEVELOPMENT

MODEL INCEPTION AND TRIAL MODEL REPORT

DECEMBER 2021

ASEAN AUSTRALIA SMART CITIES TRUST FUND
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Cover image	**Adobe Stock**

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INTRODUCTION

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1.1 BACKGROUND

Ramboll has been engaged through the ASEAN Australia Smart Cities Trust Fund (AASCTF) to conduct a Pilot Project for Penang. This Pilot Project intervention involves the development of a Transport Micro-Simulation Model of the historical centre of Georgetown that can be used to assess future mobility interventions such as public transport, traffic improvements, pedestrianization and cycling improvements.

This Pilot Project will involve the development and calibration of the micro-simulation model using PTV VISSIM software and testing of a limited set of potential future interventions for Georgetown, as well as training of Digital Penang / MBPP staff in the use of PTV VISSIM.

This report outlines the project inception including methodology, review of plans and policies and survey planning. In addition, this report describes the development of a 'Demonstration Model' which can be used by Digital Penang for stakeholder engagement.

1.2 KICK-OFF MEETING

A kick-off meeting and establishment of a working group was held on 15th June 2021. The working group will meet regularly throughout the study to update on progress.

The working group includes:

- Zabari Zainal – Digital Penang
- Alfonso Johan – Digital Penang
- Timothy Choy – Digital Penang
- Tony Yeoh – Digital Penang
- Yong Woo Soon – MBPP
- Nick Fellows - Ramboll
- Richard Sprosen – Ramboll
- Yiheng Xu – Ramboll
- Jackson Pereira – JA Consult
- Ashita Pereira – JA Consult
- Irman Haizal Sulaiman – JA Consult
- Norhafizah Kamarul Zaman – JA Consult

1.3 PROJECT OBJECTIVES

The expected outcome is to provide Penang with a **calibrated VISSIM micro-simulation** model of the core historic city centre of Georgetown, and **to use the model to test Smart Mobility strategies**. The use of this VISSIM micro-simulation model will enable Penang to:

- provide the authority with an efficient tool to check and assess the implications of developer plans, and thus improve the implementation and enforcement of transportation policies;
- test and trial the implication of different transportation policies and designs (e.g., parking, e-buses, micro-mobility, car-free spaces, etc.);
- better communicate implications of transport policies and solutions to decision makers, developers and to the public; and
- knowledge-share with planners in Georgetown to provide the skills and tools to continue to enhance and improve smart mobility strategies moving forward.

The following table examines the success factors planned to ensure each objective is achieved throughout the Pilot Project intervention methodology.

Table 1-1: Success Factors

Objective	Ensuring Success
Provide the authority with an efficient tool to check and assess the implications of developer plans, and thus improve the implementation and enforcement of transportation policies	• Model structured in a way where testing changes to demand, public transport options, mode share etc. is logical and easy • Model parameters, development, calibration and network performance are fully documented • Supporting documents / spreadsheets • Measurements within the model
Test and trial the implication of different transportation policies and designs (e.g., parking, e-buses, micro-mobility, car-free spaces, etc.)	• Full review of existing and proposed plans with a summary of potential interventions in Georgetown that can be translated into simulation model tests • Stakeholder consultation (interviews) with all relevant personnel to ascertain their thoughts on mobility for Georgetown • Four intervention scenarios will be developed from the plan review and stakeholder consultation, and tested within the model as part of this study
Better communicate implications of transport policies and solutions to decision makers, developers and to the public	• Scenarios are translated into the model such that it gives policy makers a good visual and quantitative assessment of impacts • High quality 3D representation of Georgetown transport
Knowledge-share with planners in Georgetown to provide the skills and tools to continue to enhance and improve smart mobility strategies moving forward	• Model handover and documentation is clear • VISSIM training course covers the technical requirements for running and utilising this model

TASK ORDER

This chapter outlines the agreed Task Order (i.e., the basis for the Pilot Project) as developed by Ramboll, as main framework consultant to the implementation of the AASCTF, in conjunction with the Asian Development Bank (ADB), Digital Penang and MBPP.

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2.1 PROJECT OVERVIEW

2.1.1 BACKGROUND

Penang State has set a vision of moving 'Towards a Smart International City' and has established several smart initiatives. Digital Penang was established in 2020 to coordinate these initiatives, with its vision to make Penang State digitally connected, creative, and competitive.

Digital Penang is to be situated in the heritage district of Georgetown, on Penang Island. This area has become a popular tourism, shopping, and food destination. The popularity of the heritage district of Georgetown has overwhelmed the narrow streets, and prolific on-street parking in this area, resulting in traffic congestion along with unsafe mixing of pedestrians and vehicles.

In order to address both the congestion and associated traffic safety concerns in Georgetown, while making the experience of Georgetown smarter and more enjoyable, the introduction of Smart Mobility solutions (e.g., smart parking, autonomous shuttles, electric vehicle sharing, etc.) has been proposed.

The implementation of a range of smart mobility solutions can lead to reduced traffic demand and congestion, allowing road and parking spaces to be given back to pedestrians and cyclists; hence, reducing pedestrian and vehicle interactions, and improving safety, health and enjoyment of the local population.

To evaluate the effectiveness of proposed smart mobility solutions, a digital simulation of the heritage district of Georgetown is required. Policies/strategies to encourage the adoption of smart solutions with these beneficial outcomes must also be examined.

2.1.2 OUTCOME

The expected outcome of the Pilot Project is to provide Penang with a calibrated VISSIM micro-simulation model of the core historic city center of Georgetown, and to use the model to test Smart Mobility strategies. The use of this VISSIM micro-simulation model will enable Digital Penang and Penang City Council engineering department to:

1. provide the authority with an efficient tool to check and assess the implications of developer plans, thus improving implementation/enforcement of transportation policies.
2. test/trial the implication of different transportation policies and designs.
3. better communicate implications of transport policies and solutions to key stakeholders.
4. knowledge-share to provide skills and tools to enhance/improve smart mobility strategies.

2.1.3 OUTPUT

The proposed Pilot Project intervention is broken down into two stages within the proposed Task Order on 'Smart Mobility Micro-Simulation Model Development' – Stage 1: Pilot Area Micro-Simulation and Stage 2: Expanded Area Micro/Macro-Simulation and Training / Handover. The following key outputs are sought:

- Output 1. Survey and Model Inception Report
- Output 2. Trial Micro-simulation Model Report (Stage 1 Trial Area)
- Output 3. Micro-simulation Model Report (Stage 2 Wider Area)
- Output 4. Final Report

2.1.4 IMPLEMENTATION ARRANGEMENT

Executing agency: Asian Development Bank

Implementing agency: Digital Penang/Penang City Council Engineering Dept

Both Digital Penang and Penang City Council Engineering Department represent the Penang State Government team for this project, vis-à-vis:

• Digital Penang is the State's agency tasked to lead digitalisation efforts across the State Government. In this respect, Digital Penang's role is to connect with external stakeholders to bring in technology and at the same time support internal agencies with their digitalisation journey. Digital Penang reports to the Penang State Cabinet.

• Penang City Council Engineering Department acts as matter expert for traffic policy/regulations and implementation. Penang City Council Engineering Department has decision making power on changing traffic flow, re-positioning CCTV, etc. The aim through the project intervention is to empower the Engineering Department with a traffic simulation model to better manage traffic on Penang island.

Implementation period: May 2021 to August 2022

2.1.5 ADB PROJECT OFFICER

Main Responsible: Joris van Etten, Senior Urban Development Specialist

Technical Advisory Focal Point: Shihiru Date, Senior Transport Specialist

2.1.6 SCOPE OF THE TASK ORDER

The following table outlines the methodology for this task order/Pilot Project intervention as developed pre-COVID-19 travel restrictions. Some changes to this process have been necessary due to delays in collecting the required traffic information. This is outlined further in Section 6 of this report.

Table 2-1: Task Order Scope

No.	Activity	Output
1	**STAGE 1 - PILOT AREA MICRO-SIMULATION**	
1.1	**Mobilization**	Survey and Model Inception Report (D1A & D1B)
1.2	**Data Review**	
1.2.1	Review and collation of data/reports	
1.2.2	Review TIA guidelines for Penang	
1.2.3	Preliminary desktop assessment	
1.3	**Initial Stakeholder Consultations**	
1.3.1	Stakeholder mapping	
1.3.2	Stakeholder liaison/consultation with key agencies, incl. Digital Penang, Penang City Council, etc.	
1.3.3	Liaison/consultation with other consultancies/project initiatives active in Georgetown/pilot area	
1.3.4	**Workshop 1 (W1) - Kick-off Meeting/Preliminary Scoping Workshop**	
1.4	**Develop/calibrate a VISSIM micro-simulation model of trial/pilot area of Georgetown**	Trial Micro-simulation Model Report (D2A & D2B)
1.4.1	Collect road layout, lane markings and signal timings (as appropriate) for the trial model area	
1.4.2	Collect and analyze traffic data required for the model	
1.4.3	Build the base year (current year) VISSIM model for the trial area, calibrated to traffic information collected	
1.4.4	Test elements of the current transport masterplans using the model	
1.4.4.1	Mixed Use mobility trial zone along Beach Street within the VISSIM model	
1.4.4.2	Vehicular optimisation trial zone along Pengkalan Weld within the VISSIM model	
1.4.4.3	Pedestrian optimisation trial in the pedestrian simulation zone within the VISSIM model	
1.4.5	**Workshop 2 (W2)** - Micro-simulation model of pilot area	

Table 2-1: Task Order Scope (cont.)

No.	Activity	Output
2	**STAGE 2 - EXPANDED AREA MICRO-SIMULATION AND TRAINING/ HANDOVER**	
2.1	**Develop the micro-simulation model to cover a greater area of Georgetown (UNESCO World Heritage Zone)**	Micro-simulation Model Report (D3A & D3B)
2.1.1	Expanding and calibrating the VISSIM model to an extended area of historical Georgetown	
2.1.2	Testing the transport masterplanning strategies from Stage 1 for the wider area model	
2.1.3	Evaluate the potential impact of the masterplanning strategies as tested, and advise on enhancements to the strategies	
2.2	**Propose changes to the Traffic Impact Assessment (TIA) guidelines (and other plans/policies) for Penang**	Final Report (D4)
2.2.1	Recommend changes to the Traffic Impact Assessment (TIA) guidelines and other plans for Penang	
2.2.2	Recommend any other implementation strategies to achieve pathways to implementation of the mobility improvements recommended	
2.3	**Conduct accredited PTV VISSIM training**	
2.3.1	Conduct a full, accredited PTV VISSIM training course for potential users of the model at the Penang authority	
2.3.2	Conduct a handover training session with the Penang authority	
2.4	**Stage 2 Model handover (base year + scenario tests)**	
2.4.1	**Workshop 3 (W3)** - Stakeholder workshop to validate findings on Stage 2 model	
2.4.2	Model handover (base year + scenario tests) to the authority	
2.4.3	Video product development	
2.5	**Monitoring & Evaluation of City Intervention**	Project Evaluation (D5)
2.5.1	Develop GESI Action Plan	
2.5.2	Develop M&E Action Plan/tracker	
2.5.3	Guide implementation and monitoring of GESI and M&E Action Plans	

2.1.7 KEY MILESTONES

Modified planned milestones are shown below. These have been changed as a result of COVID-19 delays and adjustments to the project methodology and are discussed in Section 6 of this report.

Table 2-2: Milestones

No.	Output and Milestone	Dates
1	Model Inception and Trial Model Report (D1A)	06 December 2021
2	Survey Report (D1B)	17 December 2021
3	Stage 1 Base Model Calibration Report (D2A)	14 January 2022
4	Stage 1 Scenario Testing Report (D2B)	04 February 2022
5	Stage 2 Base Model Calibration Report (D3A)	29 April 2022
6	Stage 2 Scenario Testing Report (D3B)	10 June 2022
7	Final Report (D4)	08 July 2022
8	Project Evaluation (D5)	05 August 2022

2.1.8 TEAM COMPOSITION

Table 2-3: Task Team Composition

No.	Position	Candidate
A.	**CORE TEAM**	
1	Urban Planner/Core Team Leader	Mr. Søren Hansen
2	Smart Technology Expert	Mr. Simon Wei Si Ngiaw
3	GESI Specialist	Ms. Catherine Grant
4	M&E Specialist	Mr. Xavier Le Den
5	Communication and Outreach Specialist	Mr. Jens Christian Riise
B.	**SENIOR INTERNATIONAL EXPERTS**	
6	Task Team Leader	Mr. Nick Fellows
7	Senior Smart Mobility Expert	Mr. Richard Sprosen
B.	**MID-INTERNATIONAL EXPERTS**	
8	Senior Modeller & PTV Vissim Accredited Trainer	Mr. Yiheng Xu
C.	**JUNIOR INTERNATIONAL EXPERTS**	
9	Traffic Modeller	Mr. Henry Ng
10	Video Production Specialist	Ms. Nina Houkjær Klausen
D.	**SENIOR NATIONAL EXPERTS**	
11	Deputy Task Team Leader	Ms. Ashita Pereira
12	Senior Transport Planner	Mr. Irman Haizal Sulaiman
13	Networking/M&E Expert	Mr. Jackson I. Pereira

PLAN AND POLICY REVIEW

This chapter outlines a review conducted on the Penang Transport Master Plan (2030) and Penang Green Transportation Plan, as they relate to potential interventions in Georgetown. This review formed the basis for development of scenarios to test within the micro-simulation model.

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3.1 PENANG TRANSPORT MASTER PLAN (2030)

Penang Transport Master Plan, also known as PTMP, is a comprehensive plan formed by the Penang state government to improve transportation within the entire state of Penang. The Plan envisages more alternative transportation modes to combat worsening traffic congestion across the state, such as Light Rail Transit (LRT) and monorail lines, a cable car line, and an undersea tunnel linking Georgetown with the town of Butterworth on the mainland. The timeline below (Figure 3.1) outlines the chronology of PTMP from inception onwards.

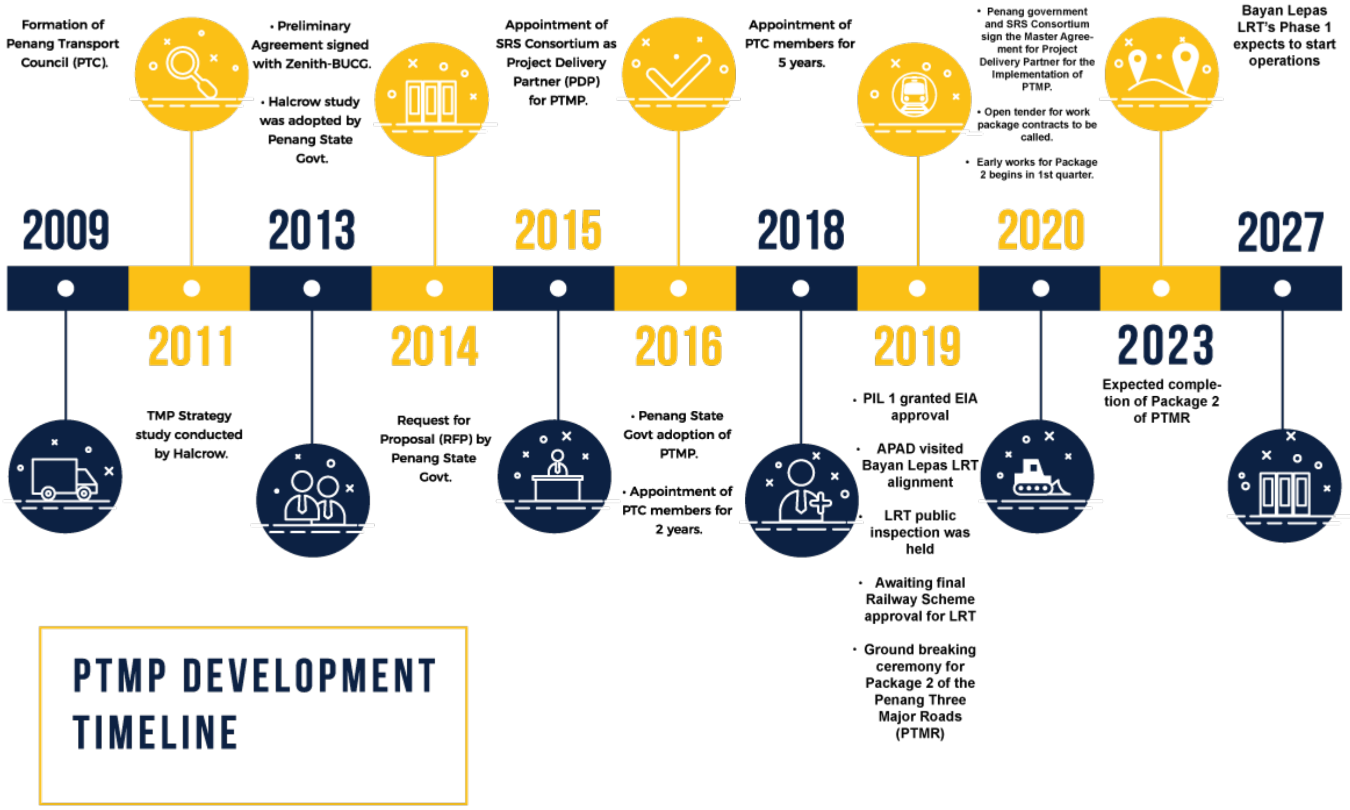


Figure 3.1: PTMP Development Timeline
Source: Penang 2030 Masterplan

The PTMP study was commissioned in recognition of the growing transportation issues within the state and aims to adopt a holistic approach in resolving transportation issues, whilst ensuring that roads are safe and user-friendly for all. PTMP emphasises moving towards greater public transport dependence, and ulitmately aiming to achieve public transport to private transport modal share of 40:60 by the year 2030.

PTMP also looks into integration between transport systems and development plans between the island and mainland of the state of Penang, as shown in Figure 3.2 below.

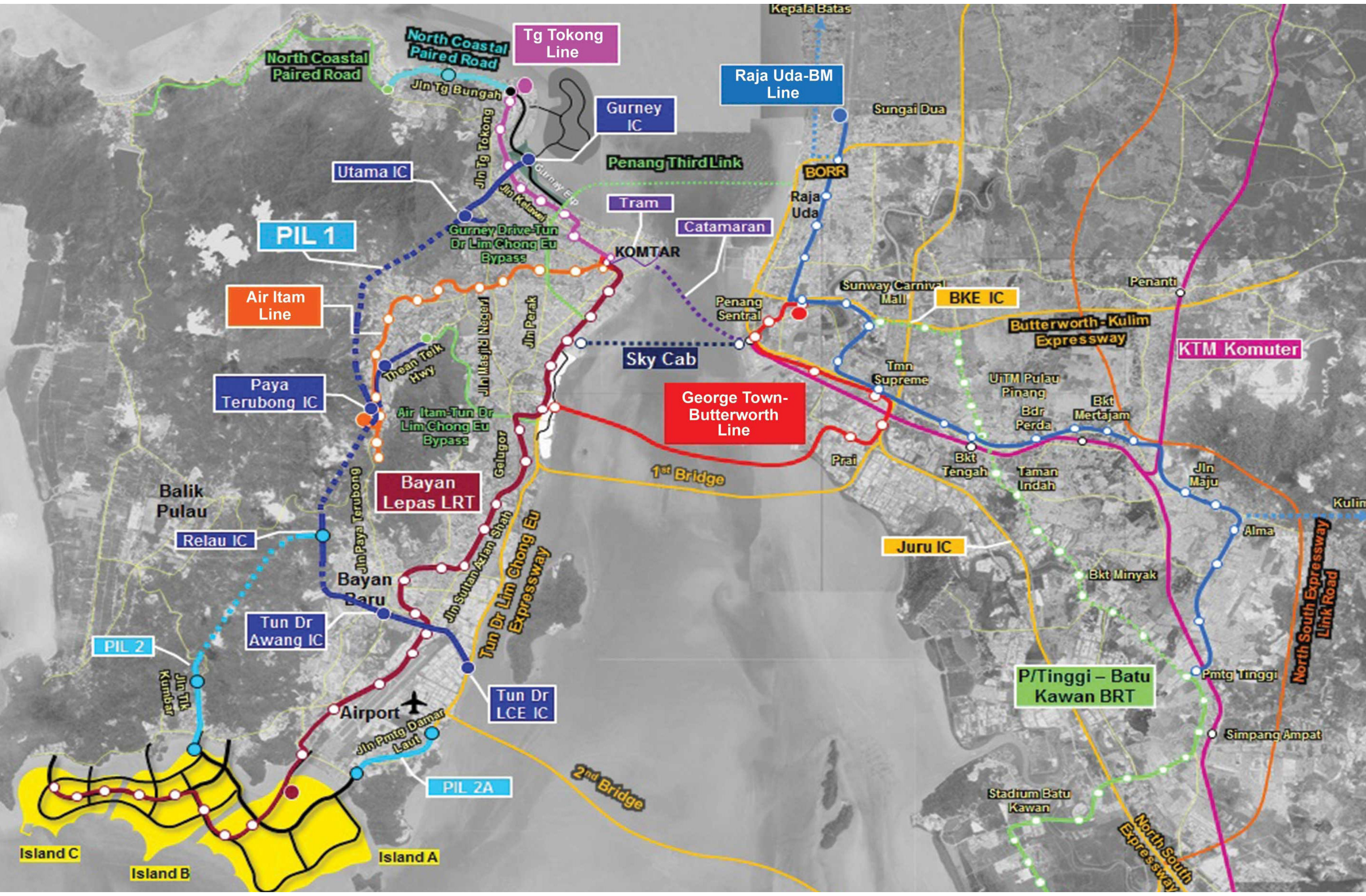


Figure 3.2: PTMP Masterplan
Source: Penang 2030 Masterplan

3.1.1 RECOMMENDED TRANSPORT MASTER PLAN STRATEGY

As deliberated in the PTMP, the following proposals are pivotal in the road infrastructure development in the state of Penang, being identified through a process and designed to meet the transportation objectives:

- Short- to medium- term proposal designed to make better use of the state's existing transport network.
- Longer-term proposal to provide additional highway and public transport infrastructure.
- Policy-based proposals aimed at reducing the future growth in private vehicle activity.

The PTMP consists of two (2) strategies, namely the Highway Strategy and the Public Transport Strategy, which were identified through a process of technical analysis, stakeholder engagement and public consultation.

3.1.2 HIGHWAY STRATEGY

The Highway Strategy was developed to ensure that road safety, accessibility, connectivity and traffic dispersal are considered as key factors to update regional and local highway and road network parameters, such as improved conditions for pedestrians, cyclists and motorcyclists, and the need to enhance existing traffuic signal intersections. Regulation and enforcement of loading, waiting parking and hawker activity are paramount to ensure smooth flow of traffic in the city centre and other activity centres whilst maintaining road safety. PTMP has highlighted the need to improve signages, way finding and road marking to provide a better driving experience. PTMP has designated to widen some 150 kilometers of existing roads, partial grade separation of 40 intersections, introduction of traffic control at a further 64 intersections and provision of full grade separation at three locations where the regional highways meet.

One of the key projects identified in the PTMP is the creation of three (3) major dispersal roads which are toll-free, believed to alleviate traffic congestion towards the northern, central and eastern parts of Penang, as listed below:

- The North Coastal Paired Road from Tanjong Bungah to Teluk Bahang (Figure 3.3)
- The Ayer Itam – Lebuhraya Tun Dr. Lim Chong Eu Bypass (Figure 3.4)
- Persiaran Gurney – Lebuhraya Tun Dr. Lim Chong Eu Bypass (Figure 3.5)

Furhter, Table 3-1 summarises details and strategies that would be scrutinised by the PTMP for highway network development, which includes type of highway, intersection type, and needs for vulnerable road users.

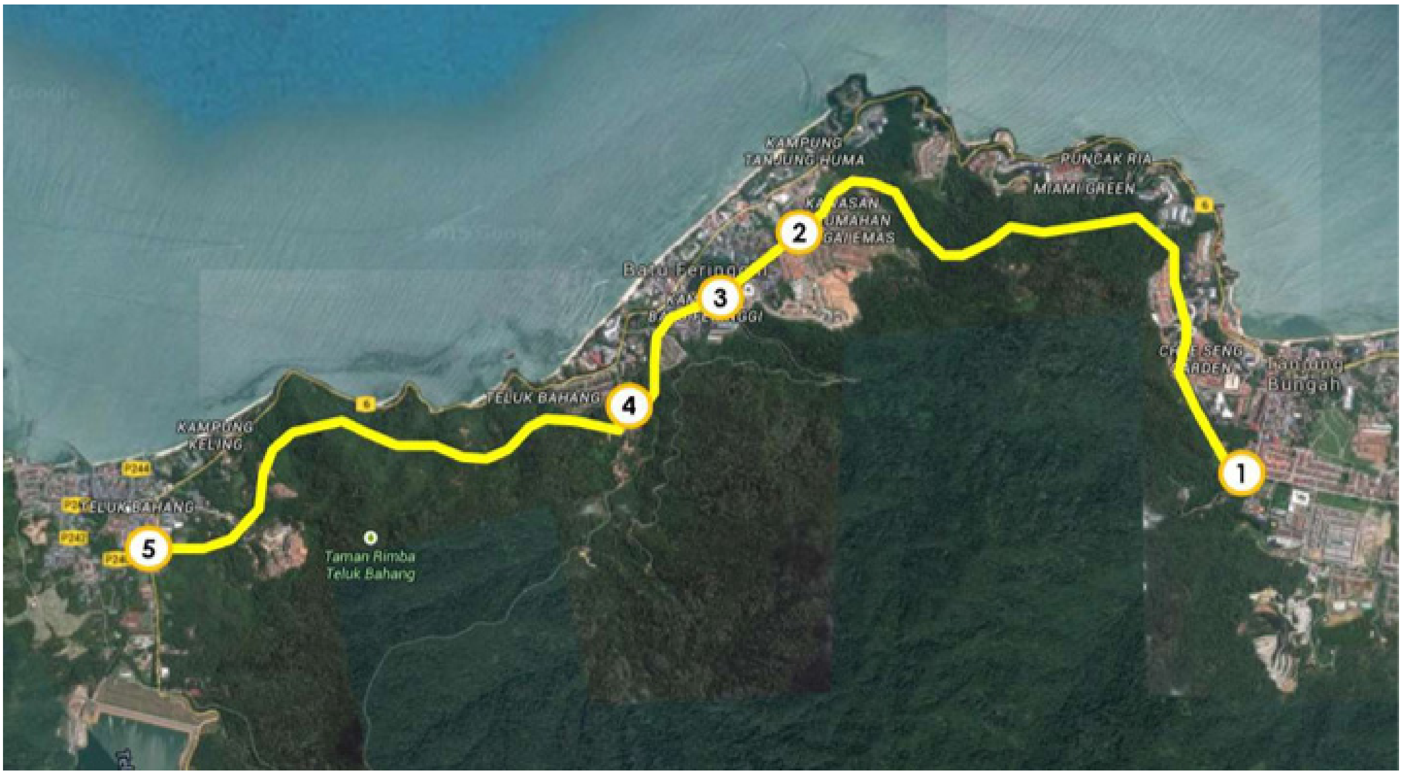


Figure 3.3: The North Coastal Paired Road from Tanjong Bungah to Teluk Bahang
Source: Penang 2030 Masterplan

Figure 3.4: The Ayer Itam – Lebuhraya Tun Dr. Lim Chong Eu Bypass
Source: Penang 2030 Masterplan

Figure 3.5: Persiaran Gurney – Lebuhraya Tun Dr. Lim Chong Eu Bypass
Source: Penang 2030 Masterplan

Table 3-1: Proposed Strategies for Highway Standard by the PTMP

Highway Status	Minimum Highway Standard	Typical Intersection Treatment	Carriageway Access Policy	Motorcycle Policy	Pedestrian Policy	Cycling Policy
Strategic National Highway	• D3 lane • Tolled highway • D2 lane, except where traffic volumes justify D3 lane	• Full grade separation at all major interchanges • Partial grade separation elsewhere	• Only via grade separated intersections • No direct frontage access from premises	• Fully segregated facilities to be provided for motorcycles, adjacent to traffic lanes	• Prohibited along road • Footbridges or underpasses to be provided across road corridor so as to provide access between adjoining communities and / or / to public transport stations / bus stops	• Prohibited along road • Footbridges or underpasses to be provided across road corridor providing access between adjoining communities.
Strategic State Highway	• D2 lane	• Partial grade separation to be used at all major intersections • Left-in / Left-out control to be imposed at minor side roads • U-turn facilities to be provided within all partially grade separated intersections	• Limited to partially grade separated interchanges and left-in left-out minor roads • No direct frontage access from premises	On all rural locations, and where possible in Urban locations • Fully segregated facilities should be provided for motorcycles In other Urban locations • Nearside traffic lanes should have adequate width to allow a car to overtake a motorcycle In all situations • Motorcycles under 250cc should be prohibited from using the elevated portion of partially grade separated intersections	In urban areas • Footways to be provided adjacent to highway • At-grade fully protected crossings to be provided within all partially grade separated intersections • Footbridges and / or underpasses to be provided elsewhere, linking communities and paired public transport stations / bus stops In rural areas • Pedestrian should be prohibited all access to the road • Footbridges or underpass should still be provided, linking communities and paired public transport stops	In urban areas • Where possible, off carriageway cycle lanes should be provided adjacent to pedestrian footways. • Cyclist should be prohibited from using the elevated portions of partially grade separated intersections In rural areas • Prohibited along road In all situations • Footbridges and / or underpasses should be provided between adjoining communities.
Strategic District Highways	• D2 lane carriageway outside Georgetown • S4 carriageway within Georgetown	• Traffic signal control at all significant intersections	• Through signalised intersections and side roads • Direct frontage access from premises should be limited as much as is possible	• Where possible, nearside traffic lanes should have adequate width to allow a car to overtake a motorcycle	In urban areas • Adequate footways to be provided • Fully protected walk the traffic pedestrian facilities to provided at all intersections. Intermediate mid-block signalised pedestrian crossings to be provided adjacent to all transit stations. In rural areas • Provision should be matched to local pedestrian / public transport passenger needs	In urban areas • On-street cycle lanes to be provided where space allows • Otherwise, parallel, off-corridor, cycle routes to be provided. In rural areas • No special provision

3.1.3 PUBLIC TRANSPORT STRATEGY

The PTMP has looked into details on rationalising and regulating public transportation, in order to improve the current situation of inconsistent demand and supply. The new public transport efforts outlined in the PTMP need to be a seamless and integrated public transport network, touching on the following salient points:

- To rationalize the existing bus network into a series of core bus routes, feeder bus routes and other supporting bus routes.
- To improve public transport integration through introduction of integrated ticketing, good interchange facilities and better management of private sector activities.
- To improve the standard of exiting public transport provision through upgrading of existing bus service to Tram (Figure 3.6), Light Rail Transit (Figure 3.7), or Bus Rapid Transit operations.
- To introduce new Tram or Bus Rapid Transit based services linked to serve the suburbs of Georgetown and to the residential and industrial areas of Bayan Lepas.
- To introduce new commuter rail service on the mainland between Butterworth and Pinang Tunggal, and Butterworth and Nibong Tebal.
- To upgrade the current ferry service between Butterworth and Georgetown.
- To introduce new ferry service between Butterworth and Gurney Quay, Butterworth and Queensbay and Straits Quay, Tanjong Tokong Island, Gurney Quay, Weld Quay, the Light and Queensbay.

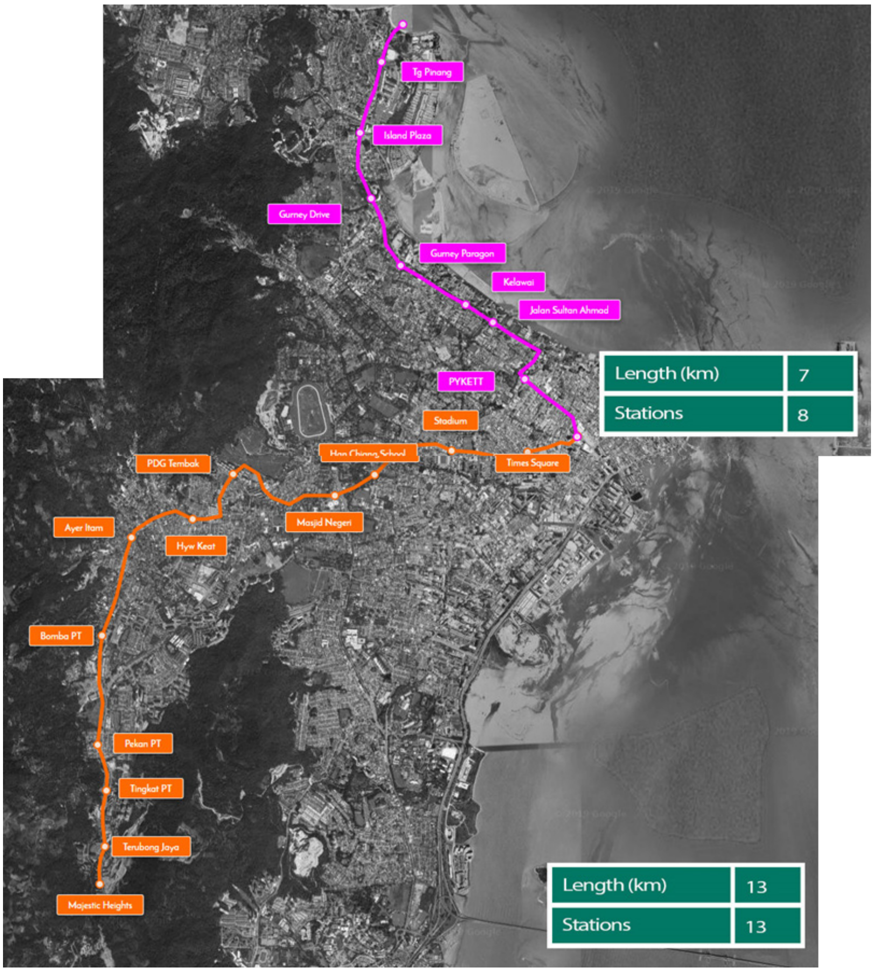


Figure 3.6: Proposed Tram
Source: Penang Transport Masterplan

Figure 3.7: Proposed LRT Penang

Source: Penang Transport Masterplan

3.1.4 CONCLUSION

Under the Penang Transport Master Plan, the highway improvement plan has identified and described a series of new road proposals. The need for these new roads has been demonstrated as part of the strategy development activity. On the basis of that, this functional role reflects the future importance of each highway to each road user. Figure 3.8 below is the status of highway / road network proposals outlined in the PTMP, that has been constructed and would be constructed in the future. Table 3-2 shows the implementation year for each of the public transportation plan.

Table 3-2: Timeline of Public Transport Planning

	2012	2015	2020-2030
	Stabilise and Plan	**Reorganise Bus Network**	**Implement Full Strategy Measures**
Network Management	Set up public transport task force to plan, regulate and oversee.	Formalise role of task force.	Oversee implementation and operation. Set policy and monitor performance.
Network Planning and Implementation	Stabilise operations, introduce new service, commence pilot core route / feeder routes.	Reorganise buses into core, feeder and other services. Introduce commuter rail, upgrade ferry.	Progressively replace core bus routes with Trams / Bus Rapid Transit. Add new ferries.
Network Accessibility	Improve bus stop access, implement UNDP Study Accessibility Schemes.	Upgrade pedestrian regime, maximise feeder bus access, introduce primary Park and Ride sites.	Complete Park and Ride network, review and improve network accessibility.
Network Awareness	Provide timetable information at bus stops. Improve mapping. Start mobile phone services.	Increase real time information services. Increase overall public transport awareness.	Expand real time service, continue awareness initiatives.
Pilot Schemes	Reorganise bus service in Air Itam corridor in core route and feeder service.	Introduce Tram in Georgetown – airport corridor.	Introduce Bus Rapid Transit in Bayan Lepas areas.

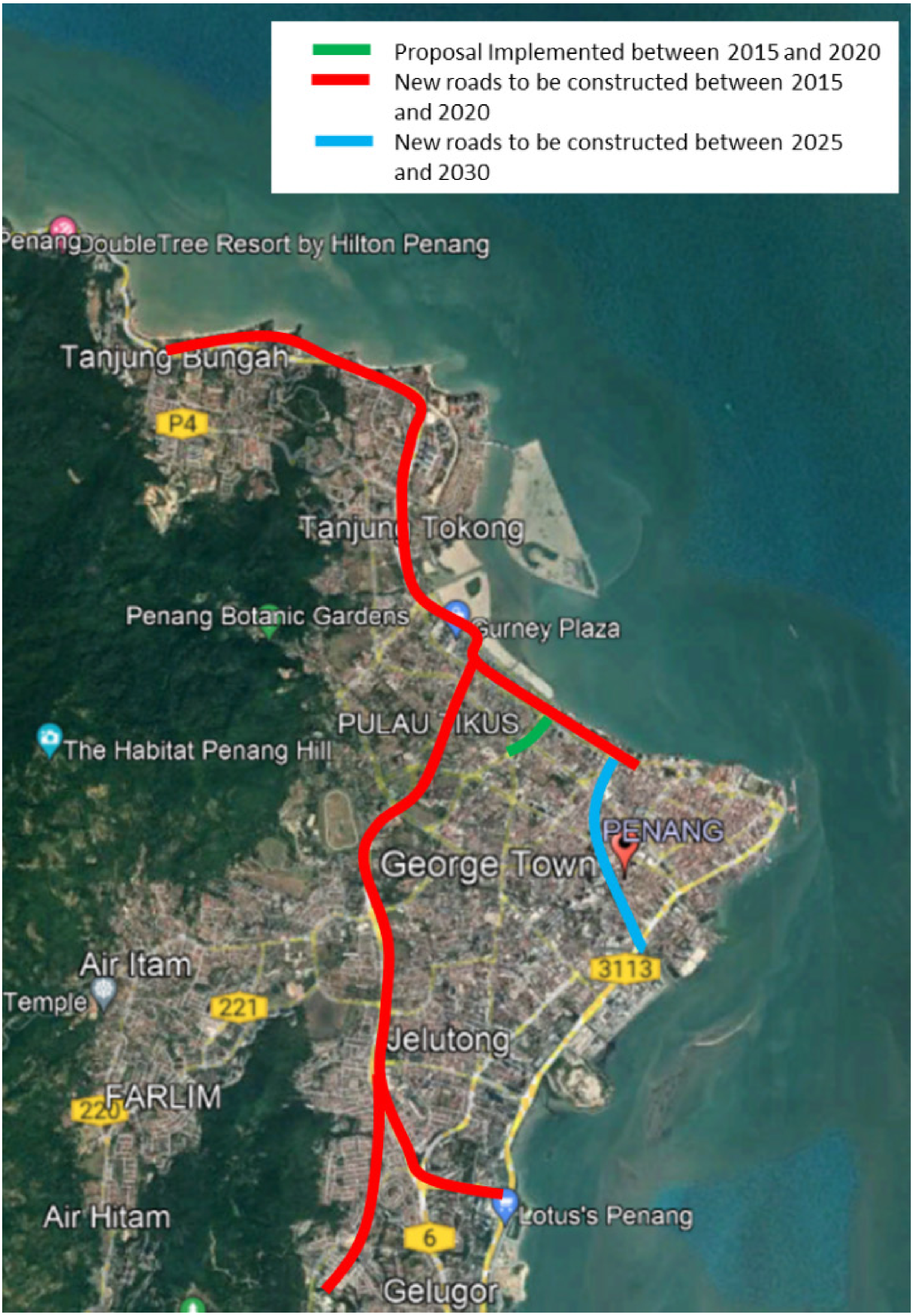


Figure 3.8: Timeline of Road Network Development
Source: Penang Transport Masterplan

3.2 PENANG GREEN TRANSPORT PLAN

The Penang Green Transportation Plan (PGTP) serves only as guidance for establishing action plans (scoping) and a framework towards achievement of Green Transportation and Green City as outlined below:

- Aiming at a significant reduction of road transport CO_2 emission.
- Promotion of walking, cycling and public spaces through greening and beautification and providing shade.
- Making the city more attractive for tourists by easing moving around.
- Enhancing the livability for all citizens.
- Shifting the focus from a city for cars to a city for people.

The objective of PGTP study is to set out a framework towards a greener urban transport system on Penang Island and to identify potential green transportation projects (scoping). The PGTP's main focus is on an action plan for green transportation projects for the short- and medium-terms involving:

- Non-Motorised Transport, including Street Design, Traffic Calming and Public Spaces
- Public Transport
- Parking Management
- Electrification Vehicle Fleet (EV)

3.2.1 APPROACH TOWARDS A GREENER TRANSPORT SYSTEM

To achieve a greener transport system and green city, the following approach needs to be considered:

- Working on a significant reduction of road transport emissions and pollution.
- Promotion of walking, cycling and public transport by creating appropriate facilities.
- Creating better and more attractive public spaces through greening and beautification.
- Making the city more attractive for tourists by easing the way moving around.
- Enhancing the livability of the city for all its residents.
- Transforming a city for cars into a city for people.
- Creating a Green City by moving towards Green Transportation.

The PGTP is based on three (3) thematic areas to create a people-oriented city, to provide a better-quality public transport service and to manage car-use, as shown in Figure 3.9.

Green transportation or sustainable transportation comprises of modes of transportation that do not depend on diminishing natural resources. Lesser numbers of people travelling by car will reduce emissions. Within the framework of the PGTP study, potential green transportation projects are identified as follow:

- Non-motorized transport and urban street design
- Public transport
- Parking
- Traffic management
- E-Mobility

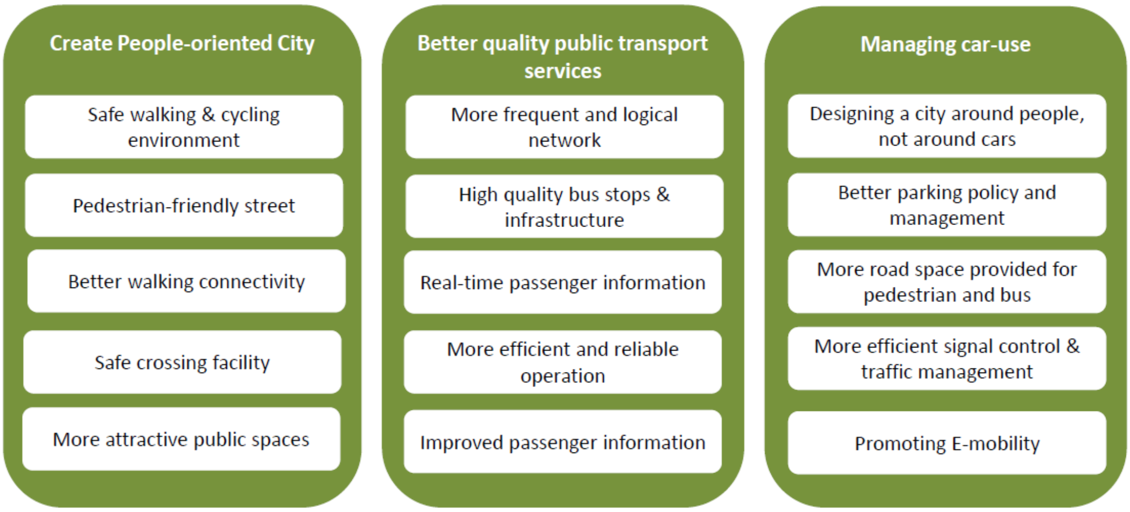


Figure 3.9: PGTP Thematic Areas
Source: Penang Transport Masterplan

3.2.2 NON-MOTORIZED TRANSPORT AND STREET DESIGN

The PGTP has identified that more space for pedestrian and cycling at the Georgetown Heritage Site is necessary. Walking should play an important role in supporting the Heritage Site of Georgetown. Although walking is in principle well supported by the block configuration of streets and five foot-way concept, nowadays walking around in Georgetown is hampered by blocked walkway, parking of cars and motorcycles, and traffic. Table 3-3 below is the summary of the non-motorised transport plan and proposal adopted from the Georgetown Heritage Site Special Area Plan.

Table 3-3: Summary of Non-Motorised Transport Plan

Current Condition	• The walkability of the city is poor because of the poor quality of the walkways. • Pedestrian crossing is limited and the design of intersection often does not take pedestrian facilities into consideration. • The waiting time for pedestrians at the traffic light is very long. • Not more than 1% of people use bicycle. • Most of the bicycle routes do not have dedicated lanes. • The design of bicycle lane is often of poor quality. • The painted bicycle lanes are not respected by motorists and often violated.
Target	• To achieve active mobility by the year 2025.
Initial Proposal	• To provide safe and user-friendly pedestrian walkways and bicycle routes along the Heritage areas.

3.3 PGTP PROJECT PACKAGES

3.3.1 PUBLIC TRANSPORT

To achieve a greener Penang and improve the quality of life in the city, public transport needs to be enhanced. Public transport efforts are to be enhanced with the following strategies depicted in the PGTP, as summarised in Figure 3.10:

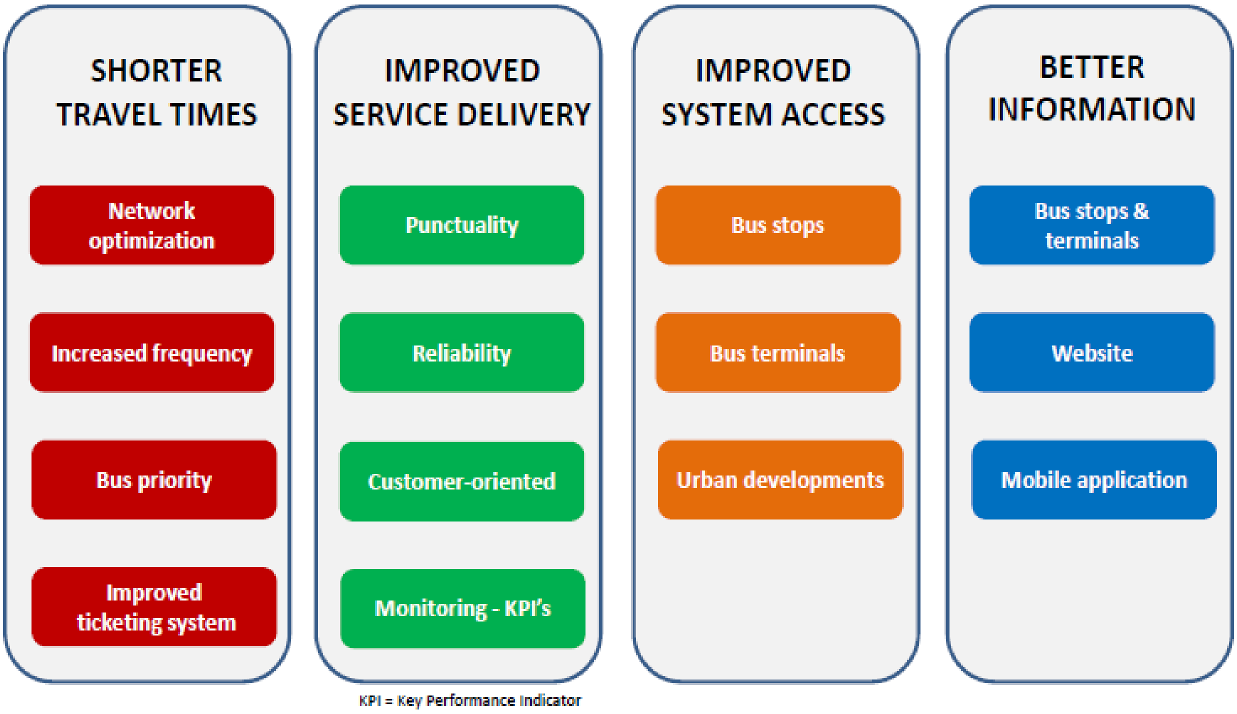


Figure 3.10: PGTP Strategies for Improving Public Transport
Source: Own Figure

Table 3-4 provides a summary of the non-motorised transport plan and proposal adopted from the Georgetown Heritage Site Special Area Plan.

Table 3-4: Summary of Non-Motorised Transportation Plan

Current Condition	• A marginal role as estimated mode share of 3% - 4% are observed. • The ridership for public transport is declining. • Public transport in Penang is rarely used by those who own a car. • The route network is not managed properly. • The route is long and complicated. • The one-way circulation within the CBD has affected the bus routes. • No detailed overall map of the route network exists. • No timetables. • Low frequency for urban services (30 – 45 minutes). • Unreliable because of congestion. • Incomplete bus lanes. • Lack of unified design and without proper lanes marking. • Very long dwell times. • Long lay-over times, low productivity. • Buses do not show their route numbers.
Target	• To achieve a variety of public transport services with broader network by the year 2025.
Initial Proposal	• To build a Tram network around Heritage areas. • To improve bus frequency around the Heritage areas. • To propose bettter ferry-taxi services.

3.3.2 PARKING

On-street parking is prevalent in Penang which requires to be regulated and relocated to enhance better street usage in lieu of green transportation. The crucial element for parking management is to create more attractive spaces for pedestrians and bicyclists. The PGTP has suggested the following strategies on parking, as shown in Table 3-5.

Table 3-5: Summary of Parking Plan

Current Condition	• Not very effective in terms of regulation. • Parking discipline of drivers is very poor. • Illegal parking in the Heritage Area. • Regulated hours appear to be insufficient. • Parking fines are difficult to collect. • Shortage of on-street parking and an oversupply of off-street parking.
Target	• To achieve complete smart parking system by the year 2025.
Initial Proposal	• To improve smart parking within the Georgetown areas. • To widen the areas that use Penang smart parking. • To build a live (real-time) electronic/digital signboard.

3.3.3 TRAFFIC MANAGEMENT

Improvement of traffic management at intersections with the aim to reduce waiting times and congestion is endorsed by the PGTP.

The PGTP suggests that a technical study by traffic management experts should be initiated to:

- Identify measures for improvement of traffic lights in combination with the geometric design at intersections.
- Study the options for implementing an Integrated Traffic Management System for Penang by applying Intelligent Transport Systems (ITS) applications and identifying the cost and benefits.

3.3.4 ELECTRIC MOBILITY

The market for Electric Vehicles (EV) has grown rapidly worldwide, in particular the deployment of electric buses is growing fast. The implementation of electric buses is possible through special financial support programmes of the national government. The pace of transition from fossil fuel-powered private cars to EVs is highly dependent on local conditions. The PGTP outlines the main conditions below:

- The extent to which the national and local governments provide financial incentives to promote a shift towards EVs and/or penalize polluting cars.
- The difference in costs - Total Costs of Ownership (TCO)- between owning and using a petrol/diesel vehicle and an EV (mainly the difference in energy costs).
- The availability of battery charging facilities.

3.3.5 CONCLUSION

For green transportation to take place, some of the challenges need to be handled accordingly. One of the challenges Penang Island faces is that it is currently a predominantly car-oriented island, more than 85% of households owned a private vehicle and only 3-4% of trips are made by public transport. The local authority needs to support and implement the policy to include green components for future development.

The local authority may also plan attractive alternative transport modes for car users by offering safe and appropriate facilities for walking and cycling and improvement and expansion of the service level of public transport. Table 3-6 below, is the indicative planning schedule by the Penang Green Transportation Plan.

Table 3-6: Indicative Planning by Penang Green Transportation Plan

Project Description		2020				2021				2022				2023				2024			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
A. WALKING, CYCLING AND PUBLIC SPACE																					
A1	More space for pedestrians and cycling - George Town	Y	Y	Y	Y	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
A2	Transformation Loring Love	Y	Y	G	G	G															
A3	Transformation Armenian Street				Y	Y	Y	G	G												
A4	Transit Mall Get Lebuh					Y	Y	Y	Y	G	G	G	G	G	G	G	G				
A5	Pedestrian walkway Swettenham Pier - Heritage Zone	Y	Y	G	G																
A6	Pedestrian connection Heritage Zone and KOMTAR	Y	Y	G	G																
A7	Bike-sharing system expansion			Y	Y	G	G														
A8	Northern Coastal Bicycle Route	Y	Y	Y	Y	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
B. PUBLIC TRANSPORT																					
B1	Improved bus route network and service level	Y	Y	Y	Y	Y	Y	G													
B2	Bus priority measures	Y	Y	Y	Y	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
B3	Reduction of stopping times at bus stops	Y	Y	G																	
B4	Bus stop enhancement program	Y	Y	Y	Y	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
B5	Improvement of passenger information	Y	Y	Y	Y	G	G	G	G												
B6	Improvement bus terminal and bus stops KOMTAR				Y	Y	Y	G	G												
B7	Improvement Weld Quay Bus Terminal	Y	Y	G	G																
B8	Improved bus stop accessibility at attraction points					Y	Y	G	G												
B9	Improvement operations performance Rapid Penang	Y	Y	G	G																
B10	Improvement bus service Airport – George Town	Y	Y	G	G																
B11	Improvement Ferry Services			Y	Y	G	G														
C. PARKING																					
C1	Adoption and implementation of Parking Policy	Y	G																		
C2	Reduction on-street parking Heritage Zone	Y	Y	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
C3	Dedicated parking locations for coaches (tourist buses)	Y	Y	G	G																
C4	Improved P&R facilities and services			Y	Y	Y	Y	G													
D. TRAFFIC MANAGEMENT																					
D1	Traffic lights and Traffic management	Y	Y	G	G	G	G	G	G	G	G	G	G								
E. ELECTRIC MOBILITY – E-VEHICLES																					
E1	Adoption of Electric Mobility Policy	Y	Y	G																	
E2	Introduction of Electric buses public transport [1]							Y	Y	G	G	G	G	G	G	G	G	G	G	G	G
E3	E-vehicles Penang State and Municipalities			Y	Y	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
E4	Taxi's, ride hail servcies and rental cars E-vehicles							Y	Y	G	G	G	G	G	G	G	G	G	G	G	G
E5	Public charging facilities E-vehicles					Y	Y	G	G	G	G	G	G	G	G	G	G	G	G	G	G
E6	Emission standards George Town Heritage Zone							Y	Y	G	G	G	G	G	G	G	G	G	G	G	G

TRAFFIC SURVEY PLANNING

This chapter outlines the traffic survey plan for data collection needed to develop the micro-simulation model. These surveys will be undertaken in November 2021 by the project sub-consultant, Fox Traffic Sdn. Bhd.

Photo: BIG Architects

4.1 SURVEY INTRODUCTION

To develop a representative simulation of transportation in Georgetown for this study, accurate and comprehensive multi-modal transport data is required to be collected across the network with a combination of on-site video capture and remote GPS data collection.

Survey data will come from two sources for this project, namely video traffic surveys and GPS data collection. On-site video traffic surveys allow us to capture an accurate and highly detailed snapshot of traffic movement around every junction and parking area, disaggregated across each peak period. GPS data collection gives us a 'birds eye view' of movement across the network, aggregated into weeks or months of travel patterns, travel times and speeds across a collective group of user experiences. Bringing these two data sources together gives us an accurate picture of transport to develop and calibrate a simulation model that is representative of on-site conditions.

The following sections describe the details of traffic survey planning.

4.2 VIDEO TRAFFIC SURVEYS

For video-based traffic surveys, it is planned to conduct classified movement counts during peak morning periods (7:00am to 10:00am) and peak afternoon/evening periods (4:30pm to 7:30pm). 'Classified' refers to counting separately the different vehicle classes including motorbikes, cars, small goods vehicles, large trucks, buses etc. In addition, car park entry and exit surveys within the historic centre of Georgetown will also be conducted to gain an understanding of not just traffic flowing through the centre, but also parking behavior within. The following sections outline the survey specifications for this study.

4.2.1 CLASSIFIED VEHICLE COUNT SURVEYS

The specifications for the classified vehicle count survey are shown in the table below. All junction surveys will be disaggregated into the various classifications for each turning movement at the junction separately.

Table 4-1: Classified Vehicle Count Survey Specifications

Item	Specifications
Survey Locations	Junctions shown in Figure 4.1
Survey Classifications	Cars, Taxis, Motorcycles, Light Goods Trucks & Small Vans, Heavy Trucks with 3 axles and above, Buses
Aggregation	All counts to be in 15-minute intervals
Pedestrians and Cyclists	All junction surveys to include pedestrian and cyclist counts across each junction arm
Queues	Maximum observed queue lengths should be recorded for each junction approach in 15-minute intervals
Signal Phase and Timings	Junction signal phase and timings should be taken from video recordings of the signal for a minimum of continuous 15 minutes in each one-hour of junction survey. Recorded signal phases, timings and videos are required to be submitted.
Survey Days	Typical Tuesday, Wednesday or Thursday (not public holidays, Ramadan period, or MCO period)
Survey Time Periods	07:00 – 10:00 and 16:30 – 19:30

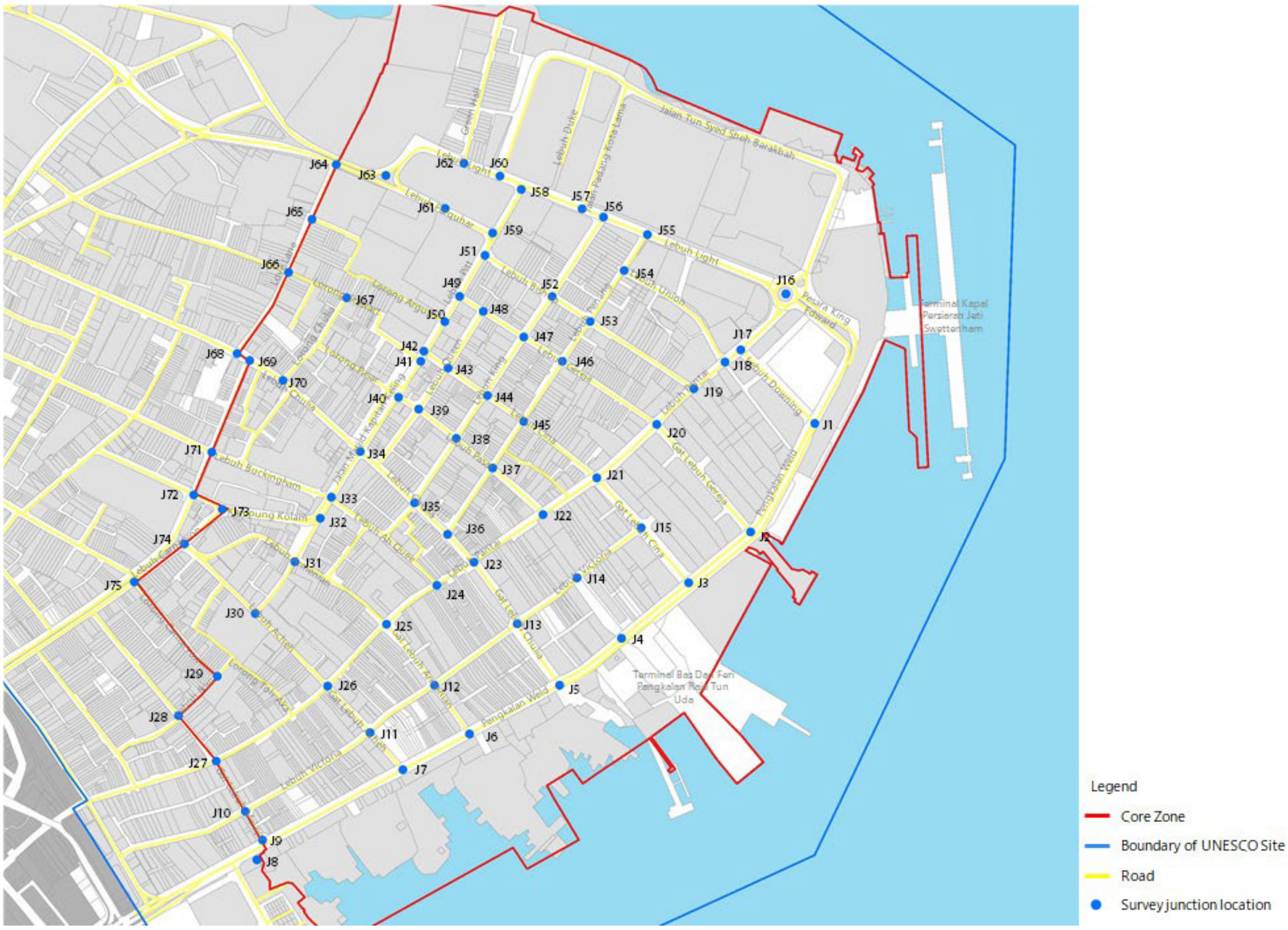


Figure 4.1: Classified Vehicle Count Survey Junctions
Source: Asian Development Bank

The survey is planned to be carried out within one week's time when 'normal' traffic resumes after the MCO* period in 2021. At the time of this report, surveys are expected in November 2021, subject to any further COVID-19 related travel restrictions.

*MCO refers to Movement Control Order, a directive from the Malaysian central government restricting movement of persons within or between states to limit the spread of COVID-19.

4.2.2 PARKING SURVEYS

Parking surveys will be conducted at both on-street and off-street parking facilities. On-street parking will be classified by street and midblock section. Illegal parking will also be recorded.

For on-street parking, the following information is planned to be captured:

1. On-street Photos by survey team (hourly): Car Park Occupancy by one-hour segments of all on-street parking across the survey period.
2. On-street video surveys (hourly 15-minute sample): Sampled arrival / departure counts and parking dwell time, by vehicle classification, at selected locations, for a period of 15 minutes within each one-hour survey period.

The following figure identifies the on-street (yellow) parking areas to be included within the parking occupancy survey (A – with photos in 1-hour segments). Selected locations for on-street parking arrival, departure, dwell time survey (B – with a 15-minute video per hour) are also indicated in purple boxes in the figure below.

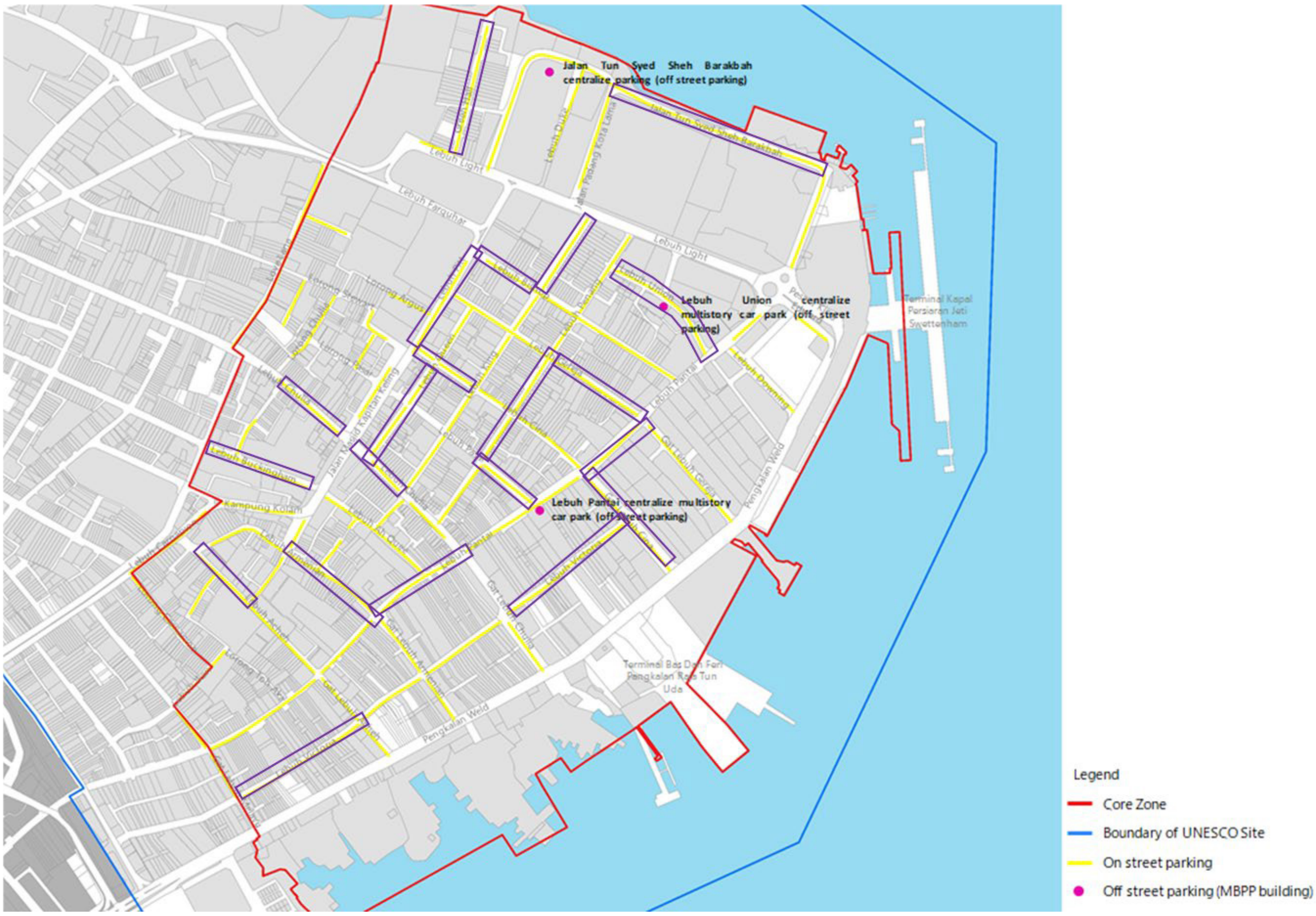


Figure 4.2: On-street Parking Survey Locations
Source: Own figure

Parking surveys will be conducted in conjunction with the surrounding junction surveys.

For off-street parking, the following information will be collected:

1. Through video recording: Arrival and departure counts, in 15-minute segments, by vehicle classification
2. Car Park Occupancy by 15-minute segments across the survey period

The following figure identifies the off-street parking areas marked in pink points that are to be included within the parking occupancy survey.

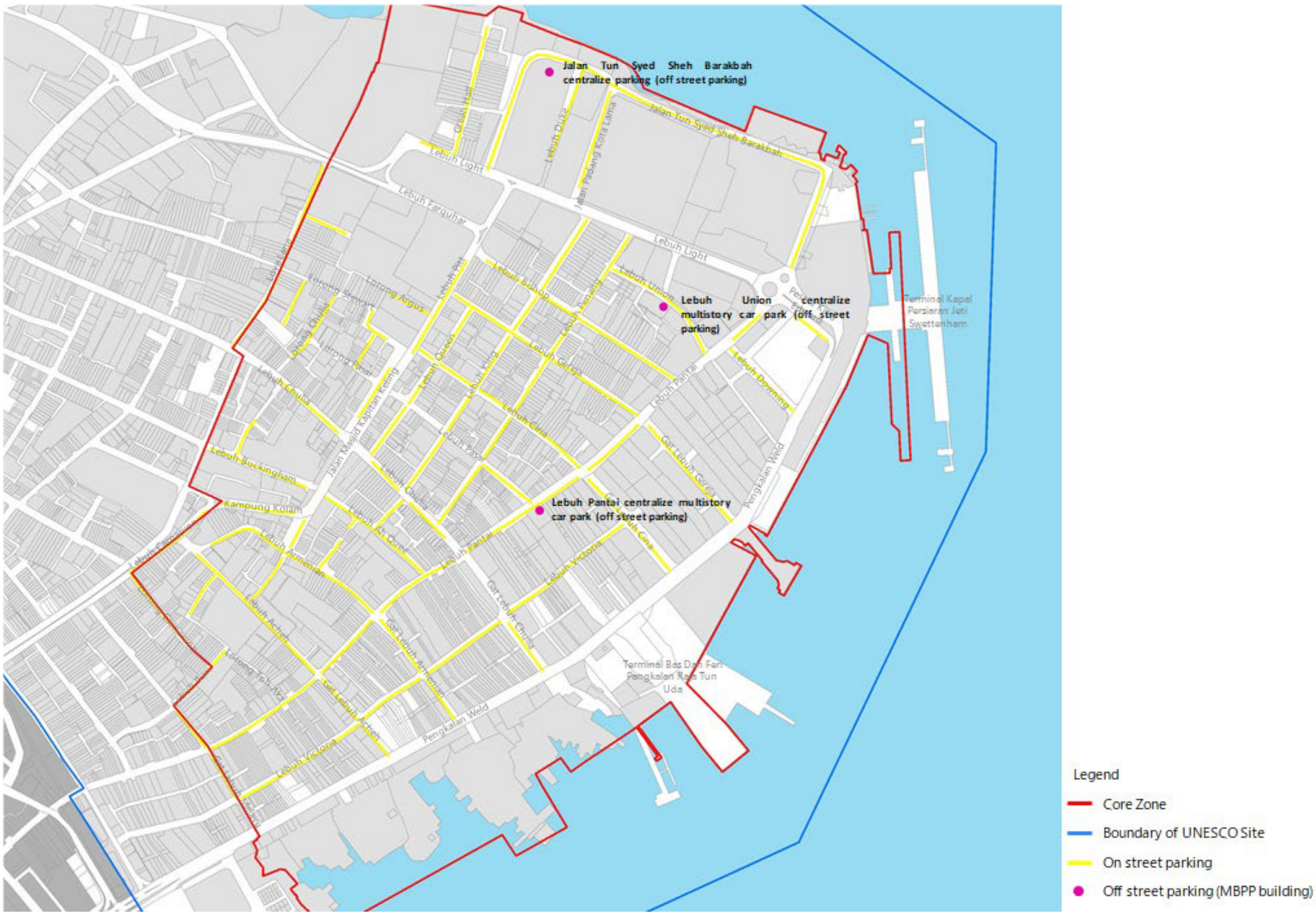


Figure 4.3: Off-street Parking Survey Locations
Source: Own figure

4.3 GPS DATA COLLECTION

GPS data to be collected for this study refer to historic data and real time data within the road network based on GPS location of vehicles on-site. This data is collected and aggregated by GPS navigation providers such as TomTom. There are two types of GPS data to be used for this study, which are travel pattern data and speed data.

Using travel pattern data, in-depth information about the distribution of the motorized traffic from various locations can be extracted to calibrate the transport models and simulations, and to better understand travel patterns.

Through speed data, bottleneck analysis of the road network can be assessed to identify significant speed reductions during peak hours, and to identify potential traffic safety issues.

The GPS data planned to be acquired to develop and calibrate the micro-simulation model includes the following components:

- Origin-destination travel pattern data; and
- Travel time and speed data

4.3.1 ORIGIN-DESTINATION TRAVEL PATTERN DATA COLLECTION

Origin-Destination Travel Pattern Data can be used to approximate the travel patterns within the model area for more accurate representation of the on-site condition. To generate this data, results from an online data platform named “TomTom O/D Analysis” was used to provide trip investigation based on a high volume of location data.

TomTom O/D Analysis uses advanced algorithms to analyze anonymized Floating Car Data (FCD) from 600+ million connected devices – providing the project with the authoritative view of what’s happening on the road. TomTom gathers real-time FCD by combining measurements of existing infrastructure with signals from anonymous TomTom connected GPS devices. TomTom also archives this data to create a historical traffic database.

All major entry and exit points to the study area will be used for collection of origin-destination travel pattern data for this simulation model.

4.3.2 TRAVEL TIME & SPEED DATA COLLECTION

Travel Time & Speed Data allows the modelled results to be compared with real-life data for further model calibration. Within this data, two types of analysis are used for this study:

- Route Analysis: to define a specific route and generate average speeds, average travel times and sample size (number of vehicles that traversed a segment).
- Speed & Density Analysis: focused analysis on sample size (number of vehicles that traversed a segment), including speed and density of the sampled vehicles.

Major arterial roads within the study area will be used for data collection of travel time and speed information. The travel time and speed data collection will occur at the same time as the traffic survey to ensure consistency between datasets.

Datasets will be compiled to aggregate data analysed over one day.

4.4 HEALTH & SAFETY

Traffic surveys will be conducted by our appointed Traffic Survey subconsultant in Malaysia, Fox Traffic Sdn Bhd. Fox Traffic will conduct a health and safety briefing for all survey staff and manage health and safety requirements in accordance with local practices and requirements. The Fox Traffic Health and Safety briefing includes:

- Taking appropriate steps to protect survey staff from the dangers of traffic and/or transport systems and have regard for the rules and regulations that govern the conduct of passengers in the interests of safety.
- Requiring staff to wear the high visibility clothing given to survey staff and make full use of any other equipment designed to improve safety.
- Briefing survey staff to take no action that can, as a consequence, result in others suffering any danger or potential danger. Survey staff should also have regard to safety of others and warn them if survey staff foresee any dangerous consequences of their actions.
- Requiring that survey staff's actions cause no unnecessary obstruction of nuisance.
- Whilst every care is taken in organizing and scheduling survey work to avoid potentially dangerous situations, survey staff should not persevere with any survey assignment if survey staff feel that personal safety is unreasonably at risk.
- Staff involved in manual traffic surveys must obey all instructions given to them by their Manager/ Supervisor. Remembering that politeness and courtesy are essential when dealing with the public, and in that way conflict situation can be avoided.
- Employees experiencing incidents of physical or verbal violence must report this immediately to their Manager/Supervisor, who will in turn report the incident to the appropriate local authority. Any incident of this nature must also be passed on to the Health and Safety manager at the earliest opportunity.

STAGE 1 SCENARIO DEVELOPMENT

This chapter outlines the development of intervention scenarios to be tested in the Stage 1 micro-simulation model.

Photo: Adobe Stock

The working group (Ramboll, JA Consult, Digital Penang and MBPP) have held a number of meetings to discuss the intervention scenarios that will be tested in the Stage 1 Trial Micro-Simulation model. The basis for developing intervention options was the outcomes derived from the Penang Transport Masterplan 2030 (PTMP) and the Penang Green Transport Plan (PGTP) as outlined in Chapter 3, the latter gave a number of specific proposals for the Georgetown area which have broadly been adopted in the scenarios outlined below.

Four scenarios have been developed each with a different focus. The scenarios will be tested in the calibrated trial area micro-simulation model. Following completion of the Task Order/Pilot Project intervention, the models will be given to Digital Penang and MBPP who can then test further interventions in the future.

The intervention scenarios include:

- Scenario 1: Pedestrian and Cyclist Priority
- Scenario 2: Traffic Improvements
- Scenario 3: Public Transport Improvements
- Scenario 4: Traffic Impact of New Development

Below the proposed interventions in each scenario have been outlined. Scenario development for Stage 2 will be conducted following the completion and presentation of Stage 1 in order to give stakeholders a clear understanding of the micro-simulation modelling strengths and capabilities.

5.1 SCENARIO 1: PEDESTRIAN AND CYCLIST PRIORITY

The following figure illustrates the interventions in this scenario.

Figure 5.1: Scenario 1 Interventions
Source: Own figure

Individual interventions within this scenario are outlined in the table below.

Table 5-1: Scenario 1 Details

Scenario 1		
Theme	**Road**	**Details (from Digital Penang)**
Pedestrian Priority	**Gat Lebuh China**: Pedestrian Walk 1 & 2	To expand the pedestrian walk with the following measurement: 1) Pedestrian walk total width: 5.5m with separation as follows: a) Walking path: 2.4m b) Small retail street: 2.1m c) Landscaping: 1m
Pedestrian Priority	**Pengkalan Weld Street**: Pedestrian Walk 1 & 2	To expand the pedestrian walk with the following measurement: 1) Pedestrian walk total width: 4m with separation as follows: a) Walking path: 2.4m b) Landscaping: 1.5m
Pedestrian Priority	**Pengkalan Weld Street**: Pedestrian Crossing 1	Propose to maintain the location with several upgrades as follows: 1) Using Traffic Clamed Crossing with: - Actuated Signalling - Vertical speed control element set 5m to 10m from the cross. - Use pedestrian-activated warning lights, flashing beacons, or High Intensity Activated Crosswalks (HAWK) to increase motorists' awareness and improve pedestrian safety. 2) Ideally, pedestrian crossing is place at the inter-junction or at the mid-block. As existing crossing exist in the middle of Gat Lebuh Pasar, propose to close the road.
Pedestrian Priority	**Pengkalan Weld Street**: Pedestrian Crossing 2	Pedestrian Cross location: 1) Shall place max 100m from Downing Street. If it takes a person more than 3 minutes to walk to a pedestrian crossing, he or she may decide to cross along a more direct, but unsafe or unprotected, route. 2) Install a pedestrian crossing where there is a significant pedestrian desire line. In this case pedestrian from Downing Street to Swettenham Pier. 3) A pedestrian crossing should be at least 3 m wide. 4) Using Traffic Clamed Crossing with: - Actuated Signalling - Vertical speed control element set 5m to 10m from the cross. - Use pedestrian-activated warning lights, flashing beacons, or High Intensity Activated Crosswalks (HAWK) to increase motorists' awareness and improve pedestrian safety.

Table 5-1: Scenario 1 Details (cont.)

Scenario 1		
Theme	**Road**	**Details (from Digital Penang)**
Pedestrian Priority	**Beach Street**: Pedestrian Walk 1 & 2	To expand the pedestrian walk with the following measurement: 1) Pedestrian walk total width: 3m with separation as follows: a) Walking path: 2.4m b) Street Light: 0.6m
Pedestrian Priority	**Lebuh Victoria**: Pedestrian Walk 1 & 2	To expand the pedestrian walk with the following measurement: 1) Pedestrian walk total width: 3m with separation as follows: a) Walking path: 2.4m b) Street Light: 0.6m
Pedestrian Priority	**Gat Lebuh Gereja**: Pedestrian Walk 1 & 2	To expand the pedestrian walk with the following measurement: 1) Pedestrian walk total width: 5.5m with separation as follows: a) Walking path: 2.4m b) Small retail street: 2.1m c) Landscaping: 1m
Pedestrian Priority	**Downing Street**: Pedestrian Walk 1 & 2	To expand the pedestrian walk with the following measurement: 1) Pedestrian walk total width: 5.5m with separation as follows: a) Walking path: 2.4m b) Landscaping: 1.5m
Cyclist Priority	**Gat Lebuh China**: Bike Lane 1 & 2	Bike lane to be design using Curbside Buffered Cycle Lane type, with the measurement as follows: 1) Lane width: 1.8m 2) Demarcation width: 1m
Cyclist Priority	**Pengkalan Weld Street**: Bike Lane 1 & 2	Bike lane to be design using Protected Cycle Lane type, with the measurement as follows: 1) Lane width: 2m 2) Demarcation width: 1m

5.2 SCENARIO 2: TRAFFIC IMPROVEMENTS

The following figure illustrates the interventions in this scenario.

Figure 5.2: Scenario 2 Interventions
Source: Own figure

Table 5-2: Scenario 2 Details

Scenario 2		
Theme	**Road**	**Details (from Digital Penang)**
Traffic Improvements	**Gat Lebuh China**: Remove Parking Spot	To remove all parking at Gat Lebuh China for giving away expansion of Pedestrian Walk with addition of space for commercial activities and landscaping.
Traffic Improvements	**Beach Street**: One-Way Street	1) Introduction of 1-way street for beach street. Start from Gat Lebuh Chulia and end at Jubilee Clock Tower. 2) Widen sidewalks to provide accessibility and increased space for pedestrians and commercial activity. Alternate parking spaces with additional curb extensions, intermittent landscaping, and dedicated spaces for vendors.
Traffic Improvements	**Gat Lebuh Pasar:** Laneways	1) Increase the frontage area available for businesses in the city and create intimate environments by transforming laneways and alleys with active ground floor uses. 2) Maintain an accessible clear path of 3.5 m for emergency vehicle access. 3) Movable furniture can be placed in the emergency access path so long as they do not impede necessary but infrequent movements.
Traffic Improvements	**Gat Lebuh Pasar:** To close	The exit of Gat Lebuh Pasar is in the middle of a pedestrian crossing. as it is a safety issue, closing of this road is proposed. Another road beside the market can be replaced as an exit road.
Traffic Improvements	**Downing Street**: One-Way Street	1) Introduction of 1-way street for beach street. Start from Gat Lebuh Chulia and end at Jubilee Clock Tower. 2) Widen sidewalks to provide accessibility and increased space for pedestrians and commercial activity. Alternate parking spaces with additional curb extensions, intermittent landscaping, and dedicated spaces for vendors.

5.3 SCENARIO 3: PUBLIC TRANSPORT PRIORITY

The following figure illustrates the interventions in this scenario.

Figure 5.3: Scenario 3 Interventions
Source: Own figure

Table 5-3: Scenario 3 Details

Scenario 3		
Theme	**Road**	**Details (from Digital Penang)**
Public Transport Improvements	**Gat Lebuh China**: Shared Street	Design principles: 1) Must prioritize vulnerable users, ensuring that clear paths are maintained. 2) Drainage channels and permeable materials should be provided in accordance with existing curb lines and slope. 3) Provide tactile warning strips at the entrance to all shared spaces. Warning strips should span the entire intersection crossing. 4) Maintain a clear path for delivery vehicles, and mark dedicated areas for vehicular movement with a change in paving pattern or type. 5) Pedestrian walk space to maintain at least 1.8m width 6) Install signage to educate the public on how to use a shared street in the early stages of conversion. 7) One-way street: traffic flow from Weld Quay Sy to Beach St.
Public Transport Improvements	**Pengkalan Weld Street:** Bus Lane 1, 2 & 3	Design using offset transit lane. The standard width for road lane is 3.3m. Benefits: 1) Offset transit lanes reduce delays due to congestion. 2) Offset transit lanes raise the visibility of high-quality services, especially rapid service.
Public Transport Improvements	**Pengkalan Weld Street:** Bus Lane turn-in	Design using offset transit lane. The standard width for road lane is 3.3m. Benefits: 1) Offset transit lanes reduce delays due to congestion. 2) Offset transit lanes raise the visibility of high-quality services, especially rapid service.
Public Transport Improvements	**Lebuh Victoria:** Shared Street	Design principles: 1) Must prioritize vulnerable users, ensuring that clear paths are maintained. 2) Drainage channels and permeable materials should be provided in accordance with existing curb lines and slope. 3) Provide tactile warning strips at the entrance to all shared spaces. Warning strips should span the entire intersection crossing. 4) Maintain a clear path for delivery vehicles, and mark dedicated areas for vehicular movement with a change in paving pattern or type. 5) Pedestrian walk space to maintain at least 1.8m width 6) Install signage to educate the public on how to use a shared street in the early stages of conversion.
Public Transport Improvements	**Gat Lebuh Gereja:** Shared Street	Design principles: 1) Must prioritize vulnerable users, ensuring that clear paths are maintained. 2) Drainage channels and permeable materials should be provided in accordance with existing curb lines and slope. 3) Provide tactile warning strips at the entrance to all shared spaces. Warning strips should span the entire intersection crossing. 4) Maintain a clear path for delivery vehicles, and mark dedicated areas for vehicular movement with a change in paving pattern or type. 5) Pedestrian walk space to maintain atleast 1.8m width 6) Install signage to educate the public on how to use a shared street in the early stages of conversion. 7) One-way street: traffic flow from Weld Quay Sy to Beach St.

5.4 SCENARIO 4: TRAFFIC IMPACT OF NEW DEVELOPMENT

The following figure illustrates the interventions in this scenario.

Figure 5.4: Scenario 4 Interventions

Source: Own figure

Individual interventions within this scenario are outlined in the table below.

Table 5-4: Scenario 4 Details

Scenario 4		
Theme	**Road**	**Details (from Digital Penang)**
Traffic Impact of New Developments	**Pengkalan Weld Street or Other Road with New Development:** Planning and Construction of New Development	Digital Penang would like to study the new traffic demand and traffic impact of new on the study area. This will apply to one new development regardless of land use to be planned and constructed in the study area. On simulating and assessing the traffic impact, the following aspect will be included in the scenario: 1) Traffic impact of new road network demand brought by new development. 2) Traffic impact of construction road diversion and construction vehicle access. 3) Traffic operations and management measures arising from post-implementation traffic issues. 4) Traffic demand management recommendations and other traffic improvement recommendations.

COVID-19 IMPACTS

Photo: Adobe Stock

The emergence of SARS-CoV-2 or COVID-19 in late 2019/early 2020 has disrupted the world, with restrictions on both international and domestic travel necessary to slow the spread of the virus. Penang was not spared from these restrictions. Movement restrictions on international travel, domestic travel between states and travel within Penang have been in force in some form since March 2020. This has rendered the traffic situation in Penang un-representative of normal conditions, and therefore it has not been possible to conduct traffic surveys as planned. Traffic surveys are usually the precursor to developing a micro-simulation model as data from these surveys is used to develop and calibrate the model.

Therefore, changes to the initially planned methodology (as described in the sections above) were required. Additionally, Digital Penang requested a demonstration of the micro-simulation model in order to engage their stakeholders further on what the project outcomes will be. The following flow chart illustrates the changes in methodology in order for us to progress the micro-simulation model development and other Pilot Project activities during the data acquisition delay caused by COVID-19.

While these changes have resulted in a delay to the overall timeframe of around 3 months, the overall delay has been minimized by progressing tasks non-reliant on data acquisition in the meantime, such as the development of a 'Demonstration Model' using existing data provided by Digital Penang as described in the following chapter.

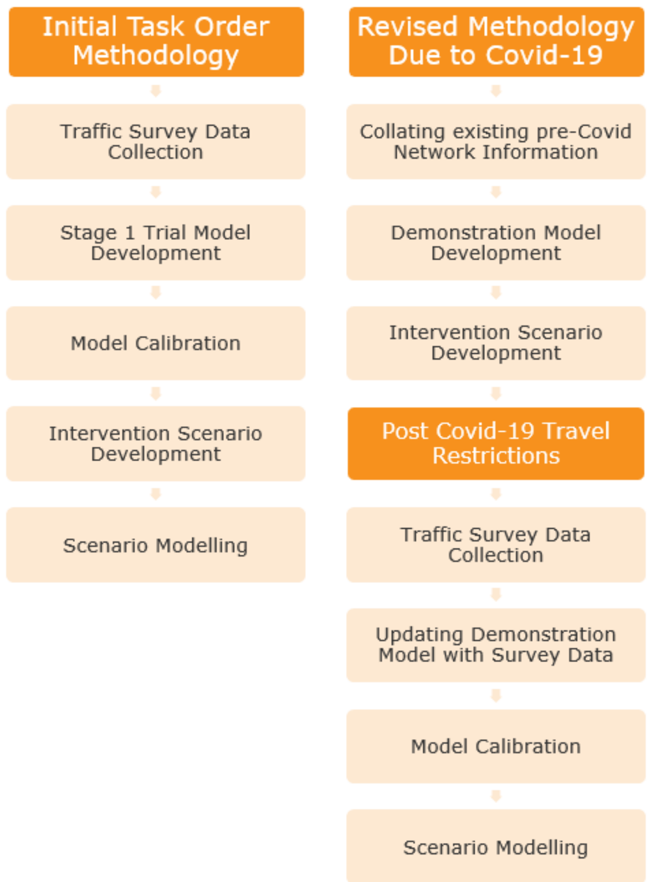


Figure 6.1: Methodology Changes due to Covid-19
Source: Own figure

VISSIM MICRO-SIMULATION MODELLING

This chapter outlines the development of a 'Demonstration Model' by conducting non-data-acquisition reliant tasks early to give a demonstration of the simulation prior to conducting traffic surveys. This process relied on available historical data from MBPP and Digital Penang.

Photo: Adobe Stock

7.1 MODEL BACKGROUND

As on-site data collection in Malaysia has been delayed due to the COVID-19 pandemic situation. Without on-site traffic data, limited modelling tasks could be completed. It was therefore requested by Digital Penang for Ramboll to conduct a demonstration model using limited historical data to test the methodology of this study and provide a demonstration of output for stakeholder engagement. The following sections document the process of the demonstration model.

7.2 MODEL STAGES

Through the entirety of the Pilot Project implementation process, there will be 3 stages conducted for the modelling:

- Stage 0 (Demonstration Model): consisting of more areas of Georgetown including major transport links and activity area with partial data and without calibration
- Stage 1 (Trial Area Model): consisting of core areas of Georgetown near waterfront's mobility trial area with full data input and model calibration
- Stage 2 (Expanded Area Model): consisting of more areas of Georgetown including major transport links and activity area with full data input and model calibration

7.2.1 STAGE 0 DEMONSTRATION MODEL

The Demonstration Model for Stage 0 has arisen from the fact that data collection has been delayed due to COVID-19 travel restrictions. The Demonstration Model was developed in order to minimise delay caused by COVID-19, to check model network coding and to provide Digital Penang with a demonstration model to engage stakeholders on the value of this Pilot Project intervention. This model used existing data to demonstrate the modeling process prior to conducting surveys.

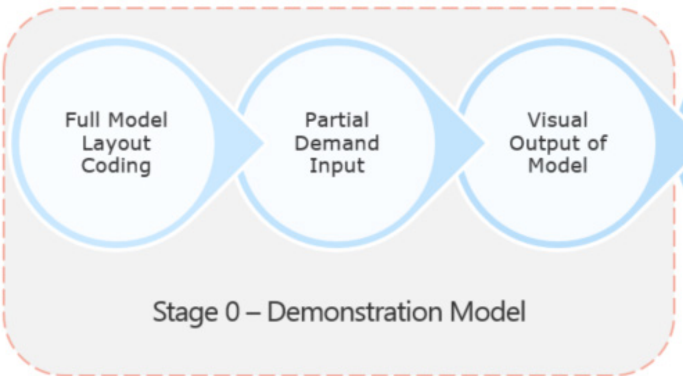


Figure 7.1 Stage 0 Demonstration Model Process
Source: Own figure

It is noted that as the surveyed traffic demand information is not incorporated into the model and is intended for process demonstration purposes only, the Demonstration Model would not be used for detailed measurement and analysis. The Demonstration Model is intended only as a visual output of the simulation model and a precursor to the Stage 1 modelling.

7.2.2 STAGE 1 TRIAL AREA MODEL

In the Stage 1 model, full data input will be available. The following process will be conducted in Stage 1.

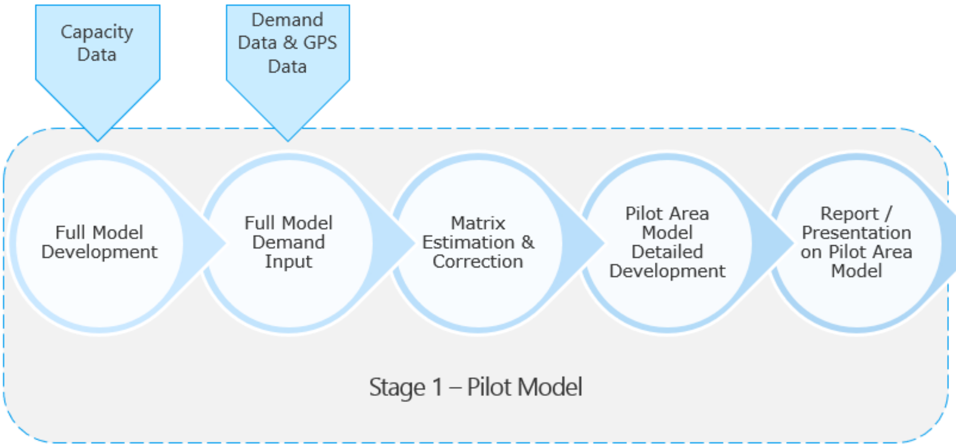


Figure 7.2: Stage 1 Trial Model Process
Source: Own figure

There are also differentiated tasks to be conducted for trial area and expanded area in Stage 1, which includes the following detailed items as set out in Figure 7.3. Some of these items, such as Network Layout Coding, the Task Team has been able to get a 'head-start' on by conducting these tasks within the Demonstration Model where they can be directly carried over into the Stage 1 modelling.

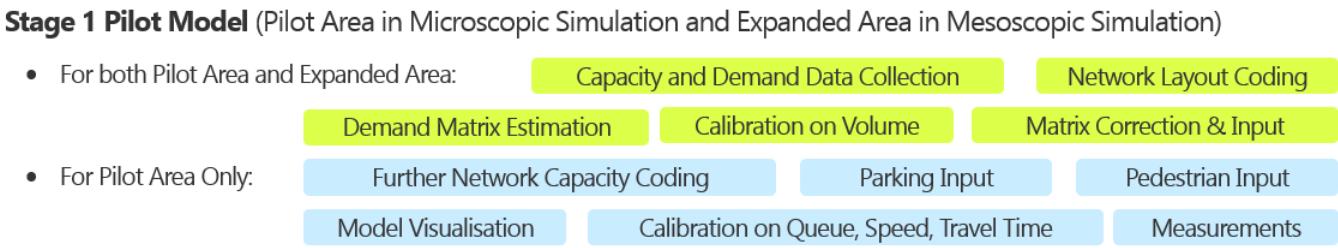


Figure 7.3: Stage 1 Tasks
Source: Own figure

Scenarios testing for the trial area will also be conducted during Stage 1. The scenarios to be tested are outlined in Section 5 of this report. Scenario testing involves coding the respective intervention scenarios within the model (such as road network changes, public transport additions etc.) and measuring network performance statistics in comparison to the base 'existing situation' model. This allows Digital Penang and MBPP to measure the performance of proposed changes to the network in a quantitative manner and justify their benefits to stakeholders.

7.2.3 STAGE 2 EXPANDED AREA MODEL

In the Stage 2 model, full data input will be available, and the model will be further developed on the basis of Stage 1. The following process will be conducted in Stage 2.

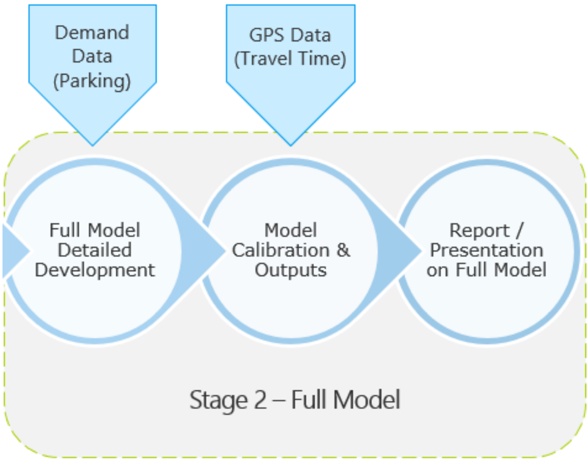


Figure 7.4: Stage 2 Expanded Model Process
Source: Own figure

Detailed tasks in Stage 2 include the following items as detailed in Figure 7.5.

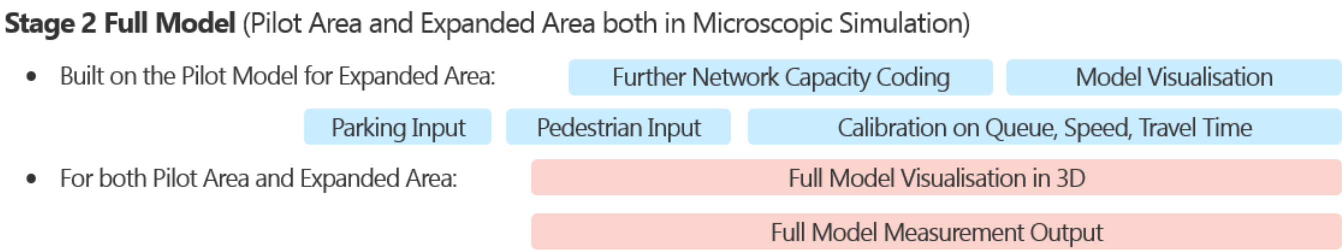


Figure 7.5: Stage 2 Tasks
Source: Own figure

As with Stage 1, intervention scenarios will be tested in the wider Stage 2 area. These intervention scenarios will be developed in collaboration with Digital Penang and MBPP upon completion of Stage 1. The scenarios for Stage 2 will represent wider area improvements that are proposed for Georgetown and the model will quantify their performance in comparison to the existing situation and allow Digital Penang and MBPP to visualize their benefit to Penang and communicate these improvements to stakeholders.

7.3 MODEL STUDY AREA

The Demonstration Model follows the study area for the expanded area model (Stage 2). This allows us to code the network early, such that work on Stage 2 can be streamlined. Therefore, all junctions for Stage 2 have been coded into the demonstration model, including:

- Junction 1: Pengkalan Road/Lebuh Downing
- Junction 2: Pengkalan Road/Gat Lebuh Gereja
- Junction 3: Pengkalan Road/Gat Lebuh China
- Junction 4: Pengkalan Road/Gat Lebuh Pasar
- Junction 5: Pengkalan Road/Gat Lebuh Chulia
- Junction 6: Pengkalan Road/Gat Lebuh Armenian
- Junction 7: Pengkalan Road/Gat Lebuh Acheh
- Junction 8: Pengkalan Road/Lintasan Pengkalan 1
- Junction 9: Pengkalan Road/Gat Lebuh Melayu
- Junction10: Lebuh Victoria/ Gat Lebuh Melayu
- Junction11: Lebuh Victoria/ Gat Lebuh Acheh
- Junction12: Lebuh Victoria/ Gat Lebuh Armenian
- Junction13: Lebuh Victoria/ Gat Lebuh Chulia
- Junction14: Lebuh Victoria/ Gat Lebuh Pasar
- Junction15: Lebuh Victoria/ Gat Lebuh China
- Junction16: Lebuh Pantai/ Pesara King Edward
- Junction17: Lebuh Pantai/ Lebuh Downing
- Junction18: Beach Street/ Lebuh Union
- Junction19: Beach Street/ Bishop Street
- Junction20: Beach Street/ Gat Lebuh Gereja
- Junction21: Beach Street/ Gat Lebuh China
- Junction22: Beach Street/ Gat Lebuh Pasar
- Junction23: Beach Street/ Gat Lebuh Chulia
- Junction24: Beach Street/ Lebuh Al Quee
- Junction25: Beach Street/ Gat Lebuh Armenian
- Junction26: Beach Street/ Gat Lebuh Acheh
- Junction27: Beach Street/ Gat Lebuh Melayu
- Junction28: Lorong Ikan/ Lebuh Melayu
- Junction29: Lorong Toh Aka/ Lorong Carnavon
- Junction30: Lebuh Acheh/Lebuh Cannon
- Junction31: Lebuh Acheh/Lebuh Armenian
- Junction32: Jalan Masjid Kapitan Keling/Jalan Kampung Kolam
- Junction33: Jalan Masjid Kapitan Keling/Jalan Buckingham
- Junction34: Jalan Masjid Kapitan Keling/Chulia Street
- Junction35: Chulia Street/Lebuh King
- Junction36: Chulia Street/Lebuh penang
- Junction37: Lebuh Pasar/Penang Street
- Junction38: Lebuh Pasar/ Lebuh King

- Junction39: Lebuh Pasar/ Queen Street
- Junction40: Jalan Masjid Kapitan Keling/ Lebuh Pasar
- Junction41: Jalan Masjid Kapitan Keling/ Lorong Stewart
- Junction42: Jalan Masjid Kapitan Keling/ Lebuh China
- Junction43: Lebuh China/Queen Street
- Junction44: Lebuh China/Lebuh King
- Junction45: Lebuh China/Lebuh Penang
- Junction46: Lebuh Gereja /Lebuh Penang
- Junction47: Lebuh King /Church Street
- Junction48: Church Street/Queen Street
- Junction49: Jalan Masjid Kapitan Keling/ Church Street
- Junction50: Jalan Masjid Kapitan Keling/ Lorong Argus
- Junction51: Jalan Masjid Kapitan Keling/ Bishop Street
- Junction52: Bishop Street/Lebuh King
- Junction53: Bishop Street/Lebuh Penang
- Junction54: Lebuh Penang/Lebuh Union
- Junction55: Lebuh Penang/Light Street
- Junction56: Lebuh King/Light Street
- Junction57: Lebuh Light/Jalan Padang Kota Lana
- Junction58: Lebuh Light/Jalan Masjid Kapitan Keling
- Junction59: Jalan Masjid Kapitan Keling/Lebuh Farquhar
- Junction60: Lebuh Light/Jalan Tun Syed Sheh Barakbah
- Junction61: Lebuh Farquhar/Local road
- Junction62: Lebuh Light/Jalan Green Hall
- Junction63: Lebuh Light/ Lebuh Farquhar
- Junction64: Lebuh Light/ Love Ln
- Junction65: Love Ln/Lorong Argus
- Junction66: Love Ln/Mountri Street
- Junction67: Lorong Stewart/Lorong Chulia
- Junction68: Love Ln/Chulia Street
- Junction69: Chulia Street/lebuh Carnavon
- Junction70: Chulia Street/lebuh Chulia
- Junction71: Lebuh Campbell/Lebuh Carnarvon
- Junction72: Pesara Claimant/Lebuh Carnarvon
- Junction73: Jalan Kampung Kolam/Lebuh Carnarvon
- Junction74: Lebuh Carnarvon/Lebuh Acheh
- Junction75: Lebuh Carnarvon/Lebuh Kimberley

The junctions are shown in the figure below, with the wider area model boundary in red and the Stage 1 Trial Model area in green.

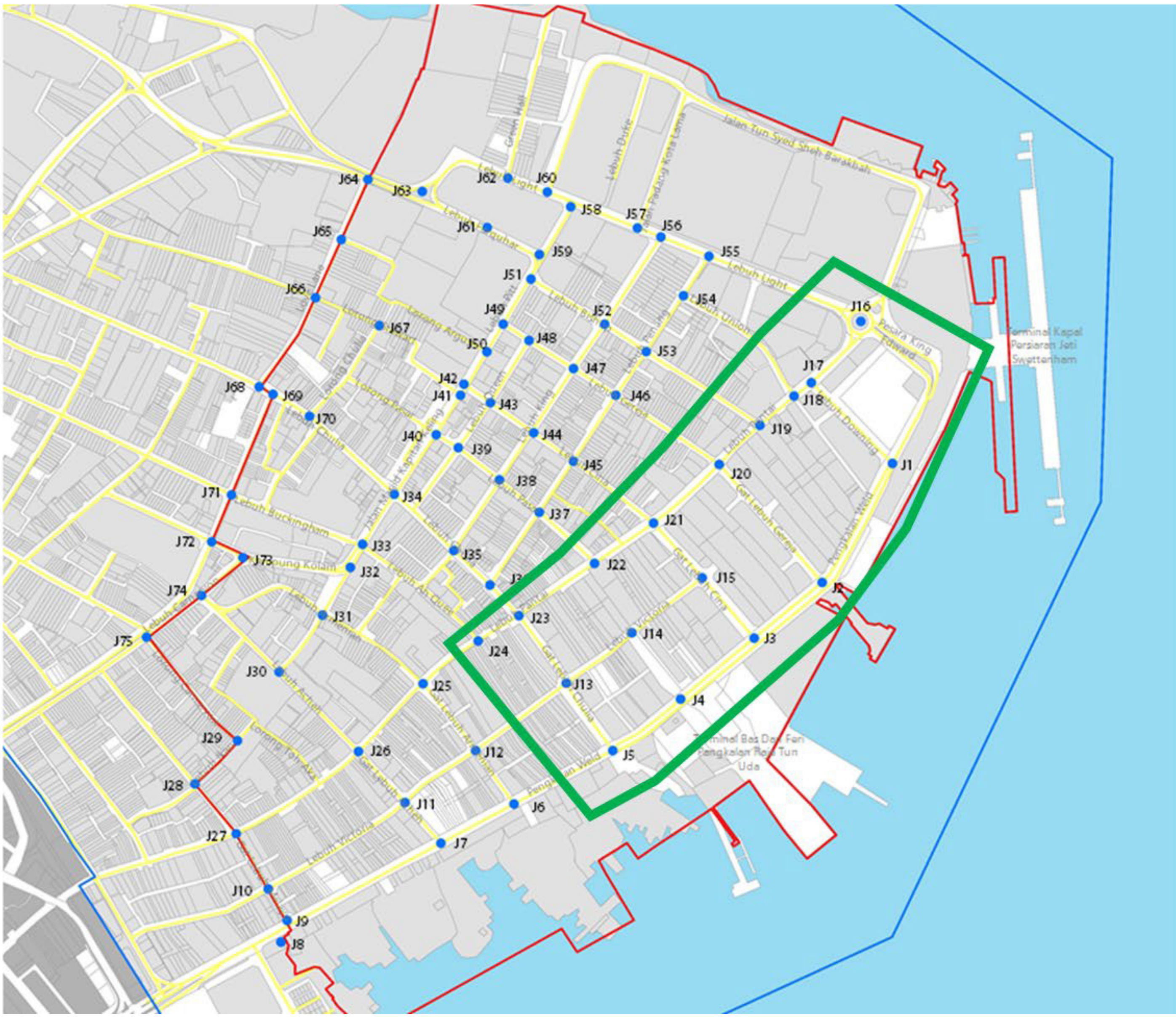


Figure 7.6 Model Area
Source: Own figure

7.4 MODEL ZONING SYSTEM

The zoning system that is adopted for the study area is as shown in the figure given below. Zones represent the entry and exit points of traffic models, where vehicular traffic arrives and departs the network. Traffic within the model will flow from one zone to another, on occasions spending time in parking spaces.

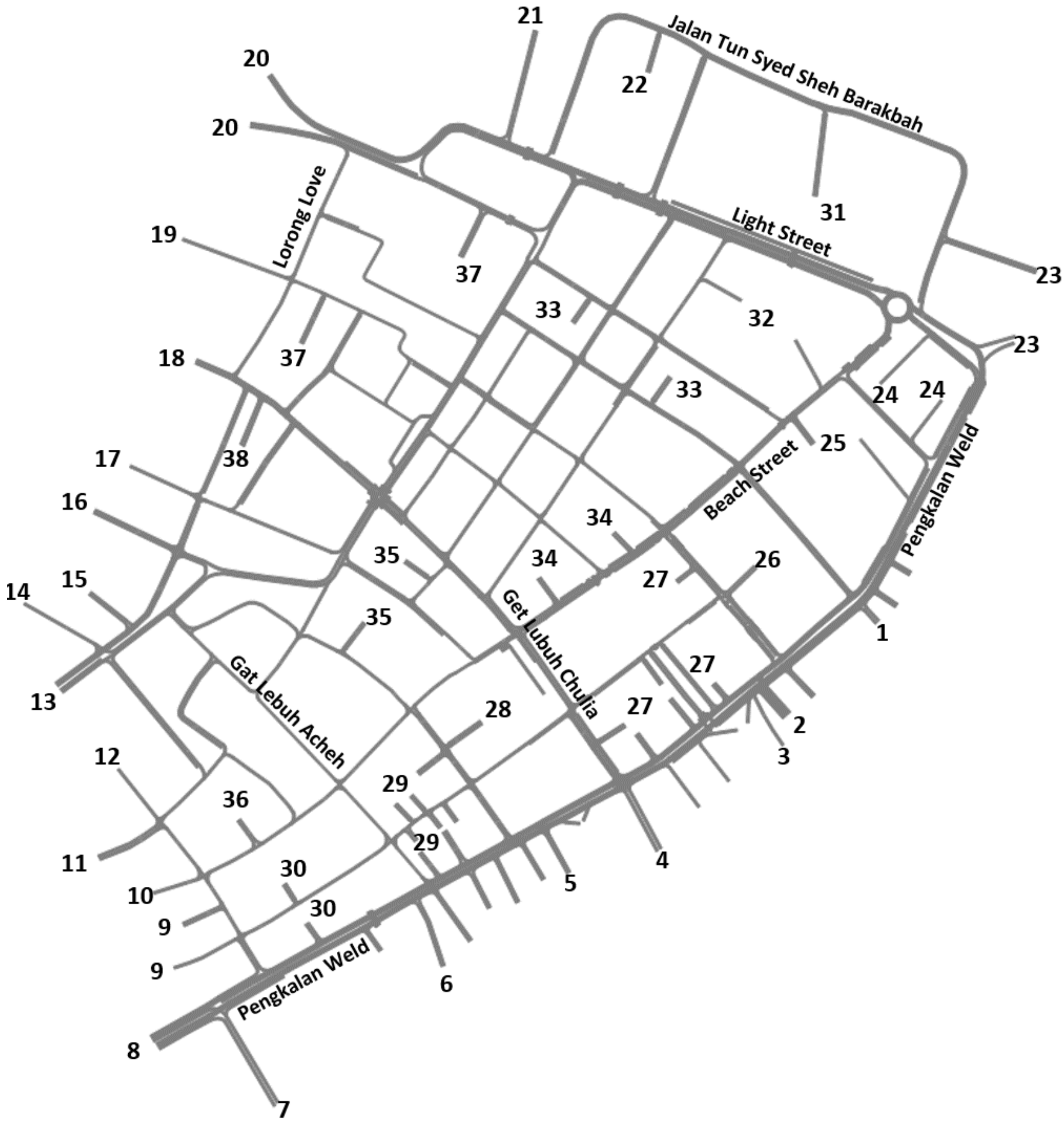


Figure 7.7 Zoning System
Source: Own figure

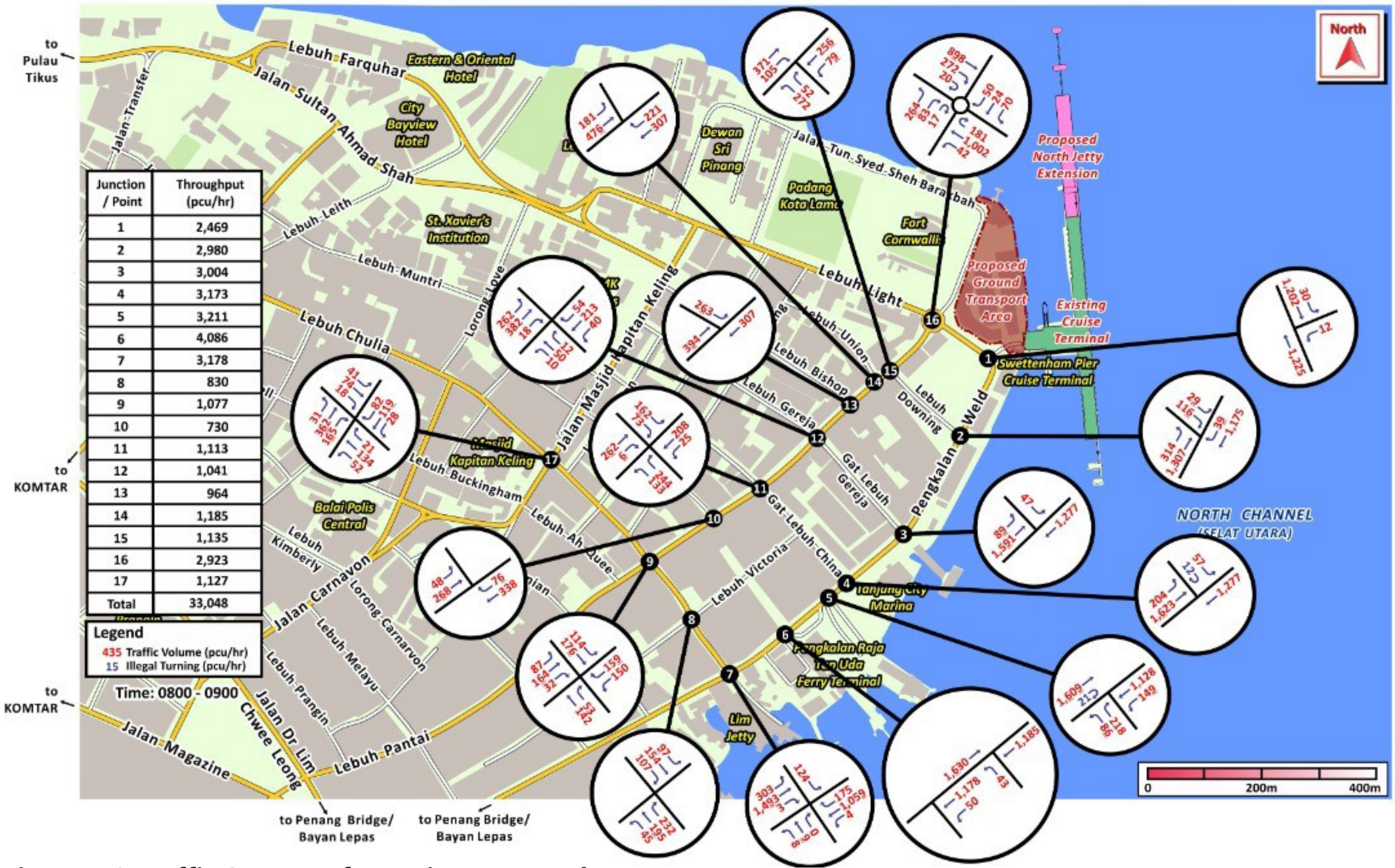
Descriptions of the zones adopted in the study area are given below.

Table 7-1: Zone Numbering and Description

Zone Number	Zone Description
1	Jalan Gereja
2	Exit from Ferry Terminal
3	Entry to Ferry Terminal
4	Local Road
5	Local Road
6	Road to Tan Jetty Thai Food
7	Raya Merdeka Highway
8	Pengkalan Road
9	Lebuh Victoria Road
10	Lebuh Pantai
11	Lorong Ikan
12	Lebuh Melayu
13	Lebuh Carnarvon
14	Lebuh Kimberley
15	Lorong Ngah Aboo
16	Pesara Claimant
17	Lebuh Campbell
18	Chulia Street
19	Muntri Street
20	Lebuh Farquhar
21	Jalan Green Hall
22	Lebuh Duke
23	Access to Cruise Terminal
24	Private Car Park Access
25	Access to Local Roads
26	Access to Pusaka Warison
27	Access to Local Roads
28	Access to Local Roads
29	Access to Local Roads
30	Access to Local Roads
31	Access to Local Roads
32	Lebuh Union

7.5 MODEL TRAFFIC SURVEY INPUT

Limited historical traffic survey information has been provided by Digital Penang/MBPP as input for this demonstration model. It is noted that the information does not cover the entire study area. Thus, the volume presented in the model is for reference only and is not reflective of up-to-date on-site conditions. The following diagram shows the traffic junction data used to derive the Origin-Destination matrix for the Demonstration Model. The process of developing the Origin-Destination matrix is described in the section below.



Junction / Point	Throughput (pcu/hr)
1	2,469
2	2,980
3	3,004
4	3,173
5	3,211
6	4,086
7	3,178
8	830
9	1,077
10	730
11	1,113
12	1,041
13	964
14	1,185
15	1,135
16	2,923
17	1,127
Total	33,048

Figure 7.8 Traffic Survey Information (AM Peak)

Source: Digital Penang

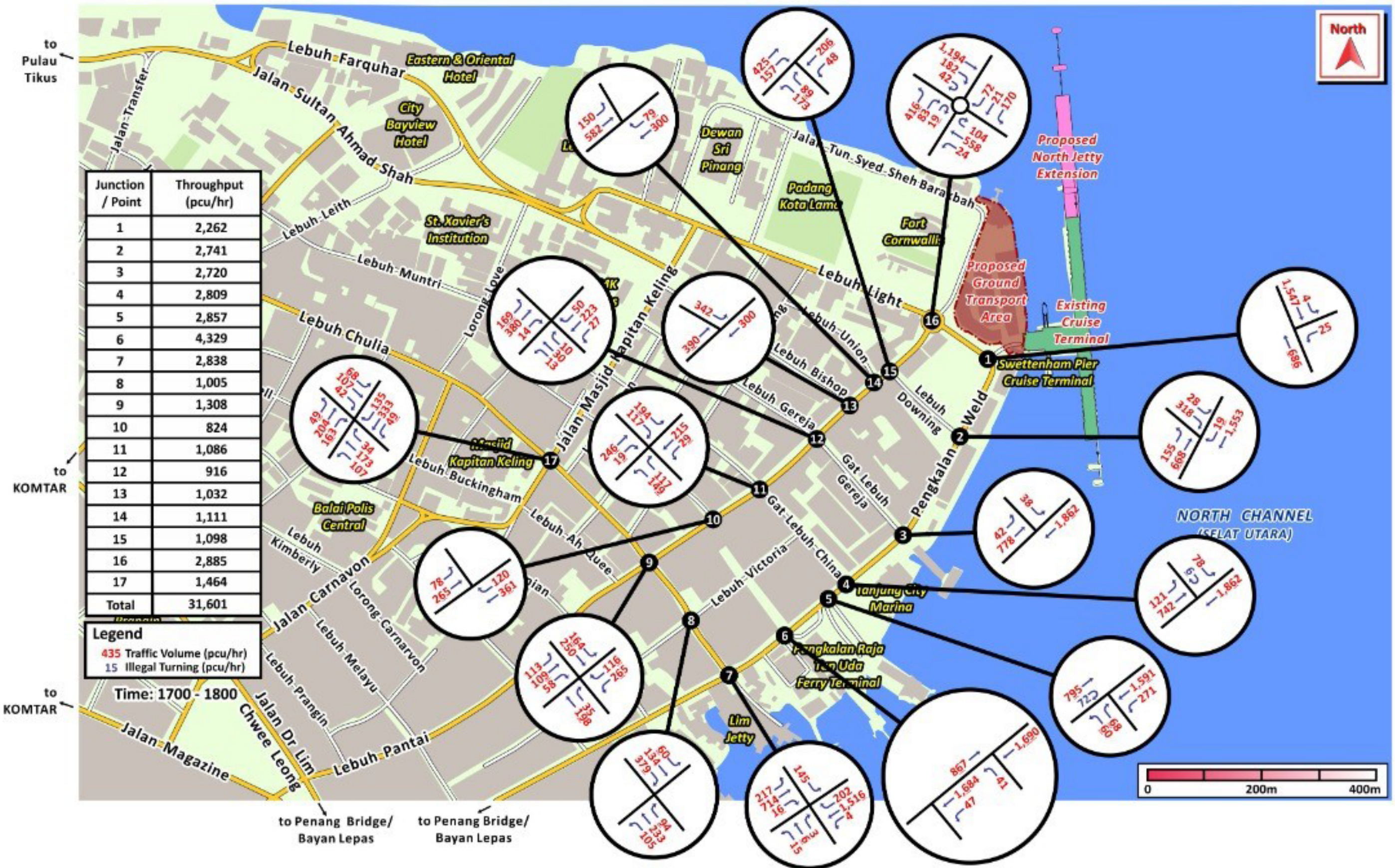


Figure 7.9 Traffic Survey Information (PM Peak)

Source: Digital Penang

The following pedestrian crossing timing, as provided by MBPP from historical records, has also been incorporated in the demonstration model.

Table 7-2 Pedestrian Crossing Timing

TRAFFIC LIGHT PEDESTRIAN CROSSING TIME SETTING IN HERITAGE AREA								
MAJLIS BANDARAYA PULAU PINANG								
NO	PEDESTRIAN CROSSING		VEHICLE (sec.)				PEDESTRIAN (sec.)	
	ROAD NAME 1	ROAD NAME 2	GREEN	FLASHING	AMBER	RED	PEDESTRIAN 1	PEDESTRIAN 2
1	Jalan Dr Lim Chwee Leong	Lebuh Lintang/Prangin Mall	90.0	3.0	3.0	2.0	25.0	16.0
2	Lebuh Carnavon		30.0	3.0	3.0	2.0	20.0	
3	Jalan Pengkalan Weld	Lim Jetty	30.0	3.0	3.0	2.0	20.0	
4	Jalan Pengkalan Weld	Rapid Penang Bus Terminal	50.0	3.0	3.0	2.0	20.0	
5	Lebuh Pantai	Alliance Bank	30.0	3.0	3.0	2.0	15.0	
6	Lebuh Pantai	Standard Chartered	30.0	3.0	3.0	2.0	15.0	
7	Lebuh Light	Dewan Undangan Negeri	30.0	3.0	3.0	2.0	18.0	
8	Lebuh Light	Lebuh King/Padang Kota Lama	30.0	3.0	3.0	2.0	18.0	
9	Lebuh Light	Bank Islam	30.0	3.0	3.0	2.0	18.0	
10	Lebuh Light	Mahkamah	25.0	3.0	3.0	2.0	15.0	
11	Lebuh Farquhar	Mahkamah	30.0	3.0	3.0	2.0	15.0	
12	Lebuh Farquhar	Jalan Penang (Hotel Continental)	60.0	3.0	3.0	2.0	20.0	
13	Lebuh Farquhar	Hotel E&O	40.0	3.0	3.0	2.0	15.0	

7.6 MODEL DEVELOPMENT METHODOLOGY

In developing a transport model, the aim is to accurately reflect on-site traffic behaviors, volumes routing and congestion levels. Traffic volumes at junctions will be collected in both morning (AM) and afternoon (PM) peak hours through video-surveys, and a process of matrix estimation is undertaken to translate traffic volumes to a matrix representing the origins and destinations of all vehicles into and out of the network. The data utilization approach is summarized in the diagram below. Once the model is run, we compare how well the estimated matrix represents the data surveyed by comparing the modelled volumes at junctions against those counted on-site.

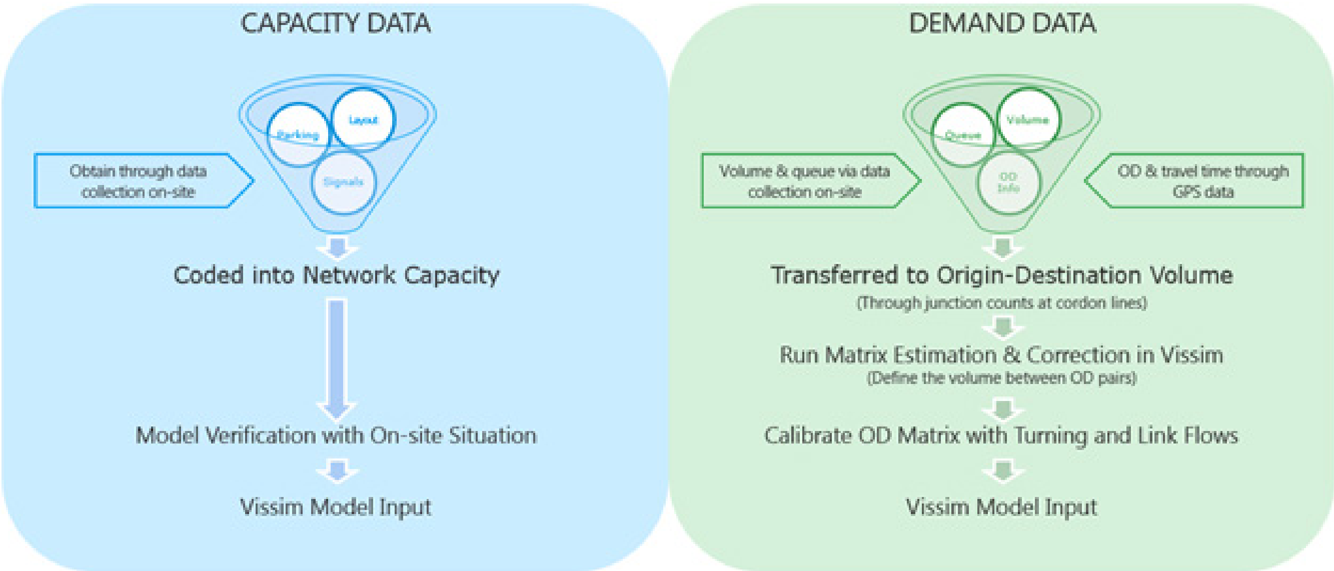


Figure 7.10 Data Utilization Approach
Source: Own figure

One way to compare two sets of traffic volumes, commonly used in traffic engineering, traffic forecasting, and traffic modelling, is via GEH statistics. The GEH Statistic is designed to compare two sets of traffic volumes. Using the GEH Statistic avoids some pitfalls that occur when using simple percentages to compare two sets of volumes. This is because the traffic volumes in real-world transportation systems vary over a wide range. The GEH statistic reduces this problem because the GEH statistic is non-linear, a single acceptance threshold based on GEH can be used over a wide range of traffic volumes. The formula for GEH statistics is:

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$$

Where M is the hourly traffic volume from the traffic model and C is the real-world hourly traffic count.

This statistic is used in the model calibration process to compare the modelled traffic against the surveyed traffic, such that we can derive the performance of our model. The matrix estimation process can then be adjusted to improve this comparison until such time that the GEH statistics are at acceptable levels for us consider the model a calibrated reflection of on-site conditions at all junctions.

The Matrix Estimation module in VISSIM is used along with the observed volume included as a user attribute in both AM and PM peak. A unit matrix (single trips between allowed origins and destinations) is used as a starting point and then iteratively adjusted to estimate the final matrices based on the observed counts as turn volumes. Several iterations are run in the process and GEH as a parameter is estimated for every iteration to ensure the matrices are fit-for-purpose and with more than 85% of the links with GEH<5, i.e., comparing the estimated flows against the observed flows.

VISSIM uses the least squares method in the matrix estimation procedure. The total of squares of the difference between the count data and volumes, and the total of squares of the differences between the original and corrected matrix values is minimized. Using ‘squares’ allows negative and positive differences to be treated equally. The number of iterations is set to 1000. Origin-Destination pairs with a volume of Zero is not adjusted. The methodology adopted for matrix estimation is outlined in the flow chart given below.

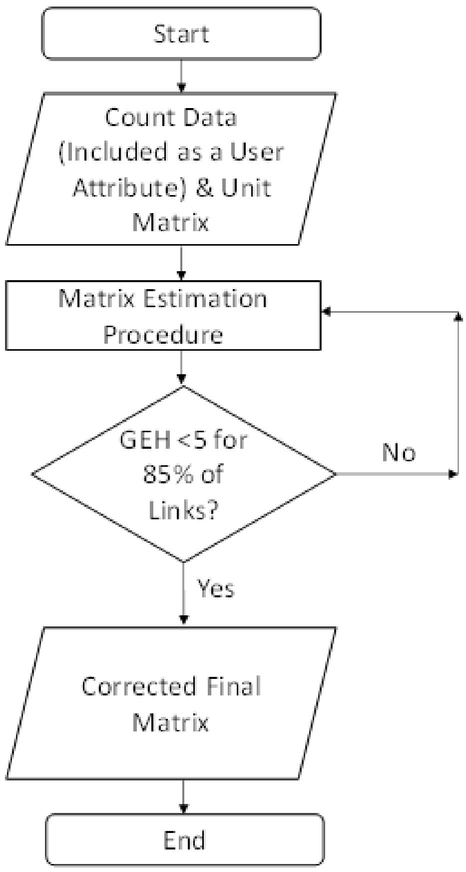


Figure 7.11 Matrix Estimation Flow Chart
Source: Own figure

In order to determine the pattern of trips through the study area from an origin to a destination, the study has utilized a dataset of TomTom Data. TomTom is a GPS navigation service provider that provides standalone units, car manufacturer GPS systems as well as integration in some mobile applications. Vehicle location and trip navigation data from vehicles equipped with TomTom enabled devices is fed back to TomTom and aggregated into a dataset that can be utilized for determining origin-destination patterns of travel across the network. The team has acquired and analysed this dataset for pre-COVID travel patterns in Georgetown and incorporated it into the matrix estimation process.

Whilst estimating the trip matrices for the study region, TomTom data extracted for both AM and PM peaks is utilized. The extracted TomTom data forms the representative travel pattern observed across the network. This data was then used to form a more accurate unit matrix to nullify the sampling errors in individual O-D travel pairs that occur in TomTom data extraction. Observed data point in TomTom data will be represented as a unit and non-observed data as Zero.

Furthermore, in comparison with the observed volumes on links forming the entry/exit of zones, zones that have no trips recorded in the survey will be made zero in the TomTom data. This representative unit matrix is adopted for both the peaks and matrix estimation/correction will be performed along with the respective observed peak hour volume on the ground.

An iterative procedure will be done in the matrix correction process until GEH for all the observed and modelled data points is less than 5 and the resultant matrix with higher percentage of links with GEH<5 is deemed fit-for-purpose. The representative unit matrix from the TomTom data that will be utilized in the matrix estimation/correction procedure is as given below with each row title representing an origin and each column title representing a destination. These correspond with the zone locations shown in the diagram in Figure 7.7 Zoning System

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	1	0
2	0	0	1	1	0	0	0	1	0	0	0	0	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0	1	0	1	0	1	1	1
3	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	1	0	1	1	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	1	0
4	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	1	1	0
5	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	1	1	1	0	0	1	0	0	1	0	0	1	0	0	0
6	0	0	0	0	0	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	0
7	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
8	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	0	0	0	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	1	0	0	1	0	0	0
10	1	1	1	0	1	0	1	1	0	0	1	1	1	1	1	0	0	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
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12	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	1	1	1	1	0	1	1	1
13	0	1	1	1	0	0	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
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15	0	0	1	0	0	1	1	1	0	0	0	0	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	1	1	1
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22	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0
23	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	1
24	0	1	1	1	1	0	1	1	0	0	0	1	1	1	0	0	0	1	0	1	1	1	1	0	1	0	1	1	0	1	1	1	0	1	1	1	1	1
25	0	1	1	1	0	0	1	1	0	0	1	0	1	1	1	0	0	1	1	1	1	0	0	1	0	1	1	0	0	0	1	1	0	0	1	1	1	0
26	0	0	1	0	0	0	1	1	0	0	0	0	1	1	0	0	0	1	0	1	1	0	1	0	1	0	1	0	1	1	1	1	1	1	1	0	1	0
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31	0	1	1	0	0	1	1	1	0	0	0	0	1	0	0	0	0	1	0	1	1	1	1	0	1	0	1	0	0	0	0	0	1	1	0	1	0	0
32	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	1	1	1	1	0
33	0	1	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	1	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1
34	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	1	0	1	1	0	1	1	1	0
35	0	1	0	0	0	0	1	1	0	0	1	0	1	1	0	0	1	1	0	1	0	0	0	0	1	1	1	0	1	1	0	1	0	1	0	1	1	1
36	0	0	0	1	0	0	1	1	0	0	0	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1
37	1	1	1	1	1	0	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
38	0	1	1	0	1	0	1	1	0	1	1	1	1	1	1	0	1	1	0	1	1	0	1	0	0	1	1	1	1	0	0	1	1	1	1	0	1	0

Figure 7.12 Unit Matrix

Source: Own figure

When the Stage 1 and Stage 2 models are developed, TomTom data will further be utilized to compare pre-COVID-19 traffic patterns with those observed during the traffic survey period.

The Task Team will also be extracting travel times from TomTom data to be used in calibrating the network performance to observed travel durations between junctions and through origin-destination routes.

While the demonstration model shows the process, without the full survey data it is not possible to calibrate the matrix.

7.7 EXTRACTED MATRIX FOR DEMONSTRATION MODEL

TomTom data extracted for the AM peak between 7:00am and 10:00am is as shown below.

Table 7-3 TomTom Matrix

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	1	8	2	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	1	0
2	0	0	6	2	0	0	0	47	0	0	0	0	4	2	1	0	0	8	0	107	2	1	3	1	6	1	1	0	0	0	0	15	0	3	0	1	9	2
3	1	3	0	0	0	0	1	10	0	0	0	0	2	1	0	0	0	2	0	10	1	0	0	2	0	0	1	0	0	0	0	2	0	1	0	0	3	0
4	0	0	1	0	0	0	4	14	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0	0	1	3	0	1	0	1	4	0
5	0	0	0	0	0	0	13	8	0	1	0	0	0	0	0	1	0	1	0	2	0	0	0	1	3	1	0	0	2	0	0	2	0	0	2	0	0	0
6	0	0	0	0	0	0	20	13	0	1	1	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0	3	0
7	1	2	1	5	6	14	0	293	4	1	2	0	12	9	1	1	3	6	8	50	9	3	1	18	26	9	32	10	15	5	8	37	6	4	3	0	24	2
8	19	51	16	20	16	15	94		33	28	8	43	255	144	30	18	24	131	28	[illegible]	136	65	40	206	253	121	251	76	288	120	57	536	91	140	79	73	421	92
9	0	0	0	0	1	1	5	16	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	4	0	1	0	0	2	0	0	0
10	1	3	1	0	2	0	2	25	0	0	1	4	18	7	1	0	0	7	1	21	0	0	0	7	11	2	10	12	14	15	1	11	7	5	13	19	4	1
11	0	1	0	0	0	0	0	3	0	0	0	4	7	1	1	0	0	1	0	3	4	1	0	0	1	2	1	0	0	1	0	2	0	0	1	2	8	2
12	0	1	0	0	0	0	0	7	0	0	0	0	14	2	0	0	0	0	1	5	1	0	0	0	0	1	1	1	0	0	1	5	2	2	0	1	2	3
13	0	20	6	2	0	0	24	967	2	22	0	13	0	206	19	13	17	96	8	165	19	11	2	10	19	10	21	13	20	12	9	95	20	52	33	63	102	222
14	0	4	0	0	0	0	4	20	2	0	0	0	19	0	0	3	1	6	0	6	0	1	0	0	4	4	0	1	1	0	0	5	0	7	0	1	5	20
15	0	0	1	0	0	2	3	11	0	0	0	0	3	2	0	1	1	1	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	1	1	3
16	0	0	0	0	1	0	4	8	0	1	0	0	3	5	8	0	1	2	0	1	0	0	0	0	0	0	0	0	1	3	0	3	0	2	1	1	2	1
17	0	6	0	1	0	0	10	81	0	0	1	5	38	28	46	5	0	23	2	23	1	3	0	2	7	1	7	3	2	0	0	6	2	4	6	12	9	35
18	1	10	12	0	1	0	11	76	2	1	0	4	20	15	6	2	4	0	3	40	1	0	0	4	5	1	10	7	2	0	2	7	6	9	10	12	26	12
19	0	3	2	1	0	1	2	19	0	0	0	1	7	5	0	2	1	3	0	27	0	0	1	1	2	2	1	0	0	0	1	16	8	4	1	3	22	0
20	12	236	33	15	10	6	280	[illegible]	1	4	19	17	85	38	13	6	7	94	23	0	111	33	52	64	166	40	87	19	21	9	65	322	80	85	32	42	324	20
21	0	6	3	0	2	1	35	87	0	3	1	0	1	0	1	0	0	1	1	16	0	3	1	5	1	1	0	0	1	0	12	9	3	0	0	0	2	0
22	0	0	0	0	1	0	0	11	0	0	0	0	0	0	0	0	1	2	0	4	1	0	1	1	0	1	0	0	0	0	1	2	0	0	0	0	0	0
23	0	0	1	0	0	0	6	55	0	0	0	0	0	0	0	0	0	1	1	10	0	0	0	0	1	0	2	1	0	0	0	0	0	0	0	0	1	1
24	0	2	3	3	2	0	10	50	0	0	0	1	2	2	0	0	0	5	0	72	3	3	1	0	4	0	4	2	0	1	1	12	0	3	1	1	11	1
25	0	4	1	1	0	0	15	73	0	0	1	0	4	1	1	0	0	6	1	47	3	0	0	6	0	1	1	0	0	0	3	18	0	0	2	2	11	0
26	0	0	1	0	0	0	3	21	0	0	0	0	1	1	0	0	0	1	0	24	2	0	1	0	5	0	1	0	1	1	1	4	4	1	3	0	7	0
27	0	3	1	1	0	0	11	31	0	0	0	1	3	4	1	0	1	3	3	27	0	0	1	1	4	0	0	0	0	2	1	9	5	4	2	0	1	0
28	0	1	0	0	1	0	8	55	1	0	0	1	7	3	1	1	0	4	1	7	2	0	0	0	2	2	3	0	4	1	0	5	1	0	3	1	1	1
29	1	2	0	0	0	0	4	66	0	0	0	0	4	3	0	0	1	1	0	10	1	0	1	2	0	0	3	1	0	0	1	9	0	3	3	1	1	0
30	0	1	0	0	0	0	3	33	1	1	0	0	4	1	1	0	1	1	0	2	0	0	1	0	2	0	2	0	1	0	1	3	1	3	0	0	1	0
31	0	2	2	0	0	1	8	26	0	0	0	0	1	0	0	0	0	2	0	15	1	1	1	0	1	0	1	0	0	0	0	0	2	1	0	1	0	0
32	2	5	2	1	1	3	17	82	0	0	0	1	7	6	1	0	2	11	5	212	6	5	2	3	8	1	3	0	1	0	0	0	0	2	2	3	22	0
33	0	1	0	0	0	0	1	14	0	0	0	0	6	0	1	0	0	4	0	10	1	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0	1	1
34	0	2	0	0	0	0	0	21	0	0	0	0	8	8	0	0	0	6	1	19	0	0	0	0	1	1	1	0	0	3	0	4	3	0	1	1	2	0
35	0	1	0	0	0	0	4	19	0	0	1	0	22	14	0	0	2	22	0	9	0	0	0	0	1	1	3	0	1	2	0	2	0	2	0	2	2	2
36	0	0	0	1	0	0	1	49	0	0	0	1	28	17	0	1	0	3	0	5	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	1	1
37	4	29	4	1	1	0	30	100	2	0	4	2	10	5	0	1	4	12	6	349	7	4	4	2	10	6	8	3	1	1	9	12	9	3	2	6	0	3
38	0	9	2	0	1	0	5	45	0	1	1	2	34	19	1	0	2	8	0	11	4	0	2	0	0	2	4	1	2	0	0	6	3	3	3	0	7	0

This data can be summarized as total trips from or to an origin or destination. This is represented in the following histogram showing trip totals from/to an origin or destination.

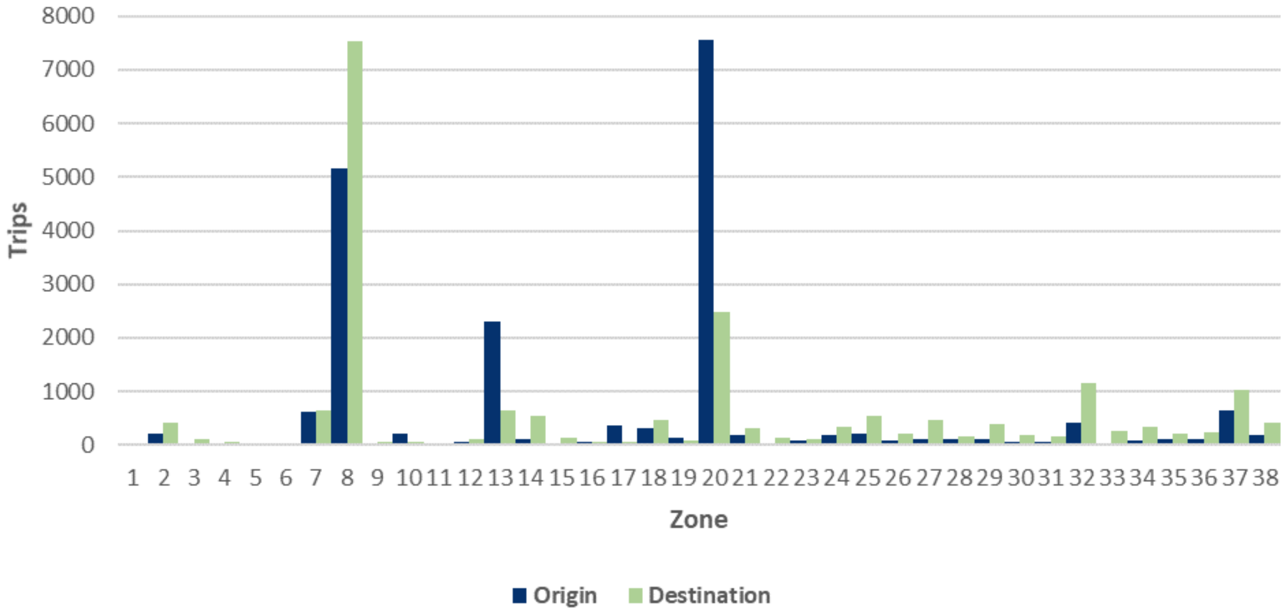


Figure 7.13: TomTom Matrix

Source: Own figure

Factors and adjustments to the TomTom matrix to derive separate matrices for Cars and Heavy Goods Vehicles (HGVs) are shown below. These derived matrices are used for the trial model. Following completion of traffic surveys where vehicle classifications are counted separately, we will have a more accurate representation of each class of traffic.

Table 7-4 Car Matrix

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	5	1	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	1	0
2	0	0	4	1	0	0	0	28	0	0	0	0	2	1	0	0	0	5	0	64	1	1	2	1	4	1	1	0	0	0	0	9	0	2	0	1	5	1
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	1	0	0	0	2	8	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	1	2	0	1	0	1	2	0
5	0	0	0	0	0	0	8	5	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	2	1	0	0	1	0	0	1	0	0	1	0	0	0
6	0	0	0	0	0	0	12	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	11	0	10	12	10	9	56	[illegible]	20	0	5	26	153	20	0	0	0	20	0	[illegible]	82	39	24	20	20	73	20	46	20	20	34	20	55	20	47	44	20	55
9	0	0	0	0	1	1	3	10	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	2	0	1	0	0	1	0	0	0
10	1	0	1	0	1	0	1	15	0	0	1	2	11	4	0	0	0	4	0	13	0	0	0	4	7	1	6	7	8	9	1	7	4	3	8	11	2	1
11	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	4	1	0	0	14	200	1	0	0	8	0	124	0	8	0	58	0	99	11	7	1	6	11	6	13	8	12	7	5	57	12	31	20	38	61	133
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	1	0	0	1	2	7	0	0	0	0	2	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	1	1	2
16	0	0	0	0	1	0	2	5	0	0	0	0	2	3	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	2	0	2	0	1	1	1	1	1
17	0	0	0	1	0	0	6	49	0	0	1	3	23	17	0	0	0	14	0	14	1	2	0	1	4	1	4	2	1	0	0	4	1	2	4	7	5	21
18	1	0	7	0	1	0	7	46	1	0	0	2	12	9	0	0	0	0	0	24	1	0	0	2	3	1	6	4	1	0	1	4	4	5	6	7	16	7
19	0	0	1	1	0	1	1	11	0	0	0	1	4	3	0	0	0	2	0	16	0	0	1	1	1	1	1	0	0	0	1	10	5	2	1	2	13	0
20	7	0	20	9	6	4	20	[illegible]	1	0	11	10	51	23	0	0	0	56	0	0	67	20	31	38	100	24	52	11	13	5	39	193	48	51	19	25	194	12
21	0	0	2	0	1	1	21	52	0	0	1	0	1	0	0	0	0	1	0	10	0	2	1	3	1	1	0	0	1	0	7	5	2	0	0	0	1	0
22	0	0	0	0	1	0	0	7	0	0	0	0	0	0	0	0	0	1	0	2	1	0	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0
23	0	0	1	0	0	0	4	33	0	0	0	0	0	0	0	0	0	1	0	6	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	1
24	0	0	2	2	1	0	6	30	0	0	0	1	1	1	0	0	0	3	0	43	2	2	1	0	2	0	2	1	0	1	1	7	0	2	1	1	7	1
25	0	0	1	1	0	0	9	44	0	0	1	0	2	1	0	0	0	4	0	28	2	0	0	4	0	1	1	0	0	0	2	11	0	0	1	1	7	0
26	0	0	1	0	0	0	2	13	0	0	0	0	1	1	0	0	0	1	0	14	1	0	1	0	3	0	1	0	1	1	1	2	2	1	2	0	4	0
27	0	0	1	1	0	0	7	19	0	0	0	1	2	2	0	0	0	2	0	16	0	0	1	1	2	0	0	0	0	1	1	5	3	2	1	0	1	0
28	0	0	0	0	1	0	5	33	1	0	0	1	4	2	0	0	0	2	0	4	1	0	0	0	1	1	2	0	2	1	0	3	1	0	2	1	1	1
29	1	0	0	0	0	0	2	40	0	0	0	0	2	2	0	0	0	1	0	6	1	0	1	1	0	0	2	1	0	0	1	5	0	2	2	1	1	0
30	0	0	0	0	0	0	2	20	1	0	0	0	2	1	0	0	0	1	0	1	0	0	1	0	1	0	1	0	1	0	1	2	1	2	0	0	1	0
31	0	0	1	0	0	1	5	16	0	0	0	0	1	0	0	0	0	1	0	9	1	1	1	0	1	0	1	0	0	0	0	0	1	1	0	1	0	0
32	1	0	1	1	1	2	10	49	0	0	0	1	4	4	0	0	0	7	0	127	4	3	1	2	5	1	2	0	1	0	0	0	0	1	1	2	13	0
33	0	0	0	0	0	0	1	8	0	0	0	0	4	0	0	0	0	2	0	6	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1
34	0	0	0	0	0	0	0	13	0	0	0	0	5	5	0	0	0	4	0	11	0	0	0	0	1	1	1	0	0	2	0	2	2	0	1	1	1	0
35	0	0	0	0	0	0	2	11	0	0	1	0	13	8	0	0	0	13	0	5	0	0	0	0	1	1	2	0	1	1	0	1	0	1	0	1	1	1
36	0	0	0	1	0	0	1	29	0	0	0	1	17	10	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1
37	2	0	2	1	1	0	18	60	1	0	2	1	6	3	0	0	0	7	0	209	4	2	2	1	6	4	5	2	1	1	5	7	5	2	1	4	0	2
38	0	0	1	0	1	0	3	27	0	0	1	1	20	11	0	0	0	5	0	7	2	0	1	0	0	1	2	1	1	0	0	4	2	2	2	0	4	0

This data can be summarized as total trips from or to an origin or destination. This is represented in the following histogram showing trip totals from/to an origin or destination for cars in the demonstration model.

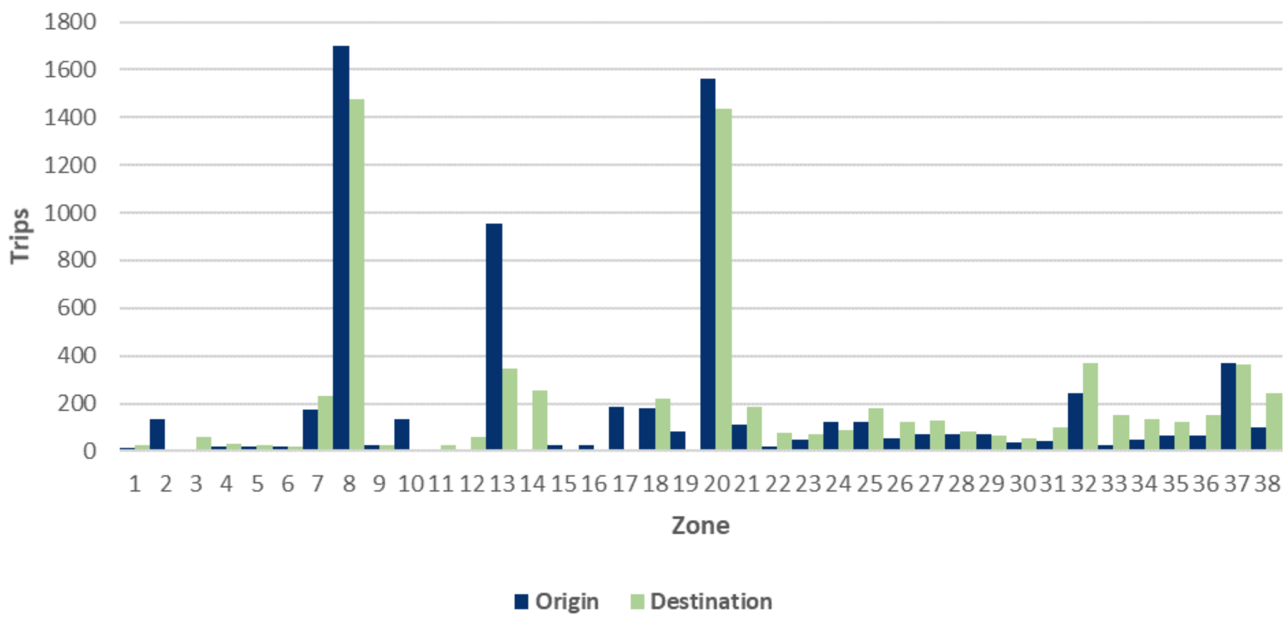


Figure 7.14: Car Matrix
Source: Own figure

Table 7-5 HGV Matrix

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1	0	1	1	1	0	3	[illegible]	1	0	0	1	8	1	0	0	0	1	0	[illegible]	4	2	1	1	1	4	1	2	1	1	2	1	3	1	2	2	1	3
9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	1	10	0	0	0	0	0	6	0	0	0	3	0	5	1	0	0	0	1	0	1	0	1	0	0	3	1	2	1	2	3	7
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	2	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
18	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
19	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
20	0	0	1	0	0	0	1	[illegible]	0	0	1	1	3	1	0	0	0	3	0	0	3	1	2	2	5	1	3	1	1	0	2	10	2	3	1	1	10	1
21	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
26	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

This data can be summarized as total trips from or to an origin or destination. This is represented in the following histogram showing trip totals from/to an origin or destination for heavy goods vehicles in the demonstration model.

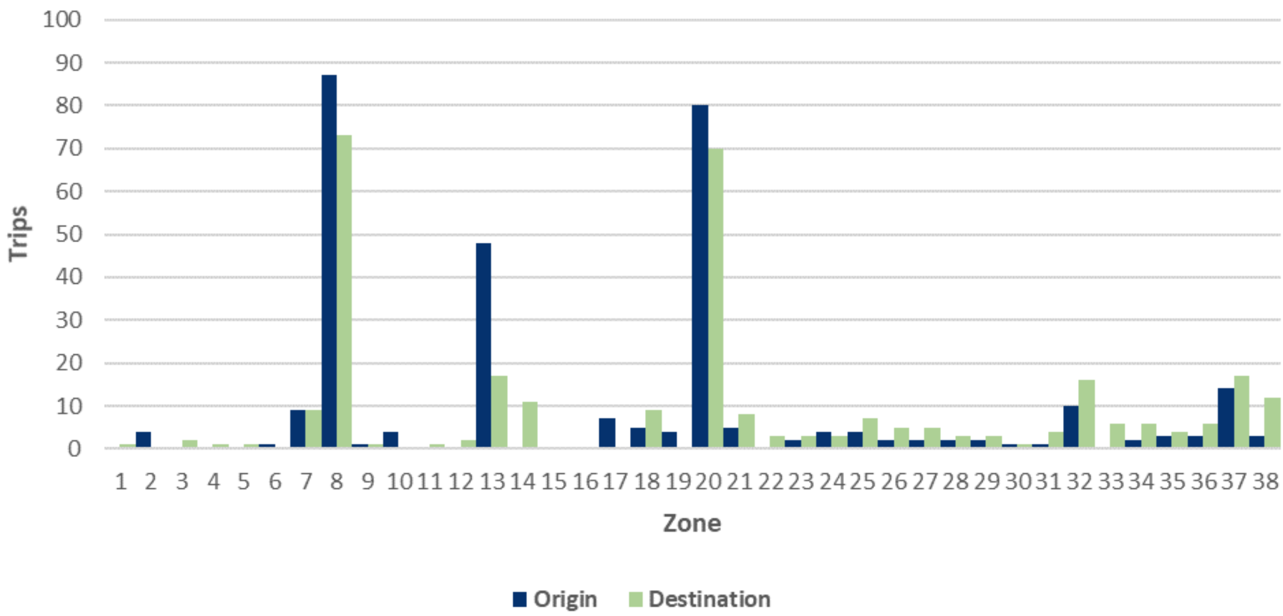


Figure 7.15: HGV Matrix
Source: Own figure

7.8 NETWORK MODEL

While the Demand Model, described above represents the estimation of traffic demand moving around Georgetown, this section documents Network Model parameters which describe the physical network attributes being simulated within the VISSIM model.

7.8.1 MODEL PARAMETER SETTINGS

There are general model parameter settings in VISSIM which control the stochastic characteristics of the model.

- Simulation Resolution: 10
- Vehicle Fleet

	Count: 7	Share	Model2D3D
Car	1	0.240	1: Car - Volkswagen Golf
	2	0.180	2: Car - Audi A4
	3	0.160	3: Car - Mercedes CLK
	4	0.160	4: Car - Peugeot 607
	5	0.140	5: Car - Volkswagen Beet...
	6	0.020	6: Car - Porsche Cayman
	7	0.100	7: Car - Toyota Yaris
	Count: 1	Share	Model2D3D
Bus	1	0.100	31: Bus - C2 Standard

- Functions and distributions: as per default
- Random Seed: 42

7.8.2 VEHICLE SPEEDS AT TURN MOVEMENTS

The speeds vehicles travel is a function of their surrounding environment, such as narrow lanes result in lower speeds, as well as the surrounding congestion and proximity to intersections or turning movements. These characteristics, which need to be represented in the model, is done in two ways. Firstly, around intersections and low speed environments, reduced speed areas are coded into the model. In other areas the model allows vehicles to run at the speed limits which are coded into each link. Secondly, vehicles themselves have intelligent characteristics where their speed behavior is altered in relation to the behavior of surrounding vehicles and upcoming movements.

Generally, reduced speed areas were placed on turn movements at intersections to consider reduced speeds and geometric delays at these locations. An even speed distribution between 20 and 25 kph has been adopted to reflect the reduced speeds in a realistic manner. 15kph is used for U-turns. These areas will be further calibrated to local conditions in Georgetown following the traffic surveys where we can study travel times in more detail using both our on-site data and extractions from TomTom of recorded travel time from GPS units.

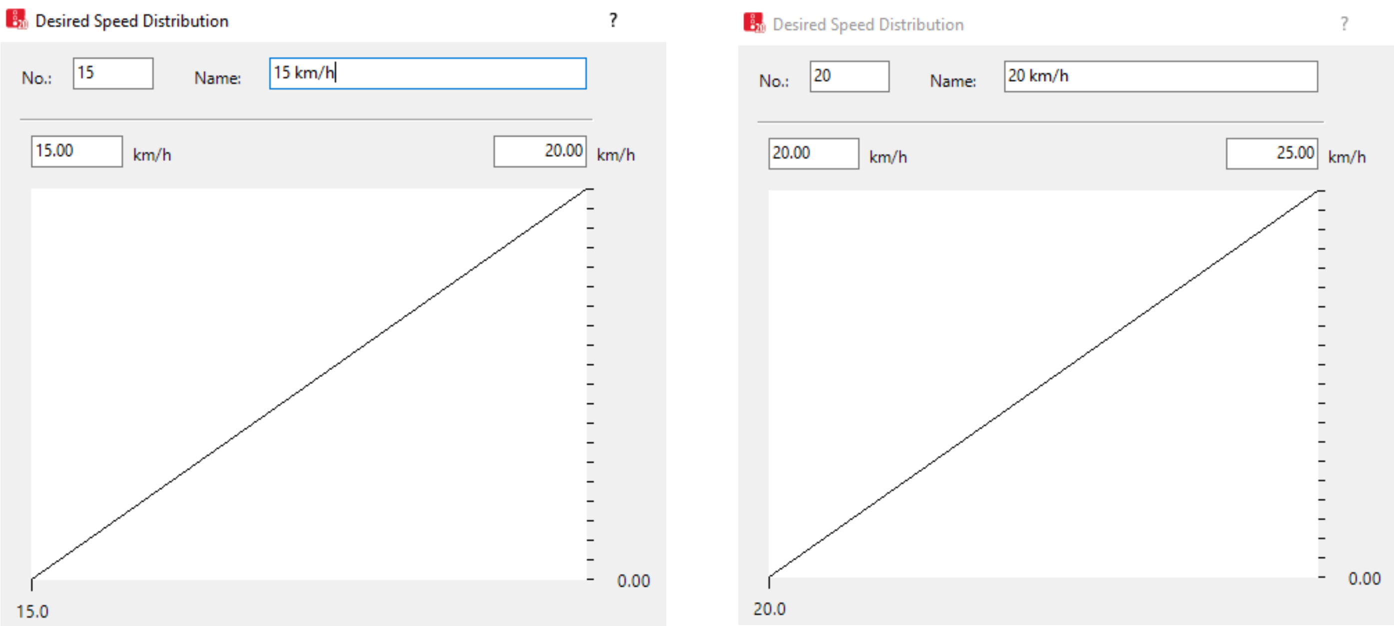


Figure 7.16: Speed Distribution at Turn Movements
Source: Own figure

7.8.3 MODELLED SPEED LIMITS

The road links modelled were assigned speeds in accordance with the posted speed limits on the roads in the study area. Predominantly, 50 kph is utilized on a majority of the road links. Speed limits on links will be verified during on-site surveys at the same time as traffic surveys.

The corresponding speed distribution for the sign posted speed limit of 60 kph is shown below:

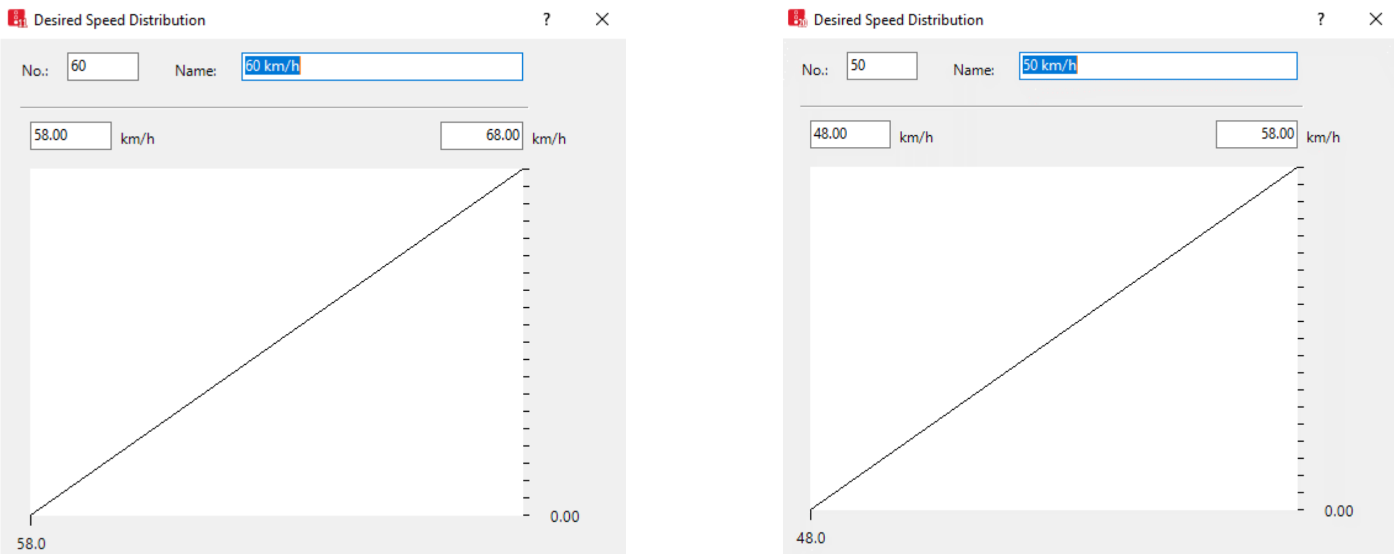


Figure 7.17: Speed Distribution for all vehicle types
Source: Own figure

7.8.4 DRIVING BEHAVIOUR

Driving behavior parameters allow us to influence the simulated driving behaviors within the model to reflect on-site conditions and local driving practices. Factors we can influence include how closely drivers will follow each other and how aggressively lane changing occurs. These factors will be calibrated to local conditions following the completion of on-site traffic surveys.

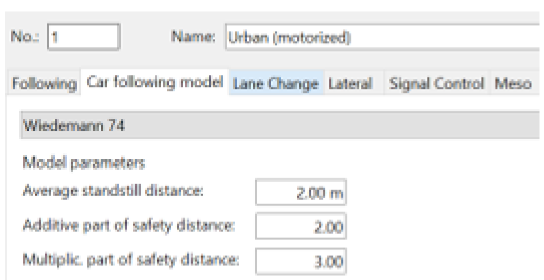
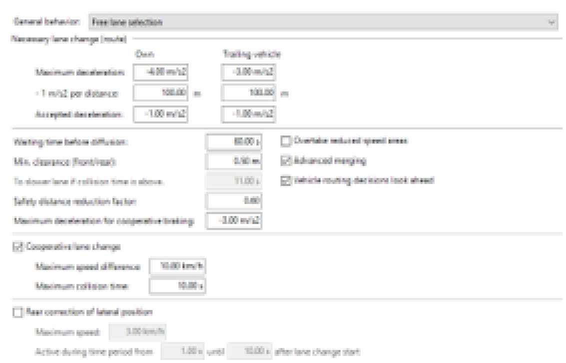
Car Following Model	Lane Change Behaviour
	

Figure 7.18: Default Car following and lane change behavior
Source: Own figure

7.8.5 BUS ROUTE

Public transport is an important component of the road network. The simulation will model bus routes and frequencies as seen in Georgetown. Buses will stop at bus stops and interact with traffic. Bus routes incorporated within the demonstration model are shown in the figure below.

Figure 7.19 Bus Route

Source: Digital Penang

7.8.6 BICYCLE PATH

Bicycle paths to be considered for the simulation are shown in the figure below. Cycling and walking are incorporated within the simulation.

Figure 7.20 Bicycle Path
Source: Digital Penang

7.8.7 PEDESTRIAN WALKWAY

Pedestrian walkways to be considered within the simulation are shown in the figure below. During Stage 1 these will be further incorporated to represent existing conditions, such that the benefits of improved pedestrian facilities can be analysed during scenario testing.

Figure 7.21 Pedestrian Walkway
Source: Digital Penang

7.9 VISUALISATION OF DEMONSTRATION MODEL

A 3D video of the Demonstration Model has been provided to Digital Penang and MBPP to illustrate to stakeholders the model that is being developed. As previously discussed, the Demonstration Model represents the road network, however without accurate traffic data from surveys it is not a true reflection of the on-site traffic situation, which will be incorporated during Stage 1 and Stage 2 modelling. Therefore, measurement of network performance was not conducted on the Demonstration Model.

Following Stage 1 and Stage 2 modelling, measurements and statistics of network performance will be provided such as travel times, delays, queue lengths, congestion for each vehicle type, as well as travel and delay statistics for pedestrians and cyclists. These will also include comparison between the existing situation and scenario tests of changes to the network layout and provisions of infrastructure for public transport, pedestrians and cyclists and traffic improvements.

The Stage 1 Trial Area network within the Demonstration Model is shown in the screenshot of the simulation model below.

Figure 7.22 VISSIM Road Network Layout (Trial Area)
Source: Own figure

The coded model network for the full Stage 2 wider area, within the Demonstration Model is shown below. By coding this wider network early, it will reduce the network coding requirements during the Stage 2 study period. On-site validation of the coded network will be performed during the survey period.

Figure 7.23: VISSIM Road Network Layout (Expanded Area)
Source: Own figure

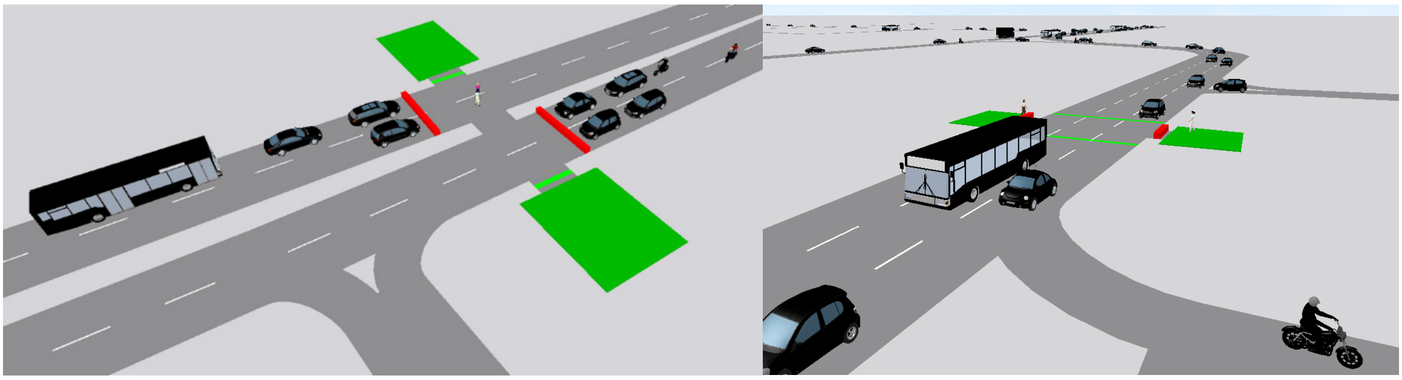


Figure 7.24: Road Link Simulation Examples
Source: Own figure

The 3D model snapshots above illustrate the model links where buses, cars and motorbikes on the road interact with a signalized pedestrian crossing. The screenshots are included for demonstration purpose at this stage.

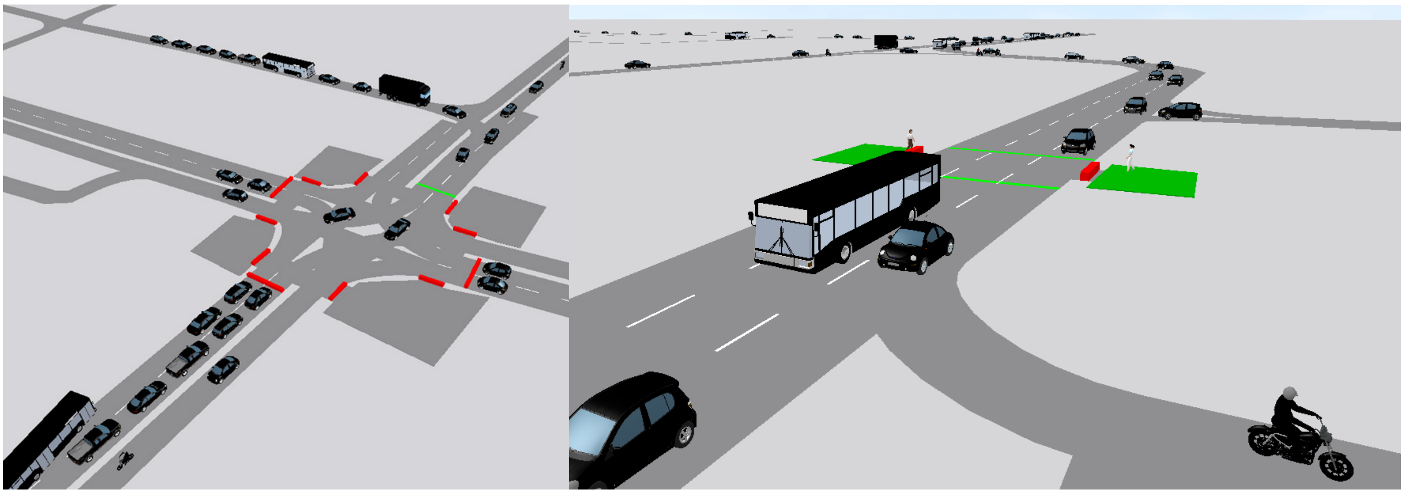


Figure 7.25: Junction Simulation Examples
Source: Own figure

The 3D model snapshot above shows an intersection configuration with vehicle movement. During the development of Stage 1 and Stage 2 the study team will investigate the incorporation of 3D building representations into the model where possible to more accurately visualize the junction and road locations within Georgetown.

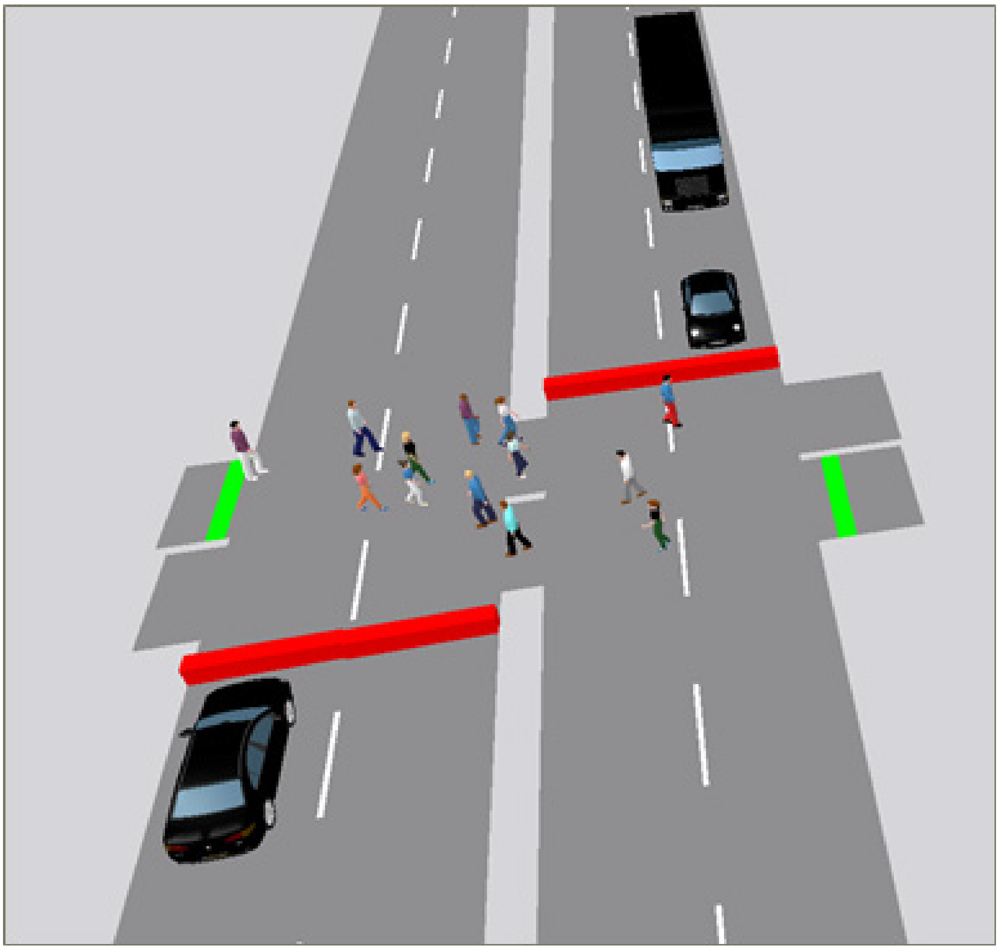


Figure7.26 Pedestrian Crossing Example
Source: Own figure

The 3D model snapshot above shows the interaction between vehicles and pedestrians at a signalized pedestrian crossing. In subsequent stages of the simulation model, pedestrian schemes will also be simulated and tested in the study.

While this report shows limited output from the development of this Demonstration Model, the primary objective was to compile data and conduct tasks that were non-dependent on the delayed traffic survey as a result of COVID-19. Therefore, this modelling was an interim exercise, and will be further developed with full performance reporting following the completion of traffic surveys and development of the Stage 1 modelling as per the original specification in the Task Order. As previously mentioned, a video to show the modelling progress of the Demonstration Model has been provided to Digital Penang and MBPP.

NEXT STEPS

Photo: Adobe Stock

Malaysia has progressively re-opened state borders and allowed inter- and intra-state travel throughout September and October 2021. Therefore, in consultation with MBPP it has been estimated that by November 2021 traffic levels will be at sufficient levels for traffic surveys to commence. These surveys will be compared to pre Covid-19 data and scaled as necessary.

The survey and data processing period will take approximately 4 to 6 weeks upon which the Stage 1 micro-simulation model will be calibrated, and scenario testing will commence.

A further Traffic Survey Report will be provided at the conclusion of the data processing, and Stage 1 Micro-Simulation report will contain information on both the model calibration and scenario testing.

Upon the acceptance of the Stage 1 micro-simulation model report, Stage 2 will commence which will include simulation of a wider area of Georgetown encompassing the full UNESCO World Heritage area.

On completion of Stage 2, Ramboll will conduct a PTV accredited training courses on the use of VISSIM software for MBPP and Digital Penang in order for the micro-simulation model to be used for ongoing testing of changes to transport within Georgetown beyond the conclusion of this Pilot Project.

ABOUT THE ASEAN AUSTRALIA SMART CITIES TRUST FUND

The ASEAN Australia Smart Cities Trust Fund (AASCTF) assists ASEAN cities in enhancing their planning systems, service delivery, and financial management by developing and testing appropriate digital urban solutions and systems. By working with cities, AASCTF facilitates their transformation to become more livable, resilient, and inclusive, while in the process identifying scalable best and next practices to be replicated across cities in Asia and the Pacific.

ASEAN AUSTRALIA SMART CITIES TRUST FUND
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