Agreement No. CE 55/2014 (CE)

DETAILED FEASIBILITY STUDY FOR ENVIRONMENTALLY FRIENDLY LINKAGE SYSTEM FOR KOWLOON EAST

/ Feasibility Study /

Report on Identification of Suitable Green Public Transport Modes

June 2017

Disclaimer: All information collected and presented in this report is exclusively for the purpose of this Study and for the EFLS mode selection exercise. Information should not be used for any other external purposes.

土木工程拓展署
Civil Engineering and Development Department

ARUP

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1 Introduction

1.1 Background

1.1.1 The Kai Tak Outline Zoning Plan approved in 2007 has incorporated the alignment of an Environmentally Friendly Linkage System (EFLS) running within Kai Tak Development (KTD). The 2011-12 Policy Address announced that Kowloon East (KE), including KTD, Kowloon Bay and Kwun Tong business areas, would be transformed into another Core Business District (CBD) to sustain Hong Kong's long term economic development. To enhance the accessibility of the new CBD, appropriate adjustments were necessary on the proposed EFLS to provide a fast and convenient intra-district connectivity service.

1.1.2 The existing public transport facilities, including MTR, buses, minibuses, taxis and pedestrian networks, in KE collectively make up the integrated multi-modal linkage system. These facilities are serving our daily transport needs at different levels, i.e. from local and intra- and inter-district commuting to leisure activities on weekends. As KE is transforming into a CBD, the initial transport demand could be met by conventional road-based transport services and the enhanced pedestrian facilities. In the long run, the Shatin to Central Link under construction and the planned Route 6 could handle the inter-district transport demand. However, due to the limited road space in KE, solely relying on existing public transport services would be difficult to maintain a good quality of service to cope with the traffic growth generated by new developments. Therefore, there is a need to introduce EFLS as an additional transport mode to deal with the rising demand and to enhance the connectivity in KE.

1.2 The Study

1.2.1 The Civil Engineering and Development Department (CEDD) of the HKSAR commissioned Ove Arup and Partners Hong Kong Limited (Arup) on 20 October 2015 to undertake the Detailed Feasibility Study for Environmentally Friendly Linkage System for Kowloon East to further investigate the EFLS to address various public concerns received during the PFS. The DFS will provide an in-depth evaluation on the most suitable green public transport mode(s) for the proposed EFLS and formulate a well-planned integrated multi-modal linkage system to enhance the connectivity of Kowloon East. The first stage of the DFS study is to identify the most suitable green transport mode as EFLS for KE before developing the EFLS scheme for the next stage, which includes the alignment, station locations, cost evaluation, procurement, and implementation strategy.

1.3 Purpose of This Report

1.3.1 This Report presents the process and outcome of the like-to-like comparison of the various green public transport modes taking account of various aspects including, but not limited to, construction, operation, maintenance requirements, costs and serviceability like system capacity, reliability, journey speed, impacts to road users, existing environment and other road-based public transport modes during construction and operation stages, land requirements, and interchangeability with other public transport modes, in particular the MTR system.

1.3.2 The Report aims to demonstrate that the various green public transport modes have been equally compared and evaluated with sufficient level of detail, supported by technical data and information to justify the merits and deficiencies of the various green public transport modes and their corresponding networks.

1.4 Organization of This Report

1.4.1 This Report contains the following sections:

- Section 1 (this chapters) provides an overview of the study as well as the purpose of this specific Report;
- Section 2 characterises the EFLS in terms of the context of Kowloon East including identifying the role/positioning of EFLS, key markets and trip attractors, and the need/rationale for EFLS;
- Section 3 presents the selection process and evaluation criteria;
- Section 4 presents the High-Level Screening of the nine prospective green transport modes based on capacity, reliability, efficiency and sustainability;
- Section 5 presents the Detailed Analysis of the most promising green transport modes, focusing on at-grade and elevated options, and identifies the preferred option to progress forward; and
- Section 6 summarises key findings and discusses the recommended option(s).

1.4.2 **Appendix F** contains the Topical Study on Assessment of Suitability of Modern Tramway for Kowloon East, which essentially summarises findings relevant to the modern tram options from the preceding sections of this Report.

1.5 Abbreviation

APM	Automated People Mover
ATN	Automated Transit Network
BRT	Bus Rapid Transit
CBD	Core Business District
CDA	Comprehensive Development Area
CE	Civil Engineering
CEDD	Civil Engineering and Development Department
CKR	Central Kowloon Route
EFLS	Environmentally Friendly Linkage System
EIAO	Environmental Impact Assessment Ordinance
EIRR	Economic Internal Rate of Return
EKEO	Energizing East Kowloon Office
EVA	Emergency Vehicle Access
FSTB	Financial Services and the Treasury Bureau
GFA	Gross Floor Area
GMB	Green Minibus

HBR	Hoi Bun Road
HKSAR	Hong Kong Special Administrative Region
HKT	Hong Kong Tramways
KBAA	Kowloon Bay Action Area
KBBA	Kowloon Bay Business Area
KE	Kowloon East
KMB	The Kowloon Motor Bus Co. (1933) Ltd
kph	kilometres per hour
KTAA	Kwun Tong Action Area
KTBA	Kwun Tong Business Area
KTCT	Kai Tak Cruise Terminal
KTD	Kai Tak Development
KTL	Kwun Tong Line
KTSP	Kai Tak Sports Park
KTTL	Kwun Tong Transportation Link
KTTS	Kwun Tong Typhoon Shelter
LRT	Light Rail Transit
MMLS	Multi-Modal Linkage System
MOC	Method of Control
MTR	Mass Transit Railway
NSR	Noise Sensitive Receiver
NT	New Territories
PC	Public Consultation
PEA	Preliminary Environmental Assessment
PFS	Preliminary Feasibility Study
PLB	Public Light Bus
PPHPD	Persons per Hour per Direction
PRT	Personal Rapid Transit
PTI	Public Transport Interchange
RDO	Railway Development Office
SCL	Shatin to Central Link
TD	Transport Department
TKO-LTT	Tseung Kwan O – Lam Tin Tunnel
TPDM	Transport Planning and Design Manual
TPEDM	Territorial Population and Employment Data Matrices
TRA	Tree Removal Application
WSD	Water Supplies Department

2 EFLS in the Context of Kowloon East

2.1 Role of EFLS in Kowloon East

2.1.1 This Report focuses on the selection of a suitable green transport system to act as the EFLS for KE. Before delving into details, it is worthwhile to look at the wider perspective and discuss the relative role and positioning of EFLS within the greater urban transport system for KE.

2.1.2 As background, Kowloon East is planned as a new core business district (CBD) to sustain Hong Kong's economic development. It is comprised of the Kai Tai Development Area, Kwun Tong and Kowloon Bay Business Areas. It enjoys a strategic transport network with linkage to various districts in Hong Kong. The Government is taking forward a series of transport infrastructure proposals, including the MTR's Shatin to Central Link (SCL) and Tseung Kwan O – Lam Tin Tunnel (TKO-LTT), which are both under construction. Furthermore, the Central Kowloon Route and the Trunk Road T2 have already been confirmed and are undergoing planning.

2.1.3 To further enhance intra-district connections within Kowloon East, transport serving the area will gradually evolve into an integrated Multi-Modal Linkage System (MMLS) with an Environmentally Friendly Linkage System (EFLS) at its heart, to fill service gaps in the existing and planned railway networks, offering high-quality connectivity essential for the district's success. The EFLS will serve as the back bone system within Kowloon East, linking to major railway stations and serving all key trip generators and attractors within Kowloon East.

2.1.4 To facilitate the redevelopment of the area into an economic and social focal point requires a multi-modal linkage system (MMLS). MMLS represents the overall green public transport system, featuring enhanced pedestrian facilities, road-based transport and feeder systems, and linkages to the major rail networks in the area.

2.1.5 The MMLS is intended to serve a variety of connectivity objectives at four connectivity levels:

2.1.6 **Strategic Level** – Connections to strategic routes that enable quick access to the airport and cross-boundary facilities, (i.e. linking to boundary crossing points, the new strategic rail links between China and Hong Kong, etc.).

2.1.7 **Inter-district Level** – Connections with other key office nodes in the territory facilitating business activities through the territory's extensive high-capacity rail network as well as select long-distance bus routes (i.e., linking Kowloon East and key business nodes in Central, Wanchai, Quarry Bay, and Tsim Sha Tsui, etc.).

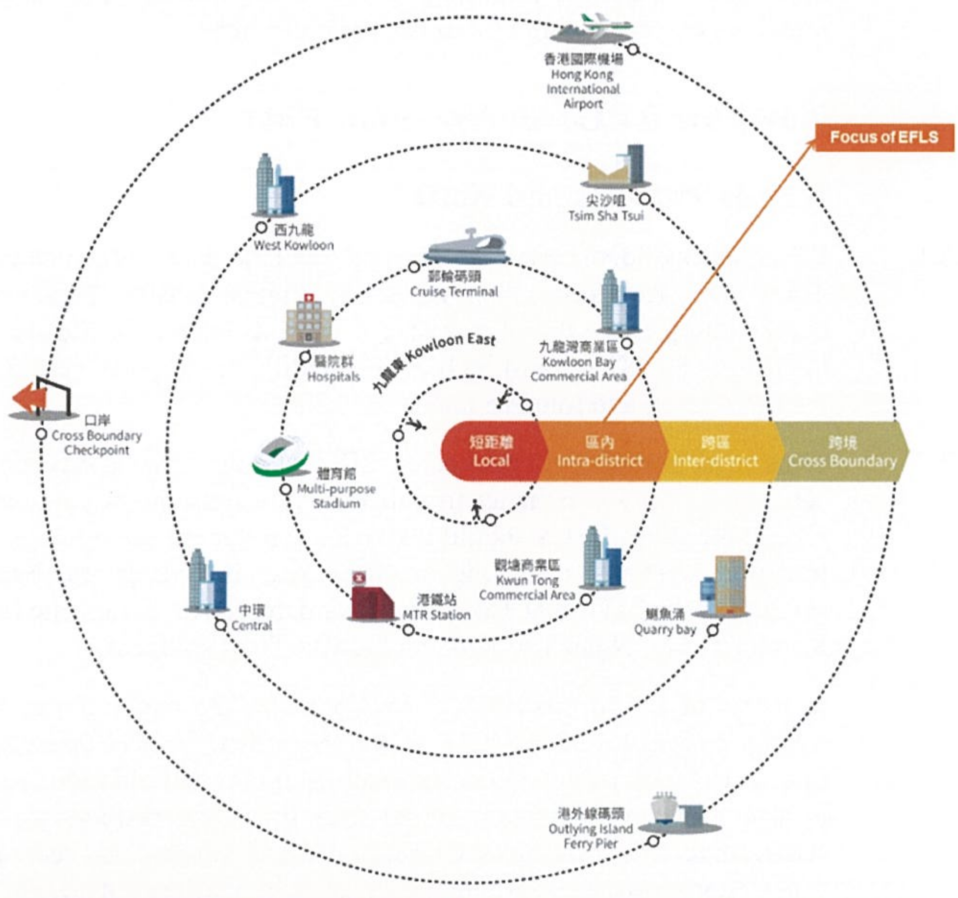
2.1.8 **Intra-district Level** – Connections within KE, in particular, with those areas not well covered by the catchment of existing or planned MTR networks provided by various green transport modes (i.e., linking Kowloon Bay and Kwun Tong Business Areas, key activity nodes, such as Kai Tak Cruise Terminal, Kai Tak Sport Park and Hospital Cluster etc.).

2.1.9 **Local Level** – Connections via pedestrian corridors, footbridges and subways, enhanced footpaths, etc. primarily through walking (i.e., including enhanced pedestrian measures and facilities to encourage walking), but also could include short-haul green transport where warranted.

2.1.10 The EFLS for KE is one component of the larger MMLS. Its important roles is to provide efficient intra-district connectivity services within the new CBD, especially for those areas not served by the existing or planned MTR networks, and facilitate inter-district travelling through interchanges with the existing MTR Kwun Tong Line (KTL) and the future Shatin to Central Link (SCL).

2.1.11 The EFLS will serve as the back bone system within Kowloon East, linking to the major railway stations and serving all key trip generators and attractors within the Kowloon East Study Area.

2.1.12 **Figure 2.1** depicts the four levels of transport connectivity with KE, including the intra-district travel, which is the focus market for EFLS.



Local	Intra-District	Inter-District	Cross Boundary
• Walking • Cycling	• Bus / Public Light Bus • Cycling	• Rail • Long-Distance Bus / Public Light Bus • Ferry	• Rail • Long-Distance Bus

Figure 2.1: Four Connectivity Levels and Focus of EFLS for Kowloon East

2.1.13 In formulating the comprehensive MMLS network, the green public transport modes are intended to service different passenger trip at the four connectivity levels as presented in **Figure 2.1**. Route options for the green public transport modes were initially reviewed and developed to provide a better and more attractive feeder service in connecting the existing railway system and future railway development to meet the rising demand and changes in travel patterns for enhancing different levels of connectivity in the Kowloon East, while building a sustainable public transport network.

2.1.14 The green public transport routes proposed in the MMLS will provide well-balanced network coverage, serving Kowloon East locally, inside and outside the area in Kowloon East, between the 300m catchment of EFLS stations (inter and intra-district), as well as strategically to greater regions, such as boundary-crossing locations by connecting with other transport hubs.

2.2 Need for EFLS in Kowloon East

Key Attractions and Nodes

2.2.1 KE consists of diverse areas with different land uses and development plans. Kwun Tong and Kowloon Bay represent higher-density built-up areas that are transforming into vibrant mixed use areas as shown in **Figure 2.2**. The Kai Tak Development (KTD) will include residential, open space, sports activity, business, entertainment, and tourism nodes.

2.2.2 Thus as an intra-district connector, EFLS should strive to directly and conveniently serve these areas to enhance mobility for residents, employees, and visitors to/from KE. In addition, EFLS should allow for convenient interchange with major public transport systems operating in the area, including the Shatin-Central Link (including the MTR Kai Tak Station), and the Kwun Tong Line (including the MTR Kowloon Bay, Ngau Tau Kok, and Kwun Tong stations).

2.2.3 In terms of future growth and development, the major zones within the KE are mainly comprised of "OU(B)" (Other Specified Uses (Business)) uses, which are intermixed with new commercial establishments and old industrial buildings. There is also a diverse range of mixed uses including residential, open space, G/IC (Government, Institution or Community) and tourism and recreational uses etc. in KTD. Residential uses are mainly located in districts outside KE, such as To Kwa Wan, Kowloon City, Ngau Tau Kok, Kwun Tong and Lam Tin.

2.2.4 Many of the key attraction points are being implemented over the next decades. Total non-domestic GFA will increase from 7.0 million sqm in 2014 to 10 million sqm in 2036, an increase of 3.0 million sqm or 43%. One component of the non-domestic GFA is commercial GFA. The existing supply of commercial/office floor area in KE is about 2 million sqm. KE has the potential to supply an additional commercial/office floor area of about 5 million sqm, bringing the total commercial/office supply to about 7 million sqm in the long run.[1]

2.2.5 Key attractions and public transport interchange locations include:

[1] GFA, population and employment data are from the Enhanced 2011-based TPEDM, the latest RDOP of the Kai Tak Development (incorporated the Rethink 2 parameters) and from information provided by EKEO.

- **Kowloon Bay Business Area (KBBA)** – Encompassing the existing Kowloon Bay Area to the west of Kowloon Bay MTR Station;
- **Kowloon Bay Action Area (AA1)** – Encompassing an area to the south of KBBA currently used by the Kowloon Bay Vehicle Examination Centre;
- **Kwun Tong Business Area (KTBA)** – Encompassing the existing Kwun Tong area from Kwun Tong Road and Kwun Tong MTR Station to the waterfront;
- **Kwun Tong Action Area (AA2)** – Encompassing an area in the vicinity of the Kwun Tong Ferry Pier;
- **Hospital Cluster** – Including hospital clusters to the west of AA1;
- **Residential Clusters** – Encompassing various residential estates in the northern corner of Kowloon Bay and Kai Tak Development Area including Kai Ching Estate and Tak Long Estate;
- **Comprehensive Mixed Use Development** – Including new mixed use developments centred at the Kai Tak Station Square, which will be a station of the Shatin-Central Link (SCL);
- **Recreational & Sports Centre** – Including the Kai Tak Sports Park (KTSP) to the southwest of Station Square and to the east of Kowloon City;
- **Hotel / Residential Belt** – Including various hotel and residential facilities located just beyond the halfway point of the former Kai Tak runway;
- **Tourism Node** – Including various tourism and visitor facilities to the east of the Kai Tak Cruise Terminal at the end of the former Kai Tak runway, facing KTBA;
- **Cruise Terminal** – Including the Kai Tak Cruise Terminal situated at the tip of the former Kai Tak runway; and
- **Kai Tak Fantasy** – Including the area in the Kwun Tong Typhoon Shelter between the Tourism Node and KTBA.

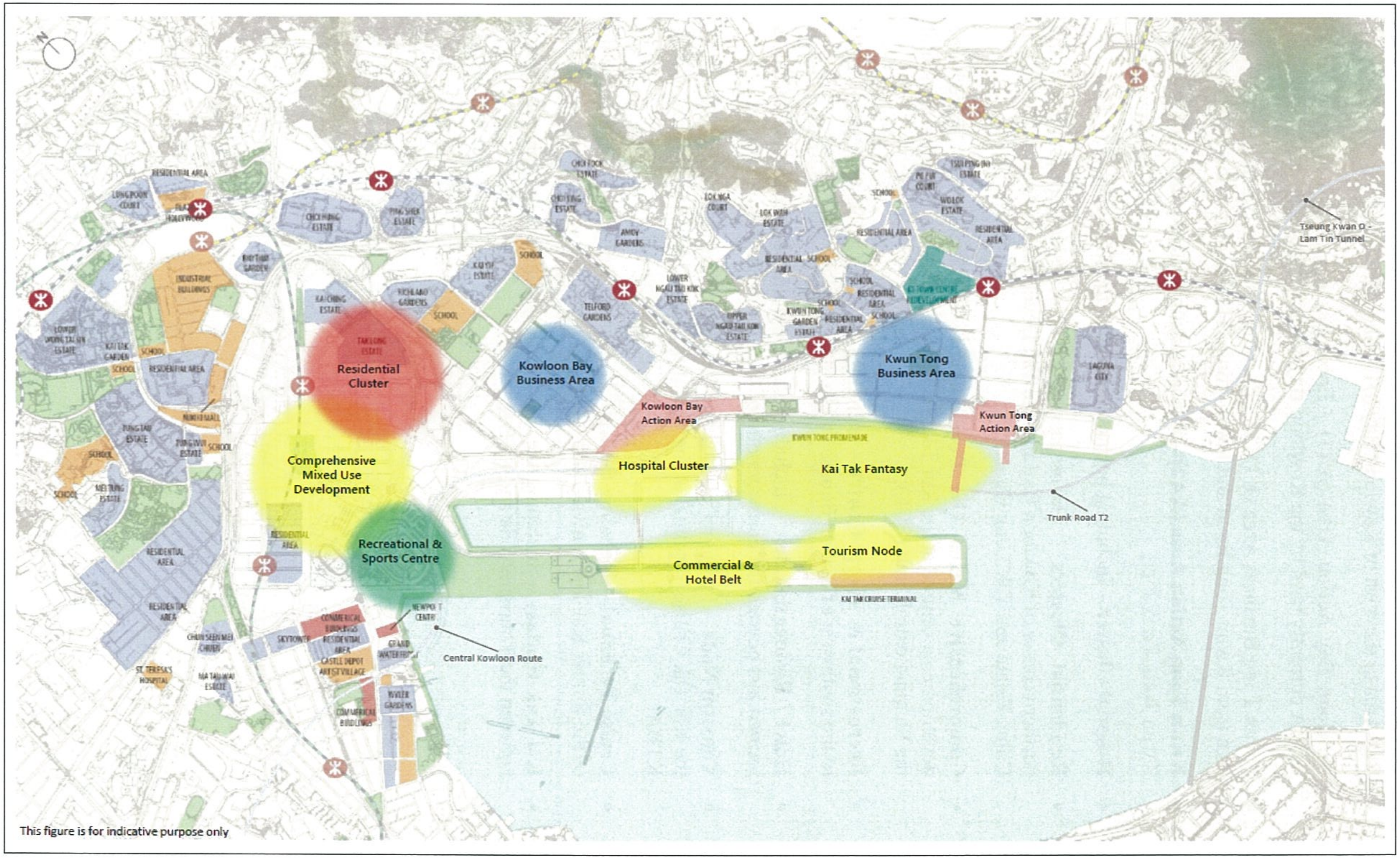


Figure 2.2: Key Attraction Points in Kowloon East to be Served by EFLS

Future Growth and Development

2.2.6 Many of the key attraction points identified in **Figure 2.2** are being implemented over the next decades. As noted, by 2036, total non-domestic GFA will increase from 7.0 million sqm in 2014 to 10 million sqm in 2036, an increase of 3.0 million sqm or 43%. One component of the non-domestic GFA is commercial GFA. Commercial GFA will increase significantly from 2.0 million sqm in 2014 to 7.0 million sqm in 2036, which includes new commercial developments and conversion of non-commercial GFA to commercial uses.[2]

2.2.7 Growth in total population and employment will also occur. The population in KTD will increase to about 134,000. Coupled with the attraction of various public facilities in the district, inevitably there will be growth in transport demand. By 2036, the development will nearly double the number of daily mechanized trips (or those trips taken in a motor vehicle, whether private vehicle, bus, etc.) from about 762,000 to nearly 1,560,000 trips.

2.2.8 Of the total daily mechanised trips to/from Kowloon East, it is estimated that 25% will be via car or taxi, while the remaining 75% will be on the public transport system.

2.2.9 Currently the public transport trips between external regions and Kowloon East, and the trips within Kowloon East, are largely handled by franchised bus and PLB, and to a minor extent the Kwun Tong Line. Without a new EFLS in place, the pace of transformation and redevelopment of KE into the new CBD would be at stake due to poor connectivity and slow travel times using current road-based public transport modes. In terms of transport planning, the poor public transport accessibility to/within the development would reduce attractiveness of the public transport network and encourage greater use of private modes. Thus, a convenient and well-linked transport system would play a key role in trip management and supporting the heavy trip-making pattern typical of a CBD.

2.2.10 To illustrate the current long journey times between key locations, a journey time survey between key activity and transport nodes in KE was carried out in September 2016. Various transport modes were included in the survey comprising walk, bus, shuttle bus and ferry. The results are demonstrated in the three figures below.

2.2.11 For instance from Kowloon Bay MTR Station to Megabox, walking takes up to 16 minutes, while a combined walk/shuttle/bus trip also takes about 16 minutes. Similarly, a trip between the Kai Tak MTR Station and Enterprise Square takes about 25 minutes to walk and 15 minutes for a combined walk/shuttle/bus trip.[3] Lastly, a trip from the Kwun Tong MTR Station to the Kai Tak Tourism Node takes over 70 minutes by walking, 36 minutes by walk/shuttle/bus, and 44 minutes by walk/ferry, respectively. In all cases, expected EFLS journey time (assuming a fully elevated option) would be considerably shorter.

[2] GFA, population and employment data are from the Enhanced 2011-based TPEDM, the latest RDOP of the Kai Tak Development (incorporated the Rethink 2 parameters) and from information provided by EKEO.
[3] The journey time is based on an assumed public transport route based on the planned road network in KTD.

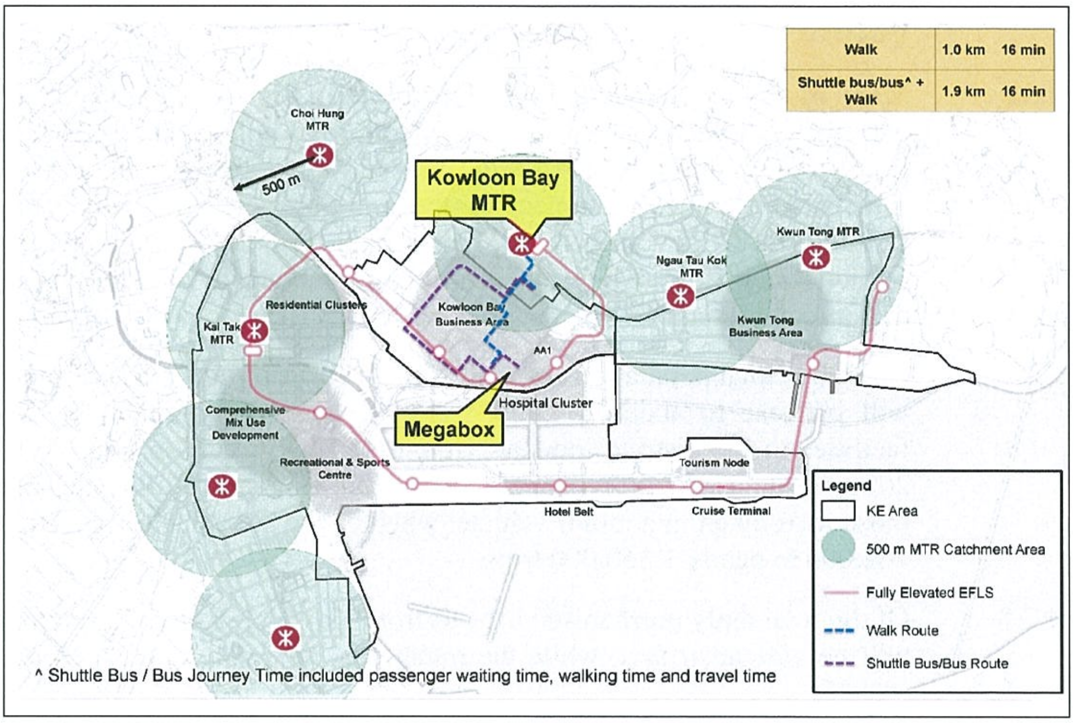


Figure 2.3: Journey Time Survey – MTR Kowloon Bay Station and Megabox

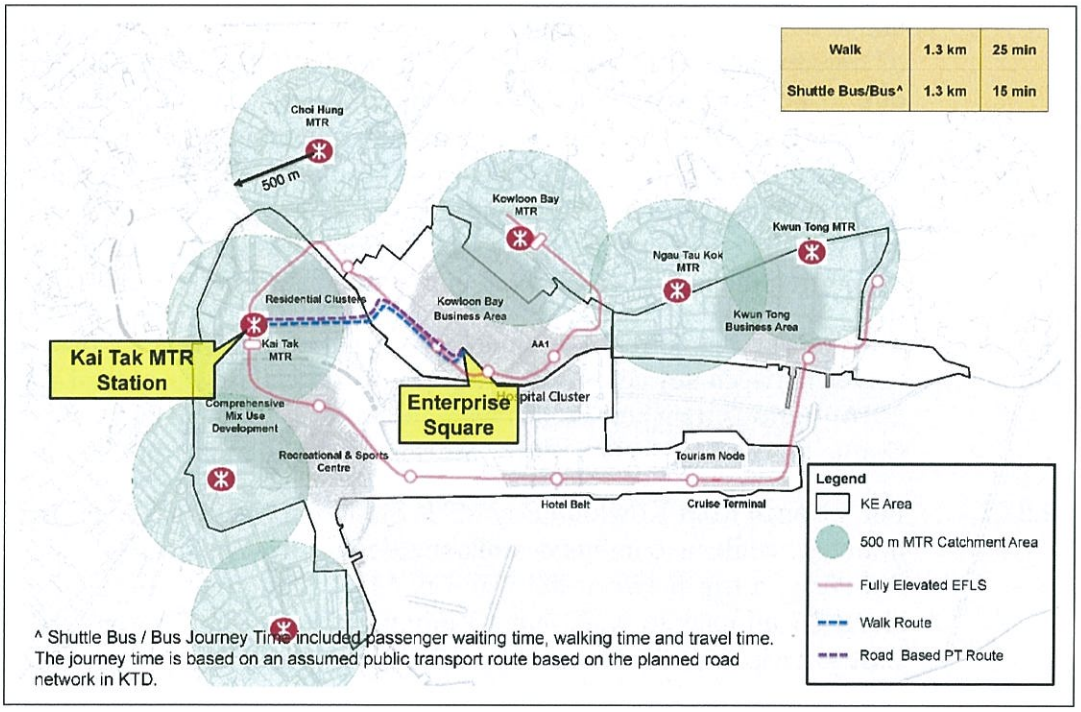


Figure 2.4: Journey Time Survey – MTR Kai Tak Station and Enterprise Square

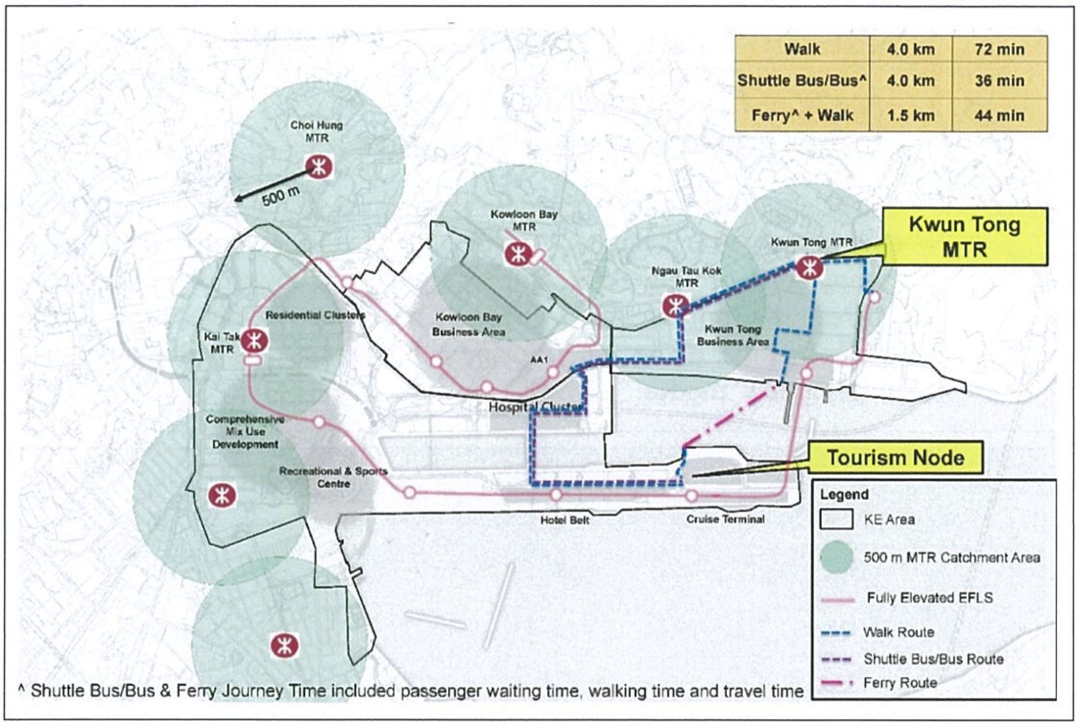
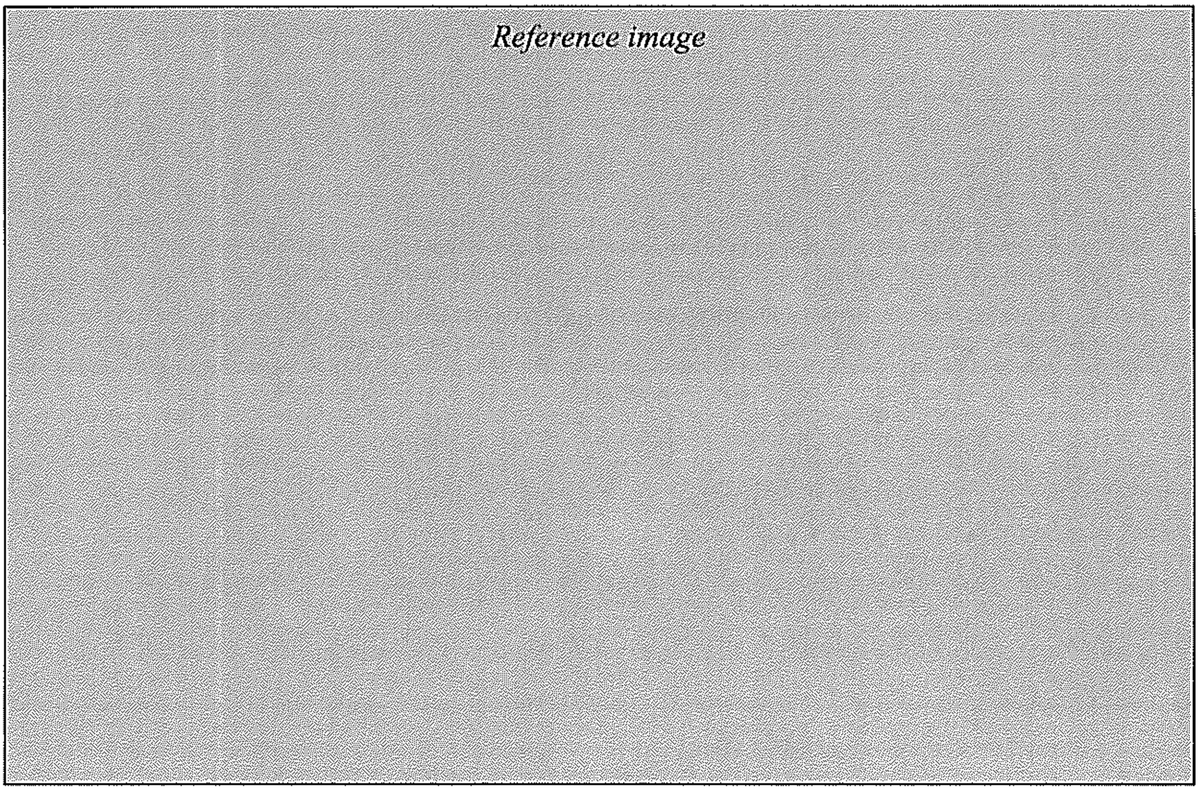


Figure 2.5: Journey Time Survey – MTR Kwun Tong Station and Tourism Node

3 Selection and Evaluation Process

3.1 Definition of Green Transport

3.1.1 Green transport can be generally defined as a transport mode that is more environmentally friendly, sustainable, healthier, efficient and cost effective compared to driving alone. The figure below shows how different modes compare as green transport modes, with single occupancy vehicles on the bottom as the least "green" mode, and public transport, bicycling, and pedestrians on the top as the most "green" modes.



Source: http://bikeportland.org/wp-content/uploads/2015/01/green-hierarchy.jpg

Figure 3.1: Green Transport Hierarchy

3.1.2 The pros and cons of each green transport mode can be categorised into four specific elements: (i) health – in terms of health of residents and employees in the area and using the noted green transport mode; (ii) economic – in terms of the economic benefits that each prospective green transport mode can generate; (iii) social – in terms of the level of equity for potential users (for instance, owning a private vehicle may be too costly for some, while riding public transport, using a bike, or walking is widely available to all); and (iv) environmental – in terms of the level of carbon and noise emissions and impact on the overall environment.

3.2 Vision and Key Requirements for EFLS

3.2.1 The overarching goals and vision for EFLS in Kowloon East are as follows and set the stage for the analysis of modal options:

Table 3.1: Goals for EFLS in Kowloon East

Goal	Description of Goal	Rationale
Goal#1: Capacity 	Provide sufficient capacity to handle expected loads in the future (this is estimated to be above 7,600 passengers per hour per direction (or pphpd), based on demand forecasts for this study.	EFLS must be capable of handling peak loads into and out of KE to encourage a high share of green public transport use that will be facilitate further growth and redevelopment of KE into a central business district and reduce driving. Insufficient capacity could result in: (i) extremely crowded vehicles and reduced passenger comfort; and (ii) situations where passengers are unable to board the arriving vehicle and must wait for the next vehicle.
Goal#2: Efficiency 	Provide efficient and convenient linkage system for all users with fast and competitive journey times as well as convenient transfer experiences.	EFLS should provide a fast and time-competitive journey compared to other modes to encourage the use of more sustainable public transport modes to facilitate the transformation of KE into the next central business district.
Goal#3: Reliability 	Provide reliable and on-time service in both directions, regardless of system maintenance, incidents, or weather	EFLS must offer a reliable, consistent and on-time service compared to private vehicles and current at-grade public transport in order to facilitate the transformation of KE into a bustling business and mixed use district.
Goal#4: Sustainability 	Provide a green and environmentally friendly service that reduces energy consumption and consumption of material resources, reduces carbon emissions, minimises impacts on residents and businesses, and supports sustainability during construction, operation, and maintenance.	EFLS, being a green transport mode, must enhance and sustain the environment and community, while minimising impacts on the environment, residents, employees, and others during both construction and operation in terms of carbon and noise emissions.

3.3 Selection Process and Flowchart

3.3.1 The selection of criteria, approach, and methodology of identification of suitable green public transport modes is described below (please refer to **Figure 3.2**). All green transport modes are equally compared against the same criteria during the high-level screening process. Those green transport modes satisfying the visionary goals would then be evaluated in greater detail during the next stage against the same set of evaluation criteria on an equal footing/basis.

- **High-Level Screening** – This screening focuses on whether a given green transport mode can satisfy the visionary EFLS goals established in **Table 3.1**. Those satisfying **all four** visionary EFLS goals proceed into the next phase – the Detailed Evaluation. Those that do not adequately achieve the envisioned goals fail the screening and will not be further considered for the EFLS (they may comprise part of the MMLS, however).
- **Detailed Evaluation** – This evaluation is a more detailed assessment for eligible green transport modes. Key evaluation criteria are derived from the four high level goals and included patronage, travel time, transfer time, road implications, impacts to other traffic, utility and building impacts, project and operating and maintenance (O&M) costs, construction timeframe, as well as economic internal rate of return (EIRR).

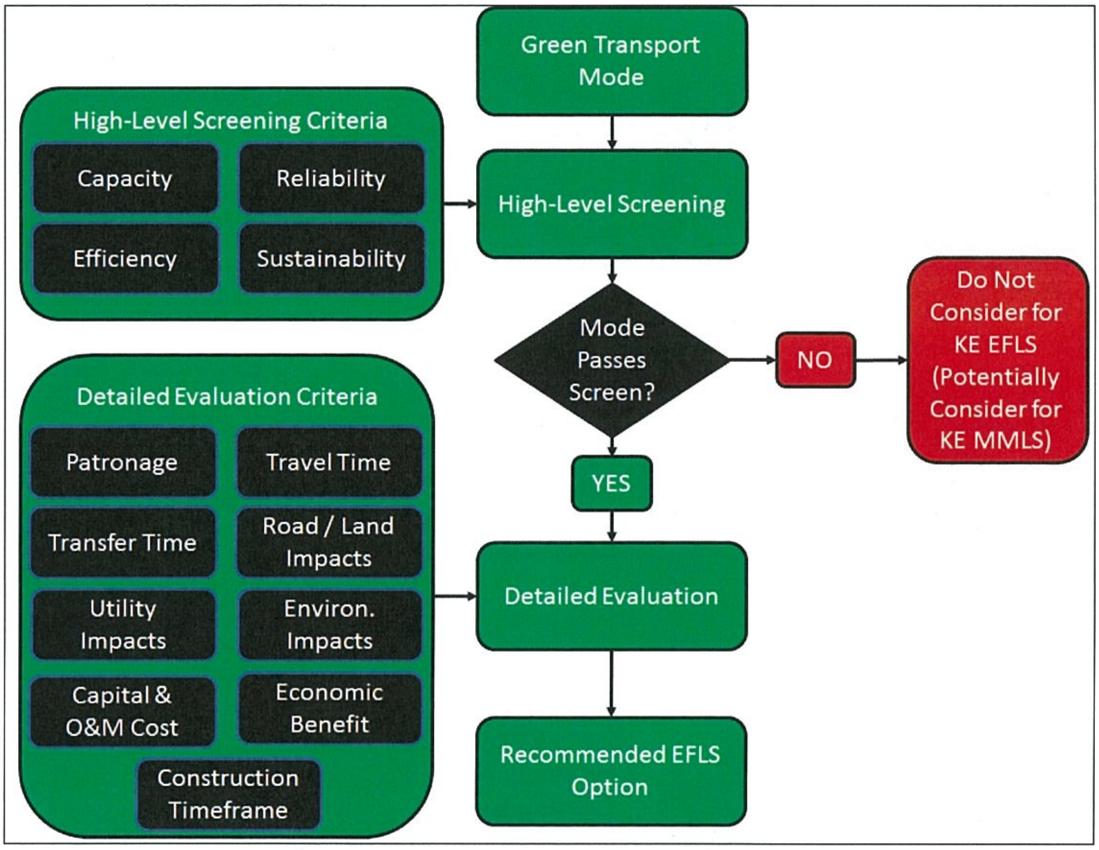


Figure 3.2: Flowchart of Selection Process

3.4 Potential Green Public Transport Modes

3.4.1 The modes under consideration for EFLS include the following modes in **Figure 3.3**. All modes represent public transport modes that can reduce automobile use (and emissions and congestion generated by automobiles), while running on clean energy/fuels or electricity.

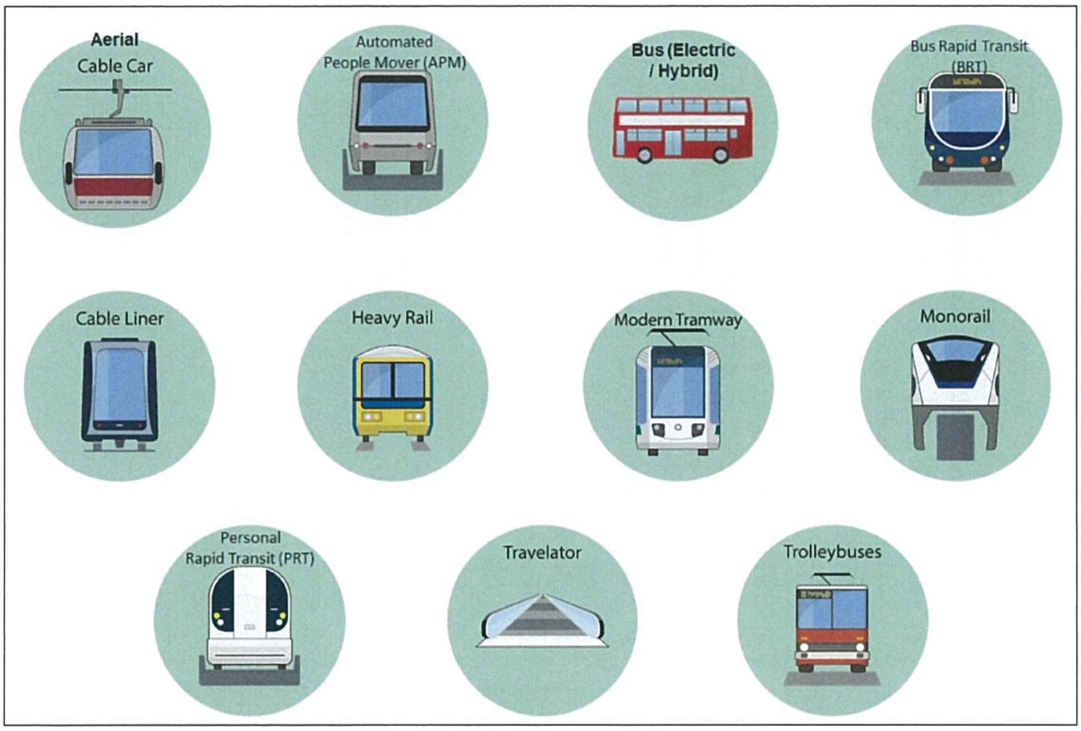
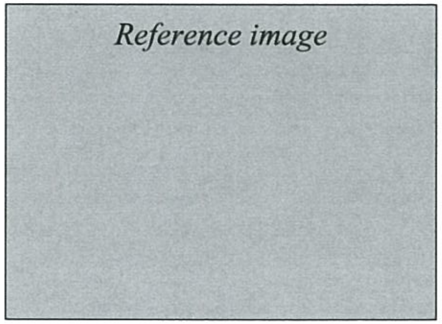


Figure 3.3: Potential Green Transport Modes for Potential KE EFLS

3.4.2 Brief descriptions of each of these modes are presented below in alphabetical order:

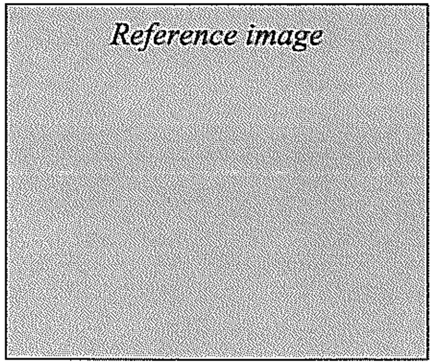
Table 3.2: Brief Description of Green Transport Modes Being Considered for the EFLS

Mode	Brief Description	Example	Applicability to KE
Aerial Cable Car	Aerial cable car is a system in which cabins are pulled by a cable and lack on-board motors or engines. Aerial systems are primarily used for tourist purposes, but in Latin America, they function as urban public transport systems due to hilly terrain that complement metro or provide public transport services as conventional bus service is considered less effective.		• Aerial cable car's limited capacity means that within KE, it likely cannot play the role of a high-capacity system. Cable car would likely serve as a specialized feeder in a niche role for tourists. • Aerial cable car has issues with reliability during inclement weather and maintenance, as well as flyover restrictions over existing structures.
Automated People Mover (APM)	APM systems use automated vehicles with rubber tires that run on a flat guideway or two parallel plinths. APM operates in fully-segregated corridors. APM vehicles operate using a third rail powered by electricity. There are no direct emissions from APM. They can handle moderate-high levels of demand depending on train length.		• Within the context of KE, APM would provide a fully segregated system that could achieve high reliability and capacity. APM would be an automated system without drivers. • APM, which operates on rubber tires, would run quieter than steel rail systems and may be appropriate in built-up areas in Kwun Tong and Kowloon Bay. • The relatively simple mechanism for switches is a benefit if switches are to be retrofitted to the system.
Bus (Electric/ Hybrid)	Bus provides a high degree of accessibility from local inter-district connectivity services, but operates in mixed flow conditions with other road traffic, generally without bus priority. Propulsion types vary, including green technologies such as electric and hybrid systems. Electric buses operate on battery power only, which could limit the distance travelled per charge (due to batter capacity). Hybrid buses use a combination of a battery and a conventional diesel combustion engine, which allows for a longer range, but is less environmentally friendly as emissions are still generated.		• Bus service would always be required in KE. Bus could play a feeder role, providing shuttle services to better connect the railway system. • Bus operates at-grade and would have reliability and capacity constraints compared to other modes.

Mode	Brief Description	Example	Applicability to KE
Bus Rapid Transit (BRT)	BRT is a high quality bus-based transit system, providing riders with a faster, more reliable, journey compared to conventional bus or trolleybus if operating in a dedicated corridor, segregated from other road traffic and users. Dedicated corridors minimise interference from other vehicles and road users, and allow buses to operate more reliably. Depending on system design, off-board fare payment, level boarding, number of passing lanes, and station layouts, corridor capacity in theory could be similar to rail systems can be achieved – but with more flexibility, lower costs, and a quicker implementation timeframe. Most BRT systems in operation today use conventional diesel combustion engines – which could be replaced by green technology in the longer term, depending on technology development. Some systems have recently begun to operate electric BRT vehicles (for instance Kuala Lumpur's BRT Sunway).		• BRT would require right-of-way for stations and bus lanes, as well as passing lanes and stations with multiple boarding areas to achieve demand levels envisioned in KE. • BRT operating on-street, even in dedicated lanes, would still be subject to mixed flow impacts at junctions. In the context of KE, BRT would occupy portions of the existing carriageway to form a designated corridor and require signal priority at junctions to achieve high capacity and high reliability. However, this would cause traffic impact to other road users given the tight space available in KE. • Without the privilege of a designated corridor and junction priority, BRT would function similar to conventional bus, which would share the road space with other traffic.
Cable Drawn Shuttles (Focusing on Cable Liners)	Cable drawn systems use cables to haul trains along the track, hence no traction motors are installed in the trains. The cables can be permanently attached to the trains, or, alternatively, the cables can be detached when the trains are stopping at stations. So-called cable liner systems have been used in both urban contexts and specialised contexts at airports or as a connector between an airport and railway. Cable drawn shuttles also include funiculars such as the Hong Kong Peak Tram, which have two trains permanently attached to the same cable with a passing loop in the middle of the line. For the purposes of the KE EFLS, the focus would be on a cable liner type system given its urban context and speed/capacity requirements.		• In the context of KE, a cable-drawn shuttle would offer a fully segregated rail system, which can be fully automated (driverless). • The guideway, essentially an elevated girder system, would be less "bulky" and potentially more visually appealing than other fixed guideway systems. • However, technical limitations of such systems constrain the number of stations and the length of the system. This in turn would limit potential carrying capacity of a cable-drawn shuttle in KE.

Mode	Brief Description	Example	Applicability to KE
Heavy Rail	A Heavy Rail system is based on about 25m long vehicles running on steel rails. Urban trains are typically 200 - 300m long. Alignment criteria are much more restrictive than other types of rail-based modes.	*Reference image*	• In the context of KE, several Heavy Metro lines already provide regional access to the area including Kwun Tong, Ngau Tau Kok, Kowloon Bay, as well as the future Shatin-Central Link's Kai Tak Station. • Internal trip flows in Kowloon East appear to be moderate and well below the capacity provided by such other rail lines in Hong Kong. Given high investment costs for Heavy Rail and the relatively modest demand forecast in KE, Heavy Rail may be financially unsustainable.
Modern Tram	Modern tram systems are based on vehicles that can operate on guideway mixed with road vehicles. Hence, the vehicles cannot be driverless. Many systems operate with low-floor trams, for convenient access.		• In the context of KE, a modern tram system operating at-grade would provide an accessible mode blended with the urban design of the corridor. • Modern tram would not offer a fully segregated rail system, which would have implications on travel speed, reliability, safety and other road users. • To operate efficiently, dedicated tram corridors should be established, which may be very difficult in KE and require reallocation of lanes to the tracks. • Headway of the tram system must be synchronized with the road signals at all crossings. This would have significant and negative impact for other road users.

Mode	Brief Description	Example	Applicability to KE
Monorail	Monorails are vehicles running on a single beam guideway. The two major categories of Monorails are straddling monorail and suspended monorail (also called under-slung monorail).		• In the KE context, monorail would offer a fully segregated system, which can be driverless. The narrow guideway could be more visually appealing and less "bulky" than other elevated guideway systems. • Switches and evacuation infrastructure may be key issues for monorail. Switches with movable support beams may require additional width beyond the envelope of the guideway. Evacuation infrastructure may be required including additional walkways and egress points that would widen the guideway and make it less visually appealing.
Personal Rapid Transit (PRT)	Personal Rapid Transit (also known as "Urban Light Transit" or "Automated Transit Network", ATN) , is a system of automated, electric small vehicles (sometimes called "pods" for 2-6 passengers) that run on segregated guideway. Stations are located off the main line, enabling non-stop journeys.		• In the context of KE, adoption of PRT would be limited by the required capacity in KE in addition to the width of stations that require passing lanes. • Although PRT can provide a unique non-stop experience from origin to destination, PRT would likely play a more specialised role as a local circulator within a discrete area and/or feeder to the EFLS and the existing MTR rail network.
Travellator	Travellator, also known as moving walkway, is a slow moving conveyor mechanism that transports people across a horizontal or inclined plane over a short to medium distance. Similar to a horizontal escalator, travellators are often provided in airports and transport facilities to offer better walking comfort and reduce effective walk distance and travel time.		• In the context of KE, travellators are most applicable as a pedestrian linkage system for short distance trips linking to/from major public transport hubs and activity centres. • Travellators could also be implemented within developments, but also between developments.

Mode	Brief Description	Example	Applicability to KE
Trolleybus	Trolleybus operates similar to conventional bus, typically in mixed flow traffic conditions, but is powered by electricity from overhead catenary. Trolleybuses operate quieter and have more efficient acceleration and deceleration profiles compared to conventional diesel buses. Trolleybus technology has improved such that hybrid vehicles, with on-board battery and diesel engine, can now operate autonomously for short distance without contacting the catenary for overtaking during emergency situations. In general, the overhead wiring network makes the system much less flexible than conventional bus.		• In the context of KE, trolleybus would be subject to mixed flow conflicts and delay while operating on at-grade, although dedicated lanes and transit signal priority could help to improve reliability and speed. • Trolleybus wires would require sufficient overhead clearance and have significant visual implications. • Trolleybus would likely require its own depot separate from existing bus depots in the area. Given the advancement of electric bus technology, trolleybus has no distinct advantage over green buses due to the provision of the overhead catenary system.

4 High-Level Screening

4.1 Overview of Section

4.1.1 The initial high-level screening assesses the 11 green transport modes against the four visionary goals for the EFLS in KE – capacity, efficiency, reliability and sustainability.

4.2 Capacity

4.2.1 Based on initial demand forecasts, a peak demand of 7,600 passengers per hour per direction (pphpd), based on the conforming EFLS scheme has been forecast for Year 2036. This serves as a reference to approximate the order of magnitude of passenger demand to be accommodated by any prospective EFLS along the entire corridor.

4.2.2 The table below presents the maximum capacity (either existing or planned - in terms of pphpd) for a given mode. Modes that could comply with the capacity requirements are presented in alphabetical order.

Table 4.1: Capacity Assessment for Green Transport Modes

Green Transport Mode	Reference System	Location	Maximum Capacity (pphpd) [A]	Meets Capacity of at Least 7,600 PPHPD?
Aerial Cable Car	Ngong Ping 360	Hong Kong SAR	3,500	NO
Automated People Mover (APM)	Macau LRT	Macau SAR	9,000	YES
Bus (Electric/Hybrid)	Various KMB Routes	Hong Kong	1,500 [B]	NO
Bus Rapid Transit (BRT)	Beijing BRT Taichung BRT	Beijing, China / Taichung, Taiwan	8,000 [C]	YES
Cable Liner	SkyMetro	Zurich, Switzerland	4,500	NO
Heavy Rail	East Rail	Hong Kong SAR	90,000 [D]	YES [E]
Modern Tram (Dedicated Corridor)	Sydney Light Rail	Sydney, Australia	13,500 [F]	YES
Monorail	Tokyo Monorail / Chongqing Monorail	Tokyo, Japan Chongqing, China	10,000-43,000 [G]	YES
Personal Rapid Transit (PRT)	Ultra	London, United Kingdom	1,500	NO
Travellator	Hong Kong / Tsim Sha Tsui Stations	Hong Kong SAR	3,000 [H]	NO
Trolleybus	Zurich	Zurich, Switzerland	2,400 [I]	NO

Notes:

[A] The maximum capacities cited in this table are not absolute, but represent the typical range of capacity for a given mode.

[B] Bus (electric/hybrid) would operate similarly to how franchised buses currently operate in Hong Kong. Assuming five minute headways for double decker vehicles holding up to 130 passengers, estimated capacity is about 1,500 pphpd.

[C] Guangzhou and Bogota both operate BRT systems with much higher capacities (on the order of 27,500 to 38,000 pphpd, respectively). This figure represents the combined headway of multiple routes within a common segment. This capacity is achieved with the use of exclusive lanes, passing lanes at stations, as well as elongated stations with multiple boarding areas. The Beijing and the Taichung (no longer operating) examples are considered more representative of what would be implemented in KE given land and space constraints (with a single corridor without passing lanes).

[D] This figure of 90,000 pphpd represents the maximum carrying capacity of the East Rail Line. Furthermore, the lowest capacity daily commute heavy rail line in Hong Kong's MTR network is the Ma On Shan Line, which operates with a maximum carrying capacity when train frequency is maximized (with 6ppsm) of 30,500 pphpd. The Disneyland Resort Line also operates with a maximum carrying capacity of 9,600 pphpd. Source: Capacity and Loading of Trains in the MTR Network, LC Paper No. CB(4)854/15-16(07), Legislative Council Panel on Transport Subcommittee on Matters Relating to Railways.

[E] Heavy rail's typical capacity is well beyond the target requirement of 7,600 pphpd.

[F] The quoted capacity is for Sydney's future CBD and South East Line, which will operate double-articulated trains with a capacity of 466 passengers, with 2 minute peak headways.

[G] The Tokyo Monorail is a medium-capacity system handling up to 10,000 pphpd, with six car trains at 4 minute headways. Chongqing's system is a high capacity system with some lines operating with 8 car trains holding up to 1,800 passengers at 2.5 minute headways (handling up to 43,000 pphpd).

[H] This refers to one direction only. The Hong Kong Mid-Levels Escalator purportedly handles up to 11,000 pphpd – this system is one of the longest in the world and includes multiple segments and entrances/exits. This peak volume includes all users that enter and exit the system along the route – not necessarily the demand passing through a single specific point over the hour. Therefore, the value of 3,000 pphpd for the Hong Kong-Central and Tsim Sha Tsui and Tsim Shat Tsui East station travellators would be a more appropriate comparison for the EFLS, which needs to serve 7,600 pphpd through a single point in the system.

[I] The Zurich trolleybus system deploys double articulated vehicles with capacity of around 270 passengers/vehicle.

4.2.3 The results from **Table 4.1** show that six modes fail to achieve the minimum peak demand of 7,600 pphpd required for the KE EFLS. This group includes PRT, travellators, cable cars, and cable liners, as well as buses (electric/hybrid) or trolleybuses. Maximum capacities for these range from 1,500 pphpd for PRT to 4,500 pphpd for cable liner in a single direction.

4.2.4 Green transport modes that meet the minimum peak demand requirement include modern tram, APM, monorail, BRT and heavy rail. Heavy rail easily meets the 7,600 pphpd capacity requirement as Hong Kong's lowest capacity commute-based heavy rail line (the Ma On Shan Line) serves a maximum carrying capacity of 30,500 pphpd.[4] In addition, East Rail handles the highest volumes at up to 90,000 pphpd.[5] However in the case of KE, heavy rail is deemed to provide excessive capacity for what is required in KE and is considered unsuitable to serve as the EFLS for KE (considering that heavy rail has the highest development costs of any green transport system).

[4] It is noted that the Disney Line has capacity for up to 9,600 pphpd, although this is considered a specialised tourist line rather than a commuter line. Furthermore the Airport Express handles up to 4,800 pphpd, although this is not an urban commute line, but a special dedicated line.

[5] Source: http://www.legco.gov.hk/yr15-16/english/panels/tp/tp_rdp/papers/tp_rdp20160419cb4-854-7-e.pdf

4.3 Efficiency

4.3.1 Efficiency is the ability of the EFLS to deliver passengers to their destinations quickly, without wasted time. This is different than reliability, which connotes the consistency and on-time performance of the system. One good proxy for efficiency is average speed of a given mode – which is assessed in the table below. The very goal of EFLS is to provide a fast and efficient journey – that is enhanced over the existing franchised bus and public light bus (PLB) systems. Typical franchised bus services in urban areas often operate around 10-15 km/hour or less including dwell time at stops (this is based on experience in Hong Kong as well as other major metropolitan cities such as London, New York City and San Francisco).

4.3.2 Using typical franchised bus services as the benchmark and requiring some minimum speed increase (i.e., a 25% speed gain), the proposed minimum average speed criteria for EFLS is about 20 km/hour. Although this is not a standard criteria, similar speed thresholds have been adopted by other systems to evaluate and justify potential improvements or the introduction of new modes (for instance several BRT projects in the San Francisco Bay Area used this speed increase threshold to assess the feasibility of new BRT service).

4.3.3 These modes accomplish this either through: (i) greater bus priority and segregated bus lanes such as BRT; or (ii) through dedicated rights-of-way that minimise (in the case of modern tram) or totally eliminate (in the case of APM, cable car, cable liners, heavy rail, monorail and PRT) interference from pedestrians and other motor vehicles.

4.3.4 Travellators are typically provided for short haul trips due to their relatively low speed – which would make them impractical to carry large numbers of users over relatively longer distances. Travellators in Hong Kong and Tsim Sha Tsui stations are designed for 0.75 m/s. Assuming pedestrians also walk on the travellators, equivalent speed would be 1.75 m/s or about 6.3 km/hour. This speed is lower than the typical travel speeds for franchised bus. Therefore, travellators would not meet the efficiency goal, which uses average speed as the assessment proxy.

4.3.5 The table below compares average green transport mode speed against the efficiency goal of 20 km/hour.

Table 4.2: Efficiency Assessment for Green Transport Modes

Green Transport Mode	Reference System	Location	Average Speeds (km/hour) [A]	Meets Efficiency Goal of 20 km/hour?
Aerial Cable Car	Portland Aerial Tram	Portland, USA	< 30	YES
Automated People Mover (APM)	Bukit Panjang LRT	Singapore	< 35 [B,C]	YES
Bus (Electric/Hybrid)	London	London, United Kingdom	< 15 [D]	NO
Bus Rapid Transit (BRT)	TransMilenio,	Bogota, Colombia	25-30	YES
Cable Liner	Oakland Airport Connector	Oakland, United States	35-40	YES
Heavy Rail	Island Line	Hong Kong	35-40 [E]	YES
Modern Tram (Dedicated Corridor)	Sydney Light Rail	Sydney, Australia	20-25	YES
Monorail	Osaka Monorail	Osaka, Japan	35-40 [C]	YES
Personal Rapid Transit (PRT)	Suncheon SkyCube	Suncheon, South Korea	< 50 [E]	YES
Travellator	Hong Kong-Central Station	Hong Kong SAR, China	< 6.5 [F]	NO
Trolleybus	San Francisco MUNI	San Francisco, USA	< 15	NO

Notes:

[A] Average speeds presented above are system-specific and approximate, which depend on local context and conditions. The maximum average speeds cited in this table are not absolute, but represent the typical range of speeds for a given mode.

[B] It is likely that APM would operate at similar speeds as other segregated rail systems such as cable liner, Heavy Rail, and monorail – however some systems exhibit speeds up to 35 km/hour, likely due to the limited number of stops.

[C] This speed assumes an urban system with frequent stations.

[D] Electric and hybrid buses would operate similarly to conventional buses in terms of speed. This speed also assumes urban conditions.

[E] The Suncheon SkyCube has only two stations.

[F] The 6.5 km/hour speed is based on the assumption all users walk on the travellator, which travels at a speed of about 0.75 m/s.

4.4 Reliability

4.4.1 To serve as a core transport system to support the connectivity of CBD, the EFLS must provide on-time, consistent and reliable service all day and all year round. Furthermore, the EFLS must remain operational regardless of the weather, maintenance work or unforeseen incidents (including vehicle breakdowns, flat tires, system breakdowns, accidents with motor vehicles or pedestrians, intrusions into the right-of-way by passengers or animals, fallen trees onto the right-of-way, etc.). Lastly, the EFLS must be flexible enough to additional demand from peak events.

4.4.2 The table below assesses each mode based on on-time performance and reliability. Modes are presented in alphabetical order.

Table 4.3: Reliability Assessment for Green Transport Modes

Green Transport Mode	Assessment of Reliability	Meets Reliability Goal?
Aerial Cable Car	• Operates in a dedicated "elevated" corridor that is not subject to road traffic or congestion, making aerial cable car considerably more reliable in terms of on-time performance than at-grade bus or BRT/tram. • Ceases operations during high winds, low visibility conditions and heavy rain. • Less flexible in terms of adding cars to service peak events or loads compared to other bus and rail systems due to limitations on the haul weight of the cable. • Closes completely during repairs (in both directions) and would require alternate means to provide mobility during these situations.	NO
Automated People Mover (APM)	• Operates in a fully segregated corridor and can offer a high level of on-time performance and service / frequency consistency. • Relatively easy to increase frequency to handle peak event loads/demand. • Maintains reliable service during adverse weather conditions.	YES
Bus (Electric / Hybrid)	• Operates in mixed flow conditions, and is therefore subject to traffic congestion and delay along its entire routes and at junctions. • Operates less reliably than BRT or tram in dedicated at-grade corridors, and much less reliably than grade segregated rail or APM systems. • Less flexible in terms of increasing frequency to deal with peak events giving at-grade congestion • Operates during all types of weather, although wet weather and flooding may result in lower reliability. • Can detour or bypass incidents along the route by using other streets.	NO
Bus Rapid Transit (BRT) (Dedicated Corridor Only)	• Operates in a dedicated corridor that allows BRT vehicles to operate more reliably than buses or trolleybuses in mixed flow lanes. • Subject to traffic congestion and interaction with other road users at intersections unless corridor fully grade segregated along the entire route, thus not as reliable compared to grade segregated rail or APM systems. • Relatively easy to increase frequency to handle peak event loads/demand, although vehicles would still be subject to traffic congestion at junctions. • Minimal impact from weather.	YES [A]

Green Transport Mode	Assessment of Reliability	Meets Reliability Goal?
	• Able to remain operational during repairs/incidents by "single tracking" using a single bus lane for both directions or by operating on adjacent general purpose travel lanes around the closure as long as the lane barriers are mountable	
Cable Liner	• Operates in a fully segregated corridor and can offer a high level of on-time performance and service / frequency consistency. • Less flexible than other rail modes to increase frequency to meet peak events given limited number of pull cables. • Maintains reliable service during adverse weather conditions. • Closes completely during repairs or cable replacement, which would be more complex and time-consuming than phased replacement of tracks for other rail-based systems	No
Heavy Rail	• Operates in a fully segregated corridor and can offer a high level of on-time performance and service / frequency consistency. • Relatively easy to increase frequency to handle peak event loads/demand. • Maintain reliable service during adverse weather conditions.	YES
Modern Tram	• Operates in a dedicated corridor that allows BRT vehicles to operate more reliably than buses or trolleybuses in mixed flow lanes. • If operates in shared corridor, then reliability and on-time performance would worsen and be similar to that for at-grade bus or trolleybus. • Subject to congestion and interaction with other road users at intersections unless corridor fully grade segregated along the entire route, thus not as reliable compared to grade segregated rail or APM systems. • Relatively easy to increase frequency to handle peak event loads/demand, although vehicles would still be subject to traffic congestion at junctions. • Maintain reliable service during adverse weather conditions.	YES ^
Monorail	• Operates in a fully segregated corridor and can offer a high level of on-time performance and service / frequency consistency. • Relatively easy to increase frequency to handle peak event loads/demand. • Maintain reliable service during adverse weather conditions.	YES
Personal Rapid Transit (PRT)	• Operates in a fully segregated corridor and can offer a high level of on-time performance and service / frequency consistency. • Maintain reliable service during adverse weather conditions.	YES
Travellator	• Minimal impact from weather so long as covered • Moderate flexible in terms of increasing frequency or capacity to detail with peak events (for instance both travellators could travel in the same direction or a travellator could be speeded up slightly). • One direction of travel would need to be closed during maintenance, which would impact on-timer performance and service in the opposite direction • Although partial closure in one direction may be feasible for short distances, this is not feasible for longer distances such as that for the KE EFLS.	NO

Green Transport Mode	Assessment of Reliability	Meets Reliability Goal?
	• If this occurred frequently enough, users would likely avoid using this system and find alternate means of transportation.	
Trolleybus	• Operates in mixed flow conditions, and is therefore subject to traffic congestion and delay along its entire routes and at junctions. • Operates less reliably than BRT or tram in dedicated at-grade corridors, and much less reliably than grade segregated rail or APM systems. • Less flexible in terms of increasing frequency to deal with peak events giving at-grade congestion • Operates during all types of weather, although wet weather and flooding may result in lower reliability. • Limited ability to detour along the route to bypass incidents or breakdowns due to the need to maintain contact with the catenary (although hybrid trolleybuses can now operate independently free of the catenary for short distances).	NO

Notes:

[A] BRT and modern tram in this instance assume dedicated corridors (with at-grade crossings at junctions). However, modern tram operating in a shared corridor would not pass the reliability goal given likely traffic impacts during the journey and at junctions (similar to what buses and trolleybuses would experience).

4.4.3 The results from **Table 4.3** show that several of the modes do not meet the reliability goal in terms of operational continuity in inclement weather or during system maintenance. Key findings are as follows:

- **Aerial Cable Car** - Cable car systems typically cease service during periods of heavy fog, heavy rain, and/or high winds. This is the case for Ngong Ping 360 and would be the case for a cable car system operating in KE. Given frequency of high winds and rain conditions in Hong Kong, closure of a KE cable car system would significantly impact reliability and convenience for passengers. In addition during maintenance of the system, the system must be shut down completely. Ngong Ping 360 shuts for several weeks during the year for system repairs and maintenance.

- **Bus (Electric / Hybrid)** – Bus operates in mixed flow conditions, meaning it is subject to traffic congestion and interference from other road users (including vehicles, cyclists, and pedestrians) throughout the journey and at junctions. This would result in considerably lower reliability than grade-separate APM or rail systems or BRT / modern tram operating in dedicated at-grade corridors.

- **Cable Liner** – Although they can operate in inclement weather (for instance in Toronto, Canada with its harsh and cold winters), cable liner systems would need to shut down for maintenance or replacement of the pulling cables. Replacement would be more time-consuming and difficult compared to phased replacement of track for other rail systems.

- **Travellator** - Travellators, while minimally impacted by inclement weather conditions so long as they are covered, can be severely impacted by system maintenance. Maintenance in one direction on a specific segment would close movement in that direction. If dual travellators are provided (one in each direction), closure of one side for maintenance would force such pedestrians to walk (this will not impact travellator movement in the other direction though).

For limited, short distances this would likely be acceptable as long as it is not a daily occurrence. However, given hot and humid weather conditions in Hong Kong, forcing one direction of users to walk relatively long distances would likely be unacceptable.

- **Trolleybus** – Trolleybus performs similarly to buses in that they both operate in mixed flow conditions, meaning it is subject to traffic congestion and interference from other road users (including vehicles, cyclists, and pedestrians) throughout the journey and at junctions. This would result in considerably lower reliability than grade-separate APM or rail systems or BRT / modern tram operating in dedicated at-grade corridors. In addition, trolleybus is constrained by needing to maintain contact with the overhead catenary wire (although some hybrid vehicles allow limited off-wire operations). This limits the ability of trolleybuses to bypass incidents along the route.

4.4.4 Other modes such as APM, BRT, heavy rail, modern tram, monorail and PRT are minimally impacted by weather conditions, while also having the ability to single track around maintenance/incidents to allow operations in both directions to be maintained (although total system capacity would be reduced).

4.5 Sustainability

4.5.1 Sustainability refers to a variety of aspects including providing a green and environmentally friendly service that reduces energy consumption and consumption of material resources, reduces carbon emissions, minimises impacts on residents and businesses, and supports sustainability during construction, operation, and maintenance.

4.5.2 All of the green transport modes operate on electricity in one form or another (assuming BRT operates with electric or zero-emission vehicles) and do not generate direct carbon emissions from the vehicles. All of them to varying degrees meet the sustainability goals as defined by the various aspects noted above. Comparing with conventional vehicles using fossil fuel that travel everywhere on land, the emission of the EFLS will be mainly in power plants, impact of which to the environment is relative easier to mitigate at source. Therefore, all potential green modes are considered to achieve the sustainability goal. Specific sustainability analysis would be undertaken in the more detailed analysis when alignment, modes, etc. are fixed.

4.6 Green Transport Modes Proceeding to Detailed Analysis

4.6.1 The table below summarises the findings from the High-Level Screening. As noted, any green transport mode that fails to align with any **single** screening criterion is eliminated and no longer considered as a potential KE EFLS option for the Detailed Analysis (although it may be considered as a potential MMLS). Key findings are summarised below:

- Bus (electric/hybrid) and trolleybus operate similar to existing franchised buses. They operate in mixed flow conditions and are subject to interference and conflicts with other road users that would significantly reduce reliability and on-time performance compared to BRT/tram in dedicated corridors or grade-segregated APM or rail corridors. Furthermore, bus and trolleybus cannot meet the projected peak demand of 7,600 pphpd, and do not meet or exceed the efficiency target speed threshold of 20 km/hour. The franchised bus companies, under the Government's subsidized trial scheme, have selected some bus routes in Hong Kong for conducting trial runs on the hybrid bus and battery electric/supercapacitor buses. Therefore, these types of green vehicles are most likely to be proven for use in Hong Kong progressively in the longer term. It is considered that hybrid/electric bus would ultimately be part of the public transport system in any case under the MMLS network. However, trolley bus is not considered suitable for KE due to need for an overhead catenary system.

- Cable car and cable liner are eliminated as potential KE EFLS due to their inability to serve the projected peak demand of 7,600 pphpd, in addition to reliability concerns. Cable car cannot operate in inclement weather and must cease two-way operations during maintenance/incidents. In a similar fashion, cable liner systems would need to be shut down during maintenance or replacement of the pulling cable(s). These activities would typically be more time-consuming and complex than phased replacement of track for other rail-based systems (which could happen overnight over several weeks/months).
- Heavy rail typically handles much higher carrying capacity than that envisioned for Kowloon East. In Hong Kong, the lowest capacity heavy rail line is the Ma On Shan Line, capable of handling up to 32,000 pphpd compared to KE's modest 7,600 pphpd. In addition, given its relatively high development costs compared to other green transport modes, heavy rail is not considered as a suitable transport mode to serve as EFLS.
- PRT is eliminated as a potential KE EFLS as it fails to meet the minimum peak capacity required (7,600 pphpd). PRT provides a personalised on-demand, point-to-point journey in very small pods. However, the current maximum capacity is on the order of 1,500 pphpd, well below the minimum threshold.
- Travellators are eliminated as a potential KE EFLS for several reasons including lack of capacity, reliability (due to closure of one direction due to system maintenance/incidents forcing users to walk, which would be unacceptable for long distances given Hong Kong's hot and humid weather) and slow average speed, which is below that of current franchised buses.
- Remaining modes meeting all four visionary goals are APM, BRT, modern tram, and monorail. All four modes achieve goals for capacity, efficiency, reliability and sustainability. These modes are carried forward into the Detailed Analysis in the next section.

Table 4.4: High Level Assessment for Green Transport Modes

Green Transport Mode	Meets Screening Criteria				Carry Forward to Detailed Analysis for KE EFLS?
	Capacity	Efficiency	Reliability	Sustainability	
Aerial Cable Car	NO	YES	NO	YES	NO
Automated People Mover (APM)	YES	YES	YES	YES	YES
Bus (Electric / Hybrid)	NO	NO	NO	YES	NO

Green Transport Mode	Meets Screening Criteria				Carry Forward to Detailed Analysis for KE EFLS?
	Capacity	Efficiency	Reliability	Sustainability	
Bus Rapid Transit (BRT)	YES	YES	YES	YES	YES
Cable Liner	NO	YES	NO	YES	NO
Heavy Rail	YES (but Excessive for Demand Required)	YES	YES	YES	NO
Modern Tram	YES	YES	YES	YES	YES
Monorail	YES	YES	YES	YES	YES
Personal Rapid Transit (PRT)	NO	YES	YES	YES	NO
Travellator	NO	NO	NO	YES	NO
Trolleybus	NO	NO	NO	YES	NO

5 Detailed Analysis

5.1 Key Criteria for Detailed Analysis

5.1.1 The detailed analysis criteria for the EFLS mode selection are presented below:

Table 5.1: Detailed Analysis Criteria for EFLS Mode Selection

#	Analysis Criteria	Description	Source
1	Daily Boardings	• The volume of passengers boarding the prospective EFLS mode over a typical weekday.	• Arup Model
2	Peak Hour Boardings	• The volume of passengers boarding the prospective EFLS mode over a typical peak hour (in terms of passengers per hour per direction or pphpd).	• Arup Model
3	In-Vehicle Journey Time	• The total duration of time (in minutes) spent on the EFLS from a specific origin to a specific destination.	• Arup Model
4	Peak Vehicle Require-ments [A]	• The number of peak vehicles required for service given roundtrip travel time, layover time (assumed to be 15% of roundtrip travel time as consistent with existing practice), and proposed peak headway	• Arup Model and proposed schedule
5	Transfer Time	• The total duration of time (in minutes) transferring from the EFLS to the MTR lines or attraction points will be estimated. Transfer time only includes the walk access time (including horizontal distance and vertical level changes to/from the centre of the platform for the EFLS or MTR stations) and includes waiting time for EFLS. • Potential transfer stations for EFLS include but not limited to (i) Kwun Tong Station; (ii) Ngau Tau Kok Station; (iii) Kowloon Bay Station; and (iv) Kai Tak Station. • It is noted that proposed locations of EFLS stations in the vicinity of the existing Kwun Tong Line stations are to be designed as separate stations with no physical or direct interchange. This is due to the fact that coordination with MTR is still on-going and there are no conclusions yet whether direct links will be provided.	• Current site maps and analysis of station locations proposed under PFS alignment

#	Analysis Criteria	Description	Source
6	Impacts to Other Traffic	• The extent and scope of impact on road traffic in terms of queuing and travel speed (km/hour) from the implementation of the EFLS.	• Arup Traffic Model
7	Road / Land Impacts	• Physical area, traffic lane, sidewalk, planting area, open space, junction modification including traffic signalling system and space implications on roads from the implementation of the EFLS.	• Analysis of existing corridor maps and proposed alignments
8	Utility Impacts	• Extent of utility impacts from the implementation of the EFLS in terms of total utility diversion costs.	• Analysis of existing utility plans and proposed alignment
9	Environ-mental Impacts	• Extent of environmental impacts from the implementation of the EFLS.	• Analysis of alignment and nearby buildings and sensitive receptors
10	Capital & O&M Cost	• The total cost to design and construct the EFLS including systems, stations, vehicles, etc. (in December 2015 prices). • Total annual operation and maintenance (O&M) cost (including state of good repair and periodic replacement of systems, vehicles, etc.)	• Analysis of alignment, length of alignment, number of stations, number of vehicles, operating plan, etc.
11	Economic Benefit	• The economic internal rate of return, which measures the generated economic benefit from the EFLS, given capital, operating, and state-of-good repair costs. This would only include local users (residents, commuters, etc.) that would potentially benefit or disbenefit.	• Analysis of economic benefit based on ridership, time-savings, capital and operating costs, etc.
12	Implement-ation Programme	• Number of years to implement the EFLS.	• Estimated based on proposed works and alignment and recent precedent

Notes:

[A] Peak vehicle requirement is presented for information only and is not used directly to compare options, as the number of buses, trams or APM/monorail trains is not directly comparable. The number of peak vehicles is captured in the overall capital costs for a given option.

5.2 Definition of Options

Grouping of Eligible Green Transport Modes

5.2.1 Four green transport modes remain as potential EFLS for KE: APM, BRT, modern tram, and monorail. APM/monorail and BRT/modern tram share similar operating and performance characteristics and are thus categorised into two groups – at-grade and elevated systems. **Going forward for the Detailed Analysis, the evaluation will focus on the performance of at-grade systems versus elevated systems.**

Table 5.2: Green Transport Mode Grouping for Detailed Analysis

Group	Modes in Group	Shared Operating and Performance Characteristics
At-Grade Systems	• BRT • Modern Tram	• Both modes principally operate at-grade (although shared operations are sometimes implemented in short segments as per the Tuen Mun Light Rail as well as the Hong Kong Tramways), in partially grade-segregated bus lanes or corridors that allow pedestrian and vehicle crossings.[6] • These dedicated corridors allow BRT and modern tram to operate faster than typical franchised buses without interruption by other traffic and carry substantially more passengers especially with passing tracks and longer stations than conventional buses. • Both modes may be subject to congestion and delay at junctions and interference/conflicts with pedestrians, cyclists, and motor vehicles, limiting average travel speeds and reliability, as well as possibly necessitating turn restrictions. • Bus lanes/dedicated corridors occupying traffic lanes and can impact road capacity. • Both modes require drivers. • The major difference is that modern tram requires an external propulsion system (either overhead catenary or ground-power supply) and operates on steel rail. BRT operates with rubber tiered vehicles that are independently powered (by combustion engine or electric system). BRT is more flexible than modern tram as vehicles may leave the lanes to bypass disabled vehicles, while trams can only run where there are tracks.
Elevated Systems	• APM • Monorail	• Both modes operate in fully segregated corridors with fully grade-separated crossings, without interference from vehicles or pedestrians. • Both systems typically operate on elevated viaduct (although APM can also operate underground as per the Hong Kong International Airport's People Mover and some systems may operate for short at-grade dedicated segments, for instance in the middle of a freeway or entering the depot). • Both systems operate faster and more reliably than at-grade systems. • Both systems can be fully automated without drivers. • Both systems have similar operating characteristics in terms of maximum speed and minimum turning radii. • The major difference between APM and monorail is that APM operates on a structural deck, while monorail operates on a narrow guide beam. Monorail switching technology is more complex than that for APM.

[6] It is noted that some BRT systems operate principally or entirely on elevated viaduct including BRT systems in: (i) Kuala Lumpur, Malaysia; (ii) Nagoya, Japan; and (iii) Xiamen, China. However, these are the exception rather than the norm as most systems are provided at-grade to reduce costs and infrastructure provision. Also, some modern tram systems operate on short elevated sections including systems in: (i) San Jose, USA; and (ii) Seattle, USA. These examples are the exception rather than the norm though.

Segregation Options by EFLS Group

5.2.2 Segregation refers to the degree/extent in which interaction or mixing with other vehicles and road users such as cyclists and pedestrians occur. The level of segregation can also be known as "right-of-way exclusivity". Right-of-way exclusivity impacts the speed and reliability of an EFLS, as more frequent conflicts and interference results in slower operating times and more delays. There are three levels of exclusivity potentially feasible for the KE EFLS groupings – these are described below.

Table 5.3: Examples of Right-of-Way Exclusivity and Operating Implications on EFLS

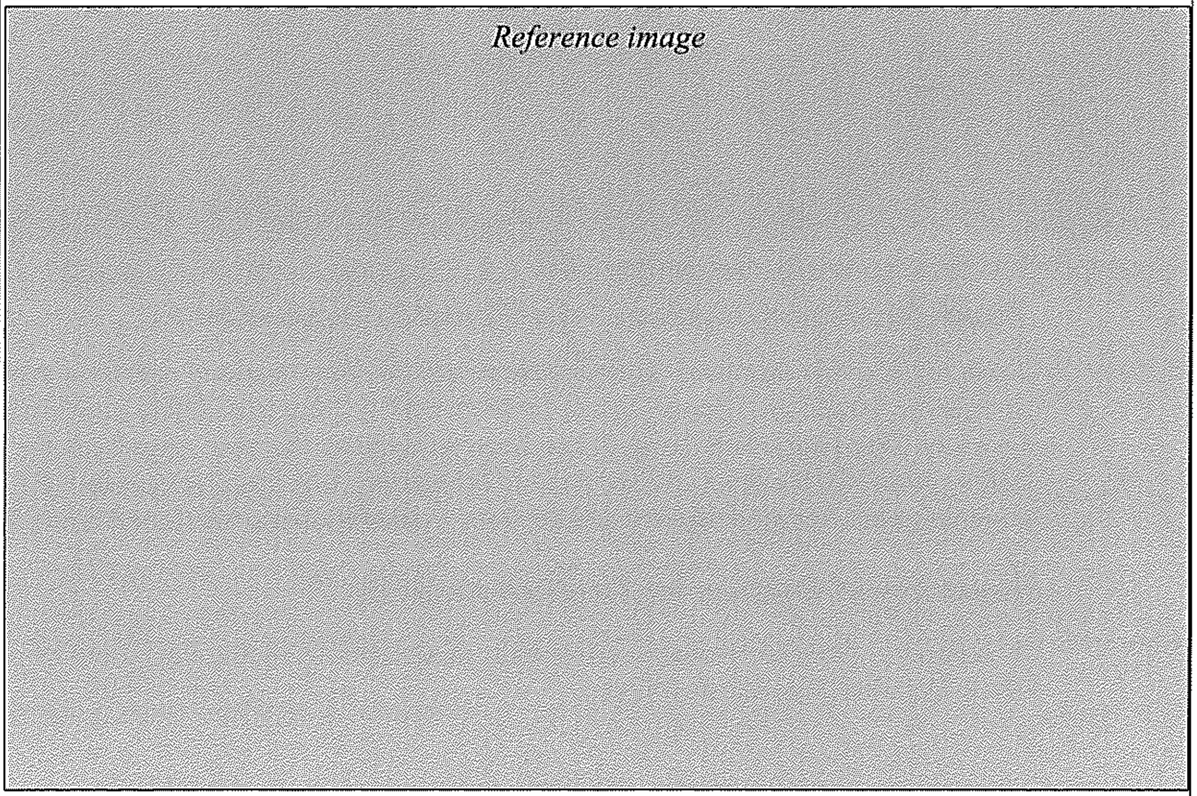
	At-Grade Systems (Shared Corridor)	**At-Grade Systems (Dedicated Corridor)**	**Elevated Systems (Dedicated Corridor)**
Photo	*Reference image* Hong Kong Tramways	*Reference image* Barcelona Tram	*Reference image* Tokyo Yurikamome
Level of Segregation from Vehicles and Mixed Flow Traffic	**No Segregation**	**Partial Segregation**	**Full Segregation**
	EFLS vehicles use the same track with other traffic such as private vehicles, taxis, and/or buses	EFLS vehicles interact with pedestrians / vehicles occurs at signalised intersections (sometimes with safety barriers)	EFLS vehicles have no interaction with other vehicles or pedestrians as corridor is completely grade-separated
Operational Implications (on Journey Time and On-Time Performance)	**High**	**Moderate**	**Low**
	EFLS vehicles impacted by road and junction traffic and congestion, and turning vehicles	EFLS vehicles impacted by junction traffic and turning vehicles	EFLS vehicles can operate at maximum speed
Potential for Driverless Operations	No	No	Yes

Note: There are some fully grade-separated At-Grade Systems – including the Sydney Tram's Inner West Rail Extension, which are built in former freight rail corridors with full grade separation. This is not considered feasible in KE as no such at-grade corridor, with full grade separation at each junction, has been established. The majority of urban at-grade modern tram and BRT systems still have at-grade crossings at select locations and some degree of interaction with other road vehicles and pedestrians.

Alignment Assumption

5.2.3 The Network Option 5 (i.e., the Preliminary Elevated Alignment) proposed under the previous feasibility study, Agreement No. CE 42/2009 (TT) Kai Tak Environmentally Friendly Transport System – Feasibility Study has been adopted as the base alignment for the evaluation of elevated green transport modes. It should be clarified that precise alignment, station location and network coverage would be further developed in the next study stage after a specific green transport mode has been confirmed and adopted. The Preliminary Elevated Alignment is depicted in **Figure 5.1** below.

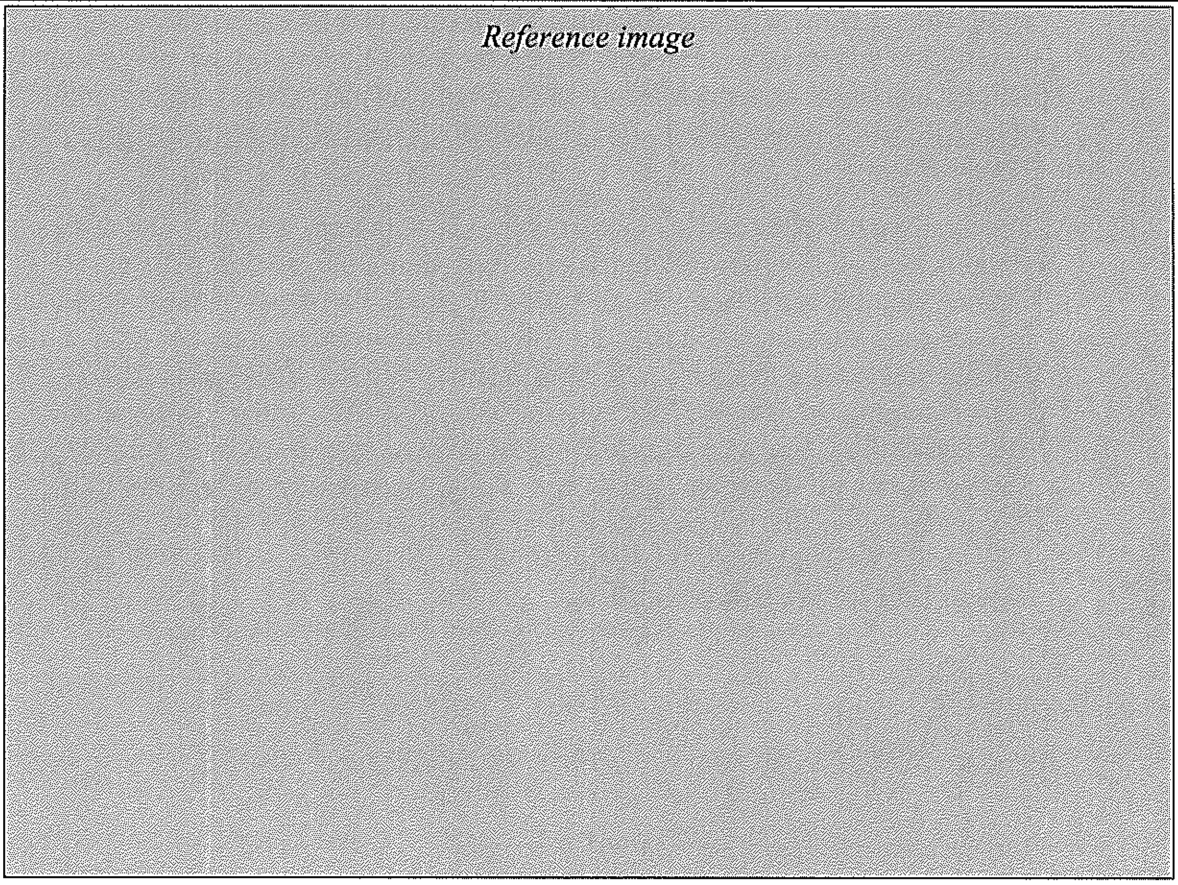
5.2.4 The Preliminary Elevated Alignment starts at Kowloon Bay and proceeds south towards the nullah, before swinging northwest along the north edge of the Hospital Cluster, along Wang Kwong Road. The Preliminary Elevated Alignment then heads west to serve various public housing estates in the northeast corner of KTD and Kai Tak Station Square. It then heads southeast past the Kai Tak Sports Park (KTSP), before running the length of the runway to the Kai Tak Cruise Terminal (KTCT). The Preliminary Elevated Alignment then crosses over the Kwun Tong Typhoon Shelter to Kwun Tong via the Kwun Tong Transportation Link (KTTL). The Preliminary Elevated Alignment is proposed to interchange with the Kwun Tong Line (at Kwun Tong Station and Kowloon Bay Station) as well as with the Shatin-Central Line (at Kai Tak Station).



Source: Agreement No. CE 42/2009 (TT) Kai Tak Environmentally Friendly Transport System – Feasibility Study

Figure 5.1: Preliminary Elevated Alignment for Green Transport Mode Evaluation

5.2.5 At-grade options would have a different alignment. This study reviewed the alignment of the Modern Tramway proposed by Hong Kong Tramway Company received during the previous feasibility study. The Hong Kong Tramway proposed alignment is shown in the figure below.



Source: Hong Kong Tramways, 2015 (provided by CEDD)

Figure 5.2: Original Hong Kong Tramways (HKT) Alignment for KE

5.2.6 Upon review, this proposed alignment was refined due to various constraints such as existing buildings, limited space, underground utilities and safety concerns in Kowloon Bay and Kwun Tong. It has been adopted as the base alignment for at-grade options for the green transport mode evaluation. The proposed at-grade EFLS alignments are further discussed and depicted in the following **Sections 5.3** and **5.4.**

Summary of Options for Detailed Analysis

5.2.7 In summary, there are four green transport mode options that are explored as part of the Detailed Analysis as follows:

5.2.8 **Table 5.4: Summary of Green Transport Mode Options for Detailed Analysis**

Option	System	Modes	Level of Segregation
1	At-Grade	BRT / Modern Tram	Dedicated Corridor
2	At-Grade	Modern Tram [A]	Shared Corridor
3	Elevated	APM / Monorail	Dedicated Corridor
4	Mixed (Elevated / At-Grade) [B]	BRT / Modern Tram	Dedicated Corridor

Notes:

[A] BRT would operate in a dedicated corridor, since BRT operating in a shared corridor would be similar to how franchised buses currently operate in the street. Therefore, Option 2 only includes Modern Tram for the at-grade shared corridor option.

[B] As will be discussed in the forthcoming sections, Option 4 (a hybrid of Option 1 and 3) is also assessed as a compromise between the two given potential road/traffic impacts in the built up area around Kowloon Bay and Kwun Tong, but not on the Kai Tak runway.

5.2.9 The following sections provide more detailed assessment of each of the three options. Each option will be profiled as follows:

- Alignment (describes the alignment of each option)
- Level of Segregation (describes the level/extent of segregation from other road users)
- Operating Assumptions (describes headway, vehicle capacity, and other operating parameters, etc.)
- Performance against Criteria (describes performance against those criteria defined in **Table 5.1**).

5.3 Option 1: At-Grade Dedicated Corridor

General Description

5.3.1 Option 1 represents an at-grade system that operates in dedicated lanes/track that are segregated from adjoining mixed flow traffic and pedestrians for most of the alignment. Interaction with other road users occurs at at-grade junctions with the corridor. This option is assumed to operate as BRT or modern tram as both modes would have similar infrastructure implications in terms of road space required. For the purposes of this analysis, modern tram is used. Alignment would follow that of the refined Hong Kong Tramways proposal.

5.3.2 Typically, stations would be at-grade and have a side platform configuration and be staggered across the intersection to reduce required width at the station. Furthermore, stations would be located at the nearside of the intersection to minimise delays on the modern tram.

Alignment

5.3.3 At-grade modern tram in a dedicated corridor would operate in its own travel lanes, segregated from general traffic. The recommended alignment would be divided into two lines: (i) Line 1 (Blue Line) from near Ngau Tau Kok to Kai Tak Cruise Terminal; and (ii) Line 2 (Green Line) from Kwun Tong Ferry Pier to Kai Tak Cruise Terminal via the Kai Tak Bridge, which is the existing Taxiway Bridge.

5.3.4 Line 1 would be approximately 6.6 km long, while Line 2 would be approximately 3.5 km long. Line 1 would have 12 stations, while Line 2 would have 5. The lines would share two stations at the south end of the Kai Tak Development. The recommended alignment of modern tram with a dedicated corridor is shown in **Figure 5.3.**

5.3.5 This at-grade modern tram would be located close to the MTR Kai Tak Station, while MTR Ngau Tau Kok and Kwun Tong Stations would be within a few blocks walk. The at-grade modern tram would not directly connect to MTR Kwun Tong Station due to congested conditions and heavy impacts along Hoi Yuen Road and King Yip Street by introducing at-grade modern tram. More than 15 vehicle accesses to nearby buildings would be blocked, while adding traffic signals would not be feasible due to the density of vehicle access points (i.e., with gaps of less than 25m between access points).

5.3.6 Furthermore, the line would not directly connect to MTR Kowloon Bay Station because full reallocation of Tai Yip Lane and Hong Tak Road to modern tram track would be required. These two roads serve as the sole access to the WSD Kowloon East Regional Building as well as the main access between Telford Garden and Kwun Tong Road, respectively.

5.3.7 Regarding the terminal arrangement on Wai Yip Street near Hoi Bun Road Park and the junction of Wai Yip Street and Hoi Yuen Road, a track switch is proposed to allow the trams to turn around, while minimising road space required. For the terminal at the Kai Tak Cruise Terminal, the modern tram would turn around by using the proposed track along the outer perimeter of the PTI to minimize the time required for turning around and to optimize service by achieving a lower headway.

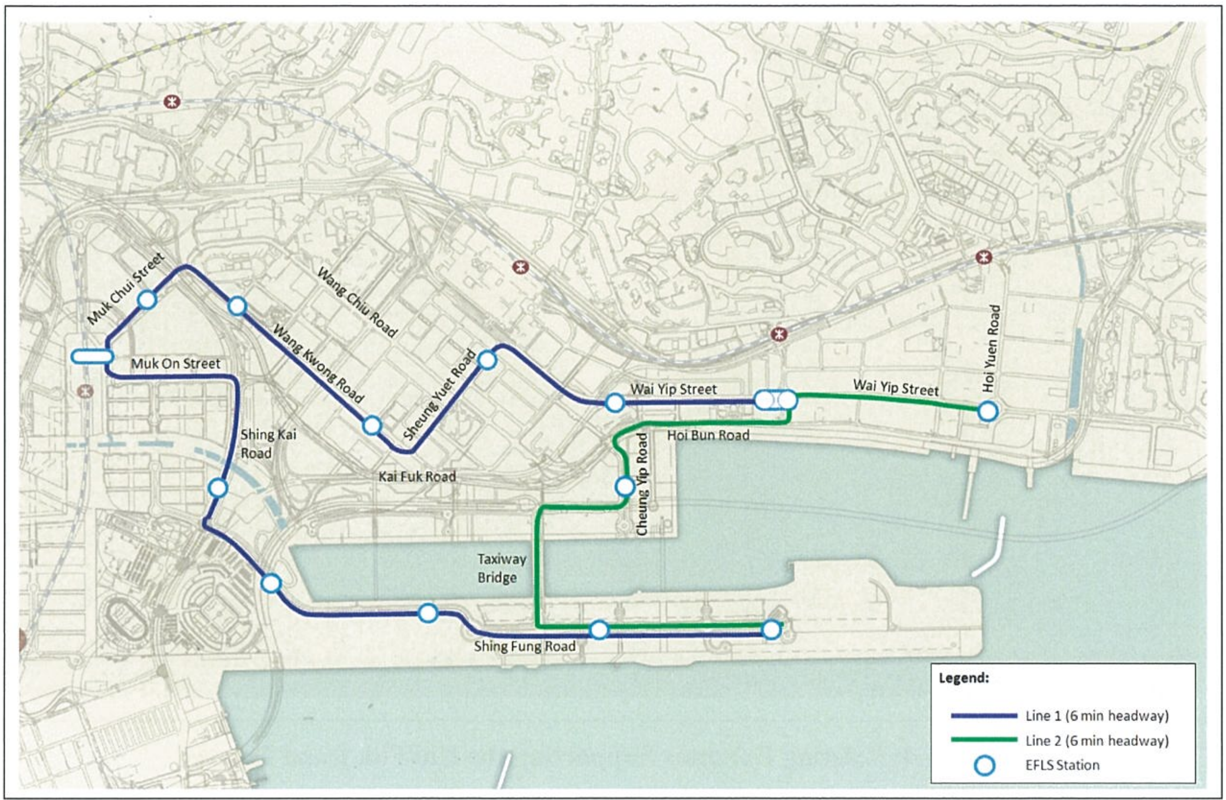


Figure 5.3: Proposed Alignment for Option 1 (At-Grade Dedicated Corridor)

5.3.8 Compared to the original Hong Kong Tramways (HKT) proposal, major differences in the alignment are as follows:

- **Terminate at Hoi Bun Road Park instead of MTR Ngau Tau Kok Station** – There is an existing 2.4m x 1.8m stormwater box culvert located along the centre of Lai Yip Street and a proposed 1800m diameter stormwater main along Wai Yip Street, connecting the Lai Yip Street junction and a proposed underground stormwater storage tank below the existing football court at Hoi Bun Road Park. This stormwater main would overlap with the original HKT alignment along these roads. Maintenance and interface would be an issue. Thus to avoid these conflicts, the alignment is proposed to terminate at Hoi Bun Road Park.

- **Travel through Sheung Yuet Road instead of underneath Kai Fuk Road** – There are numerous columns supporting Kai Fuk Road Flyover, which would conflict with any alignment along this road. To avoid these conflicts, the alignment has been refined to be along Wai Yip Street and Sheung Yuet Road. These columns are shown in **Figure 5.4**.

Figure 5.4: Existing Columns Supporting the Kai Fuk Road Flyover

- **Travel through Wang Kwong Road instead of Wang Chiu Road** – There is an existing 4.1m x 3.8m stormwater box culvert (comprised of three cells) below Wang Chiu Road, from the Sheung Yuet Road junction to Kai Yip Road junction. This culver occupies the entire width of the road. The original HKT alignment would overlap with the existing box culvert and maintenance of the box culvert is a critical issue. Although there is also an existing 2.5m x 2.3m sewer box culvert along Wang Kwong Road (please refer to drawing no. UTX/SK/0016-0019 in **Appendix E**), the impact might be relatively minor as the culvert is located along the side of the road, subject to confirmation of trial hole inspections to be carried out on-site in the next stage after confirmation of the green transport mode.

- **Travel through Muk On Street and Shing Kai Road instead of Station Square** – While the HKT alignment would cut across the large open space at Station Square, there are potential safety concerns (in terms of segregation between modern trams and pedestrians). To minimize such conflicts and the loss of open space, the alignment was refined to proceed along Muk On Street and Shing Kai Road instead.

- **Travel through Cheung Yip Street instead of Promenade** – Similarly, operation of a modern tram through the Promenade would generate safety issues with pedestrians and cyclists, as well as occupying open space. Therefore, the alignment was refined to operate along Cheung Yip Street.

- **Terminate at Hoi Yuen Road / Wai Yip Street Junction instead of MTR Kwun Tong Station** – Hoi Yuen Road is a three lane, one-way carriageway with numerous vehicle run-ins alongside. The introduction of modern tram in a dedicated corridor would conflict with the run-ins. Thus, signalised control would be required for each affected run-in to ensure safety as well as maintain accessibility. However, this is technically infeasible as the length of a modern tram (approximately 32 to 45m long) would exceed the spacing between run-ins, which are closely spaced at intervals of about 20m. Another possibility could include creation of a one-way loop along King Yip Street and Hoi Yuen Road to minimize the required space for a one-way track. Nevertheless, the vehicles entering / leaving the run-ins would still intrude into the alignment even under this one-way travel scenario, thus the concept would be infeasible. Therefore, the alignment is proposed to terminate at the Hoi Yuen Road / Wai Yip Street junction.

Level of Segregation and Corridor Width

5.3.9 Provision of dedicated lanes would improve travel speeds, reliability and safety of the modern tram or BRT. There is a cost though – provision of a median at-grade system would likely necessitate the removal of one general traffic lane in each direction, although some of the required width could be provided by reallocating existing centre median, road side planter or footpath in some locations.

5.3.10 A typical cross section of an at-grade modern tram with dedicated corridor at Wang Kwong Road is shown in **Figure 5.5** with a staggered side platform configuration. A width of 9.5m would need to be reserved at designated platform locations (including a minimum 7.0m width for the tracks and a minimum 2.5m width for a staggered single platform configuration for one direction of the EFLS). An additional pedestrian refuge with a minimum 1.5m width would be provided opposite the platform for pedestrian crossing safety and as a physical barrier to prevent vehicular traffic in the adjacent lane from entering and using the dedicated corridor. It is noted that the carriageway would be reduced to one lane in each direction. Thus, the width of the carriageway would be reduced locally to 4.5m wide for each direction wherever the tram stops are located.

5.3.11 Another typical cross section of an at-grade modern tram with a dedicated corridor at Shing Fung Road is shown in **Figure 5.6**. EFLS would operate on opposite sides of the street, outside the carriageway where possible to minimise traffic impact. EFLS tracks would be 4.2m wide, which includes the track for the tram itself, as well as supports for the overhead cable and relevant clearance requirements on both sides of the train and wires. In some locations, the EFLS tracks would need to be placed within the carriageway and displace proposed traffic lanes as the EFLS would be in conflict with columns for the Landscape Desk and/or associated vertical circulation (escalators or elevators) and the walkway or planter areas could not be used. In such a scenario, the remaining carriageway width would be 3.1m, which would not meet TPDM requirements (and would thus be subject to possible relaxation from TD). Furthermore, no public footpath could be provided where vertical circulation facilities to/from the landscape deck are provided. This would force pedestrians walking along the street to walk through private land.

5.3.12 Finally, a typical cross section of an at-grade modern tram with a dedicated corridor at Wai Yip Street is shown in **Figure 5.7.** To accommodate the station and modern tram, the number of traffic lanes in both directions would be reduced from three (3) lanes to one (1) lane in spot locations. In addition, the remaining carriageway width would be only 3.6m.

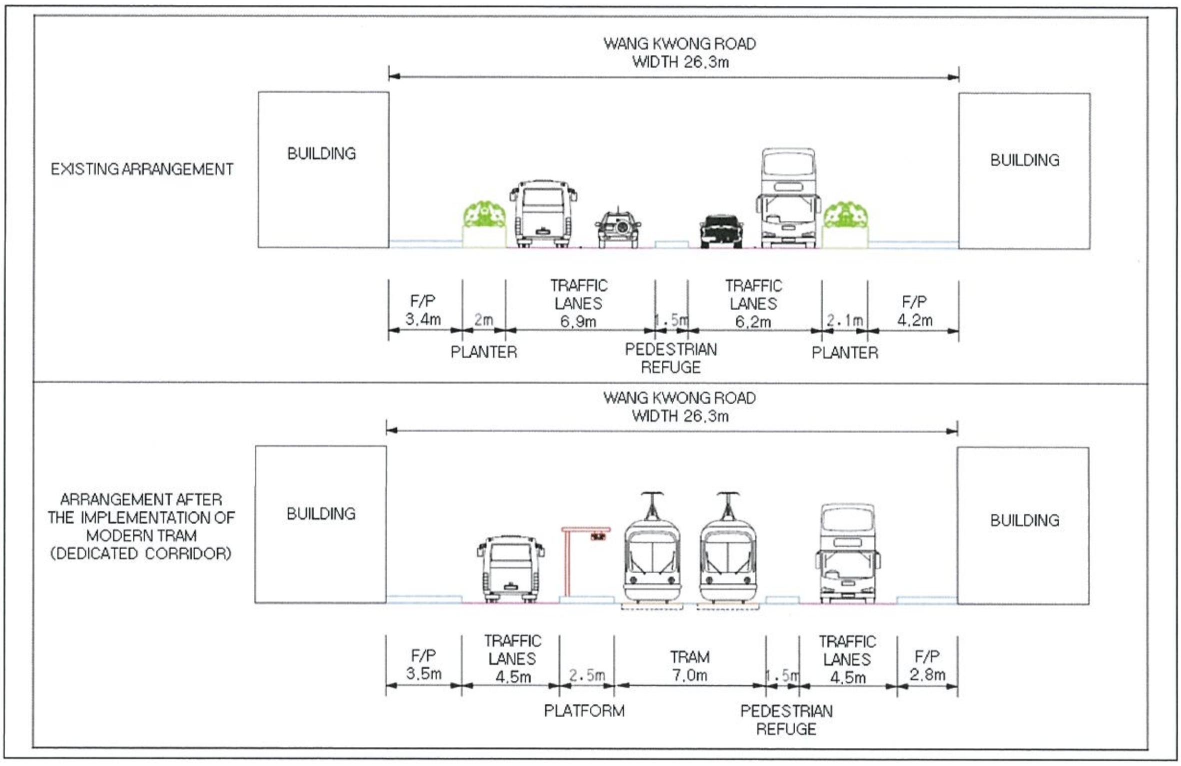


Figure 5.5: Typical Cross Section Plan of for Option 1 (At-Grade Dedicated Corridor) on Wang Kwong Road (Before and After Implementation)

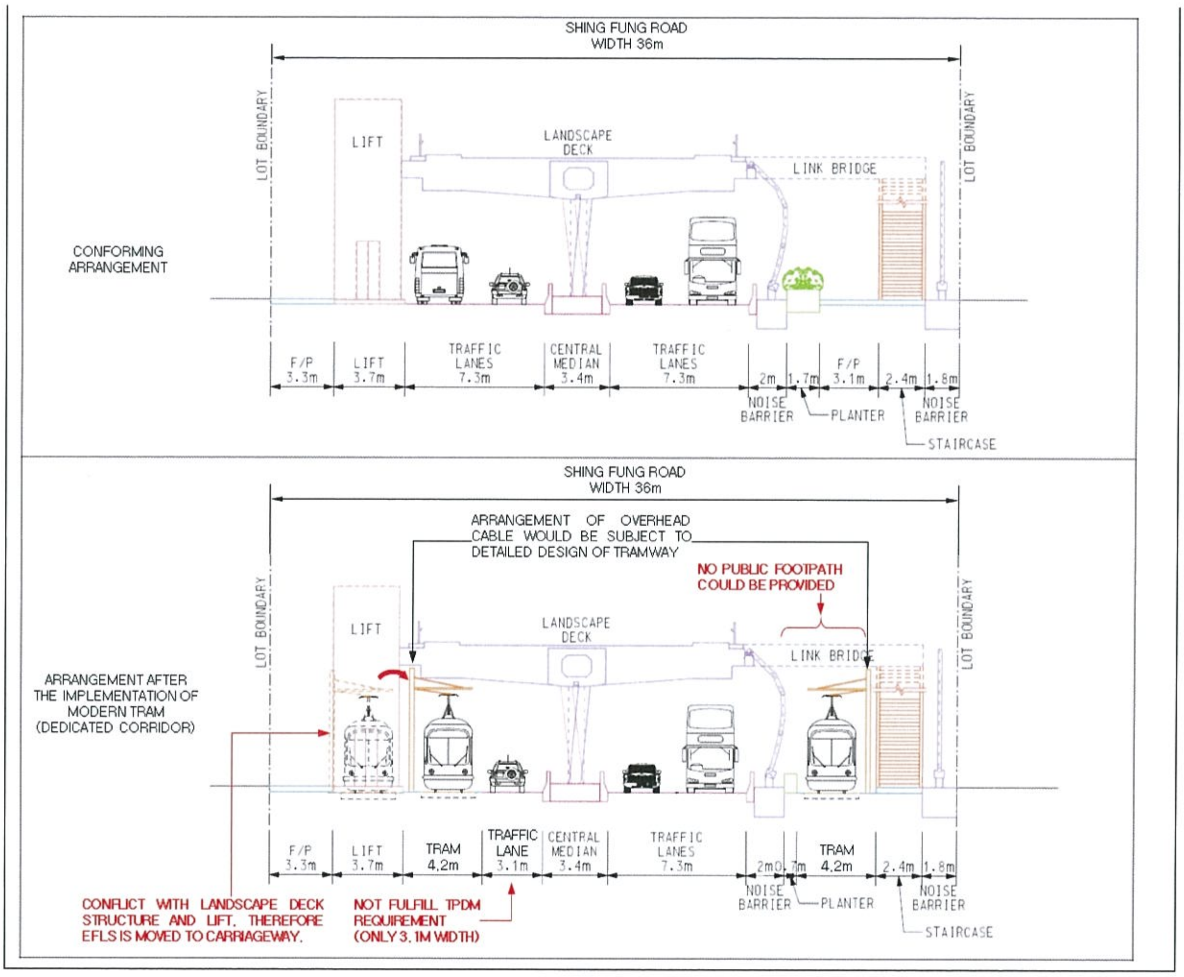


Figure 5.6: Typical Cross Section Plan of for Option 1 (At-Grade Dedicated Corridor) on Shing Fung Road (Before and After Implementation)

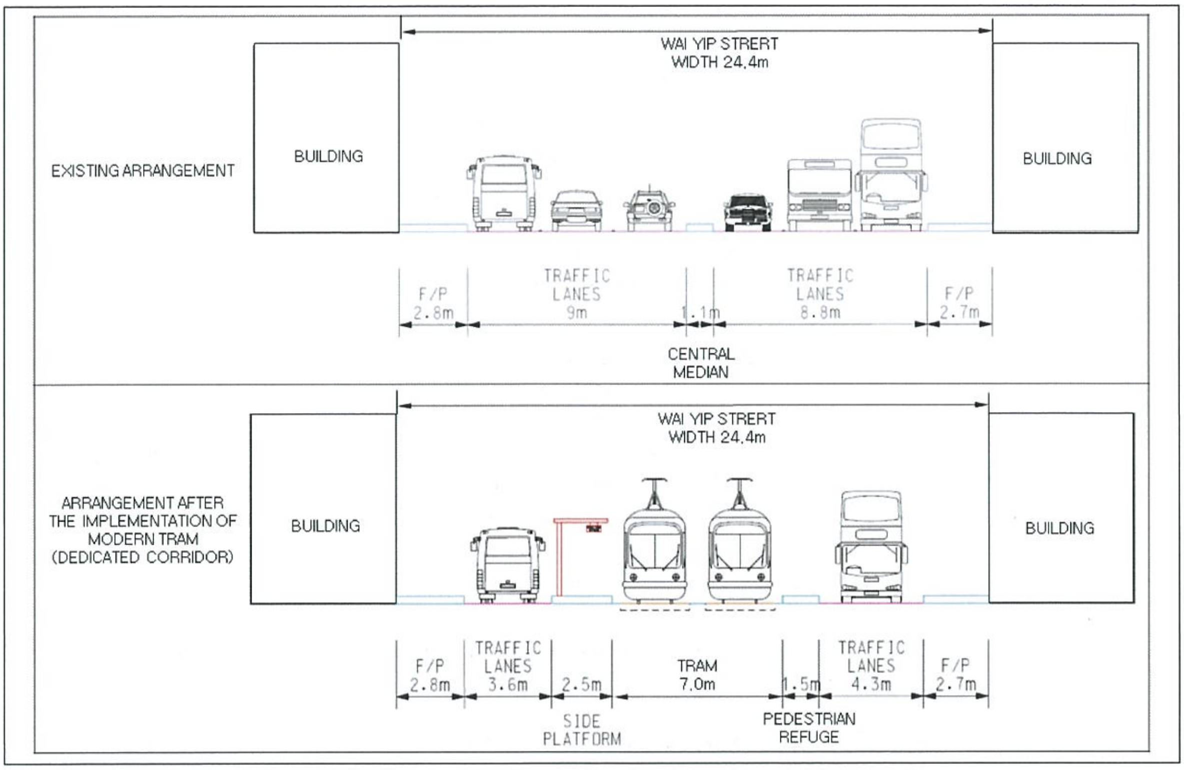


Figure 5.7: Typical Cross Section Plan of for Option 1 (At-Grade Dedicated Corridor) on Wai Yip Street (Before and After Implementation)

System / Operating Assumptions

5.3.13 By considering the local conditions including the alignment, permissible speed, round trip time, signal design to reduce the impact of modern tram to the road user especially across the road junctions, the adopted operating assumptions for this option are listed below (it is assumed that Modern Tram and BRT have similar performance)[7]:

Parameter	Assumption
Length	Line 1: 6.6 km Line 2: 3.5 km
Number of Stations	Line 1: 12 stations Line 2: 5 stations
Headway	Line 1 (Blue): 6 minutes Line 2 (Green): 6 minutes
Schedule	Similar to existing MTR system for smooth and convenient transfers (6:00AM-1:00AM)
Runningway	Dedicated track/lane with priority at junction crossings

[7] Assuming the same alignment and constrained right-of-way through Kowloon East, it is likely that an at-grade BRT would perform similarly to a modern tram due to the absence of passing lanes. The biggest difference would be that the BRT vehicles, with smaller capacity (anywhere from 120-170 passenger per articulated bus), would likely require additional service to meet demand– thus more frequent headways than the modern tram. Furthermore, BRT could operate outside of the bus lanes as "local" routes in some cases. Lastly, BRT would likely cost less than modern tram due to absence of track work and catenary. As noted previously, modern tram was used as the basis for the analysis of the at-grade dedicated option due to likely severe impacts on roads and footpaths from BRT, which could require elongated stations and passing lanes to achieve expected peak volumes.

Parameter	Assumption
Vehicle Type [A]	Modern Tram (holding 240 passengers/train at 4 ppsm or 360 passengers/train at 6 ppsm)
Capacity	Line 1: 2,400 pphpd (4 ppsm) / 3,600 pphpd (6 ppsm) Line 2: 2,400 pphpd / 3,600 pphpd (6 ppsm)
Fare	Please refer to Appendix A1 - the assumed fare is based on a distance-based mechanism instead of travel time.

Notes:

[A] The capacity is based on typical capacity for an Alstom modern tram. At 4 ppsm, the capacity would be 240 passengers. At 6 ppsm, the capacity would be 360 passengers. Capacity in Hong Kong is typically evaluated at 4 ppsm to provide a reasonable/comfortable level of crowding. However, during the peak periods, this is often exceeded (for instance on the Hong Kong Light Rail in Tuen Mun). Therefore, capacity at a higher ppsm would connote a more crowded riding experience, which could still be accommodated by the train during these peak loading periods.

Performance against Criteria

5.3.14 **Table 5.5** presents a summary of option performance against the evaluation criteria. A summary of key findings follows below:

Table 5.5: Summary of Performance – Option 1 (At-Grade Dedicated Corridor)

#	Analysis Criteria	Value
1	Daily Boardings	• 102,000 riders/day
2	Peak Hour Boardings per Direction	• Line 1: 3,300 pphpd • Line 2: 1,200 pphpd
3	In-Vehicle Journey Time	• Ngau Tau Kok to Kai Tak Cruise Terminal (KTCT): about 23 minutes • KTCT to Kwun Tong: about 12 minutes
4	Peak Vehicle Requirements [A]	• Line 1: 10 vehicles/trainsets • Line 2: 5 vehicles/trainsets
5	Transfer Time	• Between MTR Ngau Tau Kok Station and EFLS Station next to Hoi Bun Road Park: 10 minutes • Between SCL Kai Tak Station and EFLS Station at Station Square: 7 minutes • Between MTR Kwun Tong Station and EFLS Station near KTAA: 14 minutes
6	Traffic Impacts (Travel Time Delay) [B]	• Wang Kwong Road (from Sheung Yee Road to Muk Tsui Street): from 3 to 20 minutes (about 17 minutes delay) • Cheung Yip Street / Taxiway Bridge (from Shing Fung Road to Hoi Bun Road): from 4 to 20 minutes (about 16 minutes delay)
7	Road Impacts (Total Area Lost)	• 63,000 m^2 (including road space and greenspace – please refer to **Figure 5.9**)
8	Utility Impacts (Cost of Relocation)	• [redacted]
9	Environmental Impacts	• Complies with the EIAO requirements with appropriate mitigation measures if

#	Analysis Criteria	Value
		necessary, subject to preliminary environmental assessment to be carried out in the next stage
10a	Project Capital Cost [C] (Dec 2015 Prices)	• [redacted]
10b	Annual O&M Cost	• [redacted]
11	EIRR [D]	• Negative
12	Construction Timeframe	• About 5 years

Notes:

[A] Peak vehicle requirement is presented for information only and is not used directly to compare options, as the number of buses, trams or APM/monorail trains is not directly comparable. The number of peak vehicles is captured in the overall capital costs for a given option.

[B] The travel time impact is estimated using a traffic model that considers the modification of the road and junction layout, as well as method of control required by introducing at-grade EFLS.

[C] Project capital cost includes design, construction, vehicle, project management and project contingency costs. Furthermore, cost estimations are preliminary that are subject to change and update upon further design).

[D] EIRR is estimated based on benefits/disbenefits for local users (and excludes non-local users such as tourists, etc.) solely for the purpose of the evaluation of green transport modes.

Patronage

5.3.15 It is anticipated that the average weekday patronage for the proposed at-grade dedicated Option 1 would be around 102,000 passengers per day, with the busiest segment handling a peak load of 3,300 pphpd during the 2036 AM peak between M6 – M7 (Kai Ching Estate Station-Station Square Station (or the segment just north of Kai Tak Station) as illustrated in **Figure 5.8**. Peak demand on these heavily used segments would induce a level of crowding above the ideal 4 ppsm design conditions. The peak demand would thus equate to a passenger density of 6 ppsm in this peak segment.

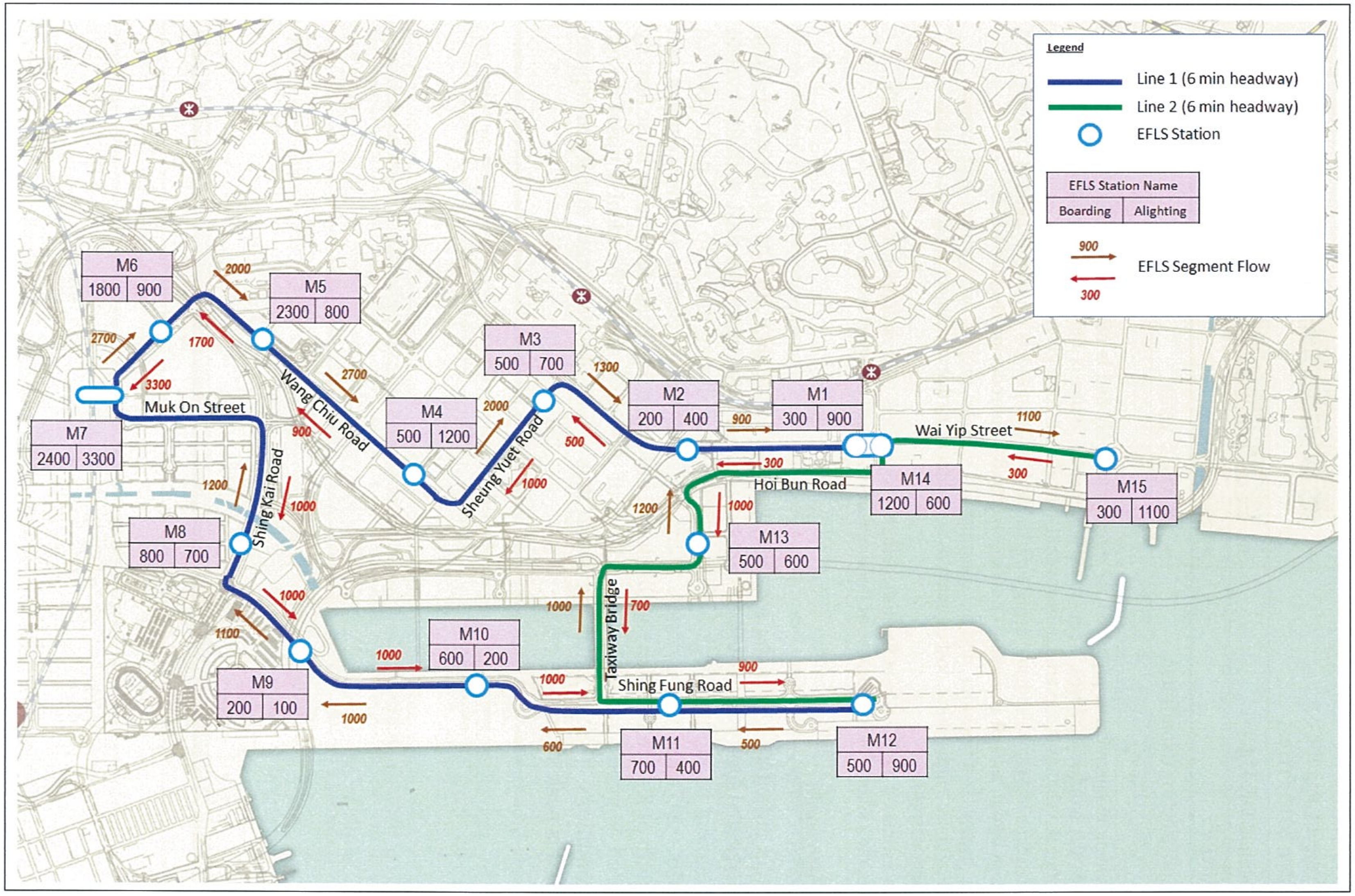


Figure 5.8: Peak Hour Segment Flows for Option 1 (At-Grade Dedicated Corridor)

In-Vehicle Times

5.3.16 The in-vehicle time represents the time spent in the vehicle between the start and end point of the line. In-vehicle time excludes access time to/from the origin/destination stations, as well as waiting time spent on the station platform.

5.3.17 Based on the length of the network, the estimated in-vehicle times are as follows: (i) 23 minutes between Ngau Tau Kok and the Kai Tak Cruise Terminal on Line 1; and (ii) 12 minutes between Kai Tak Cruise Terminal and Kwun Tong via the Taxiway Bridge on Line 2.

Transfer Time to Major Rail Stations

5.3.18 This option links into the MTR network at the Ngau Tau Kok and Kwun Tong Stations (on the Kwun Tong Line) and the Kai Tak Station (on the Shatin-Central Line). Direct and convenient linkages to the greater MTR network are necessary to encourage ridership and create synergies. Walk transfer time is estimated based on horizontal distance between the EFLS stations and MTR stations, as well as vertical level changes.

5.3.19 The proposed EFLS stations near the three MTR stations are located at-grade, while MTR stations on the Kwun Tong Line are elevated and the SCL Kai Tak Station is underground. The travel times are tabulated in **Table 5.6** below.

Table 5.6: Transfer Time to Major Rail Stations – Option 1 (At-Grade Dedicated Corridor)

MTR Stations	EFLS Stations	Waiting Time (min)	Walk Transfer Time (min)	Total Combined Transfer Time (min)
MTR Ngau Tau Kok Station	EFLS Station near Hoi Bun Road Park	3	7	10
SCL Kai Tak Station	EFLS Station near Station Square	3	4	7
MTR Kwun Tong Station	EFLS Station near KTAA	3	11	14

Road / Land Impacts

5.3.20 To implement the modern tram with dedicated corridor, a minimum width of 9.5m would need to be reserved at designated platform locations (including a minimum 7.0m width for the tracks, and a minimum 2.5m width for a staggered single platform configuration for one direction of the EFLS). Due to the provision of the dedicated track, the road section would be highly constrained at some locations and only accommodating a single 6.0m width or less traffic lane. Sidewalks would be narrowed and no planters would be provided as a barrier for pedestrians on the sidewalk. A total area of 63,000 m^2 would be lost, including both green and road space as illustrated in **Figure 5.9**.

5.3.21 Regarding the land impacts, taking Wang Kwong Road near Lam Wah Street as an example (as shown in **Figure 5.9**), the existing configuration is a single 4-lane carriageway, i.e. two traffic lanes in each direction. The current widths of the northbound and southbound carriageway are 7.2m and 7.4m respectively. An approximate 2m wide planter and sidewalk ranged from 3.4m to 4.2m are provided in both directions. To implement an at-grade BRT or modern tram with its own lanes/track, a minimum width of 9.5m would be required at designated station locations. This section, however, would only be able to accommodate a single 4.5m width traffic lane adjacent to the station and a single 4.5m traffic lane in the other direction, while sidewalks would be narrowed down to at least 2.5m without planters. A typical section has already been presented in **Figure 5.5**.

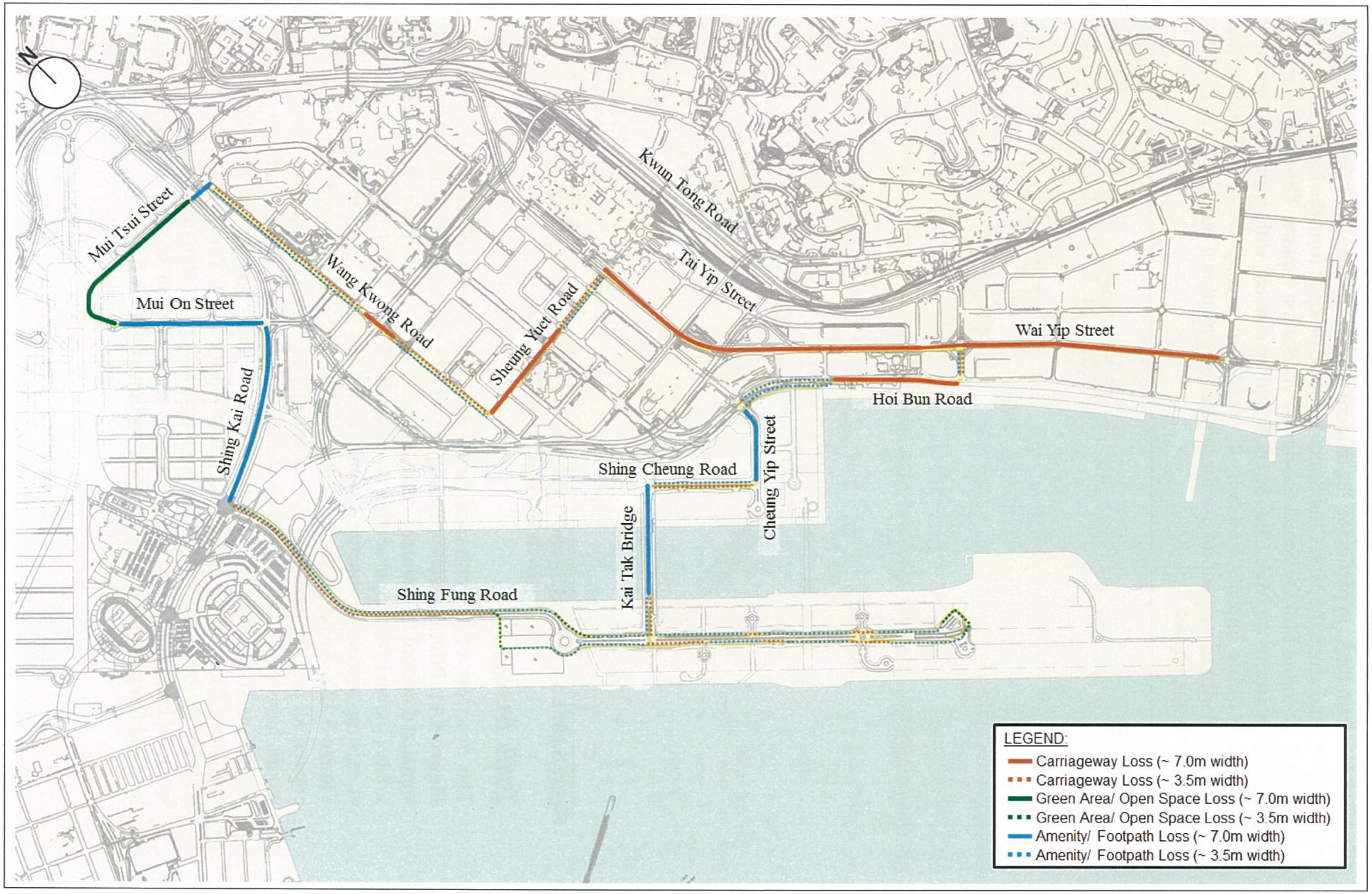


Figure 5.9: Loss of Road Space/ Open Space for Option 1 (At-Grade Dedicated Corridor)

5.3.22 Besides carriageway and footpath space, open space would be affected by the modern tram track. In particular, the modern tram track would pass through Avenue Park Phase 1 along the Muk Chui Street W/B and proceed from the Muk Chui Street cul-de sac to the Mui On Street cul-de-sac via Station Square. The running tracks and the platforms on Muk Chui Street would be situated within the open space to minimize traffic impacts, however, it would also occupy the open space in the Avenue Park and prevent its use for leisure or recreational purposes. **Figure 5.10** illustrates the impact.

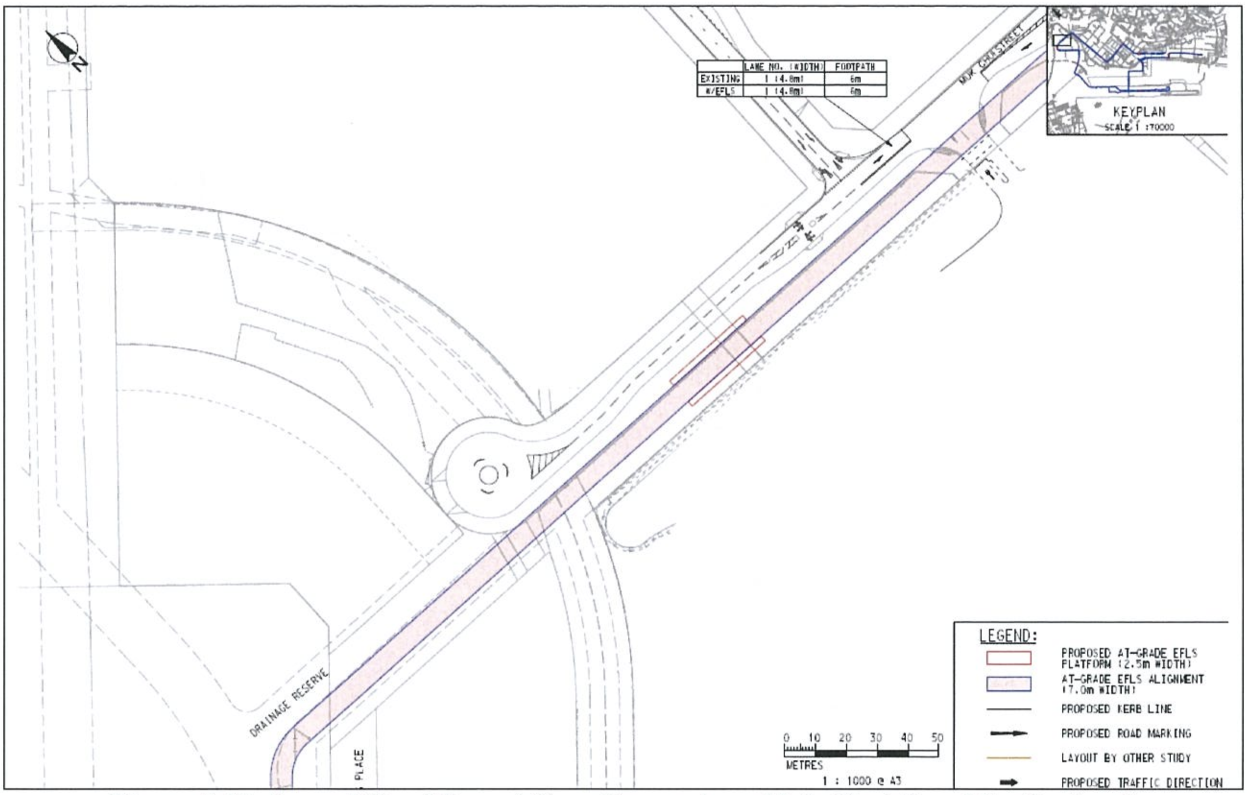


Figure 5.10: Loss of Road Space/ Open Space along Muk Chui Street for Option 1 (At-Grade Dedicated Corridor)

Traffic Impacts

5.3.23 The overview of the proposed junction modification schemes is illustrated in **Figure 5.11.** Priority junctions along the alignment would need to be converted to signalized control to maintain vehicle access and ensure vehicle and modern tram safety (shown in the upper section of **Figure 5.12**). In addition, control modification at existing signalized junctions would be needed (shown in the upper section of **Figure 5.13**). As priority junctions are closely spaced, it would be infeasible to convert all priority junctions into signalized junctions since modern tram vehicles would have insufficient queuing area prior to the stop line. Traffic movement restrictions (i.e., left-in-left-out), would thus need to be introduced for these priority junctions (shown in the bottom section of **Figure 5.12**). To allow the placement of a station in the median of the carriageway, additional signalized junction control would be introduced to allow pedestrian to cross between the platform on the farside lane and footpath (shown in the lower section of **Figure 5.13**).

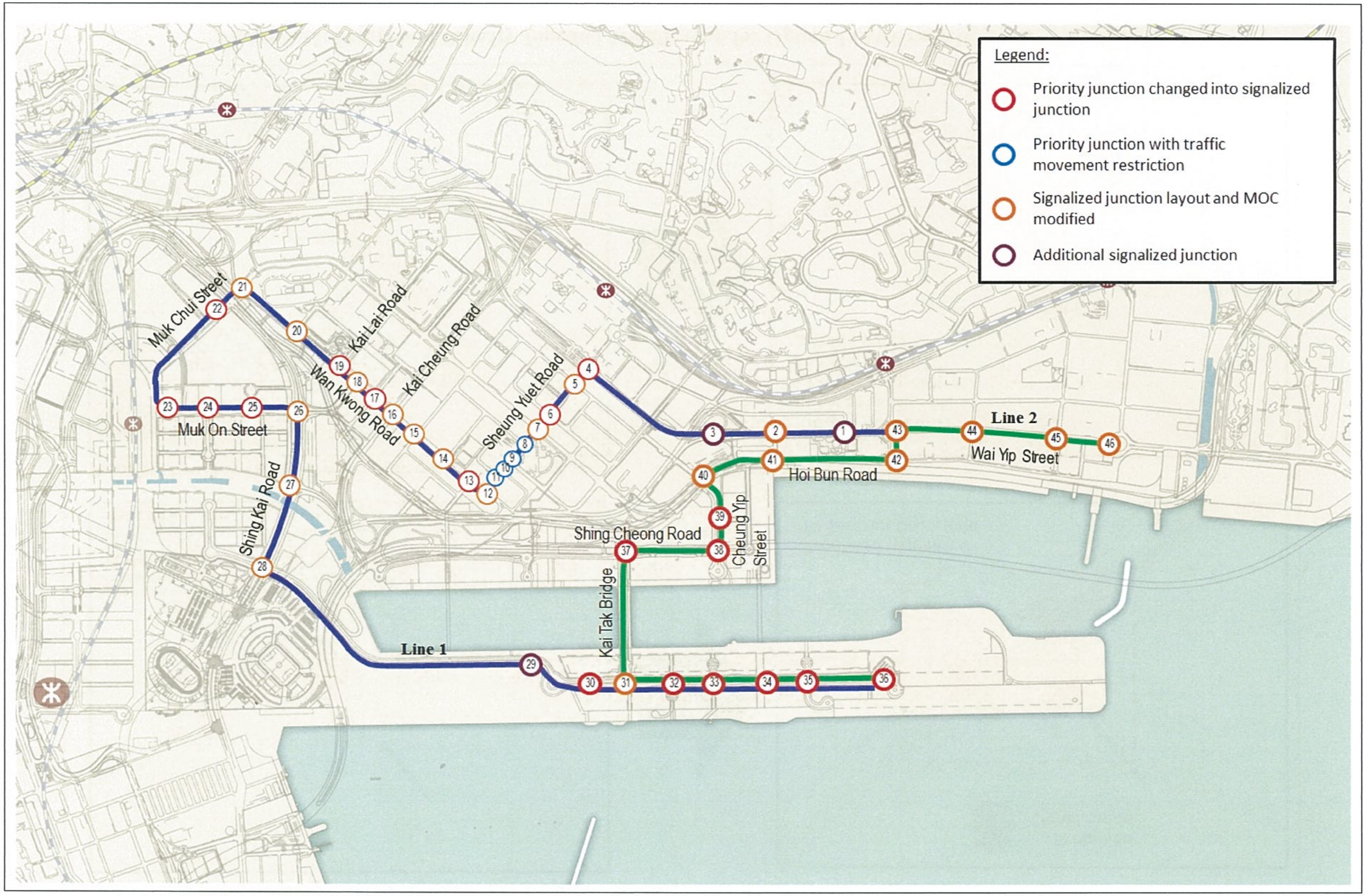


Figure 5.11: Junction Modifications Required for Option 1 (At-Grade Dedicated Corridor)

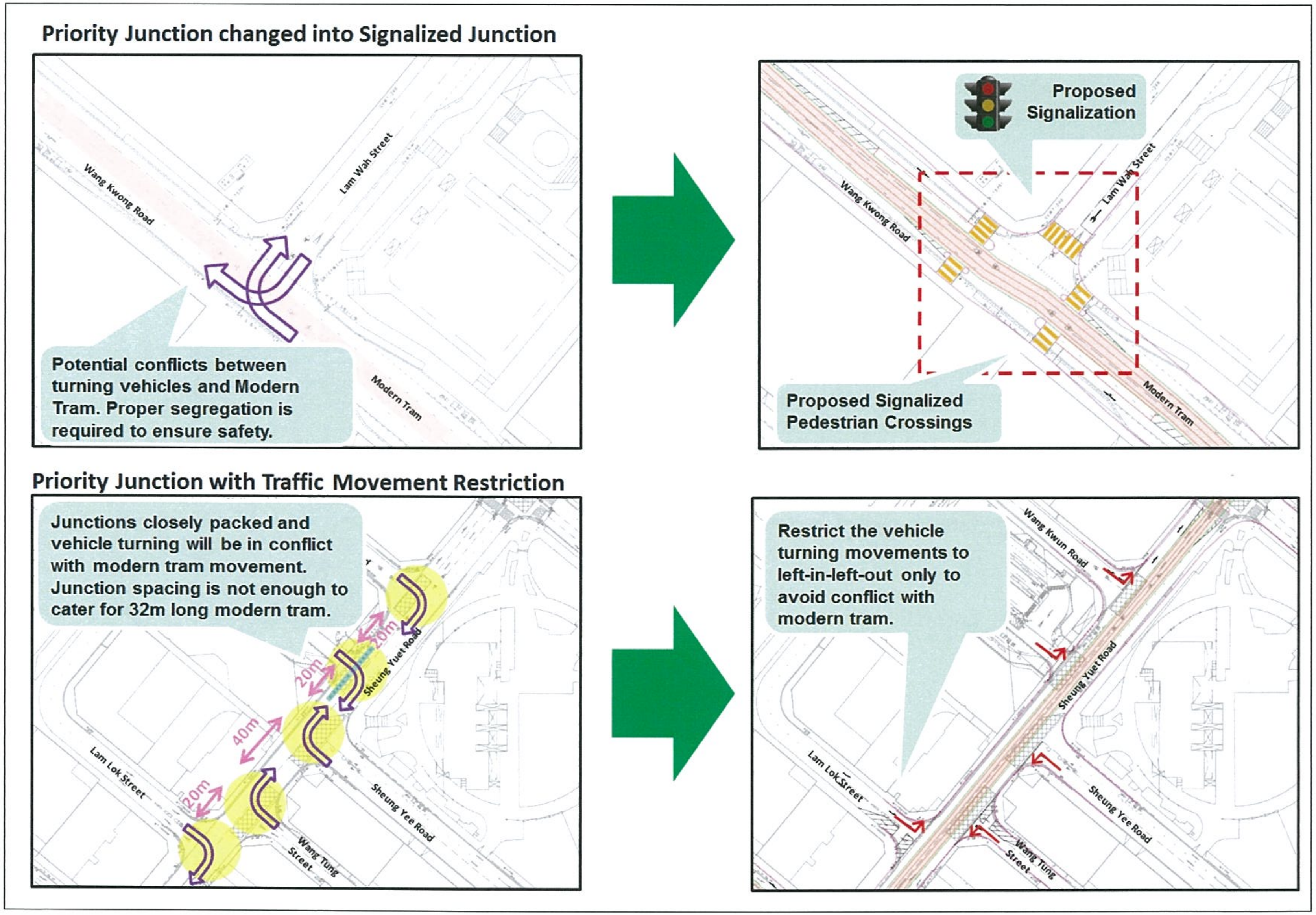


Figure 5.12: Samples of Priority Junction Modification for Option 1 (At-Grade Dedicated Corridor)

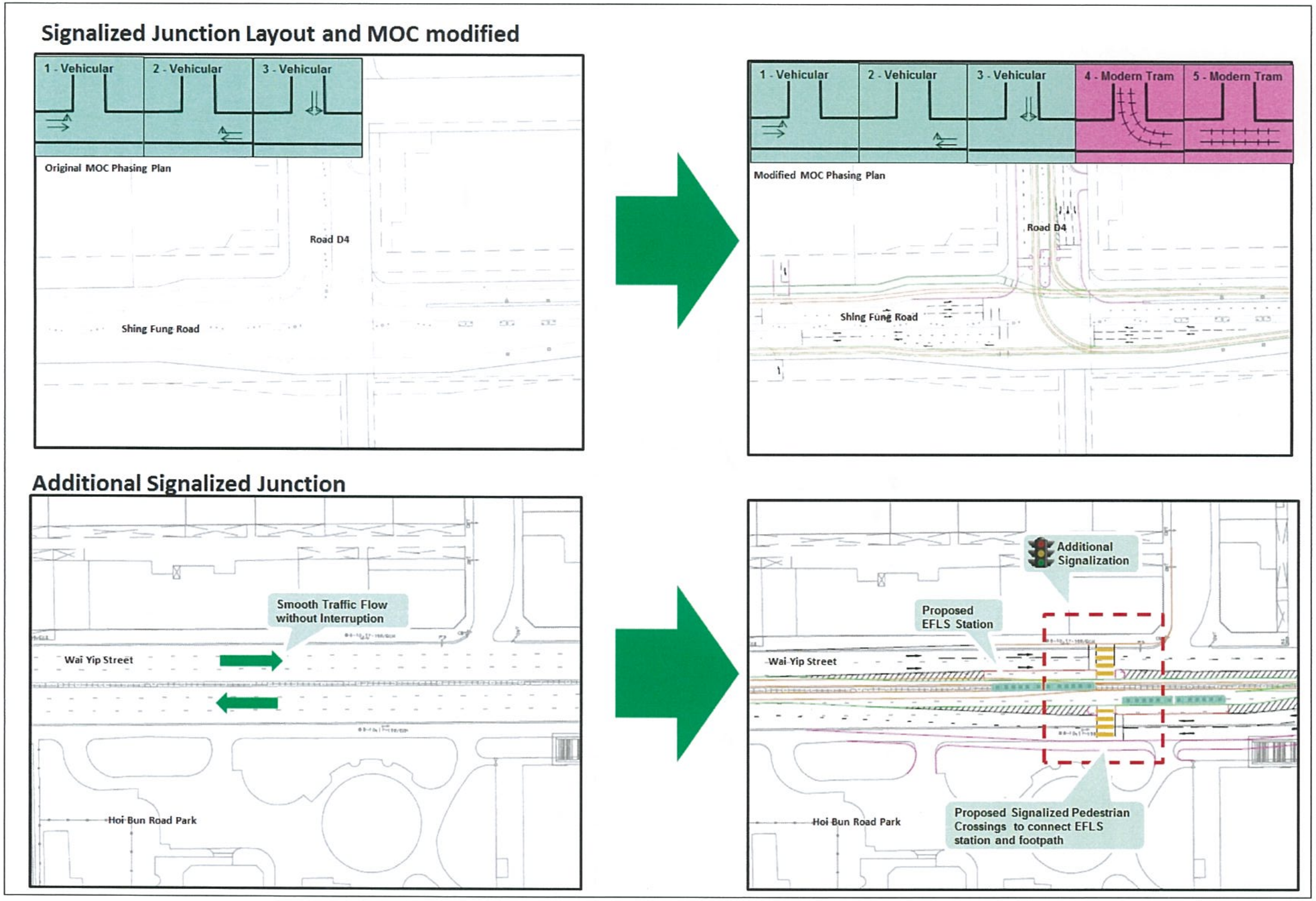


Figure 5.13: Samples of Signalized Junction Modification for Option 1 (At-Grade Dedicated Corridor)

5.3.24 Significant traffic queuing would be generated at numerous junctions throughout KE, creating queue back and congestion. Significant queues would appear along Wai Yip Street in the southbound direction, Muk On Street north and south of Road D2 in both directions, as well as Road D4 and Chung Yip Street eastbound within the Hospital Hub. The congestion would generate delay and reduce reliability and on-time performance of the at-grade EFLS, while also severely impacting general purpose traffic speeds. For instance, the travel time and speed of other traffic on the section of Muk On Street between Wang Kwong Road and Muk Tsui Street would increase from 3 minutes to 20 minutes, with speeds reduced from 18 kph to 3 kph respectively. Likewise, driving times along the section of Road D4, Cheung Yip Street and Hoi Bun Road would increase from 4 minutes to 20 minutes, with speeds reduced from 31 kph to 6 kph.

5.3.25 Traffic impacts (in terms of traffic queue) are demonstrated in **Figure 5.14**.

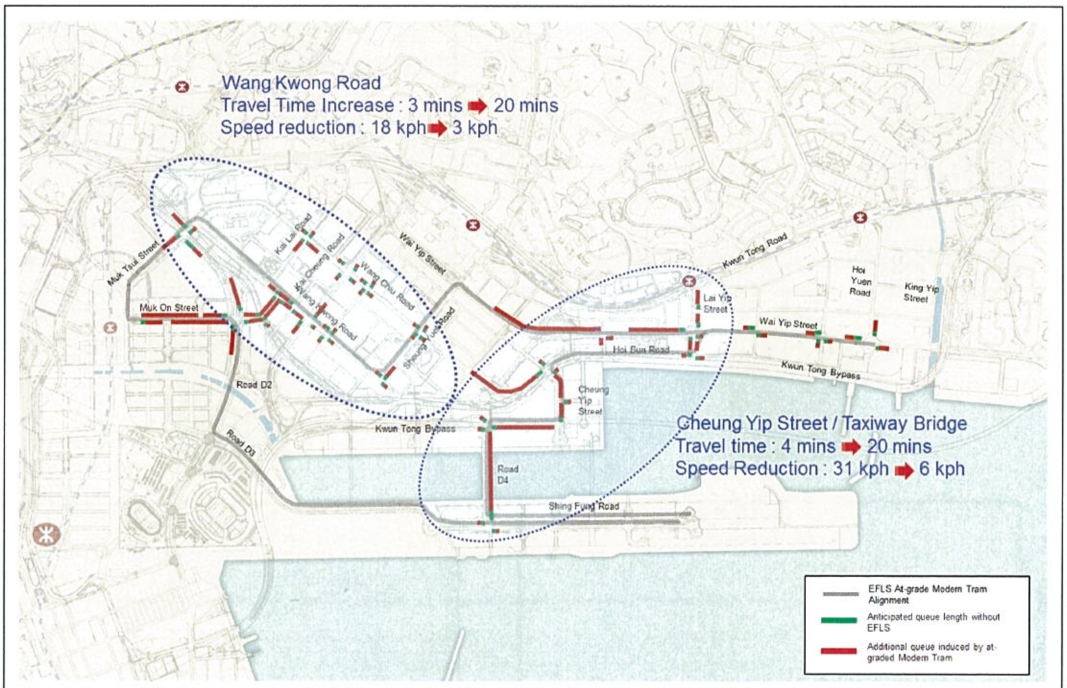


Figure 5.14: Traffic Speed and Travel Time for Option 1 (At-Grade Dedicated Corridor)

5.3.26 In addition, with the adjacent footpath narrowing to accommodate the dedicated corridor, the pedestrian environment would worsen and would be unable to cope with pedestrian demand after the transformation. As stations are located in the middle of the carriageway, the pedestrian crossing facility would need to handle not only the demand of pedestrians, but also EFLS passengers, which may lead to additional congestion. For instance, the existing pedestrian conditions at the footpath and pedestrian crossings in Yuen Long Town Centre near light rail stations are undesirable and congestion is typically observed during peak hours. Some site photos at Yuen Long Town Centre are shown at **Figure 5.15**. Similar conditions are anticipated in Kowloon East with the implementation of at-grade modern tram.

Figure 5.15: Current Pedestrian Congestion adjacent to Yuen Long LRT

5.3.27 To facilitate the diversion works of underground utilities, which would be affected by proposed at-grade EFLS alignment, temporary traffic lane closure would be required to provide necessary works area. The performance of carriageway and junction would be affected as a result. Temporary traffic diversion would be needed for the locations in which no traffic lane with absolute minimum width could not be maintained. The journey time of road users, include public transport services, would be increased, and the diverted traffic would worsen the surrounding road networks as a result. Besides, pedestrian footpaths at some locations would be narrowed or closed/ diverted to facilitate underground utilities diversion work.

Utility Impacts

5.3.28 As-built utility information, including electricity cables, gas mains, telephone ducts, water main, communication cables, district cooling system, stormwater drainage system and sewer system, was collected from utility companies and consolidated to assess the potential impact on the existing underground utilities. Underground utilities are identified in densely developed areas such as in Kowloon Bay and Kwun Tong. Different types of utilities ranging from large drainage box culverts, to electricity cables to communication cables were identified in underground spaces in these areas. For example, a 7 cell box culvert was identified near Megabox in Kowloon Bay, with some smaller box culverts found in various locations, including 400kV and 132kV running closely along the proposed alignment. Detailed utilities drawings are presented in **Appendix E**.

5.3.29 For the on-going development areas, including the former airport apron and runway, utility infrastructure planning is still on-going in some locations. A draft utilities drawings set is supplemented for information to show the potential utility diversion and relocation required due to the EFLS (please refer to **Appendix E)**.

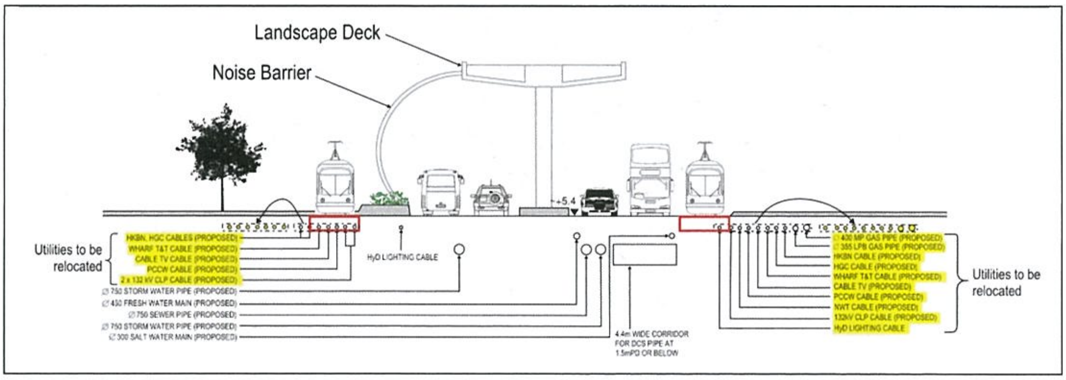


Figure 5.16: Utility Impacts along the Kai Tak Runway

5.3.31 For the purpose of this evaluation, utility impact on both modern tram system and BRT system occupies the similar road space. All utilities along the track corridor should be relocated to ensure that utility maintenance would not disrupt normal EFLS operations. For modern tramway, the required utilities would mainly be the power supply cables, signal and communication systems, which would be embedded in the ground below the track bed.

5.3.32 The extent of utility impacts is related to the at-grade alignment. Alignments through streets with dense networks of underground utilities would generate higher and more extensive impacts on the utilities.

5.3.33 Therefore, it is crucial to identify the optimal alignment that minimises utility impact. In the process of selecting the optimal alignment, major utilities such as a 7 cell box culvert (4.1m x 3.8m), 132kV and 400kV high voltage electricity cables in the Kowloon Bay area, and a 2.1m diameter drainage pipe in Kwun Tong that are difficult and time consuming to divert, have been identified. The alignment has thus been designed to avoid these sections and minimise potential utility impacts as far as possible. One specific example is at Kowloon Bay, where the alignment would be routed along Wang Kwong Road, a road with fewer identified underground utilities, compared to the adjacent Wang Chiu Road, which has large size box culverts running underneath. A draft utilities drawings set is provided in **Appendix E** to show the potential impacts to the EFLS.

5.3.34 For the Kai Tak runway section, the at-grade dedicated corridor would be located within the planter and footpath areas along the side of the proposed D3 road (i.e., the future Shing Fung Road). To avoid conflicts between the proposed underground utilities and embedded trackslab for modern tram or runningway for BRT, a dedicated zone along the planter and footpath areas would need to be reserved for embedded trackslab/runningway construction, so that utility relocation and diversion would not be required and impacts on the utilities could be minimised.

5.3.35 In terms of possible utility impact on the taxiway bridge section, the at-grade dedicated corridor would be located within the central median planter. Therefore, relocation of an existing 450mm diameter fresh water main would be required. Other major utilities such as high voltage electricity cables, gas mains and rising mains are located in the utility trough underneath the footpath at the side of the road, thus impacts to these underground utilities would be relatively minor.

5.3.36 Diverting all the underground utility would be an extremely time consuming works due to the temporary traffic management measures and more importantly, each of the utility operators would have to divert their own infrastructure. Before the construction of the at-grade option, sufficient time should be allowed for carrying out the utility diversion. For the avoidance of doubt, the project capital cost estimates of the at grade modern tramway option includes all costs for utility diversion.

5.3.37 Total estimated utility relocation costs would be about [redacted].

Environmental Impacts

5.3.38 For night operations of the at-grade modern tram or BRT, adverse noise impacts on nearby noise sensitive receivers arising from operations would not be anticipated with the implementation of noise mitigation measures such as reducing train frequency and train speed. BRT would be similar as well as it would be regarded as road traffic noise. Some potential impacts (such as vibration, change of water table, visual, etc.) would likely to be anticipated on Long Tsun Bridge (a site of archaeological interest). Appropriate mitigation measures for these potential impacts should be implemented in the early stage of the Project. Unlike the modern tram system, the BRT system would impose air quality impacts at the local street level if powered by combustion engine.

5.3.39 It is anticipated that the proposed system would comply with the EIAO requirements with appropriate mitigation measures and be similar to the other three options. Loss of open space, function and amenities in public green open space by each option is analysed below. A Preliminary Environmental Assessment (PEA) would be conducted in the next study stage after selecting the green transport mode and alignment to confirm the environmental acceptability of the Recommended EFLS Scheme and the mitigation measures that would be recommended if necessary. NSR location plan along the route, and assessment results and assumption will also be provided.

5.3.40 The at-grade alignment of Option 1 would occupy some open space area of the metro park, and the overhead cabling would cause some intrusion to the tree crown. On the other hand, the proposed tram station would occupy some portion of the planned Station Square open space. Overhead catenary may obstruct the open sky view above the large open space, and it might potentially bisect the continuity and function of the open space. However, the actual impact would depend on the detail design of the station, for example, the mass and scale of the station platform as well as its cover. Within the same area, there would be a minimum permanent loss of 7m of public open space width from the proposed track (refer to Figure 5.9). In view of this, the alignment has been planned to shift towards the edge of the open space to minimise bisecting the open space to the extent possible under Option 1 and Option 2. Despite this, any overhead catenary infrastructure would still restrict the design of the adjacent tree planting.

5.3.41 The at-grade alignment would run through Shing Kai Road, which would also affect the visual elements of new tree plantings along the roadside. The alignment along Sheung Yuet Road and Wang Kwong Road might affect the roadside tree plantings, while the adjacent commercial and industrial visually sensitive receivers might lose the green screening of the road.

5.3.42 In general, the overhead cabling would still cause minor visual impacts to the surrounding receivers. However, since the existing urban setting was not visual pleasant to begin within in the industrial area of Kowloon Bay, the at-grade route would be considered to be compatible with the surrounding within this section.

Capital & O&M Costs

5.3.43 This cost estimate assumes a modern tram system rather than a BRT system to provide a conservative cost estimate. A modern tram would require significantly more infrastructure than a comparable at-grade BRT system due to the track, trackforms, and catenary systems, as well as vehicles and depot. Therefore, Option 1 capital costs include all the costs of design, construction and management of the track, trackform, station, depot and administration building, rolling stock, as well as purchase and installation of power supply and signalling systems. In addition to the aforementioned cost items, provisions have been included to cover any costs associated with the re-provision of existing infrastructure affected by the EFLS project. In summary, the overall project capital cost is estimated to be [redacted].

5.3.44 Operating costs include the daily costs to run and operate the system (including operating and maintenance staff and power consumption), as well as state-of-good repair and periodic replacement of rolling stock, equipment and assets, averaged over a 50 year timeframe. O&M costs for Option 1 would be about [redacted]. This would be similar to that for Option 2 (At-Grade Shared Corridor), but lower than those for Option 3 (Elevated Dedicated Corridor) or Option 4 (Mixed Operation).

Economic Benefit

5.3.45 The economic internal rate of return (EIRR) is the net rate of return of the project calculated by subtracting the total cost (including project capital cost during the construction period, operating and maintenance cost during the subsequent 50 years of operation) from the economic benefits (including the time saving and operating cost saving and accident saving).

5.3.46 The EIRR for Option 1 is estimated to be negative as the time-savings benefit generated for EFLS passengers using the at-grade option would not cover the corresponding time loss for other road-based public transport passengers (in terms of longer journey times caused by congestion from the reduction of lanes). As noted, this EIRR result assumes benefits/disbenefits only for local users. Even with inclusion of non-local users, the EIRR would still be negative.

Construction Timeframe

5.3.47 The preliminary construction programme for the EFLS would be reviewed upon selection of the green transport mode under the next study stage. For the purpose of green transport mode comparison, the construction timeframes of at-grade option of modern tram and BRT are estimated based on the following assumptions:

- The EIA and TRA (Tree Removal Application) approval must be obtained prior to commencement of the works contract;
- After commencement of the contract, tree removal would occur within 30 days and tree transplanting and removal would occur within 90 days;
- A dedicated corridor, as well as requisite lands and work areas would be available upon commencement of the contract; and
- Installation of trackworks and system-wide T&C and statutory inspections would take two (2) years.

5.3.48 The total construction time including all necessary utility diversion and relocations for Option 1 is estimated at five (5) years for modern tram or BRT. It is noted that the timeframes for modern tram and BRT are very similar – both would still require utility relocation works beneath the track/bus lane, in addition to modification of the roads and segregation of the bus lanes / track and general traffic lanes. Furthermore, station and related systems work would be similar in size and extent.

5.3.49 Assuming all affected lands are acquired before the start of construction, advance works such as utility diversion would commence 2 years before EFLS main construction works such as construction of the trackform, station, depot, and administration building, as well as the installation of the power supply system. After completion of the 3 years construction works, a testing and commissioning (T&C) period taking at least one year, would begin to examine the system to ensure operations meet the designed standards.

5.3.50 A tentative construction programme for the at-grade dedicated Option 1 is attached in **Appendix B** for information.

Summary of Option 1

5.3.51 Option 1 consists of a fully at-grade modern tram operating in a dedicated corridor. Segregation of the modern tram would minimise vehicle and pedestrian conflict exclusively to junctions. This would allow Option 1 to operate relatively faster and more reliably than an at-grade options operating in a shared corridor. Option 1 would generate about 102,000 passengers per day or up to 3,300 pphpd in the peak loading segment. Transfer times would be relatively short to major rail stations on the Kwun Tong Line and Shatin-Central Link.

5.3.52 Key findings for this option are as follows (note – detailed comparison to other options is presented in **Section 5.7**):

- **Low-Moderate Level of Ridership** – The 102,000 daily riders would be on the low-moderate level of ridership. Although the alignment is dedicated, Option 1 would still encounter delays at junctions. This would make travel time less competitive than with elevated options and thus less attractive to potential users compared to other modes.
- **Vehicle Crowding Higher than Desired** – Peak demand on the most heavily used segment would induce a level of crowding above the ideal 4 ppsm density. The peak demand would thus equate to a passenger density of 6 ppsm in this peak segment. This implies that passengers would be more densely packed in the vehicles than desired, which could have impact on passenger comfort and desire to use the EFLS. This could also elongate dwell times due to longer boarding/alighting times due to blockage of doorways by passengers. This density would be equivalent to that which is often reached in peak periods on MTR trains.
- **Faster Travel Time than Shared Corridor** – The dedicated at-grade corridor would be segregated from other traffic lanes except at junctions. This means that other road vehicles would not interfere with and subsequently delay the modern tram along the majority of its alignment. This would allow the modern tram to operate faster and more reliably than at-grade options in shared corridors.
- **Significant Loss of Road Space Required** – As noted earlier, a minimum width of 9.5m would need to be reserved at designated platform locations (including a minimum 7.0m width for the dual tracks and a minimum 2.5m width for the single staggered platform). Where no station is required, the dual

tracks would need to be completely segregated from the other road vehicles. Thus, loss of road space in many locations would be inevitable with this option. In most cases, this would require the loss of one lane in each direction, particularly in the built-up areas of Kwun Tong and Kowloon Bay. Overall, an area of 63,000 m^2 would be lost, including both green area and roadspace.

- **Extensive Traffic Enhancements Required and Traffic Impacts Generated** – The at-grade operations of the modern tram would require extensive traffic enhancements including: (i) modifying priority junctions into signalised ones; (ii) restricting certain traffic movements at priority junctions; (iii) modifying signalised junction layout and method of control (MOC); and (iv) adding signalised junctions. Owing to the loss of road space, traffic impacts would be significant. For instance, speeds would be reduced from 18 kph to 3 kph on the section of Muk On Street between Wang Kwon Road and Muk Tsui Street in Kowloon Bay.
- **Negative Net Economic Benefit** – Net economic benefit would be negative as the time-savings benefit for EFLS passengers would be unable to cover the corresponding time loss for road-based users due to loss of lanes and traffic congestion.
- **Landscape and Visual** – The overhead catenary system would affect the open sky view of pedestrians from the ground level. The scale of the catenary system would be small when compared to adjacent developed building blocks and for residents at higher view levels. In view of the compatibility of the at-grade EFLS system, those cable and track would be compatible with the surrounding urban setting, like industrial and carriageway. Therefore, it is considered that the support structures and poles would cause a minor visual impact to the surrounding residential development and pedestrians. The proposed EFLS station at Kai Tak Station Square and its at-grade track would permanently occupy portions of the open space, which includes the proposed green and landscaping area, although the actual loss of area would depend on the detail design of the station platform. New tree plantings along Shing Kai Road would also be affected, which might degrade the existing roadside visual resources.

5.4 Option 2: At-Grade Shared Corridor

General Description

5.4.1 Option 2 represents an at-grade system that operates in a shared corridor. This means that the system operates in mixed flow traffic lanes along with other road users and vehicles and is subject to operational interference, which would likely result in slower operating speeds and lower reliability. This option is assumed to operate only as modern tram (as BRT has been defined as operating in a dedicated corridor). Alignment would follow that of the refined Hong Kong Tramways proposal.

5.4.2 Typically, stations would be at-grade and have a side platform configuration and would be staggered across the intersection to reduce required width at the station. Furthermore, stations would be located at the nearside of the intersection to minimise delays on the modern tram.

Alignment

5.4.3 Modern tram operating in a shared corridor would share traffic lanes with general traffic. In other words, track would be embedded into the road – general traffic and other road users could also operate on top of the track and alignment.

5.4.4 The recommended alignment would have two lines: (i) Line 1 (Blue Line) from near Kowloon Bay to Kai Tak Cruise Terminal; and (ii) Line 2 (Green Line) from Kwun Tong Ferry Pier to Kai Tak Cruise Terminal via the existing Taxiway Bridge). Line 1 would be 6.6 km long and serve 11 stations, while Line 2 would be 3.5 km long and serve 5 stations. The lines share two stations at the south end of the Kai Tak Development. The recommended alignment of modern tram with shared corridor is shown in **Figure 5.17.**

5.4.5 The modern tram would interchange with two MTR Stations – the Kai Tak Station of Shatin-to-Central Link and Kowloon Bay Station of Kwun Tong Line. Ngau Tau Kok, and Kwun Tong Stations of Kwun Tong Line would be within a few blocks walk. The modern tram would not directly connected to Kwun Tong Station due to congested conditions and heavy impacts along Hoi Yuen Road and King Yip Street by introducing at-grade modern tram.

5.4.6 The alignment would mainly follow that of Option 1 (At-Grade Dedicated Corridor), except it would connect to MTR Kowloon Bay Station instead of Hoi Bun Road Park. Under the shared corridor arrangement, Tai Yip Lane and Hong Tak Road, which are the sole accesses to WSD Kowloon East Regional Building, would be retained for vehicular use as shown in **Figure 5.18**. Connectivity could be enhanced by a convenient interchange linking the EFLS directly to the MTR at Kowloon Bay and Kai Tak stations.

5.4.7 Regarding the terminal arrangement on Kwun Tong Road and J/O Wai Yip Street and Hoi Yuen Road, a track switch would be proposed to facilitate turning around to minimise occupation of road space. For the terminal at Kai Tak Cruise Terminal, the modern tram would turn around by using the proposed track along the outer perimeter of the PTI to minimize the time required for turning around and optimize service by achieving lower headways as a result. Differences with the HKT proposal are similar to those identified earlier for Option 1.

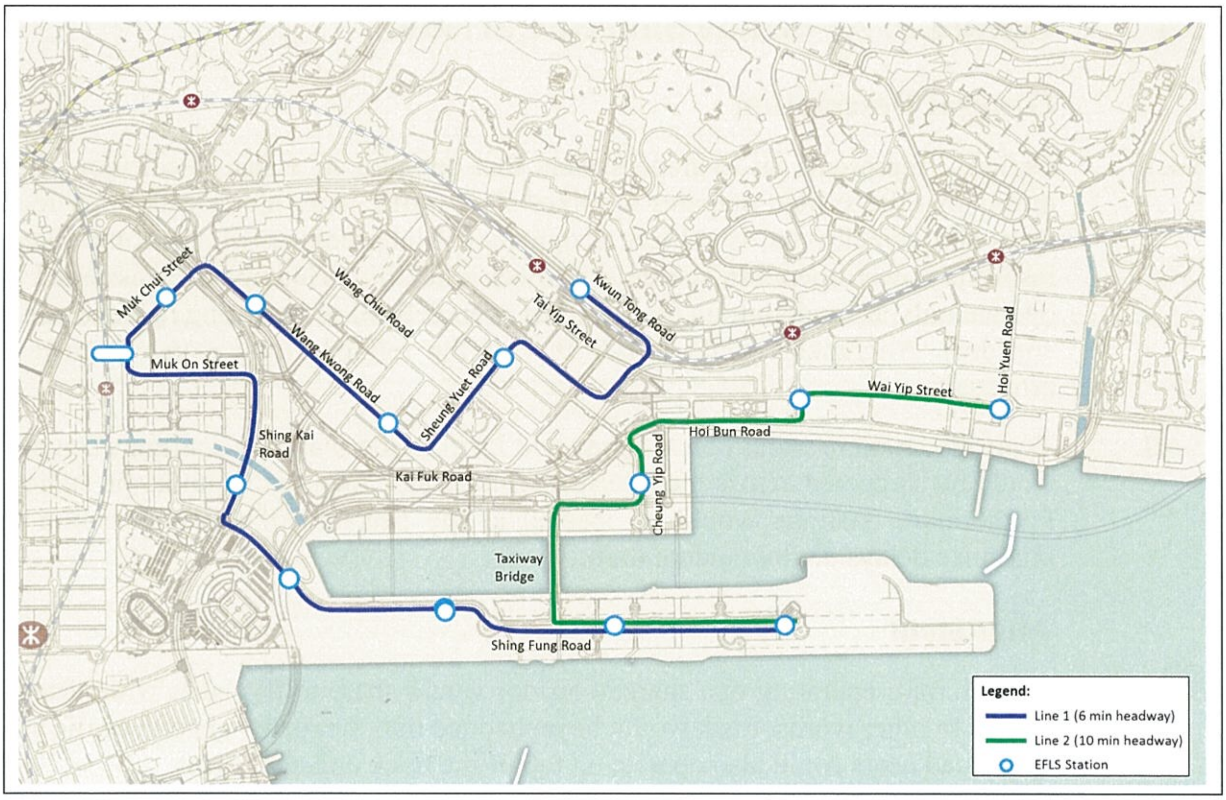


Figure 5.17: Proposed Alignment for Option 2 (At-Grade Shared Corridor)

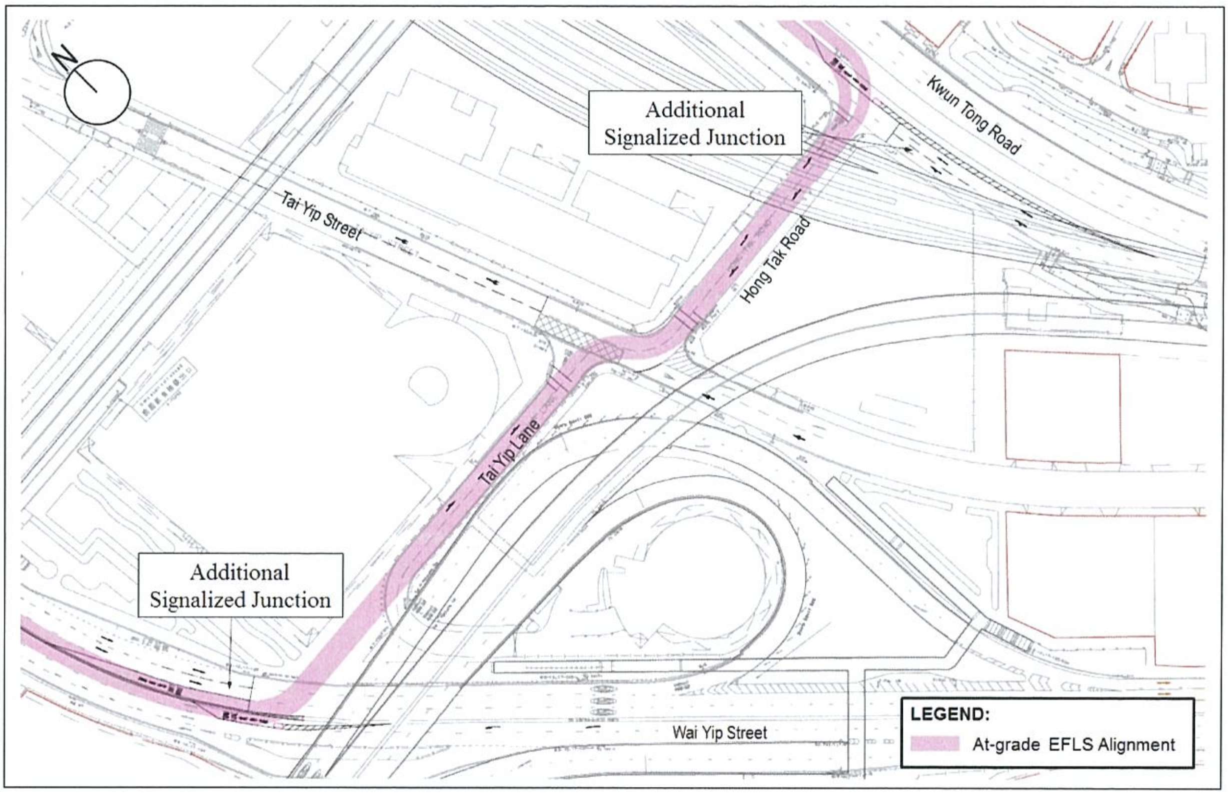


Figure 5.18: Proposed Arrangement for Option 2 (At-Grade Shared Corridor) on Tai Yip Lane and Hong Tak Road

Level of Segregation and Corridor Width

5.4.8 The purpose of the shared corridor concept would be to maintain the existing number of general purpose traffic lanes and minimise implications on road traffic. While there are cost and road traffic benefits to doing this compared to that of the dedicated EFLS corridor scenario, the major disadvantages are to the EFLS itself in terms of reduced operating speeds and poorer reliability due to mixed traffic operation. EFLS operations would come into conflict with other road vehicles throughout the alignment and be subject to traffic congestion.

5.4.9 The shared corridor concept would allow modern tram and other vehicles to operate on the same lane/track, except at station/platform sections. At station sections, a dedicated section of track would be reserved for the modern tram direction using the platform (for operational and safety purposes). The modern trams in the other direction would still operate in shared lanes that would be unsegregated.

5.4.10 A typical cross section of an at-grade modern tram with shared corridor at Wang Kwong Road and Wai Yip Street is shown in **Figure 5.19** and **Figure 5.20**, respectively, with a staggered side platform configuration. Similar to Option 1, the modern tram corridor would adopt a staggered side platform configuration. This would require a minimum 6.0m width (3.5m for the EFLS track (in one direction) and 2.5m width for the station) at station locations. As noted, EFLS vehicles in the opposite direction would operate in a shared lane with other vehicles without exclusive segregated track.

5.4.11 Another typical cross section of an at-grade modern tram with shared corridor at Shing Fung Road is shown in **Figure 5.21**. Similar to Option 1, tracks would operate on both sides of the Landscape Deck column – however, the shared track would be placed in the innermost lane alongside the median instead of at the kerb or in the planter/sidewalk area. Impact to footpath and adjacent structure would be minimal compared to Option 1.

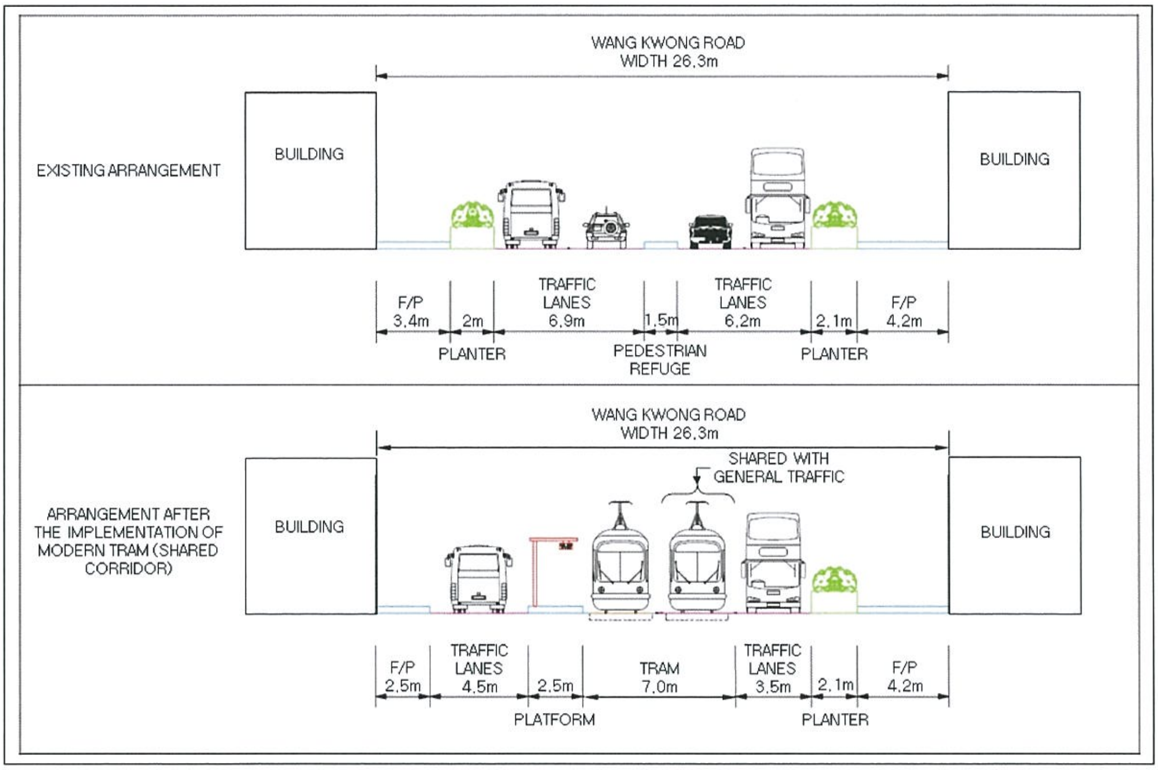


Figure 5.19: Typical Cross Section Plan of Option 2 (At-Grade Shared Corridor) on Wang Kwong Road (Before and After Implementation)

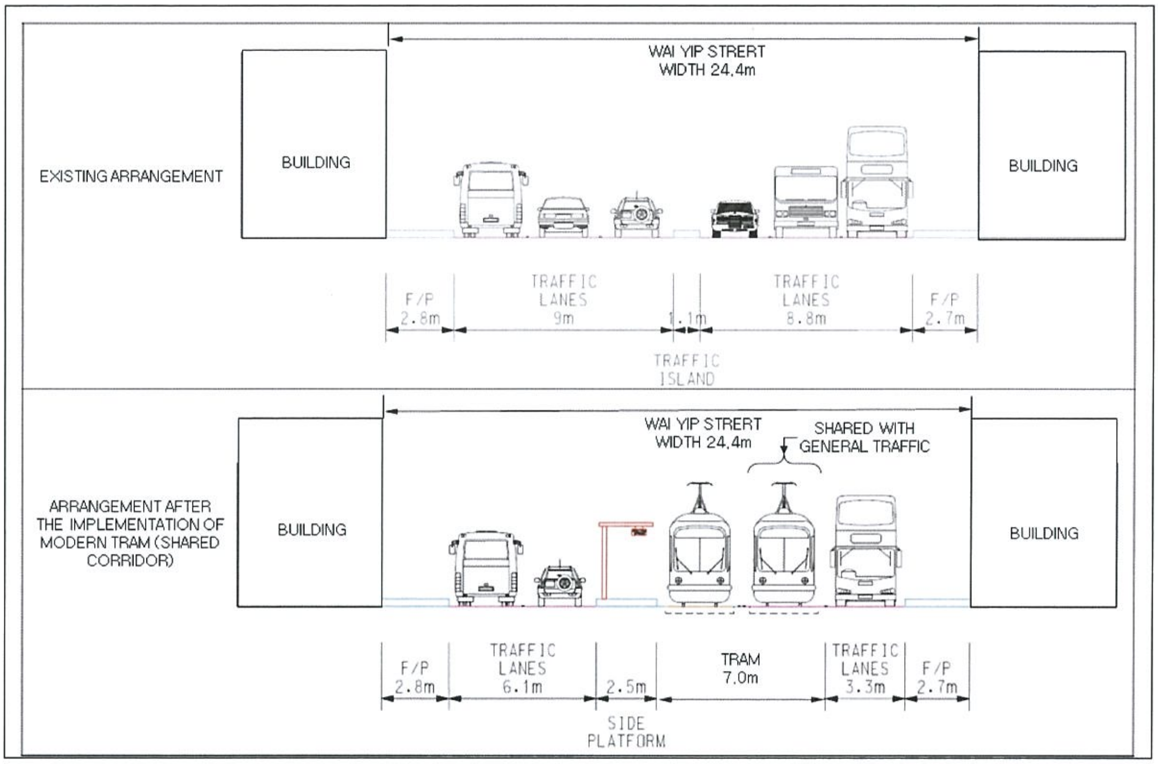


Figure 5.20: Typical Cross Section Plan of Option 2 (At-Grade Shared Corridor) on Wai Yip Street (Before and After Implementation)

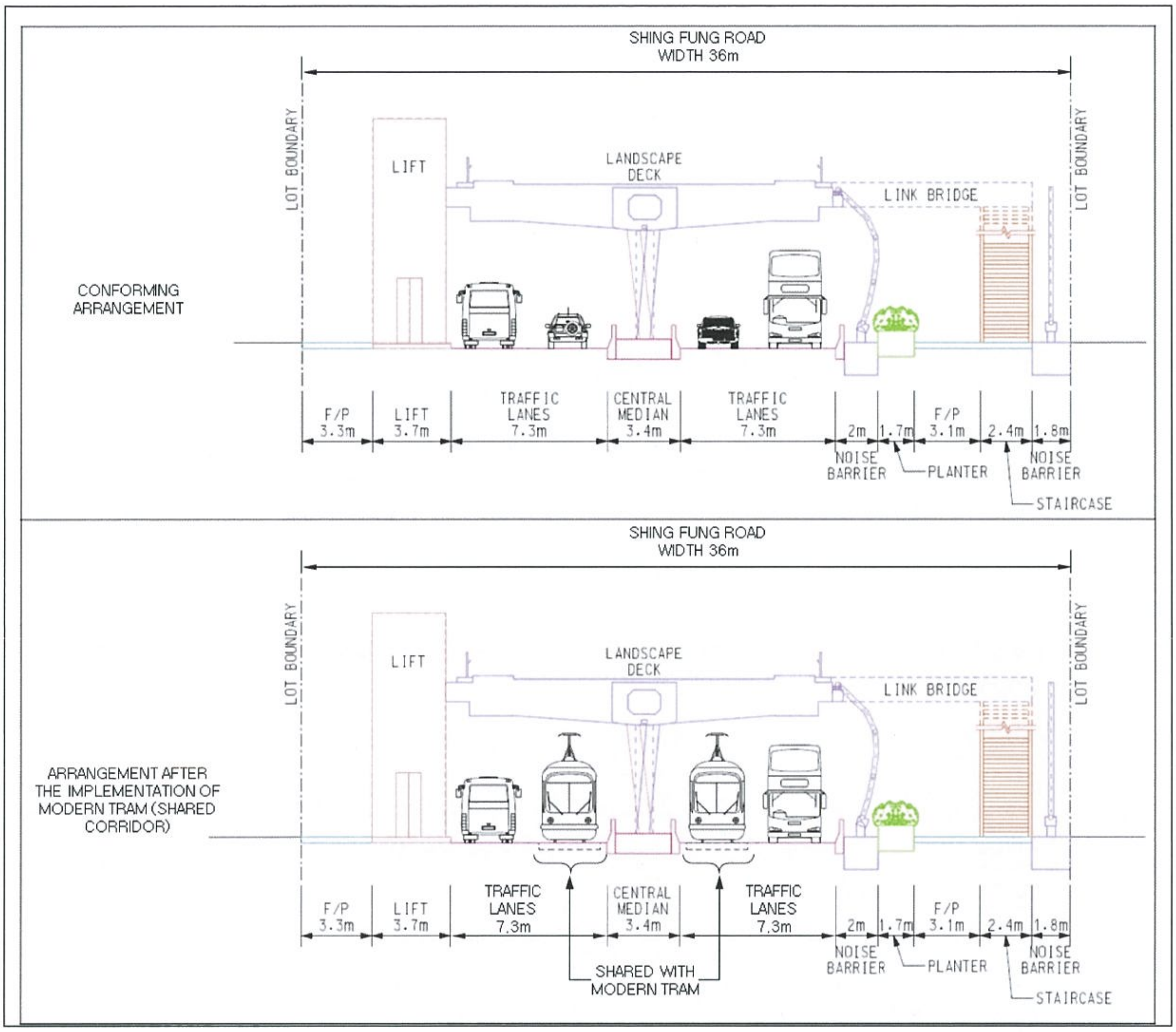


Figure 5.21: Typical Cross Section Plan of Option 2 (At-Grade Shared Corridor) on Shing Fung Road (Before and After Implementation)

Operating Assumptions

5.4.12 By considering local conditions including the alignment, permissible speed, round trip time, signal system and to reduce the impact of Modern Tram to the road user especially across the road junctions, the adopted operating assumptions for this option are listed as follows:

Parameter	Assumption
Length	Line 1: 6.6 km Line 2: 3.5 km
Number of Stations	Line 1: 11 stations Line 2: 5 stations
Headway	Line 1 (Blue): 6 minutes Line 2 (Green): 10 minutes
Schedule	Similar to existing MTR system for smooth and convenient transfers (6:00AM-1:00AM)
Runningway	Shared track with general purpose traffic

Parameter	Assumption
Vehicle Type	Modern Tram (holding 240 passengers/train at 4 ppsm or 360 passengers/train at 6 ppsm)
Capacity	Line 1: 2,400 pphpd (4 ppsm) / 3,600 pphpd (6 ppsm) Line 2: 1,440 pphpd (4 ppsm) / 2,160 pphpd (6 ppsm)
Fare	Please refer to **Appendix A2** - the assumed fare is based on a distance-based mechanism instead of travel time.

Notes:

[A] The capacity is based on typical capacity for an Alstom modern tram. At 4 ppsm, the capacity would be 240 passengers. At 6 ppsm, the capacity would be 360 passengers. Capacity in Hong Kong is typically evaluated at 4 ppsm to provide a reasonable/comfortable level of crowding. However, during the peak periods, this is often exceeded (for instance on the Hong Kong Light Rail in Tuen Mun). Therefore, capacity at a higher ppsm would connote a more crowded riding experience, which could still be accommodated by the train during these peak loading periods.

Performance against Criteria

5.4.13 **Table 5.7** presents a summary of option performance against the evaluation criteria. A summary of key findings follows below:

Table 5.7: Summary of Performance – Option 2 (At-Grade Shared Corridor)

#	Analysis Criteria	Value
1	Daily Boardings	• 82,500 riders/day
2	Peak Hour Boardings per direction	• Line 1: 3,000 pphpd • Line 2: 1,100 pphpd
3	In-Vehicle Journey Time (between Key Locations)	• Line 1: Kowloon Bay to KTCT - 28 minutes • Line 2: KTCT to Kwun Tong - 15 minutes
4	Peak Vehicle Requirements [A]	• Line 1: 13 vehicles/trainsets • Line 2: 5 vehicles/trainsets
5	Transfer Time (between EFLS and Key MTR Rail Stations)	• Between MTR Kowloon Bay Station and EFLS Station next to Fuk To Street: 7 minutes • Between SCL Kai Tak Station and EFLS Station at Station Square: 7 minutes • Between MTR Kwun Tong Station and EFLS Station near KTAA: 16 minutes • Between MTR Ngau Tau Kok Station and EFLS Station at Lai Yip Street: 12 minutes
6	Traffic Impacts (Additional Minutes of Delay) [B]	• Wang Kwong Road: 3-4 minutes • Cheung Yip Street / Taxiway Bridge: 4-5 minutes
7	Road Impacts (Total Area Lost)	• 8,600 m^2 (including road space and greenspace, please refer to **Figure 5.23**)
8	Utility Impacts (Cost of Relocation)	• [redacted]
9	Preliminary Environmental Impacts	• Complies with the EIAO requirements with appropriate mitigation measures

#	Analysis Criteria	Value
10a	Project Capital Cost [C] (Dec 2015 Prices)	• [redacted]
10b	Annual O&M Cost	• [redacted]
11	EIRR [D]	• Negative
12	Preliminary Construction Timeframe	• About 5 years

Notes:

[A] Peak vehicle requirement is presented for information only and is not used directly to compare options, as the number of buses, trams or APM/monorail trains is not directly comparable. The number of peak vehicles is captured in the overall capital costs for a given option.

[B] The travel time impact is estimated using a traffic model that considers the modification of the road and junction layout, as well as method of control required by introducing at-grade EFLS.

[C] Project capital cost includes design, construction, vehicle, project management and project contingency costs. Furthermore, cost estimations are preliminary that are subject to change and update upon further design).

[D] EIRR is estimated based on benefits/disbenefits for local users (and excludes non-local users such as tourists, etc.) solely for the purpose of the evaluation of green transport modes.

Patronage

5.4.14 It is anticipated that the average weekday patronage for the proposed at-grade shared Option 2 would be around 82,500 (about 20% lower than the at-grade dedicated Option 1). The busiest segment would handle a peak transport demand of 3,000 pphpd during the 2036 AM peak between M6 – M7 stations (or the segment just north of Kai Tak Station) as illustrated in **Figure 5.22**. Peak demand on the most heavily used section would induce a level of crowding above the ideal 4 ppsm design conditions. The peak demand would thus equate to a passenger density of 5 ppsm in this peak segment. This implies that passengers would be more densely packed in the vehicles than desired, which could have impact on passenger comfort and desire to use the EFLS. This could also elongate dwell times due to longer boarding/alighting times due to blockage of doorways by passengers. Nonetheless, this density would still be below 6 ppsm, which is often reached in peak periods on MTR trains

5.4.15 The forecast peak load would be about 90% of that for the at-grade dedicated Option 1. Compared with the at-grade dedicated Option 1, the shared corridor Option 2 would generate lower patronage due to the slower travel speed and thus longer journey times along the whole route as it shares the road with other vehicles.

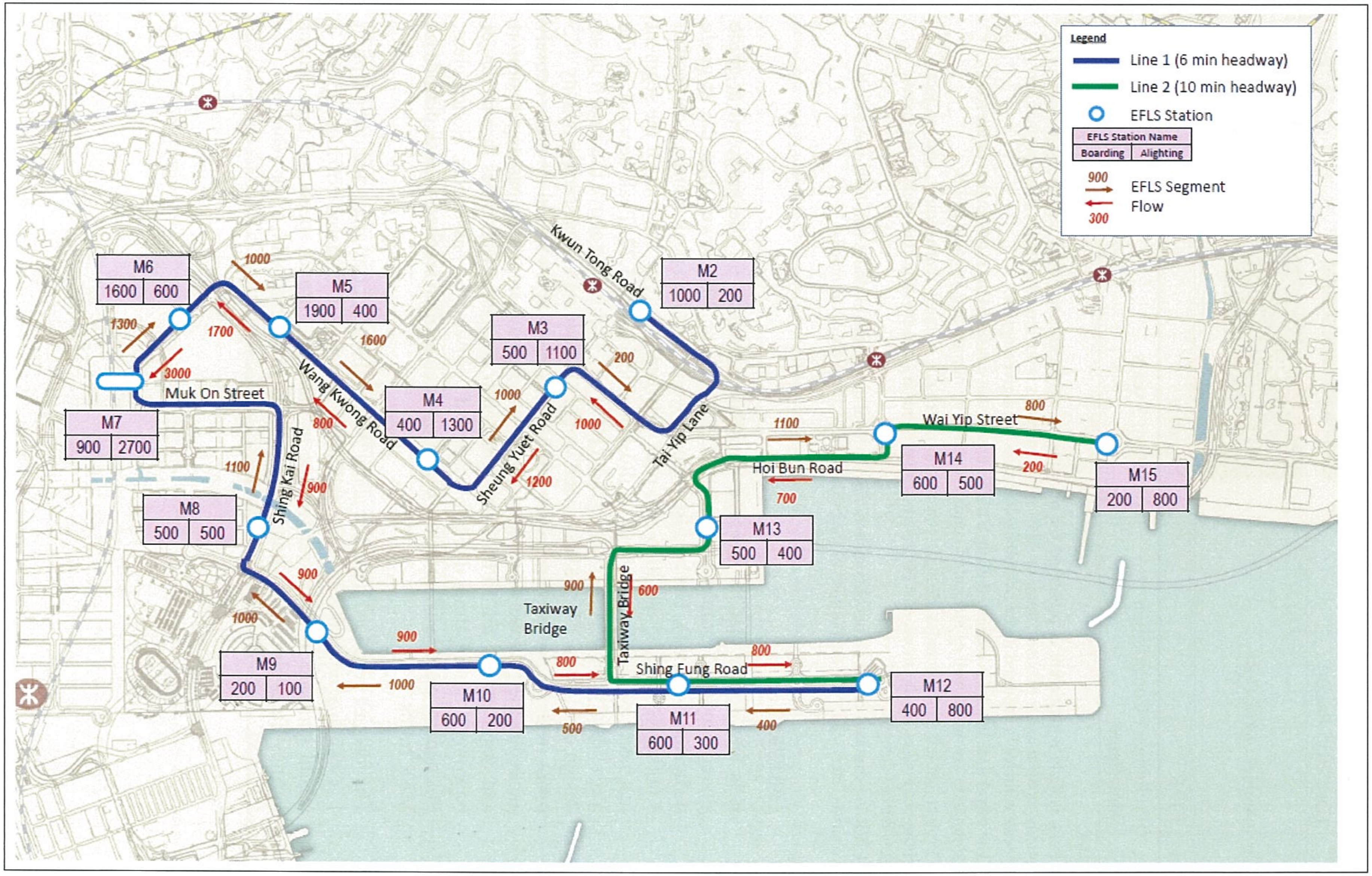


Figure 5.22: Peak Segment Flows for Option 2 (At-Grade Shared Corridor)

In-Vehicle Times

5.4.16 The in-vehicle time represents the time spent in the vehicle between the start and end point of the line. In-vehicle time excludes access time to/from the origin/destination stations, as well as waiting time spent on the station platform. Inherently, with greater mixing with other road users, EFLS may experience more stop-and-go operation with less reliable service than Option 1.

5.4.17 Based on the length of the network, the estimated in-vehicle times are as follows: (i) 28 minutes between Kowloon Bay and Kai Tak Cruise Terminal; and (ii) 15 minutes between Kai Tak Cruise Terminal and Kwun Tong via the Taxiway Bridge.

Transfer Times to Major Railway Stations

5.4.18 This option links into the MTR network at the Kowloon Bay and Kwun Tong Stations (on the Kwun Tong Line), with the latter connected through the existing pedestrian network, as well as at Kai Tak Station (on the Shatin-Central Line). Direct and convenient linkages to the greater MTR network are necessary to encourage ridership and create synergies. Walk transfer time is estimated based on horizontal distance between the EFLS stations and MTR stations. This transfer experience also includes vertical level changes. The proposed EFLS stations near the three MTR stations are located at-grade, while MTR Kwun Tong and Kowloon Bay stations along the Kwun Tong Line are elevated and the SCL Kai Tak Station is underground. Assumed walk transfer times are as follows:

Table 5.8: Transfer Time to Major Rail Stations – Option 2 (At-Grade Shared Corridor)

MTR Stations	EFLS Stations	Waiting Time (min)	Walk Transfer Time (min)	Total Combined Transfer Time (min)
MTR Kowloon Bay Station	EFLS Station near Fuk To Street	3	4	7
SCL Kai Tak Station	EFLS Station near Station Square	3	4	7
MTR Kwun Tong Station	EFLS Station at KTAA	5	11	16
MTR Ngau Tau Kok Station	EFLS Station at Lai Yip Street	5	7	12

Road / Land Impacts

5.4.19 The modern tram with shared corridor would jointly share the carriageway and track space with general traffic. No major carriageway width modification would be required except at stations. Modification may include reallocation of road space for the station platform (including carriageway narrowing, sidewalk narrowing, and planter removal), as well as to provide a dedicated section of track/bus lane at the boarding areas. This would improve safety for passengers and allow for smoother operations into and out of the station by modern tram.

5.4.20 Similar to the at-grade dedicated corridor option, a minimum 6.0m width would be required at the designated platform location (including a minimum 3.5m width for the tracks, and a minimum 2.5m width for the staggered single platform for one direction of the at-grade EFLS).

5.4.21 Using the station on Wang Kwong Road near Lam Wah Street as an example (similar to Option 1), the existing Wang Kwong Road configuration is a single 4-lane carriageway (i.e., two traffic lanes in each direction). After implementing an at-grade modern tram with shared corridor, a minimum width of 6.0m has to be reserved at designated station locations (under a staggered configuration). Like Option 1, the traffic lane adjacent to station would be narrowed to 4.5m width locally at the station locations. The carriageway in the other direction would retain its two lane configuration by allowing shared use of a lane by the modern tram and general traffic. The sidewalk next to the station would be narrowed down to 2.5m with no planters, while the opposite sidewalk would be unaffected. A total area of 8,600 m^2 would be lost, including both green and road space as illustrated in **Figure 5.23**.

5.4.22 Along the runway section, the EFLS tracks and platforms would generally be located in the carriageway area and its corridor would be shared with other traffic except at station area.

5.4.23 Besides carriageway and footpath space, open space would be affected by the modern tram track. In particular, the modern tram track would pass through Avenue Park Phase 1 along the Muk Chui Street W/B and go from Muk Chui Street cul-de sac to Mui On Street cul-de-sac through Station Square. The platforms on Muk Chui Street would also consume open space in the Station Square.

Traffic Impacts

5.4.24 The junction modification arrangement is shown in **Figure 5.24.** Priority junctions along the alignment would need to be converted into signalized control to maintain vehicle access and ensure safety of vehicles and modern trams (shown in the upper section of **Figure 5.25**). In addition, control modification at existing signalized junctions would be needed (shown in the upper section of **Figure 5.26**). As priority junctions are closely spaced, it would be infeasible to convert priority junctions into signalized junction as insufficient queuing area for modern trams would exist prior to the stop line. Traffic restrictions (i.e., left-in-left-out), would therefore be introduced for these priority junctions (shown in the lower section of **Figure 5.25**). To facilitate the EFLS travelling across the lane on the mid way of carriageway, additional signalized junctions would be proposed to avoid the conflict between general traffic and EFLS (shown in the bottom section of **Figure 5.26**).

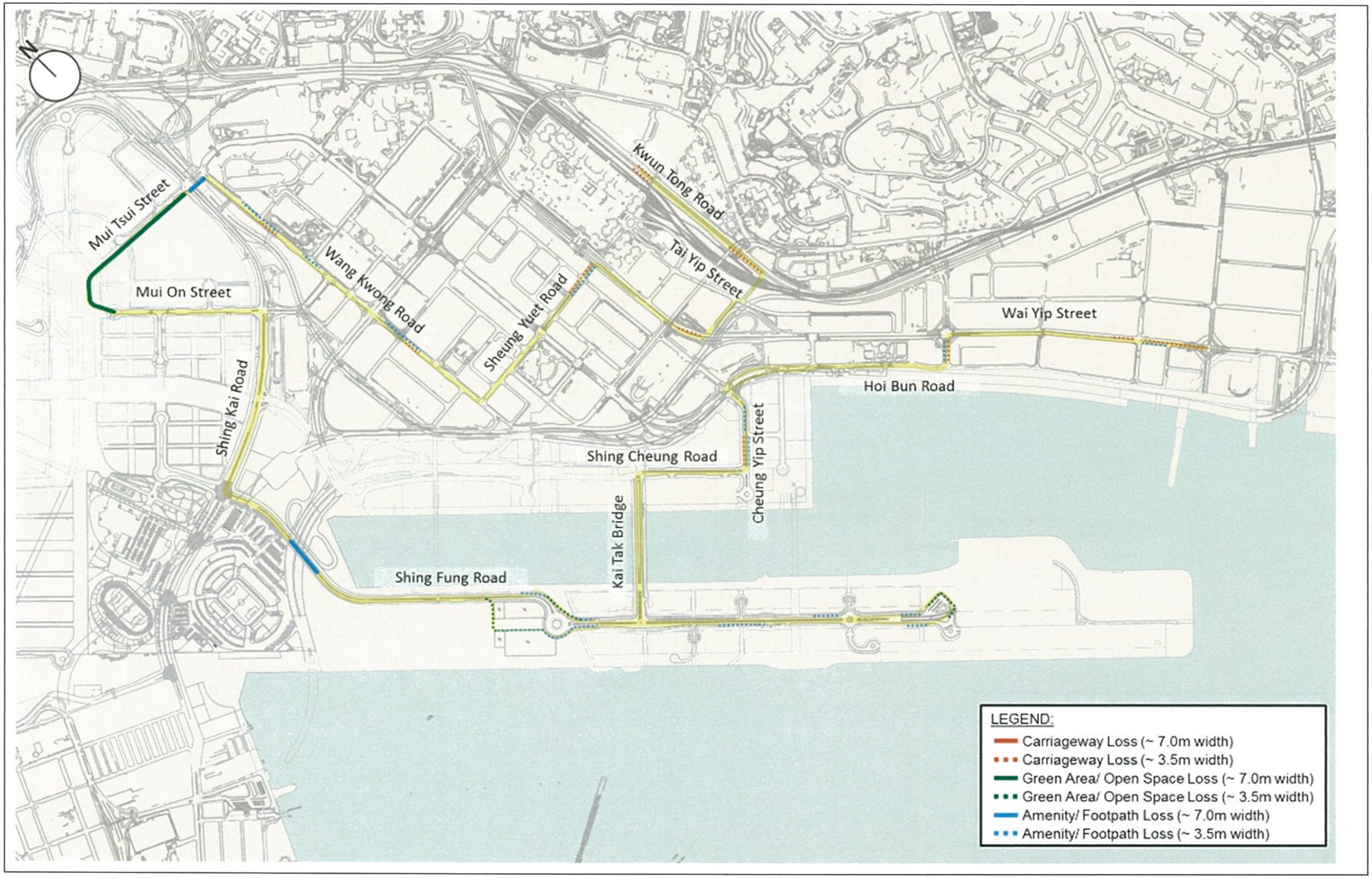


Figure 5.23: Loss of Road Space/ Open Space for Option 2 (At-Grade Shared Corridor)

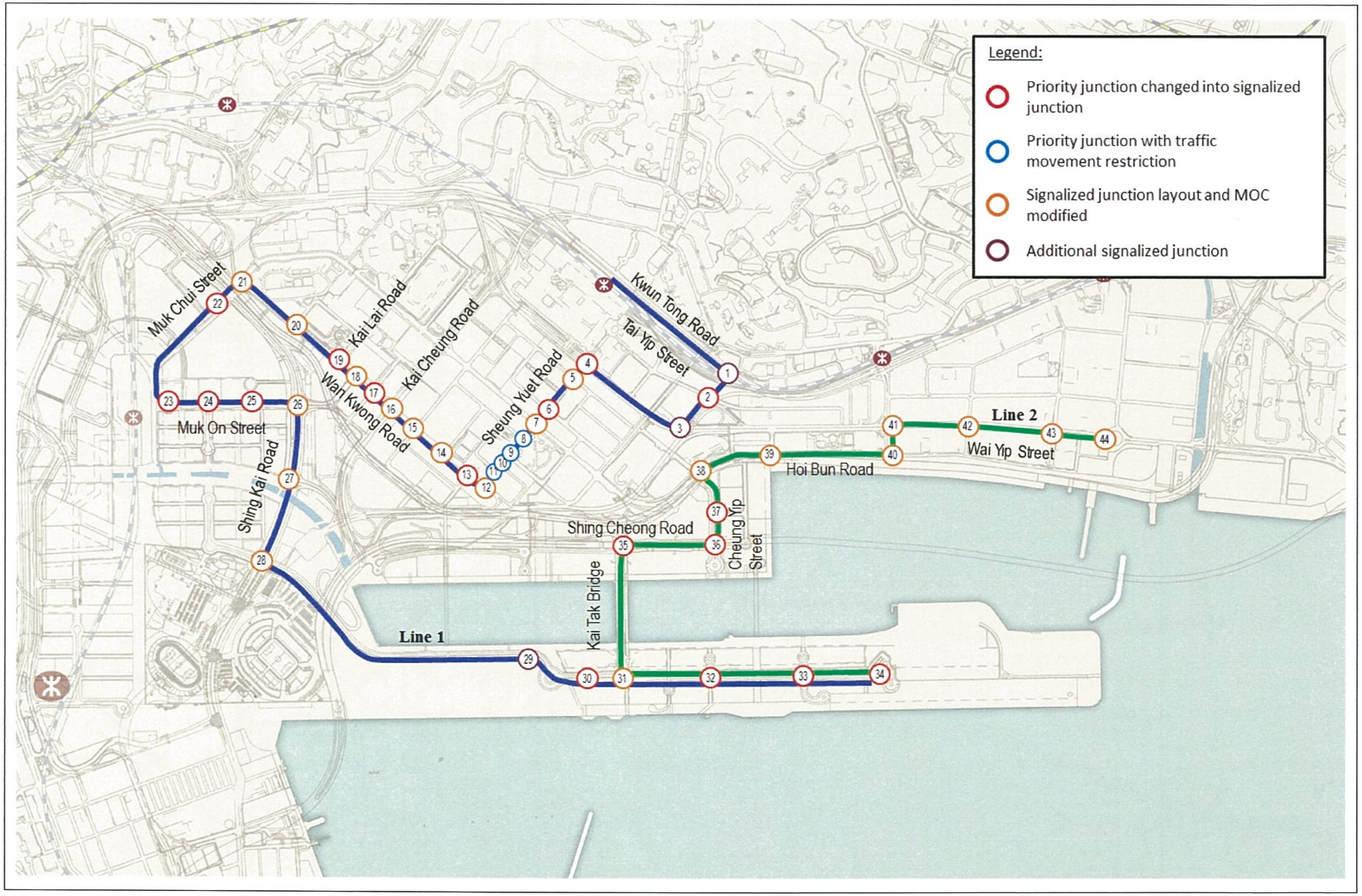


Figure 5.24: Junction Modifications Required for Option 2 (At-Grade Shared Corridor)

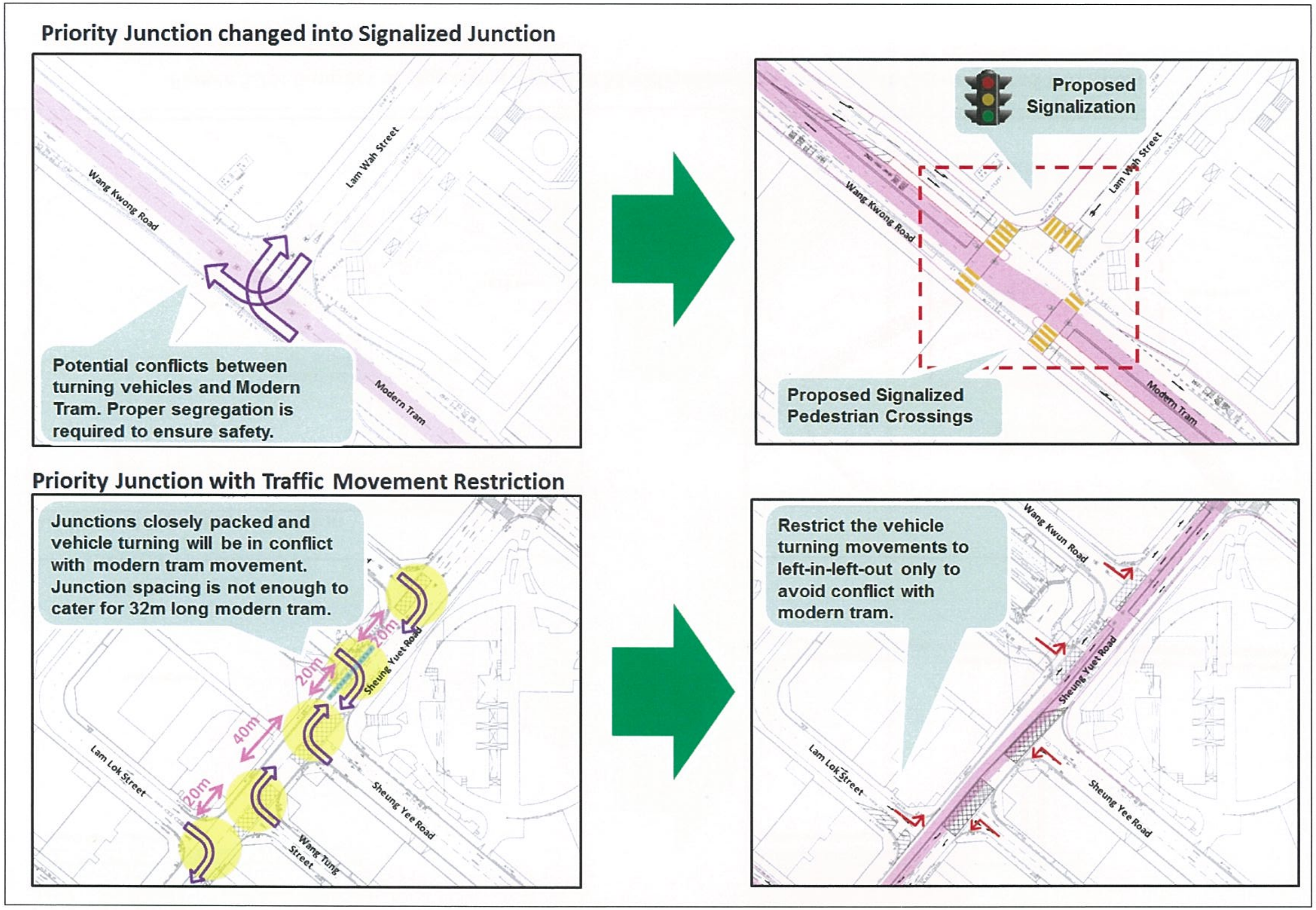


Figure 5.25: Samples of Priority Junction Modification for Option 2 (At-Grade Shared Corridor)

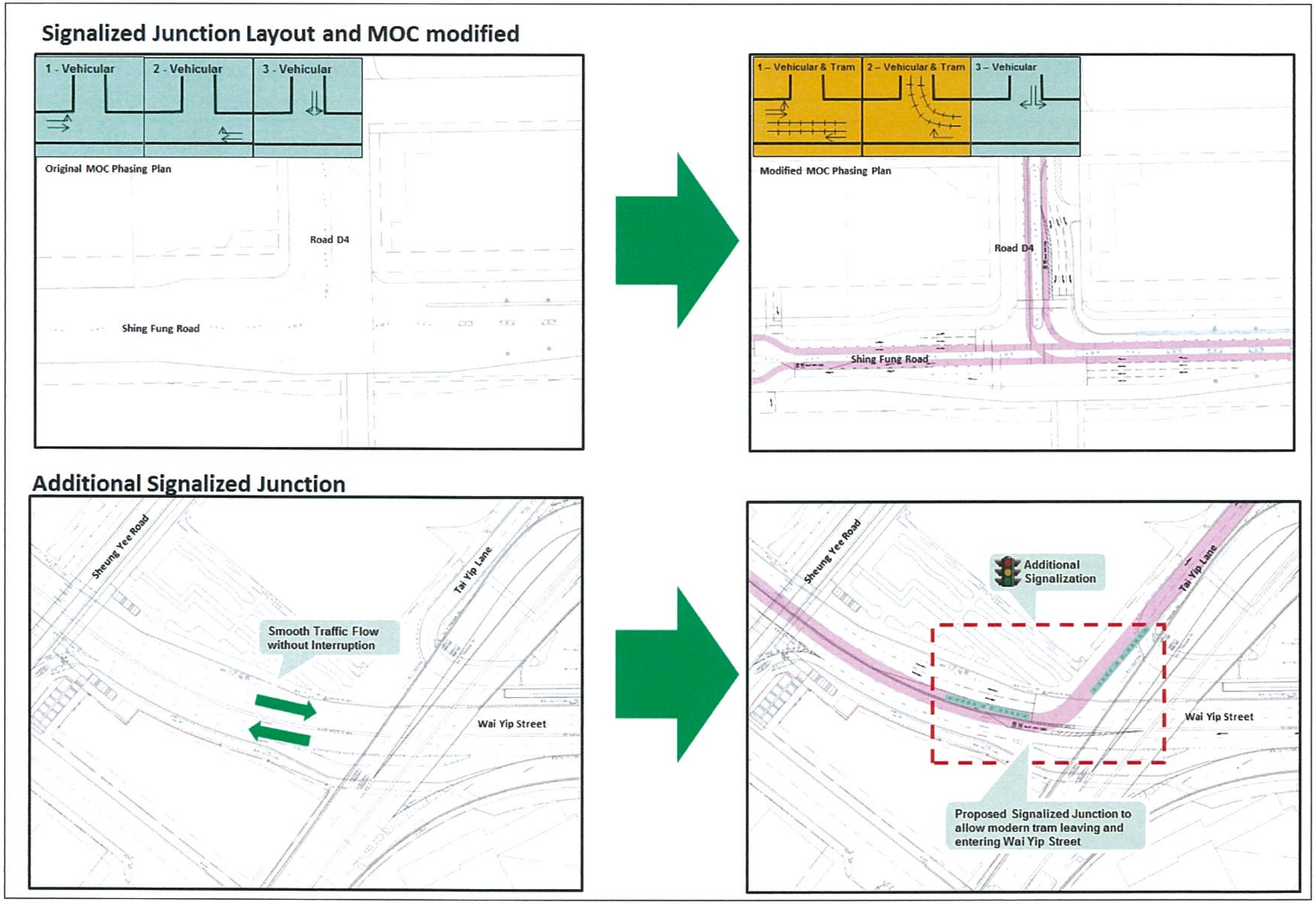


Figure 5.26: Samples of Signalized Junction Modification for Option 2 (At-Grade Shared Corridor)

5.4.25 Moderate traffic queuing would be generated at numerous junctions throughout KE increasing the level of congestion. Significant queues would appear along Muk On Street and Road D4 in both directions. Traffic queuing caused by the implementation of the shared option would be less severe than that for Option 1 (At-Grade Dedicated Corridor). For instance, the travel time and speed of other traffic at the section of Wang Kwong Road between Sheung Yee Road and Muk Tsui Street would increase from 3 to 4 minutes, while speeds would fall from 18 to 15 kph. For the section of Road D4, Cheung Yip Street and Hoi Bun Road would increase from 4 to 5 minutes, with speeds reduced from 31 to 27 kph.

5.4.26 The traffic impacts are demonstrated in **Figure 5.27**.

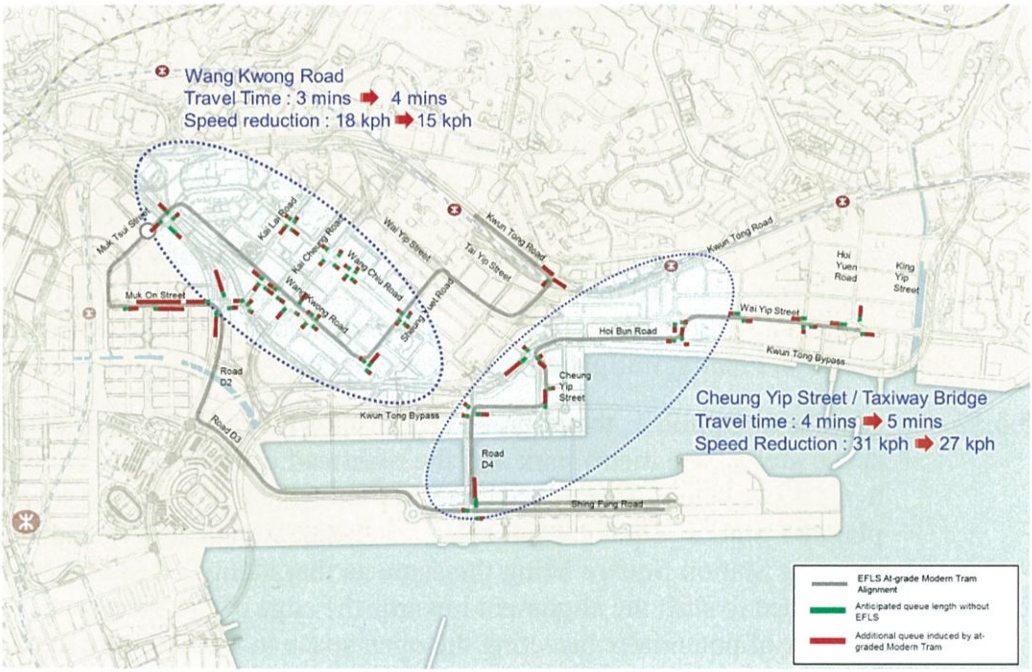


Figure 5.27: Traffic Speed and Travel Time for Option 2 (At-Grade Shared Corridor)

5.4.27 Similar to Option 1, with the narrowing of footpaths adjacent to designated station sections and introduction of pedestrian crossing to access the stations at the middle of carriageway, the pedestrian environment would worsen and may be unable to cope with the demand with the transformation.

5.4.28 To facilitate the diversion works of underground utilities, which would be affected by the proposed at-grade EFLS alignment, temporary traffic lane closure would be required to provide necessary works area. The performance of carriageways and junctions would be affected as a result. Temporary traffic diversion would be needed for locations where traffic lanes fail to meet absolute minimum width requirements. The journey times for road users, include public transport services, would be increased, and the diverted traffic would worsen surrounding road congestion. In addition, pedestrian footpaths at some locations would be narrowed or closed/diverted to facilitate underground utilities diversion work.

Utility Impacts

5.4.29 The at-grade shared Option 2 and the at-grade dedicated Option 1 share several similar characteristics. Both options would run along a similar alignment and operate on embedded track. The only difference is that the shared corridor option would allow general traffic to operate on the track and the latter option would connect to Kowloon Bay, while Option 1 would connect to Ngau Tau Kok. As Option 2 would operate on an extremely congested segment of road up to Kowloon Bay with extensive utilities, Option 2 would have more severe impacts and require additional utility relocation here.

5.4.30 Therefore, total estimated utility relocation costs would be about [redacted].

Preliminary Environmental Impacts

5.4.31 Option 2 with the shared corridor would likely generate lower noise impacts than Option 1 as it would operate slower due to mixing with other road vehicles throughout the alignment. However, there would be no significant difference in the overall level of environmental impacts between the other three options. It is anticipated that the system can comply with the EIAO requirements with appropriate mitigation measures. A Preliminary Environmental Assessment (PEA) would be conducted in the next study stage upon confirmation of the green transport mode to confirm the environmental acceptability of the Recommended EFLS Scheme. Finally, mitigation measures would be recommended, where necessary.

5.4.32 Similar to Option 1, the at-grade alignment of Option 2 would occupy some open space area of the metro park and the overhead cabling would cause some intrusion to the tree crown. The proposed tram station would also occupy some portion of the planned Station Square open space, with the visual impact and the loss of open space at Station Square being the same as that identified in Option 1. Similarly, it is planned to shift the alignment towards the edge of the open space to minimise the impacts of potentially bisecting the open space to the extent possible under Option 2.

5.4.33 The at-grade alignment would run through Shing Kai Road, which would affect the visual elements of new tree plantings along the roadside. The at-grade alignment along Sheung Yuet Road and Wang Kwong Road might affect the visual elements of roadside tree plantings, while the adjacent commercial and industrial visually sensitive receivers might lose the green screening of the road.

5.4.34 Compared with Option 1, the at-grade alignment would not cause significant visual impact to the adjacent commercial and industrial receivers. Therefore, the alignment running through Kwun Tong Road instead of Wai Yip Street would not cause a different visual impact. However, the overhead wires might potentially affect the existing mature trees along the central median of Kwun Tong Road section in Option 2.

5.4.35 In general, the overhead cabling would still cause minor visual impacts to the surrounding receivers. However, since the existing urban setting was not visual pleasant within the industrial area of Kowloon Bay, the at-grade route would be considered compatible with the surrounding within this section.

Capital & O&M Costs

5.4.36 The project capital cost for the at-grade shared Option 2 would be the same as that for the at-grade dedicated Option 1 – [redacted]. Although the alignment between Option 1 and 2 are slightly different at the terminus at Kowloon Bay/Ngau Tau Kok, the overall track length is similar, therefore the two options would be similar in cost.

5.4.37 Similar to Option 1, the costs for Option 2 would include utility diversion costs, infrastructure costs, system costs, depot costs, as well as reprovisioning costs during construction.

5.4.38 Operating costs include the daily costs to run and operate the system (including operating staff and power consumption), as well as state-of-good repair and periodic replacement of rolling stock, equipment and assets, averaged over a 50 year timeframe. O&M costs for Option 2 would be similar to Option 1, but would likely be higher ([redacted]) as the shared track would require more maintenance as other road vehicles would be driving over it constantly. The O&M costs for Option 2, however, would be less than that for Option 3 (Elevated) or Option 4 (Mixed Operations).

Economic Benefit

5.4.39 Since the service level provided by this option would be very similar to current bus services (i.e., operating in general purpose lanes) and no priority would be granted at the junctions to the EFLS, the EIRR of this option is estimated to be negative as no time benefit would be gained for either the EFLS riders or road-based public transport users under the with EFLS scenario along with the additional capital and operating costs. As noted, this EIRR result assumes benefits/disbenefits only for local users. Even with inclusion of non-local users, the EIRR would still be negative.

Preliminary Construction Timeframe

5.4.40 The preliminary construction programme for the EFLS is primarily based on the following assumptions:

- The EIA and TRA (Tree Removal Application) approval must be obtained prior to commencement of the works contract;
- After commencement of the contract, tree removal would occur within 30 days and tree transplanting and removal would occur within 90 days;
- A shared corridor, as well as requisite lands and work areas would be available upon commencement of the contract; and
- Installation of trackworks and system-wide T&C and statutory inspections would take two (2) years.

5.4.41 The total construction time for Option 2 is estimated at five (5) years. Assuming all affected lands would be acquired before the start of construction, advance works would commence in the first year, followed by construction works such as construction of the trackform, station, depot, and administration building, as well as the installation of the power supply system. After completion of construction works, a testing and commissioning (T&C) period taking at least one year would begin to examine and finetune the system to ensure operations meet the designed standards. Project completion is expected to in year five.

5.4.42 A tentative construction programme for the at-grade shared Option 2 is attached in **Appendix B** for information. Note it is expected that the construction schedule for Option 2 is similar to that for Option 1, thus the same timeline is used for both.

Summary of Option 2 (At-Grade Shared Corridor)

5.4.43 Option 2 consists of a fully at-grade modern tram operating in a shared corridor with other road vehicles. This means that other road vehicles would operate on the same track as the modern tram. Interference and delay from other road vehicles and pedestrians would occur throughout the alignment and at junctions. The major benefit of this option is that traffic impacts would be less severe than a dedicated corridor as loss of road lanes would be minimal.

5.4.44 Key findings for this option are as follows (note – detailed comparison to other options is presented in **Section 5.7**):

- **Low Level of Ridership** – The 82,000 daily riders would be on the lower end of the options, given the longer travel times, which would make this system less time-competitive and attractive than other modes. This also means lower fare revenues.
- **Vehicle Crowding Higher than Desired** – Even with the relatively lower daily demand, peak demand on the most heavily used segment would induce a level of crowding above the ideal 4 ppsm density. The peak demand would thus equate to a passenger density of 5 ppsm in this peak segment. This implies that passengers would be more densely packed in the vehicles than desired, which could have impact on passenger comfort and desire to use the EFLS. This could also elongate dwell times due to longer boarding/alighting times due to blockage of doorways by passengers. Nonetheless, this density would still be below 6 ppsm, which is often reached in peak periods on MTR trains.
- **Lower Traffic Impacts** – Option 2 would generate lower impacts on traffic and the roads compared to dedicated at-grade options, as there would be minimal reallocation of existing traffic lanes for EFLS operation.
- **Long In-Vehicle Journey Times** – The estimated in-vehicle journey times would be 28 minutes between Kowloon Bay and the Kai Tak Cruise Terminal, and 15 minutes between the Cruise Terminal and Kwun Tong via the Taxiway Bridge. These journey times would be significantly slower than those for at-grade dedicated corridor or elevated options owing to the fact that the modern tram would be delayed road congestion throughout the journey, as well as merging and turning vehicles. Delays would also be incurred at junctions.
- **Extensive Traffic Enhancements Required** – The at-grade operations of the modern tram would require extensive traffic enhancements including: (i) modifying priority junctions into signalised ones; (ii) restricting certain traffic movements at priority junctions; (iii) modifying signalised junction layout and method of control (MOC); and (iv) adding signalised junctions. Owing to the loss of road space, traffic impacts would be significant.
- **Higher Utility Relocation Costs** – Utility relocation costs for the at-grade shared Option 2 would be higher than the at-grade dedicated Option 1 as the alignment would be placed in a highly impacted utility corridor leading to Kowloon Bay MTR Station. Thus forecast utility costs would be over [redacted] higher than that for Option 1.

- **Negative Net Economic Benefit** – The net economic benefit would be negative as the time-savings benefit for EFLS passengers and volume of forecasted riders would be insufficient to offset the congestion and delay faced by the modern tram along its entire at-grade alignment.
- **Landscape and Visual** – The overall visual impact would be minor – similar in scale to that generated by Option 1. The proposed EFLS station located at the Kai Tak Station Square and its at-grade track would also permanently occupy some portion of the open space, including the proposed green and landscaping area. In addition, compared with Option 1, the overhead cabling infrastructure along Kwun Tong Road section might potentially affect existing mature trees in the central median.

5.5 Option 3: Elevated Dedicated Corridor

General Description

5.5.1 Option 3 represents an elevated system operating in its own segregated right-of-way, without interference from vehicles or other road users. As Option 3 would not be subject to road congestion and interference by other road traffic, it is likely to provide the fastest and most reliable journey of all EFLS options (i.e., Option 1 or Option 2). This option is designed to allow flexibility for either monorail or APM. Alignment is assumed to follow the Preliminary Elevated Alignment described earlier. Stations are elevated.

Alignment

5.5.2 An elevated EFLS option would provide a fully segregated system that would be able to operate faster and more reliably than an at-grade system (regardless of whether operating in a shared or dedicated corridor). It is assumed that EFLS would operate as a single end-to-end line from Kowloon Bay to Kwun Tong via Kai Tak Cruise Terminal using KTTL to Kwun Tong. The alignment is shown in **Figure 5.28**.

5.5.3 This preliminary alignment would be approximately 9.0 km long and include 12 stations. It would directly serve two MTR Station – the Kai Tak Station of Shatin-to-Central Link and Kowloon Bay Station of Kwun Tong Line. Kwun Tong Stations of Kwun Tong Line would be within a few blocks walk. It is noted that the alignment would generally be in line with the PFS Preliminary Elevated Alignment (see **Figure 5.1**) except for some minor modifications considering site conditions, lane configuration, and current development.

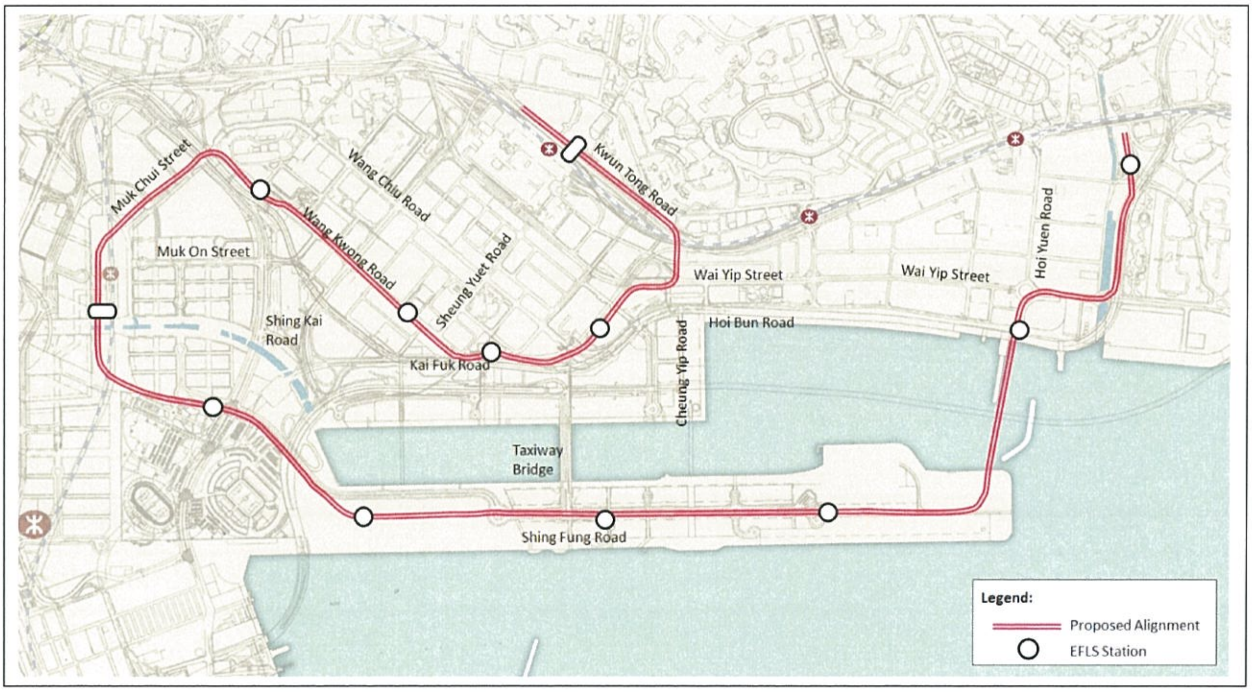


Figure 5.28: Proposed Alignment for Option 3 (Elevated Dedicated System)

Level of Segregation and Corridor Width

5.5.4 Option 3 would operate in a fully segregated viaduct without interference or interaction with road users and pedestrians. Option 3 would benefit from this segregation by operating faster, more reliably, and with higher carrying capacity than that operating at-grade (whether in shared tracks/lanes or in dedicated corridors with at-grade crossings). Faster and more reliable service typically translates into a more competitive and convenient alternative to other modes, resulting in higher ridership.

5.5.5 A typical cross section of an elevated EFLS at Wang Kwong Road is shown in **Figure 5.29**. The column and any median/barrier protection would require an average width of about 2.8m. The two existing lanes in each direction would be maintained. The footpath at some locations would be further narrowed to facilitate uncovered emergency vehicle access (EVA) with a minimum of 6m in width.

5.5.6 Another typical cross section plan of elevated EFLS at Shing Fung Road is shown in **Figure 5.30.** The columns would be principally located within the planter area outside of the carriageway, which would minimise potential impacts on traffic and pedestrians. The two existing lanes in each direction would be maintained. However, additional costs would be generated with the greater degree of physical segregation, as discussed below.

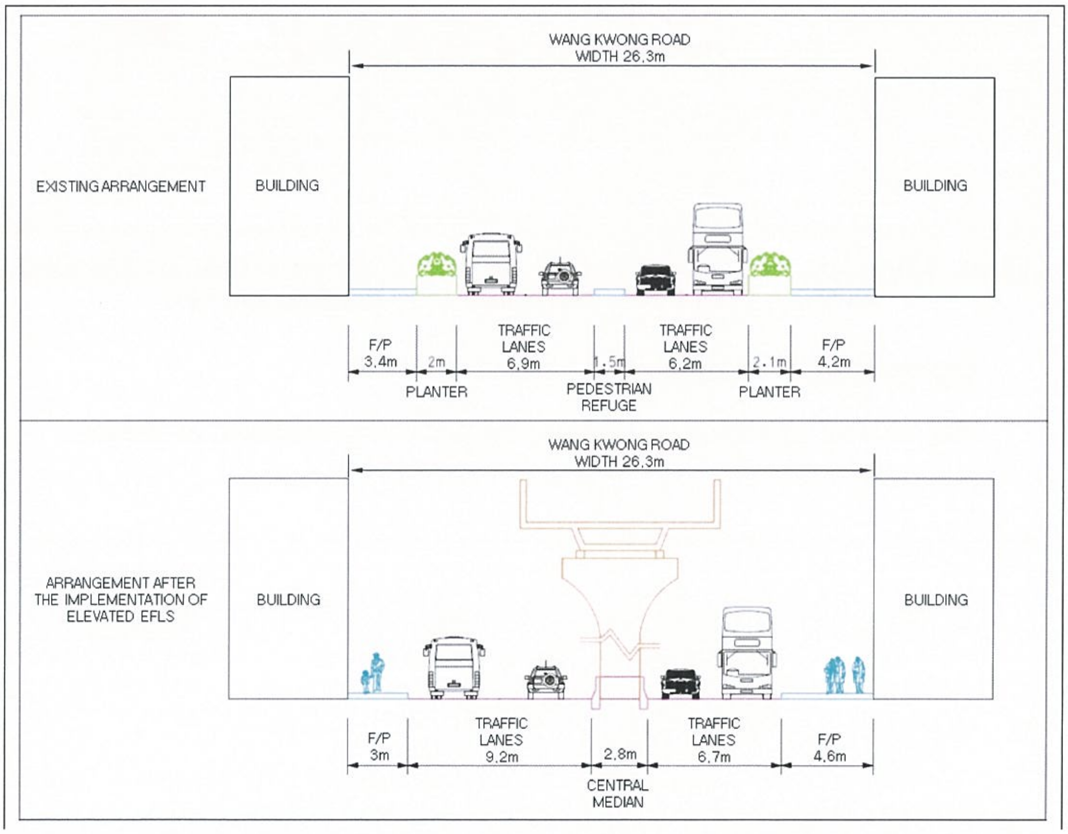


Figure 5.29: Typical Cross Section Plan of Option 3 (Elevated Dedicated System) on Wang Kwong Road (Before and After Implementation)

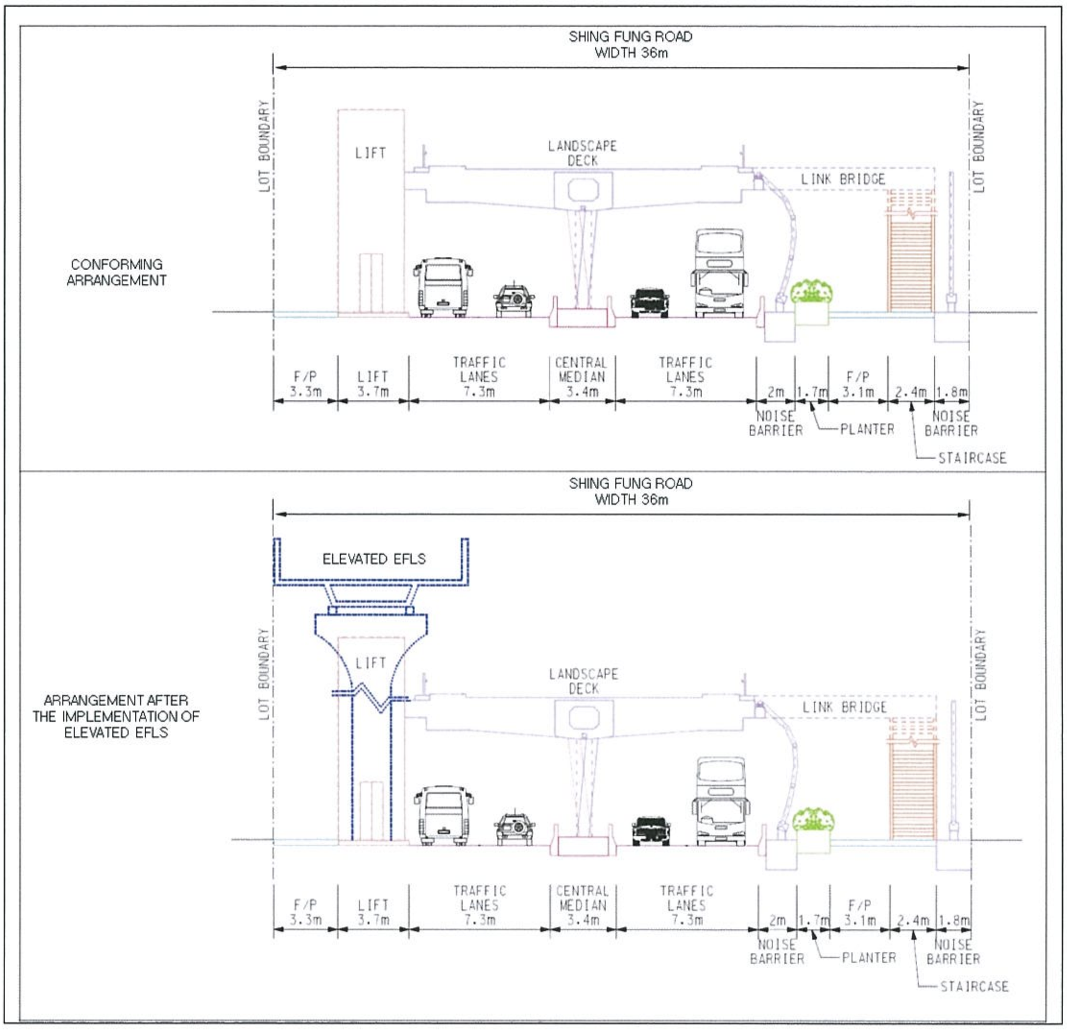


Figure 5.30: Typical Cross Section Plan of Option 3 (Elevated Dedicated System) on Shing Fung Road (Before and After Implementation)

Operating Assumptions

5.5.7 The adopted operating assumptions for this option are listed as follows:

Parameter	Assumption
Length	9 km
Number of Stations	12 stations
Headway	2.5 minutes
Schedule	Similar to existing MTR system for smooth and convenient transfers (6:00AM-1:00AM)
Runningway	Segregated elevated track
Vehicle Type [A]	Monorail / APM (holding 360-400 passengers per 4 car train assuming 4 ppsm)
Capacity	8,640 -9,600 pphpd (4 ppsm)
Fare	Please refer to **Appendix A3** - the assumed fare is based on a distance-based mechanism instead of travel time.

Notes:

[A] The capacity is based on typical capacity for a Siemens APM with capacity for about 280 passengers per three car train at 4 ppsm. Given demand requirements, a longer train would be required, which could then accommodate 360-400 passengers per four car train at 4 ppsm.

Performance against Criteria

5.5.9 **Table 5.9** presents a summary of option performance against the evaluation criteria. A summary of key findings follows below:

Table 5.9: Summary of Performance – Option 3 (Elevated Dedicated System)

#	Analysis Criteria	Value
1	Daily Boardings	• 260,000 riders/day
2	Peak Hour Boardings per Direction	• 7,600 pphpd
3	In-Vehicle Journey Time (between Key Locations)	• Kowloon Bay to KTCT: 16 minutes • KTCT to Kwun Tong: 5 minutes
4	Peak Vehicle Requirements [A]	• 21 vehicles/trainsets
5	Transfer Time (between EFLS and Key MTR Rail Stations)	• Between MTR Kowloon Bay Station and EFLS Station near Fuk To Street: 7 minutes • Between SCL Kai Tak Station and EFLS Station at Station Square: 6 minutes • Between MTR Kwun Tong Station and EFLS Station at King Yip Street: 10 minutes
6	Traffic Impacts (Additional Minutes of Delay) [B]	• Minimal (as no loss of lanes, although in some locations, lane width and footpath would be narrowed to accommodate the viaduct columns, which would not cause insurmountable traffic impacts)
7	Road Impacts (Total Area Lost)	• 4,600 m^2 (including road space and greenspace, please refer to **Figure 5.32**)
8	Utility Impacts (Cost of Relocation)	• [redacted]
9	Environmental Impacts	• Construction noise and dust impact due construction of extensive viaduct structure

#	Analysis Criteria	Value
		• Potential visual impacts from viaduct • Complies with the EIAO requirements with appropriate mitigation measures.
10a	Project Capital Cost [C] (Dec 2015 Prices)	• [redacted]
10b	Annual O&M Cost	• [redacted]
11	EIRR [D]	• >1%
12	Construction Timeframe	• About 5 years

Notes:

[A] Peak vehicle requirement is presented for information only and is not used directly to compare options, as the number of buses, trams or APM/monorail trains is not directly comparable. The number of peak vehicles is captured in the overall capital costs for a given option.

[B] The travel time impact is estimated using a traffic model that considers the modification of the road and junction layout, as well as method of control required by introducing at-grade EFLS.

[C] Project capital cost includes design, construction, vehicle, project management and project contingency costs. Furthermore, cost estimations are preliminary that are subject to change and update upon further design).

[D] EIRR is estimated based on benefits/disbenefits for local users (and excludes non-local users such as tourists, etc.) solely for the purpose of the evaluation of green transport modes.

Patronage

5.5.10 This option would generate an average weekday patronage of 260,000, with the peak segment handling up to 7,600 pphpd during the 2036 AM Peak in the southbound direction between Kowloon Bay Terminus (KBT) and Hoi Bun Road Station (HBR), just south of Kowloon Bay MTR Station as illustrated in **Figure 5.31**. Peak demand would be accommodated by the proposed capacity of the system (8,640-9,600 pphpd at 4 ppsm). As this option is elevated, the relatively faster speed and lower journey time would attract more passengers compared with the other two at-grade options.

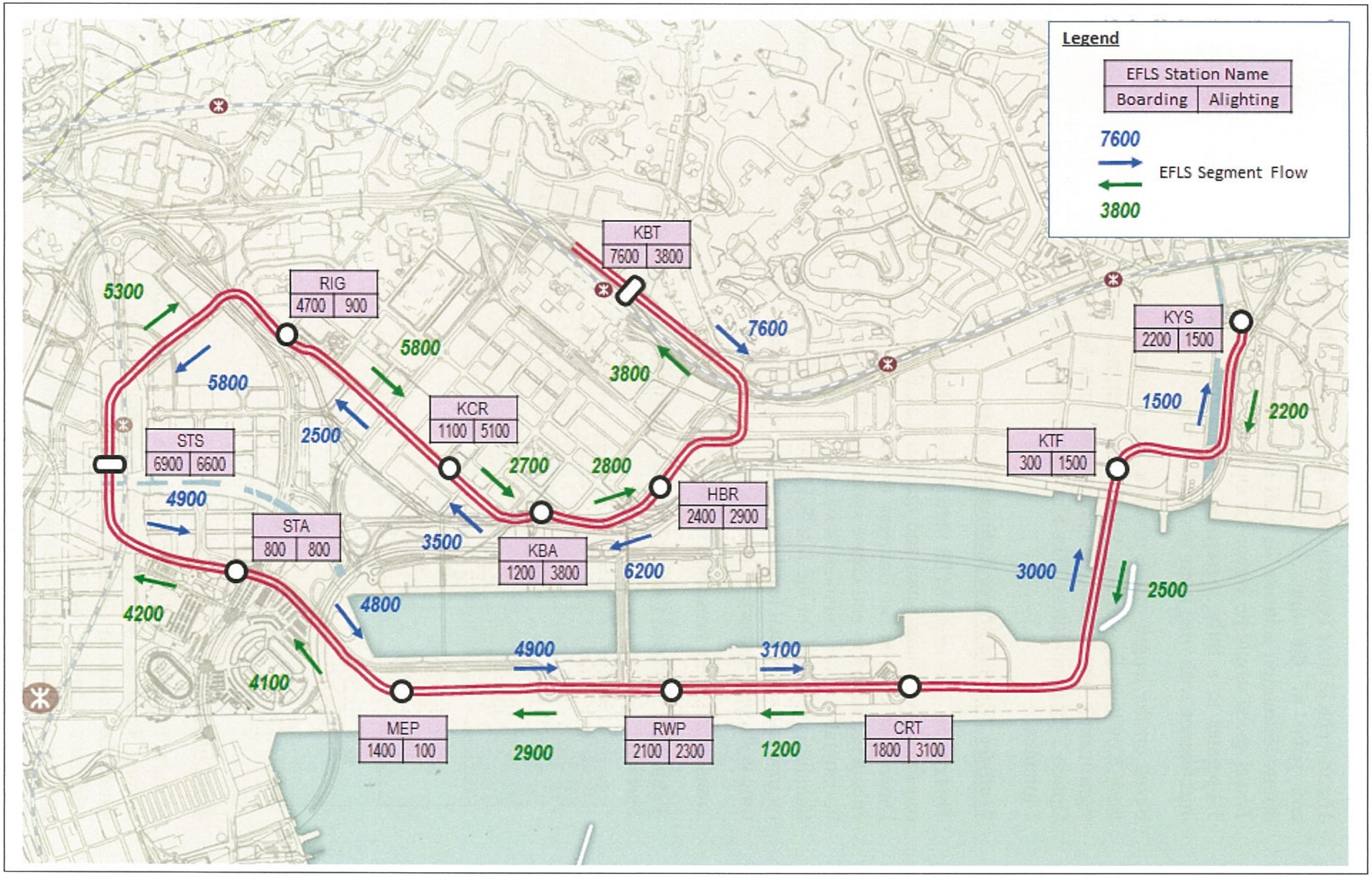


Figure 5.31: Peak Segment Flows for Option 3 (Elevated Dedicated System)

In-Vehicle Times

5.5.11 The in-vehicle time represents the time spent in the vehicle between the start and end point of the line. In-vehicle time excludes access time to/from the origin/destination stations, as well as waiting time spent on the station platform. Travel speed would be higher for Option 3 compared to Options 1 and 2 as Option 3 operates in a fully segregated viaduct that would be free from conflict and interference with road users and pedestrians.

5.5.12 Based on the length of the network, the estimated in-vehicle time is 16 minutes from Kowloon Bay to Kai Tak Cruise Terminal. This in-vehicle time would be significantly lower than the comparable times for Option 1 (at 23 minutes) and Option 2 (at 28 minutes). The Kai Tak Cruise Terminal to Kwun Tong would take 5 minutes.

Transfer Times to Major Railway Stations

5.5.13 This option links to the MTR network at the Kowloon Bay and Kwun Tong Stations (on the Kwun Tong Line) and the Kai Tak Station (on the Shatin-Central Line). Direct and convenient linkages to the greater MTR network are necessary to encourage ridership and create synergies. Walk transfer time is estimated based on horizontal/vertical distance between the EFLS stations and MTR stations. A vertical transfer is required for the Kai Tak Station, which is underground (and thus would require one additional level change than the at-grade Options 1 or 2 and thus access time is slightly longer).

5.5.14 Transfer times are presented below:

Table 5.10: Transfer Time to Major Rail Stations – Option 3 (Elevated Dedicated System)

MTR Stations	EFLS Stations	Waiting Time (min)	Average Walk Transfer Time (min)	Total Combined Transfer Time (min)
MTR Kowloon Bay Station	EFLS Station near Fuk To Street	1.25	6	7.25
SCL Kai Tak Station	EFLS Station near Station Square	1.25	5	6.25
MTR Kwun Tong Station	EFLS Station at King Yip Street	1.25	9	10.25

Road Impacts

5.5.15 In order to construct the elevated EFLS along the existing carriageway, i.e. Wang Kwong Road and Wai Yip Street, a central median of approximate 2.8m width would be provided (including a minimum 2.0m width for the column, and a minimum 0.4m for concrete profile barrier as protection for the column). In order to minimize the impact to the public, the number of traffic lanes provided would be maintained by converting footpath/planter space into carriageway. Adequate footpath width as per TPDM requirement would be provided for acceptable pedestrian service. A total area of about 4,600 m^2 would be lost, including both green and road space as presented in **Figure 5.32**.

5.5.16 For the land impacts, taking Wang Kwong Road near Lam Wah Street as an example (as shown in **Figure 5.29**), the existing configuration is a single 4-lane carriageway, i.e. two traffic lanes in each direction. The current width of the carriageway in each direction is about 7.3m for two lanes. A 2.5m wide planter and 3.2m wide sidewalk are provided in both directions.

5.5.17 To introduce elevated EFLS, a minimum width of 2.8m would be required for the central median. A width of 6.75m would be provided for the two southbound lanes, while 9.2m width would be provided for the two northbound lanes. This would include a minimum 6.75m carriageway as well as uncovered emergency vehicle access (EVA) with a minimum of 6m width. The existing planters in both directions would be removed and the sidewalk would be realigned accordingly.

5.5.18 To minimize the impact on the traffic junctions, the elevated EFLS would span the junctions and columns placed outside the junctions. This would allow current traffic turning movements to be maintained. The EVA provision requirement has been taken into account for the road layout development. For example on Wang Kwong Road, the footpath and planter space would be modified to provide sufficient carriageway width for EVA purpose.

5.5.19 For the EFLS alignment outside carriageway, the columns would be placed in off-road areas, which would impact the landscape/open space areas.

Traffic Impacts

5.5.20 The traffic impact induced by the elevated EFLS would be minimal as most of the proposed columns would be placed in the median or outside of existing general purpose traffic lanes. To accommodate the columns, a median width of 2.8m (2.0m for the column and 0.4m buffer on each side for) would be required. Therefore, the existing number of general purpose lanes could be maintained throughout the Option 3.

5.5.21 Regarding the possible impact on the runway section, columns of the elevated EFLS would be located within the planter area, footpath or central median and would thus not affect the arrangement or width of the carriageway. Therefore, no adverse traffic impacts would be expected as a result of implementing Option 3.

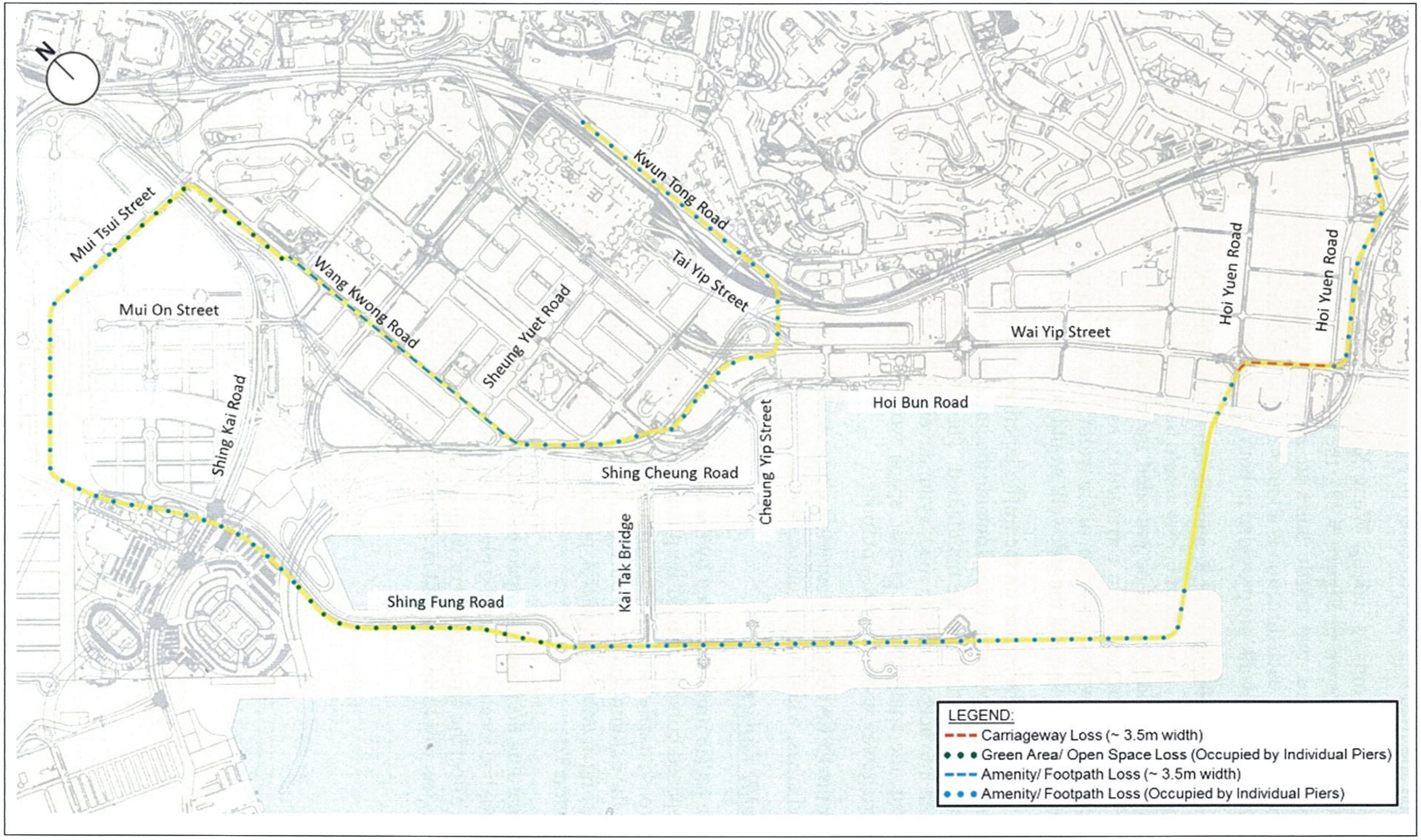


Figure 5.32: Loss of Road Space/ Open Space of Option 3 (Elevated Dedicated System)

Utility Impacts

5.5.22 Option 3 is an elevated option operating as a viaduct supported by columns or portals. Elevated stations would be provided at various key locations along the planned route. The alignment of Option 3 was specifically optimised to minimise potential viaduct column/portal implications on existing underground utilities. In general, the elevated Option 3 would have point-specific impacts where columns would be sunk into the ground to support the viaduct, whereas at-grade options would have continuous utility implications when laying the track along the alignment.

5.5.23 Total estimated utility relocation costs are about [redacted].

Environmental Impacts

5.5.24 It is anticipated that construction noise and dust impact would be generated during the construction of the viaduct structure. For train service to be operated during the night, adverse noise impacts on nearby noise sensitive receivers would not be anticipated with the implementation of practical noise mitigation measures such as reducing train frequency and reducing train speed. Those residents with windows directly overlooking the viaduct/stations would suffer residual visual impacts and mitigation measures would be required.

5.5.25 Other than the above implications, there would be no significant difference in the overall level of environmental impacts from the other three options. It is anticipated that the system can comply with the EIAO requirements with appropriate mitigation measures. Upon confirmation of the green transport mode, a Preliminary Environmental Assessment (PEA) would be conducted in the next study stage to confirm the environmental acceptability of the Preliminary Elevated EFLS Scheme and mitigation measures would be recommended where necessary.

5.5.26 The southern portion of the elevated structure in Option 3 would cross over the Kwun Tong Typhoon Shelter and extend towards the Tsui Ping River. It is anticipated that the visual resources of the Lei Yue Mun open harbour view would be partially obstructed by the viaduct from the viewing points of the Kai Tak Runway Park and Kung Tong Promenade. In addition, the extended portion of the elevated alignment towards the Tsui Ping River would potentially have some obstruction of the open view of the river channel.

5.5.27 Furthermore, the alignment would cross the future open space at the planned Kai Tak Station Square. The elevated structure (approximately 11-12m wide, supported by approximately 2.8m column piers) would partially block the open sky visual resources from the ground level. This visual obstruction would cause considerable adverse visual impact to pedestrians at the ground level, especially from the viewing point at the park, which would be beneath the viaduct. On the other hand, the alignment would run through the northern edge of the Station Square – thus as the viaduct structure would not be significant from distant views at higher levels, it would cause slight visual and noise impacts for surrounding residents in the future Comprehensive Development Area (CDA). Although the area under the viaduct could still function as public open space, the design and function of this area would be restricted, as the limited use of trees and planting might create some unpleasant space beneath. Furthermore, the elevated alignment would also cross over the proposed Kai Tak Landscape Deck and future Metro Park. This would split the open space, causing visual impact for visitors at the ground level.

5.5.28 The viaduct section along Kwun Tong Road would affect the existing mature trees in the central median. The height of the elevated structure and its supporting piers need to be carefully designed to minimise the impact on the trees.

5.5.29 The alignment for Option 3 would run adjacent to the planned view corridor of KTD, which might slightly affect the visual corridor towards Lion Rock from ground level views.

5.5.30 For the section running through the Kowloon Bay industrial area, since the existing urban setting was not visually pleasant, the structure of the elevated route would be considered compatible with the surrounding within this section.

Capital & O&M Costs

5.5.31 Project capital costs for Option 3 would include utility diversion costs, infrastructure costs for the viaduct, columns, vehicles and elevated stations, system costs, depot costs, as well as reprovisioning costs during construction.

5.5.32 Costs would amount to [redacted]. Higher costs are due to the cost of the elevated viaduct structure and elevated stations. Option 3 would also have higher system costs, with all resulting systems being installed aboveground.

5.5.33 Operating costs include the daily costs to run and operate the system (including operating staff and power consumption), as well as state-of-good repair and periodic replacement of rolling stock and equipment, averaged over a 50 year timeframe. Average annual O&M costs of Option 3 would be about [redacted], which would be higher than the O&M costs for either of the two at-grade options (Option 1 or Option 2).

Economic Benefit

5.5.34 This option would generate the largest time benefits compared with the other at-grade options as both EFLS passengers (receiving a time saving benefit compared with road-based public transport service as the elevated option is completely grade-separated and operates faster than in Options 1 or 2) and road-based public transport passengers (receiving a time savings benefit due to less congested road conditions due to EFLS diversion and shorter journey times) would save time under the with EFLS versus without EFLS scenarios. Overall, the EIRR of this option is estimated to be >1%, unlike the at-grade options with negative EIRRs. This EIRR result is only based on benefits/disbenefits for local users.

Construction Timeframe

5.5.35 The preliminary construction programme for the EFLS is primarily based on the following assumptions:

- The EIA and TRA (Tree Removal Application) approval must be obtained prior to commencement of the works contract;
- After commencement of the contract, tree removal would occur within 30 days and tree transplanting and removal would occur within 90 days;
- A dedicated corridor, as well as requisite lands and work areas would be available upon commencement of the contract; and

- Installation of trackworks and system-wide T&C and statutory inspections would take two (2) years.

5.5.36 At the beginning, land acquisition and site clearance works such as utilities diversions have to be carried out. Once these works are completed, civil works would commence, principally involving pile foundations, followed by viaduct construction, as well as station, depot and administration buildings construction. This basic infrastructure for the Option 3 EFLS would take approximately 3 years.

5.5.37 After these backbone structures are ready, various systems such as power supply and signalling system would be installed in the fourth year. Rolling stock purchased earlier would be deployed for testing and commissioning process afterwards together with its supporting systems which yields around a year. Once the EFLS has proven its safety and compliance to various statutory requirements, it would be opened for operation. The total construction period is expected to be 5 years excluding detailed design stage, land acquisition and site clearance works that are assumed to be finalised at the beginning of the 5 year construction period.[8]

5.5.38 A tentative construction programme for the elevated Option 3 is attached in **Appendix C** for information.

Summary of Option 3 (Elevated Dedicated Corridor)

5.5.39 Option 3 consists of a fully elevated APM or monorail system. As a fully elevated option, Option 3 would operate faster and more reliably than at-grade options as there would be no interference from other road vehicles or pedestrians along any portion of the alignment. At the same time though, costs would be higher to build and maintain the elevated options.

5.5.40 Key findings for this option are as follows (note – detailed comparison to other options is presented in **Section 5.7**):

- **High Ridership and Fast Journey Time** – Option 3 would generate a ridership of 260,000 daily riders and a peak load of 7,600 pphpd. Option 3 would provide the fastest journey time since it operates in a dedicated elevated corridor that would be free from interference from road vehicles experienced by the at-grade options. This directly translates into a more time-competitive options against other modes and a more attractive mode to potential users.
- **Minimal Traffic and Road Impacts** – Option 3 would operate on top of an elevated viaduct. The elevated viaduct would require columns to be placed at along the entire alignment. Given the relatively narrow width requirement of these columns (and protection barrier), the required area would typically be obtained by narrowing sidewalks or planted areas. In some spot locations, road lanes would need to be used for the column placement, however. Columns would also be placed away from junctions to minimise impacts on capacity. Therefore, minimal traffic and road impacts would be generated by this option.

[8] Construction of the viaduct in Option 3 (elevated option) would be divided into various sections and constructed concurrently. For Option 1 and 2 (at-grade option), temporary traffic arrangements have to be implemented to make space for construction, adjacent sections may not be able to construct concurrently subject to traffic impacts, therefore it takes longer time for construction. The three options are estimated have similar timeframe and compatibility.

- **Very High Capital and Relatively Higher Operating Costs, but Higher EIRR than At-Grade Options** – Compared to other options, capital and operating costs for Option 3 would be relatively high. Construction and maintenance of elevated structures and stations would be more intensive and costly than at-grade options. Unlike the at-grade options, the volume of riders forecast as well as the overall net time-savings benefit for Option 3 would be higher than that for the at-grade options, resulting in a better EIRR.

- **Landscape and Visual** – The viaduct piers would permanently occupy the future open space, causing a considerable visual impact. Although the area underneath could still function as open space, the elevated structure would create a shadow effect and potentially degrade the quality of the future landscape area. Furthermore, a viaduct crossing of the Kwun Tong Typhoon Shelter would obstruct the existing open harbour view of Lei Yue Mun. The overall visual impact of Option 3 would be relatively larger than that generated by either Option 1 or Option 2.

5.6 Option 4: Mixed Operations with At-Grade and Elevated Dedicated Corridor

General Description

5.6.1 Based on the findings from the previous sections, Option 3 (Elevated Dedicated Corridor) would operate more reliably due to the elimination of conflicts with vehicles and other road users and be able to serve higher overall capacities, but would have a high construction cost to construct a fully elevated guideway and elevated stations along the entire corridor. However, Option 1 (At-Grade Dedicated Corridor) would be less costly due to at-grade operations and stations, but also have issues with reliability and speed due to at-grade junctions, particularly in the congested built-up areas. Therefore, Option 4 has been conceived of as a compromise between Option 1 and Option 3.

5.6.2 Option 4 is aimed at reducing overall costs with an at-grade alignment along the former Kai Tak runway, where the traffic condition and potential impacts are less severe, coupled with an elevated guideway through the congested built-up areas. With "mixed operations" (with both at-grade and elevated portions), Option 4 (Mixed Operations) could provide a high level of reliability and time-savings similar to Option 3, but could be less costly than Option 3. Potential impacts in the built up areas from an elevated viaduct would be similar to those for Option 3. Meanwhile for the at-grade portion of the alignment, the impacts would be similar to those under Option 1. Potential impacts on infrastructure already under construction on the runway (i.e., the landscape deck, underground district cooling system, etc.) would be assessed as well.

5.6.3 Due to its mixed operations, Option 4 would be best operated as a modern tram/BRT given that the at-grade alignment on the runway would require level crossings and would not be fully segregated/separated. Thus, an automated system such as monorail or APM would be inappropriate from a safety perspective considering that pedestrians, cyclists and motor vehicles may cross the path of the EFLS at junctions and a driver would be needed for manual operations in such segments. Modern tram is assumed as the mode for Option 4.

5.6.4 Option 4 stations that are elevated would typically have a side platform configuration. At-grade stations would have a side platform configuration and typically be staggered across an intersection with platforms at the nearside of the junction to minimize potential delays on the modern tram.

Alignment

5.6.5 The alignment would mainly follow the elevated one (Option 3) described earlier, which would differ from the alignments of Option 1 or 2. The EFLS would operate as a single end-to-end line from Kowloon Bay to Kwun Tong via Kai Tak Cruise Terminal using KTTL to Kwun Tong.

5.6.6 The preliminary alignment would be approximately 9.0 km long and includes 12 stations. The alignment would be fully elevated except for an approximate 1.5 km stretch of at-grade operations on the runway between the Metro Park and the Kai Tak Cruise Terminal stations (along Shing Fung Road). The alignment is shown in **Figure 5.33**.

5.6.7 The option would directly serve two MTR Stations – the Kai Tak Station of Shatin-to-Central Link and Kowloon Bay Station of the Kwun Tong Line. The Kwun Tong Station on the Kwun Tong Line would be within a few blocks walk as well.

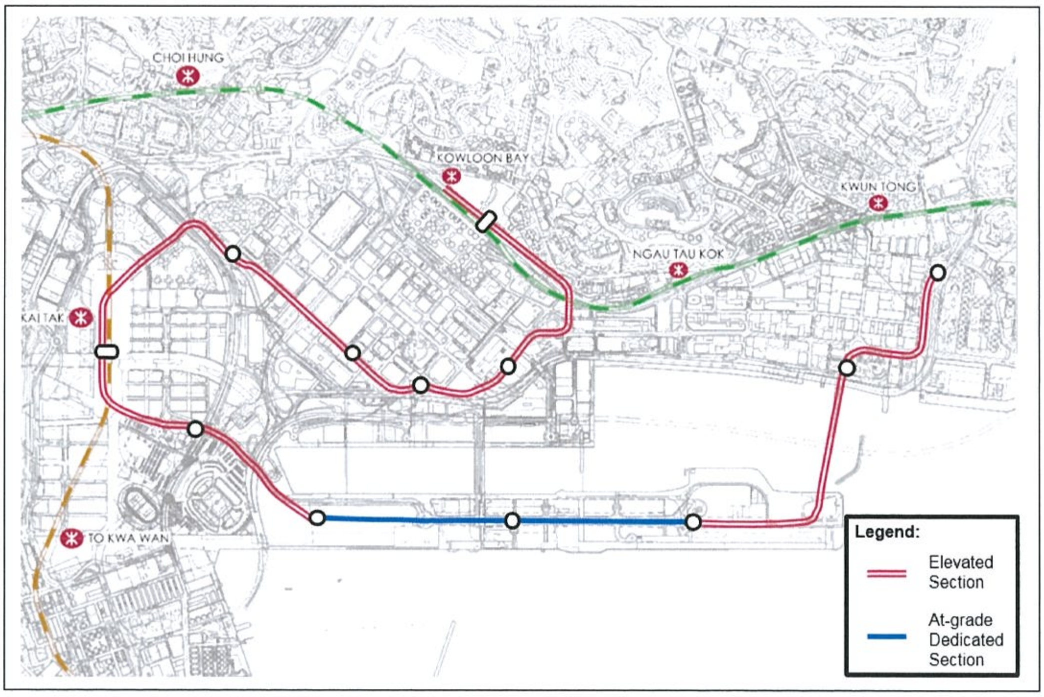


Figure 5.33: Proposed Alignment for Option 4 (Mixed Operations with At-Grade and Elevated Dedicated Corridor)

Level of Segregation and Corridor Width

5.6.8 Option 4 would operate in a fully segregated viaduct without interference or interaction with road users and pedestrians on the elevated section. Principally, dedicated lanes would be provided alongside the at-grade section of Shing Fung Road to improve travel speed, reliability and safety depending on available space (on a single section of Shing Fung Road, lanes are placed in the carriageway due to space limitations).

5.6.9 **Figure 5.34** depicts a typical cross section of elevated operations in the built-up area at Wang Kwong Road. The configuration of the elevated section would be the same as the elevated cross-section for Option 3. The column and any protection curb would require an average width of about 2.8m. The two lanes in each direction would be retained. The footpath at some locations would be further set back to facilitate uncovered emergency vehicle access (EVA) with a minimum of 6m width.

5.6.10 **Figure 5.35** depicts a typical at-grade section along Shing Fung Road. The configuration for the at-grade section would be similar to that for Option 1. Tracks would be separated on opposite sides of the road. The single track would have a width of 4.2m width and be located outside the carriageway when feasible to minimize the traffic impact. Nevertheless, the modern tram would be in conflict with the columns of the Landscape Deck and associated vertical circulation systems (elevators/escalators), therefore it would operate in the carriageway instead of in the walkway or planter. The resulting carriageway width would only be 3.1m wide. Furthermore, no public footpath would be provided at some sections due to footbridge landings, which would force pedestrians to walk through private lots.

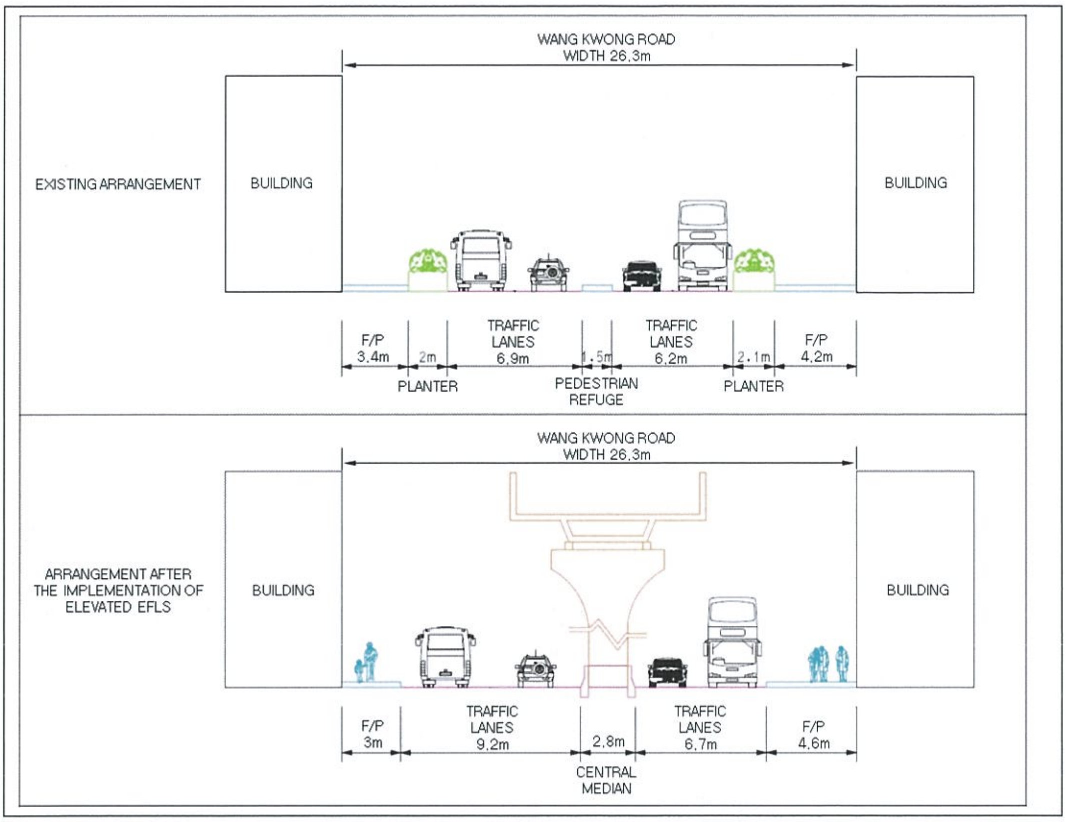


Figure 5.34: Typical Cross Section Plan of Option 4 – Wang Kwong Road (Before and After Implementation)

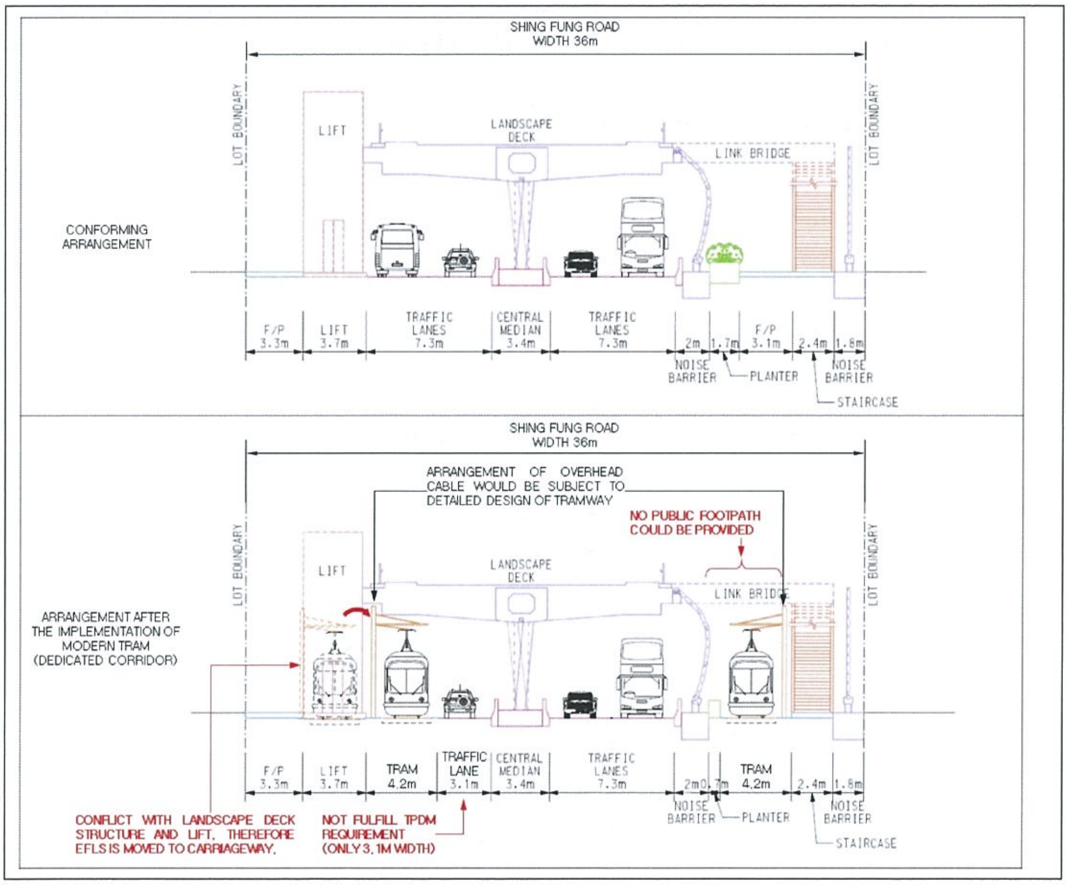


Figure 5.35: Typical Cross Section Plan of Option 4 – Shing Fung Road (Before and After Implementation)

Operating Assumptions

5.6.11 By considering the local conditions including the alignment, permissible speed, round trip time, signal system and to reduce the impact of Modern Tram to the road user especially across the road junctions, the adopted operating assumptions for this option are listed as follows:

Parameter	Assumption
Length	9.0 km
Number of Stations	12 stations
Headway	3.0 minutes
Schedule	Similar to existing MTR system for smooth and convenient transfers (6:00AM-1:00AM)
Runningway	Segregated elevated track (Kowloon Bay to Metro Park) At-grade dedicated corridor (Metro Park to KTCT) Segregated elevated track (KTCT to Kwun Tong)
Vehicle Type [A]	Modern Tram (holding 341 passengers/train at 4 ppsm or 511 passengers/train at 6 ppsm)
Capacity	6,800 pphpd (4 ppsm) / 10,220 pphpd (6 ppsm)
Fare	Please refer to **Appendix A4**.

Notes: [A] Train length assumed for the Option 4 modern tram would be longer than that for Options 1 and 2. Similar to Option 1 and 2, an Alstom tram is assumed, which could hold up to 341 passengers on a 45m train at 4 ppsm or up to 511 passengers at 6 ppsm. Option 4 trains would still fit into the proposed station platform length and would not require additional lengthening of the platforms. Therefore, capacity at a higher ppsm than 4 ppsm would connote a more crowded riding experience, which could still be accommodated by the train during these peak loading periods.

Performance against Criteria

5.6.12 **Table 5.11** presents a summary of option performance against the evaluation criteria. A summary of key findings follows below:

Table 5.11: Summary of Performance – Option 4 (Mixed Operations)

#	Analysis Criteria	Value
1	Daily Boardings	• 235,000 riders/day
2	Peak Hour Boardings per Direction	• 7,600 pphpd
3	In-Vehicle Journey Time (between Key Locations)	• Kowloon Bay to KTCT: 21 minutes • KTCT to Kwun Tong: 5 minutes
4	Peak Vehicle Requirement [A]	• 19 vehicles/trainsets
5	Transfer Time (between EFLS and Key MTR Rail Stations)	• Between MTR Kowloon Bay Station and EFLS Station EFLS Station near Fuk To Street: 7.5 minutes • Between SCL Kai Tak Station and EFLS Station at Station Square: 6.5 minutes • Between MTR Kwun Tong Station and EFLS Station at King Yip Street: 10.5 minutes
6	Traffic Impacts (Additional Minutes of Delay) [B]	• Minimal on elevated section (as no loss of lanes, although in some locations, lane width and footpath would be narrowed to accommodate the viaduct

#	Analysis Criteria	Value
		columns, which would not cause insurmountable traffic impacts) • Minimal on at-grade section (the EFLS would operate in the footpath / planter, outside of the carriageway, and would not cause insurmountable traffic impacts)
7	Road Impacts (Total Area Lost)	• 15,600 m^2 (including road space and greenspace, please refer to **Figure 5.37**)
8	Utility Impacts (Cost of Relocation)	• [redacted]
9	Environmental Impacts	• Construction noise and dust impact due construction of extensive viaduct structure • Potential visual impacts from viaduct • Complies with the EIAO requirements with appropriate mitigation measures.
10a	Project Capital Cost [C] (Dec 2015 Prices)	• [redacted]
10b	Annual O&M Cost	• [redacted]
11	EIRR	• Negative
12	Construction Timeframe	• About 5 years

Notes:

[A] Peak vehicle requirement is presented for information only and is not used directly to compare options, as the number of buses, trams or APM/monorail trains is not directly comparable. The number of peak vehicles is captured in the overall capital costs for a given option.

[B] The travel time impact is estimated using a traffic model that considers the modification of the road and junction layout, as well as method of control required by introducing at-grade EFLS.

[C] Project capital cost includes design, construction, vehicle, project management and project contingency costs. Furthermore, cost estimations are preliminary that are subject to change and update upon further design).

[D] EIRR is estimated based on benefits/disbenefits for local users (and excludes non-local users such as tourists, etc.) solely for the purpose of the evaluation of green transport modes.

Patronage

5.6.13 This option would generate an average weekday patronage of 235,000, with the peak segment handling up to 7,600 pphpd during the 2036 AM Peak in the southbound direction between Kowloon Bay Terminus (KBT) and Hoi Bun Road Station (HBR), just south of Kowloon Bay MTR Station as illustrated in **Figure 5.36**. As this option is a hybrid of Options 1 and 3, the alignment would be elevated throughout except for an at-grade section on the former Kai Tak runway. Thus, the patronage would be similar to Option 3, except those passengers along the former Kai Tak runway would divert to other public transport modes due to the relatively lower speed and longer journey time compared with Option 3.

5.6.14 Peak demand on these heavily used segments would induce a level of crowding above the ideal 4 ppsm design conditions. The peak demand would thus equate to a passenger density of 5 ppsm in this peak segment.

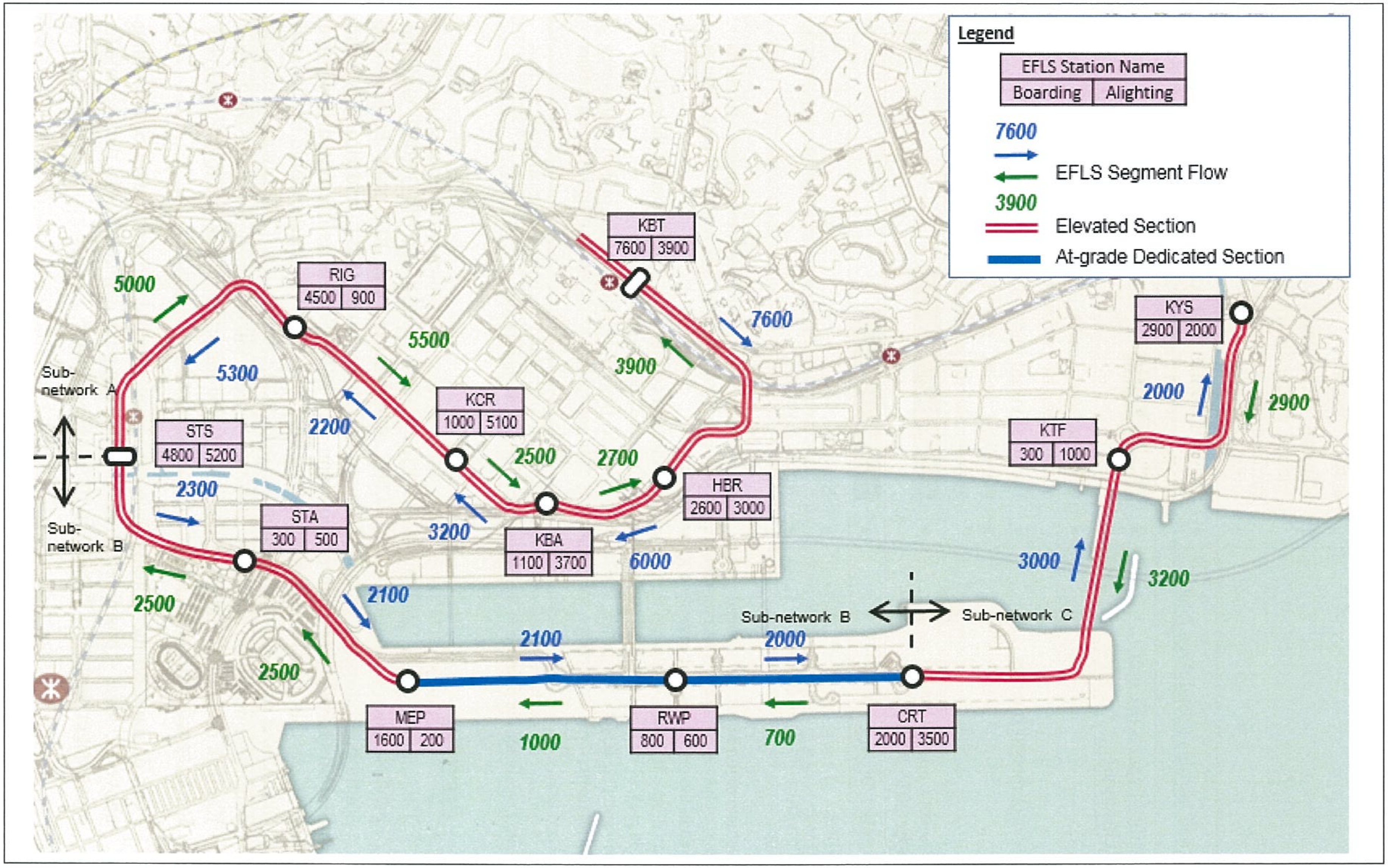


Figure 5.36: Peak Segment Flows for Option 4 (Mixed Operations with At-Grade and Elevated Dedicated System)

In-Vehicle Times

5.6.15 The in-vehicle time represents the time spent in the vehicle between the start and end point of the line. In-vehicle time excludes access time to/from the origin/destination stations, as well as waiting time spent on the station platform.

5.6.16 Based on the length of the network, the estimated in-vehicle time would be 21 minutes from Kowloon Bay to Kai Tak Cruise Terminal and 5 minutes from Kai Tak Cruise Terminal to Kwun Tong. The figures are fairly comparable to those in Option 3 (taking 16 minutes from Kowloon Bay to Kai Tak Cruise Terminal and 5 minutes from Kai Tak Cruise Terminal to Kwun Tong).

Transfer Times to Major Railway Stations

5.6.17 This option links to the MTR network at the Kowloon Bay and Kwun Tong Stations (on the Kwun Tong Line) and the Kai Tak Station (on the Shatin-Central Line). Direct and convenient linkages to the greater MTR network are necessary to encourage ridership and create synergies. Walk transfer time is estimated based on horizontal/vertical distance between the EFLS stations and MTR stations. A vertical transfer is required for the Kai Tak Station, which is underground (and thus would require one additional level change than the at-grade Options 1 or 2 and thus access time is slightly longer).

5.6.18 Transfer times are presented below:

Table 5.12: Transfer Time to Major Rail Stations – Option 4 (Mixed Operation)

MTR Stations	EFLS Stations	Waiting Time (min)	Average Walk Transfer Time (min)	Total Combined Transfer Time (min)
MTR Kowloon Bay Station	EFLS Station near Fuk To Street	1.5	6	7.5
SCL Kai Tak Station	EFLS Station near Station Square	1.5	5	6.5
MTR Kwun Tong Station	EFLS Station at King Yip Street	1.5	9	10.5

Road Impacts

5.6.19 For the elevated section (similar to Option 3), in order to construct the EFLS along the existing carriageway, i.e. Wang Kwong Road and Wai Yip Street, a central median of approximately 2.8m wide would be provided (including a minimum 2.0m width for the column, and a minimum 0.4m for a concrete profile barrier as protection for the column). In order to minimize the impact to the public, the number of traffic lanes provided would be maintained by reallocating/converting footpath and planter space into carriageway. Adequate footpath width as per TPDM requirement would be provided for acceptable pedestrian level-of-service.

5.6.20 The modern tram on the at-grade portion of the alignment along the runway would require a minimum track width of 4.2m in one direction, along with a 3.0m wide side platform. Due to the provision of the dedicated track, the road section would be highly constrained at some locations, only accommodating at most a single 3.1m wide traffic lane without a sidewalk. Furthermore, most of the planned planter areas would eliminated.

5.6.21 A total area of about 15,600 m^2 would be lost, including both green and road space as presented in **Figure 5.37**.

5.6.22 For the land impacts of the elevated section, using Wang Kwong Road near Lam Wah Street as an example (as shown in **Figure 5.34**), the existing configuration is a single 4-lane carriageway (with two lanes in each direction). The current width of the carriageway in each direction is about 7.3m for two lanes. A 2.5m wide planter and 3.2m wide sidewalk are provided in both directions. To introduce elevated EFLS, a minimum width of 2.8m would be required for the central median. A width of 6.75m would be provided for the two southbound traffic lanes, while a 9.2m width would be provided for the two northbound lanes and appropriate EVA width. The existing planters in both directions would be removed and the sidewalk would be adjusted accordingly.

5.6.23 To minimize the impact on traffic junctions, the elevated EFLS sections would span across junctions and columns would be located away from the junction. Existing traffic turning movements would be maintained. EVA requirements have been taken into account to develop the road layout.

5.6.24 For example on Wang Kwong Road, the footpath and planter space would be modified to provide minimal carriageway width for EVA purpose. On land / space constrained streets such as Wai Yip Street, median construction would require the temporary taking of one traffic lane (likely the westbound carriageway which is less busy). Minimum traffic lanes width as stipulated in TPDM or existing traffic lane width would be provided for the affected carriageway width. For the EFLS alignment outside the carriageway, columns would be placed outside of the traffic lanes (this would however generate some impact in landscaped/open space areas).

5.6.25 Regarding the land impacts on the at-grade section, the running tracks and the platforms on the runway would principally be located within adjacent open space to minimize traffic impacts (although again this would occupy open space).

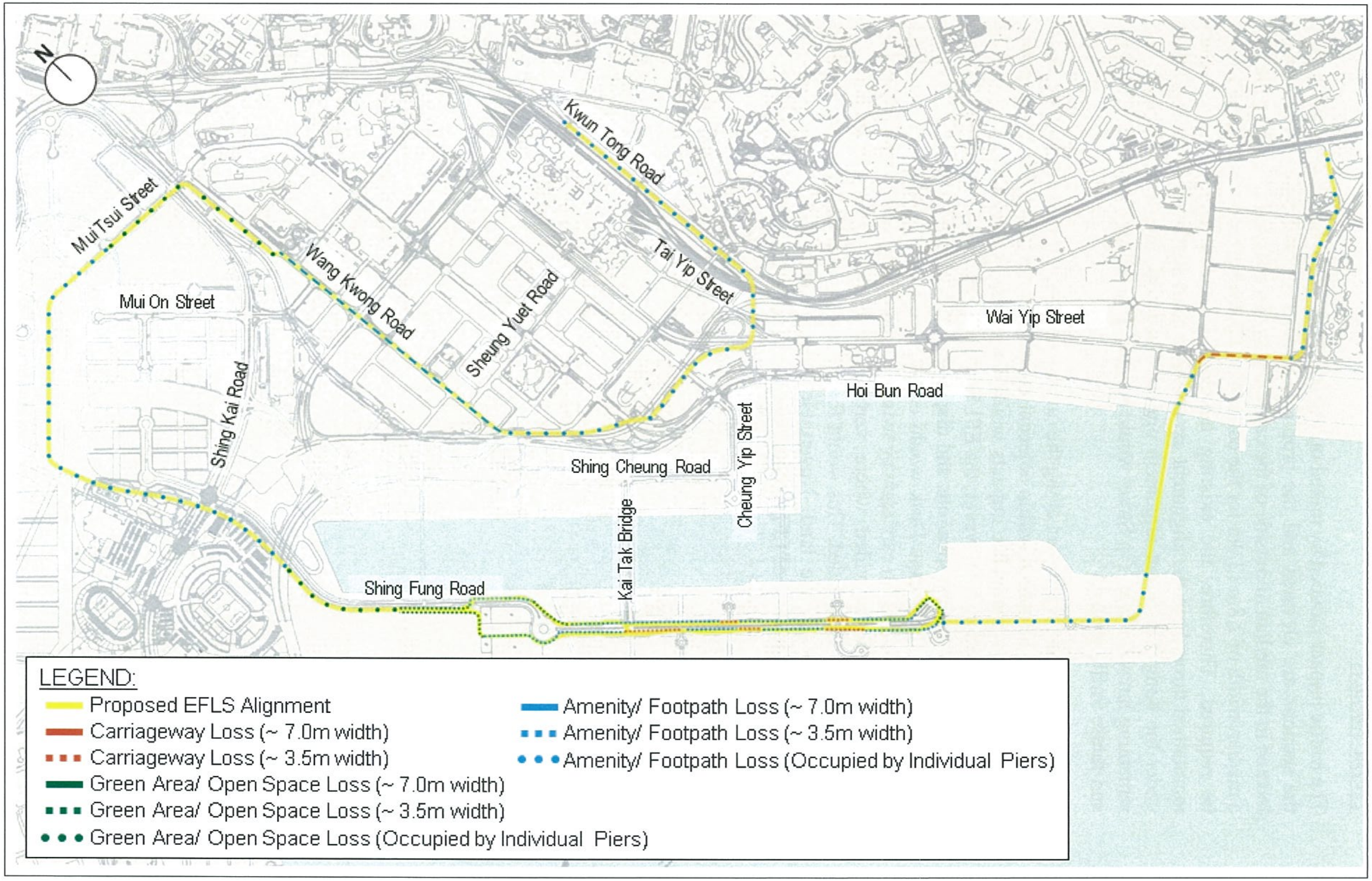


Figure 5.37: Loss of Road Space/ Open Space of Option 4 (Mixed Operation)

Traffic Impacts

5.6.26 The traffic impact induced by mixed operation EFLS would be minimal as most of the sections are elevated and the proposed viaduct support columns would be located in the median or outside of the carriageway. To accommodate the columns, a median width of 2.8m (2.0m for the column and 0.4m buffer on each side) would be required. Therefore, the existing number of general purpose lanes could maintained throughout the alignment except for a short section on Wai Yip Street under the King Yip Street alignment option. Even with this lane reduction, the remaining lanes on Wai Yip Street would be able to accommodate existing traffic and future traffic growth.

5.6.27 Regarding the possible impact along the runway section, the running tracks and the platforms would be placed within adjacent open space outside of the carriageway. Therefore, no adverse traffic impacts would be generally expected as a result of implementing Option 4. However, the EFLS tracks would need to be placed within the carriageway in some locations and displace proposed traffic lanes because the columns for the Landscape Desk would constrain use of the walkway or planter areas. Only a 3.1m width carriageway would be provided. Furthermore, no public footpath could be provided where vertical circulation facilities to/from the landscape deck are provided. This would force pedestrians walking along the street to walk through private land. Nevertheless, junction modifications would be required to suit the need of EFLS; these are presented in **Figure 5.38**.

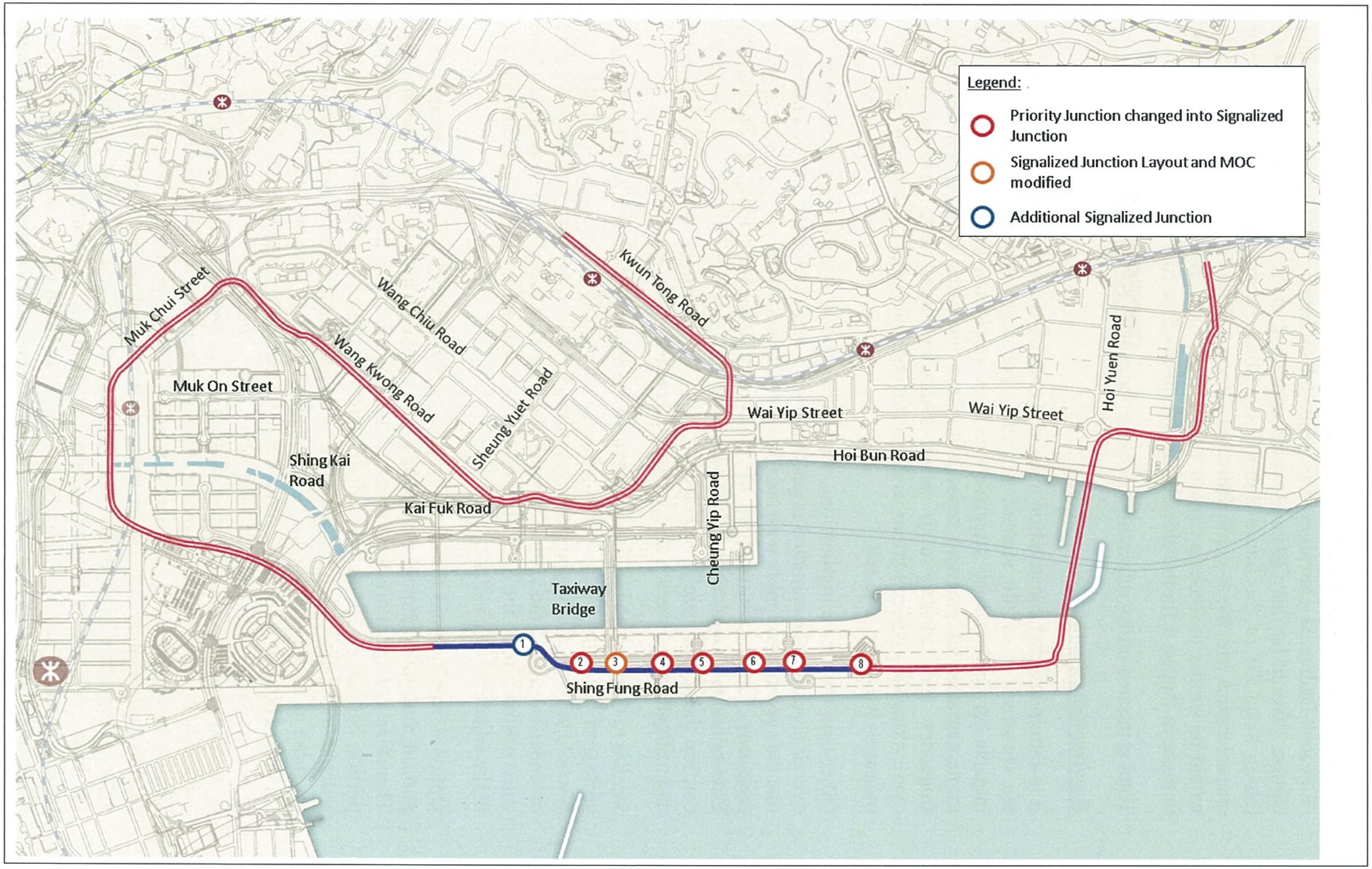


Figure 5.38: Junction Modifications Required for Option 4 (Mixed Operation)

Utility Impacts

5.6.28 Option 4 (Mixed Operations) would operate along the same alignment as Option 3 (Elevated Dedicated Corridor). The principal difference between Option 4 and Option 3 would be that Option 4 would operate at-grade on the Kai Tak runway (along Road D3 or the future Shing Fung Road) section, which shares similar characteristics with the at-grade dedicated Option 1. Thus Option 4's utility impacts would be similar to those in Option 1 for the at-grade runway portion and similar to those in Option 3 for the elevated option north of the runway.

5.6.29 Total estimated utility relocation costs are about [redacted].

Environmental Impacts

5.6.30 It is anticipated that construction noise and dust impact would be generated during the construction of the viaduct structure. For night operations, adverse noise impacts on nearby noise sensitive receivers would not be anticipated with the implementation of practical noise mitigation measures such as reducing train frequency and reducing train speed. Those residents with windows directly overlooking the viaduct/stations would suffer residual visual impacts and mitigation measures would be required.

5.6.31 Other than the above implications, there would be no significant difference in the overall level of environmental impacts from the other two options. It is anticipated that the system can comply with the EIAO requirements with appropriate mitigation measures. Upon confirmation of the green transport mode, a Preliminary Environmental Assessment (PEA) would be conducted in the next study stage to confirm the environmental acceptability of the Preliminary Elevated EFLS Scheme and mitigation measures would be recommended where necessary.

5.6.32 Similar to Option 3, the southern portion of the elevated structure in Option 4 would cross over the Kwun Tong Typhoon Shelter and extend toward the Tsui Ping River. It would still obstruct visual resources of the Lei Yue Mun open harbour view. The extended portion of the viaduct towards the Tsui Ping River would potentially have some obstruction on the open view of the river channel and also cause some impact to the adjacent Laguna Park.

5.6.33 Option 4 would avoid the visual impact to the future Kai Tak Landscape Deck portion, and the alignment would shift towards the edge of the future Metro Park. Therefore, the visual impact would be less severe than that for Option 3 within this portion. Similar to Option 3 though, the alignment would also cross the future open space at the planned Kai Tak Station Square and cause considerable visual impact for those at the ground level. The elevated structure (approximately 11-12m wide, supported by approximately 2.8m column piers) would partially block the open sky visual resources from the ground level. This visual obstruction would cause moderate to significant adverse visual impact to pedestrians at the ground level, especially from the viewing point at the park, which would be beneath the viaduct. Similar to Option 3, the alignment would run through the northern edge of the Station Square, thus the viaduct structure would not be significant from distant views at high levels. Therefore, the alignment would cause a slight visual impact for high level views for the adjacent residents at the future Comprehensive Development Area (CDA). Similar to the case of Option 3, the design and function of the underneath area would be restricted, as the limited use of trees and plantings might potentially create unpleasant space beneath.

5.6.34 The viaduct section along Kwun Tong Road would affect existing mature trees in the central median. The height of the elevated structure and its supporting piers need to be carefully designed to minimise the impact on the trees.

5.6.35 The alignment in Option 4 would run adjacent to the planned view corridor of KTD, which might slightly affect the visual corridor towards Lion Rock at views from the ground level.

5.6.36 For the section through the Kowloon Bay industrial area, since the existing urban setting was not visually pleasant, the structure of the elevated route would be considered compatible with the surrounding within this section.

Capital & O&M Costs

5.6.37 Project capital costs for Option 4 would include utility diversion costs, infrastructure costs for the viaduct, columns and elevated/at-grade stations, system costs, vehicle costs, depot costs, as well as reprovisioning costs during construction.

5.6.38 Costs would amount to [redacted]. Higher costs are due to the cost of the elevated viaduct structure and aerial stations that account for 80% of the alignment for Option 4. Compared to at-grade options, Option 4 would have higher system costs as a result of the elevated portion off the runway.

5.6.39 Operating costs include the daily costs to run and operate the system (including operating staff and power consumption), as well as state-of-good repair and periodic replacement of rolling stock and equipment, averaged over a 50 year timeframe. Average annual O&M cost for Option 4 would be [redacted], which would be higher than that for the fully at-grade options (Options 1 or 2), while being less than that of the fully elevated option (Option 3).

Economic Benefit

5.6.40 This option would generate positive time benefits, but somewhat less than that compared with Option 3, even though the cost would be lower. This is mainly due to extensive diversion of EFLS passengers to other public transport modes along the former Kai Tak runway (due to relatively longer journey times compared to Option 3), and thus a reduced net time savings. Overall though, the EIRR of this option is negative. This EIRR result is only based on benefits/disbenefits for local users.

Construction Timeframe

5.6.41 The preliminary construction programme for the EFLS is primarily based on the following assumptions:

- The EIA and TRA (Tree Removal Application) approval must be obtained prior to commencement of the works contract;
- After commencement of the contract, tree removal would occur within 30 days and tree transplanting and removal would occur within 90 days;
- A dedicated corridor, as well as requisite lands and work areas would be available upon commencement of the contract; and
- Installation of trackworks and system-wide T&C and statutory inspections would take two (2) years.

5.6.42 At the beginning, land acquisition and site clearance works such as utilities diversions have to be carried out. Once these works are completed, civil works would commence, mainly involving pile foundations, followed by viaduct construction, at-grade trackslab, elevated and at-grade stations, depot and administration buildings construction that form the basic infrastructure of the EFLS in this Option 4, which is estimated to take approximately 3 years.

5.6.43 After these backbone structures are ready, various systems such as power supply and signalling system would be installed in the fourth year. Rolling stock purchased earlier would be deployed for testing and commissioning process afterwards together with its supporting systems which yields around a year. Once the EFLS has proven its safety and compliance to various statutory requirements, it would be opened for operation. The total construction period would be 5 years excluding detailed design stage, land acquisition and site clearance works that are assumed to be ready at the beginning of the 5 year construction period.[9]

5.6.44 A tentative construction programme for the mixed at-grade and elevated Option 4 is attached in **Appendix D** for information.

Summary of Option 4 (Mixed Elevated and At-Grade Dedicated Corridor)

5.6.45 Option 4 has a mixed configuration with both elevated and at-grade operating segments. The at-grade portion on the runway would subject the modern tram to junction congestion and interference, while the elevated portion through the rest of the alignment would provide a more reliable and faster journey time without interference from other road vehicles or pedestrians. Option 4 has a similar performance with Option 3, but would have slightly longer travel times due to the at-grade runway section, which would result in slightly lower ridership numbers. Option 4 though would be marginally less expensive than Option 3, but more costly to build and maintain than either of the at-grade options.

5.6.46 Key findings for this option are as follows (note – detailed comparison to other options is presented in **Section 5.7**):

- **High Ridership and Fast Journey Time** – Option 4 would generate a ridership of 235,000 daily riders and a peak load of 7,600 pphpd. Option 4 would be slightly slower than Option 3, but would nonetheless provide a fast journey time since it operates principally in a dedicated elevated corridor that would be free from interference from road vehicles experienced by the at-grade options. This relatively fast journey time directly translates into a more time-competitive options against other modes and a more attractive mode to potential users.
- **Vehicle Crowding Higher than Desired** – Peak demand on the most heavily used segment would induce a level of crowding slightly above the ideal 4 ppsm density. The peak demand would thus equate to a passenger density of 5 ppsm in this peak segment. This implies that passengers would be more densely packed in the vehicles than desired, which could have impact on passenger

[9] Construction of the viaduct in Option 3 (elevated option) will be divided into various sections and constructed concurrently. For Option 1 and 2 (at-grade option), temporary traffic arrangements have to be implemented to make space for construction, adjacent sections may not be able to construct concurrently subject to traffic impacts, therefore it takes longer time for construction. The three options are estimated have similar timeframe and compatibility.

comfort and desire to use the EFLS. This could also elongate dwell times due to longer boarding/alighting times due to blockage of doorways by passengers. Nonetheless, this density would still be below 6 ppsm, which is often reached in peak periods on MTR trains.

- **Minimal Traffic Impacts** – Option 4 would operate on top of an elevated viaduct for most of its alignment, which would require support columns. Given the relatively narrow width requirement of these columns (and protection barrier), the required area would typically be obtained by narrowing sidewalks or planted areas to provide a wider median. Columns would also be placed away from junctions to minimise impacts on capacity. In the at-grade section of the alignment, the tracks would be located in the footpath or planter areas outside of the carriageway where possible. Thus in both options, minimal traffic impacts would be generated by this option.

- **Moderate Loss of Road / Green Space** – A total area of 15,600 m^2 would be lost due to the implementation of the modern tram system, most of this on the runway where the track would be located on the sidewalk or planter areas outside of the carriageway (although loss of road would occur at spot locations in both the elevated and at-grade sections).

- **High Capital and Relatively Higher Operating Costs and Negative EIRR** – Compared to other options, capital and operating costs for Option 4 would be relatively high and on par with that for Option 3. Construction and maintenance of elevated structures and stations would be more intensive and costly than at-grade options. Unlike the at-grade options, the volume of riders forecast as well as the overall net time-savings benefit would be higher under Option 4, however, the EIRR is still negative.

- **Landscape and Visual** – Similar to Option 3, viaduct columns would permanently occupy the future open space. The elevated structure would create a shadow effect and potentially degrade the quality of the future landscape area – causing a considerable visual impact in this section. The viaduct crossing of the Kwun Tong Typhoon Shelter would obstruct the existing open harbour view of Lei Yue Mun. The overall visual impact of Option 4 at Kai Tak Runway section, however, would not be as large as that from Option 3, but would still be larger than that generated by Option 1 or Option 2.

5.7 Comparison of Options

5.7.1 The following table compares the performance of the three options and identifies the option (or options) that perform the best in each of the Detailed Analysis criteria.

Table 5.13: Comparison of Performance for the Four EFLS Options

#	Analysis Criteria	Performance	1 (At-Grade Dedicated)	2 (At-Grade Shared)	3 (Elevated Dedicated)	4 (Mixed Operations)	Notes
1	Daily Boardings	Daily Passengers	102,000	82,500	260,000	235,000	• Option 3 would have the highest patronage at 260,000 riders/day due to its faster speed as it operates in a segregated corridor, without interference from vehicles and road users. • Option 4 would have the second highest ridership as it operates in an elevated guideway for most of the alignment, although the at-grade portion results in passenger diversion to other modes. • Option 1 would perform better than Option 2 as it operates in a dedicated corridor and does not share its track/lane with general traffic at-grade.
		Best Performer			✓		
2	Peak Hour Boardings	Hourly Passengers	3,300	3,000	7,600	7,600	• Option 3 and Option 4 would have the highest peak hour boardings compared to Option 2 and for Option 3. The difference would be due to the level of segregation and thus travel speed/time. • Peak loading on the peak segment would exceed the desired passenger density of 4 ppsm for Options 1 (6 ppsm), Option 2 (5 ppsm), and Option 4 (5 ppsm). This implies a higher level of crowding compared to Option 3. Therefore, Option 3 would score the best, even though both Options 3 and 4 have the same level of peak boardings.
		Best Performer			✓		
3	In-Vehicle Journey Time (Kowloon Bay to Kai Tak Cruise Terminal)	Time (Minutes)	23	28	16	21	• From Kowloon Bay to Kwun Tong, Option 3 would have the fastest in-vehicle time of 16 minutes and be nearly 5 minutes or 24% faster than Option 4, 7 minutes or 30% faster than Option 1 and 12 minutes or 43% faster than Option 2. • Option 3 would outperform Option 4 with its at-grade section. • Option 1 would outperform Option 2 as Option 1 operates in a dedicated corridor, while Option 2 operates in shared lane.
		Best Performer			✓		

#	Analysis Criteria	Performance	1 (At-Grade Dedicated)	2 (At-Grade Shared)	3 (Elevated Dedicated)	4 (Mixed Operations)	Notes
4	Peak Vehicle Requirement	Peak Vehicles	15	18	21	19	• Option 3 would require the most peak vehicles given its 2.5 minute headway, followed by Option 4 with 3 minute service. • Option 1 would require the fewest peak vehicles given faster journey time than Option 2.
		Best Performer	Note these are not directly comparable due to different vehicle types. Peak vehicle requirements comprise part of the total capital costs for the options.				
5	Transfer Time	Time (Minutes)	7-14	7-16	6-10	7-11	• Option 3 would have a marginally better transfer performance in terms of transfer time (which includes walk access and wait time) compared to the other options.
		Best Performer			✓		
6	Traffic Impacts	Traffic Impacts (Delay in Travel Time (Minutes))	From 3 to 20 minutes	From 3 to 5 minutes	Minimal	Minimal	• Option 3 would have minimal traffic impact as no general traffic lanes would be lost in the built up areas or on the runway. • Option 4 would have minimal traffic impacts, although along the runway, local stretches of track may be located in the carriageway when sidewalk / planter area is unavailable. Thus, Option 3 would perform better than Option 4. • Option 1 would generate the most severe delays and queues as two lanes of traffic would be reallocated for the dedicated track. • Option 2 would result in slower EFLS traffic, but not major road traffic impacts as no lanes would be reallocated, but additional EFLS vehicles would share the road with traffic.
		Best Performer			✓		
7	Road / Land Impacts	Area Lost (m^2)	63,000	8,600	4,600	15,600	• Option 3 would result in the lowest amount of total road area lost (about 4,600 m2). • Option 1 would require significant reallocation of road space to the EFLS lane/track and thus the highest amount of road space lost (about 63,000 m2 including greenspace). • Option 4 would require a moderate reallocation of road space since it would operate elevated through existing built up areas.
		Best Performer			✓		

#	Analysis Criteria	Performance	1 (At-Grade Dedicated)	2 (At-Grade Shared)	3 (Elevated Dedicated)	4 (Mixed Operations)	Notes
8	Utility Impacts	Cost (HK$)	[redacted]	[redacted]	[redacted]	[redacted]	• Options 3 and 4 would have the lowest utility relocation costs [redacted]. These options have fully or partially elevated alignments, which reduces utility relocation to specific point locations along the viaduct. • Options 1 and 2 would generate higher utility relocation costs due to the need to fully relocate utilities beneath the at-grade track or bus lane. Option 2 would have the highest utility relocation cost of about [redacted]. This would be higher than that for Option 1 as the alignment connects to Kowloon Bay, which would highly impact existing underground utilities.
		Best Performer			✓		
9	Environ-mental Impacts	Impacts	Complies with EIAO requirements subject to PER				• Option 3 would generate visual impacts from the elevated viaduct that neither Option 1 nor 2 generate. • Option 4 would have visual impacts on its elevated portion, but also generate impacts on its at-grade portions. • Options 1 and 2 would run through the edge of the open space and occupy/bisect parts of this area. Options 3 and 4 would also dissect and degrade the quality of the open space. • Option 1 and Option 2 would generate environmental impacts due to the permanent loss of planned open space at Kai Tak Station Square and Avenue Park from the at-grade track. However, Option 3 and Option 4 would also degrade the quality of open space due to its elevated viaduct. Options 2, 3 and 4 would generate environmental impact due to potential impacts on existing trees along Kwun Tong Road. • Overall, the four options would generate different impacts in terms of visual and landscape aspects. However, other environmental impacts are considered to be the same among the four options. Since each of option would comply with EIAO requirements with appropriate mitigation measures, the overall performance is considered to be the same.
		Best Performer	✓	✓	✓	✓	

#	Analysis Criteria	Performance	1 (At-Grade Dedicated)	2 (At-Grade Shared)	3 (Elevated Dedicated)	4 (Mixed Operations)	Notes
10a	Project Capital Cost	Cost (HK$)	[redacted]	[redacted]	[redacted]	[redacted]	• Option 3 would be the most expensive option by far at [redacted] for the elevated viaduct and stations. • Options 1 and 2 would have the same cost due to similar trackwork and station costs. • Option 4 would fall between Options 1 / 2 (at-grade) and 3 (elevated) due to its mixed operations.
		Best Performer	✓	✓			
10b	Annual O&M Cost	Cost (HK$) / Year	[redacted]	[redacted]	[redacted]	[redacted]	• Elevated systems would have a higher maintenance cost than at-grade systems due to their elevated structures/stations. • Option 1 would perform slightly better than Option 2 as the shared track would require higher maintenance as other road vehicles would be constantly driving over the right-of-way.
		Best Performer	✓				
11	Economic Benefit (only for Local Users)	EIRR	Negative	Negative	>1%	Negative	• Option 3 performs better than all other options as it generates a positive EIRR. • Option 3 would perform the best due to faster travel time for EFLS passengers as well as other road-based public transport and road users by removing EFLS vehicles from the road and providing faster and more reliable service than Options 1 or 2. • Option 3 performs better than Option 4 as its alignment would be fully elevated throughout.
		Best Performer			✓		
12	Construction Timeframe	Years	5	5	5	5	• All options would have a five year implementation timeframe and perform similarly.
		Best Performer	✓	✓	✓	✓	

5.7.2 Key findings from the table are as follows:

- Option 3 would generate a better EIRR than all other options.
- Options 3 and 4, although more costly, would provide a superior level of service for customers in terms of travel time and reliability, which is reflected in the higher daily and peak hour boardings forecasted. Options 3 and 4 would generate nearly three times the ridership of Option 1 and more than double the ridership of Option 2. This is a direct result of the fully elevated corridor that Option 3 operates in and the mostly elevated alignment of Option 4, which would eliminate interference and conflict with road vehicles and junctions. Option 1 would be constrained by junction interference, while Option 2 would operate the slowest due to use of a shared corridor where road vehicles would also operate in the same lane/track.
- Options 3 and 4 would have minimal impact on traffic and the road itself as they would be completely (Option 3) or mostly elevated (Option 4). Options 3 and 4 also would not require extensive reallocation of existing general purpose travel lanes for the EFLS, thereby maintaining existing road and junction capacity, and potentially reducing the number of vehicles on the road. Options 1 would require the reallocation of roadspace in the built up area and in some portions of the runway. Option 2 would require spot reallocation of roadspace at stations in the built up areas and at select locations along the runway.
- While Options 1, 2 and 4 would be less costly in terms of capital and operating costs and would comply with EIAO requirements subject to a PER similar to Options 3, Option 3 is still considered superior due to its fully elevated alignment and positive EIRR.

6 Summary and Recommended Option(s)

6.1 Summary

6.1.1 This Report presents the EFLS green transport mode selection process and key screening and evaluation criteria. The High-Level screening assessed the eleven prospective green transport modes against four visionary goals including capacity, reliability, efficiency, and sustainability. Four green transport modes met all four goals – APM, BRT, modern tram and monorail. For the Detailed Analysis, these modes were combined based on common operating and infrastructure characteristics into two groups: (i) at-grade systems including BRT and modern tram; and (ii) elevated systems including APM and monorail. A mixed operation option with both elevated and at-grade sections was also evaluated.

6.1.2 Each of these options underwent more detailed analysis including characterisation of road impacts, patronage, travel time, costs and EIRR. At-grade options were further divided into dedicated corridors (where the equivalent of two general purpose travel lanes would be reallocated for EFLS use) and shared corridors (where EFLS and general traffic mix in the same lanes/corridor). The at-grade dedicated corridor option was not recommended due to the severe traffic and road impacts caused by the loss of two travel lanes along the entire EFLS alignment. The at-grade shared option was not recommended due to poor EFLS performance in terms of ridership and travel time, as well as EFLS reliability and most importantly a negative EIRR, which implies no net benefit. The mixed operation option, while generating a positive EIRR and sizeable ridership was also not recommended due to the at-grade portion on the Kai Tak runway, which could generate impacts on speed and reliability given potential conflicts with road users and pedestrians.

6.2 Recommended Option(s)

6.2.1 The recommended option to carry forward is a fully elevated option (Option 3). This option generates the highest EIRR, in addition to the highest levels of ridership and best performance in terms of travel and transfer time compared to the mixed operations Option 4. As a fully elevated option, Option 3 would not be subject to interference from other road vehicles or pedestrians along its entire alignment.

6.2.2 The recommended elevated Option 3 at this point assumes either APM or monorail as the green transport mode. Following the outcome of the PC, more detailed analysis would be conducted to select the most appropriate green transport mode for KE's EFLS, which will be delved into further in the ensuing stages of this study.

Appendix A

Fare Tables for the Four EFLS Options (For Internal Reference Only)

Appendix B

Implementation Schedule - Option 1/2 (At-Grade Dedicated and At-Grade Shared Corridor) (For Internal Reference Only)

Appendix C

Implementation Schedule - Option 3 (Elevated Dedicated Corridor) (For Internal Reference Only)

Appendix D

Implementation Schedule - Option 4 (Mixed Operations) (For Internal Reference Only)

Appendix E

Utility Implications of Prospective EFLS Options
(For Internal Reference Only)

Appendix F

Topical Study on Assessment of Suitability of Modern Tramway for Kowloon East

1 Purpose of the Topical Study

1.1 Purpose of Topical Study

1.1.1 This Topical Study seeks to describe modern tramway technology/systems and assess its suitability as a potential Environmentally Friendly Linkage System (EFLS) within Kowloon East (KE).

1.2 Use and Applicability of Topical Study

1.2.1 Although part of the latter Report, the Topical Study is meant to be a stand-alone document that for public outreach and engagement. Therefore, the level of detail and information in this summary has been modified to suit the target audience.

2 Summary of Modern Tram Systems

2.1 Introduction to Modern Tram Systems

2.1.1 Modern trams are rail vehicles of varying lengths that run on tracks which are typically integrated into public areas such as streets and parks. They are powered by electricity that the vehicles source from either overhead catenary or in-ground contact and contactless systems. Modern trams can operate in:

- Fully segregated corridors with no grade crossings for vehicles or pedestrians (i.e., crossings are grade-separated);
- Dedicated corridors with at-grade crossings for road traffic and pedestrians;
- Shared corridors with other vehicles; or
- Shared corridors with pedestrians.

2.1.2 Segregation refers to the degree/extent in which interaction or mixing with other vehicles and road users such as cyclists and pedestrians occur. The level of segregation impacts the speed and reliability of modern tram, as more frequent conflicts and interference results in slower operating times and more delays. Based on the nature of modern tram, there are two levels of segregation which are described below.

Table 2.1: Level of Segregation and Operating Implications on Modern Tram

	Shared Corridor	Dedicated Corridor
Level of Segregation from Vehicles and Mixed Flow Traffic	**No Segregation** Modern tram use the same track with other traffic such as private vehicles, taxis, and/or buses	**Partial Segregation** Modern tram interact with pedestrians / vehicles occurs at signalised intersections (sometimes with safety barriers)
Operational Implications (on Journey Time and On-Time Performance)	**High** Modern tram impacted by road and junction traffic and congestion, and turning vehicles	**Moderate** Modern tram impacted by junction traffic and turning vehicles
Potential for Driverless Operations	No	No

2.1.3 It is common for a modern tram system to operate in all fashions along a route, although segregated and dedicated corridors can allow for better speed and reliability than shared lanes, with most new modern tram systems operating in dedicated corridors instead of shared lanes. Although modern trams typically run along streets at-grade, sections of track can also be elevated or run underground, if available land area proves to be a prohibitive constraint. This flexibility allows for modern trams to be used to overcome various space constraints. When operating along at-grade streets, signal priority is typically provided to reduce intersection delay.

2.2 Precedent Systems

2.2.1 Modern tram systems today can be divided into two types. The first type are those that evolved from historic tram and trolley lines – principally seen in Western and Central Europe. Cities such as Amsterdam (Netherlands), Leipzig (Germany), and Zurich (Switzerland) upgraded historic lines to handle modern trams in order to maintain continuity and utilise infrastructure and systems already in-place. In many of these locations, modern tram operates in shared lanes with other traffic.

2.2.2 Newer systems such as those in French cities such as Bordeaux and Nantes, as well as Dublin (Ireland), Barcelona (Spain), Sydney (Australia), and Dallas, Houston, and Phoenix (United States) have implemented modern tram in new corridors – often with the goal of remaking the street and urban feel, as well as using abandoned freight rail corridors. In these newer locations, most modern tram systems operate in dedicated corridors, with at-grade crossings at intersections. In Hong Kong, the Tuen Mun Light Rail is an example of a modern tram system that operates in segregated right-of-way as well as shared street environments with motor vehicles at intersections.

3 Key Characteristics of Kowloon East

3.1 Description of Kowloon East

3.1.1 Kowloon East consists of diverse areas with different land uses and development plans. Kwun Tong and Kowloon Bay represent higher-density built-up areas that are transforming into vibrant mixed use areas as shown in **Figure 3.1**. While significant travel demand would be generated in these areas, there are several significant physical constraints including: (i) heavy congestion on the existing roadways as well as street activities in terms of loading/unloading of freight and cargo, as well as heavy pedestrian movements; (ii) lack of available land to widen the roads given existing development and planned growth; (iii) closely spaced junctions as well as access to/from buildings (i.e., run-ins); and (iv) extensive underground in-situ utilities.

3.1.2 The Kai Tak Development (KTD) will include residential, open space, sports activity, business, entertainment, and tourism nodes. Compared to the Kwun Tong and Kowloon Bay areas, the Kai Tak runway will be newly developed with new roads and new developments, along with a Landscape Deck down the main road spine. The main issue would be integration with these new developments, the Landscape Deck and the new railway stations of the Shatin-Central Link.

3.2 EFLS Connectivity Role in Kowloon East

3.2.1 As an intra-district connector, the EFLS should strive to directly and conveniently serve these areas to enhance mobility for residents, employees, and visitors to/from KE. In addition, EFLS should allow for convenient interchange with major public transport systems operating in the area, including the Shatin-Central Link (including the MTR Kai Tak Station), and the Kwun Tong Line (including the MTR Kowloon Bay, Ngau Tau Kok, and Kwun Tong stations).

3.2.2 Many of the key attraction points are being implemented over the next decades (which are depicted in the figure below). Total non-domestic GFA will increase from 7.0 million sqm in 2014 to 10 million sqm in 2036, an increase of 3.0 million sqm or 43%. The existing supply of commercial/office floor area in KE is about 2 million sqm. KE has the potential to supply an additional commercial/office floor area of about 5 million sqm, bringing the total commercial/office supply to about 7 million sqm in the long run.[1]

[1] GFA, population and employment data are from the Enhanced 2011-based TPEDM, the latest RDOP of the Kai Tak Development (incorporated the Rethink 2 parameters) and from information provided by EKEO.

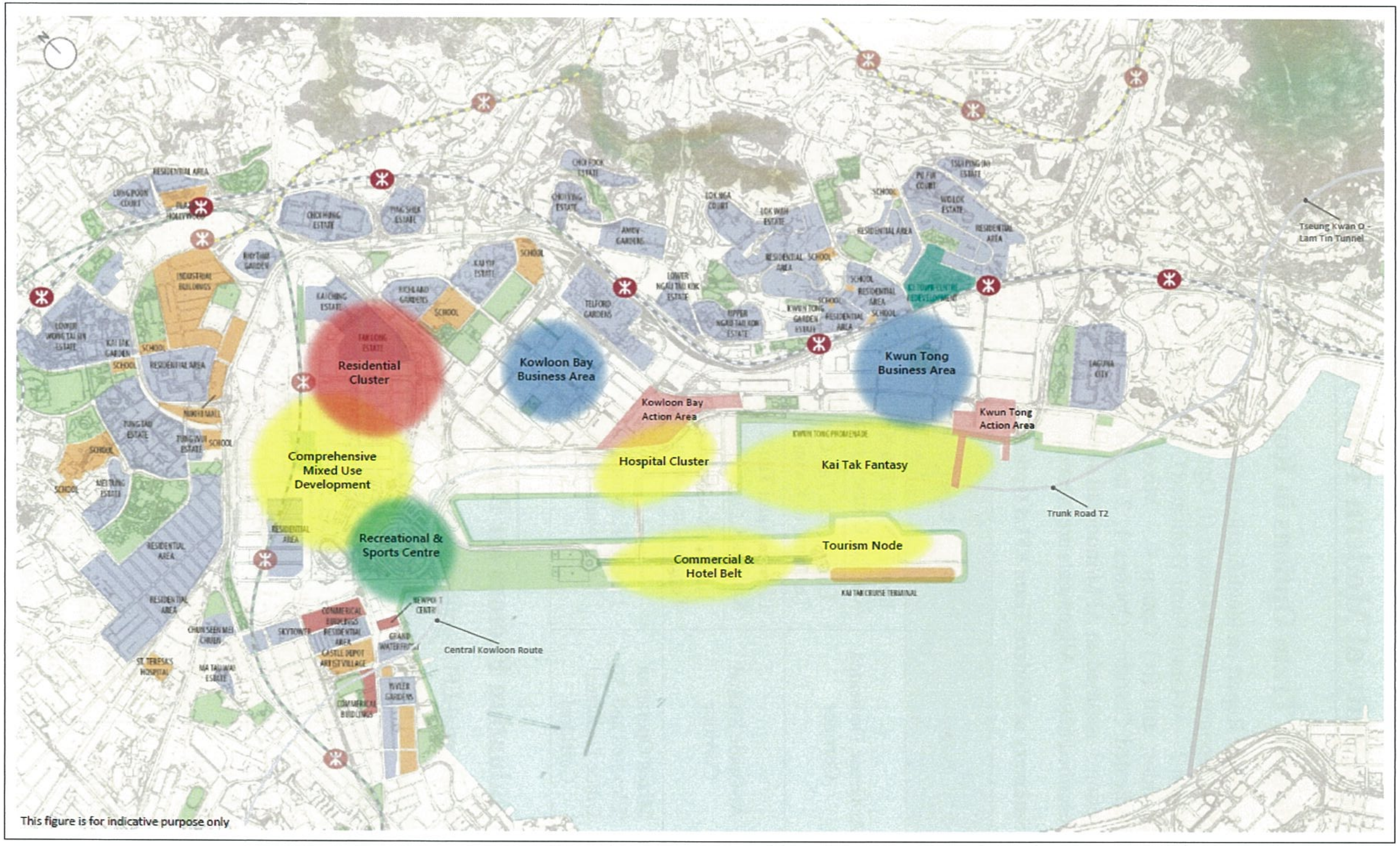


Figure 3.1: Key Attraction Points in Kowloon East to be Served by EFLS

4 Suitability of Modern Tram in Kowloon East

4.1 Modern Tram Options in Kowloon East

4.1.1 As per the Report on Identification of Suitable Green Public Transport Modes, four EFLS options were assessed: (i) Option 1 – At-Grade Dedicated Corridor; (ii) Option 2 – At-Grade Semi-Dedicated Corridor; (iii) Option 3 – Elevated Dedicated Corridor; and (iv) Option 4 – Mixed Operation with Elevated and At-Grade Dedicated Corridor. Options 1, 2 and 4 assumed a modern tram system, while Option 3 assumed an APM/monorail system. The relevant modern tram options are described below. Alignments are presented in the following sections for each option.

Table 4.1: Summary of Modern Tram EFLS Options under Consideration

Option	Name	Lines	Length (km)	Number of Stations	Peak Headway (mins)
1	At-Grade Dedicated Corridor	Line 1 (Ngau Tau Kok to Kai Tak Cruise Terminal)	6.6	12	6.0
		Line 2 (Kai Tak Cruise Terminal to Kwun Tong)	3.5	5	6.0
2	At-Grade Shared Corridor	Line 1 (Ngau Tau Kok to Kai Tak Cruise Terminal)	6.6	11	6.0
		Line 2 (Kai Tak Cruise Terminal to Kwun Tong)	3.5	5	10.0
4	Mixed Operation (Elevated and At-Grade Dedicated Corridor)	Line 1 (Kowloon Bay to Kwun Tong)	9.0	12	3.0

4.2 Evaluation Factors for Modern Tram

4.2.1 The potential EFLS options were assessed against a set of criteria identified below:

Table 4.2: Evaluation Factors for Modern Tram EFLS Options

#	Analysis Criteria	Description
1	Daily Patronage	• The volume of passengers boarding modern tram over a typical weekday.
2	Peak Hour Patronage	• The volume of passengers boarding modern tram over a typical peak hour (in pphpd).
3	In-Vehicle Journey Time	• The total duration of time (in minutes) spent on the modern tram from a specific origin to a specific destination.
4	Connection to MTR Stations	• The total duration of time (in minutes) transferring from the modern tram to the MTR lines or attraction points will be estimated. Transfer time only includes the walk access time (including horizontal distance and vertical level changes) and includes wait time. • Potential transfer stations for modern tram include but not limited to: (i) Kwun Tong Station; (ii) Ngau Tau Kok Station; (iii) Kowloon Bay Station; and (iv) Kai Tak Station.

#	Analysis Criteria	Description
5	Traffic Impacts	• The extent and scope of impact on road traffic in terms of queuing and travel speed (km/hour) from the implementation of modern tram.
6	Road and Land Impacts	• Physical area, traffic lane, sidewalk, planting area, open space, junction modification including traffic signalling system and space implications on roads from the implementation of the modern tram.
7	Utility Impacts	• Extent of utility impacts from the implementation of the modern tram in terms of total utility diversion costs and time implication.
8	Environmental Impacts	• Extent of environmental impacts from the implementation of the modern tram.
9	Project Capital & O&M Costs	• The total cost to design and construct the modern tram including systems, stations, vehicles, etc. (in December 2015 prices). • Total annual cost to operate and maintain the system (including state of good repair and periodic replacement of systems, vehicles, etc.)
10	EIRR	• The economic internal rate of return (EIRR), which measures the generated economic benefit from the modern tram, given capital, operating, and state-of-good repair costs.

5 Option 1 – Modern Tram in At-Grade Dedicated Corridor

5.1 General Description

5.1.1 Option 1 represents an at-grade system that operates in dedicated lanes/track that are segregated from adjoining mixed flow traffic and pedestrians for most of the alignment. Interaction with other road users occurs at at-grade junctions with the corridor. Alignment would follow that proposed by Hong Kong Tramways. Typically, stations would be at-grade and have a side platform configuration and be staggered across the intersection to reduce required width at the station. Furthermore, stations would be located at the nearside of the intersection to minimise delays on the modern tram.

5.1.2 At-grade modern tram in a dedicated corridor would operate in its own travel lanes, segregated from general traffic. The recommended alignment would be divided into two lines: (i) Line 1 (Blue Line) from near Ngau Tau Kok to Kai Tak Cruise Terminal; and (ii) Line 2 (Green Line) from Kwun Tong Ferry Pier to Kai Tak Cruise Terminal via the Kai Tak Bridge, which is the existing Taxiway Bridge. Line 1 would be approximately 6.6 km long, while Line 2 would be approximately 3.5 km long. Line 1 would have 12 stations, while Line 2 would have 5. The lines would share two stations at the south end of the Kai Tak Development. The proposed alignment and stations are depicted below.

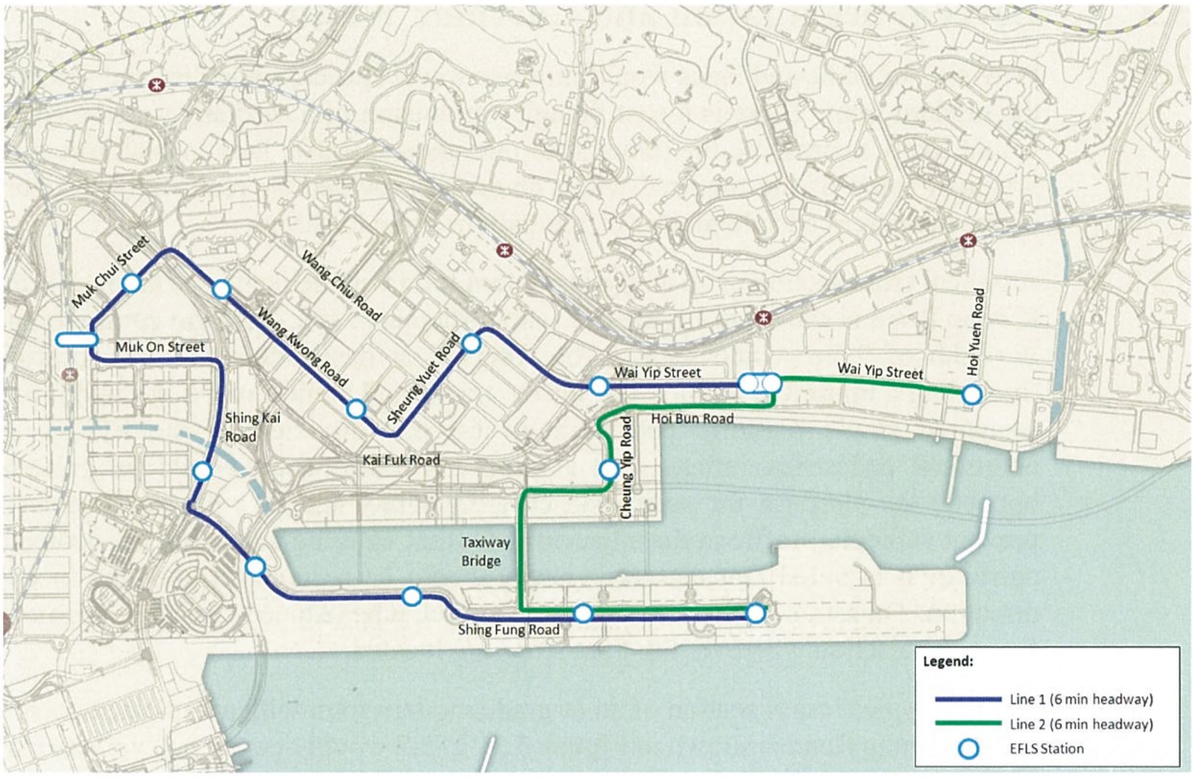


Figure 5.1: Proposed Alignment for Option 1 (At-Grade Dedicated Corridor)

5.2 System/Network Parameters

5.2.1 System and network parameters are presented below.

Parameter	Assumption
Length	Line 1: 6.6 km Line 2: 3.5 km
Number of Stations	Line 1: 12 stations Line 2: 5 stations
Headway	Line 1 (Blue): 6 minutes Line 2 (Green): 6 minutes
Schedule	Similar to existing MTR system for smooth and convenient transfers (6:00AM-1:00AM)
Runningway	Dedicated track/lane with priority at junction crossings
Vehicle Type [A]	Modern Tram (holding 240 passengers/train at 4 ppsm or 360 passengers/train at 6 ppsm)
Capacity	Line 1: 2,400 pphpd (4 ppsm) / 3,600 pphpd (6 ppsm) Line 2: 2,400 pphpd / 3,600 pphpd (6 ppsm)

[A] The capacity is based on typical capacity for an Alstom modern tram. At 4 ppsm, the capacity would be 240 passengers. At 6 ppsm, the capacity would be 360 passengers. Capacity in Hong Kong is typically evaluated at 4 ppsm to provide a reasonable/comfortable level of crowding. However, during the peak periods, this is often exceeded (for instance on the Hong Kong Light Rail in Tuen Mun). Therefore, capacity at a higher ppsm would connote a more crowded riding experience, which could still be accommodated by the train during these peak loading periods.

5.3 Level of Segregation and Corridor Width

5.3.1 Provision of dedicated lanes would improve travel speeds, reliability and safety of the modern tram. There is a cost though – provision of a median at-grade system would likely necessitate the removal of one general traffic lane in each direction, although some of the required width could be provided by reallocating existing centre median, road side planter or footpath in some locations.

5.3.2 A typical cross section of an at-grade modern tram with dedicated corridor at Wang Kwong Road is shown in **Figure 5.2** with a staggered side platform configuration. A width of 9.5m would need to be reserved at designated platform locations (including a minimum 7.0m width for the tracks and a minimum 2.5m width for a staggered single platform configuration for one direction of the EFLS). An additional pedestrian refuge with a minimum 1.5m width would be provided opposite the platform for pedestrian crossing safety and as a physical barrier to prevent vehicular traffic in the adjacent lane from entering and using the dedicated corridor. It is noted that the carriageway would be reduced to one lane in each direction. Thus, the width of the carriageway would be reduced locally to 4.5m wide for each direction wherever the tram stops are located.

5.3.3 Another typical cross section of an at-grade modern tram with a dedicated corridor at Shing Fung Road is shown in **Figure 5.3**. EFLS would operate on opposite sides of the street, outside the carriageway where possible to minimise traffic impact. EFLS tracks would be 4.2m wide on both sides. In some locations, the EFLS tracks would need to be placed within the carriageway and displace proposed traffic lanes as the EFLS would be in conflict with columns for the Landscape Desk and/or associated vertical circulation (escalators or elevators) and the walkway or planter areas could not be used. In such a scenario, the remaining carriageway width would be 3.1m, which would not meet TPDM requirements (and would thus be subject to possible relaxation from TD). Furthermore, no public footpath could be provided where vertical circulation facilities to/from the landscape deck are provided. This would force pedestrians walking along the street to walk through private land.

5.3.4 Finally, a typical cross section of an at-grade modern tram with a dedicated corridor at Wai Yip Street is shown in **Figure 5.4.** To accommodate the station and modern tram, the number of traffic lanes in both directions would be reduced from three (3) lanes to one (1) lane in spot locations. In addition, the remaining carriageway width would be only 3.6m.

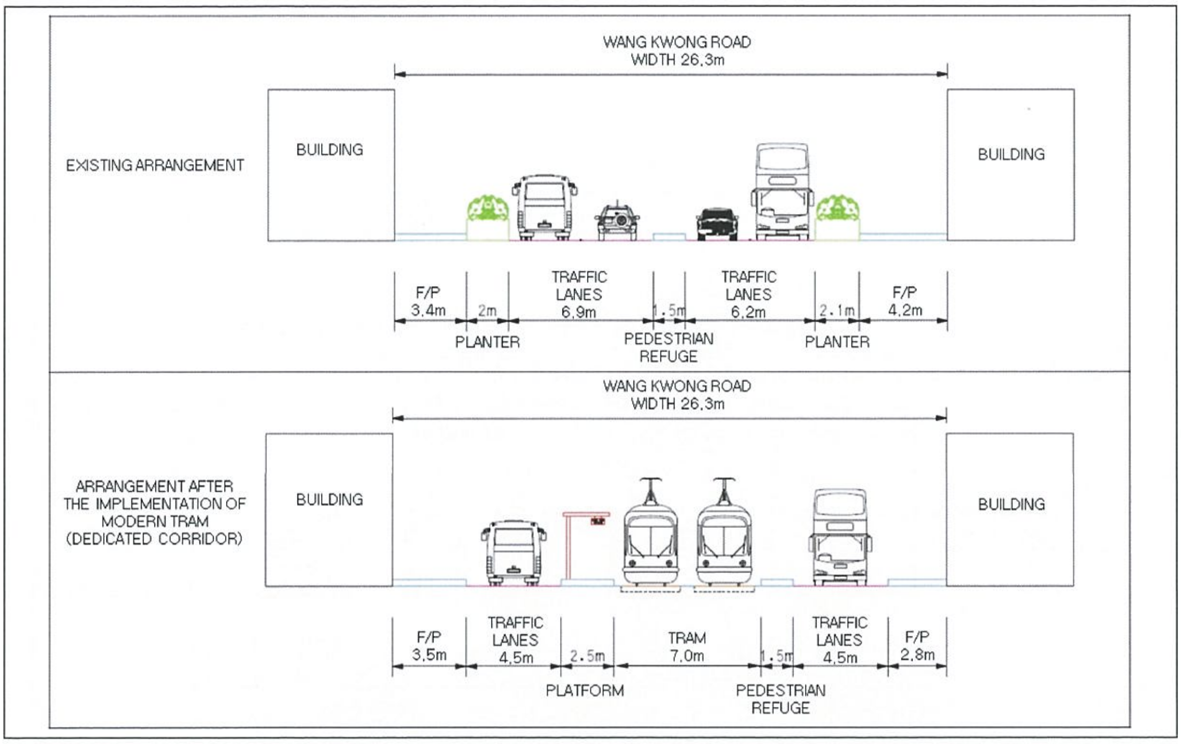


Figure 5.2: Typical Cross Section Plan of for Option 1 (At-Grade Dedicated Corridor) on Wang Kwong Road (Before and After Implementation)

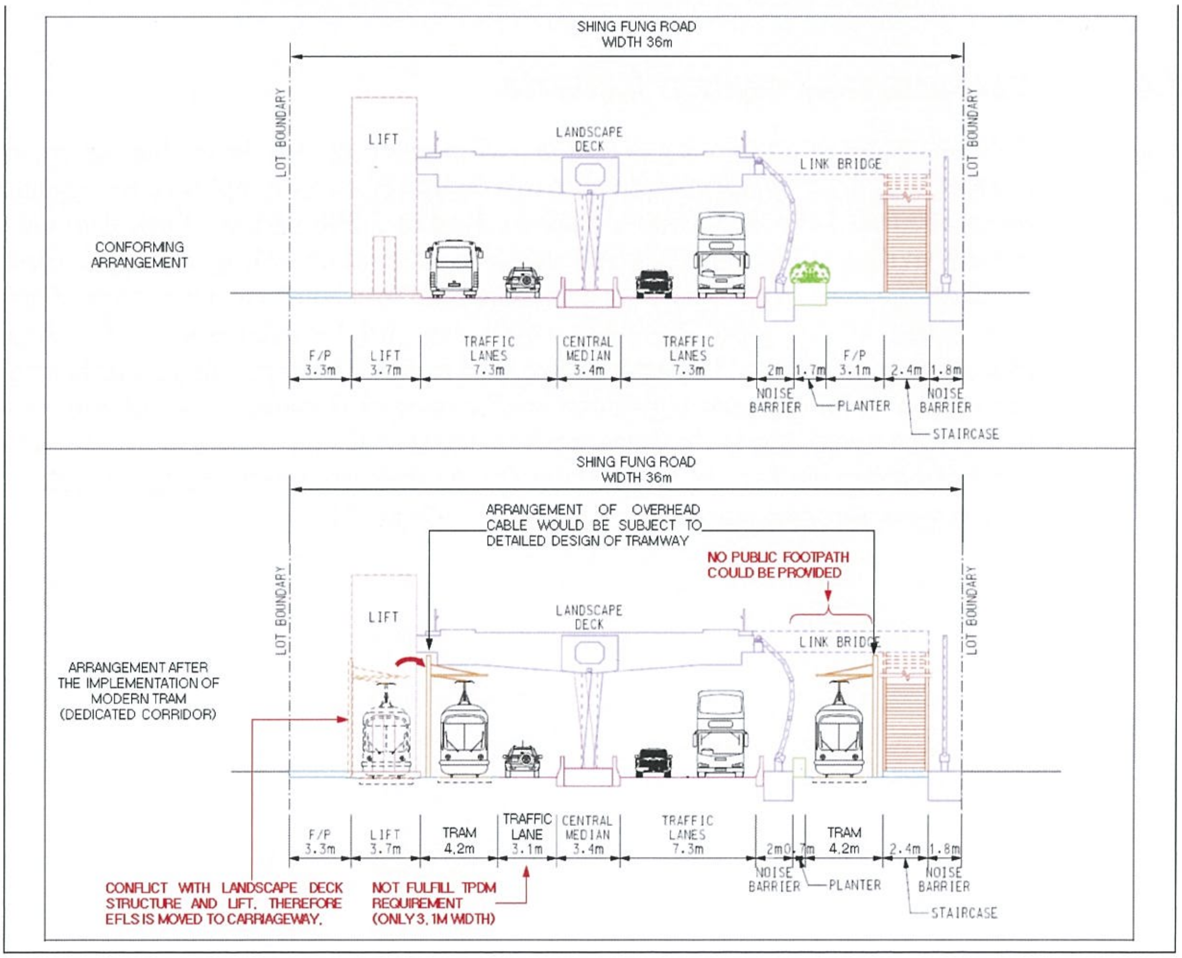


Figure 5.3: Typical Cross Section Plan of for Option 1 (At-Grade Dedicated Corridor) on Shing Fung Road (Before and After Implementation)

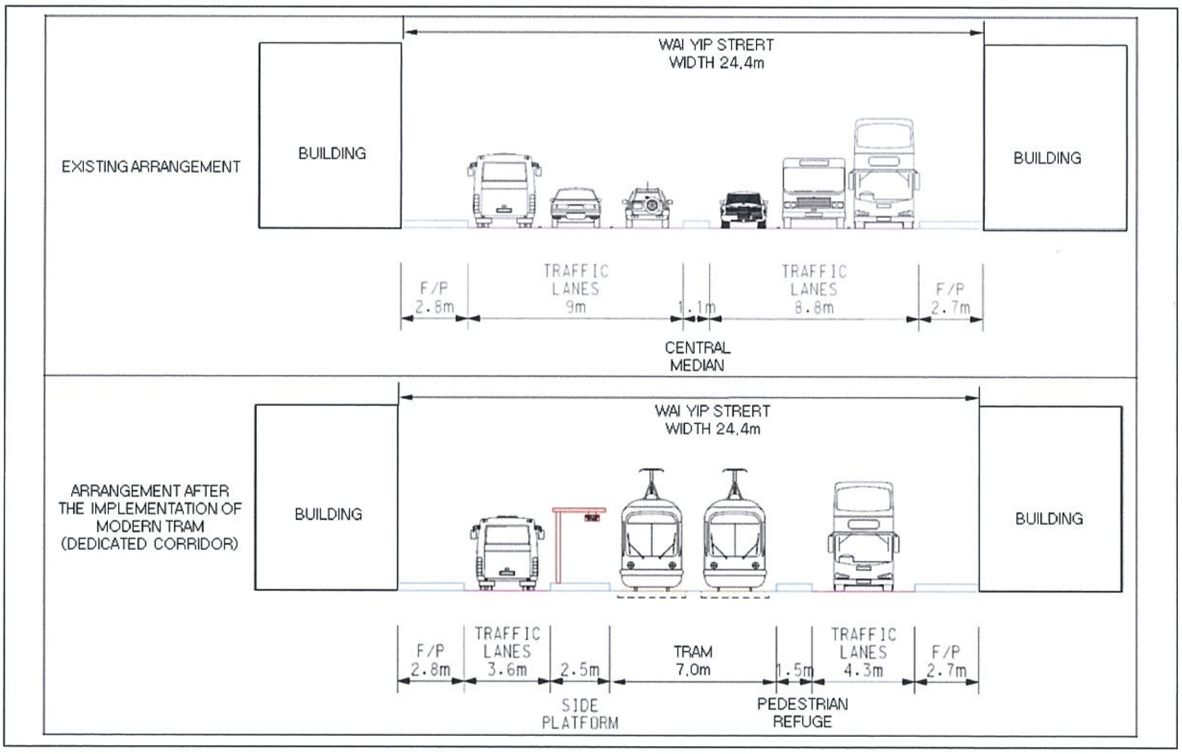


Figure 5.4: Typical Cross Section Plan of for Option 1 (At-Grade Dedicated Corridor) on Wai Yip Street (Before and After Implementation)

5.4 Performance against Criteria

5.4.1 **Table 5.1** presents a summary of option performance against the evaluation criteria. In summary, the at-grade modern tram in a dedicated corridor option could generate up to 102,000 daily riders and a peak loading of 3,300 pphpd. Peak demand on these heavily used segments would induce a level of crowding above the ideal 4 ppsm design conditions. The peak demand would thus equate to a passenger density of 6 ppsm in this peak segment, which can still be accommodated although passenger comfort would be affected (as well as dwell time possibly). Furthermore, this option would generate significant traffic impacts (in terms of travel time delay to other road vehicles) in the dense built-up areas of Kwun Tong and Kowloon Bay and necessitate the loss of travel lanes for the dedicated tram track. Overall, this option generates a negative net economic benefit (EIRR).

Appendix F - Topical Study on Assessment of Suitability of Modern Tramway for Kowloon East

Table 5.1: Summary of Performance – Option 1 (At-Grade Dedicated Corridor)

#	Analysis Criteria	Value
1	Daily Boardings	• 102,000 riders/day
2	Peak Hour Boardings per Direction	• Line 1: 3,300 pphpd • Line 2: 1,200 pphpd
3	In-Vehicle Journey Time	• Ngau Tau Kok to Kai Tak Cruise Terminal (KTCT): about 23 minutes • KTCT to Kwun Tong: about 12 minutes
4	Peak Vehicle Requirements [A]	• Line 1: 10 vehicles/trainsets • Line 2: 5 vehicles/trainsets
5	Transfer Time	• Between MTR Ngau Tau Kok Station and EFLS Station next to Hoi Bun Road Park: 10 minutes • Between SCL Kai Tak Station and EFLS Station at Station Square: 7 minutes • Between MTR Kwun Tong Station and EFLS Station near KTAA: 14 minutes
6	Traffic Impacts (Travel Time Delay) [B]	• Wang Kwong Road (from Sheung Yee Road to Muk Tsui Street): from 3 to 20 minutes (about 17 minutes delay) • Cheung Yip Street / Taxiway Bridge (from Shing Fung Road to Hoi Bun Road): from 4 to 20 minutes (about 16 minutes delay)
7	Road Impacts (Total Area Lost)	• 63,000 m^2 (including road space and greenspace)
8	Utility Impacts (Cost of Relocation)	• [redacted]
9	Environmental Impacts	• Complies with the EIAO requirements with appropriate mitigation measures if necessary, subject to preliminary environmental assessment to be carried out in the next stage
10a	Project Capital Cost [C] (Dec 2015 Prices)	• [redacted]
10b	Annual O&M Cost	• [redacted]
11	EIRR [D]	• Negative
12	Construction Timeframe	• About 5 years

Notes:

[A] Peak vehicle requirement is presented for information only and is not used directly to compare options, as the number of buses, trams or APM/monorail trains is not directly comparable. The number of peak vehicles is captured in the overall capital costs for a given option.

[B] The travel time impact is estimated using a traffic model that considers the modification of the road and junction layout, as well as method of control required by introducing at-grade EFLS.

[C] Project capital cost includes design, construction, vehicle, project management and project contingency costs. Furthermore, cost estimations are preliminary that are subject to change and update upon further design).

[D] EIRR is estimated based on benefits/disbenefits for local users (and excludes non-local users such as tourists, etc.) solely for the purpose of the evaluation of green transport modes.

5.5 Summary of Option 1 (At-Grade Dedicated Corridor)

5.5.1 Option 1 consists of a fully at-grade modern tram operating in a dedicated corridor. Segregation of the modern tram would minimise vehicle and pedestrian conflict exclusively to junctions. This would allow Option 1 to operate relatively faster and more reliably than an at-grade options operating in a shared corridor. Option 1 would generate about 102,000 passengers per day or up to 3,300 pphpd in the peak loading segment. Transfer times would be relatively short to major rail stations on the Kwun Tong Line and Shatin-Central Link.

5.5.2 Key findings for this option are as follows:

- **Low-Moderate Level of Ridership** – The 102,000 daily riders would be on the low-moderate level of ridership. Although the alignment is dedicated, Option 1 would still encounter delays at junctions. This would make travel time less competitive than with elevated options and thus less attractive to potential users compared to other modes.

- **Vehicle Crowding Higher than Desired** – Peak demand on the most heavily used segment would induce a level of crowding above the ideal 4 ppsm density. The peak demand would thus equate to a passenger density of 6 ppsm in this peak segment. This implies that passengers would be more densely packed in the vehicles than desired, which could have impact on passenger comfort and desire to use the EFLS. This could also elongate dwell times due to longer boarding/alighting times due to blockage of doorways by passengers. This density would be equivalent to that which is often reached in peak periods on MTR trains.

- **Faster Travel Time than Shared Corridor** – The dedicated at-grade corridor would be segregated from other traffic lanes except at junctions. This means that other road vehicles would not interfere with and subsequently delay the modern tram along the majority of its alignment. This would allow the modern tram to operate faster and more reliably than at-grade options in shared corridors.

- **Significant Loss of Road Space Required** – As noted earlier, a minimum width of 9.5m would need to be reserved at designated platform locations (including a minimum 7.0m width for the dual tracks and a minimum 2.5m width for the single staggered platform). Where no station is required, the dual tracks would need to be completely segregated from the other road vehicles. Thus, loss of road space in many locations would be inevitable with this option. In most cases, this would require the loss of one lane in each direction, particularly in the built-up areas of Kwun Tong and Kowloon Bay. Overall, an area of 63,000 m^2 would be lost, including both green area and roadspace.

- **Extensive Traffic Enhancements Required and Traffic Impacts Generated** – The at-grade operations of the modern tram would require extensive traffic enhancements including: (i) modifying priority junctions into signalised ones; (ii) restricting certain traffic movements at priority junctions; (iii) modifying signalised junction layout and method of control (MOC); and (iv) adding signalised junctions. Owing to the loss of road space, traffic impacts would be significant. For instance, speeds would be reduced from 18 kph to 3 kph on the section of Muk On Street between Wang Kwon Road and Muk Tsui Street in Kowloon Bay.

- **Negative Net Economic Benefit** – Net economic benefit would be negative as the time-savings benefit for EFLS passengers would be unable to cover the corresponding time loss for road-based users due to loss of lanes and traffic congestion.
- **Landscape and Visual** – The overhead catenary system would affect the open sky view of pedestrians from the ground level. The scale of the catenary system would be small when compared to adjacent developed building blocks and for residents at higher view levels. In view of the compatibility of the at-grade EFLS system, those cable and track would be compatible with the surrounding urban setting, like industrial and carriageway. Therefore, it is considered that the support structures and poles would cause a slight visual impact to the surrounding residential development and pedestrians. The proposed EFLS station at Kai Tak Station Square and its at-grade track would permanently occupy portions of the open space, which includes the proposed green and landscaping area, although the actual loss of area would depend on the detail design of the station platform. New tree plantings along Shing Kai Road would also be affected, which might degrade the existing roadside visual resources.

6 Option 2 – Modern Tram in At-Grade Shared Corridor

6.1 General Description

6.1.1 Option 2 represents an at-grade system that operates in a shared corridor. This means that the system operates in mixed flow traffic lanes along with other road users and vehicles and is subject to operational interference, which would likely result in slower operating speeds and lower reliability. Alignment would follow that proposed by Hong Kong Tramways. Typically, stations would be at-grade and have a side platform configuration and would be staggered across the intersection to reduce required width at the station. Furthermore, stations would be located at the nearside of the intersection to minimise delays on the modern tram.

6.1.2 The recommended alignment would have two lines: (i) Line 1 (Blue Line) from near Kowloon Bay to Kai Tak Cruise Terminal; and (ii) Line 2 (Green Line) from Kwun Tong Ferry Pier to Kai Tak Cruise Terminal via the existing Taxiway Bridge). Line 1 would be 6.6 km long and serve 11 stations, while Line 2 would be 3.5 km long and serve 5 stations. The lines share two stations at the south end of the Kai Tak Development. The proposed alignment and stations are depicted below.

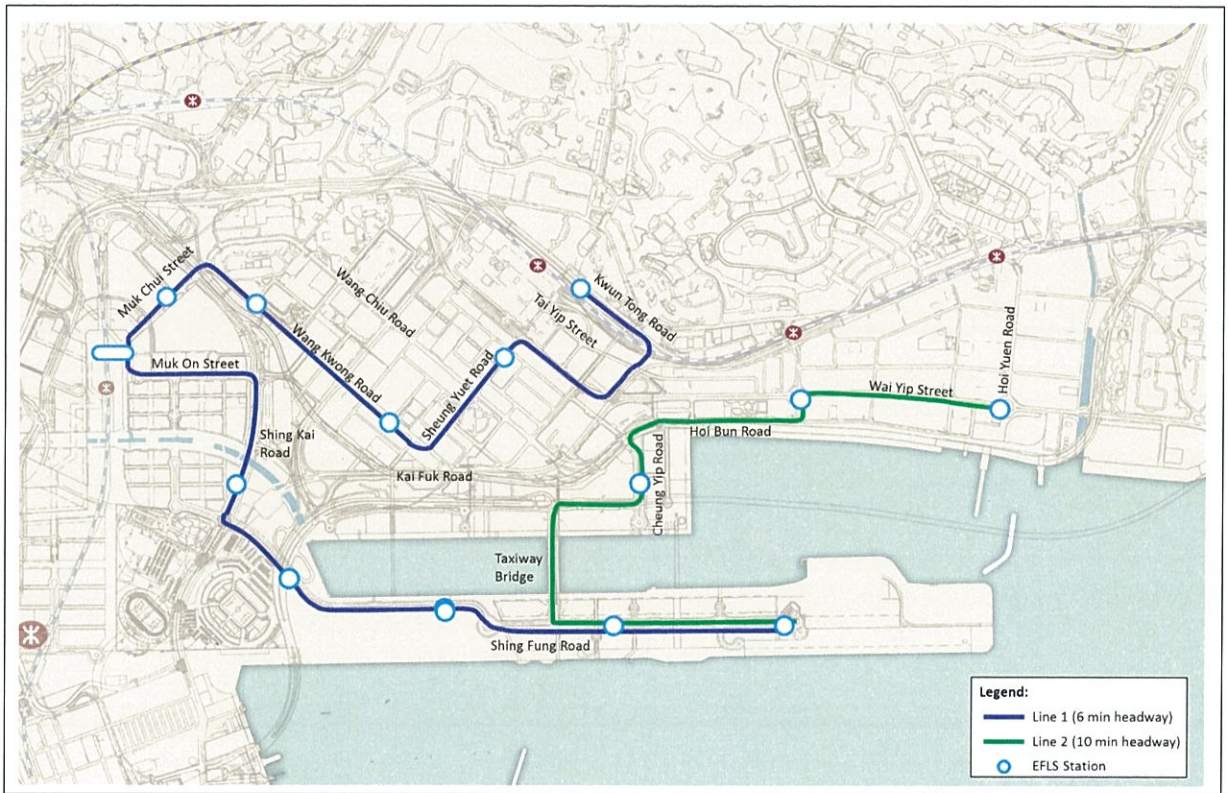


Figure 6.1: Proposed Alignment for Option 2 (At-Grade Shared Corridor)

6.2 System/Network Parameters

6.2.1 System and network parameters are presented below.

Parameter	Assumption
Length	Line 1: 6.6 km Line 2: 3.5 km
Number of Stations	Line 1: 11 stations Line 2: 5 stations
Headway	Line 1 (Blue): 6 minutes Line 2 (Green): 10 minutes
Schedule	Similar to existing MTR system for smooth and convenient transfers (6:00AM-1:00AM)
Runningway	Shared track with general purpose traffic
Vehicle Type	Modern Tram (holding 240 passengers/train at 4 ppsm or 360 passengers/train at 6 ppsm)
Capacity	Line 1: 2,400 pphpd (4 ppsm) / 3,600 pphpd (6 ppsm) Line 2: 1,440 pphpd (4 ppsm) / 2,160 pphpd (6 ppsm)

[A] The capacity is based on typical capacity for an Alstom modern tram. At 4 ppsm, the capacity would be 240 passengers. At 6 ppsm, the capacity would be 360 passengers. Capacity in Hong Kong is typically evaluated at 4 ppsm to provide a reasonable/comfortable level of crowding. However, during the peak periods, this is often exceeded (for instance on the Hong Kong Light Rail in Tuen Mun). Therefore, capacity at a higher ppsm would connote a more crowded riding experience, which could still be accommodated by the train during these peak loading periods.

6.3 Level of Segregation and Corridor Width

6.3.1 The purpose of the shared corridor concept would be to maintain the existing number of general purpose traffic lanes and minimise implications on road traffic. While there are cost and road traffic benefits to doing this compared to that of the dedicated EFLS corridor scenario, the major disadvantages are to the EFLS itself in terms of reduced operating speeds and poorer reliability due mixed traffic operation. The operation of EFLS and other vehicles on the road would interrupt with each other, the EFLS would now be subject to traffic congestion and additional conflicts with other road vehicles.

6.3.2 The shared corridor concept would allow modern tram and other vehicles to operate on the same lane/track, except at station/platform sections. The platform section for modern tram would be dedicated for modern tram only to maintain smooth vehicular movements and avoid safety issues with passengers at the platform.

6.3.3 A typical cross section of an at-grade modern tram with shared corridor at Wang Kwong Road and Wai Yip Street is shown in **Figure 6.2** and **Figure 6.3** with a staggered side platform configuration. Similar to Option 1, the modern tram corridor would adopt a staggered side platform configuration. This would require a minimum 6.0 m width (3.5 m for the EFLS track (in one direction) and 2.5m width for the station) at station locations. As noted, the other direction of the EFLS would share the track with other vehicles and thus not require dedicated width exclusively for the EFLS at the station.

6.3.4 Another typical cross section of an at-grade modern tram with shared corridor at Shing Fung Road is shown in **Figure 6.4**. Similar to Option 1, the track would be separated by the median, however, the shared track would be in the inner-lane alongside the median instead of at the kerb or in the planter/sidewalk area. Impact to footpath and adjacent structure would be minimal compared to Option 1.

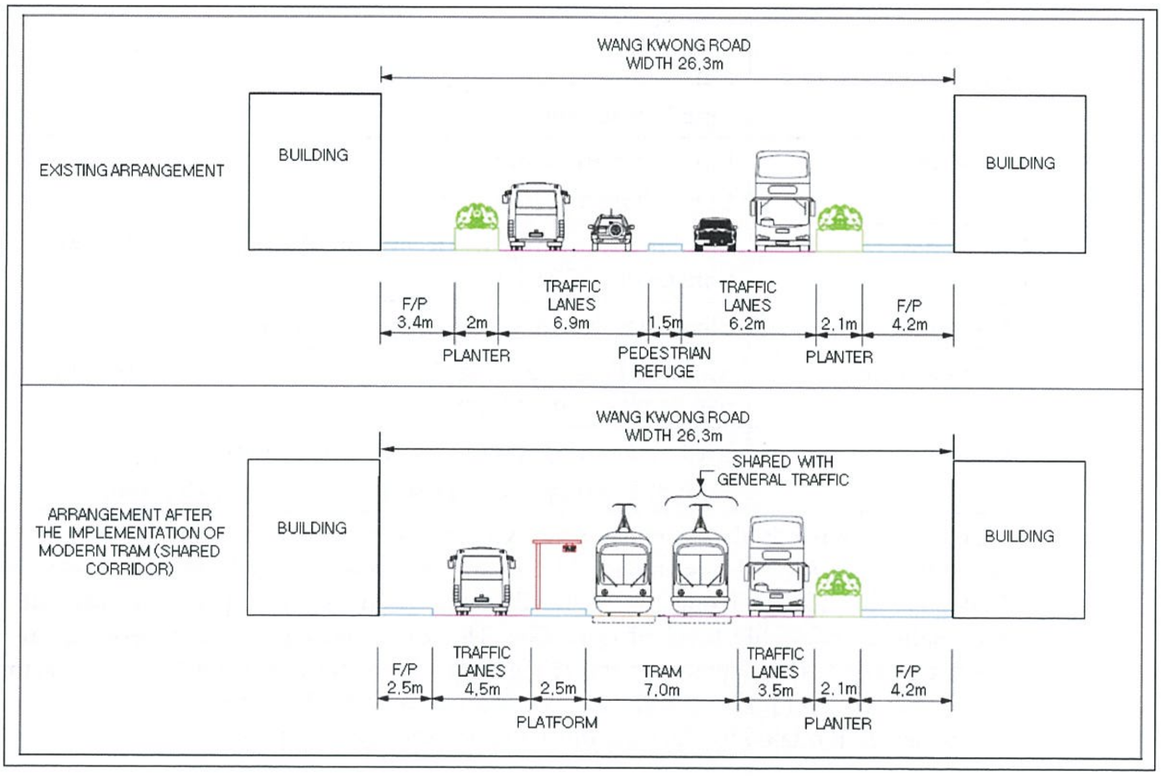


Figure 6.2: Typical Cross Section Plan of Option 2 (At-Grade Shared Corridor) on Wang Kwong Road (Before and After Implementation)

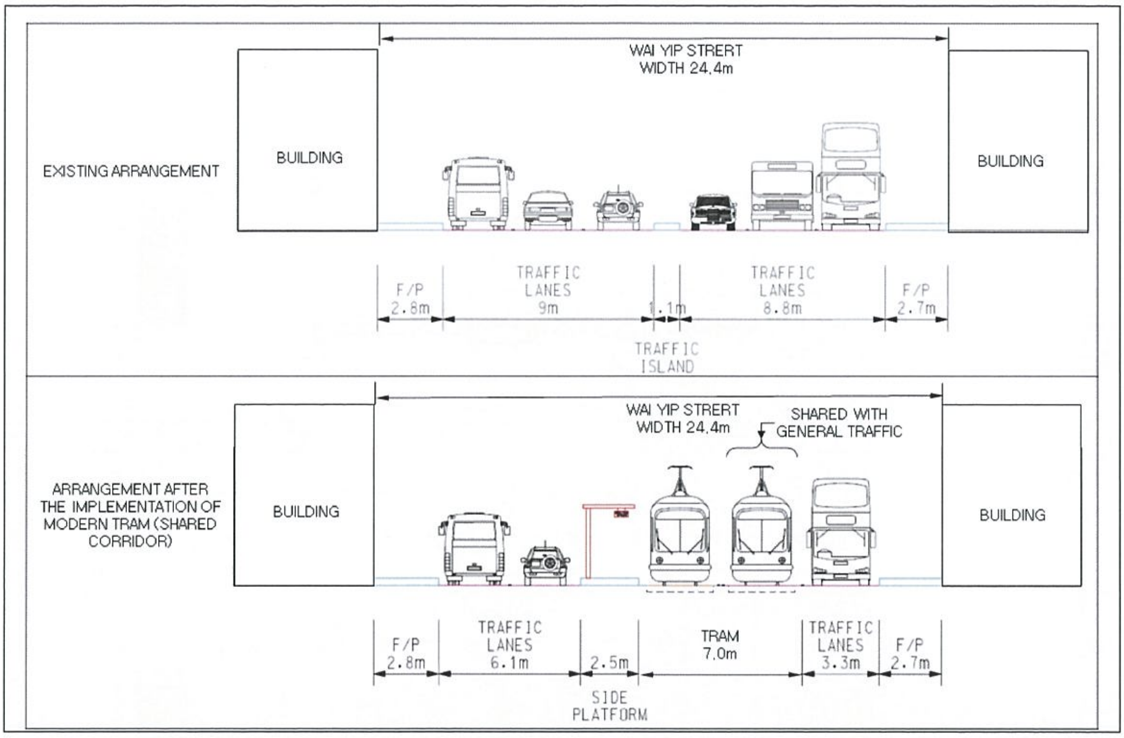


Figure 6.3: Typical Cross Section Plan of Option 2 (At-Grade Shared Corridor) on Wai Yip Street (Before and After Implementation)

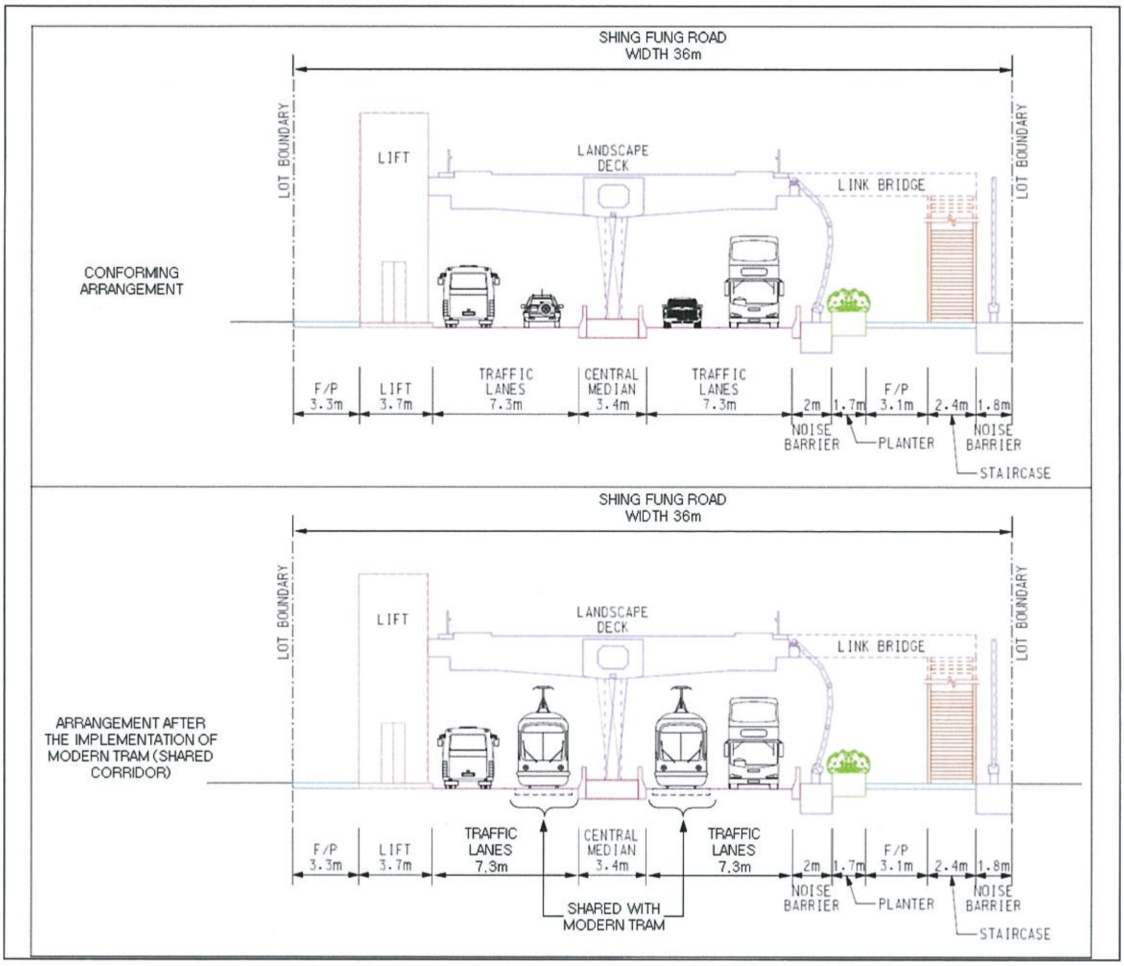


Figure 6.4: Typical Cross Section Plan of Option 2 (At-Grade Shared Corridor) on Shing Fung Road (Before and After Implementation)

6.4 Performance against Criteria

6.4.1 **Table 6.1** presents a summary of option performance against the evaluation criteria. In summary, the at-grade modern tram in a dedicated corridor option could generate up to 82,500 daily riders and a peak loading of 3,000 pphpd. This option would generate journey times that would be about 10 minutes longer than the at-grade dedicated Option 1. Although traffic impacts and road impacts would be less severe than those for Option 1, Option 2 would generate fewer riders and have lower time savings – still resulting in a negative net economic benefit (EIRR).

Table 6.1: Summary of Performance – Option 2 (At-Grade Shared Corridor)

#	Analysis Criteria	Value
1	Daily Boardings	• 82,500 riders/day
2	Peak Hour Boardings per direction	• Line 1: 3,000 pphpd • Line 2: 1,100 pphpd
3	In-Vehicle Journey Time (between Key Locations)	• Line 1: Kowloon Bay to KTCT - 28 minutes • Line 2: KTCT to Kwun Tong – 15 minutes
4	Peak Vehicle Requirements [A]	• Line 1: 13 vehicles/trainsets • Line 2: 5 vehicles/trainsets

#	Analysis Criteria	Value
5	Transfer Time (between EFLS and Key MTR Rail Stations)	• Between MTR Kowloon Bay Station and EFLS Station next to Fuk To Street: 7 minutes • Between SCL Kai Tak Station and EFLS Station at Station Square: 7 minutes • Between MTR Kwun Tong Station and EFLS Station near KTAA: 16 minutes • Between MTR Ngau Tau Kok Station and EFLS Station at Lai Yip Street: 12 minutes
6	Traffic Impacts (Additional Minutes of Delay) [B]	• Wang Kwong Road: 3-4 minutes • Cheung Yip Street / Taxiway Bridge: 4-5 minutes
7	Road Impacts (Total Area Lost)	• 8,600 m2 (including road space and greenspace)
8	Utility Impacts (Cost of Relocation)	• [redacted]
9	Preliminary Environmental Impacts	• Complies with the EIAO requirements with appropriate mitigation measures
10a	Project Capital Cost [C] (Dec 2015 Prices)	• [redacted]
10b	Annual O&M Cost	• [redacted]
11	EIRR [D]	• Negative
12	Preliminary Construction Timeframe	• About 5 years

Notes:

[A] Peak vehicle requirement is presented for information only and is not used directly to compare options, as the number of buses, trams or APM/monorail trains is not directly comparable. The number of peak vehicles is captured in the overall capital costs for a given option.

[B] The travel time impact is estimated using a traffic model that considers the modification of the road and junction layout, as well as method of control required by introducing at-grade EFLS.

[C] Project capital cost includes design, construction, vehicle, project management and project contingency costs. Furthermore, cost estimations are preliminary that are subject to change and update upon further design).

[D] EIRR is estimated based on benefits/disbenefits for local users (and excludes non-local users such as tourists, etc.) solely for the purpose of the evaluation of green transport modes.

6.5 Summary of Option 2 (At-Grade Shared Corridor)

6.5.1 Option 2 consists of a fully at-grade modern tram operating in a shared corridor with other road vehicles. This means that other road vehicles would operate on the same track as the modern tram. Interference and delay from other road vehicles and pedestrians would occur throughout the alignment and at junctions. The major benefit of this option is that traffic impacts would be less severe than a dedicated corridor as loss of road lanes would be minimal.

6.5.2 Key findings for this option are as follows:

- **Low Level of Ridership** – The 82,000 daily riders would be on the lower end of the options, given the longer travel times, which would make this system less time-competitive and attractive than other modes. This also means lower fare revenues.

- **Vehicle Crowding Higher than Desired** – Even with the relatively lower daily demand, peak demand on the most heavily used segment would induce a level of crowding above the ideal 4 ppsm density. The peak demand would thus equate to a passenger density of 5 ppsm in this peak segment. This implies that passengers would be more densely packed in the vehicles than desired, which could have impact on passenger comfort and desire to use the EFLS. This could also elongate dwell times due to longer boarding/alighting times due to blockage of doorways by passengers. Nonetheless, this density would still be below 6 ppsm, which is often reached in peak periods on MTR trains.

- **Lower Traffic Impacts** – Option 2 would generate lower impacts on traffic and the roads compared to dedicated at-grade options, as there would be minimal reallocation of existing traffic lanes for EFLS operation.

- **Long In-Vehicle Journey Times** – The estimated in-vehicle journey times would be 28 minutes between Kowloon Bay and the Kai Tak Cruise Terminal, and 15 minutes between the Cruise Terminal and Kwun Tong via the Taxiway Bridge. These journey times would be significantly slower than those for at-grade dedicated corridor or elevated options owing to the fact that the modern tram would be delayed road congestion throughout the journey, as well as merging and turning vehicles. Delays would also be incurred at junctions.

- **Extensive Traffic Enhancements Required** – The at-grade operations of the modern tram would require extensive traffic enhancements including: (i) modifying priority junctions into signalised ones; (ii) restricting certain traffic movements at priority junctions; (iii) modifying signalised junction layout and method of control (MOC); and (iv) adding signalised junctions. Owing to the loss of road space, traffic impacts would be significant.

- **Higher Utility Relocation Costs** – Utility relocation costs for the at-grade shared Option 2 would be higher than the at-grade dedicated Option 1 as the alignment would be placed in a highly impacted utility corridor leading to Kowloon Bay MTR Station. Thus forecast utility costs would be nearly [redacted] than that for Option 1.

- **Negative Net Economic Benefit** – The net economic benefit would be negative as the time-savings benefit for EFLS passengers and volume of forecasted riders would be insufficient to offset the congestion and delay faced by the modern tram along its entire at-grade alignment.

- **Landscape and Visual** – The overall visual impact would be similar to that generated by Option 1. The proposed EFLS station located at the Kai Tak Station Square and its at-grade track would also permanently occupy some portion of the open space, including the proposed green and landscaping area. In addition, compared with Option 1, the overhead cabling infrastructure along Kwun Tong Road section might potentially affect existing mature trees in the central median.

7 Option 4 – Modern Tram in Mixed Operation (Elevated and At-Grade Dedicated Corridor)

7.1 General Description

7.1.1 Option 4 would operate elevated for most of its alignment, but have an at-grade section along the Kai Tak runway. The goal of Option 4 is to reduce overall costs with an at-grade alignment along the former Kai Tak runway, where the traffic condition and potential impacts are less severe, coupled with an elevated guideway through the congested built-up areas. With "mixed operations" (with both at-grade and elevated portions), Option 4 (Mixed Operations) could provide a high level of reliability and time-savings similar to the elevated option, but be less costly.

7.1.2 Due to its mixed operations, Option 4 would be best operated as a modern tram (or BRT) given that the at-grade alignment on the runway would require level crossings and would not be fully segregated/separated. Thus, an automated system such as monorail or APM would be inappropriate from a safety perspective considering that pedestrians, cyclists and motor vehicles may cross the path of the EFLS at junctions and a driver would be needed for manual operations in such segments. Option 4 stations that are elevated would typically have a side platform configuration. At-grade stations would have a side platform configuration and typically be staggered across an intersection with platforms at the nearside of the junction to minimize potential delays on the modern tram.

7.1.3 The recommended alignment would be 9.0 km long and include 12 stations, directly serving two MTR stations – the Kai Tak Station of the Shatin-Central Link and Kowloon Bay Station of the Kwun Tong Line. The Kwun Tong Station of the Kwun Tong Line would be within a few blocks walk. The alignment would be fully elevated except for an approximate 1.5 km stretch of at-grade operations on the runway between the Metro Park and the Kai Tak Cruise Terminal stations along Shing Fung Road.

7.1.4 The proposed alignment and stations are depicted below.

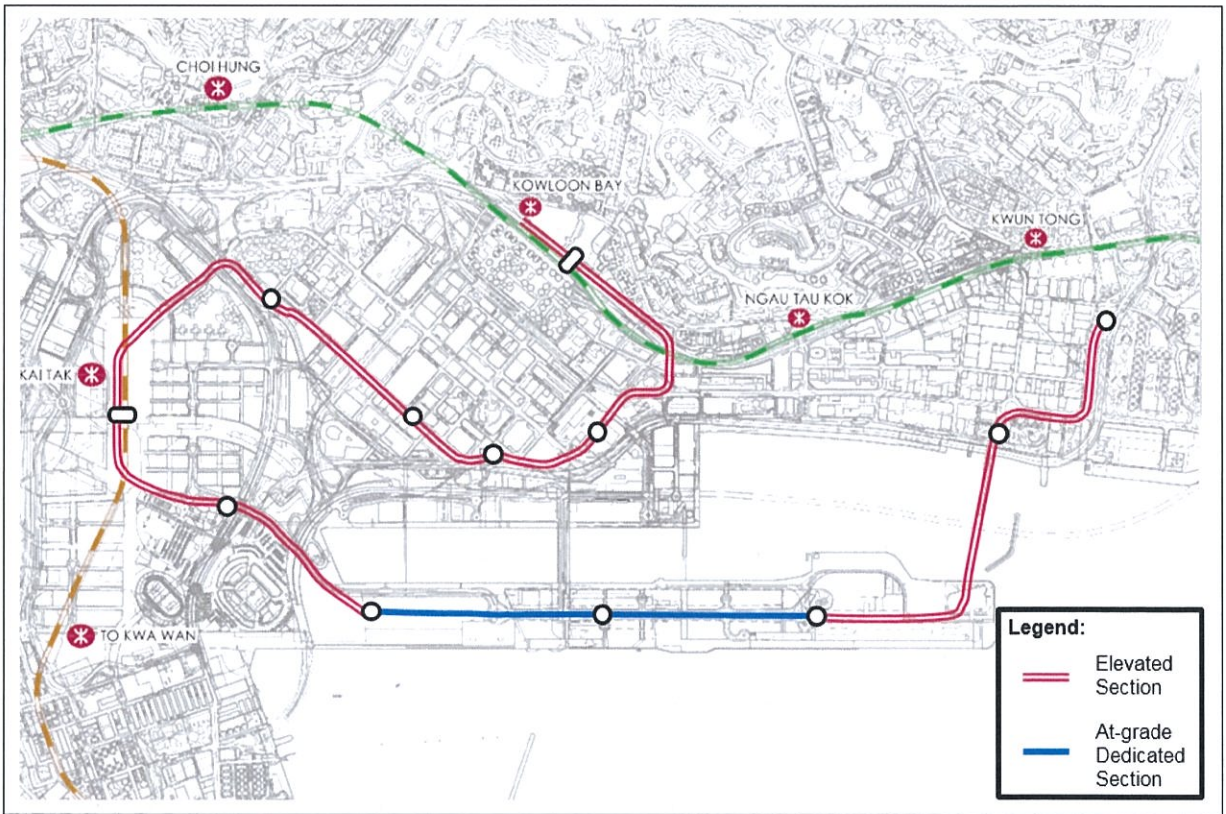


Figure 7.1: Proposed Alignment for Option 4 (Mixed Operations with At-Grade and Elevated Dedicated Corridor)

7.2 System/Network Parameters

7.2.1 System and network parameters are presented below.

Parameter	Assumption
Length	9.0 km
Number of Stations	12 stations
Headway	3.0 minutes
Schedule	Similar to existing MTR system for smooth and convenient transfers (6:00AM-1:00AM)
Runningway	Segregated elevated track (Kowloon Bay to Metro Park) At-grade dedicated corridor (Metro Park to KTCT) Segregated elevated track (KTCT to Kwun Tong)
Vehicle Type [A]	Modern Tram (holding 341 passengers/train at 4 ppsm or 511 passengers/train at 6 ppsm)
Capacity	6,800 pphpd (4 ppsm) / 10,220 pphpd (6 ppsm)

[A] The capacity is based on typical capacity for an Alstom modern tram. At 4 ppsm, the capacity would be 240 passengers. At 6 ppsm, the capacity would be 360 passengers. Capacity in Hong Kong is typically evaluated at 4 ppsm to provide a reasonable/comfortable level of crowding. However, during the peak periods, this is often exceeded (for instance on the Hong Kong Light Rail in Tuen Mun). Therefore, capacity at a higher ppsm would connote a more crowded riding experience, which could still be accommodated by the train during these peak loading periods.

7.3 Level of Segregation and Corridor Width

7.3.1 Option 4 would operate in a fully segregated viaduct without interference or interaction with road users and pedestrians on the elevated section. On the 1.5 km section on the runway between Metro Park and the Kai Tak Cruise Terminal stations, the modern tram would operate in a dedicated at-grade corridor.

7.3.2 **Figure 7.2** depicts a typical cross section of elevated operations in the built-up area at Wang Kwong Road. The column and any protection curb would require an average width of about 2.8m. The two lanes in each direction would be retained. The footpath at some locations would be further set back to facilitate uncovered emergency vehicle access (EVA) with a minimum of 6m width. Two traffic lanes would be maintained in each direction.

7.3.3 **Figure 7.3** depicts a typical at-grade section along Shing Fung Road on the runway. The configuration for the at-grade section would be similar to that for Option 1. Tracks would be separated on opposite sides of the road. The single track would have a width of 4.2m width and be located outside the carriageway when feasible to minimize the traffic impact. Nevertheless, the modern tram would be in conflict with the columns of the Landscape Deck and associated vertical circulation systems (elevators/escalators), therefore it would operate in the carriageway instead of in the walkway or planter. The resulting carriageway width would only be 3.1m wide. Furthermore, no public footpath would be provided at some sections due to footbridge landings, which would force pedestrians to walk through private lots.

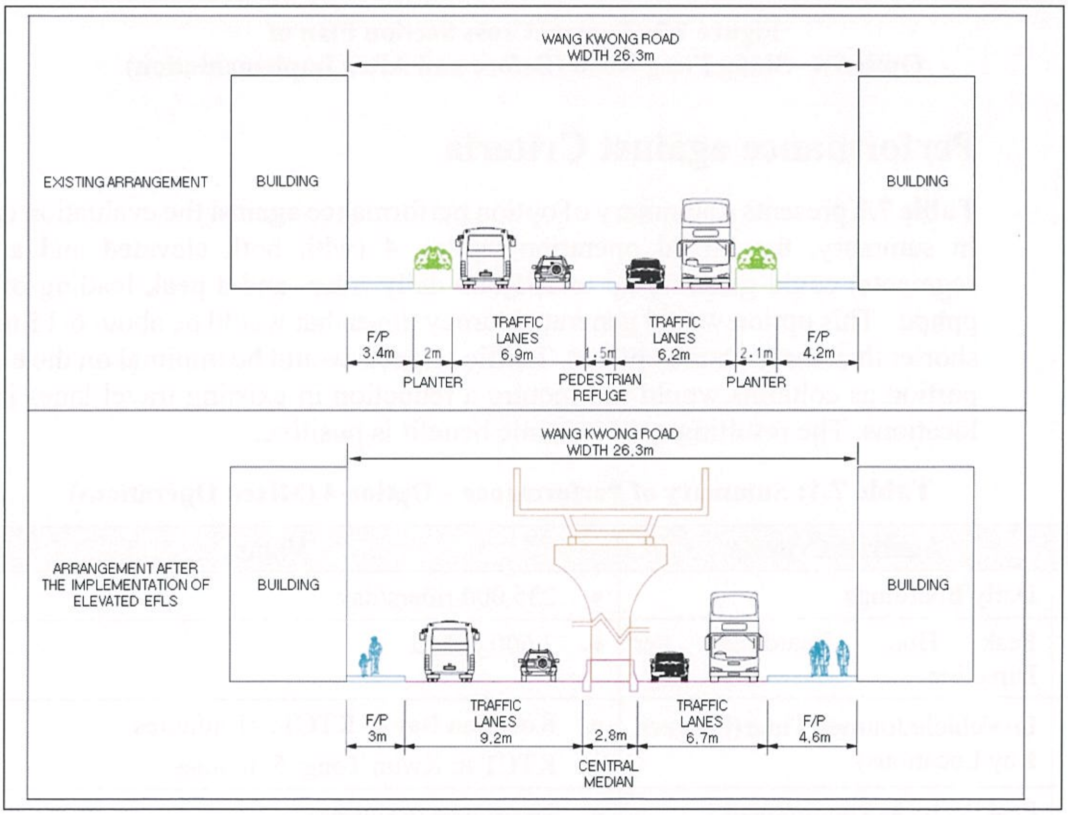


Figure 7.2: Typical Cross Section Plan of Option 4 – Wang Kwong Road (Before and After Implementation)

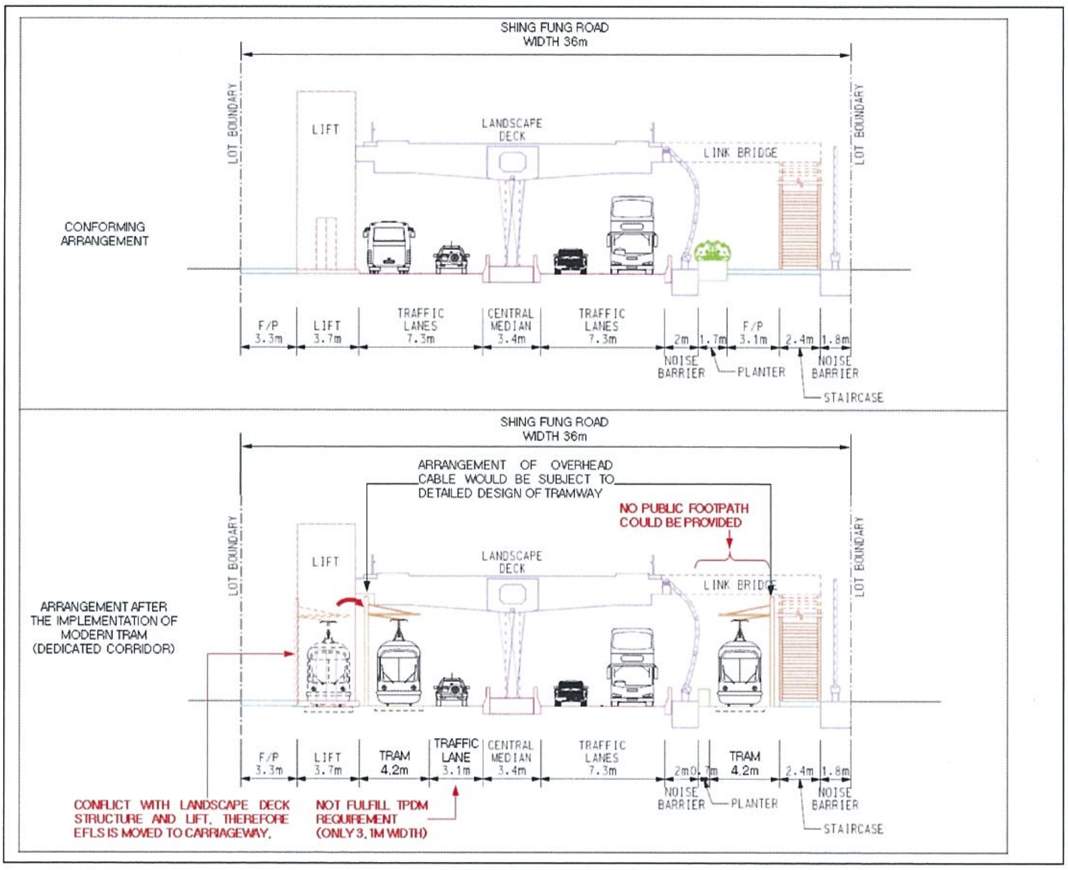


Figure 7.3: Typical Cross Section Plan of Option 4 –Shing Fung Road (Before and After Implementation)

7.4 Performance against Criteria

7.4.1 **Table 7.1** presents a summary of option performance against the evaluation criteria. In summary, the mixed operation Option 4 (with both elevated and at-grade segments) could generate up to 235,000 daily riders and a peak loading of 7,600 pphpd. This option would generate journey times that would be about 6-15 minutes shorter than the at-grade options. Traffic impacts would be minimal on the elevated portion as columns would not require a reduction in existing travel lanes in most locations. The resulting net economic benefit is positive.

Table 7.1: Summary of Performance – Option 4 (Mixed Operations)

#	Analysis Criteria	Value
1	Daily Boardings	• 235,000 riders/day
2	Peak Hour Boardings per Direction	• 7,600 pphpd
3	In-Vehicle Journey Time (between Key Locations)	• Kowloon Bay to KTCT: 21 minutes • KTCT to Kwun Tong: 5 minutes
4	Peak Vehicle Requirement [A]	• 19 vehicles/trainsets
5	Transfer Time (between EFLS and Key MTR Rail Stations)	• Between MTR Kowloon Bay Station and EFLS Station EFLS Station near Fuk To Street: 7.5 minutes • Between SCL Kai Tak Station and EFLS Station at Station Square: 6.5 minutes

#	Analysis Criteria	Value
		• Between MTR Kwun Tong Station and EFLS Station at King Yip Street: 10.5 minutes
6	Traffic Impacts (Additional Minutes of Delay) [B]	• Minimal on elevated section (as no loss of lanes, although in some locations, lane width and footpath would be narrowed to accommodate the viaduct columns, which would not cause insurmountable traffic impacts) • Minimal on at-grade section (the EFLS would operate in the footpath / planter, outside of the carriageway, and would not cause insurmountable traffic impacts)
7	Road Impacts (Total Area Lost)	• 15,600 m^2 (including road space and greenspace)
8	Utility Impacts (Cost of Relocation)	• [redacted]
9	Environmental Impacts	• Construction noise and dust impact due construction of extensive viaduct structure • Potential visual impacts from viaduct • Complies with the EIAO requirements with appropriate mitigation measures.
10a	Project Capital Cost [C] (Dec 2015 Prices)	• [redacted]
10b	Annual O&M Cost	• [redacted]
11	EIRR	• Negative
12	Construction Timeframe	• About 5 years

Notes:

[A] Peak vehicle requirement is presented for information only and is not used directly to compare options, as the number of buses, trams or APM/monorail trains is not directly comparable. The number of peak vehicles is captured in the overall capital costs for a given option.

[B] The travel time impact is estimated using a traffic model that considers the modification of the road and junction layout, as well as method of control required by introducing at-grade EFLS.

[C] Project capital cost includes design, construction, vehicle, project management and project contingency costs. Furthermore, cost estimations are preliminary that are subject to change and update upon further design).

[D] EIRR is estimated based on benefits/disbenefits for local users (and excludes non-local users such as tourists, etc.) solely for the purpose of the evaluation of green transport modes.

7.5 Summary of Option 4 (Mixed Elevated and At-Grade Dedicated Corridor)

7.5.1 Option 4 has a mixed configuration with both elevated and at-grade operating segments. The at-grade portion on the runway would subject the modern tram to junction congestion and interference, while the elevated portion through the rest of the alignment would provide a more reliable and faster journey time without interference from other road vehicles or pedestrians.

7.5.2 Key findings for this option are as follows:

- **High Ridership and Fast Journey Time** – Option 4 would generate a ridership of 235,000 daily riders and a peak load of 7,600 pphpd. Option 4 would be slightly slower than a fully elevated alignment, but would nonetheless provide a fast journey time since it operates principally in a dedicated elevated corridor that would be free from interference from road vehicles experienced by the at-grade options. This relatively fast journey time directly translates into a more time-competitive options against other modes and a more attractive mode to potential users.

- **Vehicle Crowding Higher than Desired** – Peak demand on the most heavily used segment would induce a level of crowding slightly above the ideal 4 ppsm density. The peak demand would thus equate to a passenger density of 5 ppsm in this peak segment. This implies that passengers would be more densely packed in the vehicles than desired, which could have impact on passenger comfort and desire to use the EFLS. This could also elongate dwell times due to longer boarding/alighting times due to blockage of doorways by passengers. Nonetheless, this density would still be below 6 ppsm, which is often reached in peak periods on MTR trains.

- **Minimal Traffic Impacts** – Option 4 would operate on top of an elevated viaduct for most of its alignment, which would support columns. Given the relatively narrow width requirement of these columns (and protection barrier), the required area would typically be obtained by narrowing sidewalks or planted areas to provide a wider median. Columns would also be placed away from junctions to minimise impacts on capacity. In the at-grade section of the alignment, the tracks would be located in the footpath or planter areas outside of the carriageway where possible. Thus in both options, minimal traffic impacts would be generated by this option.

- **Moderate Loss of Road / Green Space** – A total area of 15,600 m^2 would be lost due to the implementation of the modern tram system, most of this on the runway where the track would be located on the sidewalk or planter areas outside of the carriageway (although loss of road would occur at spot locations in both the elevated and at-grade sections).

- **High Capital and Relatively Higher Operating Costs and Negative EIRR** – Compared to other options, capital and operating costs for Option 4 would be relatively high and on par with that of a fully elevated option. Construction and maintenance of elevated structures and stations would be more intensive and costly than at-grade options. Unlike the at-grade options, the volume of riders forecast as well as the overall net time-savings benefit would be higher under Option 4, however, the EIRR is still negative.

- **Landscape and Visual** – Viaduct columns would permanently occupy the future open space. The elevated structure would create a shadow effect and potentially degrade the quality of the future landscape area. The viaduct crossing of the Kwun Tong Typhoon Shelter would obstruct the existing open harbour view of Lei Yue Mun. Thus the overall visual impact of Option 4 at Kai Tak Runway section would still be larger than that generated by Option 1 or Option 2.

8 Key Findings and Conclusion

8.1 Key Findings

8.1.1 This Topical Study describes modern tram technology and assesses its feasibility to serve as an EFLS within KE. Three different modern tram options were assessed, which differed in terms of the level of segregation from road traffic and pedestrians. Option 1 would operate at-grade in a dedicated corridor, with mixing with other road users only at junctions. Option 2 would operate at-grade in a shared corridor, with other road users sharing the same track as the modern tram. Option 4 would operate in a mixed elevated and at-grade configuration, with no interference or mixing with other road users on the elevated portion.

8.1.2 The assessment finds that at-grade modern tram (whether in dedicated or shared corridors) would generate a negative net economic benefit. Reasons for this include relatively lower ridership, which is a direct factor of the slower journey times compared to elevated modes due to at-grade interference from congestion and junction delay. While Option 1 (at-grade dedicated corridor) would generate higher ridership than Option 2 (at-grade shared corridor), traffic impacts would be severe from reallocation of existing travel lanes to the modern tram guideway. Option 2 (at-grade shared corridor) would be subject to vehicular conflict along its entire alignment.

8.1.3 Option 4 (mixed elevated and at-grade dedicated corridor) performs better than either of the at-grade options in terms of ridership and journey time (again intrinsically linked). Along its primarily elevated alignment, Option 4 would operate without interference from road users and pedestrians. Traffic impacts would be minimal. However, operating and capital costs would be higher for Option 4, which would generate a negative EIRR.

8.2 Conclusion

8.2.1 In summary, a partially elevated modern tram alignment appears to be more feasible than at-grade options given the significant traffic impacts generated by the loss of travel lanes for the tramway track and/or relatively slow journey times provided – although higher operating and capital costs still generate a negative EIRR for any of the three modern tram options. Thus, given these findings, it may be appropriate to assess other modes for the EFLS. For reference, the Report on Identification of Suitable Green Public Transport Modes assesses these three modern tram options and a fully elevated Option 3 for the green transport mode selection assessment.

Appendix G

Estimated Transit Times between EFLS and Major Nearby Railway Stations

Table G-1: Comparison of Transfer Times between EFLS and Major Railway Stations by Option

		Transfer Time (including Walk / Wait Times) (in Minutes)			
MTR Station	**EFLS Station**	**Option 1 – At-Grade Dedicated Corridor**	**Option 2 – At-Grade Shared Corridor**	**Option 3 – Elevated Dedicated Corridor**	**Option 4 – Mixed Operations**
MTR Kowloon Bay Station	EFLS Station near Fuk To Street	-	7.0	7.25	7.5
MTR Kwun Tong Station	EFLS Station at King Yip Street	-	16.0	10.25	10.5
	EFLS Station near KTAA	14.0	-	-	-
MTR Ngau Tau Kok Station	EFLS Station at Lai Yip Street	-	12.0	-	-
	EFLS Station near Hoi Bun Road Park	10.0	-	-	-
SCL Kai Tak Station	EFLS Station near Station Square	7.0	7.0	6.25	6.5

Note: Alignments for each option may differ, thus station locations may be slightly different by option.