

Appendix B.8

Design Criteria



Hamilton Rapid Transit Preliminary Design and Feasibility Study

B-LINE

DESIGN CRITERIA REPORT

Version: 1.0



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September 2011

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1.0 Introduction

The Hamilton LRT B-Line is an innovative project for the City of Hamilton, and as such, has very little precedent associated with it to base its design and system component definitions on.

This draft design criteria captures results of preliminary discussion with the representatives of the City of Hamilton involved with this Project.

This document is intended for the Preliminary design stage only. Certain system elements are still evolving and will be added at the next design phase including cathodic protection, utilities, civil works, hydrology, drainage, right of way criteria and any other related matters. In terms of subsystems, all elements are discussed except for the automatic fare collection system. The Presto system is assumed to be the preferred fare collection system, and further details related to the fare collection will be developed in the next design phase.

2.0 Project Configuration

The B-Line consists of 13.9 km of dual track, 16 on-street stops and two terminals (See Figure 2.1).

At the time of writing this document, the Maintenance and Storage Facility (MSF) has yet to be determined.

The LRT will operate with one vehicle per train, on both shared and 100% segregated, although mostly at-grade guideway to allow cross-movements and access to properties, with 100% priority at signalled intersections achieving notably higher operational speed, pertinently in the peak periods, when compared to any other mode of transport (such as buses and private vehicles).



FIGURE 2.1 Proposed Hamilton B-Line from Sta 0+000 to 13+900

3.0 Document content and format

The Design Criteria is presented as follows:

- Operational Design Criteria;
- Prototype Vehicle Specification;
- Alignment Design Criteria;
 - Roads
 - LRT
- Stop Design Criteria
- Power Supply and Distribution;
- Trackwork;
- Communication Systems;
- Signalling; and
- Traffic Signals and Illumination;

4.0 Operational Design Parameters

The following table outlines the general operational design parameters for the proposed system.

Specification	Unit	Notes	Comments
Minimum Headway	4.0 minutes		
Average dwell time at intermediate stops (assumed)	20 seconds	To be confirmed by ridership forecasting	
Maximum Cruising Speed	60 km/hr		
Acceleration	1.0 m/sec ²		
Deceleration	0.9 m/sec ²		
Minimum Dwell time at terminals	5.0 minutes	May be reduced to adjust schedule.	
Target commercial operational speed at peak periods	25 km/hr		
Operational Hours - first vehicle from terminal - last vehicle from terminal	5:00 am 1:30 am		Bus operation possible at night
Degraded operations with track segment between cross-overs of operations - maximum directional headway	8.0 minutes		
Fare Collection System	TBD	Preferred system is Presto, but system to be assessed in detailed design phase.	Assumed pre-paid passenger tickets from vending machines at stops

5.0 Prototype Vehicle Specifications

Listed below are typical performance specifications which satisfy the operational parameters listed in Section 4 of this document. Further specific vehicle characteristics will be developed in the detail design phase.

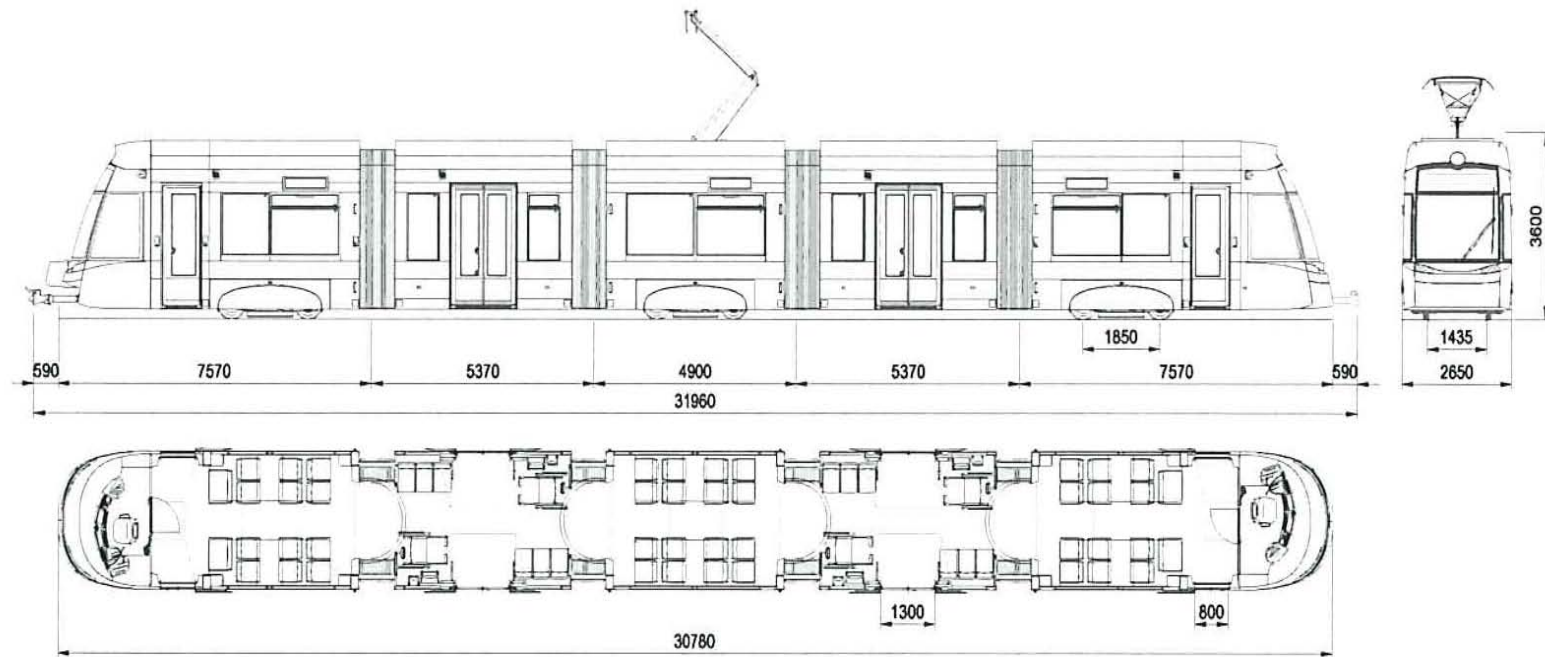
Table 5.1: Current Prototype Vehicle Proposed Performance Specifications

Dimensions and Weight:	
Length of Vehicle	32 m
Height above top of rail	3.6 m
Width	2.65 m
Floor height above TOR - Low floor entrance	350 mm +/- 11 mm
Percentage of low floor area	100% (level boarding)
Electric double-sliding doors	2 double doors and 2 single doors on each side of vehicle
door clearance height	2,072 mm
door clearance width	1,300 mm
Electric single-sliding doors	1 per side
door clearance width	800 mm
Aisle width	630 mm
Wheel diameter	640 mm
Gauge	1,435 mm
Minimum horizontal curve radius	25 m
Minimum vertical curve radius, crest	520 m
Minimum vertical curve radius, sag	260 m
Car weight (empty)	49.5 t
Maximum Car weight (AW2 load:6 pass./m2)	70.1 t
Maximum axle load	11.8 t
Buffer Load	400 kN
Height of Pantograph in lock position	3.70 m
Minimum Pantograph operating height	3.96 m
Maximum Pantograph operating height	6.80 m

Technical Characteristics	
Nominal Voltage Supply	750 VDC
Energy Recuperation - Low voltage	28 VDC
Four/six 3-phase asynchronous motors	125 Kw
Air-cooled motor	2 powered bogies; 1 trailer bogie
Electrical service brake	Regenerative
Mechanical service brake	Disc brake
Magnetic brake	6 x 66 kN
Noise Level	75 dBA at 15 m offset accelerating from 0 to 70 km/hr

Performance Capacity	
Maximum Speed	70 km/h
Acceleration Rate	1.2 m/s ²
Deceleration - service brake - emergency braking rate	1.34 m/s ² Min. 2.2
Maximum gradient	6% (maximum gradient will be 5% at maximum speed of 25 km/h for an unlimited distance and 6% sustained for 250m)
Seated passengers	50
Standing passengers (6 pass./m ²)	192
Bicycle and wheelchair locations	2 of each
Degraded Operation	A vehicle with an AW2 load should be capable of pushing or towing a disabled train with AW2 load of equal length to the next stop. After unloading both trains push/tow to the end of the line

**Figure 5.1 Hamilton LRT – Preliminary Design and
Environmental Assessment**
Current Prototype LRT Design Vehicle (32 m overall length)



6.0 Alignment Design Criteria

The design criteria presented below are for both the road associated with the LRT alignment and for the LRT guideway area itself.

6.1 Roads

Specification	Unit	Notes
Road Category on LRT Alignment - Existing - With LRT	UAU 60 UAD 60	Current maximum posted speed limit 60 km/hr
Design Vehicle at intersections	WB – 20.5	
Minimum Stopping Distance	110 m	
Equivalent minimum 'k' factor	25	
Cross fall - Roadways - Sidewalks	2% 1%	
Minimum horizontal radius	115 m	
Lane Widths - Desirable through lanes - Minimum through lanes - Desirable left turn turning lane - Minimum left turn turning lane - Desirable right turn turning lane - Minimum right turn turning lane - Parking lanes - Lane adjacent to side platform	3.50 m 3.30 m 3.30 m 3.0 m 3.5 m 3.3 m 2.6 m 4.0 m	In 'Local Traffic Only' conditions
Desirable Sidewalk width Minimum Sidewalk width	2.50 m 1.50 m	
Vertical Clearance	5.00 m	
Minimum Curb radii - Cars only - WB – 20.5 truck - Buses	6.00 m 14.00 m 15.00 m	Radii adjusted to reflect actual constraints and verified by turning template.
Guideway Curb - Height - Width	150 mm 300 mm	Does not apply at intersections and sections of shared use where vehicles are allowed to cross the guideway ROW.
Storm design protection	25 years	System-wide drainage meets existing criteria
Minimize Pipe Sizes - Culverts under LRT - Storm Sewers - Catch Basin Leads - Subdrains	500 mm 300 mm 300 mm 150 mm	Culverts and storm sewers to be removed from under loading conus of guideway
Minimum pipe clearance from top of rail to top of pipe - For New pipes - For Existing pipes	1850 mm 1300 mm	(with sleeves) Otherwise relocation is required (with sleeves)
MSF Yard drainage	–	Storm Water Management Plan required

6.2 LRT

Specification	Unit	Notes
Design Speed	70 km/hr	10 km/h over posted speed
Minimum Radius <ul style="list-style-type: none"> - Commercial Operation - In MSF 	25 m (Absolute min) 17.25 m	
Minimum Tangent between horizontal curves	40 m or 0.57V for speeds less than 70 km/hr	V = actual speed at curve
Desirable Minimum Circular Curve Length	0.57V	
Guideway Width	6.98m 7.68m	w/o central catenary pole w/ central catenary pole
Maximum Longitudinal Grade	6%	
Maximum Longitudinal Grade at Stops	2%	
Desirable Vertical Tangent between Vertical Curves. Absolute minimum vertical tangents between vertical curves	30 m 12.5m	
Vertical curve lengths <ul style="list-style-type: none"> - Desirable - Preferred minimum - Minimum vertical curve (crest) - Minimum vertical curve (sag) 	60A 30A $AV^2/215m$ $AV^2/387m$	Where A = Absolute value of [Grade of outbound – Grade inbound]
Minimum Vertical Curve Radius <ul style="list-style-type: none"> - Crest - Sag 	250 m 350 m	
Stop Platforms <ul style="list-style-type: none"> - Length - Minimum Width <ul style="list-style-type: none"> - Side - Central - Terminal Stop - Height above Top of Rail (max) 	40 m 3.00 m 4.00 m 6.00 m 350 mm	
LRT System wide Ductbank <ul style="list-style-type: none"> - For Traction Power 100 mm - For Communications signalling, electrical and others 50 mm 	2 each 12 each	Two Tier

7.0 Stop Design Criteria

7.1 General

Two stop design configurations are planned:

- Side platform stops, consisting of a platform for each running direction;
- Central platform stops, having one platform to serve both running directions.

All stop platforms should be 350 mm above the top of rail to allow seamless access from the platform to the 100% low floor vehicle.

The surface of the platforms should have a 1 % cross fall away from the adjacent track. All platforms should be on the tangent segments of tracks. The maximum longitudinal grade should be 2 % and the minimum 0.25 %.

The stop design criteria are provided for the preliminary design phase, in order to allocate appropriate space requirements and provide principal dimensions of the stop components. Detailed stop platform design will be developed in the detailed design phase.

7.2 Platform Configuration

The platform length should be 40.00 m. The minimum side platform width should be 3.00 m. The minimum central platform width should be 4.00 m. Figures 7.1, 7.2 and 7.3 show typical stop platforms.

Each platform should be connected to the street level at its narrow end(s) by ramps with a 1:20 grade. The width of the platforms (between railings) should be:

- For 3.00 m side platform: 2.25 m
- For 4.00 m central platform : 3.00 m
- For 6.00 m central platform : 3.75 m

A strip with 0.60 m width along the track side platform edge should be treated as anti-skid surface. The same strip should be also detectable by the visibly impaired users.

If the side platform is adjacent to the road traffic lane, a safety railing should be provided along the road side. If the side platform is flushed and adjacent to a sidewalk, streetscape measures such as planters may be utilized to delineate the platform edge.

7.3 Shelters

Shelters are required at all platforms, except when side platforms are shared use with the sidewalk. In this case, if feasible, roof only shelters, without provisions for seating and supported by columns at the back of the platform should be applied. It is desirable that the roof of the shelter extend over the edge of the platform and on to the side of the stopped vehicle.

For side platforms and 4.00 m wide central platforms, the shelter will also provide limited side protection (See Figures 7.1 and 7.2). The 6.00 m central platform should accommodate fully enclosed shelters (See Figure 7.3)

7.4 Platform Structure

The platform should consist of pre-fabricated slab/beams elements which are 3.00 m or 4.00 m wide depending on the configuration, and 8.00 m long mounted over point foundations forming a grid 3.0 m x 8.0 m or 4.0 m x 8.0 m. The space between the point foundations allows for crossing utilities connections to run between the buildings and the longitudinal main utility lines.

7.5 Platform Structures and Facilities

7.5.1 Principles of Design of Stop Platforms, Structures and Facilities

- **Clarity of Path/Sequence of movement:** The stop's prime function is to be a direct conduit to guide people to and from the trains. There is a basic functional organization through arrival, information provision, ticketing, orientation at the platform and waiting for the train. This requires a systematic progression that is easy to follow for the first-time user and is consistent between stops across the system. Spaces should be oriented to direct decision making as a linear series of single choices.
- **Level of Service:** The stops' spaces and circulation elements should be sized based on level of service standards required for passengers. Consideration should be given to exit capacity in case of emergency.
- **Crime Prevention through Environmental Design:** The stop design should make extensive use of glass at platform level to strengthen visual connectivity.
- **Universal Access:** For stops, disabled access incorporates all persons with limiting conditions, from those with impaired movement through to those with cognitive disabilities or impaired senses. Universal access refers to the integration of consideration for disabilities within the mainstream of the design.
- **Organization of Ancillary Functions:** The ancillary space functions at the platforms can represent up to 20% of the total floor area. They require special planning for spatial and functional relationships to be maintained and to accommodate equipment repairs and replacement.
- **Construction Method:** The construction method is important to the sequence and scheduling of the work. Key interfaces between the guideway and the stops influence both design and construction methodology. Modular design elements should be developed to provide the most economical and practical stop implementation system allowing for fast installation and construction.

7.5.2 Platform Components

The platform components should be designed as an extension of the shelters. The catenary poles, street lighting, traffic lights, pedestrian lighting, banners, street furnishings and intersection marker poles take their cues from the stop and combine to create an integrated downtown streetscape.

- **Catenary wires/Light Poles:** In addition to the overhead wiring, the catenary poles are designed to accommodate street lighting, traffic lights, pedestrian lighting, banners, hanging planters and signage.
- **Paving:** The platforms should be paved with integrally coloured concrete pavers. The pattern will be composed of a mosaic of randomly placed similar colours offset by distinctive coloured bands that relate to the structural grid of the shelters. The mosaic of random colours will allow for a single paver to be replaced without requiring an exact colour match.
- **Anti-skid pads:** The anti-skid pads should be formed from integrally coloured precast concrete. They should be constructed from a number of pieces and mounted to the substructure of the platform with recessed stainless steel fasteners. This will allow for easy replacement or adjustment of the tactile strip if required.
- **Handrails and Guardrails:** Handrails and guardrails should be provided where required. They should be fabricated from stainless steel. They should be detailed with bolt connections to reduce the number of site welds.

- **Seating:** Hard plastic or stainless steel seating of modular design should be provided in the shelters. Arm rests are to be located at each seat to not only provide comfort but to limit possibilities for loitering/sleeping on the benches.
- **Planters:** If space allows, platform planters should be constructed from precast concrete and are coloured to complement the platform paving. The planters are installed above grade to protect the planting and to not disrupt underground services. Waste receptacles, recycling containers and salt boxes should be integrated into the design of the planters.
- **Lighting:** The platforms should be illuminated by the lights mounted on the catenary poles, pole mounted light fixtures, and by the lights at the shelters.
- **Newspaper boxes:** Newspaper boxes could be integrated into the design of the platforms
- **Tickets Vending Machines:** Two ticket vending machines per platform should be provided. The machines should be under cover and should be accompanied by a display board with user instructions and a Transit System Map.
- **Electrical and Communications Cabinets:** These metal cabinets should contain all the electrical controls and communications equipment required for the stop functioning. The communication equipment is outlined in Section 10.0 of the Design Criteria: Communications Systems.
- **Fire protection:** The street fire hydrants should have the capacity to cover the stop platforms.

7.6 Staff Restrooms

Staff restrooms should be provided in the immediate vicinity of the two terminal stops. The exact size, partitions and rooms designation will be determined in consultation with the Transit Authority during the next design stage.

7.7 Barrier Free Design

The stop platforms will incorporate accessibility elements in order to be in accordance with the City of Hamilton Barrier Free Design Guidelines. Details will be incorporated in the next design phase, but for the purpose of Preliminary Design, the following elements will be considered:

- The minimum clear width for the enclosed passenger shelter is 950 mm;
- System-wide, all access ramps on stop platforms have a slope of 1:20;
- A detectable warning surface is used along the edge of the stop platforms and will be used at the intersection of the ramp and cross walk in accordance with the City of Hamilton's Urban Braille requirement.

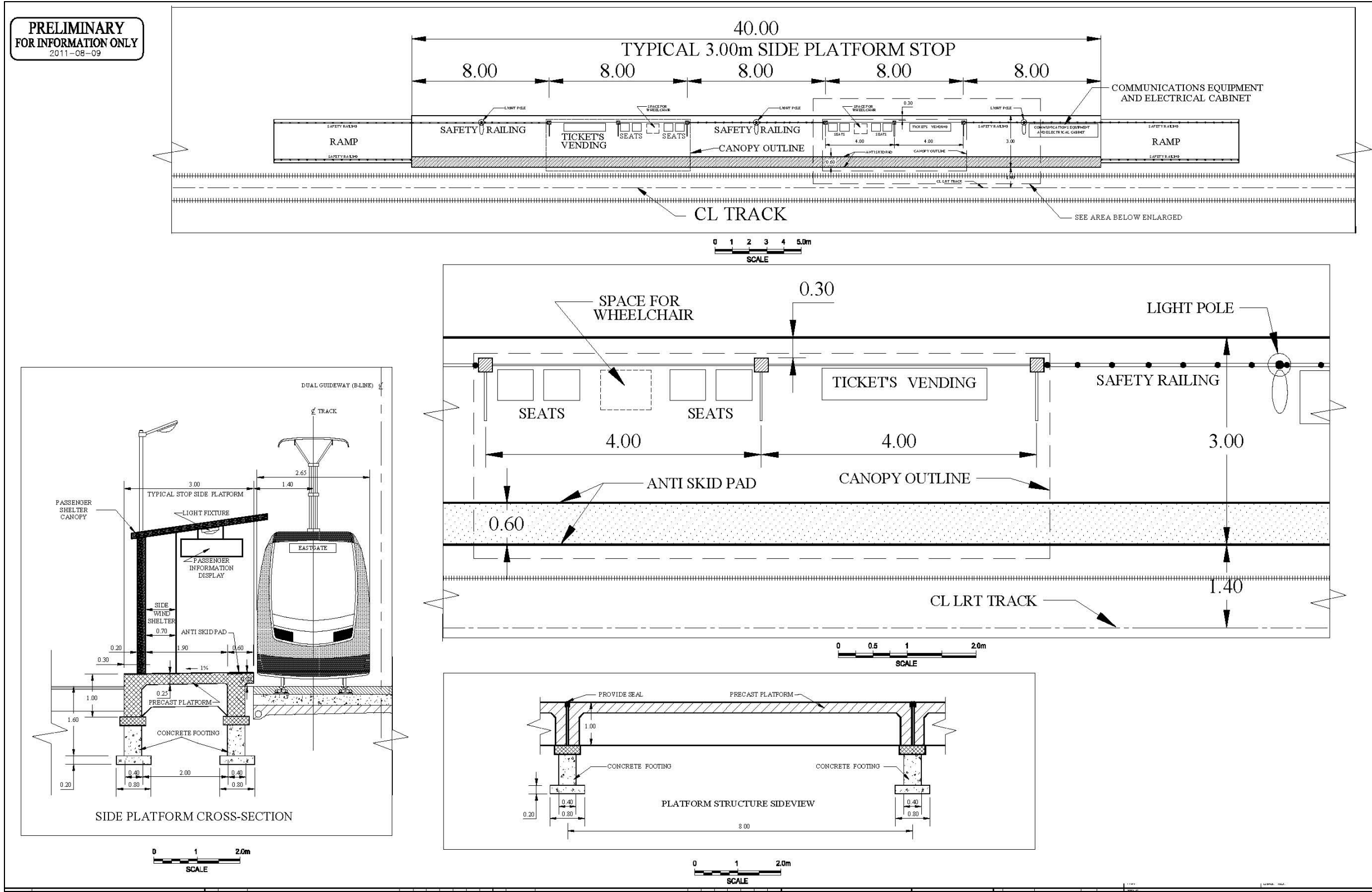


Figure 7.1 Typical Side Platform Stop Configuration

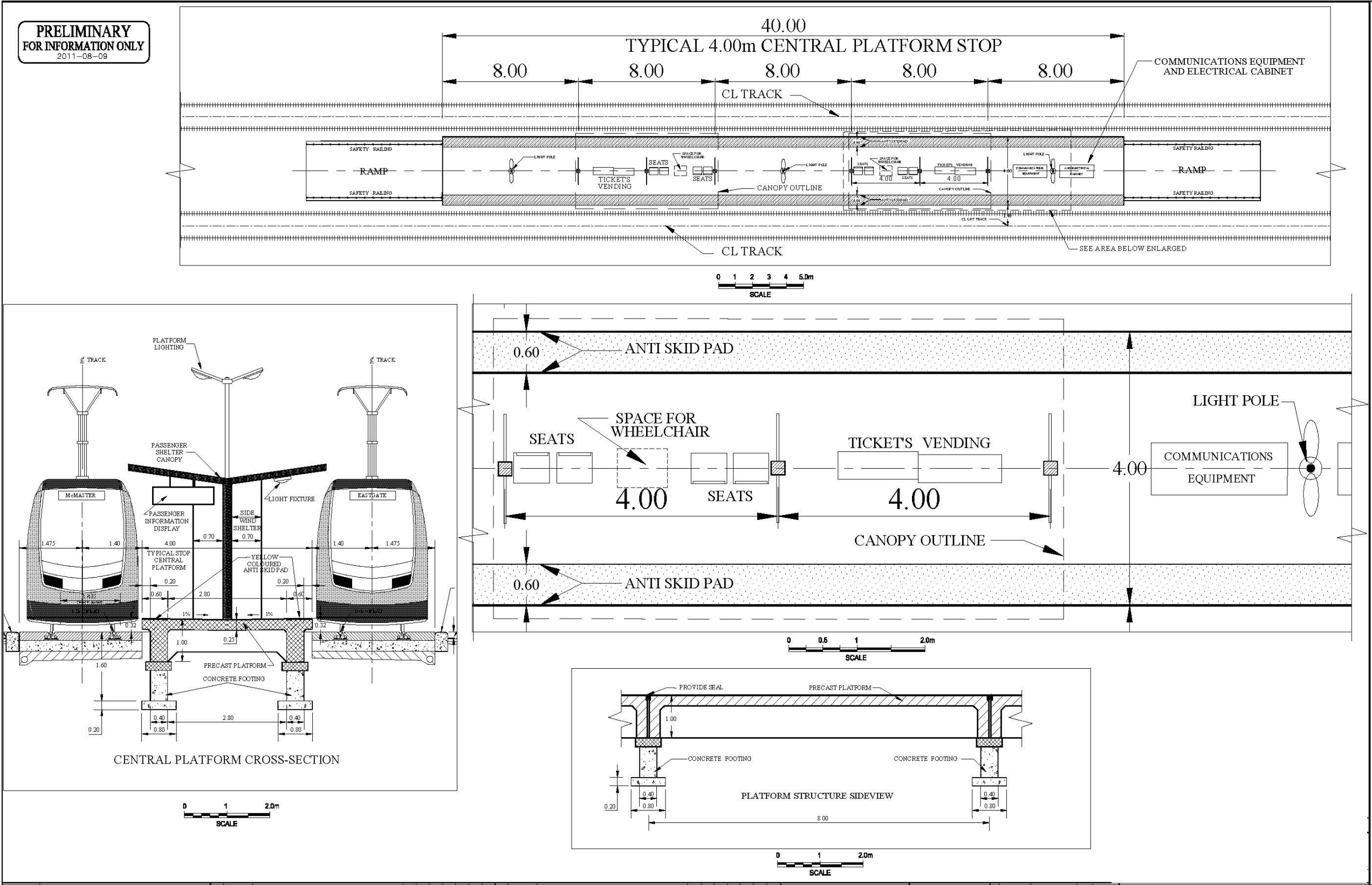


Figure 7.2: Typical 4.00 m Central Platform Stop Configuration

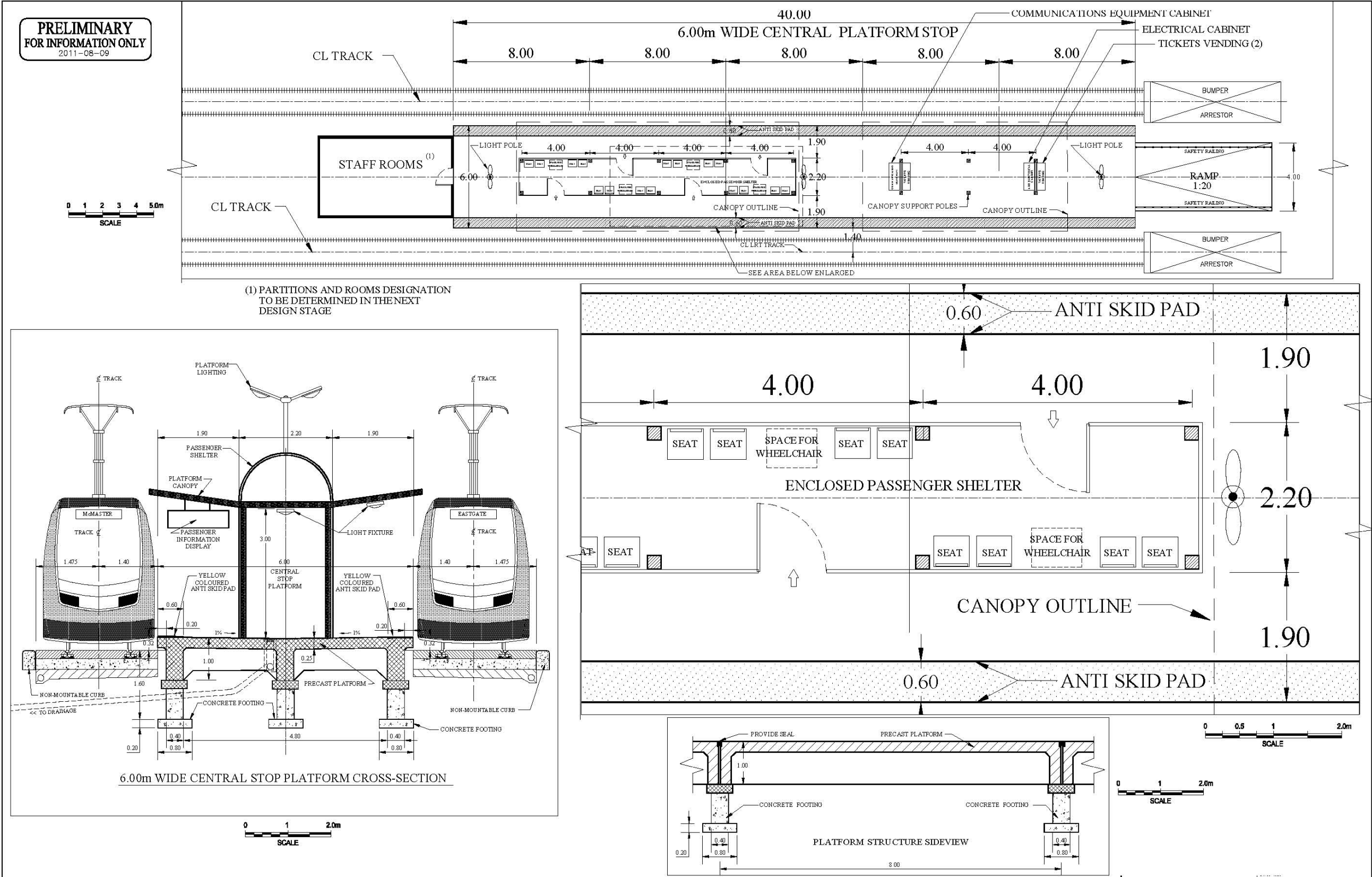


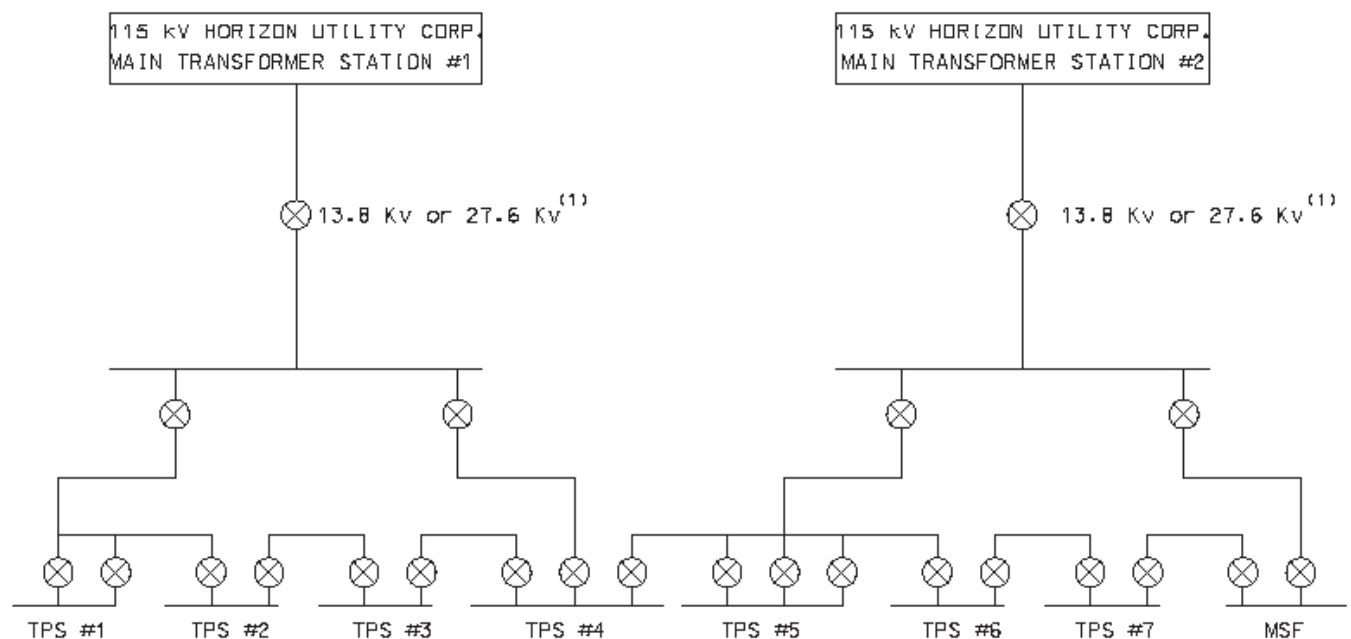
Figure 7.3: Typical 6.00 m Central Platform Stop Configuration

8.0 Power Supply and Distribution – Selection of Traction Power Voltage

8.1 Traction Power Supply

The external power supply will be provided by Horizon Utilities from the existing 115 kV/13.8 kV or 27.6 kV Transformer stations (see Figure 8.1). The underground feeders will be brought to the external wall of each TPS by Horizon Utilities. Further details including further specifications of the Overhead Catenary System, EMI/EMC protection standards, corrosion strategies and touch potential standards will be developed in the detailed design phase.

Figure 8.1: Schematic External Power Supply Diagram



(1) TO BE DETERMINED BY HORIZON UTILITIES

Table 8.1: Traction Power Supply Design Criteria

Specification	Unit	Notes
High Voltage Feed to LRT System	13.8 OR 27.6 Kv	To be defined by Horizon Utility Corporation
Feed Cables Main Transfer Stations - Traction Power Stations	TBD	Underground conduit to be installed by Horizon Utility Corporation
Traction Power Substations Basic Specifications - Type - Size - Length - Width - Height - Access - Optimum Distance between TPSS and OCS feed point	Prefabricated – architecturally, if a TPS building is preferred the TPS components will be placed in a large building 17 m 5.00 m 7.00 m Adjacent to road Not more than 25 m	To minimize section gap arching during Light Rail Vehicle (LRV) acceleration
Overhead Catenary System - Support Poles - Type - Distance between Poles - On Tangent - On Curves	- Centre - Symmetrical - Side-double Cantilever - Both Sides suspended OCS - Side-single Cantilever 50 m (max) Variable	Contact wire to be designed to uniformly sweep width of pantograph to minimize localized pantograph wear For single track sections (in MSF only) Depending on radius and length of curve

9.0 Trackwork

9.1 General

13.9km track along Queenston Rd. from Centennial Parkway Street West to Main Street continuing along Main Street to King Street with grade separation at Chedoke expressway then along connecting along Main Street to Cootes Drive at McMaster University. There should be a connection to the MSF.

Specification	Unit	Notes
Vehicle Mass	70.1 t	
Buffer Load	400 kN	
Revenue Track	Mainline running track including turnout	
Secondary Track	MSF tracks including lead tracks	
Trackway	Dedicated or shared with road vehicles	
Track Centre Spacing (tangent track)	3.29 m minimum on all revenue tracks with a 0.2 m buffer between dynamic envelop of both vehicles	
Storage Track Spacing	4.0 m minimum in the MSF	
OCS supports location	Between tracks or on sidewalks	
Safety Zone	200 mm between the light rail vehicles exclusive of the dynamic envelope and the vehicle bodyline displacement due to curvature for side catenary support and 900 mm for central catenary support.	
Track Spacing Widening	May be required on tight curves	
Vehicle Dynamic Outline	TBD	
Track Gauge	1435 mm measured 16 mm below top of rail	
Track Construction Tolerances	TBD (in mm)	
Rail inclination - For Ballasted Track - For Embedded Track	1:20 No Rail Inclination	
Superelevation - For Embedded Track - Elsewhere	None required except to match pavement crossfall in curves If required, limited to 150 mm achieved by rotating high rail above low rail	
Rail – designed at CWR, shall be insulated to mitigate against stray current	TBD based on availability and economy (rough estimate 2,900 t – 3,300 t exclusive of MSF and turnouts, MSF approximately 700 t)	
Tee Rails	TBD 100RE / 100 ARA-a to 54E1 / 115RE tensile strength and grade TBD	
Street Rails	TBD Ri35G or Ri52 to Ri59 or Ri60 tensile strength and grade TBD	
Concrete Sleepers	1:20 rail cant	

Specification	Unit	Notes
Concrete Sleepers for Girder rail	Zero cant	
Trackbed	Compacted granular base with 3% crossfall away from centre of guideway, a concrete base steel reinforced slab with level surface for rail fixing and a filler to embed the rails. The filler is conventionally concrete material, although other alternative surface materials can also be used to enhance the urban environment.	
Track anchor embedment	Minimum 100 mm	
Elevated bridge	400 m; can be DFF with derailment protection that may be achieved with Jordan rails or concrete curbs	
Rail anchors	May be required if rail expansion joints are utilized	
Fastener Spacing - For Tangent to 150 m TBC - For Tangent > 150 m TBC	750 mm 600 mm	
Direct Fixation Fastener (DFF)	Bonded fasteners	

9.2 Special Trackwork

Specification	Unit	Notes
Turnouts	25mR turnouts and crossings for embedded track	
Embedded track turnouts	1:6R50 embedded track turnouts and diamond crossings	
Ladder Tracks for MSF	1:4R25	
Turnouts for MSF	1:4R25	
Turnouts for yard lead tracks	1:6R50	
Frogs	All rigid	
Rail expansion joint on aerial structure	TBD	

10.0 Communication Systems

This section outlines the conceptual design of the communications systems required to support Hamilton LRT. The communications systems are based around a centralised operations concept where decisions regarding service delivery and safety are made at the Operations Control Centre and supported by drivers in each vehicle. The communication systems also facilitate stop operations and roving vehicle attendants in their role as support to service delivery and safety.

The following systems are presented in this section:

- Fibre Optic System
- Integrated Telecommunications System
- Operations and Maintenance Radio
- Vehicle Radio and Data System
- Passenger Emergency Intercom
- Integrated Alarm Data Acquisition System (IADS) and Supervising Control and Data Acquisition (SCADA)
- Information Management System
- Vehicle Public Address
- Stop Public Address
- Public Address System in MSF
- Passenger Information Displays
- Closed Circuit Television System
- Stop Emergency Cabinets
- Operations Control Centre (OCC)
- OCC Equipment

10.1 Fibre Optic System

10.1.1 General Description

The Hamilton LRT will be provided with a public address (PA) system covering all stops and vehicles. The PA system will allow automated, manual and emergency audible announcements to be made to passengers and operations and maintenance personnel.

All communication sub-systems will use a trunk fibre optic transmission system. The light rail vehicle control system supplier will also have the option to use this system, shown schematically in Figure 10.1.

The trunk multi-fibre optical system will link all stops and facilities with the OCC. The system offers high quality video, voice and data transmission with freedom from the electrical and magnetic interference that is a feature of electric transit system.

10.1.2 Configuration

The Fibre Optic system configuration is shown in Figure 10.1.

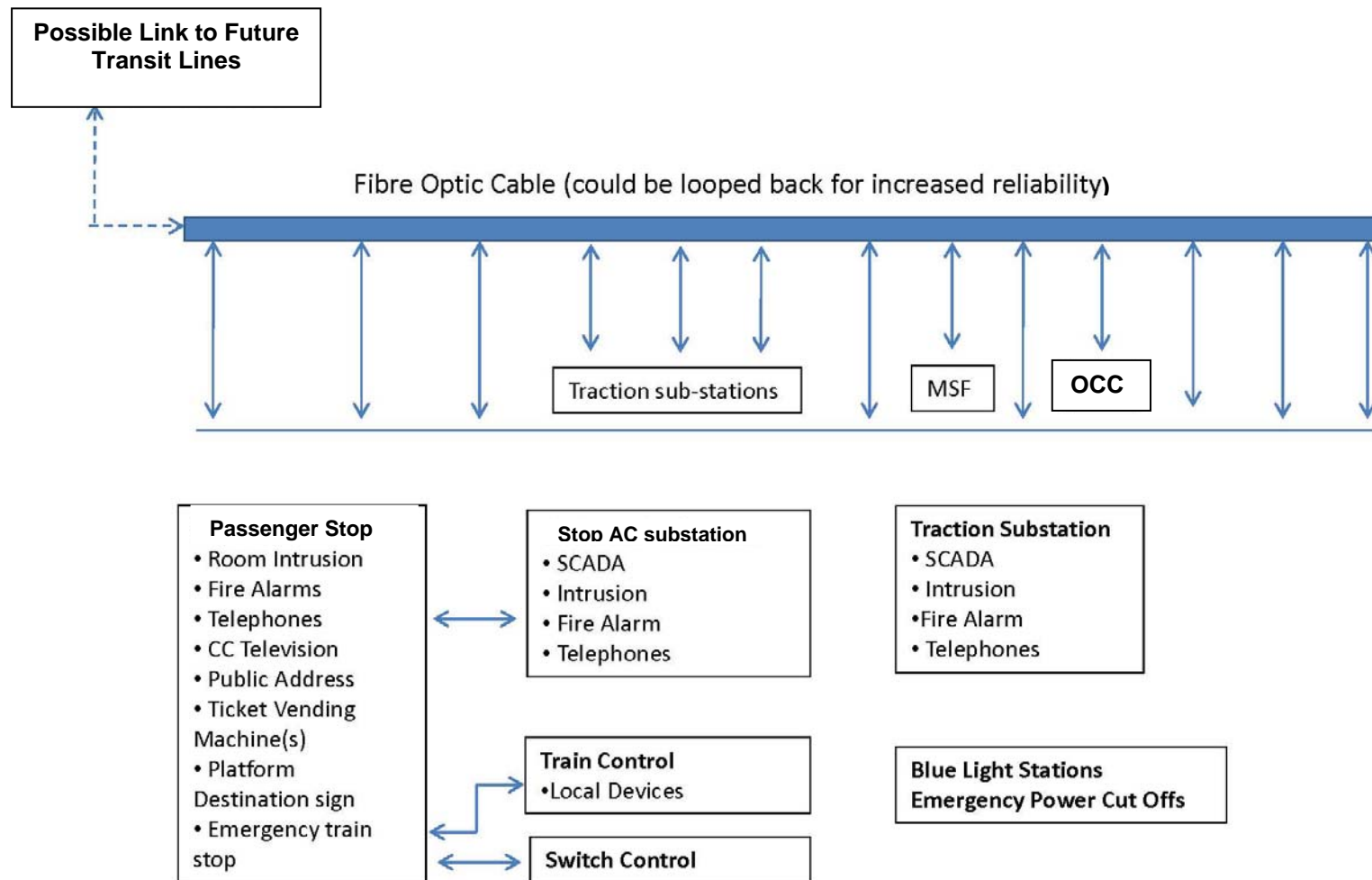


Figure 10.1 Fibre Optic Communication Trunk System B-Line

10.2 Integrated Communication System

10.2.1 General Description

All integrated Telecommunication System is the heart of the communication system. A standard dual processor telephone switch (PABX) will be used to handle all voice (and some data distribution) as well as providing an internal telephone system. The switch should be located in the OCC and linked to various stops and other sub-systems through the fibre optic system, including the TPSS.

The PABX switch will link all radio channels and public address systems so these can be accessed from any telephone set. A blocking feature can be used to prevent unauthorized access to certain sub-systems from specified extensions, including any used by the public – information and emergency phones to the Police and Fire services.

Emergency phones linking each platform with the OCC and protected by sealed transparent covers could be provided if deemed necessary by the City of Hamilton.

10.2.2 Multi-Channel Voice Recorder

A multi-channel voice recorder is recommended to automatically record all control room telecommunication and radio conversations on a 24-hour basis. These tapes can be retained for incident investigation; otherwise they will be periodically erased and reused.

10.3 Operations and Maintenance Radio

10.3.1 General Description

The system should be a standard off-the-shelf mobile radio system. Bands and frequencies must be selected to meet Hamilton area regulations.

Two full duplex channels are required for the initial system, designated Operations One, and Maintenance Two. This provides flexibility in that the maintenance channel can be used for an emergency leaving the other free for routine traffic. Subject to a reception study along the route, additional repeaters or directional antenna may be required to provide adequate coverage.

10.3.2 System Configuration

Stationary Radio Sets should be located in the OCC of the Operations' Manager Office in the MSF and will be subject to agreement with the Hamilton Police Department Service Desk.

Multi-channel mobile radio sets should be provided to all LRT security staff, maintenance and operations supervisors and working crew foremen.

10.4 Vehicle Radio and Data System

10.4.1 General Description

This is a mobile radio system for use on LRT vehicles. The two-way voice system should be augmented by data capabilities.

The central controller can be either on the vehicle public address, the on-board emergency intercom (if provided) or the on-board operator intercom. In the reverse direction central control will receive voice communications from the driver or from the emergency intercom located in each car. An Automatic Identification System (AIS or VIS) will indicate the location of the call within the vehicle of the calling car. The driver position will have a switch permitting use of the vehicle channel or one of the two regular operations channels.

Each vehicle requires an antenna on the roof. Line coverage may require repeater stations with additional frequencies. To augment the radio systems, or to handle inadequate frequency allocation, the use of cellular telephones can be considered, while not operating the vehicle.

In total, a minimum of 6 radio spectrum frequencies are recommended.

10.4.2 Data Sub-system

The two-way voice system could be augmented by data capabilities. These can be used for remote vehicle diagnostics and to control any automatic voice announcements or on-board displays.

If the LRT vehicle drivers are fully trained to recognize and react appropriately to the warning signals on the dashboard, the remote vehicle diagnostics could be spared and a simpler version of controlling the on-board automatic announcements and chargeable displays would be recommended.

10.5 Passenger Emergency Communications

10.5.1 Types of Emergency Communications

Each vehicle will be provided with the following:

- Discrete Passenger Alarm Strips,
- Passenger Alarm Call Buttons,
- Passenger Intercoms,
- Vehicle Health Monitoring.

Activation of any of the above alarm systems will result in an alarm being raised in the Operations Control Centre and with the Driver. The driver will be responsible for answering the call, but under certain situations the Operations Control Centre operator will handle the call.

10.5.2 Passenger Emergency Intercom

This sub-system of the Vehicle Radio allows a passenger to make contact with either the driver or with central control from one or more intercoms built into the walls of each vehicle. Passenger intercoms are now regarded as essential security features in LRT systems. To reduce costs it is recommended the intercom be limited to connection to the driver who can then relay any information to the central control.

10.6 Integrated Alarm Data Acquisition System (IADS) and Supervising Control and Data Acquisition (SCADA)

10.6.1 IADS

IADS is part of the communication system providing data and control between the control centre and various points throughout the LRT System. It incorporates all system fire alarms, fire and overheating detectors and flood levels in low laying areas. IADS informs the OCC of the nature of the emergency and location, thus prompting a quick response.

IADS is also used to switch the stop public address systems, by entire stops, by groups of stops or system-wide. IADS switches the CCTV cameras through sequential video switches in each stop, under control of the CCTV matrix switcher. This reduces the number of discrete video circuits required between each stop and the control centre.

10.6.2 SCADA

The SCADA system will provide the monitoring and control of traction stations - unless the City opts for the sub-station supplier to provide an independent system. The colour video displays and a keyboard should be located in the OCC vehicle control desk. Schematics at different hierarchical levels can be selected to show the power system status: system wide, by sections, or by individual sub-stations. Circuit breakers throughout the system can be remotely operated, individually or to isolate one or more sections simultaneously. Intrinsic protection allows OCS sections, breakers of sub-stations to be locked out for maintenance activities. OCC operators must have passwords or keys to gain system access.

The system can also monitor ticket vending machines for security maintenance diagnostics and, if required, usage reports.

10.7 Information Management System

The Information Management System is an interface between the light rail vehicle (LRV) control system and public information. It takes a data output from the LRV control computer that provides real time information on the location, status and destinations of all LRVs. It uses this output to trigger digital passenger signs in stops and vehicles and to trigger automatic messages on the vehicle and stop public address systems.

The Information Management System is very comprehensive, but since the current design of the alignment is just the B-line, it is recommended that the more economical option to be used is the announcement of stops through pre-recorded messages located on the vehicle activated through stop approach beacons.

10.8 Vehicle Public Address

The Vehicle Public Address system is a component part of the Vehicle radio and Data System using an amplifier in the radio package to transmit through loudspeakers.

Intelligibility of vehicle public address systems is optimized by more frequent loudspeaker placement. The Vehicle Public Address system can use the Information Management System for next stop and end-of-line announcements, or these messages can be triggered by the driver, or by stop approach beacons. The digitized messages can be stored in either a central location or on each vehicle. The Vehicle Public Address system can also be used for messages directly from either the Operations Control Central or the vehicle driver.

10.9 Stop Public Address

To obtain good intelligibility each stop is equipped with closely spaced speakers, an equalizer to tune the sound to best meet the acoustics of each location and ambient noise monitoring to automatically adjust volume. The Stop Public Address system is addressed through the integrated Alarm, Supervisory Control, and data Acquisition system, with messages from the OCC.

A minimum of 4 speakers per platform is recommended.

10.10 Public Address System in the Maintenance and Storage Facility

The Depot Public Address is a conventional PA system covering the yard, maintenance centre, associated facilities; and offices. Access and control is from any authorized telephone extension and the control room comsets.

10.11 Passenger Information Displays

The Hamilton LRT B-Line operations plan is to have identical light rail vehicles operating on a single route without any short-turn or express service. Consequently the need for passenger information displays will match the level of information currently provided on City buses with the same visual and audible features. The displays provided shall be:

- On the front and side of each vehicle indicating destination;
- Inside each vehicle alternating between next stop and destination; and
- On each platform indicating LRV destination and time next to LRV.

All displays shall clearly identify when the vehicle is scheduled to make its final revenue run before going out of service.

10.12 Closed Circuit Televisions

CCTV cameras will be used for both security and operational purposes. The latter requires cameras that monitor the stop platform showing levels of crowding and LRV door status. Each platform requires two cameras with cross vision, electronically combined onto one split screen to give a composite picture of the entire platform. The terminal stops will require 4 cameras each. The City of Hamilton may connect these cameras to their police surveillance stop as well.

Recording of video images shall be provided to assist in the investigation of incidents and court proceedings. These images could be retained for a period of time before being erased. Images may also be copied from the system and archived. Recordings will be stamped with date, time and camera location to assist in recovery of data.

10.13 Stop Emergency Cabinets

Located on each platform are Stop Emergency Cabinets. These contain an Emergency Services Telephone, a standard PABX telephone, a fire extinguisher, and a keyed reset switch for the integrated alarm system IADS.

The Emergency Services Telephone should be accessible by the passengers upon breaking through a protective cover. The CCTV cameras should cover the Stop Emergency Cabinets to facilitate investigation and protection from unwarranted use.

10.14 Uninterruptible Power Supply

All communication systems require an Uninterruptible Power Supply to ensure safety and security during power outages. Such UPS systems are provided in vehicles, stops (in the communications cabinet) at TPSS, the OCC and at the workshop building.

These systems should be used to supply the various communication requirements. The UPS systems should be battery supplied and have a capacity specified by code, typically 30 minutes for emergency lighting and two hours for communications and controls. At the OCC and workshop building the large UPS will be backed up by a diesel stand-by generator giving central communication facilities an extended availability for at least 24 hours.

10.15 Passenger Counting

The Hamilton Line will be provided with Passenger Counting System to allow ridership data to be collected on an ongoing basis. The ticket machines will record the number of tickets sold throughout the hours of operation. This information can be conveyed to a recording centre at the OCC. The validation equipment on board of the vehicles will also record the users of pre-paid passes. These counters can be processed at the MSF at the end of the day, for downloading the recorded number of on-board users.

10.16 Master Clock

The Master Clock System provides the following functionality:

- Single Common Time base synchronised to GPS,
- Distributes Common Time to all systems and clocks

The system maintains a precise time of day reference and distributes this to all systems and clocks requiring accurate time and date information. The system time is synchronized to GPS normally, but under failure situations the system will continue to maintain accurate time using its own internal free running clock.

Precise time across all systems and around the lines clocks is required to ensure consistence during incident investigations and accuracy of scheduling and passenger information.

11.0 Light Rail Vehicle (LRV) Operations, Control and Signalling

11.1.1 General Description

This section outlines the conceptual design of the signalling system required to support Hamilton LRT. Operation will be based on a “drive-on-sight” approach, where the driver is responsible for the operation of the vehicle including the brakes and the positioning of the track switches if needed to be changed from the pre-set main direction. Two exceptions for automatic over-riding of the manual controls will be provided on board include:

- Provision for safe LRV separation (detection of preceding vehicle initially giving a warning) and if no brakes applied, engaging the emergency brakes; and
- The “Dead Man’s Switch” (optional). This device is used to avoid accidents caused by a suddenly incapacitated driver. The vehicle speed controller is fitted with a capacity touch sensor to detect the driver’s hand. If the hand is removed for more than a short period of time, the vehicle brakes are activated.

11.1.2 Wayside Signs

All trackside signs required for safe LRV operation should be installed facing the driver in the normal direction of operation. This will include:

- Stop boards;
- Stop limit boards;
- Location signs.

Permissible speeds, temporary speed restrictions and associated warnings for degraded mode of operation should be displayed at the wayside to allow continued operation when the permissible speed cannot be displayed in the cab. Wayside signs should be auto-reflective.

11.1.3 Light Rail Signal Priority

The Light Rail Signal Priority will be provided by:

- LRT Detection:
 - Loops between tracks;
 - Advanced detector (check-in) past upstream signal. In the case of closely spaced signalized intersections, advanced detectors may need to be located further upstream;
 - Cancel detectors (check-out) positioned on the existing intersection;
 - Where left turn movements are allowed across the LRT track, separated protected left turn phase from a parallel roadway across the LRT tracks should be provided.
- Separate signal heads for LRT;
- LRT priority should be provided through Transit Priority Function, with parameters set on an intersection-by-intersection basis, based on the individual operational requirements of each intersection. However, in general terms, signal operation should be set up within the following guidelines:
 - Vehicle phases are shortened or lengthened as necessary to provide LRT priority, whilst maintaining minimum green and minimum clearance periods for all phases;
 - No phases could be skipped, except for left turn protected phases where vehicle detection is provided. In this case, skipping is considered on an intersection-by-intersection basis;

- Signal operation reverts to normal operation when LRT has passed through cancel detector;
- Where signal intersections are co-ordinated within a fixed network cycle time, signal operations will always aim to return to the co-ordinated cycle time (but allowing individual cycle time extensions to maintain LRT priority and other phase minimums);
- Compensation timings (green time re-allocated in subsequent signal cycle after a cycle with a LRT phase served) will generally be given to the main road phase, although this will be done on an intersection-by-intersection basis.
- LRT, vehicular and pedestrian phases can be skipped if no call (i.e. no recall);
- Coordination is maintained by completing all phases adjustments within one cycle;
- Time taken from cross street and left turn phases during priority is not restored in subsequent cycles;
- Time used for LRT priority is always added to the main Street phase;

12.0 Operations and Control Centre (OCC)

12.1.1 Functions and Location

The LRT system will consist of mainline and yard tracks some of which may be signalled. Signalled territories contain track circuits, signals, switched, and interlocking which shall indicate their status to the Operations Control Centre (OCC) located at the depot. (See Figure 12.1)

The operations controllers will use the OCC consoles to perform the following functions:

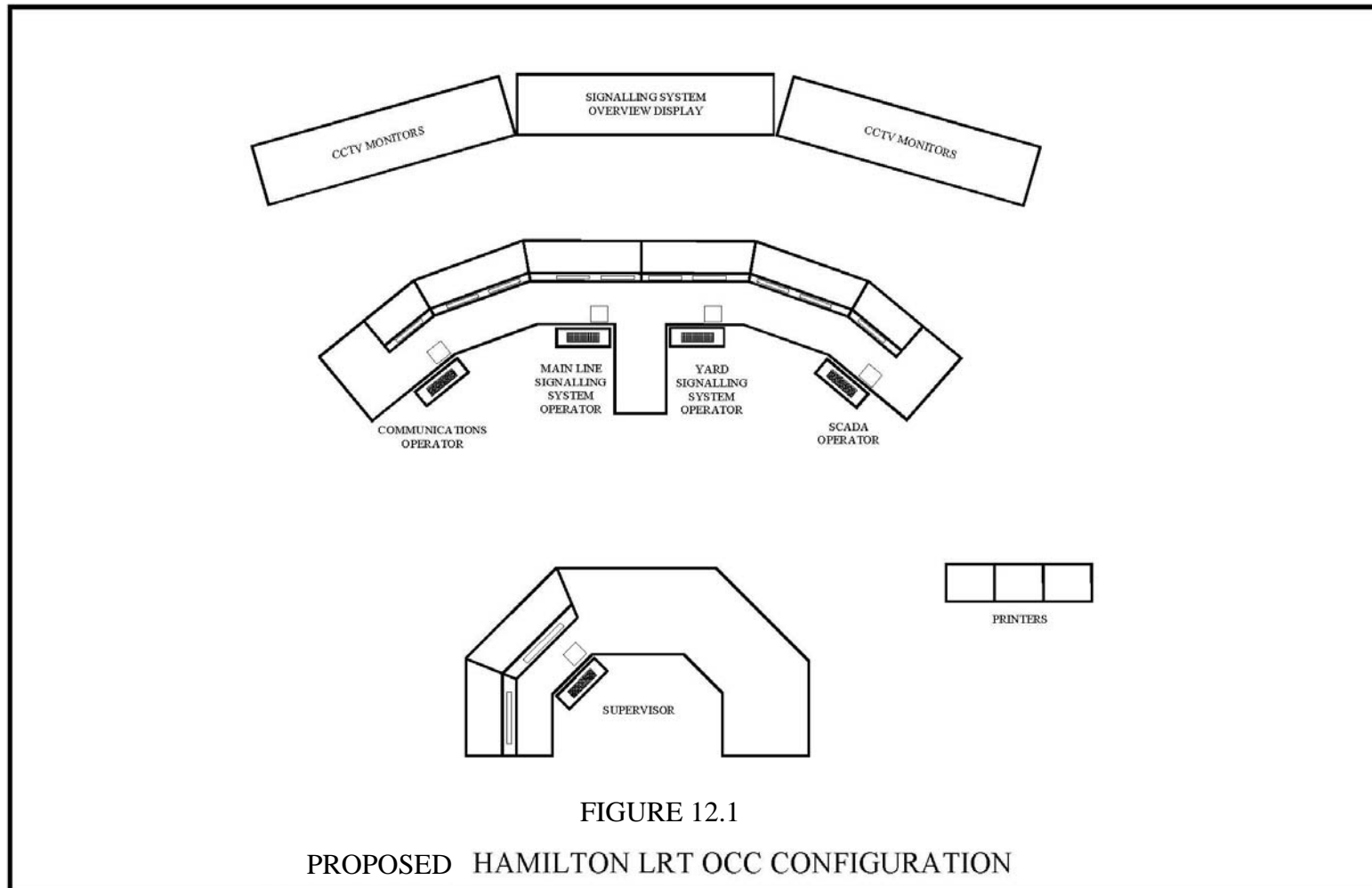
- Monitor and control of vehicles' movements;
- Intervene directly and implement procedures to recover from delays;
- Supervise safe movement of LRVs, LRV movements against the established direction of traffic;
- Monitor and record any signal violations;
- Monitoring schedule adherence;
- Reporting equipment problems to the proper maintenance personnel;
- Monitoring the correct functioning of the Train Control System (TCS) equipment and notifying the appropriate response personnel.

The Operations and Control Centre will acquire and use data at mainline entrances and exists to:

- Determine and obtain the identity of LRVs;
- Establish the tracking of identified LRVs leaving the yard to enter the mainline;
- Terminate the tracking of LRVs exiting the mainline and entering the yard;
- Identify and maintain record of the vehicles, and their position within each LRV;
- Accumulate each vehicle's mileage for the day; and
- Monitor performance to schedule.

As the B-line system is relatively small, there is the option of having two CC's integrated in one OCC with an additional console for the yard dispatcher who directs the LRV movements inside the yard with radio communications with the LRV operations (MSF jockeys, not the main line drivers). As normally this dispatcher is located at a good vantage high point in the MSF to oversee the yard, such an integration will require the entire OCC to be located in the MSF.

The City of Hamilton may want to have the OCC within an integrated Transit Operations Centre which includes the bus operations and the interface with other transit subsystems like GO and neighbouring municipalities. If this is the case, one has to consider the substantial cost of the fibre-optic cable linking the LRT to the OCC located away from the guideway and the risks to damage this cable by other parties working along this route.



12.1.2 OCC Equipment

The Operations Control Centre will be equipped with 3 control consoles (TCS, Power Director, and Security/Communications consoles). Each console shall provide for two Operator positions in such a manner that any function available to one operating position shall be equally available at the other operating position. The TCS Operations Control console shall have access to all information necessary to supervise all light rail vehicles (LRVs) operating on the mainline portion of the system and to remotely control all interlocking.

A large graphic display monitor shall be provided to facilitate the monitoring of LRV service and signaling equipment. The display shall provide a continuous overview of the position of all LRVs on the mainline, including the yard entry/exit zones.

Track circuit areas shall be colored to distinguish between adjacent track circuits and between tracks.

As minimum, the display shall include the following labeled indications:

- Indications to show the extent of routes set, on a one-for-one basis, to available track circuit indications. Sufficient track and route indications shall be provided to give a reasonably complete representation of a continuous line. Indications shall be set within the track circuit symbols. A separate route entrance indication shall be provided to show when a complete route has been set and ATP signals selected.
- Indications to show the destination and position of turnouts and their interlocking status. Indications shall show turnout status within the track circuit symbol when routes are set.
- Indication to show direction of travel for which the route is set.
- Indication of Stop names, platform limits and designation.

13.0 Traffic Signals and Illumination

13.1.1 General Description

Although there are existing traffic signals and continuous illumination along the corridor, the interaction with the implementation of the LRT system may require modifications or additions to the current system. The particular components of the signalling and illumination will be defined in the detailed design phase, but for the purpose of preliminary engineering, the main criteria required are listed below.

13.1.2 Traffic Signals

The following work will be required for the traffic signals along the B-Line Route:

- Retrofitting of approximately 54 existing signalized intersections controllers with accepting and honouring the request for priority coming from between-the-LRV vehicle detectors;
- Installing of approximately 4 new traffic signals along the route with the same interface as above;
- New phasing cycles will be required at intersections when need to accommodate left turns across the LRT transitway.

To implement the new signals, temporary aerial-span signal system will be required to maintain traffic control at intersections and to facilitate construction staging and subsequent installation of permanent signals.

13.1.3 Illumination

Continuous illumination exists along the whole corridor in the form of independent light poles, lights on joint-use traffic and joint-use utility poles. In some areas towards the city's downtown, independent decorative lighting poles/luminaires are installed that provide a unique character to the section of roadway likely to encourage economic activity in the area generally during the hours of darkness. For this section and all others, it is assumed that the light levels throughout the proposed route meet present-day lighting criteria.

As a result of the new construction, it is not likely that all the illumination can be maintained during construction. Although portions of the lighting may be unaffected, in certain areas where the new track work and stop platforms are to be installed, existing lighting will need to be relocated or possibly new lighting installed depending on the age of the lighting system.

Light poles should be installed along the outsides of the roadway. In an effort to minimize pole pollution, it is tempting to use the centre poles of the track system. If this is considered, it may present logistical problems at the time of system maintenance for both the illumination and the track span wire. Appropriate safety procedures will need to be in place to avoid potential electrocution.

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