TORONTO TRANSIT COMISSION
PLATFORM EDGE DOOR STUDY
FEASIBILITY REPORT

PREPARED BY

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with

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March 2025

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Revision History

Rev #	Date	Revised By:	Revision Description

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March 28, 2025

TTC G85-362

AECOM Project # 60602481

Dear Mr. Hagshenas:

Subject: Toronto Transit Commission, Platform Edge Door Study
Feasibility Report

I am attaching the feasibility report for the platform Edge Door study for your review and comment. This is our final deliverable for the PED study project as per our contractual requirements.

Please contact me if you have any questions.

Sincerely,
AECOM Canada ULC

Walter Gaudet, OAA, SAA, NSAA, MRAIC LEED AP BD+C
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AECOM: 2015-04-13

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Executive Summary

TTC has previously conducted engineering and business case studies to review the retrofitting of existing stations with PEDs and now requires a more comprehensive feasibility study and business case that involved an investigation study for retrofitting all of the existing stations with a PED system and adding PEDs to future extension lines, as well as providing the TTC with the necessary tool for projecting consequences of initiative of implementing the installation of PEDs throughout it subway system.

The Investigation Report documented observed conditions at each subway station that will ultimately be equipped with a Platform Edge Door (PED) system. The Investigation Report refined the previously identified classifications of stations with greater specificity to facilitate the identification and grouping of installation solutions. The refined station classifications are Type 1-Typical Underground Station with Side Platform, Type 2-Station at Grade with Side Platform, Type 3-Elevated Station with Side Platform, Type 4 -Underground Stations with Center Platform: 4A - Concrete Box Structure and 4B -Paired Iron Tunnel Structure, Type 5 -Station at Grade with Center Platform and Type 6 -Elevated Station with Center Platform.

The Investigation report also identified conditions specific to each station that may influence the required approach or the selection of system/components. The issues with station construction and conditions observed on-site or found within existing documentation which must be remediated or could be efficiently addressed during a PED system installation were identified for further consideration in the current phase of work to produce the Feasibility Report. Initial investigations into the issue of electrical grounding/ isolation, options for PED systems, along with implications for system communications and control commenced with the Investigation Report and have been developed with this phase to identify renovation works that may be required for each station to be defined in more detail in this report. This Feasibility report phase is the second phase whereby the knowledge gained from the investigation and assessment of each station has been analyzed and correlated to inform a group of representative designs for PED installation. The Feasibility Report has been developed in coordination with the TTC Concept of Operations for PEDs. Refer to **Appendix H** for the TTC Concept of Operations.

Each subway station has been paired with one of four structural solutions proposed in the report and a largely standardized PED system for costing purposes along with minimum but necessary station modifications. A PED system controller and associated room and services have been identified for each station and similarly included in the costing exercise.

A summary of Class 5 cost estimate for all 74 station platform levels including interchange stations has been included with this report giving an overview of cost per station and each subway Line (1, 2 & 4).

A proposed construction schedule is included in this report using a phased approach launched with pre-installation and preparation work taking place in four phases along each platform. Also, the prioritization of stations could be based off of the implementation of PED system at the stations with higher ridership (e.g.: Bloor-Yonge Station, Union Station, etc.). The station will be prepared for the installation of structural members and relocation of any interferences with the PED system. The modular PEDs and breakaway panels will be installed along with the infrastructure to run and operate the system. This approach will limit impacts to station operation so that the stations will remain fully operational during construction.

Construction issues and station conditions observed on-site or found within existing documentation that must be remediated were identified for further consideration in this phase of work. The previous investigations into the issue of electrical grounding/isolation, options for PED systems, along with implications for system communications and control commenced with the Investigation Report, have been developed with this phase of work.

The proposed PED system consists of pre-assembled sliding door units supported from the header/ actuator, with a threshold/guidance system set within the depth of the existing platform finish. The grounding system for the PEDs required to mitigate the electrical shock hazard was selected in consultation with TTC stakeholders with the objective to avoid active systems with maintenance requirements and minimize station rework and associated costs. It consists of a durable non-conductive finish material applied to all potential contact surfaces.

All proposed structural systems employ Hollow Structural Steel (HSS) posts and lintels to support the sliding door units. In most of the stations, (other than TYSSE stations), the edges of the existing platforms are cantilever concrete slabs that do not have the structural capacity in bending to support the platform edge doors due to wind loading and piston effect. Each of the four structural solutions has been designed to minimize rework of the existing platforms and can be described as follows: under-platform cantilevered beam, laterally restrained post on the base slab, partial cantilever replacement, and isolated base plate on cantilever.

A PED implementation solution has been identified for each station, and the constructability of each solution has been addressed. PED implementation at all stations will require a sequential approach with staged installation of structural elements followed by door units with minimal hoarding to maintain platform capacities and access to egress facilities.

The implementation work will have an impact upon each station but is not anticipated to significantly diminish the function of the station, including entrances or circulation spaces. However, some hoarding of work zones will be required at the platform level. Typical available windows for working at platform level will be during the nightly shutdowns between the hours of 2:30 to 4:30am from Monday to Saturday and 2:30am to 6:00am for Sunday. It would be beneficial for TTC if all contractors took advantage of temporary station shutdowns or full weekend shutdowns at stations to complete the PED preparation work (e.g.: Relocation of existing utilities/interferences and platform preparation), asbestos abatement as required, work associated with the PED control room and installation of the full length of preassembled PEDs in the station. This would limit the contractors time on site and impact to daily operations, which in turn should reflect in a cost savings for TTC.

The installation of the PED system on the platforms will be an incremental process closely contained within work zones with a priority on safety. It is anticipated PED supports and pre-assembled sliding door modules will be delivered to the station platforms by dedicated customized work cars, and these units will be staged at a TTC yard convenient to the project(s).

Research was conducted into PED systems currently in service with agencies in Europe Asia and the Americas, an evaluation and comparison were performed, leading to a selection of recommended suppliers that should be invited to participate in workshops as part of the design & specification process. It is recommended TTC hold a workshop with the potential suppliers as part of the next stage of the PED project, upon receiving funding approval.

Noise, Air Quality, and Tunnel Ventilation System effectiveness are issues with PED retrofit projects where the existing station design was reliant upon the piston effect from train movement to move air through the platform, as is the case with the TTC system. Noise and Air Quality study completed in this phase of the design largely confirm previous findings with air quality issues nominally altered with the installation of PEDs, and no appreciable impact on SVS performance subject to the spatial configuration of individual stations. Platform noise was found to be improved with full height unenclosed installations and more so with fully segregated systems. It should be noted the current cost estimating does not include ventilation measures to mitigate air quality issues.

Procurement strategies are discussed with a strong recommendation that prior to the next stage of PEDs project (Planning), TTC to seek funding for a pilot installation at the stations representing a typical group of stations' structure. This would refine the design requirements, identify constraints, refine risks, cost, schedule, and lessons learned for each type of station's structure as well as obtain customer feedback, assess O&M impact, and generate public interest.

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Acronyms/Definitions

APM – Automated People Mover
ATC – Automatic Train Control
ATO – Automatic Train Operation
ATP – Automatic Train Protection
C&L – Closed and Locked
I/O – Input / Output
PED – Platform Edge Doors
PSD – Platform Screen Door
SES – Simulation Computer Program
TBTC – Transmission-based Train Control
UPS – Uninterruptible Power Supply

1. Introduction

1.1 Overview of the Draft Investigation Report

The preceding phase of work produced the Investigation Report, which documented observed conditions at each subway station that will ultimately be equipped with a platform edge door (PED) system. The Investigation Report refined the previously identified classification of stations with greater specificity to facilitate the identification and grouping of installation solutions. The report also identified conditions specific to each station that may influence the required approach or the selection of system and components. Gaps in information and considerations for future PED operations were identified for further investigation and resolution in the subsequent design phase.

Site visits and documents reviewed identified potential issues with station construction and condition that must be remediated or could be efficiently addressed during a PED system installation. These issues are included in this report for further consideration.

Initial investigations into the issue of electrical grounding/isolation and options for PED systems, along with implications for system communications and control, commenced during the preceding phase of work, and were summarized in the Investigation Report' These have been further developed during this phase and renovation works that may be required for each station are defined in more detail in this report.

1.2 Assessment of Site-Specific Conditions

The Investigation Report highlighted several significant issues that are common to a number of subway stations, as detailed hereafter. Although in some instances an issue was found to be limited to a single classification of station, however, it was not always present in all stations of that type given that the date and method of construction varied between stations. The resolution of some of these issues may require extensive station works to fully rectify the problem during PED implementation, as detailed further in this report. Refer to **Appendix C** for the Station Characteristics Chart attached to this report.

Following is an assessment of the observed site-specific conditions:

Deteriorated Platforms

Several platforms are in poor condition and will require significant rehabilitation, which may include reconstruction of the cantilever portion or complete replacement of the platform slab. As any such rehabilitation work will need to be carried out in an operating station, then the works' schedule is expected to be lengthy, or alternative construction solutions — such as replacement with precast structural units and prefabricated floor finish materials such as granite or precast terrazzo tiles, need to be considered.

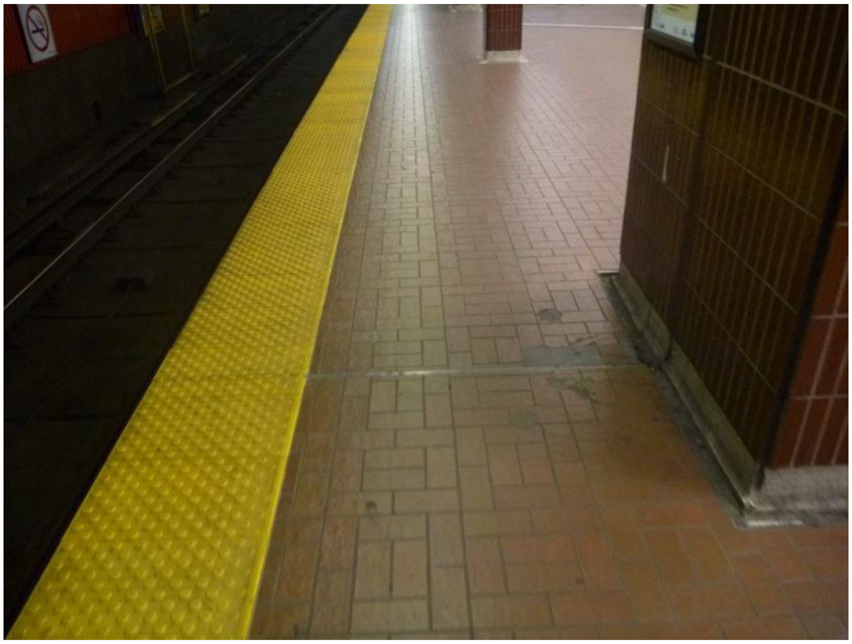


Figure 1: Deteriorated Platform

Rock Swelling

A couple of the earlier constructed stations on Line 1 were constructed with platforms founded directly on bedrock without a base slab. Over time, rock swelling occurred, as manifested in the shifting and cracking of platforms. It is recommended that these platforms be restored under a separate early works contract since any future rock swelling after PED system installation could impact door function.

Figure 2: Station with the potential of rock swelling (King Station)

High Ceilings / Roof Structures

The cross section of the vertical structure incorporated in PED systems is generally small to minimize obstructions to platform passengers or emergency breakaway panels. High ceilings / roof structures may preclude lateral bracing at the top and necessitate a more robust cantilever design exerting higher forces on the platform cantilever.

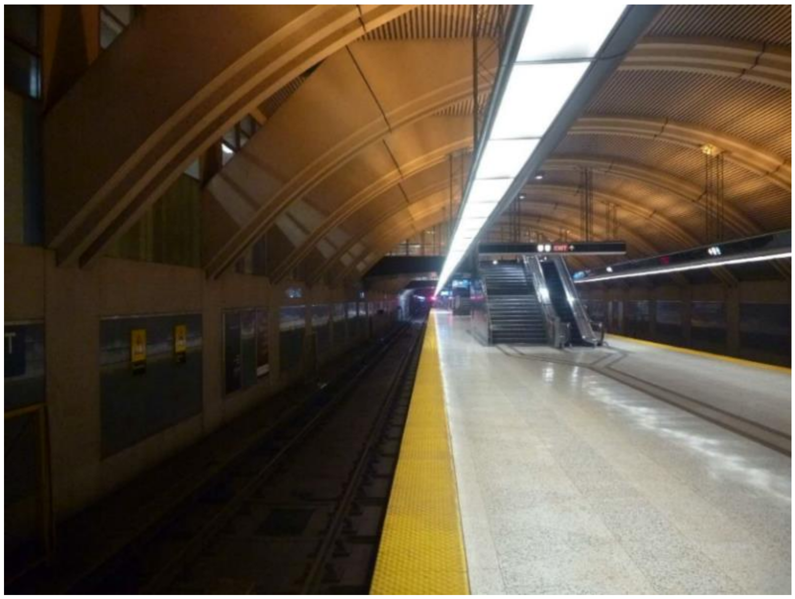


Figure 3: High Ceiling (Sheppard West)

Stations Without Base Slabs

Some stations were constructed with grade beams or other foundation systems that do not offer a base slab that may serve as bearing/anchorage for PED system columns. In such cases, the PED structure will either cantilever from the platform slab or from new foundations to be provided beneath the platform cantilever.

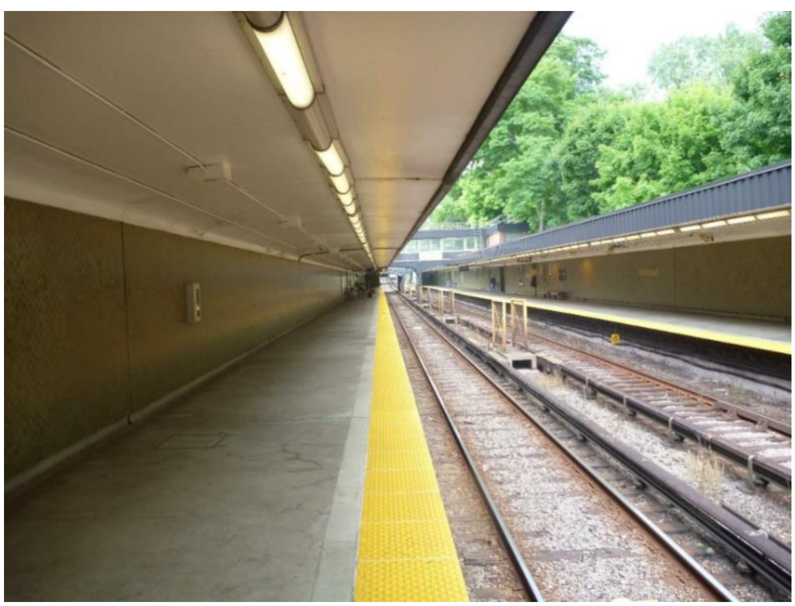


Figure 4: Station with no base slab (Rosedale Station)

1.3 Station Classifications

The Investigation Report proposed six primary classifications under which existing subway stations that shared similar characteristics and issues were grouped. Sub-classifications were added to identify the proposed PED solution. The classifications were maintained through the feasibility concept work and are summarized hereafter, with a listing of stations that fall under each classification. Refer to **Appendix A** for concept drawings, detailing PEDs at each station classification listed below.

Type 1 – Typical Underground Station with Side Platform

This station type represents the majority of stations built on Line 1 during the 1950s and Line 2 during the 1960s. It is characterized by column-free parallel side platforms with a depth to the back wall of the platform ranging from 1.58 m to 5.27 m. Vertical circulation is primarily in wells off the back of the platforms.

Stations within this classification include Bloor-Yonge (Line 1), College, Dundas, Dupont, King, Queen, Spadina, St Clair, St Clair West, Summerhill, Union, Wellesley, Bathurst, Broadview, Castle Frank, Chester, Christie, Coxwell, Donlands, Dufferin, Dundas West, Greenwood, Jane, Lansdowne, Main Street, Ossington, Pape, Royal York, Runnymede, Sherbourne, Spadina, Woodbine and Sheppard-Yonge (Line 4).

Type 2 – Station at Grade with Side Platform

This open-air station type is characterized by parallel side platforms usually situated below prevailing grade with a circulation facility / concourse space above and canopy coverage at least over the platforms, though some stations include a full roof over the trainway. The clear platform depth ranges from 1.58 m to 3.69 m.

Stations within this classification include Rosedale, Davisville and Eglinton West.

Type 3 –Elevated Station with Side Platform

This station type found on Line 2 outside of the city centre features parallel side platforms with full roof coverage and open air at both ends. Vertical circulation from the concourse level below is situated at the back of the column-free platforms, which have a depth ranging from 2.78 m to 3.70 m.

Stations within this classification include Keele, High Park, Old Mill and Victoria Park.

Type 4 -Underground Stations with Centre Platform

The following two subclassifications fall under this station type:

Type 4A – Concrete Box Structure

This station type is commonly found at current or former terminus stations and the more recent Line 4 and extensions of Line 1 stations. It typically has one or more rows of columns on the platform with vertical circulation along the center line; the combined platforms range in width from 9.00 m to 10.30 m with a concrete slab above the finish ceiling.

Stations within this classification include Downsview Park, Kennedy, 407, Eglinton, Finch, Finch West, Lawrence, Lawrence West, Museum, North York Centre, Osgoode, Pioneer Village, Sheppard West, Sheppard-Yonge (Line 1), St Andrew, St George, Vaughan Metro Centre, Wilson, York Mills, York University, Bay, Bloor-Yonge (Line 2), Islington, Bayview, Bessarion, Don Mills and Leslie.

Type 4B – Paired Iron Tunnel Structure

This station type is uncommon within the TTC system; it is comprised of a pair of iron tunnels situated parallel but spaced apart with each containing a trainway and platform such that the platforms are effectively back-to-back. All vertical circulation is located in the separation space between the tunnels and is accessed by lateral connections between the two tunnels. The platforms are unobstructed and have a width ranging from 3.30 m to 3.50 m.

Stations within this classification: Queen's Park and St. Patrick.

Type 5 – Station at Grade with Centre Platform

This station type has full roof coverage with higher ceiling / roof structures and a center row or two rows of columns. It is open to the environment at each end and is usually situated at or just below prevailing grade with a center line of vertical circulation from the concourse / entrances above. The combined platform width ranges from 7.30 m to 9.00 m.

Stations within this classification include Glencairn and Kipling.

Type 6 – Elevated Station with Centre Platform

This station type has full roof coverage with a high ceiling and center row of structure and is open to the environment at both ends. Circulation is from a lower concourse level into the center of the platform or from the ends. the combined platform width ranges from 7.50 m to 9.00 m.

Stations within this classification include Yorkdale and Warden.

1.4 List of Known TTC Station Projects and Current Programs

The TTC usually has several ongoing programs involving the repair, maintenance or upgrading of subway infrastructure, in addition to station-specific projects. Once PED implementation commences, it will be possible to achieve efficiencies in schedule and cost between programs, and to minimize disruption to or degradation of service.

Currently, the TTC has the following ongoing programs that will have an impact on PEDs implementation; these programs are at various stages of execution.

- Easier Access Program;
- Stations Modernization;
- Subway Ventilation;
- Line 1 Automatic Train Control (ATC) Project;
- Second Exit/Entrance Projects;
- Bloor-Yonge Capacity Improvement Project;
- Other Major Projects;
- Rail Projects;
- Train Door Monitoring (TDM); and
- Subway Radio Antenna System (SRAS).

1.5 PEDs impact on Line 1 and Line 2 Capacity Enhancement

Following is a listing of PED's impact items on capacity enhancement to reduce headway; further information is provided in the body of this report:

- Stopping accuracy;
- Train misalignment;
- PED equipment failures;
- Non-PED equipment failures;
- Impact of PEDs on dwell time;
- Impact to operations and maintenance;
- Access to trackside;
- Train alignment;
- Monitoring train/PED doors;
- Non-vital PED signals;
- Impact to TVs; and
- Impact to station capacity.

1.6 Full Height Partially Segregated PEDs

This report is based on the implementation of full height partially segregated PEDs that are approximately 2100 mm high plus header and framing, with a minimum 300 mm high louvre above it (Figure 5). This configuration will allow air to flow freely from trackside to platform side as per original design of the stations; thus avoiding the need to change any of the existing mechanical equipment in the stations. For stations that do not have a high enough ceiling to accommodate louvres above the PEDs, the space above will remain open. PSDs (Platform Screen Doors) have also been used or referred to barrier doors separating the track from the platform.

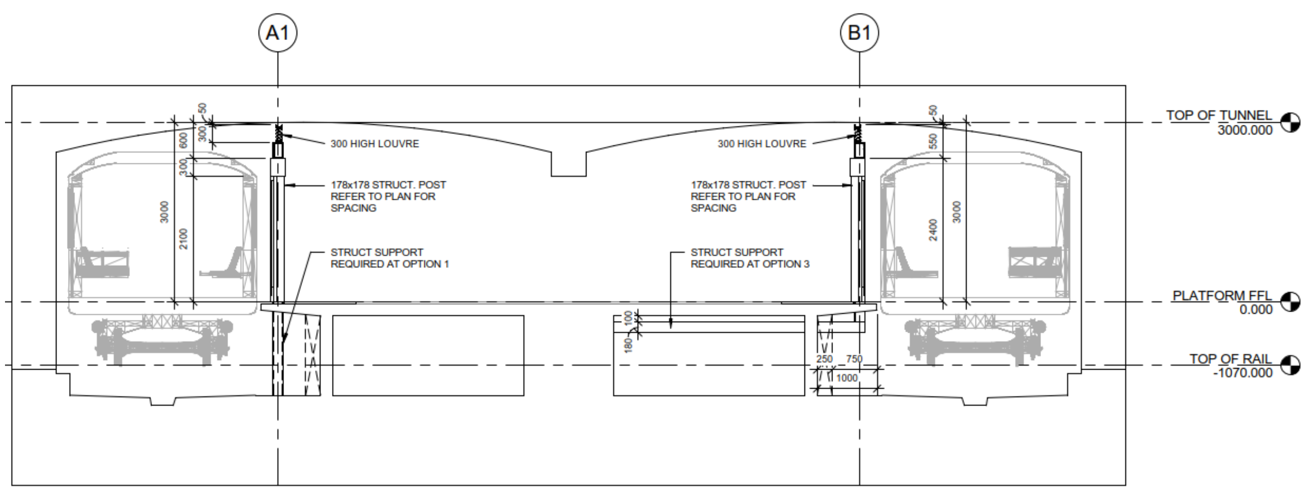


Figure 5: Typical PED section with louvres above

Perforated breakaway panels (Figure 6) may be incorporated within the PED system to achieve an adequate airflow from trackside to platform side in lower ceiling stations. These breakaway panels will meet TTC Concept of Operations (ConOps) requirements in that they can be used as an emergency exit if the train misaligns, loses power or becomes subject to any other emergency event, or they can be removed to offload any equipment from a work car onto the platform.

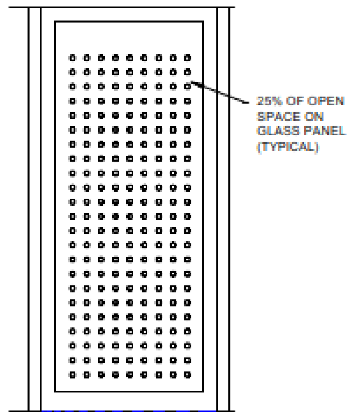


Figure 6: Conceptual perforated breakaway panel

1.7 Assessment of the Safety Impacts of Introducing PEDs

The primary purpose of the PED system is to separate the trainway from the passenger platform to provide a safer platform environment to protect both passengers and transit employees on the platform from the tracks and train, as outlined in the TTC ConOps.

The severity of platform level passenger accidents is greatly reduced with the elimination of slips and falls, pushing incidents or suicide attempts that result in a track level incursion. Statistics obtained from installed PED systems from other jurisdictions provide proof to the effectiveness of PEDs in preventing injuries associated with such platform incursion incidents.

Following are examples of some recent statistics from existing transit agencies with a PED system that attest to the effectiveness in suicide prevention:

- Paris Metro Network reports an average of 150 suicides or suicide attempts per year. Line 14, the only line that is PEDs equipped, has had zero attempts since its installation in 1998; and
- MTRC in Hong Kong reported an average of 20 suicides or suicide attempts per year. After the installation of PEDs on all new lines was completed, the number of attempts dropped to zero.

The space created on the trainway side between the train car doors and the PED system doors may present a hazard should a passenger become trapped between closed doors. The depth of the space for the non-interfering clearance gap, between the platform doors and the train doors, is estimated to be in the range of 215 mm. Based on TTC's dynamic envelope diagram, the distance from the edge of the platform to the face of the PED door has been calculated to be a minimum of 145 mm, in line with the TTC ConOps to prevent pedestrians from being trapped between the train doors and PED system.

If the premise that the dynamic envelope within the station is constrained by the platform itself is accepted, it may be possible to reduce this dimension further to perhaps 75 mm. To further mitigate this hazard, the design of the sliding doors could include tapered guards (deflectors) to fill the gap between the doors. The design would also prevent any potential pinch points between sliding doors and frame. Intrusion detection may be installed to detect objects between the PEDs and the train; however, this will lead to additional cost and maintenance item and may not be necessary if the gap/space is minimized.

Emergency egress must be reviewed with the provision of PEDs. According to the Ontario Building Code (OBC, 3.13.4.5 (4)) and in conformance with National Fire Protection Association (NFPA) 101 (5.5.6.3), a minimum clear width of 1117 mm is required for a safe means of egress. The installation of PEDs— and in particular, the breakaway pivoting emergency egress panels between sliding door units — could potentially conflict with NFPA 101 requirement.

A number of existing stations within the TTC system have narrow platforms that do not currently meet NFPA 101 requirements. In the event of a significantly misaligned train, the pivoting door panels will be released by trainway side push bars and pivot into the platform space, thus further reducing the platform width available for egress. An exiting analysis is recommended for each station to determine the impact breakaway door panels in the open position will have on platform function. Fixed panels may need to be installed in select locations on narrow platforms to maintain passenger flow, thereby relying upon the open gangway of the Toronto Rocket trains to allow passengers access to adjacent train doors.

Platforms equipped with PEDs will not have the typical 600 mm wide warning tile, the floor finish along the PED wall will be distinct from the tactile warning strip at open edge platforms. This will allow visually impaired passengers to differentiate between the two platform edge conditions and better recognize a potential hazard. A platform equipped with PEDs has fixed loading positions that may be differentiated in the floor finish with colour and tactile elements to improve passenger queuing and positioning for accessibility.

Toronto Transit Commission – Consultant Study – Platform Edge Doors Feasibility Study – Preliminary Engineering Report – Final (Rev.1) – September 2010.

2. Considerations for Construction

2.1 Proposed Station Modifications

It is anticipated that hollow structural steel (HSS) posts will be required to support the sliding door units for the PEDs. In most stations, the existing platform edges are cantilever concrete slabs, and in general, (excluding the TYSSE stations) the platform cantilevers do not have the structural capacity in bending to support the PEDs due to wind and piston effect loadings acting on the doors and panels. Additionally, the space beneath the platforms is required as a refuge space, and in many instances contains services, emergency ladders and other items as part of TTC's subway system, which will need to be accommodated by the new structural support for the PEDs. With the implementation of PEDs this refuge space will only be required for authorized trackside personnel. The proposed spacing of the HSS posts is such that refuge areas will be available at certain locations and may be clearly marked.

In order to minimize cost and disruption to TTC operations, the preferred solution for each station should minimize impact on the existing platform by maximizing prefabrication work.

The preferred structural alternative would then be to support the HSS posts from the invert slab below the cantilever and extending through a notch in the platform to support the doors. A connection between the posts and cantilever slab will be required to support the post laterally. This system will result in new boundary conditions for the cantilever slab, which will need to be analyzed to determine if additional reinforcement is required. The plan and section views of this system are shown in Figure 1.

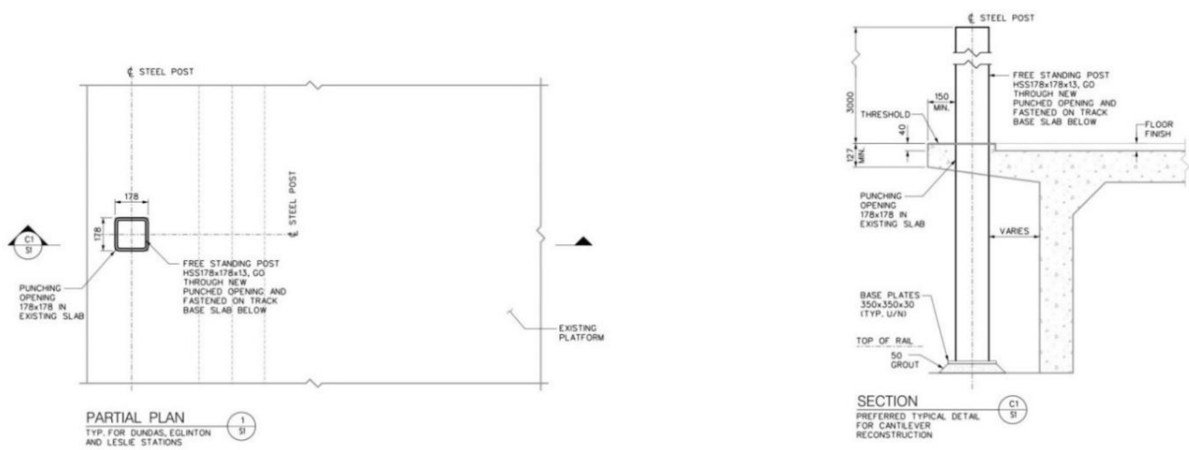


Figure 7: PED Structural Support on the base slab below the cantilever extending above the platform to support the doors

For Line 1 Northbound that cannot accommodate the posts below the cantilever, or where the cantilever slab does not have adequate capacity to support the PEDs, it will be necessary to reconstruct sections of the platform cantilever slabs to resist all the imposed loads from the posts, as illustrated in Figure 9.

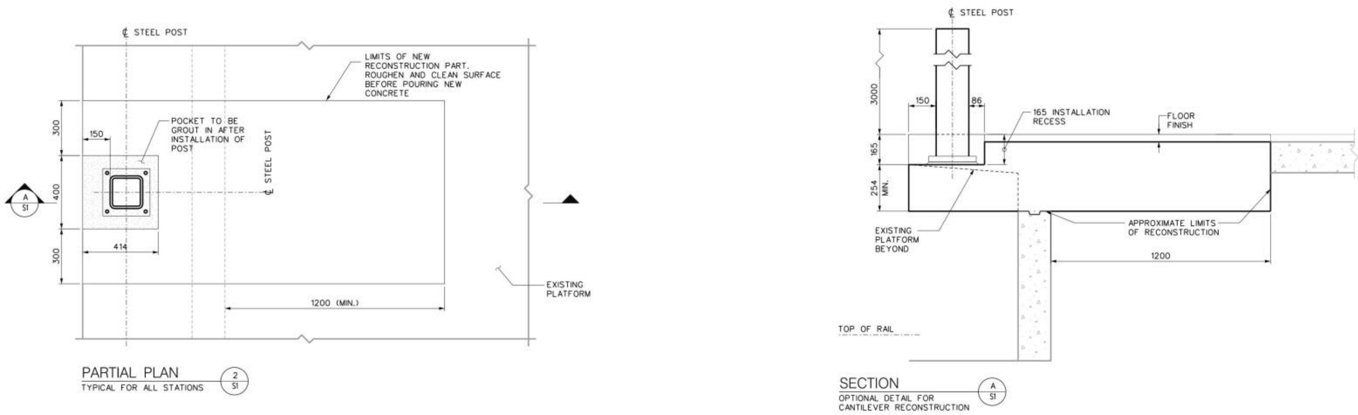


Figure 8: Cantilever Reconstruction Option

The newer stations along the TYSSE line have been designed and constructed with provisions for the future implementation of PEDs; therefore, the PEDs may be installed directly on the platform edge without the need for any structural work. These stations also include an electrical isolation system beneath the platform edge that could permit a variation in the approach to PED isolation. Figure 10 shows the current platform edge design standard.

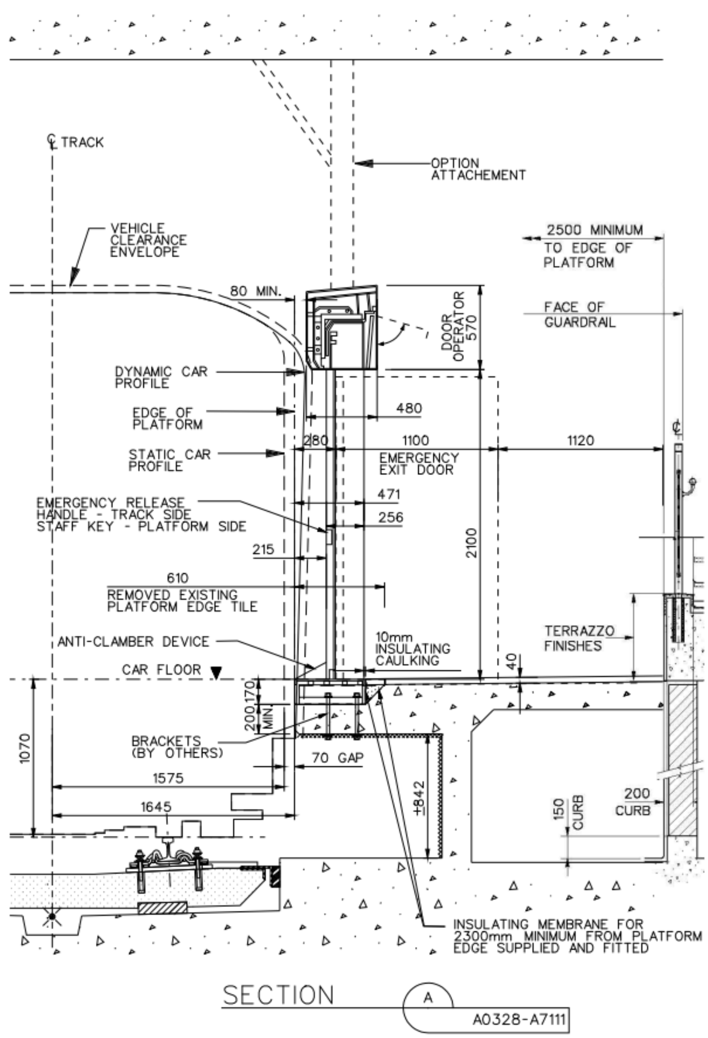


Figure 9: PED installation at TYSSE Stations and future line extensions

Alternatives to supporting the PEDs from the roof were not considered feasible for a variety of reasons, including a potential safety hazard posed by the connection to the roof that would likely require embedded anchors in tension, which have been known to fail suddenly. Additionally, this system would require significant bracing to resist piston effect loads, and any differential movement between the roof and the platform could hinder the operation of the sliding doors. Another reason to preclude such an approach is that many of the stations have very high ceilings or are in open air.

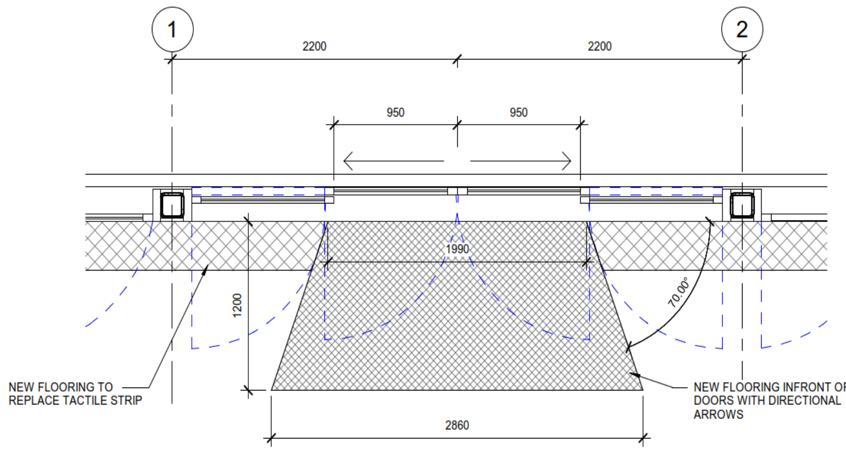


Figure 10: Platform removals & replacement at PED openings

2.1.1 Required Platform Modifications

Installation of the new PED door system will require some platform modifications, such as removal of the tactile strip at the edge of each platform. The indicative PEDs design is nominally 400 mm deep, leaving 200 mm on the platform side that will be refinished with new granite or terrazzo tile.

The indicative design prepared for this report includes replacement of a portion of platform floor finish in front of each sliding door unit. This area will be replaced with new tiles designed to guide passengers where to stand while waiting for the train, along with directional arrows to allow for improved passenger flow while entering or exiting the train, as per TTC ConOps. In addition, this demarcation zone may be installed with a slight slope to the sliding door threshold to facilitate level train boarding, where required.

2.1.2 PED Control Room Modifications

For each station, PED implementation will require a PED control room. The design should take advantage of the existing emergency response rooms (ERR, which will become redundant with the implementation of PEDs) or another suitable vacant or underutilized room near the ends of the platform. One room will serve both platforms and will house all PED control equipment. Figure 7 is an example of an ERR that will be repurposed as a PED control room, which will also require a small air-conditioning (AC) unit to regulate room temperature to prevent overheating of equipment. This unit will be directly vented to the exterior of the station. The PED control room will also require a floor drain (if not already provided) to allow for drainage in the event of flooding.

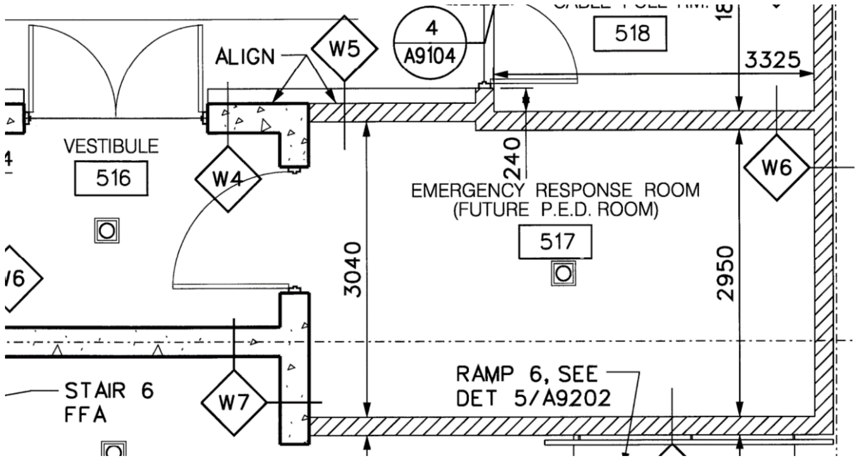


Figure 11: PED Control Room (407 Station)

2.1.2.1 PED Controls at Station Platforms

In addition to the necessary architectural, structural and civil- station modifications, the PED control system will also require a local control panel (LCP), which allowing an authorized TTC employee to control and monitor the PEDs directly from the platform (as may be required for maintenance activities or to support in degraded modes of operation). The dimensions and attributes of this LCP vary depending on the manufacturer and product selected, but a visual example is provided in Figure 13.

Figure 12: Example of a Local Control Panel from Stanley

One of these LCPs is typically placed at each end of the platform to control and monitor the corresponding PEDs. While it is possible to install these LCPs in the station equipment rooms with the rest of the PED hardware, it would be far more beneficial if they are installed right on the platform beside the PED structure. This location will provide TTC employee with a clear view of the PEDs while manipulating the control functionality of the LCP since LCPs are designed with line-of-sight considerations in mind.

The TTC PED system should include installation of one LCP on each end of each PED-equipped platform to provide an easy and precise operation of the PEDs, as necessary.

2.2 Maintainability and Constructability of the Proposed PED System

Based on station survey results, a limited number of PED implementation solutions are proposed to address the different station configurations and conditions. The PED implementation work will be focused on the platform areas of the station but may require minor modifications at other areas of the station for routing of additional power cables, etc.

The performance of the implementation work will have an impact upon each station but is not anticipated to significantly diminish the function of the station including entrances or circulation spaces, although hoarding of work zones will be required at platform level. The installation of the PED system on the platforms will be an incremental process within contained work zones, the best (and far more complex) recent example is the AECOM Second Platform project at Union Station whereby the active subway platform was sequentially renovated including replacement and relocation of escalators and stairs, repositioning of structural columns and complete replacement of the platform floor finish. With the PED project, as currently contemplated and costed, station finishes will be retained unless directly impacted as in the case of the tactile platform edge tile and the proposed door demarcation.

2.2.1 Construction Sequencing

PED implementation will require a sequential approach with staged installation of structural elements followed by door units with minimal hoarding to maintain platform capacities and access to egress facilities. The most challenging part of the PED system implementation is the preparatory work which involves modification to the existing platform structure, adding new service room, installation of the rough-in services, and the relocation of some vital electrical and communication services interfering with the PEDs installation such as ATC, CCTV, OPTO, lighting, PA, etc. As the majority of the work take place at the track level, the work hours are limited to only non-operating hours in coordination with other ongoing State of Good Repair work in the subway tunnel and stations. Therefore, the subway station closures and station bypass would be required to complete the work. The PED system sliding door units will remain open for the entire installation process to permit normal platform operation.

The anticipated sequence for platform edge reconstruction is as follows:

- During nightly work windows, install temporary supports beneath the platform (either anchored to the wall or supported on the base slab where required); for Union Station, they were anchored to the wall;
- During nightly work closures, remove the tactile edge tile and install a temporary edge finish;
- During nightly work closures, raise the edge finish to cut column notches in the existing cantilever and beam holes through lower support wall;
- During nightly work closures, install the support beams under the platform and PED support columns;
- Remove the temporary supports, as appropriate;

- During nightly closures, install door head supports;
- Once the PED framing system has been installed and modifications made to the platform to accommodate the PEDs, deliver the PEDs by work car and install during non-operating hours. It is anticipated that it will take several working windows to install all the PEDs, unless weekend closures can be accommodated to install all the PEDs at one time. Keep the PEDs in the open position during construction, until completely installed and tested; and
- During temporary night closures, remove and replace floor finish at door locations.

2.2.2 Available Working Windows at Platform Level

Typical available working windows at platform level are during the hours of 2:30am to 4:30am from Monday to Saturday and 2:30am to 6:00am for Sunday. Contractors will be able to request nightly station shutdowns to expedite the work on site. Majority of the construction work takes place during non-operating hours which are pending track access availability and other possible closures. It would be beneficial for TTC if all contractors take advantage of a full weekend shutdown at stations to install the full length of preassembled PEDs in the station, this will limit the contractors time on site and impact to daily operations, which in turn should reflect in a cost savings for TTC.

2.2.3 Interferences and Relocation of Existing Platform Equipment

2.2.3.1 Station Signage

Station signage that is situated directly above the platform edge or close enough to present an obstruction to the PED system in low ceiling stations will be removed and repositioned. Alternatively, the PED door head has sufficient vertical dimension to accommodate new station signage while maintaining a piston vent area above.

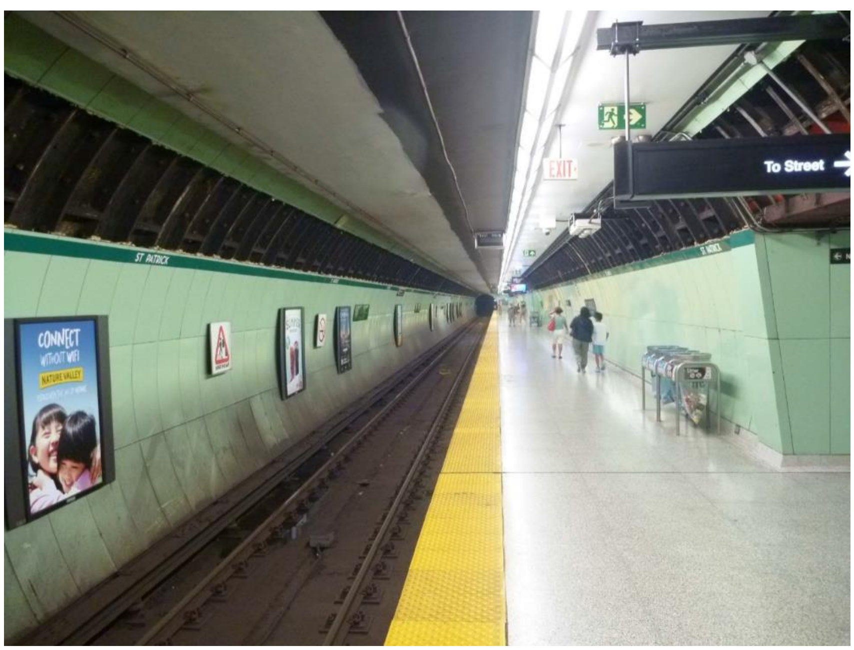


Figure 13: Station with signage above the platform edge

2.2.3.2 Platform Lighting

Platform lighting located directly above the platform edge or in proximity to it that may represent an impediment to PED installation will be relocated or replaced. New lighting calculations and potentially new fixtures will be required as part of station design contracts accounting for the reflectivity of the predominantly glass screen wall of the PED system. Atypical platform edge lighting is provided in Figure 8.

2.2.3.3 Utilities

Station utilities running above and parallel with the platform may require relocation where in conflict with PED installation; similarly, radio cables may require relocation to avoid electrical interference from PEDs. A majority of the stations have a small number of conduits running along the ceiling above the platform edge.

Utilities running under the platform edge will remain but require temporary repositioning with support and protection to permit installation of PED support structures. Station design contracts will include further study to determine the use of each cable in this area and identify cables that are inactive.

Figure 14: Station with utilities and lighting running along platform edge

2.2.4 Laydown Areas for Construction Equipment

The station platforms are generally fully occupied spaces with little or no opportunity for storage of construction materials and equipment. Contractors will therefore be required to closely hoard around active work areas and deliver most material and equipment to site on a daily as required basis; however, some storage/ laydown areas may be identified on other floor levels within the stations as may be determined during station design contracts. It is anticipated that, at minimum, the fabricated structural steel PED supports, and preassembled sliding door modules will be delivered to the station platforms by work car. These units will require a secure protected storage area at a TTC yard convenient to the project(s). Additional facilities will be required for contractor receiving and staging activities and for project trailers/office within the yard, with ready access to the dedicated work car(s).

2.2.5 Construction Access Under the Platform

A majority of the station platforms throughout the system are equipped with access hatches to allow for access to the underside of the platform. These access hatches will be utilized for the work involved at stations that will be using structural option #3. The work area beneath the platforms is considered a confined space and contractors will be required to follow the Occupational Safety and health Administration (OSHA) regulations for confined space procedures, along with TTC guidelines for entering confined spaces.

2.2.6 Working Car Requirements for Material Delivery

The location of the work at platform level suggests contractors will be utilizing work cars on the TTC tracks to transport the majority of materials and assemblies directly to the station platforms during nightly closures. It is anticipated that the construction contract(s) will require dedicated and customized work cars to facilitate efficient loading, transportation and installation of PED support structure components and preassembled sliding door units. Examples of specialized work cars with lifting systems have been employed for projects in other jurisdictions (Figure 13).

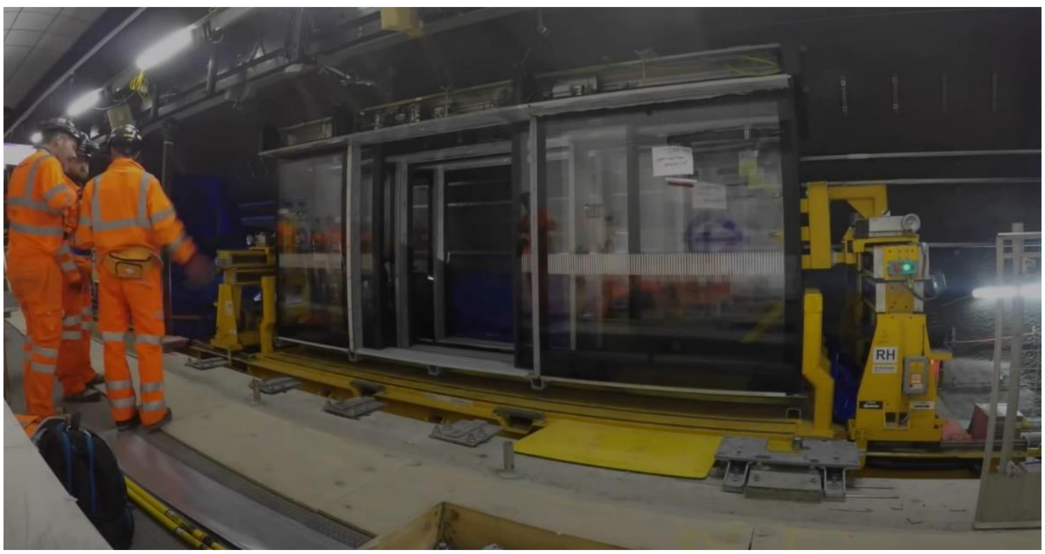


Figure 15: Workers using a customized work car to lift preassembled PED sections into place

2.2.7 Minimizing Removals at Platform Level

All of the PED structural solutions have been devised to minimize the removal and replacement of the existing platform structural slab and, by extension, the requirement to replace terrazzo floor finishes. This is made possible in part by the selected strategy for grounding and isolation of station elements to mitigate the shock hazard to passengers and staff. The approach does not involve electrical isolation of the PED support structure from station ground, instead the PED system components – including support structure, sliding door units, header frames and breakaway panels –will be faced on the platform side with a non-conductive cladding. Disruption to the platform floor finish will be minimized by only removing the 600 mm deep platform edge tile and a guidance area in front of each sliding door pair. These floor areas will be reinstated with a granite or terrazzo tile providing for a much quicker installation over the traditional cast in place terrazzo.

2.2.8 Maintainability of the PED System

Upon installation and commissioning of the PEDs, TTC may assume responsibility for maintenance of the PED system by utilizing their own forces, procuring a local service provider or bundling a multi-year service contract with PED procurement. A majority of the recommended manufacturers of PED systems require trained authorized service providers to maintain the equipment. Therefore, it is recommended that, during PEDs procurement, TTC include requirements for the manufacturers to have service providers in the region.

The selection of the PED system supplier may impact the timeline for obtaining replacement components when sourced from overseas manufacturers; however, this could be mitigated by including local inventory requirements in the supply contracts.

Based on available information, it is recommended that manufacturers include Clearsy (France), Faiveley (Pennsylvania, USA), Horton (Ontario, Canada), Stanley (Connecticut, USA), Singapore Technologies Engineering (Singapore) and Knorr-Bremse (Munich, Germany).

2.2.9 Anti-Vandalism

With the proposed PED system, it will be possible to apply an anti-vandalism finish to the PEDs glass panels to facilitate the removal of unwanted markings. Anti-vandalism protective coatings for the non-conductive material that will be applied on conductive PEDs materials will need to be further investigated during the design phase of this project.

2.3 Review of Impact on Platform Space

The indicative PED system design developed for the TTC platforms will nominally occupy 400 mm of the platform measured from the existing platform edge and situated entirely within the 600 mm-wide band of the existing tactile tile warning strip. Without PEDs, passengers will generally remain behind the 600 mm tactile warning strip; but, with the installation of PEDs, the usable platform space will effectively be increased by 30 m^2 (0.2 m x 152 m). Utilizing the TTC space planning standard of Fruin's Level of Service "C" (1.39–2.33 m^2/passenger) then this additional area translates into a capacity increase of approximately 18 passengers.

From an emergency egress perspective, the PED system will have a negative impact on the platform egress passage width in the case where a train is misaligned resulting in the emergency breakaway panels swinging open onto the platform.

2.4 Evaluation of Impact on Access to Track Level

The proposed PED system will prevent passenger access to track level; however, it will not affect authorized track level access, since the latter will require staff to unlock and utilize an access door at each end of each platform leading to the safety walkway. Based on a PED layout for a standard 152.4 m platform with a standard module for door units and breakaway panels, the end of platform access doors which are beyond the active platform may be set at an angle to the platform edge to accommodate a full width door. It is anticipated that the access doors will be keyed and alarmed, as per the TTC ConOps.

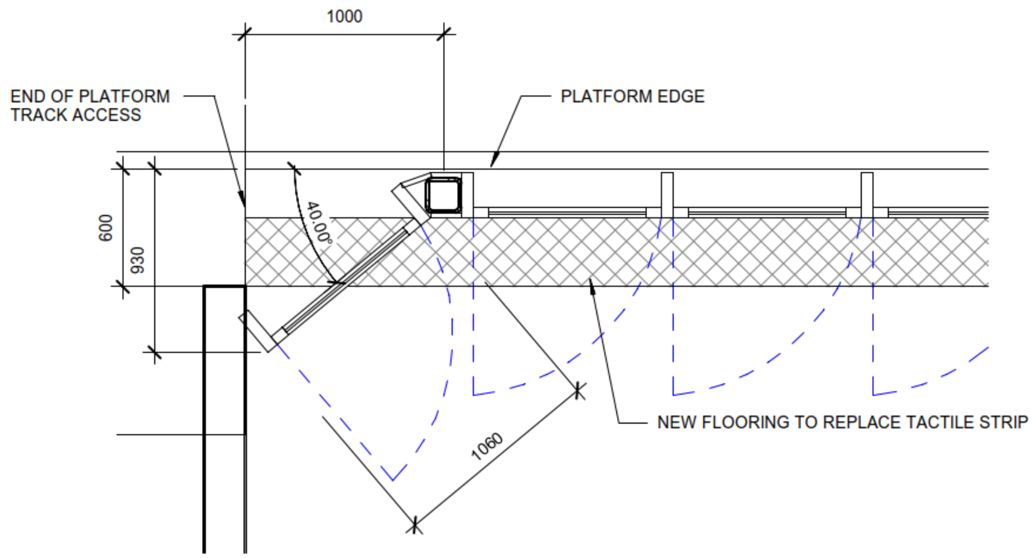


Figure 16: End of platform track level access

2.5 Considerations for Outdoor *vs*. Indoor Stations

TTC stations are not conditioned spaces; hence, equipment at platform level in underground stations will be exposed to fluctuations in temperature and humidity. The temperature at platform level may in winter periodically dip below freezing while in summer it may become exceedingly warm. Both at grade and elevated station classification types 2, 3, 5 and 6 will be exposed to temperature variation from -40°C to +40°C, with the outdoor stations additionally being exposed to precipitation and icing conditions in winter. The future design contracts for stations will be required to assess the operating conditions for the PED system and potentially adjust the specifications to include the appropriate classification of water tightness and supplemental heating systems. For the purpose of this report, the cost estimate includes door threshold heat tracing only for outdoor and elevated stations.

2.5.1 PED Control Equipment

Since the majority of the PED control equipment is recommended to be installed in each station's ERR, as discussed elsewhere in this document, then the station platform environment (outdoor *vs.* indoor) will not have an impact on or require changes to the PED control hardware. The only PED control equipment that may be located outside of the ERR is the LCP, which is recommended to be installed on the station platform itself. The LCPs are typically enclosed in key-locked rated watertight housings, so the station environment (outdoor *vs.* indoor) will not impact the PED LCP function.

2.6 Prioritization Plan for Implementing PEDs

This report presents a high-level phased prioritization plan to retrofit PEDs across the TTC subway system. The plan is based on multiple separate tender packages in groupings of similar stations to permit multiple contractors to work concurrently at a controlled rate and to refine their means and methods across multiple similar stations.

Alternative PED implementation plans, such as full implementation across the TTC subway system, or simultaneous implementation of each station group, were evaluated. It was determined that there would be significant cost to TTC and large disruption to the system with system-wide or group-wide implementation plans. Therefore, the phased prioritization recommendation was determined to be the most appropriate as it allows the TTC to control the annual capital expenditure, plan contracts to minimize disruption to the overall system and employ lessons learned from early contracts to improve the installation process at subsequent stations.

It is further highly recommended that TTC implement a number of PED installation pilot projects at different stations representing the typical condition for each type of design solution. Representative stations are proposed based on low ridership numbers to minimize impact to the subway system and ridership inconvenience associated with performance of the work and the anticipated learning curve. Potential stations include North York Centre, Lawrence, Glencairn and Old Mill. This variety of stations will allow contractors to familiarize themselves with all station groups and structural solutions.

It is expected the pilot projects will yield valuable lessons learned that may lead to design refinements, contract modifications, and schedule and project budget adjustments, leading to more successful major contracts for bundles of stations.

Following the completion and evaluation of the pilot projects, the remaining subway stations may be prioritized and bundled into multi-station contracts. It is recommended that TTC tender out packages of stations starting with Line 1, as it is equipped with the infrastructure to support the PED system. It is further recommended that packages run simultaneously, starting at the ends of each subway line, then progressing towards the city core. This will allow the contractors to develop a strong understanding and methodology for PED installation and solutions for common issues experienced with earlier stations within their tender packages.

The above-proposed PED implementation plan should help minimize service disruptions with the more congested stations within the city core. As well, offsetting station packages at each end of subway lines will allow contractors to utilize their own areas within the various train yards, allowing them to have enough laydown areas without any overcrowding or the need to share work cars or equipment with other contractors.

Each tender package may consist of a group of approximately four similar stations, with similar construction and structural solutions, and in close proximity to each other and to one of TTC's train yards (Davisville, Wilson, Greenwood and Keele yards). It is recommended that PED system implementation within each package be carried out in two phases to offset construction by at least one station to allow continued service to the public in that area of the subway system.

There are many alternative approaches to rolling out PED implementation that may be investigated/developed in more detail in the future, such as:

- the sequential station PED implementation, starting on Line 1 at Vaughan Metropolitan Centre Station and ending at Finch Station; or
- implementation according to station priority, starting with high priority stations then medium priority stations and ending with low priority stations. The stations with higher ridership (e.g.: Bloor-Yonge Station, Union Station, Etc.) will be prioritized.

All options proposed could allow TTC to implement stations at a controlled rate to manage yearly funding.

2.6.1 Implementation Phases and Packages

The following phases and package are recommended for PED implementation across the TTC subway system. The recommended approach for implementing the PED (Platform Edge Doors) system across the TTC subway system involves each package consisting of 2 stations, and Phases 2, 3, and 4 operate simultaneously. The process involves completing the design and starting construction for each package, and as this progresses, the next 2 packages are prepared for design and construction. This approach ensures that the design and construction of 4 stations are continuously underway until all packages are finished. You can also refer to **Appendix G** for a subway map.

The attached Pedestrian Edge Door concept schedules found in **Appendix F** is broken into the following four Phases:

- Phase 1 – PED Pilot Package
- Phase 2 – Line 1 PED Packages
- Phase 3 – Line 2 PED Packages
- Phase 4 – Line 4 PED Packages

Station List:

- **Phase 1**
  - Package 1A – North York Centre Station;
  - Package 1B – Lawrence Station;
  - Package 1C – Glencairn Station; and
  - Package 1D – Old Mill Station.
- **Phase 2 (Line 1, 2 Station per Package)**
  - Package 2A – Finch and Pioneer Village;
  - Package 2B – Vaughan Metropolitan Centre and Highway 407;
  - Package 2C - York University and York Mills;
  - Package 2D – Sheppard-Yonge (Lines 1 and 4);
  - Package 3A – Eglinton and St Clair;
  - Package 3B – Finch West and Downsview Park;
  - Package 3C - Sheppard West and Wilson;
  - Package 3D - Summerhill and Bloor-Yonge (Line 1);
  - Package 4A – Wellesley and College;
  - Package 4B – Yorkdale and Lawrence West;
  - Package 4C – Eglinton West;
  - Package 4D – Dundas and Queen;
  - Package 5A – King and Union;
  - Package 5B – St Andrew and Osgoode;
  - Package 5C – St Clair West, Dupont and Spadina (Line 1);
  - Package 5D – St George (Line 1) and Museum;
  - Package 6A – Davisville;
  - Package 6B – Queen's Park;
  - Package 6C – Rosedale; and
  - Package 6D – St Patrick;
- **Phase 3 (Lines 2 and 4, 2 stations per Package)**
  - Package 7A – Bayview, Bessarion, Leslie and Donlands;
  - Package 8A – Islington and Royal York;
  - Package 8B – Jane;

- Package 8C – Warden and Victoria Park
- Package 8D – Runneymede;
- Package 9A – Woodbine and Coxwell;
- Package 9B – Kennedy and Main Street;
- Package 9C – Kipling;
- Package 9D – High Park and Keele
- Package 10A – Dundas West and Lansdowne;
- Package 10B – Greenwood and Donlands;
- Package 10C – Pape and Chester;
- Package 10D – Dufferin and Ossington;
- Package 11A – Christie, Bathurst, and Spadina (Line 2);
- Package 11B – Broadview and Castle Frank;
- Package 11C – Sherbourne and Bloor Yonge (Line 2);
- Package 11D – St George and Bay;

2.7 Evaluation of Construction Strategies

The following construction strategies were evaluated during the investigation stage:

- There are two main types of PED installations available, namely top supported and bottom supported; the former is typically the preferred type since they provide a simpler installation process along with safer conditions during construction;
- Structural modifications to the platform edges of subway stations were evaluated before PEDs can be installed; those that minimize structural modifications to the platform were selected;
- The TTC preferred grounding scheme for the PED system is to fully insulate all exposed conductive materials of the entire PED structure through the use of a non-conductive cladding. Since there will be no exposed metallic parts of the PEDs to the public, then the risk of shock to passengers between the train and PED is mitigated. Grounding of the structure is not required; however, utilization of this method allows the PED structure to be grounded to the station ground if so desired to mitigate issues between the PED motors and door actuation assemblies and the PED structure. This selected grounding scheme was used as basis for the cost estimate;
- Any station with less than 30 kVA of excess power capacity should be identified and its power upgraded to take into consideration, in addition to PEDs requirements, any potential future expansions to the station equipment;
- It is recommended that existing rooms be retrofitted to provide dedicated PED equipment rooms at stations that have available space. A potential room that could be repurposed for the PED system is current the ERR that will become redundant after the installation of PEDs;
- CFD modelling was performed under Contract D85-9A to assess whether PEDs would affect the piston effect induced ventilation at Wellesley Station. The results showed that there will be a negligible impact on the station ventilation with full height partially segregated PEDs. As such, no additional ventilation requirements are anticipated, in line with the requirements laid out in the TTC ConOps;
- A PED testbed installation is recommended at several stations to test the communication systems and PED impact;

- Radio surveys are recommended before and after testbed installation to measure the impact on the radio system; the results should then be extrapolated to the rest of the subway system to understand PED effects on the radio system;
- It is recommended that three new security cameras be added at each station to allow for the viewing of PED doors as part of operational procedure;
- It is recommended that a monitor screen be provided on the station platform at the front of the train to permit monitoring of the proposed cameras by either the driver or a station attendant;
- The PEDs should be connected to SCADA for performance monitoring and remote control;
- OBC compliance will be an issue at several stations based on their substandard platform widths; as such, alternative solutions may need to be developed to obtain the building permits;
- Potential additional work (to be confirmed with station design contracts) include new or additional lighting, relocation of blue light and emergency power cut-off station, new signage and wayfinding elements, and making good retrofitting station finishes associated with power and control cable routing;
- While station lighting should be sufficient after PED installation, track level illumination may be reduced. Additional light fixtures are not assumed to be required; however, it is recommended that a lighting study is performed to ensure illumination standards and safety requirements are met;
- It is recommended that TTC procure PEDs for the overall system under one contract to ensure the same manufacturer is used at all stations. This will improve the installation process over time and allow for similar maintenance across the system. Following the procurement of the PEDs, and as previously discussed, it is recommended that TTC award groups of stations to separate contractors. This will allow TTC to implement the PEDs at a controlled rate as well as develop lessons learned for future contracts;
- It is estimated that the total construction duration for installation and commissioning of PEDs at a station could range between 200 and 220 business days; and
- The proposed schedule is based on minimizing impact to TTC operations during construction, with work at or near track level being carried out during non-operating hours. Refer to Appendix F for a detailed Construction Schedule. It is anticipated that some of the work will be done during normal hours within hoarded areas. Access to the under-platform areas would be from inside the station, where possible, as opposed to accessing the under-platform areas from the track. To accelerate the schedule and save costs, the following proposals could be considered:
    - Prolonged non-operating hours: Consideration could be given to closing the stations at an earlier hour, such as 10:00 p.m., to allow the contractor to access the platform and begin preparatory work on the platform to install the PED support system. Subway operations would continue as normal, with relatively short two- to three-hour construction windows at platform level. It is anticipated that this would save approximately 20% in construction time;
    - Weekend closures: This could be considered to accelerate construction of the PED support system and the PED doors. Under this scenario, a series of subway stations could be closed for the weekend to allow construction of the PED supports and PED doors, with subway operations closed and buses used to maintain transit operations. This has been used on numerous construction projects by the TTC. It is anticipated that preparatory works, such as the PED supports, would be carried out prior to the closures. PED doors could be installed within two or three weekend closures. It is anticipated that this would save approximately 50% in construction time;

- Full Station Closure: For this proposal, it is anticipated that subway operations would need to continue, with the station being closed and subway cars passing through the station without stopping. This would allow work within the platform areas to be carried out during normal working hours. The PED supports would still need to be installed during non-operating hours; however, as much of the work could be done within the station, it is anticipated that the PEDs could be installed within three to four weeks under a full station closure; and
- A combination of Full Station Closures and Weekend Closure: This would be the optimal solution. Under this scenario, the station would be closed to carry out preparatory works for the PED installation under a full station closure. During the full weekend closure, the PED support system could be installed, followed by the PED door installation the following week. It is anticipated that the PEDs could be installed within two to three weeks under this scenario.

It should be noted that under all these scenarios, advanced work would be required to prepare the systems, relocate existing conduits, etc. Additionally, temporary station closures may only be appropriate for certain stations with low volumes and with alternate transportation routes. Further studies should be carried out during subsequent design phases to optimize the constructions strategies.

2.8 Assessment of the Feasibility of Retrofitting PEDs on Existing Subway Platforms

The proposed PED support system with HSS support extending below platform level will impact the safe refuge space underneath the platform. As the PED system is designed to prevent the public accessing track level within the station, PEDs with HSS support should not impact public safety. However, the proposed spacing of the HSS posts is such that refuge areas will be available at certain locations; but not be readily available throughout the platform. This interruption in availability of continuous refuge space underneath the platform may pose a safety hazard to TTC staff working within the platform area. To minimize such risks, the following alternatives could be considered:

- Elimination of the posts below platform level, this would require replacing all the platforms in all the stations, which would be costly and time consuming;
- Clearly marking out safe refuge areas such that TTC staff will have a clear indication where to proceed in the event of a potential hazard; or
- Where feasible, constructing safety refuge cages at side platform stations between the tracks.

It should be noted that if work is being carried out within the station platform area, there should be an impassable work zone in place to minimize risk. For safety inspections, TTC inspectors should be accessing the platform at stations, and not be at track level within the stations.

It should also be noted that the recent TYSSE line and future extensions have been designed for the implementation of PEDs. Therefore, there will be no impact to the refuge space at these stations as additional structural support is not required.

Figure 17: Safety refuge cages installed along the center lane of tracks

3. Assessment of PED Systems

3.1 Configuration and Characteristics of Typical PED Systems

3.1.1 Typical PED Systems

The current TTC system operates without barriers between the trackside and the platform edge where passengers embark and disembark trains. Incorporating PEDs at the passenger exchange area of platforms is essentially equivalent to the passenger exchange protection afforded in an elevator system. PEDs include sets of automatically operated door panels fixed to the platform edge, aligned at the train berthing locations, to provide a physical barrier between passengers on the platform and the trackside. Train doors and PEDs operate in unison and only when a train is stopped and berthed properly at the station.

Figure 18: Horton PEDs at Toronto-Pearson Airport

The PED automatic platform door openings are typically larger than the train door openings to allow for the train's stopping accuracy/tolerance. PED automatic operation is permissible even with misalignments of the train stopping at the platform up to a specified limit as permitted by industry standards.

In addition, to ensure passengers on board a train can disembark a train in which a rare situation or failure condition has occurred such that a train does not align with the automatic platform door opening, the complete PED system includes sets of emergency egress doors (EEDs) equipped with emergency push bars between each set of platform doors, as well as at the ends of the platform passenger exchange area.

Another safety aspect regarding the installation and implementation of PEDs is the consideration of the gap that would exist between the automatic platform doors and the train doors. Industry standards require a means to detect the entrapment of an object between the automatic platform doors and the train doors for gaps greater than some minimum distance. This has been accomplished in various manners, such as equipping the automatic platform door panels with an “L-shaped-bracket” that sweeps the gap, such that if that bracket hits an object, the doors re-open just as they would be due to a door obstruction.

Functionally, the platform doors operate (i.e., open and close) in conjunction with and in synchronization with the opening and closing of the train doors. Platform doors are prevented from unlocking and opening unless a train is properly berthed (i.e., aligned with the automatic platform doors within allowable stopping tolerance) in the station and associated train door(s) open command has been generated, as required by the TTC ConOps. Additionally, trains are prevented from entering and/or departing a station platform unless all platform doors provide a Closed & Locked (C&L) indication, as per the TTC ConOps.

Typically, the unlocking of platform doors (i.e., the “door enable”) and the permission given to trains to enter/depart the station platform based on the platform doors C&L indication are vital Automatic Train Protection (ATP) functions. In contrast, the open and close door commands are considered to be non-vital Automatic Train Operation (ATO) functions.

Automatic Train Control (ATC) systems typically utilize their version of their ATP’s platform occupancy signals to indicate that a train is berthed, and they use the C&L vital indication from the platform door system to control the speed command (or other permissive command) that is sent/transmitted to the train. Computer Based Train Control (CBTC) is terminology that can be used interchangeably with ATC, however for the purpose of this report all automated train control will be referenced by the abbreviation ATC for consistency.

As is the case with train doors, platform doors also can recycle upon obstruction detection during the closing cycle, as required by the TTC ConOps. Depending on the integration with the train control system, it may be possible to have some synchronization of the train doors and platform doors during this event.

In most cases, the PED controller will interface directly with the wayside ATC system, which provides synchronous operation of the PED and vehicle doors. This is typical for modern ATC implementations, and it would include everything from dwell time to door recycling and C&L indication. A C&L indication is sent to the ATP when all PED doors are vitally verified as completely closed. In the case of a brownfield application, it is recommended that the ATC system is modified to restrict any train movement in the station area when the PED C&L indication is not present, or the PED controller unit is set to a “bypass” mode. This common approach provides vital assurance that passengers will not have access to the trackway when a train is approaching.

While many rail transit systems have operated and continue to operate with an open platform design, increases in ridership in recent years have raised several concerns, specifically in regard to safety. With increased congestion on the platforms comes an elevated risk of someone accidentally being pushed or falling onto the tracks. In addition to this safety risk, the increased congestion on the platforms can cause trains to remain in the station longer due to passengers delaying door closure. Many new systems, particularly in Asia, are being constructed with PEDs; and many existing systems, particularly in Europe, are having PEDs retroactively installed.

3.1.2 Other Technologies Considered

There are several platform edge technologies options other than full-height platform doors, although most of these systems are noticeably less common. Some of those other technologies include sensor-based track intrusion detection systems, rope-based platform screen doors, and half-height platform screen doors.

Those other technologies were thoroughly reported on separately in the TTC Platform Edge Doors Study: Alternative Technology document, a brief description and evaluation of some of these alternative technologies is provided in the following subsections.

3.1.2.1 Sensor-based Track Intrusion Detection Systems

Sensor-based track intrusion systems create a virtual barrier at the edge of the platform using optical/laser sensors and/or cameras. These sensors detect when an object is close to the edge of the platform or has passed the edge of the platform onto the trackway, and incoming trains can then be automatically emergency braked (although possibly not quickly enough to prevent a collision, depending on when the intrusion occurs relative to the train speed and position). These systems are not intended to prevent unauthorized track access like platform doors; instead, they are intended to detect and react to unauthorized track access. These systems provide the lowest level of safety and security; however, they are also the cheapest.

Sensor-based track intrusion detection systems have been installed in several different applications, but there are several different types of sensors that could be used for these systems, such as Mechanical Pressure Sensors (Vancouver), Infrared Sensors (Lyon), and Hyper Frequency Sensors (Nürnberg). A track intrusion system has been utilized on the Vancouver TransLink SkyTrain system.

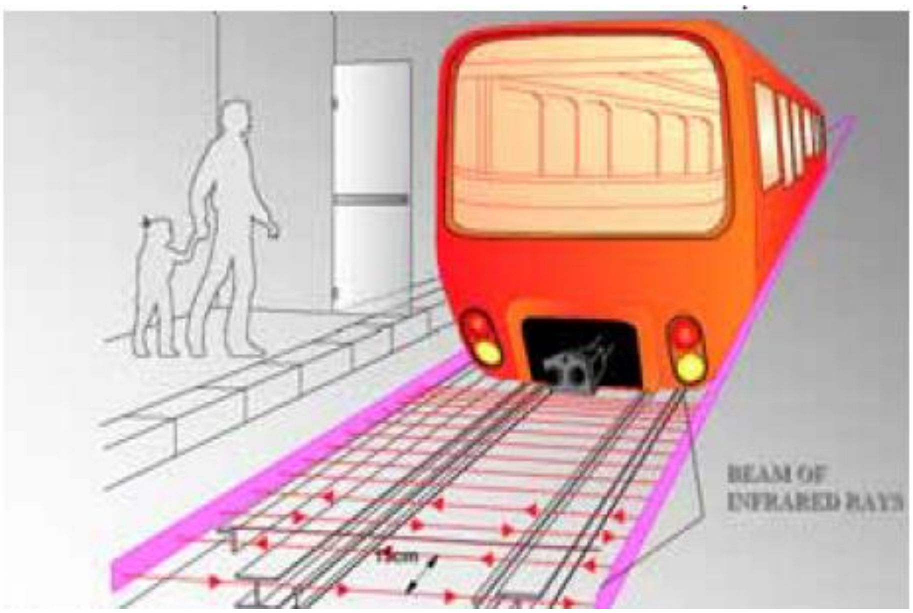


Figure 19: Infrared Sensor Alternative to PEDs (Clearsy)

These sensor-based track intrusion systems are rarely implemented because they do not prevent intrusion onto the trackside from the platform, either from people or objects. These systems only provide detection of track intrusions, they do not prevent track intrusions from occurring. Vancouver TransLink is currently conducting a study on their existing track intrusion system and is considering the implementation of PEDs as one of the possible alternatives. Transit authorities that have implemented them have also noted an impact on availability, such as due to occasional false detections registered by the sensors (i.e., a bird flying onto the tracks could potentially halt a train). Overall, these track intrusion detection systems are not recommended, especially since they cannot meet the specific needs of TTC.

3.1.2.2 Rope-based Platform Screen Doors

Rope-based Platform Screen Doors are a fairly new-to-market technology offered by the South Korean company SKD/Shinbo that consist of a series of cables at the edge of the platform that raise up towards the ceiling to allow passengers to enter/exit berthed trains. This system is less expensive than full-height and half-height Platform Edge Doors, but it is still possible for passengers to stick their arms/legs or other objects through the cables to potentially get hit by a train. Such an alternative was developed specifically to deal with legacy station platform infrastructure and multiple different train/door configurations. This system also may not be as visually appealing as other options, but it does provide cost savings in comparison. This product has very few service-proven references compared to the other solutions. It has been installed at a few locations as a test bed application, and their first permanent transit system installation is located in Bulgaria (12 stations).

Figure 20: Rope Screen Door installation at Munyang Station in South Korea

The main advantage of the rope-based product is the cost. This would not just be a cheaper cost for the product itself, but since this option likely weighs much less than traditional PEDs, there could be a partial reduction of the costs associated with platform reinforcement work to allow for the new barrier structure at the platform's edge. Although the platform edge reinforcement work could be reduced, it would not be fully eliminated. This product would still require some level of platform edge reinforcement for the rope housing, structure, pillars, attachment points, new conduits and cables for power, communications, and local control panels at the station level, new equipment in the control room, etc.

The product could also carry some other benefits such as less consideration required for the "piston effect" since more airflow is allowed, a greater tolerance allowed for manual train stopping position, and a less complicated and have costly installation and commissioning program. The main disadvantage is that while the ropes may prevent accidental access onto the tracks, it appears that it may still be possible for passengers to reach their body parts through the ropes or bend the ropes outward from the platform (depending on the flexibility of the rope configuration) as a train is approaching, which may result in serious injury or death. It also appears easy for passengers to throw debris onto the tracks, which is not possible with traditional PEDs. There are some other negatives associated with this system, such as no door structure or door panels which would have allowed for advertising space (PEDs allow for advertising revenue from traditional signs or electronic displays), more noise in the stations as trains arrive and depart since there is no reduction of sound from a traditional PED barrier, more brake dust and dirt being blown into the station which would be prevented with traditional PEDs, inability to prevent a section of the ropes from opening if a particular train door is locked out so entrapment may be more likely (a traditional PED door set would not open if the corresponding train door set does not open), the ropes could be considered less appealing from an aesthetic standpoint, etc.

There are also potential safety implications of a situation highlighted in videos of the Bulgaria transit system where rope screen doors are implemented. These videos show the ropes opening while a train is still approaching (instead of opening after the train is fully stopped and berthed), and the train starts to accelerate several seconds prior to the ropes closing all the way (instead of accelerating after the ropes are fully closed). This violates industry standard safety protocols for vital door closed and locked indications and train movement.

3.1.2.3 Half-height Platform Edge Doors

Half-height PEDs are operationally identical to full-height PEDs, but their vertical form factor is different. While full-height PEDs create a full floor-to-ceiling barrier that completely restricts access to the trackside, half-height PEDs only provide a partial barrier to the trackside. The height of this barrier can vary depending on the requirements of the agency, but all half-height PEDs will have a section of open air above the top of the barrier (thus appearing more like a gate than a full door).

As discussed in Section 3.3, the TTC-recommended solution is a hybrid between full-height PEDs (in terms of the door height and door header area) and half-height PEDs (because the vertical footprint of the doors would not reach the station ceiling, so an open mesh would be utilized above the door header area).

Figure 21: Half-height Platform Screen Doors on the Honolulu Skyline in Hawaii

3.1.2.4 Evaluation of Other Technologies

The TTC Platform Edge Doors Study: Alternative Technology document evaluated the other technologies and scored them in various weighted categories including safety/security, cost, complexity of installation, potential impact to operations, flexibility for future upgrades, and service proven references. The highest scoring technology for the TTC application was shown to be full-height Platform Edge Doors, followed by half-height Platform Edge Doors, then sensor-based track intrusion systems, and finally Rope-based Platform Screen Doors. The table below shows the scoring for the other technologies.

Evaluation Criteria / Assigned Weight (0 – 1)	**Full-Height Platform Edge Doors**	**Half-Height Platform Edge Doors**	**Sensor-Based Track Intrusion System (including Guideway Intrusion Detection System)**	**Rope-Based Platform Screen Doors**
Safety and Security (1)	**SCORE: 9** Safest and most secure option. Fully isolate the trackway from the platform area (floor to ceiling).	**SCORE: 7** Not as safe/secure as full-height PEDs, but still significantly safer and more secure than existing condition. Partially isolate the trackway from platform area. Passengers seeking unauthorized track access may be able to climb over.	**SCORE: 4** Does not prevent access to the trackway in any way. Provides some level of safety/security by detecting when a person enters the trackway and attempts to stop trains (but they may or may not stop in enough time to prevent collision).	**SCORE: 5** Not as safe/secure as full-height PEDs, but still significantly safer and more secure than existing condition. Fully isolate the trackway from platform area (floor to ceiling). However, people can still stick their arms, legs, or objects/debris through the cables.
Cost (0.8)	**SCORE: 2** Most expensive option, but most comprehensive solution.	**SCORE: 3** Almost as expensive as full-height PEDs. Some costs are saved in materials, but only marginally cheaper than full doors due to installation/structural costs.	**SCORE: 8** Likely the least expensive option, but not the same type of product as full-height, half-height, and rope-based PEDs since no trackway access prevention provided.	**SCORE: 5** Less expensive than full-height PEDs and half-height PEDs, but likely more expensive than track intrusion systems.
Complexity of Installation (0.6)	**SCORE: 3** Most complex to install. Platform reconstruction work likely required.	**SCORE: 4** Almost as complex to install as full-height PEDs. Platform reconstruction work likely required, but possibly less than full-height PEDs.	**SCORE: 7** Least complex to install. Conduits/cabling and ATC integration is required, but no platform edge reconstruction work required.	**SCORE: 6** Platform reconstruction work may be required, but likely less than full/half height PEDs.

Evaluation Criteria / Assigned Weight (0 – 1)	Full-Height Platform Edge Doors	Half-Height Platform Edge Doors	Sensor-Based Track Intrusion System (including Guideway Intrusion Detection System)	Rope-Based Platform Screen Doors
Potential Impact to Operations (0.8)	**SCORE: 8** Low probability of impacting operations.	**SCORE: 7** Low probability of impacting operations.	**SCORE: 2** False positive detections (birds, small animals, debris blowing onto tracks, objects thrown onto tracks, weather, etc.) would fully stop revenue service for the impacted line. Future low headway likely impacted.	**SCORE: 4** Potentially has a low probability of impacting operations but has not been service proven in many locations.
Flexibility for Future Upgrades (0.5)	**SCORE: 4** Costly modifications required if new trains with different train door spacing/sizing are procured or if additional cars are added to train consist sizes.	**SCORE: 4** Large space between support posts allows for high level of flexibility for train stopping accuracy and future train door spacing/sizing. Costly modifications required if additional cars are added to train consist sizes.	**SCORE: 8** High level of flexibility. System does not rely on train door spacing/sizing or train consist size.	**SCORE: 6** Large space between support posts allows for high level of flexibility for train stopping accuracy and future train door spacing/sizing. Costly modifications required if additional cars are added to train consist sizes.
Service Proven References (0.7)	**SCORE: 9** Numerous service-proven references from all over the world in many different climates.	**SCORE: 9** Numerous service-proven references from all over the world in many different climates.	**SCORE: 6** Numerous service-proven references from all over the world in many different climates.	**SCORE: 2** A few test bed projects have been completed. Only one multi-station system has been commissioned for revenue service operation (Sofia Metro in Bulgaria).
Total Weighted Score	**27.1 (Highest)**	**25.7 (Second Highest)**	**24.4 (Third Highest)**	**20.2 (Fourth Highest)**

3.2 PED Grounding Approach

3.2.1 Background

When designing a PED system for retrofit on an existing railway, thorough consideration needs to be given to the grounding scheme. The steel wheeled TTC trains operate on 600VDC and use running rails, which are insulated from earth ground, as the return path for traction power current. The platform elements such as the elevators, electronic signage, and metallic structure elements are grounded to the local earth at the passenger station. Therefore, the voltage of running rails (consequently the body of the railcars) and the grounded equipment in the stations are at a different potential.

If a passenger were to touch an active train and a metallic platform element simultaneously, a mild shock could occur, which would be alarming and discomforting. A risk exists for serious shock causing ventricular fibrillation, pacemaker malfunction, medical device implant malfunction, or in extreme cases, even death due to voltage potential difference between the train and platform.

The system is currently designed so that a passenger cannot touch a train and a platform metallic element simultaneously (thus minimizing this risk). However, PEDs introduce a new station element that will be positioned much closer to trains and will also extend out further into the platform area. It would be much easier for a passenger to make intentional or incidental contact with a PED and a train at the same time. As a result, safe and proper grounding of the PEDs is of vital importance.

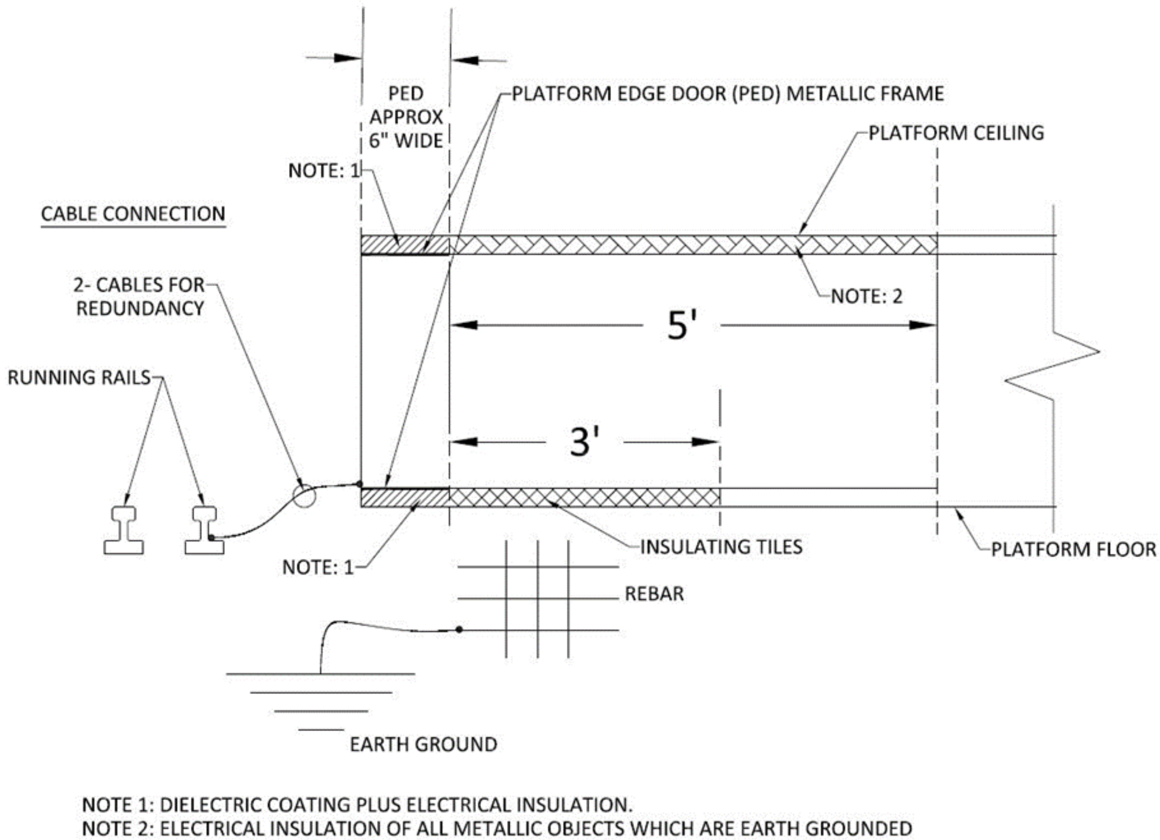
3.2.2 Potential Shock Hazard

The installation of PEDs will introduce two distinct scenarios for a potential shock hazard. First, a passenger or maintenance person may touch a PED and the train at the same time. Second, a passenger or maintenance person may touch a PED and a metallic station element at the same time. Potential shock hazard exists in both scenarios, and this must be considered in the design.

Several options for PED grounding schemes are available that take these two hazard scenarios into account. The PEDs can either be connected to station ground, which requires that the touch potential between the railcar body and the PEDs be mitigated, or the PEDs can instead be bonded to the negative rail, which requires that the touch potential between the non-grounded PEDs and any station equipment within close proximity to the PEDs is mitigated. Additionally, since this negative rail bonding method does not provide a ground, it requires that the power supplies to the PEDs be managed in such a way as to avoid an electrical fault on the PEDs structure from the power supplies (which can be overcome with Ground Fault Circuit Interrupters or GFCIs). Four different alternatives for PED grounding schemes are briefly discussed below.

3.2.3 Possible Grounding Alternatives

3.2.3.1 Alternative 1: Isolation of PED from Station Platform and Station Elements



In this design, the PED metallic structure will be bonded to the running rail, and the PED structure will be isolated from station earth ground. This means that the risk of shock will be eliminated when a passenger simultaneously touches the PED structure and the train, since these will be at the same potential.

However, this also means that the PED's structural array will need to be insulated from all grounded equipment in the passenger stations that is within touch (hand-to-hand or hand-to-foot) distance. This includes rebar in the platform slab to prevent damaging DC stray currents from going through platform metallic elements, which causes corrosion (metal loss) and other problems such as arcing, a negative impact on the structural steel and rebar in the station structure, and possible interference with sensors. Construction efforts will be required on each platform in order to create an area of isolation. At a minimum, this will consist of structurally reinforcing the edge of the platforms and installing dielectric mats (or use of similar materials in construction).

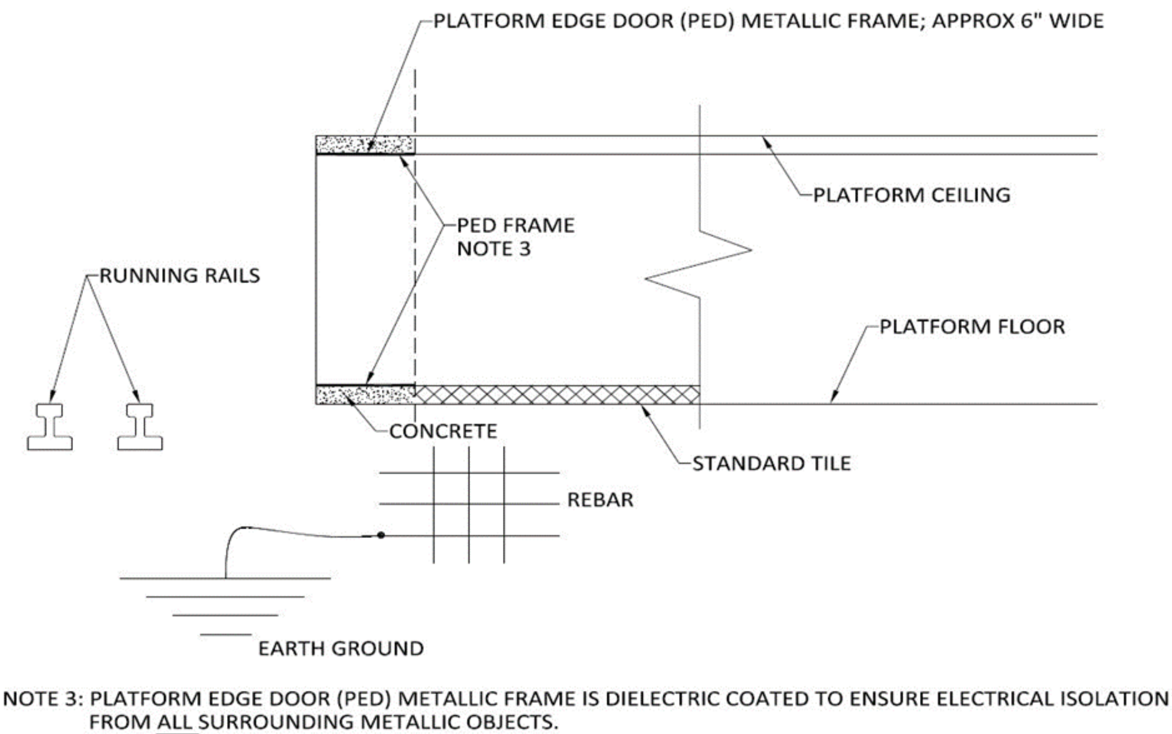
Since the addition of PEDs in this configuration essentially extends the touch potential of the insulated running rail out deeper into the platform area, metallic station elements within touch (hand-to-hand or hand-to-foot) distance of the PEDs will also need to be insulated if this alternative is selected. Insulation of the metallic station platform elements (metallic conduit, pipe, lighting fixture, etc.) will protect against a passenger or maintenance worker from simultaneously touching one of those elements and the PED structure, which could have a significantly differing voltage potential. A sensor, such as an ANSI device 64, can be installed to monitor the insulation resistance between the PED and the platform. If this resistance significantly decreases, a visual, audible, and/or SCADA alarm can be activated.

Since the PED is permanently bonded to running rail, it becomes part of the negative return circuit. During lightning strikes to (or near) the running rails or during 3rd rail-to-running rail short circuits, dangerous voltage potentials could be placed on the PED structure.

When annual track-to-earth resistance testing occurs, the measured resistance will also include the PED structure to earth resistance.

This alternative may be a viable long-term solution for TTC, although ultimately, the PED supplier/installer will be responsible for the design choice.

3.2.3.2 Alternative 2: Insulation/Dielectric Coating of Entire PED

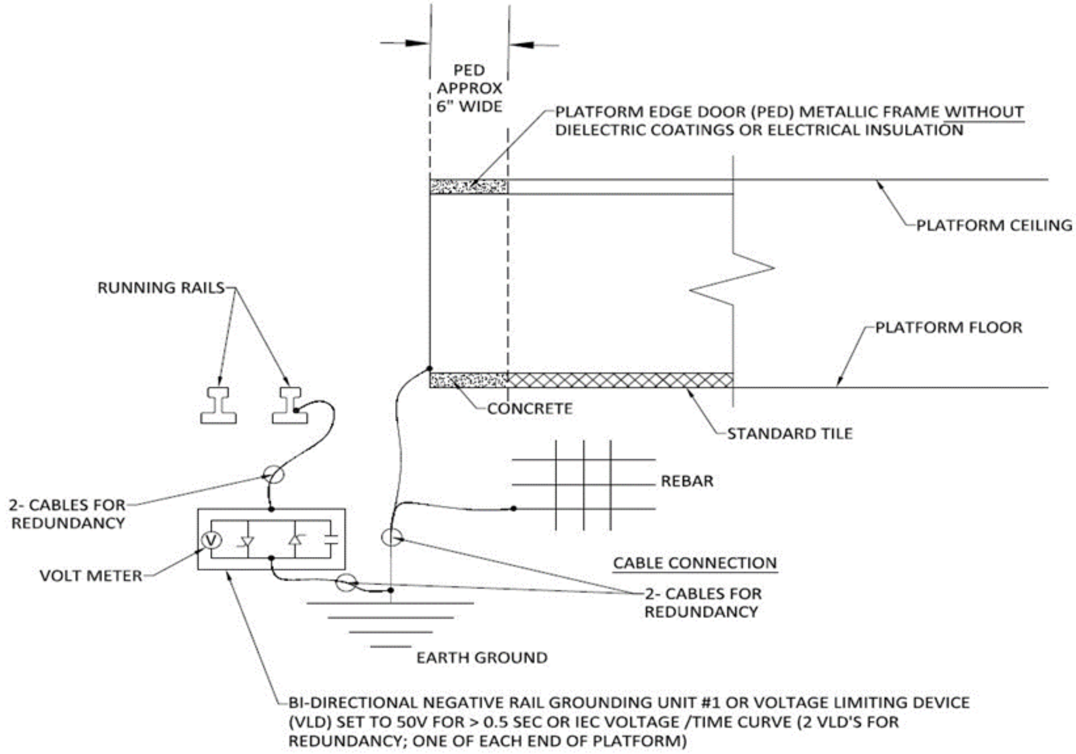


This design method fully insulates all conductive materials of the entire PED structure through the use of non-conductive components, special dielectric coatings, or cladding. Since there will be no metallic parts of the PEDs exposed, the risk of shock to passengers between the train and PED is mitigated. Grounding of the structure is not required, but utilization of this method allows the PED structure to be grounded to the station ground is so desired, which mitigates the issues between the PED motors and door actuation assemblies and the PED structure.

This method may be feasible, but it is not known to be service-proven and could create a risk if the dielectric coating or cladding is damaged or vandalized. TTC has directed the team to investigate its feasibility as part of the Feasibility Study. Furthermore, TTC has instructed the team to focus specifically on either construction of the PED structure using an alternative non-conductive material or incorporating the use of a cladding or veneer (such as fiberglass or some type of composite plastic for example), since TTC indicated that a dielectric coating will not be acceptable.

The details and feasibility of this alternative are presented in Section 3.2.6.

3.2.3.3 Alternative 3: PED Structure Grounded and Negative Grounding Device

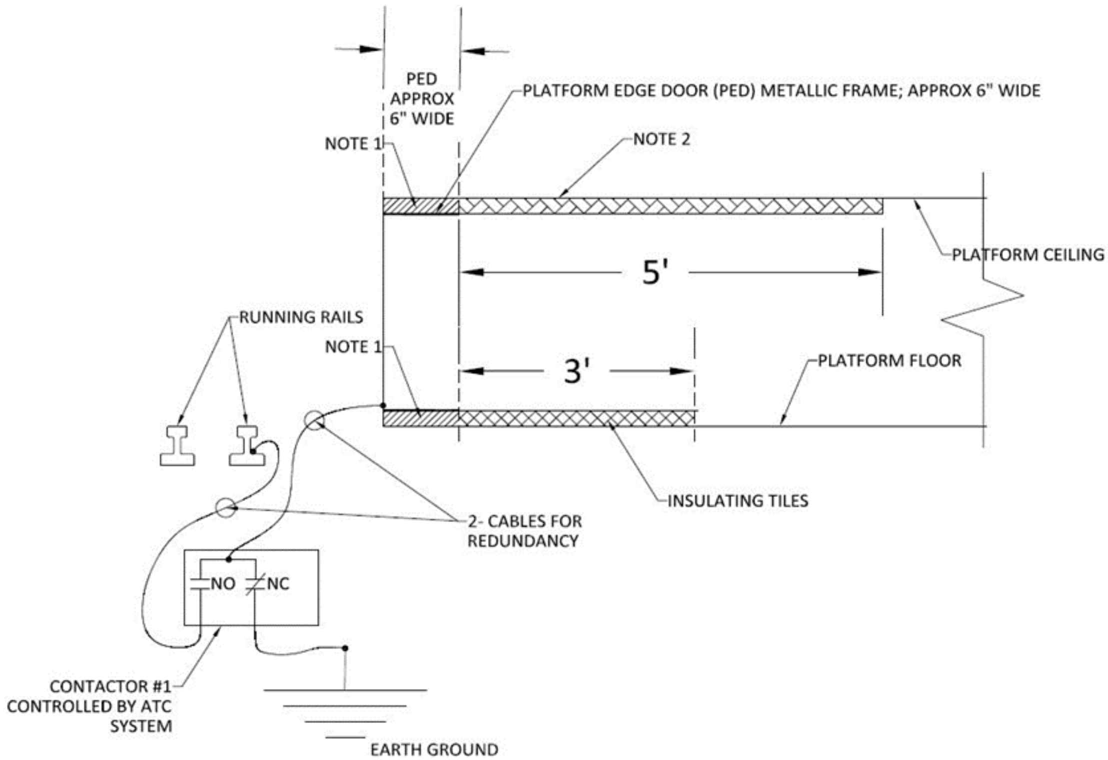


This design method would bond the PED structure to station earth ground so the PEDs are grounded. Devices known as Negative Grounding Devices (NGD) or Overvoltage Protection Devices (OVPD) could be used to mitigate the potential for passenger shock at stations. These devices could be installed at or near to each platform in between the running rail and the PEDs earth ground connection. When the voltage between the running rail and PED is rising to an unsafe level when a train is stopped at a station platform, the NGD would temporarily close and create a low-resistance pathway from running rail to station platform earth ground, which would eliminate any voltage potential between the PED and running rail.

This will minimize the risk of shock for passengers, but as it is connecting the floating negative running rails to the station ground, it promotes DC stray current in the system which can corrode the structure of the platform such as the integrated rebar and structural steel. In addition, DC stray current can corrode metallic water and gas pipes in the area. Furthermore, while NGDs are reliable, passengers would not be protected from shock in the case of an NGD failure (although a redundant OVPD could be installed). In addition, the NGD would require conduits and cables for the power supply, alarms & indications, and the connections to the running rail and the station earth ground. If one NGD has a problem, SCADA would be notified so maintenance can be scheduled while the second NGD continues to operate.

Due to the condition of several stations as noted in the Site Survey portion of the Investigation Report, the repeated tying of the running rail to station earth ground will promote DC stray currents and may further degrade the integrity of the stations. As a result, this method is not recommended.

3.2.3.4 Alternative 4: Insulate the PED from Station Platform and Station Elements with Contactor



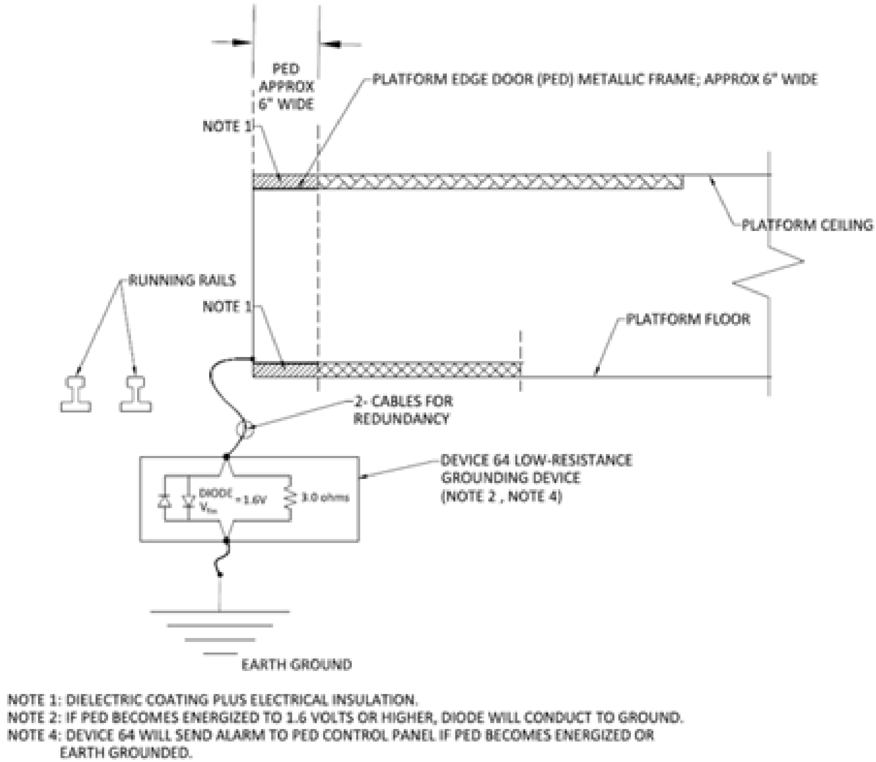
NOTE 1: DIELECTRIC COATING PLUS ELECTRICAL INSULATION.
NOTE 2: ELECTRICAL INSULATION OF ALL METALLIC OBJECTS WHICH ARE EARTH GROUNDED.
NOTE 4: CONTACTOR #2 INSTALLED ON OTHER END OF PLATFORM.
NO = NORMALLY OPEN WHEN RELAY COIL IS ENERGIZED BY ATC SYSTEM.
NC = NORMALLY CLOSED WHEN RELAY COIL IS ENERGIZED BY ATC SYSTEM.

In this design, the PED metallic structure will be isolated/insulated from station earth ground through dielectric mats, epoxy coatings, and other insulating methods, similar to Alternative 1. Dual independent contractors which are normally de-energized will connect the PED structure to earth ground. When a train approaches the platform, the Automatic Train Control (ATC) system notifies the PED controller to energize the contactors (before the doors open), which temporarily connects the PED to the running rail. After the doors close and the train starts departing, the PED controller de-energizes the contactors, which connects the PED structure to station earth ground. This means that the risk of shock will be eliminated when a passenger simultaneously touches the PED structure and the train, since these will be at the same potential. Also, since the PED structure is insulated from earth ground, DC stray currents cannot flow into the surrounding metallic steel reinforcement and metal pipes/conduits.

The contactors would require conduits and cables for the power supply, alarms & indications, and the connections to the running rail and the station earth ground. If one contactor has a problem, SCADA would be notified so maintenance can be scheduled while the second contactor continues to operate.

This alternative is the most comprehensive long-term solution with the highest level of safety, although ultimately the PED supplier/installer will be responsible for the design choice.

3.2.3.5 Alternative 5: Floating PED Structure with Low-Resistance Grounding Device



In this design, the PED metallic structure will not be bonded to the rail, and it will not be directly connected to the station earth ground. Instead of being grounded, the PED structure would be floating. This would help mitigate the touch potential hazard between the train and the PED structure, and it would also help mitigate touch potential hazard between the PED structure and any station elements.

In the event that the PED structure would happen to pick up a perceptible charge, a low-resistance grounding device connected to the PED structure would tie the structure to station earth ground to mitigate the touch potential hazard. This design would not require a layer of electrical insulation on the station floor or ceiling, but the PED structure would still need to be insulated from station earth.

3.2.4 Comparison of Alternatives

Although TTC has directed the consultants to pursue the feasibility of Alternative #2, the following chart provides a reference comparison of the pros, cons, constructability, cost, and maintenance of each alternative.

Alternative	Pros	Cons	Constructability	Cost	Maintenance
#1 – Isolation of PED from Station Platform and Station Elements	No potential difference (shock potential) will ever exist between the train body and PED structure due to redundant bonding. No separate electrical systems need interfaced together.	PED is permanently bonded to running rail, so it becomes part of the negative return circuit. This will make the PED structure susceptible to dangerous voltage potentials due to lightning strikes or	Installing and testing the dielectric coatings / electrical insulation between PED structure and platform metallic elements is time consuming and expensive.	Expensive.	Insulation resistance testing between PED and station ground will need to be performed periodically. Periodic inspection of the insulation of the platform grounded elements will need to be performed.

Alternative	Pros	Cons	Constructability	Cost	Maintenance
		short circuits affecting the rail.			
#2 – Insulation / Dielectric Coating of Entire PED	No potential difference (shock potential) will ever exist between the train body and PED structure as long as the dielectric coating is not damaged or worn away. No separate electrical systems need to be interfaced together. Does not require the platform edge to be replaced/insulated.	This alternative has not been service-proven in other locations. Requires customized design from PED supplier. Requires maintenance to ensure the covering is not damaged.	PED structure and assembly is quick and easy to install since electrical insulation on the platform is not required. An up-front design effort will likely be required by the PED supplier since this option has not been implemented before.	It is less expensive to install, but the PED vendor's cost will increase due to the up-front design costs and cost of a unique solution. Does not require the expensive civil costs associated with platform edge insulation.	Dielectric covering resistance testing will need to be performed periodically to ensure integrity. This will consist of putting a voltage on the PED structure, and then measuring for current leakage.
#3 – PED Structure Grounded and Negative Grounding Device	No dangerous potential difference (shock potential) will ever exist between train body and PED structure as long as the redundant NGDs are functioning correctly and voltage/time setpoints programed correctly.	It is unknown how frequently the NGD will be activated. If this occurs frequently, the platform steel can quickly become corroded and degraded. Two separate electrical systems need interfaced together (PED and NGD).	PED structure and assembly is quick and easy to install since electrical insulation does not need to be installed and tested between PED structure and platform. All PED assemblies bonded together to structure, and structure grounded.	Least expensive option. No dielectric coatings or electrical insulation needed.	Annual maintenance of Negative Grounding Device.
#4 – Insulate the PED from Station Platform and Station Elements with Contactor	Most comprehensive solution with highest level of safety. No stray current corrosion issues.	An additional change to ATC software is likely required. Three separate electrical systems need interfaced together (PED Controller, ATC, Contactor).	Installing and testing the dielectric coatings / electrical insulation between PED structure and platform metallic elements is time consuming and expensive.	Most expensive option. Requires periodic testing of dielectric coatings and electrical insulation. Requires testing of the interfaces between the ATC, PED Controller, and Contactors.	Annual maintenance of Contactor.
#5 – Floating PED Structure with Low-Resistance Grounding Device	Does not require the platform edge to be replaced/insulated.	Two separate electrical systems need to be interfaced together (PED Controller and low-resistance grounding device.	Fairly straightforward and inexpensive to install.	Requires additional hardware but does not include costly platform edge insulation work.	Annual maintenance of low-resistance grounding device.

3.2.5 Discussions with TTC Stakeholders

At the meeting in February 12, 2020 with TTC stakeholders from the TTC traction power engineering group, the above five grounding schemes were presented for discussion.

TTC eliminated both Alternative #1 (Isolation of PED from Station Platform and Station Elements) and Alternative #4 (Insulate the PED from Station Platform and Station Elements with Contactor) because TTC interpreted the

Ontario Electrical Safety Code (OESC) as specifically disallowing elements like PEDs from being bonded to the rails. The related OESC section text has been provided below:

> ***10-106 Railway track as grounding electrodes***
> *Railway track shall be permitted to be used as a grounding electrode only for railway lightning arresters and for the rail circuit itself.*

Although TTC interprets the OESC as specifically disallowing the bonding of the PED structure to the rails, this method is one of the most commonly used PED voltage-potential mitigation methods for railway applications. Since PEDs do not currently exist in the TTC system, it is unlikely that the authors of the OESC anticipated the future possibility of bonding PED structures to the rails. It may benefit TTC to initiate discussions with the Ministry of Consumer Services department of the Provincial Government of Ontario and the Electrical Safety Authority in order to consider the possibility of bonding PED structures to the rails as is done on many other transit systems around the world. The resulting decisions (such as potential updates to the OESC) may allow for more flexibility in PED grounding options when TTC is ready to initiate a PED pilot program or full system rollout of PEDs across the TTC system.

TTC eliminated both Alternative #3 (PED Structure Grounded and Negative Grounding Device) and Alternative #5 (Floating PED Structure with Low-Resistance Grounding Device) because TTC has had bad experiences with Negative Grounding Devices (NGDs) in the past, the NGDs may corrode the station structure resulting in degradation due to stray current, and it would be difficult to implement a “floating” PED structure since components such as door motors inside of the frame would still need to be grounded.

With four alternatives eliminated, only Alternative #2 (Insulation/Dielectric Coating of Entire PED) remained as a viable option to TTC, although this option is not known to be service proven and likely requires special fabrication work by a supplier. As a result, TTC instructed the team of consultants to further investigate the feasibility of this Alternative #2 in this Feasibility Study.

3.2.6 Feasibility of TTC’s Selected Grounding Method

As discussed in Section 3.2.3.2, the “Insulation/Dielectric Coating of Entire PED” solution consists of either:

- Applying a dielectric coating to a standard PED structure
- Covering a standard PED structure with a full non-conductive cladding/veneer
- Constructing the PED structure using alternative non-conductive materials

It is highly likely that an applied dielectric coating would be susceptible to scratching and/or vandalism, so the preferred methods of utilizing this alternative are either constructing the entire PED structure out of non-metallic elements or covering a standard PED product with a custom-fabricated full non-conductive cladding or veneer.

In comparison with a dielectric coating, either of these methods would provide much more comprehensive shock hazard protection over a longer period of time. Coatings would also require a higher amount of costly maintenance in order to test for damaged areas of the coating application. As a result, this section does not discuss dielectric coatings.

Since this grounding method is not known to be service-proven, the consulting team reached out to several different PED suppliers to research the feasibility of this alternative. The results were generally positive since multiple suppliers have noted that this grounding method could be feasible for their products.

3.2.6.1 Faiveley

The discussions with Faiveley (a Wabtec company) were particularly promising. A company representative from Faiveley stated that they could adapt their product to whatever earthing and bonding arrangements are required for the PED structure. Faiveley initially proposed a dielectric coating (such as polyvinylidene difluoride or PVDF). However, this option would not meet TTC's needs, since the insulative properties may degrade in the event of damage or vandalism. But Faiveley also stated that they could use a composite material cladding to cover all potentially exposed metallic parts of the PED structure. Furthermore, they stated that they have already applied this covering for the installation of their product on Paris Metro Line 4.

Figure 22: Faiveley's Composite Cladding on a Paris Metro Installation

Figure 21 shows the Paris Metro Line 4 installation of Faiveley's PED product, where the posts and header sections of the PED structure are shown to be covered with curved moulded composite claddings. The covers intrinsically provide a long-lasting surface insulation, even when they are scratched or receive minor damage. They also allow for more customization of the PED structure since the covers can be shaped in different ways.

In Faiveley's recent projects, both the sliding door panels, and the emergency egress door panels are fully glazed, which creates a naturally insulated surface on the platform-facing side of the structure. The glass of the sliding doors and emergency egress doors would then also be mounted with a subframe arrangement in order to have a fully glazed surface side to side without any accessible metallic surfaces on the platform-facing side of the structure.

However, in the prototype stage of a TTC-specific project, it would be important for the project team to review detailed information about the non-conductive properties of such a solution to ensure that humans would be safe from shock hazards. Faiveley would also need to determine a method of insulating the trackside-facing portions of the PED structure with a similar composite cladding and panel arrangement since it could be possible for passengers to touch the backside of the PEDs and the train body at the same time (for example, in the event that the train doors open but the PED doors do not open). Insulation of the trackside-facing portions of the PED equipment is also important to TTC in order to reduce the shock hazards for maintenance personnel working trackside.

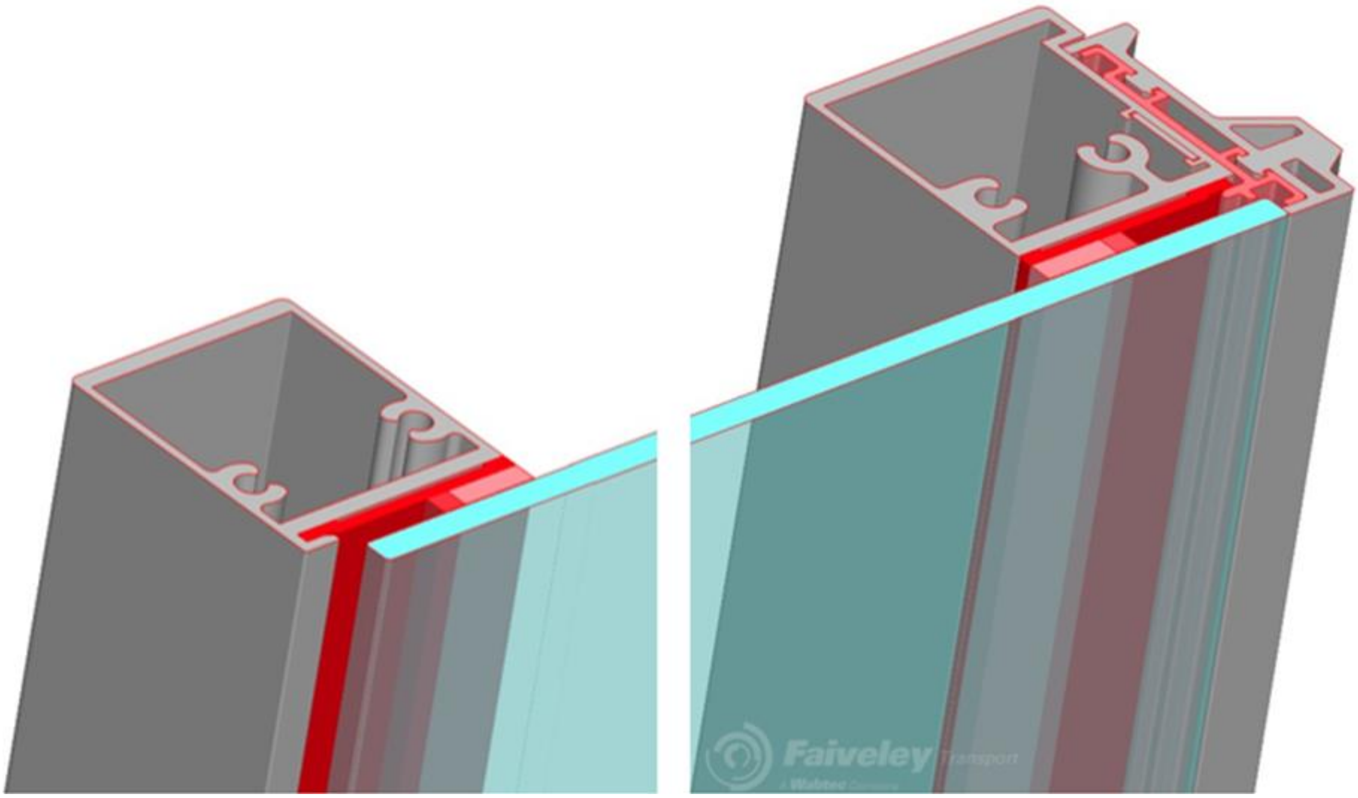


Figure 23: Faiveley's Glass Mounted in Subframe Arrangement on PED Door

3.2.6.2 Singapore Technologies

Singapore Technologies has stated that it is possible for them to design and engineer a custom non-metallic cladding for the PED structure in a way such that all exposed surfaces of the PED structure are non-conductive. Even though this would be a custom solution, they do not expect a particularly high-risk profile for the solution. It seems that it would be straight forward for the engineering team to use alternative construction materials and non-conductive coverings. However, the challenge would be for the engineers to select composite materials with the required insulation properties that would be suitable for the particular TTC system environment while still meeting the structural needs of the application.

Since Singapore Technologies has not implemented a design like this for other PED systems, they stated that it would be difficult for their team to present anticipated pricing information for a custom TTC solution. They would need to be contracted to perform an engineering study in order to determine material needs, structural design, and other attributes of a product that could ultimately be rolled out on TTC's system to meet the TTC-specific needs.

3.2.6.3 Stanley

The Société de Transport de Montréal (STM) recently solicited a “call for interest” related to installing platform doors on the Orange Line and Blue Line of the Montreal Metro. Stanley was one of the suppliers who responded to STM, so they are aware of the high level of Canadian interest in rolling out PED systems. As of March 2020, STM has not yet fully defined their grounding/isolation scheme, and it seems that they will be looking to suppliers for recommendations.

STM does not have an issue in using metallic structures; however, they require that the structure be electrically insulated from the platform structure without the use of a dielectric membrane. Stanley has stated that this could be accomplished on their product by using insulation in the anchoring system between the PED structure and the platform and surrounding structures. The PED equipment, such as the door motors, would still need to be grounded in some way to mitigate a touch potential in case of a power short such as a loose power wire inside of the door drive mechanism.

When discussing the TTC-specific non-conductive covering or alternative material use for construction, Stanley was unsure of the feasibility of this approach for their products. Almost all of the components within their equipment are metallic and, therefore conductive. It may not be possible (or at the very least, it may be very difficult) to cover the many exposed moving parts, fasteners, etc. in a dielectric cladding. As a result, Stanley has stated that while it may be possible for them to meet TTC’s needs, they would first require a major design effort in order to confidently make that determination. Since engineering work would be required before understanding feasibility or design details, Stanley has stated that they are unable to provide pricing information on a potential TTC-specific solution.

3.3 Summary of Full Height Partially Segregated Doors

Generally, there are three types of platform doors implementations:

1) full-height installations between the ceiling and the floor that completely separates the platform from the track
2) half-height installations that do not reach the ceiling
3) low-height installations that are similar to half-height but are not taller than a meter or so

Industry nomenclature refers to full-height installations as “platform screen doors” (PSD), and half-height installations as “platform edge doors” (PED) or “platform screen gates” (PSG). However, the TTC-specific type of doors discussed in this document are an exception to the industry standard naming scheme, since these are referred to as PEDs.

In order to meet the TTC-specific requirements, the consulting team has been working with something of a combination between full-height and half-height systems. The barrier design is envisioned to be “full height” in terms of door size and the use of door headers above the barrier, but “half-height” in the sense that the industry definition states that half-height doors do not reach fully to the ceiling. Instead of extending the top portion of the PED to the ceiling (which would be a problem in some of the TTC platform types), this upper space shall be left open and covered with a mesh screen to freely allow the flow of air. This design minimizes potential impacts to tunnel/platform ventilation and temperature control.

In the interest of consistency, the TTC platform door system is referred to as a “PED” that is considered to be “full height”. This solution has been named “full height, partially segregated”.

3.4 Summary of the Use of PEDs in Other Transit Systems

Members of this consulting team have been previously engaged by other transit agencies in various capacities that involved both the study and the deployment of PED systems. Some of this work was similar to the TTC Feasibility Study in that it involved assessing the feasibility of future platform door systems for transit agencies who prioritized addressing platform crowding, restricting passengers from entering the trackway, and increasing overall system safety and security.

This section highlights some of the lessons learned from previous consulting work with other transit agencies that the TTC can leverage in their consideration of PED installation.

3.4.1 Practical Expectations for Cost of a PED Retrofit

Numerous European and Asian systems have retrofitted their platforms with PEDs because the agencies decided that the benefits of platform door systems far outweighed the required investment. The implementation of PEDs in North America (and more specifically, the United States) has generally not yet been as successful as the European and Asian countries. A recent example of this is the BART system in the San Francisco and Oakland area of California. BART invested around $2 million in 2017 to study the installation of PEDs on their system, to have a testbed fully installed on a platform by 2025. However, the $30+ million price tag of the retrofit, coupled with the fact that BART was in the process of awarding a new ATC contract for their entire system, swayed the agency to cancel the PED program. Another similar example is New York City Transit's cancellation of a $40 million pilot project to install platform doors on the Third Avenue Station of the L Line in Manhattan.

A significant factor that affected this situation was the condition of the existing platforms since the higher costs of a PED implementation often come from the civil side of the project. Generally, the platforms that have been retrofitted with PEDs in Asia have been in relatively newer and well-maintained condition, which would limit the extent of civil reinforcement costs. For example, all the above-ground stations of the Singapore MRT were retrofitted with platform doors by 2012, but the MRT system itself was only commissioned in 1987. The newer platforms had not seen as much wear and degradation as platforms on an older system. It is important to keep in mind that the TTC system contains platforms that will require significant rehabilitation in order to support the additional weight of a PED structure. This will add to the required investment, but it will also reinforce the integrity of ageing platforms, which will help create a better overall system for TTC.

3.4.2 Importance of a Pilot Program Before System-wide Implementation

Complexity should not be taken for granted when it comes to a project that aims to integrate a new system like platform doors with an intricate existing system such as a railway that includes automatic train control. If unforeseen issues or "growing pains" are going to occur during the installation and integration of the platform doors, it is best to work through those issues at a station that does not have high ridership.

A pilot installation at the stations representing a typical group of stations' structure (e.g. Old Mill, Glencairn, Lawrence and North York Centre). This would refine the design requirements, identify constraints, refine risks, cost, schedule, and lessons learned for each type of station's structure as well as obtain customer feedback, assess O&M impact, and generate public interest Four proposed stations from each station classification to be done as part of pilot program.

3.4.3 Coordination with Authorized Suppliers

As demonstrated in previous projects that involved members of the consulting team, it is certainly preferable if a system's ATC supplier and PED supplier have worked together in the past. An existing relationship not only helps the project run smoothly, but it also helps ease the concerns of a successful integration with the train control technology. Fortunately, PED system interfaces are relatively similar between the various suppliers, so ATC integration concerns can be minimized. Another positive is that due to the number of systems around the world that have been installing platform doors, most major ATC suppliers (Thales, Hitachi, Bombardier, etc.) have worked with most of the major PED suppliers (Faiveley, Stanley, Singapore Technologies, etc.) at one point or another. Whenever suppliers are shortlisted by TTC for the future TTC PED implementation, it would be beneficial for TTC to obtain insight of the specific supplier relationships and even seek the feedback of other transit agencies.

3.4.4 PED Implementation Does Not Need to be Delayed due to Lack of ATC

The fact that TTC's Line 2 does not yet have ATC should not sway the decision-makers away from rolling out PEDs to interface with the existing Line 2 technology. Perfectly viable PED solutions exist for non-ATC-equipped station(s), and these solutions would be "ATC-ready" so they can easily be integrated whenever the line is upgraded to ATC.

There are numerous types of PED control methodologies. Some are "semi-independent" or "independent", which means that they can sense when a train has berthed and command the PEDs to quickly follow behind the opening of the train doors. Others can be interfaced directly with both older fixed-block systems and newer ATC systems. The availability of these different types of PED systems means that the scope of a PED rollout does not need to be limited to only ATC-equipped stations.

A key example of this is the Paris Metro. Paris wanted platform doors but recognized that they would need to wait a very long time to roll out PEDs in conjunction with their ATC upgrades. Therefore, the decision was made to install platform doors with trackside antennas, plus modify their vehicles to communicate directly with the platform door controller through these new trackside antennas. The resulting system consisted of PEDs that could communicate directly with berthing vehicles, and the platform doors could then be operated completely independently from the ATC system. This migration was planned so that the doors could be connected to the new ATC as the new system is rolled out. This allowed them to deploy PEDs as soon as possible without the added cost and complications of interfacing with a system they intended to remove/upgrade anyway. These controllers were then cut over to the new system, making the platform door controllers operate like a normal ATC system.

It is also worth noting several other kinds of PED control systems. A few examples of these are:

- Wayside antennas are utilized to communicate directly with vehicles.
- Remote controls can be provided to the train operators, and door sensors can be installed to sense train alignment along the platform. The sensors determine which doors to open, and the operator controls their opening/closing directly via the remote controls.
- Sensors can be utilized at each doorset's position at the train berth. These sensors can detect the doors opening/closing and respond accordingly with the action of the PEDs.

All the above include independent door recycling functions and entrapment protection. The primary downside of not interfacing the PEDs to ATC is related to mitigation of safety hazards associated with potential failures in which automatic platform doors are open when no train is berthed. Despite this downside, the benefit of these systems is that they are easier to initially deploy (without waiting for ATC) and they can be engineered for a smooth cutover to a future ATC upgrade.

3.4.5 PED Grounding Scheme is Essential

Since the PEDs are intended to be retrofitted on the existing TTC system instead of a “greenfield” project where the power system configuration can be planned in parallel with the PED design, it is important to consider the grounding scheme of the PED structure in relation to the existing station power architecture. Due to the potential impact that this item could have on the project, it is further discussed in Section 3.2.1.

3.4.6 Network Considerations for Vital Signals

As mentioned above, it is not an easy task to install PEDs in retrofit installations, particularly when they are being integrated with older systems. As another layer of complexity, TTC’s system has a distributed Station Equipment Room (SER) architecture. Because of this, consideration should be given to how signals are currently run across the network, particularly vital signals that may need discrete I/O satellite to SER, redundancy, and highly reliable protocols. The integration of PEDs with the ATC system may not be as simple as merely adding some I/O racks to the station, unless TTC has plenty of spare cabling between stations to accommodate new signals. Some transit agencies made the mistake of underestimating how important this is to consider in a new retrofit implementation, which quickly added unanticipated costs.

3.4.7 Standardization of a Solution

TTC plans only to operate one type of train vehicle with a fixed number of doors on PED-equipped stations, which will, fortunately, lessen the complexity of the PED implementation. Although various consist lengths will need to be considered, this is quite easy in comparison with other systems that have required to accommodate various vehicle types and door spacings. But the unique nature of the various TTC station profiles may be limiting or challenging at the least. From the consulting team’s observations and investigative work, this is not an impossible task, and the dimensions and mechanical design of the PED system can likely be reasonably standardized for TTC (effectively iterating the same base design).

3.4.8 Coordination with ATC Migration Project(s)

Depending on how far along TTC is with the creation of a contract for the Line 2 ATC upgrade (or any other future upgrades), it would be beneficial to modify the contract to include requirements for platform door controls. This would help ease and coordinate door implementation when the rest of the system is upgraded to ATC, particularly if the interface between the ATC supplier and the door supplier is facilitated. PEDs should be considered as early as possible for all future upgrade work.

3.4.9 Planning for Maintenance of PEDs

Once PEDs have been installed on a transit system, the owner needs to follow a comprehensive maintenance program to ensure that the PEDs maintain proper operation and therefore achieve optimal reliability. Based on lessons learned from previous PED-related project work with other transit agencies, the consultants have put together a preliminary list of recommended maintenance items that should be considered in the project design phase. Please refer to Section 3.9 for this list.

3.4.10 Potential for Additional Advertising Revenue

Other transit agencies have considered ways to increase revenue through advertising methods that incorporate the PED structure itself. Some systems that do not currently have PEDs installed use the back wall of subway stations behind the tracks as advertising space that can target passengers waiting on the platform. However, this results in a need for trackside access every time the advertisements are due to be changed.

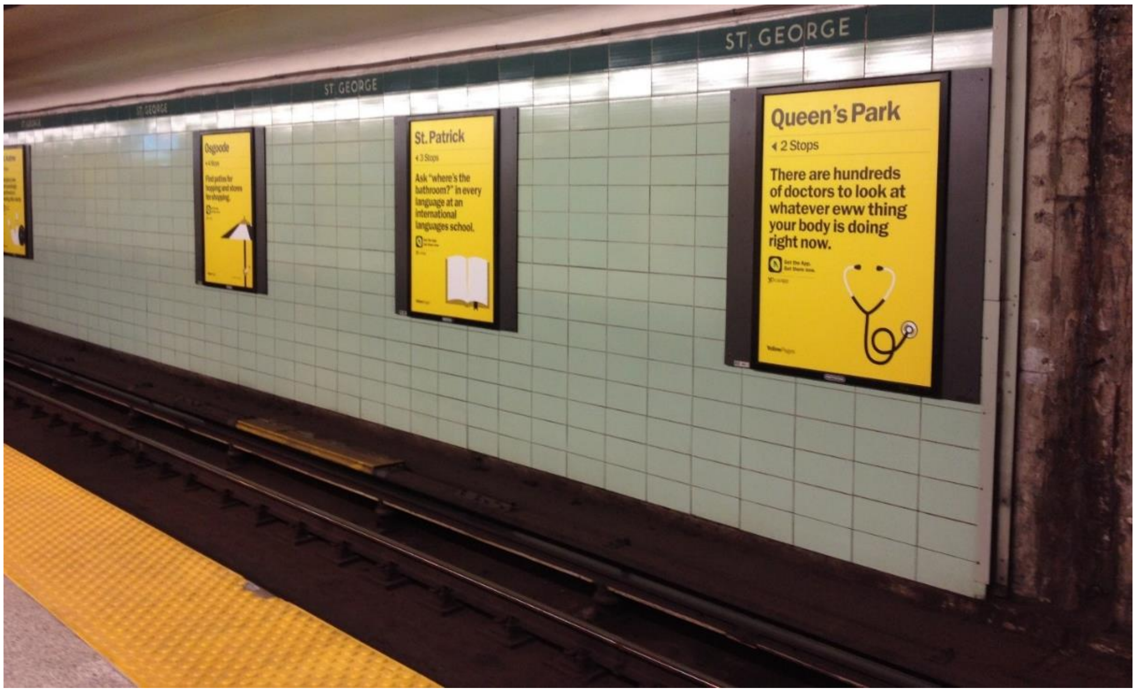


Figure 24: Advertisements on the Back Wall of TTC's St. George Station

If PEDs were to be installed, these advertisements can instead be moved closer to the waiting passengers on the platform-facing side of the PED structure. This provides a much easier way to change advertisements since trackside access would no longer be required. Since the PED structures are closer to passengers than the back wall of the station, this also allows for smaller and more compact ads, which results in the ability to accommodate more ads into the passengers' visual field (and therefore can create additional revenue).

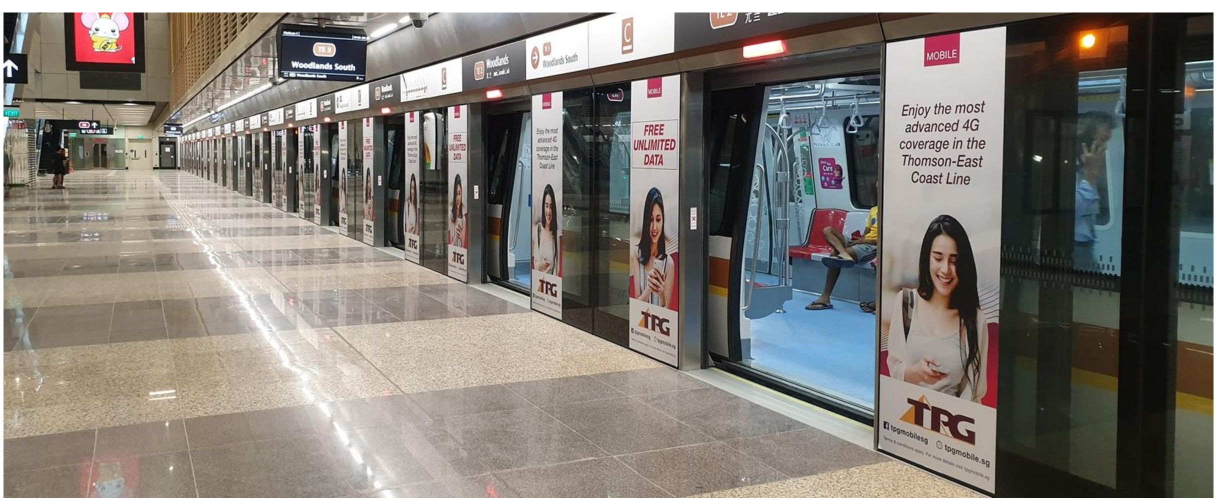


Figure 25: Advertisements on PED Panels

The non-operating glass panels on PEDs can also accept electronic changeable advertising screens, which provides an even easier method of swapping out advertisements. A side benefit of using electronic screens for advertising is that the screens can also be used to display important system-related information when necessary (special service announcements, special events, subway closures, etc.).

3.4.11 Weight of Doors

During the PED design phase, the PED supplier will need to define the width and size of the PED doors. Larger doors will provide a larger threshold for inaccurate station stops, since trains would be able to stop farther away from the door centerlines without impacting the ability for passengers to pass through the doorway opening. This is particularly important when trains are being operated in manual mode. However, larger doors will also result in the doors being heavier, which increases power consumption and slows the opening speed.

The industry practice for PED design parameters is to size the doors large enough to accommodate the worst-case stopping accuracy for all train types that use each station, while still sizing the doors small enough that the system performance will not be impacted due to excessively long opening times. For the purpose of this Feasibility Study, the consultants have analyzed the related TTC system attributes and found that the industry standard door size is considered acceptable for use in the TTC system (see Section 3.6.4 for the detailed analysis and calculations).

Material selection is also important to potentially reduce weight. Previous discussions with TTC highlighted an interest in fabricating the barriers using only non-conductive materials or using a non-conductive cladding to mitigate potential shock hazards related to grounding. Since this is a non-standard solution, little information is currently available on potential weight reduction of barriers that are constructed with alternative materials in comparison to stainless steel, but it is assumed that the material would be a polymer of sufficient thickness as to resist any abrasions or chipping. The potential weight difference will be factored by the supplier in determining loading conditions and platform structural requirements. Construction of the PEDs using an alternative non-conductive material would likely reduce the weight of the doors, whereas applying a non-conductive cladding to an existing metallic PED structure would likely increase the weight of the doors.

In addition to sizing of each door width, the width of the barrier itself is also a factor in weight. The current design required by TTC will provide enough ceiling support and clearance from other station elements to reduce the overall width of the barrier. Depending on how this is anchored to the platform/ceiling with supports, this may be an effective method of reducing the overall weight.

However, regardless of other precautions taken, lessons learned from other systems clearly indicate that brownfield PED systems almost universally require platform reconstruction work to implement. Even in the best-case scenario with the lightest barrier weight possible, it is unlikely that the existing platforms on the TTC system will be able to handle the additional load of PED barriers without reconstruction/reinforcement work. Reducing the weight of the doors would likely decrease these reconstruction requirements and therefore save costs.

3.4.12 Installation

In prior PED projects, proper staging of the installation is key to delivering the system as efficiently as possible. In many Asian brownfield PED projects, the entire station is shut down completely for one or two weeks (depending on supplier estimates). Work can then take place around the clock with the largest components being transported in via the tunnel from the yards during the night, and small equipment and personnel using the main station entrance during the day. This shutdown period also allows for longer testing windows to verify the installation before opening them to the public. Finally, this also prevents passengers from interacting with unfinished installation, which mitigates some hazards present before the PED can be tested and enter operation.

While this does cause a severe disruption to service that is difficult to implement across multiple station successively (or at the same time, depending on available manpower) the alternative of only working within limited windows during night and/or weekend shifts often prolongs the project considerably. In addition to labor costs, smaller installation windows are generally much less efficient due to the time it takes to properly set up and remove installation equipment, particularly regarding civil reconstruction.

However, if service must be continued with minimal disruption during the installation process, it is recommended that weekend shutdowns are utilized to reinforce the platform and implement components that will not adversely affect passengers (e.g., cable and conduit runs, ERR retrofits). Once this prep work is completed, then the actual barrier installation can begin. During this time, TTC and the supplier must decide if they are able to shut down the platforms (i.e., lock installed doors closed) or keep them operating (i.e., lock installed doors open) one at a time. This introduces some risks of passengers and trains interacting with the barriers before they have been tested, such as during a train misalignment, so it is crucial train operators are trained prior to any installation work.

Finally, to better understand resource loading, construction times, and potential hazards, it is strongly recommended that TTC initiate a pilot project on a low traffic station before any other work on the system takes place (preferably one pilot PED installation on each of the six platform types defined in this study). A pilot program for low-traffic stations would provide valuable lessons learned that can be carried forward to other higher-traffic stations.

3.5 Summary of Recommended Manufacturers and Suppliers

As a result of research into TTC's system, years of industry knowledge, and lessons learned that have been accumulated from multiple experiences with PED vendors, this section contains a list of potential suppliers for the TTC PED system.

It is important to note that this is NOT a procurement "short list" of eligible suppliers, and it is also important to note that these suppliers are presented in no particular order. The suppliers discussed throughout this document have been the subject of focus because of their industry reputation and the consultants' familiarity with their previous work in the industry.

1. Clearsy
2. Faiveley Transport (acquired by Wabtec)
3. Horton Automatics
4. Stanley Access Technologies
5. Singapore Technologies Engineering Electronics (STEE or STE)
6. Knorr-Bremse (or Westinghouse Platform Screen Doors)

Of the above suppliers, Faiveley, Stanley Access Technologies and Singapore Technologies Engineering Electronics are the 3 companies that could meet TTC grounding requirements as stated in Section 3.2.6. Some examples of each supplier's projects and, as noteworthy, solutions will be presented in their own sections below. If TTC decides to engage in a pilot program for installation of PEDs on one or more platforms after completion of the feasibility study, it is recommended that these suppliers be invited to Toronto for a workshop to refine details and answer questions about their products and how they can be applied explicitly to TTC.

Fortunately, there are many different PED options that could be applied to the TTC system. Some suppliers offer alternative control schemes where the PED controller operates as a relatively self-contained subsystem, but doing so would move some PED system safety functions to operator procedure. These alternative solutions will be presented in the relevant supplier sections for informational purposes; however, as it is currently assumed that only Line 1 ATC-equipped stations will be seriously considered for PED implementation, they will not be considered throughout the study in-depth.

As noted above, this list of suppliers should NOT be considered as a “short list”. Information about each company is provided for informational purposes to take into consideration during the next step of the TTC PED investigation and roll out process. Contact information for each supplier is included in **Appendix B**.

3.5.1 Clearsy (France)

Below is a summary of some Clearsy projects:

- Paris Metro (Line 1 & Line 13) – It is worth noting that Paris included a number of “curved” platforms which were accommodated with the Clearsy system design.
- Sao Paulo Metro (Lines 1, 2, & 3)
- Sao Paulo Monorail (Line 15)
- Stockholm Metro
- Caracas Metro (Los Teques Line)

3.5.2 Faiveley (Pennsylvania, USA)

Below is a summary of some Faiveley projects:

- Paris Metro (Line 4 & Line 14)
- Hong Kong (HKSAR) – Notably Hong Kong also used a terrazzo floor finish, which Faiveley helped install.
- Copenhagen (Line 2)
- Guangzhou (Line 1 and Line 2)
- Sydney North West Rail Link

3.5.3 Horton (Ontario, Canada)

Below is a summary of some Horton projects:

- Toronto Pearson Airport (YYZ)
- San Francisco Airport (SFO)
- Dallas/Fort Worth Airport (DFW)
- Phoenix Sky Harbor Airport (PHX)
- Washington Dulles Airport (IAD)

3.5.4 Stanley (Connecticut, USA)

Below is a summary of some Stanley projects:

- Honolulu Rail Transit (HART) – Though this project has not yet been commissioned, this is currently the only metro system in North America that includes platform edge doors. Note this is a greenfield project.
- Orlando Airport (MCO)
- Dubai Airport (DXB)

3.5.5 Singapore Technologies Engineering (Singapore)

Below is a summary of some STE projects:

- Taipei (Neihu-Mucha)
- Singapore (MRT)
- Bangkok (SkyTrain)

3.5.6 Knorr-Bremse (Munich, Germany)

Below is a summary of some Knorr-Bremse projects:

- Copenhagen
- Dubai
- London
- Hong Kong
- Shenzhen (China)

3.5.7 Alternative PED Control System

Various types of control schemes beyond ATC-controlled PED controllers exist. Two alternative systems that may be used on the TTC, though not recommended in this report, are outlined below along with potentially a third option.

3.5.7.1 Clearsy COPPILOT

Clearsy's COPPILOT uses laser sensors on both ends of the berthing positions to detect when a train has stopped at the platform. These laser sensors ensure that the train is properly berthed and that it currently is sitting at zero speed. Then another set of laser sensors that are aligned with each doorset along the train consist detects when the vehicle opens and closes its doors. This information is fed to a controlling cabinet, which will then command the platform doors to open and close in parallel with the vehicle doors (although a small delay on the order of 300ms is introduced). The optimized number of lasers required for a particular application is defined from cooperation between Clearsy and the contractor to reach safety expectation. In its current configuration the COPPILOT does maintain a SIL3 certification and presents a viable option of implementing platform doors without need to modify the train vehicles or existing wayside equipment.

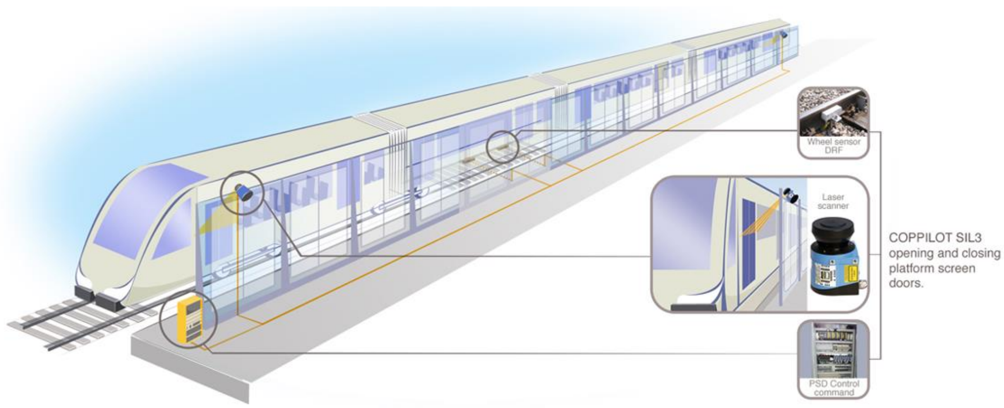


Figure 26: Clearsy COPPILOT

3.5.7.2 Singapore Technologies Engineering Solutions PEPS

A noteworthy solution implemented in Toronto by Singapore Technologies Electronics (STE) is their Platform Edge Protection System (PEPS). The general framework of the system is a series of trackside laser sensors grouped per train consist length that feeds information back to a station controller cabinet. From there, wireless communication between the modified train and the controller cabinet exchange information after the sensors have verified that the train has stopped in the correct position, thus ultimately aligning the vehicle and platform doorsets opening/closing. As a backup in case the laser sensors fail, the system can utilize RFID tags that are installed to correspond with proper train stopping positions. The tags are detected by the wireless system and a train operator bypass signal is used to determine train lengths and control the doors.

Additionally, as the system was designed with train operators in mind, it includes tower lamps to give visual indication to the operators when the trains are properly aligned with the platforms, including a closed and locked indication from the PEDs. This design includes vital circuits for monitoring the C&L signal, but it functions independent of the ATC system. These systemic ATC functions are substituted with operational functions (indication lamps), meaning it does not offer the same level of protection as full ATC integration.

The indicator lamp design of this solution is most relevant to TTC, since important information can be relayed to the train operators about the status of the platform doors and the vehicle alignment. This system could also be used on TTC with typical PED installations in case trains are being operated by drivers in manual mode.

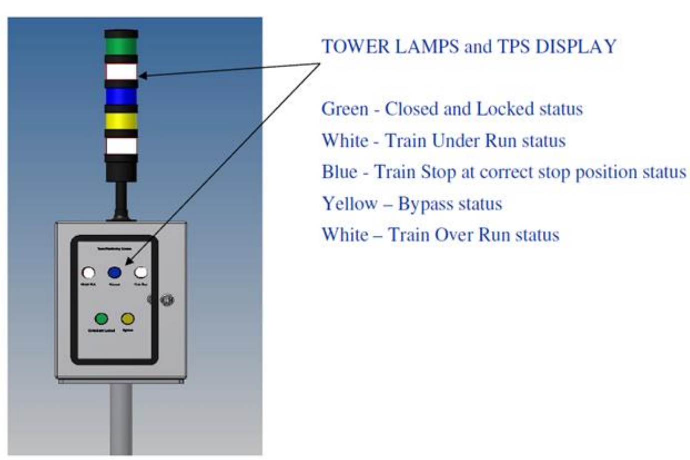


Figure 27: Example of Indicator Lights (STEE, PEPS solution)

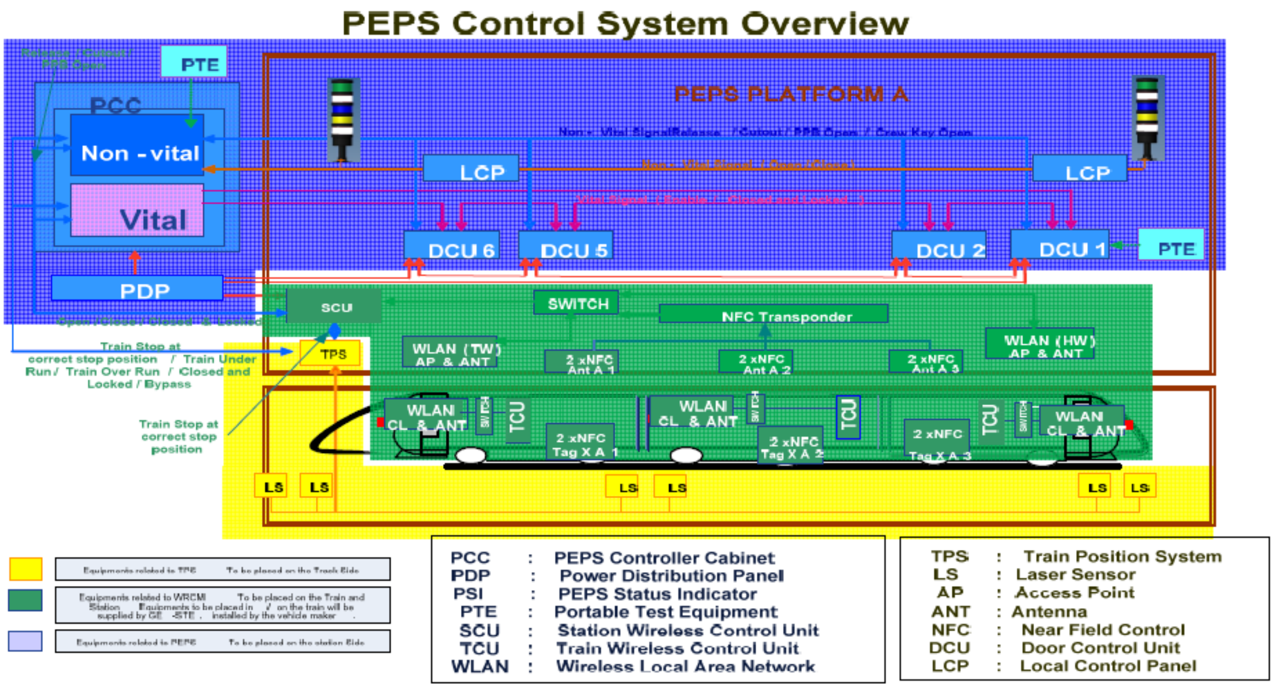


Figure 28: STE PEPS

3.5.7.3 Unique Faiveley Solutions

Faiveley is one of the most prolific and inclusive suppliers around the world, capable of both manufacturing and supply. They have many different and unique custom solutions currently in operation such as “autonomous”, “semi-autonomous”, and “fully-integrated” products. Unfortunately, NDAs prevent sharing information about their customized solutions. If TTC is interested in learning more about alternate solutions that can be provided by Faiveley, a supplier workshop is recommended.

3.6 Impact of PEDs on Subway Operations

3.6.1 System Impact of PEDs

In ATC systems that are integrated with PEDs, the synchronous opening of the platform doors with the vehicle doors is one of the most important factors of operation. For systems that do not utilize train operators for door commands, both the platform doors and the train doors are vitally enabled and then non-vitally commanded open by the wayside ATC. These commands are executed by the PED controller while subsequently being processed on the carborne controller. For the TTC system which does use train operators, the operators are responsible for initiating the door closure and departure sequence after the dwell timer has expired. Regardless, the operation of the vehicle doors in sync with the PEDs is the greatest impact on operations that PEDs may have.

3.6.1.1 Impact of PEDs on Dwell Time

For this section, “dwell time” is defined as the total time from when the train comes to a complete stop to when the train begins to move again.

By analyzing the data compiled within a study titled “Operational Impacts of Platform Doors in Metros” that was published in the Journal of the Transportation Research Board (JTRB) for the Transportation Research Record (2018), we can use aggregate data on the operational impact of platform door systems collected from 33 metros around the world. That study determined that platform door systems are observed to have a net negative impact on dwell times, while having a net positive impact on operations.

The consultants also reached out to several platform door suppliers for specific data related to dwell time impact for projects that the suppliers have implemented. While specific data was not available due to that information being considered as confidential by transit agencies, two of the platform door suppliers referred the consultants to the same JTRB study that had been independently used as a source of data prior to contacting suppliers.

The JTRB study states that implementing PEDs has typically shown a small net negative impact on dwell times. This delay is separated into three components:

1. slower door opening and closing times,
2. slower passenger flow rates (boarding and alighting),
3. and larger departure delays after all doors are closed.

Generally, platform doors are wider than their associated vehicle doors by approximately 22% to 48%, which means they are both heavier and slower to close. Longer close times result in delays to achieving Closed & Locked status to allow train departure. An average increase of approximately 1sec to 2secs was attributed to slower door opening and closing times in the JTRB study.

Second, the addition of platform doors may impact the flow rate of passengers on/off the train vehicles due to a new doorset being implemented deeper into the station away from the platform edge . The analysis indicates that platforms doors could provide a minimal delay of approximately 0.1sec per passenger. On its own, this almost seems negligible, however in peak hours with many passengers boarding and alighting at once, this can add up. For example, if 10 passengers alight then 20 passengers board, this may have an impact of up to 3secs per dwell. However, as no real and definitive data could be provided, this portion of the dwell time delay should not be factored in for a potential impact to TTC’s system.

The largest negative impact PEDs would have on dwell times as stated in the JTRB study is the larger departure delay after all doors are closed. The departure delay can be compounded by an operator lookback procedure to see if the platform is cleared. While much higher delays were noted worldwide (an average of 12secs and worst case of 25secs), these findings were also factoring in many Chinese systems that require operators to physically exit the trains to perform lookback procedures. Since such a train exit procedure is not a requirement for TTC, those particular inputs should be disregarded for this feasibility report. An average increase of approximately 1sec to 10secs was attributed to the larger departure delay after all doors are closed in the JTRB study. However, since the process of exiting the train and performing lookback procedures can be disregarded for the TTC-specific implementation, this 1sec to 10secs range could be reduced to only 1sec to 2secs in the JTRB study.

These JTRB study figures of 1sec to 2secs for slower door opening and closing times, 2secs to 3secs for slower passenger flow rates, and 1sec to 2secs for larger departure delay after all doors are closed combine for an estimated impact of 4secs to 7secs on the station dwell time. However, as noted above, the middle figure (passenger flow rates delay) can be disregarded because no concrete evidence of that estimate was provided in the study. As a result, the final anticipated range of values for potential dwell time impact on a system like TTC’s as supported by the data in the JTRB study is between 2secs to 4secs.

In summary, according to the JTRB study and the specifics of the TTC system, platform doors could be expected to have a net negative impact on train dwell time by 2secs to 4secs , although there are several ways to improve passenger flow and departure processes so that this potential dwell time impact can be minimized or even fully offset.

3.6.1.2 Safety Impact of PEDs

Foremost among considerations for PEDs is of course the impact on safety, as the barriers notably help prevent suicide attempts or other trackside intrusions such as passengers who stumble off the platform or are otherwise pushed. Every system that has implemented platform doors and published the results has noted a distinct decrease in suicide attempts, which approaches zero on platforms equipped with barrier doors. Full-height barriers (or “nearly” full-height barriers with an upper layer of mesh screen reaching the ceiling like the design envisioned for TTC) obviously generate the best results. This in turn prevents system-wide cascading delays if a platform is shut down due to an unfortunate injury or death on the trackside, which in turn helps keep day-to-day operations more consistent and helps train adhere to a more regular service schedule. This provides the largest overall net positive in terms of system operations, customer satisfaction, and safety.

It must also be mentioned that PEDs introduce an additional risk in regard to safety. A person might become caught in the closing doors, or a person could even potentially become trapped inside the small gap between the barrier and the train. Numerous safety measures are typically taken to mitigate these hazards and reduce them as much as possible.

For example:

- Door Recycle: A very common function of both platform and vehicle doors, electrical or pressure sensors detect an obstruction is slowing the closing of doors and responses by reopening them. This allows whatever obstruction, be it a person or object, to be cleared before the doors attempt to close again. In ATC systems, platform doors and vehicle doors often recycle together as a door set, allowing whatever might be within the gap between the barrier and vehicle to be cleared safely. The train can only begin to depart after all doors (both platform doors and vehicle doors) are closed and locked.
- Entrapment Protection: Almost all PED systems include entrapment protection. This concept consists of designs and methodologies intended to monitor the gap between the barrier and train in order to detect any reasonably sized obstruction. Sometimes entrapment protection even uses redundant systems to further ensure safety. ASCE21-13 requires no greater than 127mm of “unmonitored” area between the Automatic Sliding Door (ASD) and the vehicle, which ensures that obstructions would be detected, thus triggering vital signals to prevent the train from departing. Some suppliers even refine their entrapment protection tolerance down to 2mm. Entrapment protection solutions include but are not limited to:
    - Physical components of the automatic sliding doors that sweep the unprotected space to trigger an obstruction detection resulting in a door recycle. These are often “toe guards” or “L-brackets” mounted inside the automatic sliding doors.
    - Sensors to detect the presence of objects in unprotected space. Such sensor systems, if used, must meet a high safety and reliability rating.
    - Any PED element used for emergency egress should not be locked from the guideway / train side at any time.

A well designed and implemented PED system should easily provide a net positive impact to safety, and transitively to overall system operations.

3.6.1.3 Impact on Subway Maintenance Vehicles

The impact on subway maintenance vehicles (work cars) will ultimately depend on the specific product selected by TTC. The vendor/product may be able to accommodate work cars, but maintenance procedures would need to be altered if they cannot.

To help accommodate work cars and maintenance personnel, it is recommended the platform barrier ends follow the "bubble" design. In this design, the barrier is angled away from the trackside or is designed such that it flares out as it approaches the ends of the platform to provide a space for work cars to swing doors open or offload equipment. Unfortunately, larger equipment will likely be obstructed. Based on the experience of other transit authorities, it is recommended that these special cases be handled operationally. In other words, the emergency egress doors could be utilized as a pass-through for larger equipment during non-revenue shutdown hours (after the maintenance crew has obtained permission to ensure that it is safe to perform this operation).

3.6.1.4 Other Impacts of PEDs

PEDs have a variety of other potential impacts that may not be immediately noticeable like the impact to the dwell time and system safety.

Systems like TTC that utilize train operators have noted that the barriers allow for faster train speeds when entering a platform area. As the PEDs provide a vital assurance of trackside integrity, the transit authority can allow the ATC to permit higher train speeds while approaching platforms, and the operators can follow this trend. Although inconclusive, findings seem to indicate a positive impact on operation times of around 2secs.

As platform doors prevent people from falling onto the track, they also prevent objects or debris from being tossed on the trackside, as outlined in the TTC ConOps. This reduces the delays caused by removing/retrieving such objects and prevents fire hazards. Unfortunately, no conclusive data can be provided, but anecdotal evidence of course points to a net positive impact on operations.

Space along the platform may more safely be utilized by the passengers, right up to the barrier itself, without major cause for concern. This allows congested stations to offer more passenger room, and thus may slightly increase station capacity. However, as passengers are more likely to form an orderly queue on systems with PEDs, the net effect is arguable.

PEDs will also significantly benefit customers using mobility devices and customers with vision loss who will be able to travel easier along and feel safer on subway platforms, especially center subway platforms, without fear of inadvertently falling off.

There are of course additional downsides too, such as increased costs of operation and another potential point of failure. But these are discussed more in their own sections, as generally PED systems are highly reliable and offer positive impacts on operations.

3.6.2 Failure Management

The addition of the PEDs must be incorporated into TTC’s failure management plan or similar on a per station basis. When implementing a platform door system, a Preliminary Hazards Analysis (PHA) and a Risk Register should be created to identify potential risks and problems and the corresponding mitigation methods.

3.6.2.1 PED Equipment Failures

Routine maintenance should be performed by TTC maintenance personnel on any PED. The supplier should train TTC staff how to perform preventive maintenance in accordance with pre-established procedures to achieve the set reliability, availability, and maintainability (RAM) goal.

The PED should ideally also be of a service proven design. Given that the majority of platform door systems are integrated with ATC, this is not expected to be an issue as most major PED suppliers have worked with most major ATC suppliers like Alstom extensively in the past. In the case of deviation, TTC should review the special accommodations and determine whether to deem them acceptable prior to implementation.

3.6.2.2 Non-PED Equipment Failures

Since the PEDs should be synchronized with the vehicle doors, an onboard vehicle failure that results in the train doors remaining closed will also result in the PEDs remaining closed.

If a vehicle fails to properly alight at the platform, this will also prevent the PEDs from opening per typical industry standard designs.

If a failure occurs within the controlling CBI, then all affected PEDs should revert to a failsafe mode (i.e. a default unpowered mechanical setup that would not cause any risk to passengers or TTC personnel).

To protect against the case of the PED system becoming inoperable due to power loss, it is recommended that a UPS provides power to continue normal operations for the same duration that the CBI (or similar) UPS allows the train control system to continue its normal operations. If the PED UPS does not provide sufficient power to operate the door opening/closing, the PED should default to a Closed & Locked state.

3.6.3 Emergency Operation

3.6.3.1 Possible Emergency Situations

The following are considered possible emergencies that might impact the PED system:

- Fire in the station
- Fire onboard a train
- Medical emergency on a train
- Loss of power to the ATC System
- Loss of power to the PED System
- Person trapped on the trackside

3.6.3.2 Failsafe Mode

In the event of any emergency situation along the platform, the doors shall be required to default to a failsafe mode. In this failsafe mode, the doors shall be closed and locked. If the PED system itself has failed, then the failsafe mode must still include the closing and locking of the doors. The PED will not default to an open state in any circumstance, even in the event of a fire or a medical emergency aboard the train. If the PED is still responsive, it will open its doors when commanded. Otherwise, the PED gates can be manually opened from the trackside, or the EEDs can be used. In the event that a person is on the trackside and cannot manually open the EED or other doors, the PED will still remain Closed & Locked, and the refuge area can be used.

While it may be possible for TTC personnel to manually open failed PED doors and bypass the C&L circuit to continue operations with PEDs that are constantly in the "open" state, it is <u>highly</u> recommended that this practice be avoided. Instead, the normal operational procedure in the case of inoperable PEDs would be to force all trains to skip the affected platform. Since passengers who use a PED-equipped subway system daily will become conditioned to view open PED doors as a sign that it is safe to walk through the open doors to board a train, it is vitally important that the doors are only open when it is safe to walk through them. If a train is not present at the platform (or is quickly approaching a platform) while passengers walk through an open set of PEDs, injury or death could occur.

3.6.4 Door Misalignment and Train Stopping Accuracy

Directly related to the impact on operations is the stopping accuracy of the trains, and subsequently, how often the doors might be misaligned. The stopping accuracy is defined here as how consistently the trains stop exactly where they are supposed to along the platform according to the design parameters.

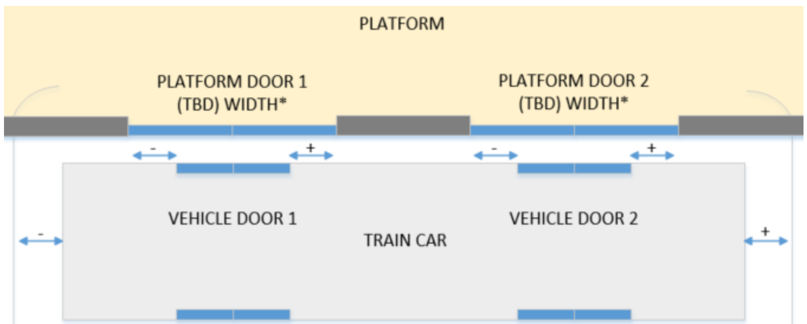


Figure 29: Train Alignment with PEDs

The platform doors are typically wider than the train doors in order to accommodate variance between train stops at the platform while still providing the same opening width that the vehicle doors would have provided without the addition of platform doors.

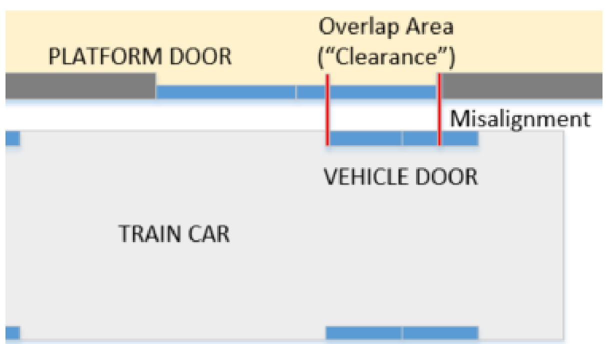


Figure 30: Acceptable Misalignment with Minimum Egress Width (Clearance)

According to the ATC information provided, the "correctly docked" icon for a Toronto Rocket train should have a stopping accuracy within ±150mm (assumed to be 99.9% of stops) for platforms with PEDs when using ATO mode. The Toronto Rocket door opening width has also been identified at 1525mm.

As noted in the Investigation Report, the ASCE21-13 standard mandates that a minimum clear opening width of 820mm must be provided when the doorsets are open to allow for passengers walking on and off of the train. This is calculated through application of the following formula:

$$\left(\left(\frac{Vehicle\ Door\ Width}{2}\right) + (Max\ Stopping\ Error) - (Vehicle\ Door\ Width - Min\ Opening)\right) \times 2$$

However, it is important to note that the high level of stopping accuracy achieved by the Toronto Rockets would result in a minimum opening width that is significantly smaller than industry standard sizes, which tend to range around 2040mm. In cases of very precise stopping accuracy such as the ±150mm required for TTC, it makes sense to set the Min Opening variable to the same value as the Vehicle Door Width variable. Then if a train were to misalign within the ±150mm stopping accuracy tolerance, passengers would still have plenty of room to walk through the doors. This simplifies the formula to:

$$\left(\left(\frac{Vehicle\ Door\ Width}{2}\right) + (Max\ Stopping\ Error)\right) \times 2$$

When inserting the corresponding values, the minimum required PED door width for a system with 1525mm vehicle door opening width and ±150mm ATC stopping accuracy to meet a minimum 1525mm opening is 1825mm. This minimum opening width is still slightly smaller than the industry standard size of 2040mm. The use of a wider platform door width (such as the industry-standard size) would allow for greater stopping accuracy tolerances, which would be beneficial if a train were to be operating in manual mode instead of ATO mode. The downside to increasing door size is that the weight of the doors would also be increased, thus slowing their opening speed and increasing the power needed to open them. But since 2040mm is typically the industry standard opening width and has been implemented in numerous other systems around the world, it should adequately accommodate the TTC PED needs.

In addition to ATO mode stopping accuracy, the accuracy for manually operated train station stops must also be considered because occasionally, trains will need to be run in manual mode (e.g. in the event of an ATC system failure). In order to determine the manual stopping accuracy required for industry standard PED door widths of 2040mm, the original formula can be applied and solved for a different variable

When inserting the corresponding values, the maximum manual stopping accuracy value allowed for a system with 1525mm vehicle door opening width, a minimum 820mm opening width, and an industry standard 2040mm PED door size is:

$$\left(\left(\frac{1525mm}{2}\right) + (Max\ Manual\ Stopping\ Error) - (1525mm - 820mm)\right) \times 2 \ = \ 2040mm$$

This equation can then be rearranged and solved, which results in a manual mode stopping accuracy of ±962mm. This margin allows for sufficiently large stopping accuracy for drivers operating trains in manual mode while still allowing for adequate door opening space for passengers to enter/exit the train.

As a result, the standard PED door opening width of 2040mm that is used in many PED installations around the world is shown to be sufficient for use on the TTC system. This door size would allow for a maximum stopping error of ±962mm for trains driven manually by train operators. A diagram of the resulting widths is shown below.

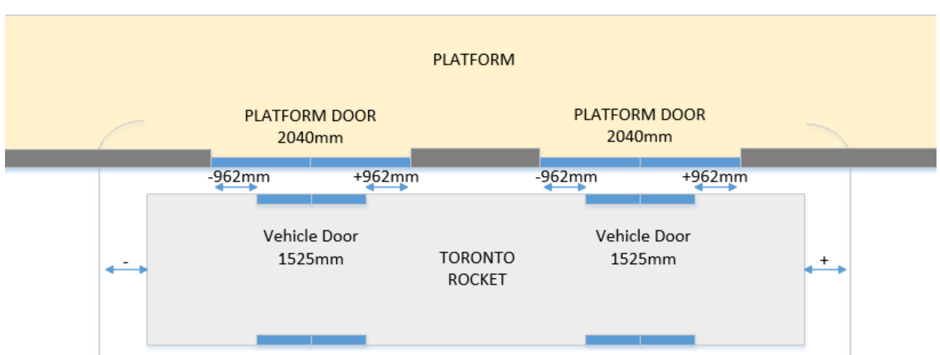


Figure 31: Finalized Representation of Door Size

3.7 Identification of Interfaces with the PED System

The PED system must consider all potential interfaces or possible concerns related to Fixed Facilities or other Station Equipment. The PEDs must be designed to interface directly with the train control system in order to send, at a minimum, vital information to the CBI. Another major point of interface for the PEDs involves the grounding of the PED structure at each station.

For this section, note that the TTC DM-0402-06 states a minimum 2500mm clearance between platform edge and station elements, yet as discovered during site surveys, some stations already do not adhere to this. The platform doors will further shorten this distance since they will extend into the platform area, which means either that exceptions must be made by TTC, or the stations must be redesigned to adhere to this minimum clearance requirement.

3.7.1 Fixed Facilities

3.7.1.1 Stairs and Handrails

Stairs and handrails should have no impact on the PED, with the exception of any metallic station elements that fall within 2500mm from the edge of the PED barrier. Depending on the PED structure grounding method selected by TTC or recommended by the PED supplier, it may be necessary to mitigate any touch potential between the barrier and handrails.

3.7.1.2 Ventilation

Ventilation concerns, particularly with the piston effect of oncoming/outgoing trains, were one of the major drivers for selecting barrier designs which do not fully isolate the platform and trackside. Instead, the PEDs proposed by TTC will have an upper mesh screen between the ceiling and door headers installed to keep the flow of air, particularly because TTC platforms are not power-ventilated. Otherwise, the PED system is not expected to need any kind of interface with ventilation.

3.7.1.3 Elevators and Escalators

Similar to ventilation, elevators and escalators should have no impact on the PED, with the exception of any metallic surface that falls within a 2500mm distance from the edge of the PED barrier. Depending on the PED structure grounding method selected by TTC or recommended by the PED supplier, it may be necessary to mitigate any touch potential between the barrier and the elevators/escalators.

3.7.2 Station Equipment

3.7.2.1 Passenger Information System

Typical ATC installations use displays and other visual and audio indicators to announce when the platform doors are opening/closing. However, the PEDs themselves can be installed with these indicators incorporated into the design. The impact of the PEDs on the train-based audible and visual external route announcement system will largely depend on the final design of the barrier itself; however, at this stage, it is assumed that visual displays will still be visible from behind the glass EEDs. The audio announcements will likely be distorted, so it is recommended that the PED barrier itself incorporate audio announcements in addition to "standard" visual/audio indications.

This method has been used by other transit systems to handle similar problems in the past. An alternative solution would be to modify the PA systems depending on its capacity / interconnections with the ATC system.

3.7.2.2 Fire Detection and Alarms

The PED is not expected to have any interface with the Fire Detection and Alarm system. Although it is an additional station element, the PED itself will have no direct impact on fire detection.

3.7.2.3 Fire Suppression

The PED is not expected to have any interface with the Fire Suppression system. Although it is an additional station element, the PED itself will have no direct impact on fire suppression.

3.7.2.4 Closed-Circuit Television (CCTV)

Platform barrier walls will obstruct the ability for operators to look out their cab windows and check the platform area. To aid train operators in ensuring the platform doors are cleared of people or other obstructions, the TTC ConOps requires that the PED façades have cameras installed with a field of view aimed along the barrier. This field of view should provide similar visuals to what an operator currently sees when looking back, and although it would be preferable to have cameras positioned around each automatic sliding door and angled to view adjacent areas. Screens which display this camera feed could then be installed next to the train cab window height at the stopping positions along the platform, allowing the operator to verify the barrier is cleared before departing. It is assumed these cameras may then be connected to TTC's CCTV network for video logging and remote viewing.

As an alternative, mirrors installed at either end of the platform might be a simpler solution more readily accepted by PED suppliers (which generally avoid "CCTV Lookback" systems) but the field of view would not be as clear for the operators. Combined with entrapment protection systems, such as "L" brackets that sweep the closing area and/or optic sensors to detect intrusions between the train and barrier, operators can have a high degree of confidence the area is safe before departing.

3.7.2.5 Uninterruptible Power Supply (UPS)

Since the existing UPS system is not designed for the additional load of a new subsystem like the PEDs, the PED design and implementation project will need to include provisions for installing new UPS hardware to handle the PEDs.

It is recommended that the complete PED system is powered by a UPS that provides enough backup power to allow the PEDs to operate for the same duration as the train control equipment on the CBI UPS. If this not possible, at a minimum, a UPS should be provided to power the PED control and monitoring functions and not open/close the doors. Without UPS power to operate the doors, the PED would need to be manually opened by the procedure.

3.7.3 PED Signals to ATC

A fully integrated PED system with ATC would require:

- Vital signals
    - Door Closed & Locked (C&L)

- Door Enable (Enable)
- Non-vital signals
    - Door Open Command (Open)
    - Door Close Command (Close)
    - Door Status
    - Remote Door Commands

These are each discussed in more detail below. For the actual interface with the connections to the ATC system, refer to Section 1.22.

3.7.3.1 Vital PED Signals

Closed & Locked (C&L): Vital signal transmitted by the PED controller. Inside the PED system, this signal typically travels through safety relay contacts with the PED controller. The coil is pulled by a completed circuit throughout the façade connecting through each platform door. In the event that the doors are opened, the relay will drop and the zone controller (through the CBI interface) will lose the signal, indicating it is not safe for trains to depart or enter the platform. Until that circuit is completed (or bypassed within the LCP or door header) the zone controller will not allow train movements through the platform.

Door Enable (Enable): Since opening the doors compromises the façade integrity and can introduce a hazard if a train is not present, the opening of the PED doors is considered to be a vital function. The Door Enable signal is generated from the SMIO which prepares the appropriate platform doors corresponding to vehicle doors for the Door Open signal from the non-vital system, ensuring they are only allowed to open so long as the SMIO confirms the signal.

3.7.3.2 Non-Vital PED Signals

Door Open Command (Open): Once the ATP confirms the train is properly berthed and the doors are aligned, and the vital Door Enable signal is received by the PED controller, and then both the vehicle and platform doors can be commanded open synchronously by initiating the Door Open Command. There is usually a delay in the opening of the larger, heavier platform doors, but this can be mitigated through programmed delays in the vehicle door opening (as discussed in other sections of this report).

Door Close Command (Close): After the dwell timer has expired, the train operator receives the “door close” icon on their ATOD which allows them to command the vehicle doors to close. This action initiates the Door Close Command. Modifications will need to be made on both the ATC and the CBI / zone controller to ensure that the same Door Close Command is sent in parallel to the PED controller. As with Door Open Command above, the vehicle doors will need to have a programmed delay to synchronize with the platform doors, particularly because unlike most other ATC systems the train operator is commanding the doors closed (they are not automatically closed by the ATC after the dwell time).

Door Status Indications: Status indications from the PED controller should be routed back to SCADA to remotely monitor their operation, especially any high priority alarms which might indicated safety concerns (note: such alarms do not prevent the ZC from performing safe operations, but rather just act as indicators at SCADA to help resolve the issue). The industry standard is to typically include the following status indications:

- Door(s) Open / Close: These signals identify which doors are currently opened or closed (on each platform). This assumes normal operation merely meant to relay status back to SCADA.

- LCP Command Request: During maintenance or during degraded operations, a LCP shall request command of the local barrier doors from central before taking command (rather than taking control immediately).
- Door Bypass: Whenever a door is bypassed either in the door header or via the LCP, an alarm should be generated to Central.
- Door Malfunction: Any event in which the barrier doors are compromised must send an alarm to Central. Preferably, this should also be sent to the System Diagnostic and Maintenance (SDM) as well. This status/alarm information can either be applied generally per platform or parsed out into specific alarms (i.e., “ASD#1 Failed to Open”, “EED#1 Opened”, etc.). In the latter case, this helps immensely with troubleshooting, but of course is slightly more complex and time consuming to implement.

Remote Door Commands: The same Ethernet connection which sends PED controller status and alarms back to Central can also be used for bilateral communication, which allows Central to remotely command the platform doors. The industry standard is to typically include the following commands:

- Selective Door Opening (SDO): This allows Central Control Operators to open and subsequently close one or more doors in any platform barrier simultaneously. As required by the TTC ConOps, if a train is currently berthed at a platform, Central would have the ability to command open associated PED doors along with their associated vehicle doors.

3.8 Proposed Location of New PED Control Equipment and Connections to Existing Systems

3.8.1 Location of New Control Equipment

In most systems that utilize PEDs, each station will have a freestanding PED controller cabinet that is located in each station equipment room, which commands the local platform barriers. However, it has been noted by TTC that many of the equipment rooms in the SS and even some of the SERs do not have the spare space available to accommodate additional equipment cabinets. This should be analyzed on a case-by-case basis during the design project, but as an alternative, the Emergency Response Rooms (which TTC has determined will be rendered redundant after the installation of PEDs) are proposed as reasonable locations to install the PED controller cabinets. Two other alternative locations have also been proposed but are not generally recommended unless no other course is viable.

First, previous studies have indicated it is possible to install the PED control equipment (such as the controller cabinet) on the end of the platform itself within a restricted area created by the barrier (i.e. a platform end door “bubble”). This is not advisable due to two primary considerations:

1) The environment of a platform area is very different from the more controlled environment of an equipment room or isolated room like the ERR. This means the cabinet enclosure will need to contend with a far greater degree of dust and water (minimum rating of IP66 or IP67 / NEMA4 or NEMA6) while the internal components will need to be rated for a much higher temperature tolerance. This would also include a greater degree of shock and vibration due to proximity to train movement.
2) This conflicts with the purpose and most likely location of the LCPs. The purpose of the LCPs is to provide a controller mechanism for maintenance and station personnel to command the barrier doors “within line-of-sight”; their existence as part of the system renders installing the PED controller on the platform obstructing in already limited platform space.

Second, centralized location of the PED controller using distributed I/O to command barriers in remote stations (i.e., install one controller in the SER to command associated SS platform barriers remotely). This is more feasible than the platform option discussed above and can be undertaken, however it also presents two issues to consider:

1) This is not a standard approach for the industry. As such, most supplier products do not include enough hardware within a cabinet to command so many platform doors. Most solutions typically

design their cabinets to command two to four platforms from a single controller, but TTC Line 1 has several stations between Davisville and King where a single SER "centralized" PED controller could be commanding as many as eight platforms between the local SER platforms and up to three SS platforms.

2) This approach is generally not advisable from a troubleshooting perspective. For example: in the event of a lost signal traced back to the controller cabinet the maintenance crew would need to travel and coordinate between stations to repair the problem.

While the two options above are workable designs meant to present the considerations that would need to be undertaken when coordinating with a PED supplier, they are not recommended. Rather, the initial consideration of one PED controller cabinet per station, preferably in the Emergency Response Room, is the recommended approach.

In any event, it is unlikely the UPS has been sized for the addition of PEDs, therefore additional UPS should either be installed as part of the existing bank, or a separate UPS dedicated to the PED installed in the ERR (as discussed in another section of this report). In the latter case, the ERRs will likely require extensive ventilation and fire suppression modifications to implement the new UPS, if the rooms are not already compliant.

3.8.2 Connections to Existing Equipment

Next to civil retrofitting of the platforms, one of the greatest challenges of implementing a brownfield PED is interfacing the PED with the ATC. There are many approaches that can be taken depending on the extent to which TTC desires to integrate the PED with the ATC architecture, but the working assumptions for this section are:

- PEDs shall only be installed in stations that have already been upgraded to ATC
- The PED system will be fully integrated with the ATC
- Platforms outfitted with PEDs shall only be serviced by Toronto Rocket trains (As per the TTC ConOps)

Continuing under these parameters, the specific interfaces described within this section apply directly to the Alstom ATC solution provided on Line 1. There are various other PED solutions with their own implementation requirements that could be rolled out in other stations across TTC, but these are discussed elsewhere in the document. It has been understood for this report that the Business Case would exclude installation of PEDs in stations not equipped with this ATC or servicing trains other than Toronto Rockets, therefore these other methods are presented for consideration by TTC but not discussed in detail.

Furthermore, it will be assumed that one PED controller cabinet will be installed per station in the ERR alongside a dedicated UPS – the actual interface is almost identical no matter where in the station the cabinet is installed, be it the utility room, ERR, or even platform. The centralized PED controller architecture will also be presented in a more limited capacity, but even so much of the functionality remains the same.

3.8.2.1 Carborne Connections

Fortunately, TTC's Toronto Rockets readily accommodate the addition of PEDs through their existing interfaces. The "train spotted" icons provide excellent referencing information for properly aligning the train doors with the platform, making coordination between the train operator and platform doors much less of an issue than on other brownfield PED systems.

Icon	Description	Meaning
	Train with green arrow	Correctly docked
	Train with red arrow	Overshoot
	Train with yellow arrow	Undershoot

Figure 32: Train Spotted Icons – ATC Subway Vehicle Operation – Resource Book: A3-6

Icon	Description	Meaning
	Yellow arrow	Train proceed—this command will appear only once the station has been serviced and the doors are closed
	Yellow open doors icon	A command to open doors—this command will appear only once the train is correctly docked
	Yellow close doors icon	A command to close doors—this command will appear only once the dwell time is up

Figure 33: Departure Command Icons – ATC Subway Vehicle Operation – Resource Book: A3-6

In ATO mode, the Toronto Rockets stop accurately at the platform and open their doors automatically. After the dwell timer has expired, the train operator commands the doors closed manually (after checking that the vehicle doors are cleared of people or other obstructions). The addition of PEDs require that they also be commanded closed by the train operators. The ATC radio communication between the train and wayside can pass this “doors commanded close” signal off to the wayside equipment (this process is discussed more below). This would require a software modification to be rolled out on every Toronto Rocket operating in the system to send this information to the wayside. Additionally, the platform doors close at a slower rate than the vehicle doors, which combined with a delayed command signal from the train could mean the vehicle doors close much quicker than the platform doors. As a result, a delay in the vehicle door closing could be configured to help synchronize with the platform door closing.

No further hardware or software modifications would be expected on the Toronto Rockets when implementing PEDs. It is possible to add additional icon(s) to the ATOD to display the status of the PEDs directly to the operators, but this is not recommended since practical alternatives exist that would be much less intrusive.

3.8.2.2 Wayside Connections

An ATC system typically operates by constant radio communication and the use of “moving blocks” which represent the train’s position in real-time, adjusted for positioning error by using odometers and small wayside beacons along the track read by a train antenna. This removes the need for “fixed blocks” and difficult to maintain wayside equipment such as track circuits. For station stops, this also means that trains can stop much more accurately than in other system designs.

The addition of fully integrated PEDs with TTC’s ATC system will take time, effort, and careful consideration. However, this will be notably easier than other brownfield projects which are not equipped with ATC. While typical brownfield challenges will be discussed, most ATC systems (such as Alstom’s) readily support the addition of platform doors, minimizing the impact on existing architecture or future cutover strategies.

Foremost, consideration needs to be given on how these connections between the ATC and the PED will be made. TTC’s ATC architecture is “distributed”, that is to say there are main stations that act as controller hubs (SERs), and “satellite” stations with less equipment that are “slaved” to these SERs (SSs). Wayside equipment is controlled by a centralized Computer-based Interlocking (CBI) with distributed Smart I/O (SMIO) racks within each SER to command and status the various wayside equipment. Note: this is not inherently always the case, as some SS appear to have SMIOs installed (such as St. Clair and College stations). These SMIO racks use vital input and output boards to manage these signals, connected to a “vital interface relay rack” that isolates the SMIO from power supplied to wayside equipment such as 110VAC to power switch machines. This vital interface relay rack is then in turn connected to “entrance racks” before being wired out to field equipment.

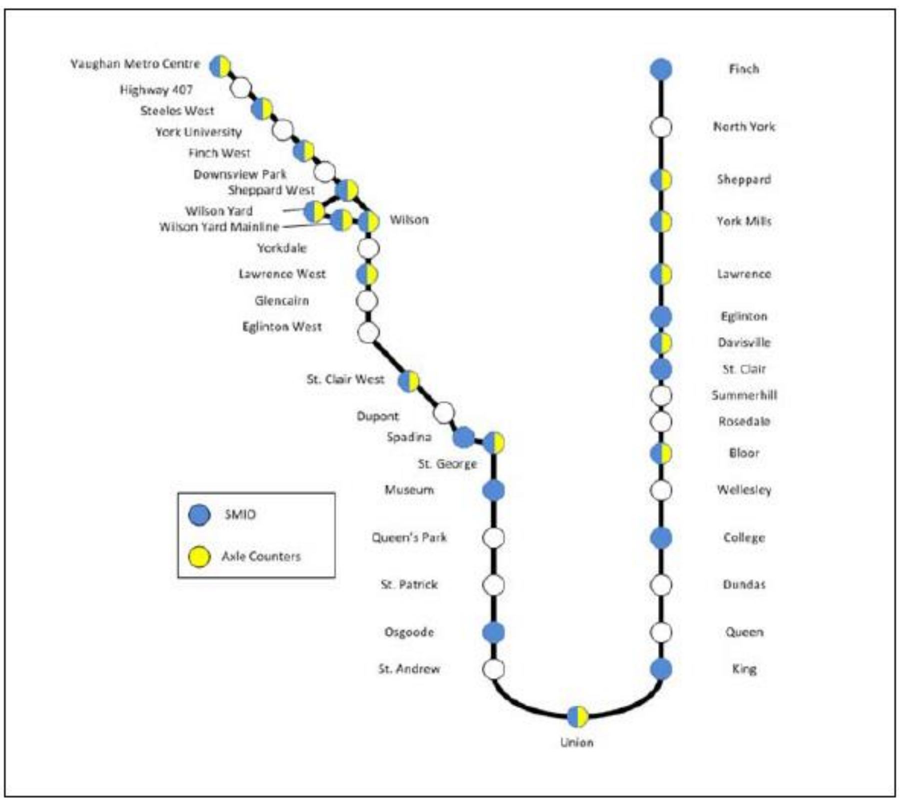


Figure 34: SMIO and ACS Layout – ATC System Overview Manual: B5-2

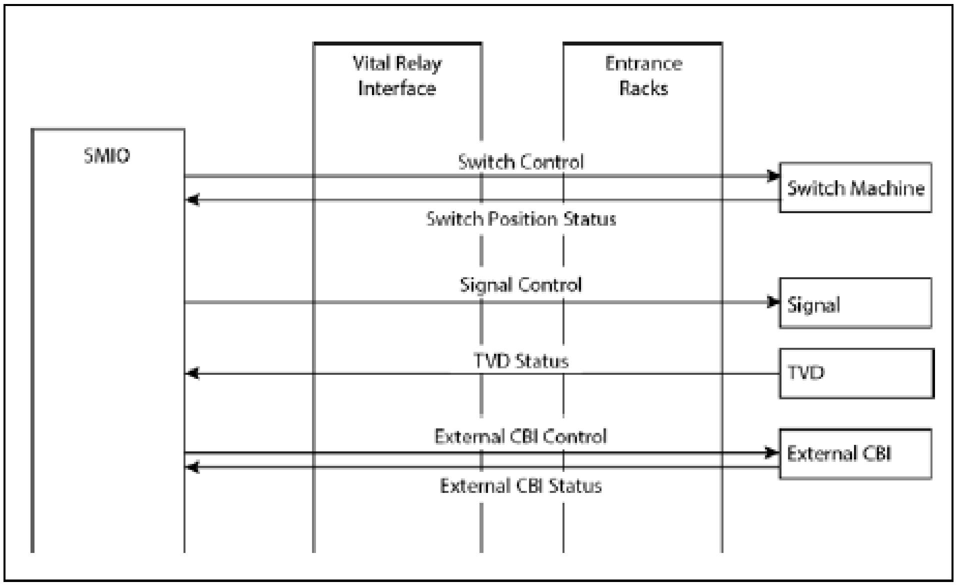


Figure 35: SMIO to Wayside Equipment Interface – ATC System Overview Manual: B5-2

Using this established convention, the addition of PEDs would necessitate the SMIO racks to be expanded with additional vital I/O boards to interface with the PED controller. Otherwise, if no spare slots are available, a new SMIO will need to be added. As there will be one PED controller in each station, and not every station has a SER/SMIO, some interface across the Data Communication System (DCS) will be required. The controlling SMIO will also need to contain enough boards to account for multiple station platforms. These signals would need to be fed back to the Central Logic Controller (CLC) within the CBI system. All of this necessitates that TTC survey the DCS to ensure it can accommodate these additional signals (i.e. verify if the Ethernet Switches have spare ports available). Theoretically, as this vital communication is handled over redundant Ethernet switches, the bulk of the work in this regard would be within the software and communication protocols, both in the CBI and the DCS. Note that this is typically handled using discrete I/O, although the TTC-specific alternative is viable as well.

Non-vital signals such as the “Open” and “Close” commands to the PED controller (issued separately from the vital Enable command for synchronization with the vehicle doors) will need to be interfaced with the Logical Elaboration Assembly (LEA) within the CBI. These signals will likewise be connected over DCS.

3.8.2.3 Alternative Solution with Migration Strategy

ATC is not implicitly required to implement a PED system. In fact, many systems across the world operate platform doors without ATC. While this comes with its own challenges, other transit authorities have rolled out platform doors ahead of ATC upgrades. While some PED controllers are operated using older ATC systems, others operate entirely independently and hence require little to no ATC integration.

Some systems, notably several lines on the Paris metro and São Paulo, implemented “self-contained” or “autonomous” PED controller systems that operate independently of ATC. While this results in the loss of vital information such as the C&L indication or Door Enable, it does allow those systems to benefit from the safety features of a platform barrier sooner. Then, as ATC is rolled out, those PED controllers are cut over and fully integrated with the ATC, thus operating as a subsystem of the ATC per industry norms.

Using the list of suppliers and some of the solutions highlighted earlier in the report, this is an option TTC can explore on stations not equipped with ATC. Many of these “autonomous” systems still show a high degree of reliability. It would allow TTC to implement platform barriers in other stations with high passenger density that might otherwise have not been available, such as stations along Line 2 or Line 4.

However, this approach is only recommended if there are several stations where it would be a priority to implement platform barriers without ATC. The design of an “autonomous” system is different from an ATC-controlled PED controller, and in addition to the other risks inherent with platform doors without vital signals such as the C&L, a person could be trapped trackside with no way for the ATP to be informed of the possible danger.

Limited interfacing to older fixed-block systems is also possible (particularly for vital information), but this would depend on the availability in older systems and the desire for TTC to design an interface they plan to render obsolete and will need to cut over as ATC is rolled out. This would largely depend on how long the “semi-autonomous” PED controller would remain in operation before upgrading that station.

3.9 Resources to Operate and Maintain the PED System

Once PEDs have been installed and commissioned in the TTC system, it will be imperative for the system to be properly maintained to ensure correct and reliable operation. Since the PEDs will require several new maintenance activities at each station in which they are installed, TTC will likely need to expand their existing maintenance capabilities through the hiring of additional staff.

The exact staffing needs will be dependent on the current TTC workforce (at the time PED commissioning), the number of stations in which PEDs are installed, and the manufacturer recommended maintenance items of the product that TTC ultimately selects. While the specific maintenance items and prescribed maintenance schedule for a PED product will be recommended by the selected PED supplier and defined during the actual PED design project, the consulting team has compiled a list of several items that should be considered so TTC knows what to expect in terms of PED maintenance.

Item	Description	Recommended Schedule	Procedure
1	Make sure that all doors are fully closed and locked.	Weekly	Visual and manual check. Perform full close and recycle of doors to check that C&L signal is being received by ATC.
2	Make sure that the glass is clean and unbroken.	Weekly	Visual check and cleaning.
3	Make sure that wiring is properly connected and secured from sharp edges and moving parts.	Monthly	Visual and manual check. Manually move wiring to clear sharp edges and moving parts.
4	Make sure that all fasteners are present and tight.	Monthly	Visual and manual check. Re-tighten any loose fasteners.
5	Make sure that the platform area is free of debris.	Monthly	Visual check. Regularly clean the platform area.
6	Inspect and clean load wheels and bottom guide track.	Monthly	Visual check and cleaning.
7	Inspect and clean interior and exterior of fixed panel.	Monthly	Visual check and cleaning.
8	Inspect and adjust PED bottom clearance.	Trimonthly	Visual and manual check.
9	Inspect and adjust drive belt tension.	Yearly	Visual and manual check.
10	Inspect, adjust, and lubricate solenoid lock assembly.	Trimonthly	Visual check, manual check, and cleaning.
11	Inspect, adjust, and lubricate PED manual release linkage.	Trimonthly	Visual check, manual check, and cleaning.
12	Inspect and clean PED manual release handle.	Trimonthly	Visual check and cleaning.
13	Manually test PED release handle fully opens and closes the door(s).	Monthly	Visual and manual check.
14	Inspect and adjust EED bottom clearance.	Yearly	Visual and manual check.
15	Inspect and adjust EED upper pivot.	Yearly	Visual and manual check.
16	Inspect and adjust EED latch/crashbar.	Yearly	Visual and manual check.

Item	Description	Recommended Schedule	Procedure
17	Inspect and adjust EED Closed & Locked monitor switches.	Yearly	Visual and manual check.
18	Check unlocking and opening force is equal to or less than 35lbs.	Monthly	Measurement.
19	Check key locking function is working properly.	Monthly	Manual check.
20	Check locking zone is equal to or less than 0.25".	Monthly	Measurement.
21	Check that there is no gap greater than 1".	Monthly	Measurement.
22	Check keyswitch manual open function is working properly.	Trimonthly	Manual check.
23	Check keyswitch cutout function is working properly.	Trimonthly	Manual check.
24	Check that door opening time is less than 4secs.	Trimonthly	Measurement.
25	Check that door closing time is less than 6secs.	Monthly	Measurement.
26	Check that the closing force of doors is equal to or less than 30lbs.	Monthly	Measurement.
27	Check that obstruction detection/door recycle detects 1" obstruction.	Monthly	Measurement.
28	Check that EED manually opens with a force equal to or less than 35lbs.	Monthly	Measurement.
29	Check sensors detect train alignment equal to or less than 36".	Monthly	Measurement and check logs at PED Controller terminal.
30	Check sensor detect train door opening.	Monthly	Visual check and check logs at PED Controller terminal.
31	Check sensor detects train door being forced open and recycles platform door.	Monthly	Visual check and check logs at PED Controller terminal.
32	Check sensor detects train door closing.	Monthly	Visual check and check logs at PED Controller terminal.
33	Check that when Closed & Locked signal is lost a zero speed is applied on the platform within 2sec.	Monthly	Measurement and check logs at PED Controller terminal.
34	Check that the dielectric PED covering provides sufficient insulation against shock hazards at each platform.	Monthly	Measurement.

*Note that the items highlighted in yellow in the table above provide some typical measurement values for information and discussion purposes only. The actual specific values associated with these items will need to be defined during the actual PED design and implementation project.

4. PED Impact on Fire Ventilation System

4.1 PED Impact on Fire Ventilation System

4.1.1 Introduction

Jensen Hughes (JH) is tasked with analyzing the impact on the station fire ventilation system with the installation of PED for the Toronto Transport Commission (TTC) underground and enclosed stations. The potential impact of PED on the performance of the fire ventilation system in the current analysis is deduced from an earlier study of PED impact on the fire ventilation system performed for the Wellesley Station in 2011[1].

4.1.2 Objective

The objective of the current study is towards evaluating the impact of installation of PED at the existing underground and enclosed TTC stations on the station fire ventilation system based on the previous 2011 study on PED impact on the SVS for the Wellesley station.

4.1.3 Summary of the CFD Analysis Conducted in 2011

4.1.3.1 PED and Station Configuration

The impact of PED on fire ventilation systems was previously studied in 2011 for a specific underground station: Wellesley Station, with conclusions extended to stations of similar configuration (side platform underground stations). The 2011 analysis evaluated two full-height, partially segregated PED configurations:

- PED Option 1: Open to the trackway above the PED header
- PED Option 2: Louver above the PED header with 50% effective open area

It is understood that PED Option 2 is TTC's preferred option.

The 2011 study incorporates <u>proposed</u> ventilation measures, with assumed fan flow rates taken from recommendations from previous studies, assumptions regarding implementation of fans in existing end-of-station vent shafts, an all-exhaust 'pull-pull' fire ventilation strategy for the station, and an assumption that exits doors for the station were open to street level to provide makeup air pathways. The PED study for the Wellesley Station considered north and south exit paths as egress paths from the platform level to the concourse level with the North entrance being still in the planning stage at the time of this PED study.

To confirm that the 2011 study parameters will remain applicable, the validity of all the above assumptions will require additional analysis at design stage.

4.1.3.2 Station Air Flow Characteristics

PED impact study results indicate a minimal change in station airflow characteristics with the PED configurations that were examined. In conjunction with the CFD results demonstrating improved conditions along the station

[1] *Fire Ventilation Upgrade Project: CFD Fire Simulations – Wellesley Station Platform Edge Doors (PEDs) study, 96106-18,., March 2011*

egress paths, the evaluation supports the conclusions that PED installation will not have a detrimental impact on fire ventilation performance at Wellesley Station for the ventilation parameters and assumptions that have been incorporated. The applicability of these conclusions to other stations will directly depend on if the station configuration and ventilation strategy/measures are sufficiently similar to the condition evaluated in the 2011 study.

The 2011 study quantifies the change in airflow through key locations in the station resulting from the implementation of the PED for two different operational modes; operation of Wellesley Station fan plants in isolation, and operational of Wellesley Station fan plants in conjunction with fan plants at adjacent stations. The simulations demonstrated a change at the station entrances of less than 1% in average flow rate [Table 1] for PED option 1, compared to no PED option and an average flow rate change of less than 3% for PED option 2 [Table 2] for the two operating conditions. These results indicate a minimal change in the station airflow characteristics with the PED installed. Changes in the air flow leaving the platform into the trainway was not discussed thoroughly in the previous report.

Table 1: Airflow rates at the station entrances evaluated for PED option 1 for one of the fan modes

Exit Component	Average Flow Rate (m^3/s) (into model)		Percent Change
	No PEDs	PED Option 1 (open space above header)	
South Openings to Street			
Concourse Door 1	4.44	4.38	-1.44%
Concourse Door 2	5.83	5.74	-1.51%
Concourse Door 3	4.46	4.40	-1.35%
Concourse Door 4	4.70	4.66	-0.83%
Concourse Door 5	6.18	6.14	-0.66%
Concourse Door 6	6.18	6.11	-1.09%
Concourse Door 7	5.94	5.91	-0.49%
Concourse Door 8	6.09	6.07	-0.39%
Concourse Door 9	5.97	5.95	-0.44%
North Openings to Street			
Regular Exit	9.53	9.50	-0.27%
Emergency Exit	10.92	10.88	-0.32%
Average			-0.80%

Table 2: Airflow rates at the station entrances evaluated for PED option 2 for one of the fan modes

Exit Component	Average Flow Rate (m^3/s) (into model)		Percent Change
	No PEDs	PED Option 2 (50% open louver in space above header)	
South Openings to Street			
Concourse Door 1	4.44	4.28	-3.76%
Concourse Door 2	5.83	5.60	-3.93%
Concourse Door 3	4.46	4.31	-3.28%
Concourse Door 4	4.70	4.57	-2.68%
Concourse Door 5	6.18	6.04	-2.31%
Concourse Door 6	6.18	5.96	-3.56%
Concourse Door 7	5.94	5.80	-2.39%
Concourse Door 8	6.09	5.96	-2.22%
Concourse Door 9	5.97	5.84	-2.24%
North Openings to Street			
Regular Exit	9.53	9.37	-1.67%
Emergency Exit	10.92	10.73	-1.70%
Average			-2.70%

4.1.3.3 Station SVS Performance

The conclusion of the 2011 study was that both PED configurations are viable as the performance of the SVS for the proposed Wellesley Station fire ventilation mode was demonstrated to not be adversely affected by the PED assemblies. More specifically, the CFD results demonstrate conditions along the station north and south egress paths were improved with the incorporation of PED for the simulations that were conducted. Simulations results presented in the report shows significant improvement in tenability for the non-incident platform while the improvements in tenability for the incident platform are marginal. Figure 36 and Figure 37 show example results from the report visualizing the effects of PED on temperature and visibility (red contours indicate acceptance limit criteria for temperature and visibility), respectively.

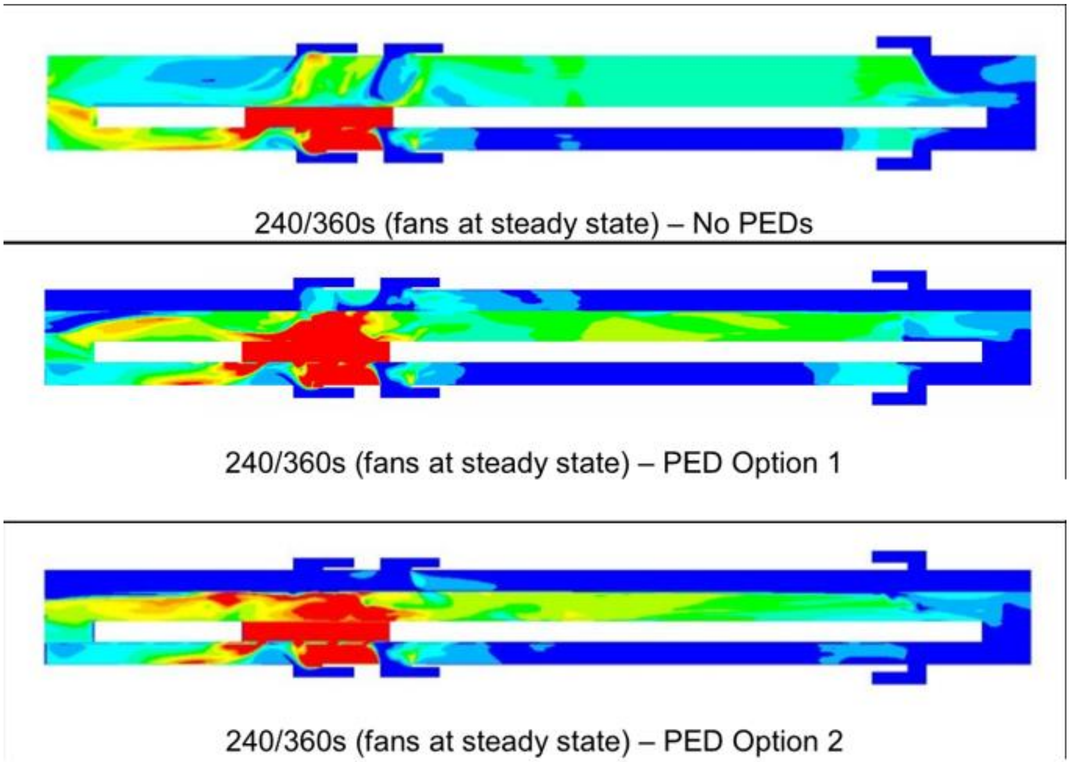


Figure 36: Temperature contours at platform section comparing the PED effectiveness

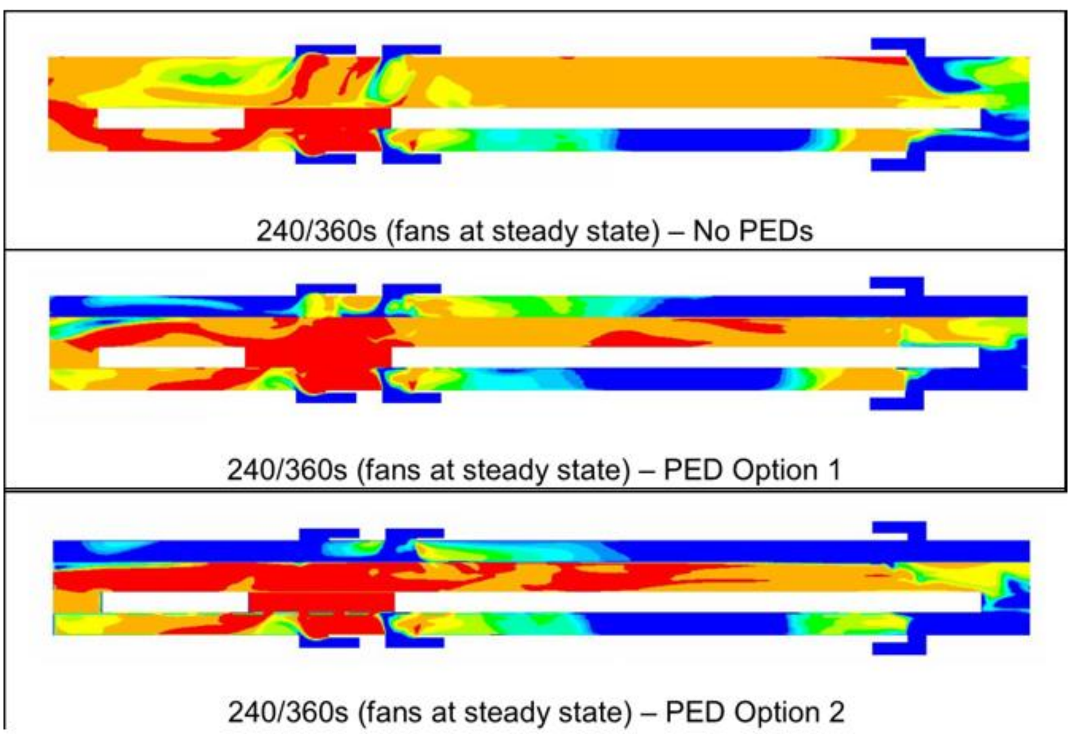


Figure 37: Visibility contours at platform section comparing the PED effectiveness

4.1.3.4 PED Header Clearance

The PED configurations that were analyzed incorporate a gap above the PED header of approximately 0.5 m, based upon the information included in the study [Figure 38].

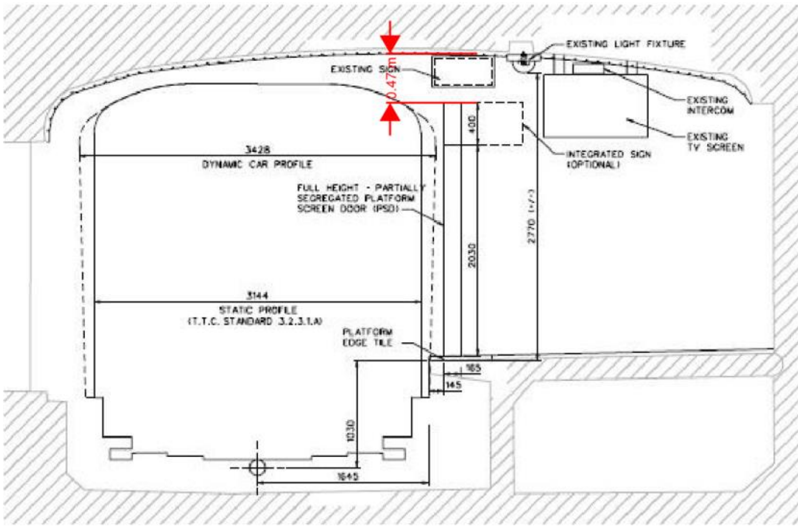


Figure 38: Section from the 2011 Study indicating PED configuration

For side platform underground stations with sufficiently similar available space above the PED header for airflow, similar conclusions as to those from the 2011 study would be expected to be valid provided the fire ventilation approach and parameters are the same. Based on site investigations of the Line 1 stations, this would be expected to apply to King, Queen, Dundas, College, Wellesley, Bloor-Yonge, Summerhill, St. Clair, Spadina, Dupont, and St. Clair West Stations. Where aspects of the station configuration differ, further evaluation is warranted. For example, North York Centre Station and Union Station feature lower ceiling heights over the platform. Additionally, Union Station incorporates signage along the length of the platform that would be in a position to obstruct airflow above the PED header [Figure 39]. These differences in configuration in Union Station compared to Wellesley Station that was evaluated in the 2011 study would be expected to detrimentally impact the performance of the station fire ventilation response as the open area above the PED would be negatively impacted, which would require further detailed evaluation to quantify.

Figure 39: Lower platform ceiling height and increased obstruction by signage at Union (left) compared with Wellesley (right)

In addition to evaluating the relative impact of installing PED in a direct comparison with simulations without PED, the study also provided recommendations relative to improving Wellesley station performance for aspects that are irrespective to the PED retrofit. These improvements include:

- Wider design for the second (south) exit for Wellesley Station
- Possibility of incorporating a third exit
- Potential incorporation of an over-track exhaust system
- Installation of smoke screen baffles at the platform exit stairs
- Enhanced visual guides at intervals of less than 5 m
- Installation of additional low-level lighting, exit signs, and egress path markings
- Assessment of survivability in the predicted conditions at platform level

Further information is needed regarding these recommendations that extend beyond PED implications, and any changes that may have subsequently been incorporated into the planned Fire Ventilation Upgrade project

4.1.4 SVS considerations for PED Installation

The potential impact that PED could have upon the performance of a fire ventilation system will depend upon several factors, such as:

- Extent of segregation between the trackway and the platform of the PED design (space above the PED system to the ceiling)
- The station configuration (side platform or center platform),
- The station ventilation strategy/operational mode (all exhaust or push-pull)

SVS are typically used in response to both station train fire scenarios and for fire scenarios within the tunnels. As such, the impact of PED on SVS performance should be evaluated relative to:

1. Station emergency ventilation response (train fire at the platform)
2. Tunnel emergency ventilation response (train fire within the running tunnels)

The extent to which the PED forms a physical barrier to airflow between the platform and the trackway is a critical aspect of the PED implementation and the impact on the SVS response. Fully segregated PED have become more commonly used in hot climates, where platform air is conditioned/tempered for occupant comfort. With fully segregated PED the fire ventilation needs for the stations/tunnels could be substantially impacted, as the platform areas would be separated from the exhaust/supply locations at ventilation shafts within the trackway and would require substantial changes to the ventilation response strategy in order to effectively exhaust smoke from platform areas. One possible approach would be to install active smoke dampers above the PED that would automatically open during a platform fire scenario. In contrast, fully segregated PED on SVS response for tunnel fire scenarios would be expected to be beneficial, as more airflow will be generated within the incident tunnel segment if station air flow paths are obstructed.

Partially segregated PED (full-height assemblies that provide an open area above the PED header), and half-height PED configurations provide an open area between the platform and the trackway that allows for SVS equipment within shafts serving the trackway to generate airflow through the stations via entrance doors or other openings at grade. These configurations will have lesser impact on the SVS performance for station train fire scenarios when compared to fully segregated PED assemblies, provided sufficient open area is incorporated above the door system. Partially segregated PED would be expected to result in limited impact on tunnel emergency ventilation response relative to the existing condition with no PED installed. The study shows that the air flow rate changes for partially segregated PED installation with open PED header was about 1% lower than no PED configuration and the difference was 3% for the partially segregated PED installation with 50% porous PED header.

PED impact on the SVS in the previous study only considered the impact of PED for one specific type of station configuration (side platform with station running in all exhaust mode with a PED header height of 0.5m). As such, the impact of PED installation in underground stations warrant further evaluation to a wider variety of other considerations which include:

- PED height and interface with the platform ceilings and fixtures
- Extent of enclosure above the PED
- PED effectiveness for other station geometries which include:
    - Side platform stations with low ceilings
    - Center platform stations
- Tunnel ventilation strategy when it is significantly different from the ventilation strategy considered for the Wellesley Station

5. Assessment of PEDs Impact on Noise and Air Quality

5.1 Assessment of PEDs Impact on Noise

The implementation of PEDs has various effects on a station platform related to sound since the acoustic characteristics of the space are altered. Specifically, the overall room volume proportions and surface finishes would change causing the acoustic room response to be altered. Examples of the potential impact of PEDs safety considerations, include the effect on public address systems or the level of protection from noise induced hearing loss for transit users and workers. The extent of changes to the room response due to the introduction of PEDs when compared to standard platform areas with none depend on a number of variables such as:

- Side platform vs Island Platform Orientations
- Existing or planned acoustic finishes (e.g., acoustic absorption in ceilings or walls)
- Overall platform area dimensions and specific locations of interest
- PED material construction detail
- Type of trains and their associated operating parameters

A review of the potential effects on the acoustic environment due to implementing either full height or partial height PEDs was completed based on desktop research of publicly available research papers as well as contacts with other transit agencies who have implemented PEDs into their networks. A discussion of the findings from this research as well as AECOM experience is provided below.

5.1.1 Metrics in Assessing Acoustic Impact

The effect of PEDs on the acoustic environment at platform level may either be positive or negative depending on the factors discussed above. It is therefore useful to identify metrics which can be used to quantify and qualify the changes due to the introduction of PEDs. These metrics include:

- *Reverberation Time (RT):* The time taken for the specific reduction of sound energy over a defined time period within a space of interest. A standard reverberation time (RT60) has been defined as the time (in seconds) for a 60-dB decay from its original level. In the context of this study, for speech intelligibility, the focus of the RT60 value is typically centered in the 500Hz and 1000 Hz (speech) frequencies. In general, a lower RT60 value represents a more “acoustically dead” space. Conversely, a higher RT60 value represents a more “acoustically live” space.

- *Speech Transmission Index (STI):* A single unitless value between 0 and 1 representing the quality of speech transmission. STI predicts the likelihood of syllables, words and sentences being comprehended by native speakers. The higher the STI value, the higher the quality of speech transmission.

- *Inter Aural Cross Correlation (IACC): IACC* is a parameter that describes the spaciousness or spatial impression of a room by describing the difference in signals received by each ear of a person. The IACC value can range from -1 to +1. Where a value of:

    - -1 means the signals are identical but completely out of phase with each other,
    - +1 means they are identical; and

- 0 means they have no correlation at all or is balanced

Humans interpret lower IAAC values as a broader sound image (i.e., more immersive) and a higher value as a narrow sound image (i.e., frontal). This has implications on the effectiveness of speech communication especially with public address systems.

- *Change in Sound Pressure Level (SPL):* In the context of this study, the reinforcement in sound level at the platform from sound sources (i.e., public address). This reinforcement correlates to the STI performance.
- *Noise Reduction Level (NRL):* In the context of this study, the difference in sound pressure level due to primary sources of noise at platform level of PED vs no PED. These primary sources may include arriving or departing trains.

5.1.2 Research Findings

Asian and European metro systems have been increasingly incorporating PEDs as a part of new stations as well as retrofits of existing stations. However, the application of PEDs across each transit agency and even each individual station is not consistent. That is, multiple types of PEDs are utilized based on the needs at each individual location. PEDs can generally be categorized into three (3) categories:

- *Solid Full Height:* full height PEDs with mobile doors for passage which may be classified into two (2) sub classes:
    - Mobile Closed Full Height (MCFH) – floor to ceiling completely closed or sealed separation between platform and track or tunnel area.
    - Mobile Open Full Height (MOFH) – physical barrier does not completely meet the underside of ceiling separating platform area from track or tunnel thus allowing unobstructed air or sound to travel over.
- *Solid Half Height:* half height continuously solid PEDs that may be classified into two (2) sub classes:
    - Mobile Half Height (MHH) – mobile doors for access to and from trains
    - Fixed Half Height (FHH) – fixed barrier locations with permanent openings at train door locations
- *Fixed Barrier (FB):* half height PED similar to a fence or gate with fixed locations and permanent openings at train door locations

Desktop research of existing studies to understand the impact implementing PEDs on acoustics were completed. These studies included:

- Acoustic effects of platform screen doors in underground stations (Y.H. Kim, Y. Soeta 2014)
- Effects of platform screen doors on noise characteristics in train stations (Y. Soeta, R. Shinkokura 2011)

In addition to the above studies, transit agencies in other jurisdictions were also contacted to request an information exchange. Some feedback was received from past AECOM projects (Union Pearson Express) at other transit agencies (Metrolinx) which implemented PEDs. This feedback primarily noted that acoustics was not an objective rationale for their inclusion and a quantitative review or assessment of the benefits or drawback of PEDs relating to acoustics was not completed. However, anecdotal and general comments were also provided relating to the impact based on their experience following construction completion was provided. This feedback was in line with and is reflected in the research that was reviewed as a part of this study. To date, requests from other transit agencies remain active and awaiting responses to requests for information.

The findings of the effects of PEDs from desktop research are summarized in Table 3.

Table 3: Acoustic Research Findings

Metric	Description
RT	◆ Results based on scale model test measurement results indicated that the RT showed improvement (i.e., reduced) following the implementation of PEDs of all types across each platform configuration. • Full height PEDs MCFH and MOFH showed the highest reduction in both station configurations. • MCFH and MOFH have similar levels of reductions (0.25s – 0.35s) despite the upper portion opening for MOFH. • Side platform outperforms island platform by a large margin 20% for MOFH and 100% for MCFH. ◆ MHH, FHH, and FB PEDs showed similar reductions (0.25s – 0.75s) with minor variability between island and side platform configurations.
STI	◆ Results based on scale model test measurements indicated that: • MOFH showed the most increase in performance (3% island platform and 6% side platform). • MCFH showed a decrease in performance in both configurations. • For MHH and FHH PEDs results indicated that: • Similar STI performance improvements to MOFH for island platform configuration. • MHH showed similar STI performance improvements compared to MOFH. • FHH showed marginally lower performance improvements compared to MOFH. ◆ FB showed no change for island configuration and an improvement similar to the MHH and FHH PED types.
IACC	◆ Research shows that: • MOFH showed the largest decrease of IACC for both island (-0.065) and side (-0.051) platform configurations • MCFH showed a modest decrease of IACC for island (-0.035) and a marginal (-0.005) change for side platform configurations • MHH showed a marginal change (-0.05) for island and modest change (-0.02) for side platform configurations • FHH showed a modest increase of IAAC for island (+0.03) and marginal increase for side (+0.005) platform configurations ◆ FB showed a +0.02 increase of IACC for island configuration and -0.01 decrease of IAAC for side platform configuration
ΔSPL	◆ Results based on scale model test measurements indicated that: • MCFH showed the most noise reinforcement in either platform configuration (3 dB) • MOFH showed a noise reinforcement for both platform configurations (1 – 2 dB) • For MHH and FHH PEDs had similar results with marginal sound level reinforcement. ◆ FB PEDs showed a measured decrease in sound level

NRL	◆ The NRL was calculated for various sound sources for 13 difference receiver positions along the platforms. The averaged results of the research indicated that: • MOFH showed the most noise reduction of approximately 4.3 – 5 dB (island vs side platform) • MHH showed a reduction of 1.1 – 1.4 dB (island vs side platform) ◆ FHH and FB showed similar reductions of 0.8 – 0.9 dB (island vs side platform)

5.1.3 Discussion

Based on the results provided in **Table 5-1 Acoustics Research Findings,** a summary of the PED types optimal for acoustic performance is provided below for the island and side platform configurations.

- Reverberation Time: Regardless of platform configuration, the optimal PED choice is either MCFH or MOFH.
- STI: For island platform configurations, MOFH, MHH and FHH are expected to equally improve STI performance. For side platform configuration, MOFH and MHH PED types are expected to similarly improve STI performance.
- IACC: MOFH showed the largest improvements in IACC following the implementation of the PEDs by a large margin compared with other types. This result indicates that the MOFH PED type would maximize STI at the platform level.
- SPL: Similar to the results for STI, the side platform configuration showed the highest level of sound reinforcement. The MCFH style PED provided the soundest reinforcement when compared to other styles for either platform configuration. The upper walls of the PEDs were found to be an important factor in the reinforcement of the SPL.
- NRL**:** MOFH style PED provides the most significant NRL when compared to the other PED styles. MHH, FHH and FB style PEDs provide marginal reductions that are generally within the margin of error of measurement for sound level meters.

The findings from the research may vary depending on platform designs with special architectural or structural features that alter elements such as room finishes, volume and shape. However, in general the relative magnitude in performance between each style of PED is expected to be similar to the findings of the research. Overall, research indicates that MOFH is the most effective for maximizing STI with the lowest IACC as well as higher noise reduction performance.

5.2 Assessment of PEDs Impact on Air Quality

5.2.1 Introduction

PEDs have been broadly used in transit systems around the world as they are effectively eliminating the risk of intentionally or accidently entering the tracks or tunnel area to improve passenger safety; an added benefit identified by TTC is to reduce debris blown onto the tracks that may cause track fires. TTC is working to provide a cleaner (regarding air quality) and quieter platform environment for passengers.

Passengers spend most of their time in the transit system during their commute, but the exposure to pollution in this public system could cause negative health effects. Environmental pollutants can become trapped and accumulate in enclosed underground environments such as subway systems which can lead to detrimental long-term health effects to passengers [1]. Particulate matters (PM), aromatic hydrocarbons, carbonyls and airborne bacteria have been identified as the primary air pollutants inside subway systems. PM was always identified as the primary pollutant in the subway system. Iron (Fe) was found to be the most dominant PM element as the mechanical wear between the brake–wheel and wheel–rail interfaces was commonly recognized as the primary PM source [2].

Certain factors were reported that may affect the subway system air quality, they include the service time of subway system, frequency of passing train, ventilation mode and airflow rate, the age and airtightness of the subway train, interior materials, the number of passengers and the ambient pollution level outside the subway stations [2].

There are numerous studies around the world that have discussed the PEDs' impact on air quality, by comparing before and after the installation of the PEDs. During the research, numerous studies related to PEDs and air pollutants in the subway system were performed in the Republic of Korea [1, 3, 4, 5]. However, it is important to note that the studies were based on full height PEDs, and the platform areas are air-conditioned or equipped with forced ventilation, which are different from the “open” platforms system in TTC.

This assessment focuses on the air pollutants that were identified as being the most significant by research and published articles, particulate matter (PM_{10} and $PM_{2.5}$), carbon dioxide (CO_2) and nitrogen dioxide (NO_2). Other less significant air pollutants are summarized and described how they are generated in the subway system. The exposure limits of significant pollutants based on Ontario’s regulations and guidelines will be provided in this assessment as a reference. Within Ontario’s Ambient Air Quality Criteria (AAQCs), developed by the Ontario Ministry of Environment, Conservation and Parks (MECP), the AAQC concentration limits for NO_2, PM_{10} and $PM_{2.5}$ are defined [6]. Canadian Ambient Air Quality Standards (CAAQS) are the driver for air quality management across Canada, reviewed every 5 years to ensure stringent requirements to protect human health and the environment. The requirements for NO_2 and fine particulate matter ($PM_{2.5}$) management levels are contained with the CAAQS [7, 8]. The exposure limit of CO_2 was defined in Canadian Centre for Occupational Health and Safety (CCOHS), recommended by American Conference of Governmental Industrial Hygienists (ACGIH) [9]. Residential Indoor Air Quality (IAQ) guideline has also provided the limits for $PM_{2.5}$ and NO_2 [10].

The experience of PEDs use from some other transit authorities will be explored and other air purifying technologies that should work alongside with the PEDs to improve the air quality in the subway system will be discussed.

5.2.2 Contaminants

5.2.2.1 Particular Matter PM_{10} and $PM_{2.5}$

Particular matter is one of the major pollutants within indoor subway environments. They are generated mainly from the wear and tear between the rails and train wheels and the dust generated from the brake pads.

PM_{10} concentrations at the platform were significantly reduced after PED installation, indicating the particulate matter was introduced to the platform from the tunnel [1]. Another study characterized PM_{10} in three (3) sources such as ferrous, soil / road dust, and fine secondary aerosol sources (emitted from outside combustion activities), and confirmed that after installing PED, the average PM_{10} concentration was decreased by 20.5% during the study period. However, since the platform and tunnel area were blocked by the screen doors, adverse effects occurred in the platform area as the fine secondary aerosol sources emitted from outside combustion activities was increased significantly [3]. In Asia, the concentrations of PM_{10} and $PM_{2.5}$ were measured continuously before and after the PED system was installed. The mean PM_{10} concentration in post-PED installation was significantly reduced by 16–30% compared to the pre-PED installation, findings summarized by Xu & Hao [2].

Son *et al.* investigated PM concentrations in subway trains in Seoul subway system after the PEDs were installed. It was found that the mean PM_{10} concentration in the trains after PEDs installation increased significantly by 29.9% compared to that before installation, this also suggested that air mixing between the platform and the tunnel after PEDs installation was extremely restricted, revealed that PM levels in subway trains increased significantly after all underground PEDs were put in use [5], based on the fully segregated PEDs. Another study by Son *et al.* also reported that the PM_{10} levels in the tunnels were significantly increased by the PEDs, while those in the platform and waiting room decreased. A tunnel ventilation system with adequate flowrate will help to reduce the PM_{10} to the desired indoor air quality limits. **Figure 35: PM concentrations comparisons from various studies by Son et al. [4]** below summarized the PM concentrations from the subway systems around the world [4]. Depending on the sampling locations and the design of the transit systems, the PM concentrations varies largely.

Table 1. Comparison of particulate matter (PM) concentrations in subway stations from various studies.

Study	Location	Particle size	Sampling site	Concentration (μg/m³)
Pfeifer *et al.*, 1999	London, UK	$PM_{2.5}$	Underground	246 (±52)
Seaton *et al.*, 2005	London, UK	$PM_{2.5}$	Station platform Inner subway	270-480 130-200
		PM_{10}	Station platform Inner subway	1000-1500
Priest *et al.*, 1998	London, UK	PM_9	Inner subway	795 (500-1000)
Sitzmann *et al.*, 1999	London, UK	PM_5	trains and on platforms	801
Aarnio *et al.*, 2005	Helsinki, Finmland	$PM_{2.5}$	Underground Ground Inner subway	47 (±4) and 60 (±18) 19 (±6) 21 (±4) 60 (23-103)
Kim *et al.*, 2008	Seoul, Korea	$PM_{2.5}$	Ground and Underground	48.9-126.8 115.2-135.7 81.6-176.3
		PM_{10}		122.6-310.1 28.68-356.6 237.8-480.1
Kim *et al.*, 2012	Seoul, Korea	PM_{10}	Platform	116 (76-164)
		$PM_{2.5}$		66 (39-129)
Park and Ha, 2008	Seoul, Korea	PM_{10}	Underground stations and Ground stations	123±6.6-145.3±12.8
		$PM_{2.5}$	Underground stations and Ground stations	105.4±14.4-121.7±16.1
Adams *et al.*, 2001	London, UK	$PM_{2.5}$	Underground Ground Underground	247.2 (105.3-371.2) 29.3 (12.1-42.3) 157.3 (12.2-263.5)
Fromme *et al.*, 1998	Berlin, Germany	PM_{10}	Summer Winter	153 (S.D.=22.0) 141 (S.D.=17.0)
Johansson and Johansson, 2003 Karlsson *et al.*, 2005	Stockholm, Sweden	$PM_{2.5}$	Platform	165-258 (34-388)
		PM_{10}		302-469 (59-722) 357
Braniš, 2006	Prague, Czech	PM_{10}	Underground	103
Salma *et al.*, 2007	Budapest, Hungary	PM_{10}	Underground Underground	155 (25-322) 180 (85-234)
		$PM_{2.5}$	Underground	
Grass *et al.*, 2010	New York, USA	$PM_{2.5}$	Underground	56±95
Onat and Stakeeva, 2012	Istanbul, Turkey	$PM_{2.5}$	Underground	49.3-181.7
Ripanucci *et al.*, 2006	Rome, Rome	PM_{10}	Underground	407 (71-877)
Awad, 2002	Cairo	PM_{35}	Ground and Underground	794-1096 (938.3±124)
Cheng *et al.*, 2008	Taipei	PM_{10}	Platform/Inside train	11-137/10-97
		$PM_{2.5}$		7-100/8-68
Li *et al.*, 2007	Bejing, China	TSP PM_{10} $PM_{2.5}$ PM_1	Underground Inner subway	456.2±176.7 324.8±125.5 112.6±42.7 38.2±13.9
		TSP PM_{10} $PM_{2.5}$ PM_1	Ground inner subway	166±78.7 108±56.0 36.9±18.7 14.7±6.6

Figure 40: PM concentrations comparisons from various studies by Son et al. [4]

Fine particulate ($PM_{2.5}$) related to the PED was also discussed in other studies. It was found that $PM_{2.5}$ concentrations in train cabins were observed to be constantly higher than that on platforms due to ventilation in subway trains exchanging air with foul tunnel air, which is further deteriorated by the sealing off by PEDs. $PM_{2.5}$ has notable health impacts on commuters, regardless of age and gender. It can be breathed more deeply into the lungs, remain suspended for longer periods of time, penetrate more readily into indoor environments, and are transported over much longer distances. $PM_{2.5}$ can pass from our lungs into our blood supply and be carried throughout our bodies [11]. Other studies have also found that the station design, and warmer (stronger ventilation) periods and colder periods (weak ventilation) related to the ventilation system performance has an effect on the $PM_{2.5}$ concentration. Appropriate ventilation modes should be applied to the subway system to obtain both PM reduction and energy conservation [12].

The $PM_{2.5}$ and PM_{10} limits per the AAQC concentration are 30 $\mu g/m^3$ and 50 $\mu g/m^3$ in averaging time of 24-hour, respectively [6]. CAAQS for $PM_{2.5}$ is required to meet the Air Quality Management levels and goals to be less than 27 $\mu g/m^3$ for the 24-hour average concentration and to be less than 8.8 $\mu g/m^3$ for annual (1-year) average concentration by Year 2020 [7]. The Residential IAQ guidelines for fine particular matter ($PM_{2.5}$) are to keep indoor levels as low as possible, without a posted limit, and do not allow smoking indoors. There's no mention of PM_{10} in the Residential IAQ guidelines [10]. It is suggested to perform a baseline air sampling on PM_{10} (or Total Suspended Particulate) on selected stations to determine if PM concentration during normal operation is within the guideline limits.

5.2.2.2 Carbon Dioxide CO_2

CO_2 at the station platform was released mainly by the passengers. The higher passenger volume, the higher the concentration. In the study it was found that CO_2 levels on the platform were increased slightly after full height PEDs installation which correlated with the number of passengers in the station, while there was no correlation of CO_2 between indoor and tunnel concentration [1]. This is due to the full height PED creating an airspace area separation between platforms and tunnels. The concentration of the CO_2 shall not have a huge impact with the half or ¾ height PEDs as the air can travel freely above the PEDs, ventilated by the piston effects of the travelling trains.

The exposure limit of CO_2 according to CCOHS has a Time-Weighted Average (TWA) of 5,000 ppm and Short Term Exposure Limit (STEL) of 30,000 ppm [9]. Based on the study performed in Seoul Metro the CO_2 concentration remained below 1,000 ppm [1], which is five times lower than the CCOHS TWA limit, it is reasonable to assume the CO_2 concentration will not post a major concern on the TTC platforms regardless the style of PEDs to be installed. Further study may be required to confirm the CO_2 concentration at the TTC platform at the peak hours. There's no mention of CO_2 in the Residential IAQ guidelines [10].

5.2.2.3 Nitrogen Dioxide NO_2

NO_2 at the station platform was generated by vehicular ground traffic from outdoors, which infiltrated into the platform from the air passages such as ventilation shafts or subway station entrances. The study has found the PED could reduce the entry of the outdoor air with NO_2 to the indoor spaces, especially to the platform; and the outdoor air entering through the open entrance concourse level was not adequately dispersed deeper into the platform area [1]. The same discussion in CO_2 shall apply depending on the style of the PEDs (full or ¾ height) to be installed in order to achieve improvement of NO_2 at the platform level.

The NO_2 limits per the AAQC concentration is 200 $\mu g/m^3$ (0.1 ppm) in averaging time of 24-hour and 400 $\mu g/m^3$ (0.2 ppm) in average time of 1-hour [6]. CAAQS for NO_2 is required to meet the Air Quality Management levels and goals to be less than 60 ppb by Year 2020 and 42 ppb by Year 2025 for the 1-hour average concentration; and to be less than 17 ppb by Year 2020 and 12 ppb by Year 2025 for the annual (1-year) average concentration [8]. Sampling should be performed in the future to confirm if the NO_2 concentration is in compliance with AAQC and CAAQS standards.

5.2.2.4 Other pollutants

Other air pollutants detected in American regional transit systems include volatile organic compound (VOCs), benzenes, polycyclic aromatic hydrocarbons (PAHs), microorganisms, fungi, bacteria and metals (Iron (Fe), Chromium (Cr), Manganese (Mn), Zinc (Zn), Copper (Cu)). The concentrations and sampling methods were summarized in the article and **Figure 36: Summary of air pollutants in America transit systems [2]** below by Xu & Hao [2]. PEDs will also have an impact on reducing Radon gas at the platform level reported by other studies in Korea.

VOCs including benzenes and PAHs are the pollutants from automobile exhaust from outside of the station and flow into the subway systems through ventilation shafts and stairs or openings from the ground and concourse levels. Fungi and bacteria were found at the stations and its concentration levels vary depending on the depth of the station, temperature and relative humidity of the stations, and tunnel area. Various metal pollutants were also found due to the wear and tear of the rail tracks, train wheels, and brake pads.

Table 2
Summary of the air pollutant measurements in America.

City	Metro built year	Measurement year	Pollutant species	Average concentration	Instrument	Reference
Newark	1907	1977	Chemical composition	N/A.	A six-stage suspended particle fractionating sampler (Model 2354, Research Appliance Company, USA)	(Trattner et al., 1977)
Boston	1897	1989–1990	VOCs	12.5 μg m^{-3}	GC-FID (HP 5890, Hewlett Packard Co., USA)	(Chan et al., 1993)
Washington D.C.	1976	1999	PM	10^6 particles m^{-3}	Optical aerosol counter (Model 237A, Met One Inc., USA)	(Birenzvige et al., 2003)
New York City	1907	2013	Microorganisms	N/A	Fluid impinger (Omni 3000, InnovaPrep LLC, USA)	(Robertson et al., 2013)
		1999	Fe, Cr, Mn	500, 84, 240 ng m^{-3}	HR-ICP-MS (N/A)	(Chillrud et al., 2004; Chillrud et al., 2005; Grass and Family, 2010)
		2007–2008	$PM_{2.5}$	30.6 μg m^{-3}	Personal monitor (AM510 SidePakTM, TSI Inc., USA)	(Morabia et al., 2009; Wang and Gao, 2011; Vilcassim et al., 2014)
Los Angeles	1990	2012	PM	27,500 particles cm^{-3}	Particle counter (Model 3007, TSI Inc., USA)	(Houston et al., 2016)
		2010	PM_{10}, $PM_{2.5}$	78.0, 56.7 μg m^{-3}	DustTrak (Model 8520 TSI Inc., USA)	(Kam et al., 2011a; Kam et al., 2013)
		2011	PAHs	93 μg m^{-3}	Air pollution monitors (PAS 2000 CE, EcoChem Inc., USA)	(Houston et al., 2013)
Mexico City	1969	2002	$PM_{2.5}$, PM_{10}	78.0, 126 μg m^{-3}	Gravimetric analysis (DataRAM, MIE Inc., United Kingdom)	(Gómez-Perales et al., 2004; Mugica-Álvarez et al., 2012b; Vallejo et al., 2004)
		2002	Benzene	4 ppb	GC/FID (DKK Corporation, Japan)	(Gómez-Perales et al., 2004)
		2002	VOCs	22.2 μg m^{-3}	GC–MS (HP6890-HP5973, Hewlett Packard Co., USA)	(Shiohara et al., 2005a)
		2010–2011	Fungi, bacteria	284, 415 CFU m^{-3}	Two-stage multiorifice cascade impactors (Lot 1280573, Becton–Dickinson and Company, USA)	(Hernández-Castillo et al., 2014a)
Montreal	1966	2003	Manganese	32 ng m^{-3}	Pumps equipped with Teflon filters AirCon-2 (Gillian Corp., USA)	(Boudia et al., 2006)
Buenos Aires	1913	2005–2006	TSP	211 μg m^{-3}	Pumps equipped with Millipore polycarbonate HTTP 0037 filters (Gillian Corp., USA)	(Murruni et al., 2009)
		2005–2006	Fe, Zn, Cu	86, 0.08, 0.8 μg m^{-3}	PIXE technique developed at the TANDAR Laboratory accelerator facility of the National Commission of Atomic Energy	(Murruni et al., 2009)
Santiago	1975	2011–2012	$PM_{2.5}$	16.9 μg m^{-3}	DustTrak (Model 8532, TSI Inc., USA)	(Suárez et al., 2014)

Figure 41: Summary of air pollutants in America transit systems [2]

5.2.3 Other Transit Authorities Experience

Figure 37: Platform doors used for other transit systems around the world [13] provides the information where the PEDs are used and distributed around the globe. Please note this data did not include the 'people movers' that are used in some airports. It gives an indication that PEDs are not commonly used in the American regions, followed by some use in European countries, and very common in the counties in South-East Asia.

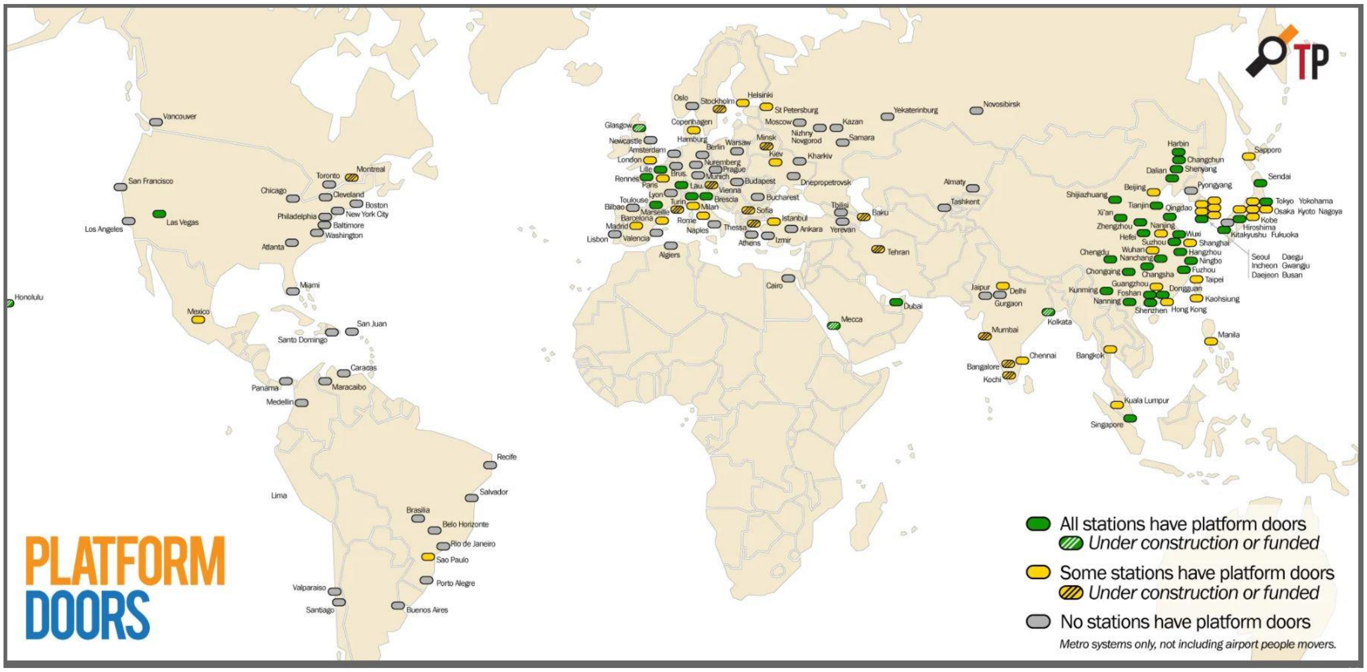


Figure 42: Platform doors used for other transit systems around the world [13]

Asian countries have been quickly developing over the few past decades, and a lot of new subway systems were built. PEDs were easy to include as part of the new platform constructions compared to implementing them into existing subway systems due to platform structure incompatibility and creating impact to the daily operation and interruption to passengers. Therefore, PEDs are mostly installed, or considered for, new subway systems.

In this assessment, a list of questions below were formulated to ask for feedback from other transit authorities regarding the air quality impacts related to the use of PEDs.

Questions:

1. What types of PEDs are used in your transit system (full height, ¾ height)?
2. Did you observe any changes on the platform air quality related to carbon dioxide, particular matters (mainly from brake dust) and Nitrogen Dioxide?
3. Did you experience any air quality impacts in the tunnel after the installation of the PEDs?
4. Did you perform any air quality study on the PEDs? Are you willing to share the findings?
5. Provide any other observations on the PEDs related to air quality?

The following is the list of transit authorities that we were trying to contact:

1. Metrolinx Up Express Line – full height PEDs on 2 stations
2. Las Vegas Monorail – sky train type – all stations with ¾ height PEDs, outdoor platform
3. Montreal Transit (STM) – feasibility study was planned in 2018 to install PEDs on a few stations as a pilot test
4. Sao Paulo Metro – ¾ PEDs on some of the stations
5. Metro Sevilla (Spain) - ¾ PEDs on some of the stations
6. Barcelona Metro TMP (Spain) - ¾ PEDs on some of the stations

This assessment did not contact the transit authorities in the Asian regions due to the following reasons:

- Seoul Metro in Korea has published a number of articles about their findings and experience
- The stations in Asia are tropical or sub-tropical climate and they are mostly air-conditioned platforms, which is different from the TTC platforms condition.

5.2.3.1 Metrolinx Up Express Line

Metrolinx's Up Express was launched in June 2015. It has 4 stations and a total of 23 km route providing service between Union Station and Toronto Pearson Airport in 25 minutes ride with a 3.5M annual passenger trips. PEDs were installed at 2 stations, Union Station (see **Figure 38: Metrolinx Up Express Union Station (Source: CBC.ca)**) and Person Airport Terminal 1. According to the input from AECOM architecture department who was involved in the Up Express project, full height PEDs were used, and they are integrated into the wall construction as part of the building envelope. The 2 stations with PEDs were pressurized to keep out of the diesel fumes from the trains. Note that the stations are outdoors above ground and elevated on a viaduct, the platform conditions and the flow of the air contaminants will be different compared to the TTC subway system.

Figure 43: Metrolinx Up Express Union Station (Source: CBC.ca)

However, there was not a lot of feedback from other transit authorities at the time of writing, mainly due to the current COVID-19 situation which is happening around the globe.

5.2.4 Concluding remarks

PEDs are commonly used in subway systems to prevent accidents and to minimize service interruptions such as impeding unauthorized entries to the track and tunnel area. Depending on the configuration of PEDs to be installed, either a full height or ¾ height PEDs, the impact to the air quality will be different.

The air contaminants discussed in this assessment that were impacted by PEDs are PM, CO_2 and NO_2. Full height PEDs, as most articles discussed in this assessment, which form a barrier between the platform and tunnel area, have effectively reduced PM concentrations at the platform area. However, higher PM concentration could result in the tunnel area, and the air quality in the train car will be adversely impacted, depending on the filtration system on the train cars. Higher CO_2 has also been reported at the platform level with full height PEDs, and its concentration is directly proportional to the volume of the passengers at the platform. NO_2 due to vehicular traffic from ground level infiltrate to the platform area by vent shafts can be reduced with the full height PEDs was also reported.

Regardless of which type of PED system to be installed, a strategic ventilation plan shall be developed for the stations to control underground environments in a subway station to achieve the most desirable conditions related to air quality at the passenger accessible areas. The piston effect alone (with no additional mechanical ventilation in the tunnel) produced by the movement of the trains was not an effective approach to obtain good air quality in the subway system [12]. Table 4 below summarized the findings:

Table 4: PED configurations versus air quality in different areas of subway system

PED Configurations	¾ Height or Partial Segregation	Full Height or Full Segregation
Platform Air Quality Impact	Minimal change	Will improve
Tunnel Air Quality Impact	Minimal to no change	Will degrade
Train Car Air Quality Impact	Minimal change	Will degrade (depending on current train cars filtration system)
Passenger Safety	Will improve	Will improve
Ventilation System change	Minimal change (study suggested forced ventilation will help reduce PM_{10} accumulations)	Will require change or upgrades to work with PED

Previous studies done by TTC also have the following supporting statements:

- In the Final PED Preliminary Engineering Report prepared by ARUP dated September 2010, it is mentioned that partially segregated solutions did not improve air quality in comparison to full segregation, or also prevented brake dust from entering the platform area.
- In the TTC PED High-Level Concept of Operations Report dated March 2017, it was mentioned that existing tunnel ventilation systems designed based on “open” platforms and this would likely preclude the use of full-height PEDs on existing station platforms.

Other than PED, some transit agencies have developed in-train air purifiers on the ceiling of the train cars for effective PM_{10} removal; adsorbent purification utilizing granular activated carbon at the subway ventilation system for VOC and NO_2 removal; and innovative PED system with controllable slits help reducing energy consumptions [2] to improve the overall air quality in the subway system.

During the research, it was noted that innovative vertical PEDs were tested at the Barcelona Metro system, shown in **Figure 39: Vertical PED trials at Barcelona Metro [14].** The main advantages of the vertical PEDs are that they provide much broader access space to accommodate different types of trains and they do not require highly precise stops. Also, the vertical PEDs are quicker and easier to install compared with horizontal doors with less structural reinforcement and claimed to have less impact on passenger flow during installation [14]. In regard to air quality impact, it will be the same effect to the ¾ height horizontal PEDs as discussed.

Figure 44: Vertical PED trials at Barcelona Metro [14]

5.2.5 Air Quality Study

As requested by TTC Safety and Environment, an air quality study was completed. The study concluded the following:

- For the central platform tests, where the piston effect is stronger, the PED system was shown to slightly reduce the time-averaged total PM level on the platform. However, this came at the cost of greater PM fluctuations in time, leading to an increase in the maximum total platform PM level observed. On the other hand, the spatial variance of PM along the platform length was seen to decrease with inclusion of PEDs.
- For the side platform tests, the PED system was shown to effect total platform PM levels less significantly. This is most likely due to the lower strength piston effect in these stations, and different physics mechanisms under the configuration.
- The results appear to confirm findings from field tests by Martins et al.[4], which suggest underground platforms with no mechanical ventilation (where the piston effect alone is responsible for air movement) receive less benefit from installation of PEDs in relation to PM reduction, than platforms with mechanical ventilation provided. If mechanical ventilation were to be featured inside the platform/concourse areas, PM would be expected to fall, according to the same Martins et al.[4] study and also a similar study of pre- and pos-PED installation field tests in Seoul subway station by Han et al.[5]
- The effectiveness of the PED system appears to be very sensitive to the dynamic velocity profile of the air arriving and leaving the platform areas, which is governed by train movement. The results of arbitrary alternative velocity profiles showed roughly similar mechanisms to the results observed for the standard piston effect velocity profile developed. However, the strength of these mechanisms and therefore also the final levels of PM above the platform, were shown to depend heavily on the

velocity profile used. Should a more detailed CFD analysis exploring PED effectiveness be desired past this feasibility stage, an extensive exercise of velocity measurement in the TTC underground network is recommended.

5.2.6 References

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6. Cost Estimate

6.1.1 Project Description

The TTC Platform Edge Door Study, Feasibility Report for the subway stations located in Toronto, Ontario is comprised of the following key elements:

The study focuses on installation of Platform Edge Door (PED) system in 74 stations platform levels including interchange stations. Installation solutions are outlined according to the station classifications identified during site investigation carried out in each station. The scope of work includes but is not limited to PED system with support framework and nonconductive cladding, modifying existing emergency response room into PED Control Room, and other required mechanical and electrical systems modifications and/or new implementations. No specific LEED designation is targeted but the project will meet all applicable codes and standards.

	Line 1	Line 2	Line 4
Underground Station with Side Platform	13	20	1
Station at Grade with Side Platform	3	-	-
Elevated Station with Side Platform	-	4	-
Underground Station with Center Platform w/ Conc Box	17	5	4
Underground Station with Center Platform w/ Iron Tunnel	2	-	-
Station at Grade with Center Platform	2	2	-
Elevated Station with Center Platform	1	-	-
Total	**38**	**31**	**5**

6.1.2 Exclusions

This Class 5 Estimate does not provide for the following, if required:

- Cost of contaminated soil removal;
- Financing costs;
- Escalation contingency;
- Premiums associated with Public-Private Partnership procurement model;
- Restoring deteriorated platforms (other than platform cantilever re-construction in Davisville and Rosedale stations);
- Epoxy coated and stainless-steel reinforcement, and mechanical couplers;
- Premiums associated with sourcing non-local materials;
- Tender assigned values;
- Premiums associated with a compressed schedule;
- Currency risk;
- Extended warranties;
- Direct liaison with the authorities having jurisdiction to interpret and/or resolve issues concerning the Ontario Code and other applicable codes or guidelines;

- Pending OBC changes, if impactful;
- TTC operational impacts and costs;
- Soft costs;
- Building permit;
- Development charges;
- Easement cost;
- Fundraising cost;
- Land acquisition costs and impost charges;
- Legal fees and expenses;
- Owner's staff and associated management;
- Preventative maintenance contracts;
- Professional fees and expenses;
- Relocation of existing facilities, including furniture and equipment;
- Right of way charges;
- Engineering and management;
- Interface between ATC and PED Door;
- Business losses;

6.1.3 Summary of Cost Estimate

The total project cost estimate is listed in Table 5 which is based on Class 5 Cost Estimate[1]. The cost estimate reflects the cost escalation projected to approximate mid-point of construction (2036).

Table 5: Summary of PEDs Project Cost Estimate

Description	Cost Per Station
Average Project Cost Estimate of Each Station	\$55M
Total Cost Estimate of Line 1	\$2.1B
Total Cost Estimate of Line 2	\$1.8B
Total Cost Estimate of Line 4	\$0.2B
All 74 Station Platform Levels	\$4.1B

[1] A class 5 Cost Estimate typically has a project maturity level of 0%-2% and a low expected accuracy range of -20%-50% and high range of +30%-100%.

7. Safety Certification Plan

A safety certification plan has been developed and is included as **Appendix D**. This includes a plan for both above grade and below grade stations. The plans differentiate due to the different ventilation requirements for above grade and below grade stations. Above grade stations will be able to ventilate with the outside air and below grade stations will have to ventilate through the existing systems. Each plan includes a chart identifying all the required safety certificates and potential hazards. Each plan includes a package of safety certificates for each certifiable element, along with high level design requirements.

8. Appendices

Appendix A – Concept Drawings

Appendix B – Platform Edge Door Supplier Contact List

Appendix C – Station Characteristics Chart

Appendix D – Safety Certification Plan

Appendix F – Construction Schedule

Appendix G – Subway Map

Appendix H – TTC Concept of Operations

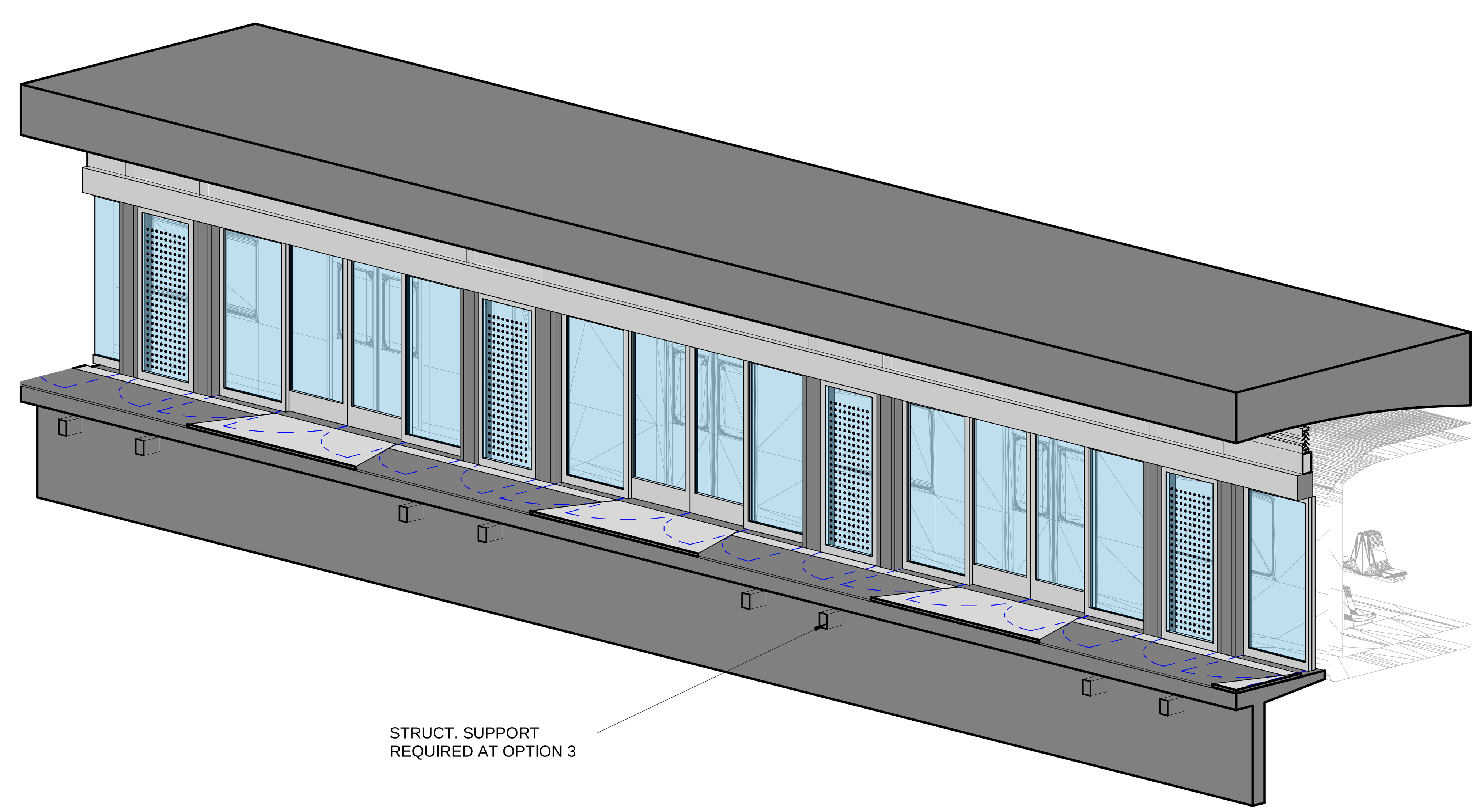
Appendix A

Concept Drawings

Typical Center Platform Station with Low Ceiling

CADD FILE NAME:C:\Users\mastinsekj\Desktop\TTC PED\PED layouts_Typical Station Center Platform 1.rvt

1 OVERALL PLATFORM PLAN
1 : 200



2 3D VIEW

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YYYY/MM/DD
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CHECKED BS
CORRECT BS
SCALE

PED STUDY

OVERALL PLATFORM PLAN AND 3D VIEW

Contract: G85-362

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Plot Date:

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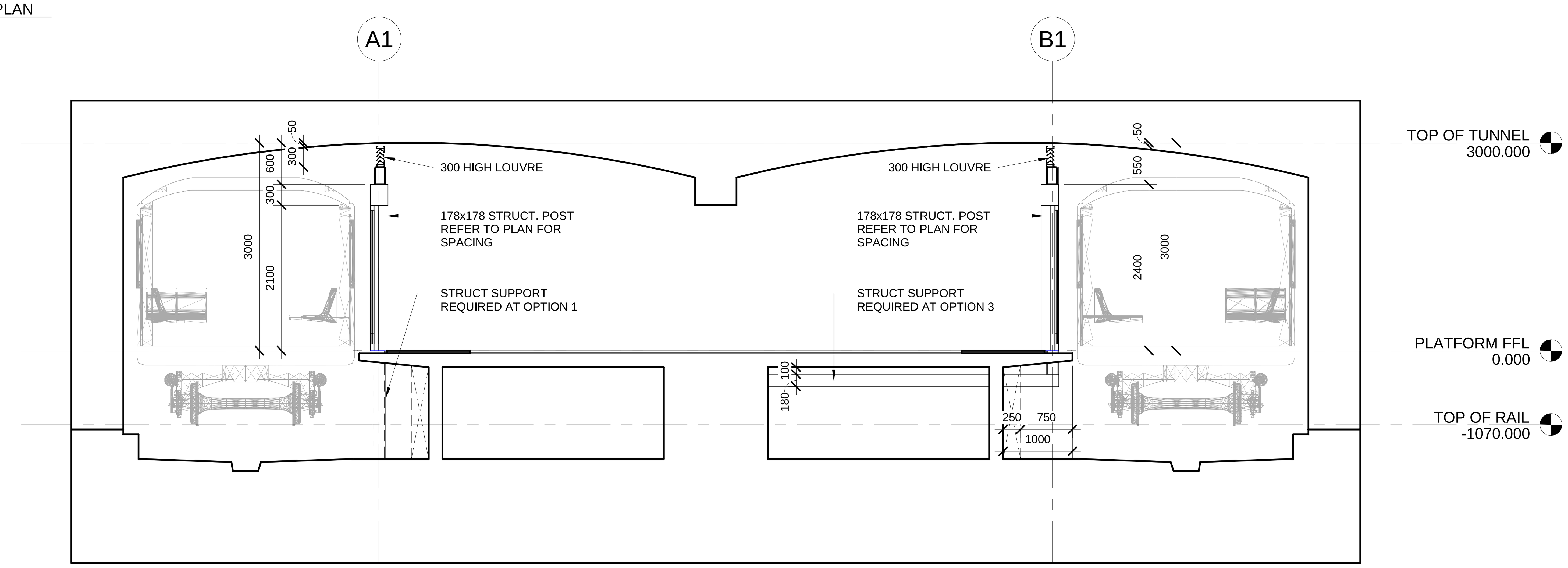
1 ENLARGED PLATFORM PLAN
1 : 100



2 SECTION
1 : 50

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Typical Side Platform Station with Low Ceiling

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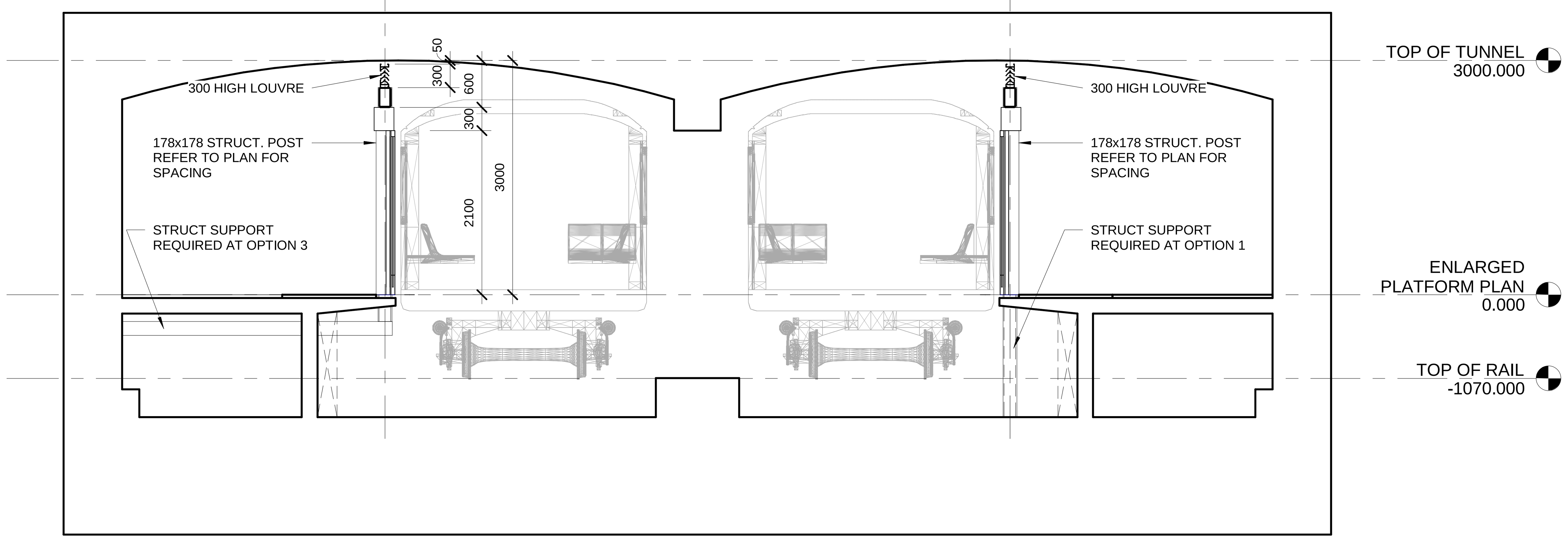

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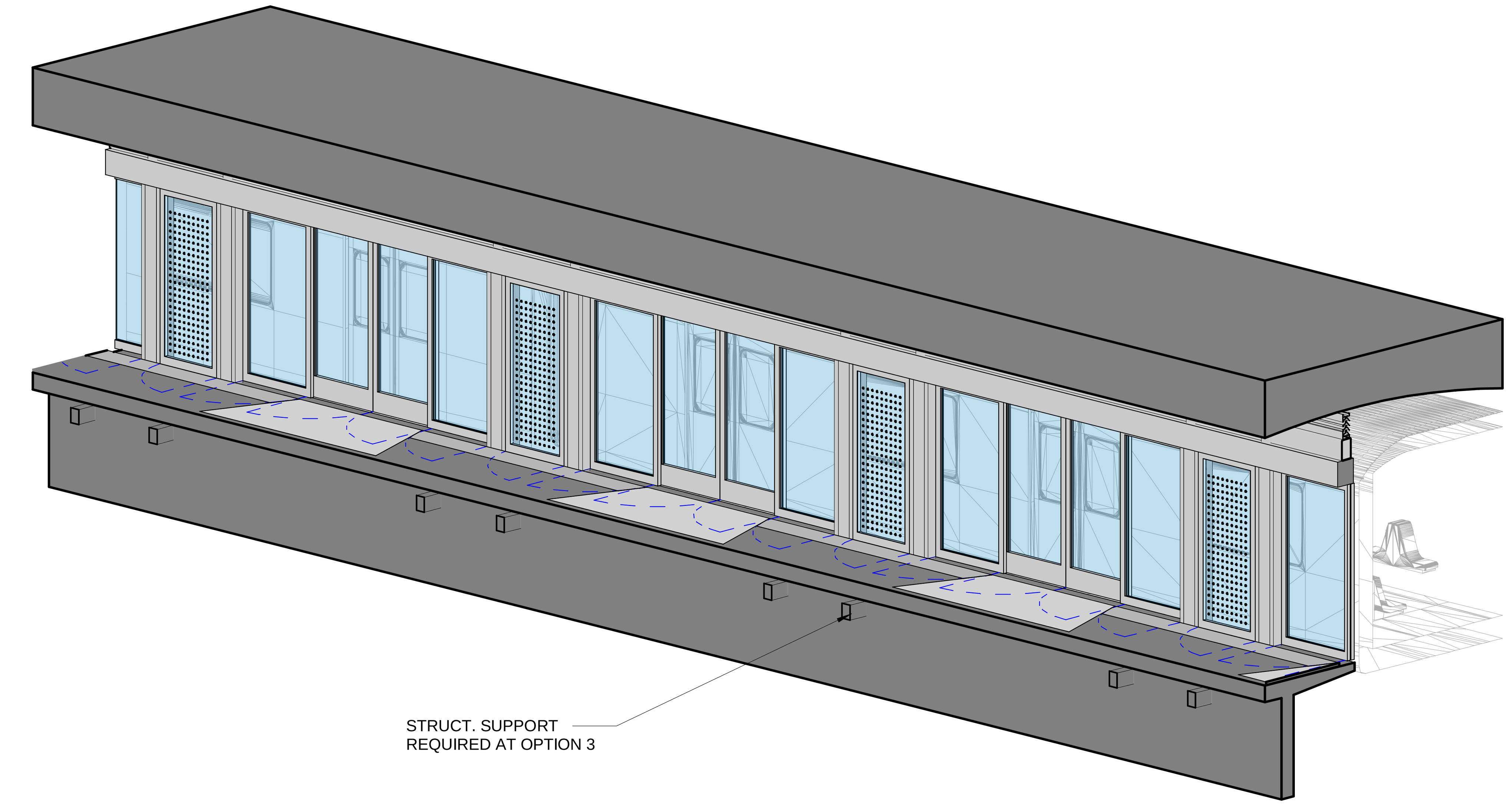
1 : 50



2 PERSPECTIVE

3 PLATFORM FFL Full platform
1 : 200

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1 ENLARGED PLATFORM PLAN
1 : 100

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ENLARGED PLATFORM PLAN

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Rev. No.
Sheet No.
Plot Date:

Typical Station with Ceiling Higher than 3500mm

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3 PLATFORM FFL Full platform
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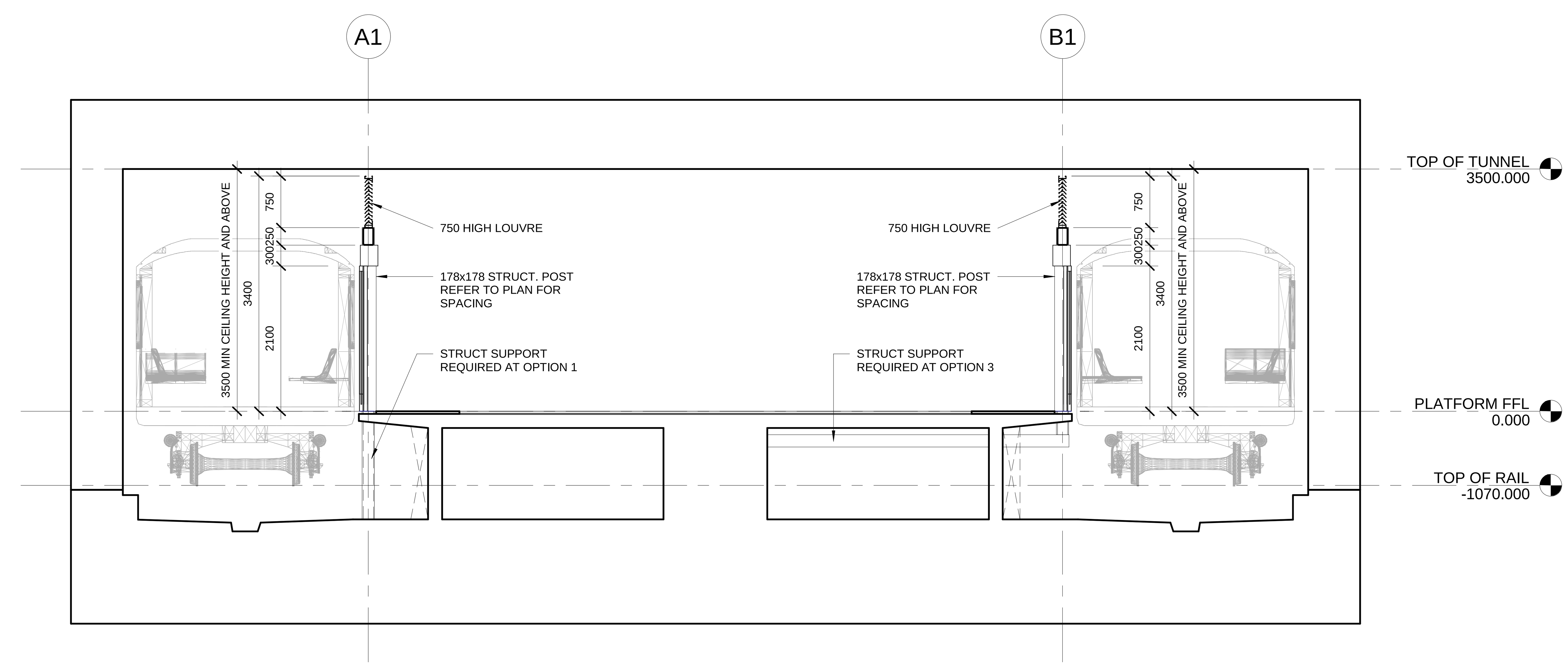

4 SECTION
1 : 50

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OVERALL PLATFORM PLAN AND SECTION

Contract: G85-362

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Plot Date:

Typical Center Platform Station with Cast Iron Tunnel

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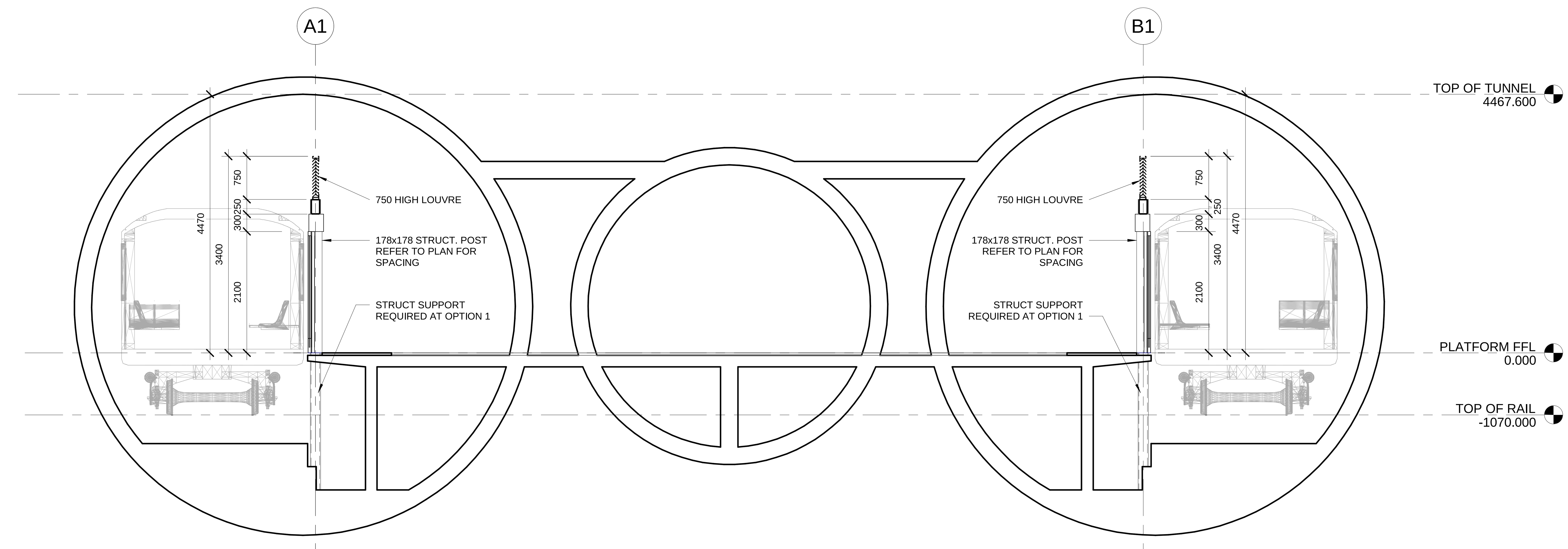

2 SECTION
1 : 50

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OVERALL PLATFORM PLAN AND SECTION

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Plot Date:

Typical Station with Low Ceiling That Cannot Accommodate Louvre Panels Above PEDs

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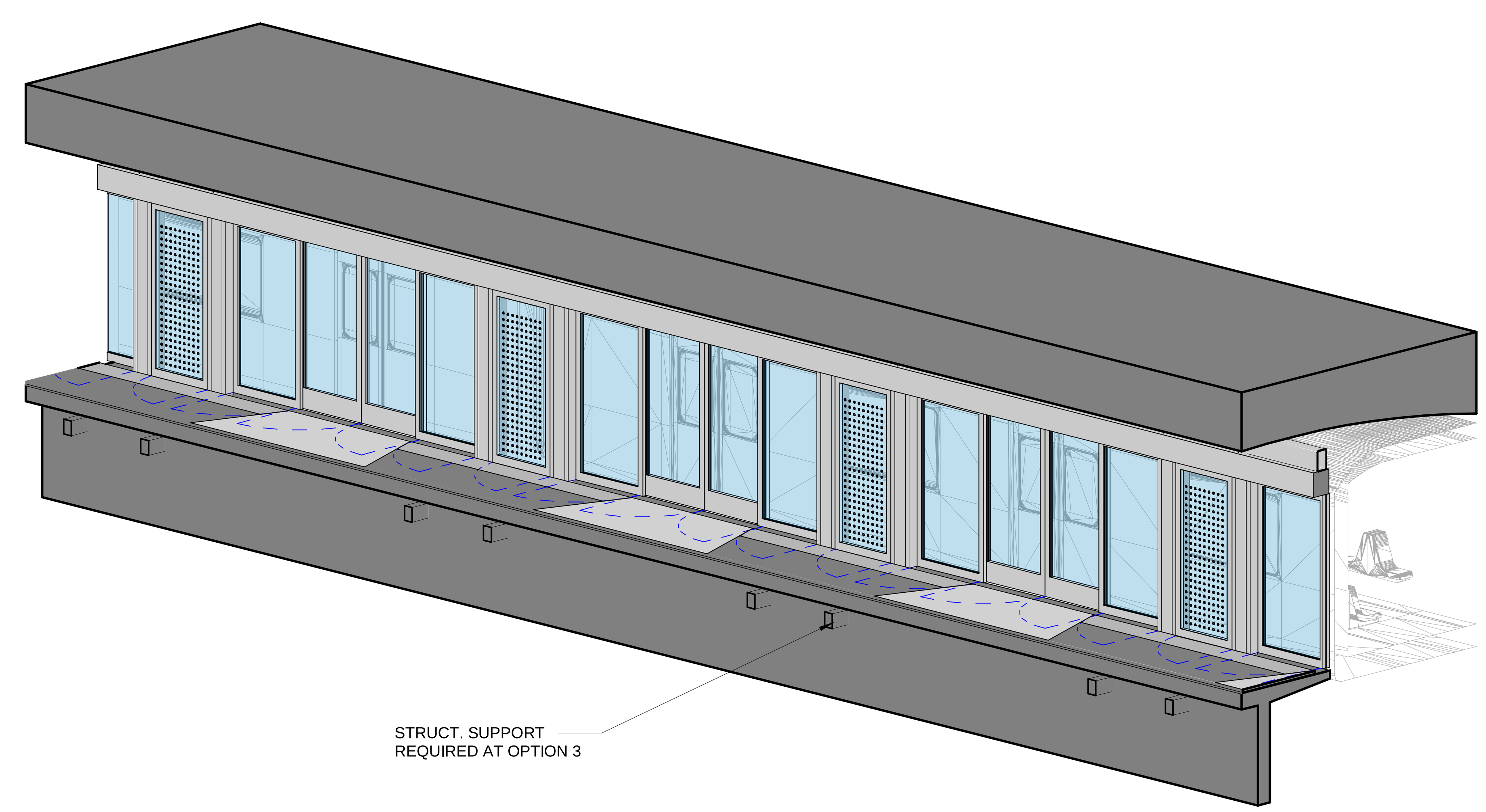
1 OVERALL PLATFORM PLAN
1 : 200



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PED STUDY

OVERALL PLATFORM PLAN AND 3D VIEW

Contract: G85-362

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Rev. No.
Sheet No.
Plot Date:

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1 ENLARGED PLATFORM PLAN
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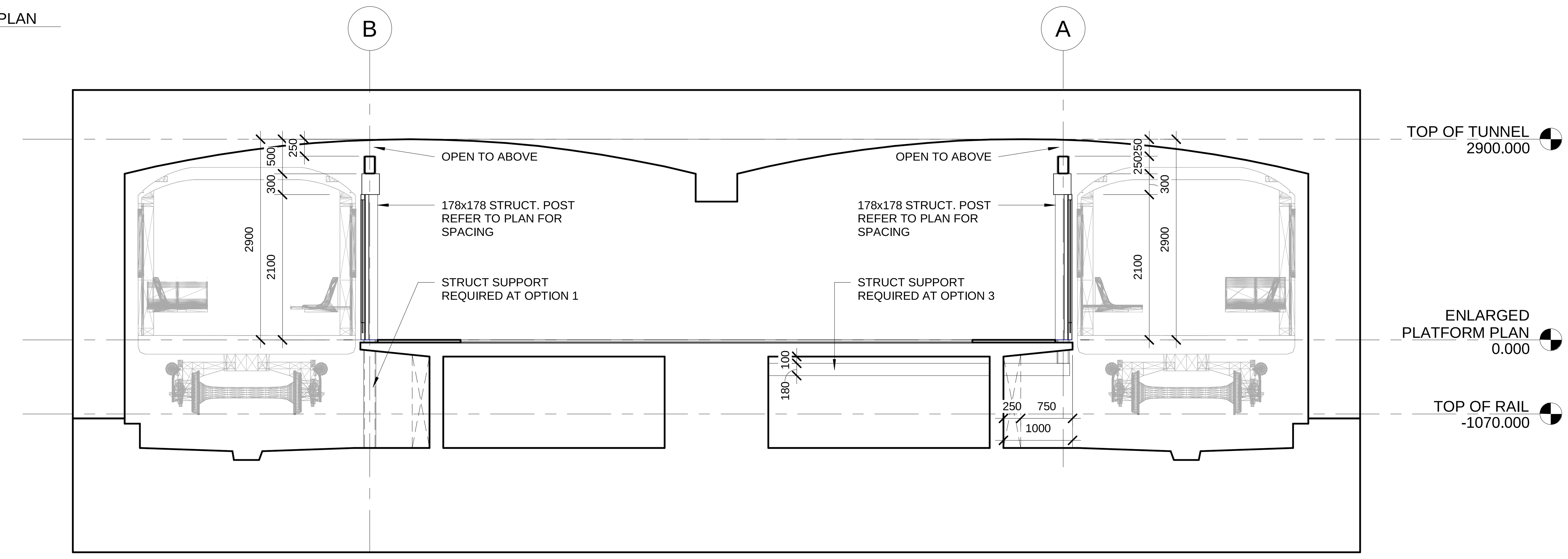

2 SECTION
1 : 50

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ENLARGED PLATFORM PLAN AND SECTION

Contract: G85-362

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Rev. No.

Sheet No.

Plot Date:

Typical Details

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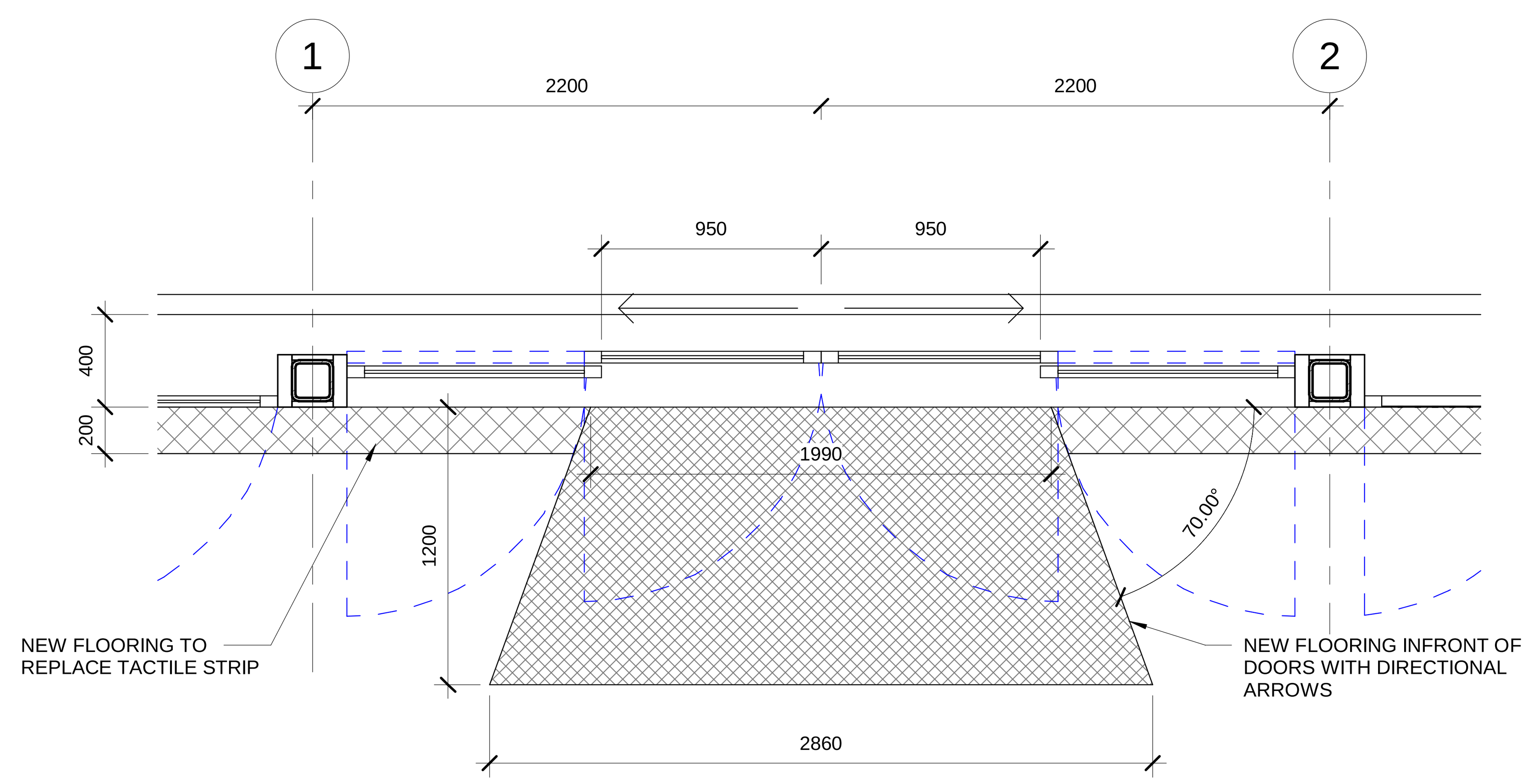
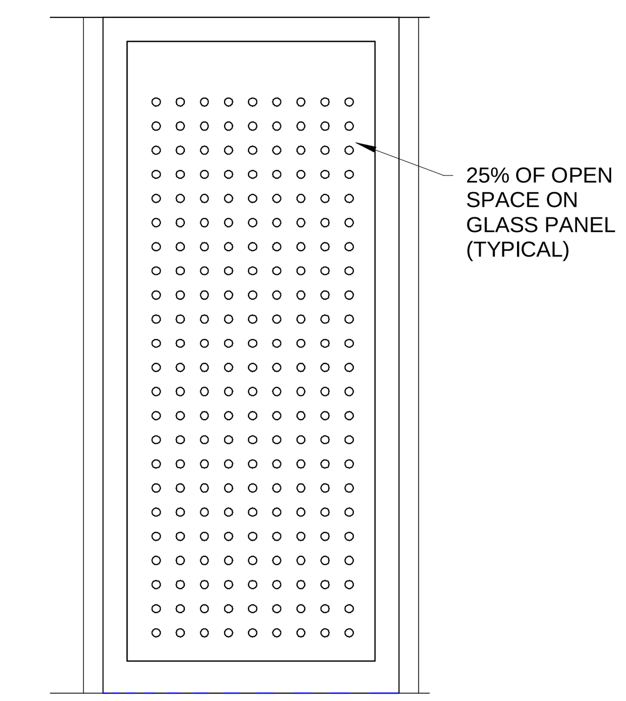
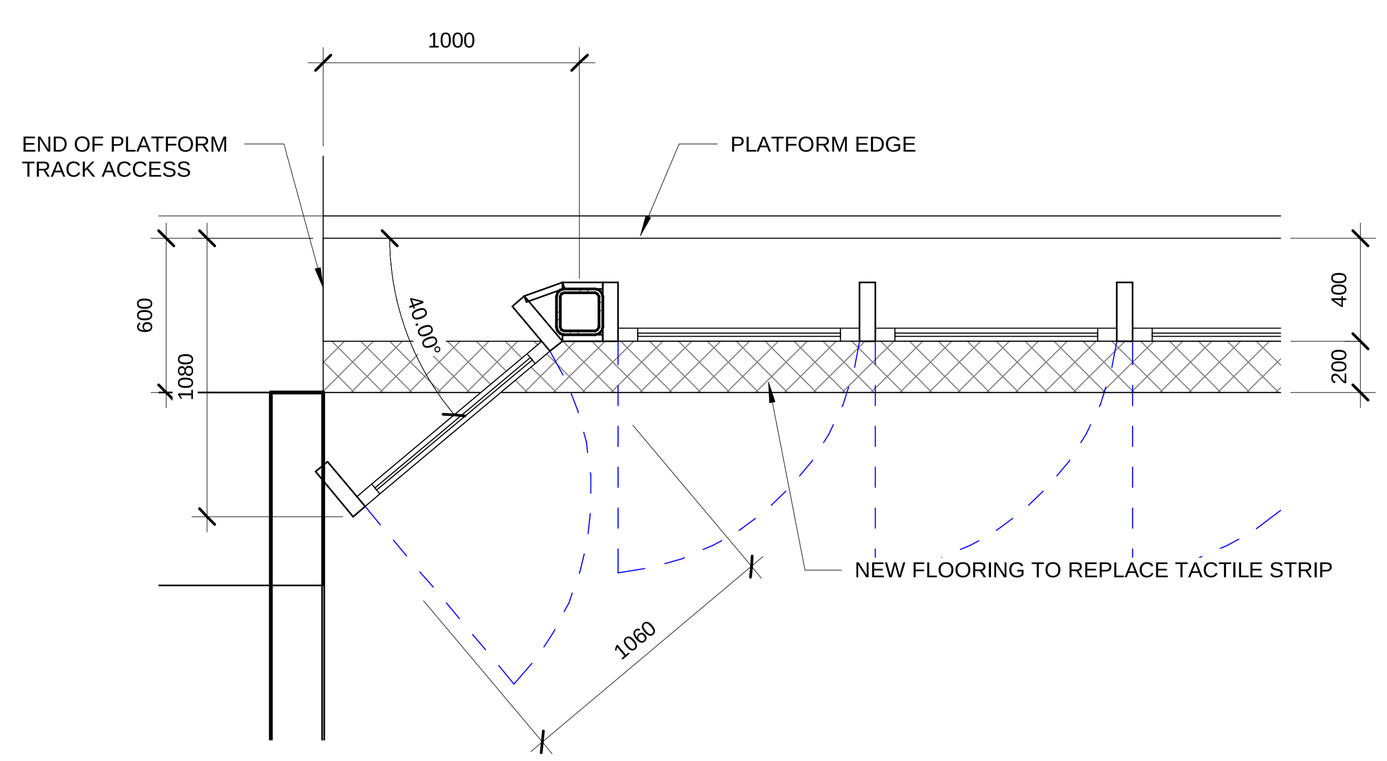


3 TYPICAL PED OPENING
1 : 25



1 TYPICAL PEFORATED PANEL
1 : 20



2 END OF PLATFORM ACCESS DETAIL
1 : 25

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TYPICAL DETAILS

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Plot Date:

Appendix B

Platform Edge Door Supplier Contact List

Clearsy Contacts (Partnered with Stanley)
*Note – Clearsy is a control system designer for PEDs, not a manufacturer

- Sebastien.chabanel@clearsy.com (Sebastian Chabanel, Railway Sales, Marketing, Support Engineering)
- Christian.acard@clearsy.com (Christian Acard, International Sales and Development Consultant for North America)

Clearsy Projects

- Paris Metro (Line 1, Line 13, & Line 4)
- Sao Paulo Metro (Lines 1, 2, & 3)
- Sao Paulo Monorail (Line 15)
- Stockholm Metro
- Caracas Metro (Los Teques Line)

Faiveley Transport Contacts (Wabtec)

- DChiappini@Wabtec.com (Dean Chiappini, Business Development for Rail and Platform Doors)
- JFink@Wabtec.com (John Fink, Vice President of Sales and Marketing)

Faiveley Projects

- Hong Kong (HKSAR)
- Copenhagen (Line 2)
- Guangzhou (Lines 1 & 2)
- Sydney North West Rail Link

Horton Automatics Contact

- Kirk_Tierce@overheaddoor.com (Kirk Tierce, Transit Business Manager)

Horton Projects

- Toronto Pearson Airport (YYZ)
- San Francisco Airport (SFO)
- Dallas/Fort Worth Airport (DFW)
- Phoenix Sky Harbor Airport (PHX)

Stanley Access Technologies Contacts (Partnered with Clearsy)

- Peter.DeLeonardis@SBDinc.com (Peter DeLeonardis, Director of Transit)

Stanley Projects

- Honolulu Rail Transit (HART)

- Orlando Airport (MCO)
- Dubai Airport (DXB)

Singapore Technologies Engineering Electronics Contacts (STEE or STE)

- rama@stee.stengg.com (Ramaswamy Muthuraman, Vice President, PSD Department Manager)
- lim.sh.spencer@stee.stengg.com (Spencer Lim Siang Huat, Deputy Director, Marketing)

Singapore Technologies Engineering Projects

- Taipei (Neihu-Mucha Line)
- Singapore (MRT)
- Bangkok (SkyTrain)

Knorr-Bremse Contacts (Knorr Brakes aka Westinghouse Platform Screen Doors)

- Samuel.Chretien@techlanka.com (Samuel Chrétien, Sales Manager for Canadian Region)

Knorr-Bremse Projects

- Copenhagen
- London
- Beijing
- Hong Kong

Appendix C

Stations Characteristics Charts

Line 1 Stations

Station Group	
1	Underground Station with Side Platform
2	Station at Grade with Side Platform
3	Elevated Station with Side Platform
4a	Underground Station with Center Platform w/ Conc Box
4b	Underground Station with Center Platform w/ Iron Tunnel
5	Station at Grade with Center Platform
6	Elevated Station with Center Platform

Station Structure	
1	Concrete Slab
2	Concrete Slab & Beams
3	Concrete Cantilever
4	Cast Iron Tunnel
5	Steel Frame

	Count
Stations Ready for PEDs	7
Stations That Require Platform Edge Support	31
Stations With Platform Depth Less Than 1800	2
New Stations	7

Station Name	Station Group	Station Structure	Structural Option	Platform Depth	Ceiling Height	Floor Material	Ceiling Material	Platform Lighting to Be Removed/Replaced	Signs in Conflict to be Removed/Replaced	Number of Conduits Above Platform Edge	Height of Louvre Above PED (m)	Perforated Breakaway Panels required
Bloor-Yonge	1	1	3	3.51	3.09	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	3	0.386	Yes
College	1	1	3	3.5	2.98	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	1	N/A Open	Yes
Davisville	2	5	1	1.58	2.86	Concrete	Plywood	Yes	Yes	Cable Tray	N/A Open	N/A
Downsview Park	4a	2	N/A	3	4	Terrazzo	Concrete	No	Yes	0	0.75	No
Dundas	1	1	3	3.45	2.98	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	1	N/A Open	Yes
Dupont	1	1	3	2.4	3.03	Tile	Ceiling Slats/ Concrete	Yes	Yes	0	0.326	Yes
Eglinton	4a	1	3	2.15	2.84	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	3	N/A Open	Yes
Eglinton West	2	2	1	3.55	3.02	Tile	Concrete	No	No	0	0.316	Yes
Finch	4a	2	3	2.53	3	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	1	0.296	Yes
Finch West	4a	2	N/A	2.5	3.88	Terrazzo	Concrete	No	No	0	0.75	No
Glencairn	5	2	1	2.49	4.7	Tile	Concrete	Yes	No	0	0.75	No
Highway 407	4a	2	N/A	2.55	3.27	Terrazzo	Alum Panels/ Concrete	No	No	0	0.566	Yes
King	1	1	3	2.91	3	Tile	Ceiling Slats/ Concrete	Yes	Yes	4	0.296	Yes
Lawrence	4a	1	3	3.91	3.25	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	1	0.546	Yes
Lawrence West	5	2	1	3.17	3.05	Tile	Concrete	No	No	0	0.346	No
Museum	4a	1	3	2.09	2.87	Terrazzo	Concrete	Yes	Yes	1	N/A Open	Yes
North York Centre	1	2	3	3.91	3.25	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	1	0.546	Yes
Osgoode	4a	1	3	2.13	2.87	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	1	N/A Open	Yes
Pioneer Village	4a	1	N/A	2.5	4.45	Terrazzo	Concrete	No	No	3	0.75	No
Queen	1	1	3	3.51	2.99	Terrazzo	Concrete	Yes	Yes	1	N/A Open	Yes
Queen's Park	4b	4	1	3.33	3.29	Terrazzo	Drywall	Yes	Yes	1	0.586	Yes
Rosedale	2	5	1	2.87	3	Concrete	Plywood	Yes	Yes	0	N/A Open	N/A
Sheppard West	4a	2	N/A	2.5	3.14	Terrazzo	Concrete	No	No	0	0.436	Yes
Sheppard-Yonge	4a	2	3	2.33	3	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	4	0.296	No
Spadina	1	1	3	3.29	3.01	Tile	Ceiling Slats/ Concrete	Yes	Yes	3	N/A Open	Yes
St Andrew	4a	1	3	1.95	2.83	Terrazzo	Concrete	Yes	Yes	3	N/A Open	Yes
St Clair	1	2	3	3.46	2.96	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	0	N/A Open	Yes
St Clair West	1	1	3	2.51	3.03	Tile	Ceiling Slats/ Concrete	Yes	Yes	0	0.306	Yes
St George	4a	1	3	2.12	2.89	Terrazzo	Concrete	Yes	Yes	1	N/A Open	Yes
St Patrick	4b	4	1	3.34	3.29	Terrazzo	Drywall	Yes	Yes	1	0.566	Yes
Summerhill	1	1	3	3.47	2.99	Terrazzo	Ceiling Slats/ Concrete	Yes	No	0	N/A Open	Yes
Union	1	1	3	1.58	2.52	Tile	Alum Panels/ Concrete	Yes	Yes	0	N/A Open	Yes
Vaughan Metropolitan Centre	4a	2	N/A	2.46	3.6	Terrazzo	Alum Panels/ Concrete	No	Yes	0	0.75	No
Wellesley	1	1	3	3.5	2.96	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	0	N/A Open	Yes
Wilson	4a	2	3	2.12	3.65	Terrazzo	Ceiling Slats/ Metal Deck	No	No	0	0.75	No
York Mills	4a	1	3	3.93	3.23	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	1	0.506	Yes
York University	4a	2	N/A	2.88	4.48	Terrazzo	Ceiling Slats/ Concrete	No	No	0	0.75	No
Yorkdale	6	3	1	2.91	3.5	Terrazzo	Concrete	Yes	Yes	2	0.75	No

Line 2 Stations

Station Group	
1	Underground Station with Side Platform
2	Station at Grade with Side Platform
3	Elevated Station with Side Platform
4a	Underground Station with Center Platform w/ Conc Box
5	Station at Grade with Center Platform
6	Elevated Station with Center Platform

Station Structure	
1	Concrete Slab
2	Concrete Slab & Beams
3	Concrete Cantilever
4	Cast Iron Tunnel
5	Steel Frame

	Count
Stations Ready for PEDs	0
Stations That Require Platform Edge Support	31
Stations With Platform Depth Less Than 1800	0
New Stations	0

Station Name	Station Group	Station Structure	Structural Option	Platform Depth	Ceiling Height	Floor Material	Ceiling Material	Platform Lighting to Be Removed/Replaced	Signs in Conflict to be Removed/Replaced	Number of Conduits Above Platform Edge	Height of Louvre Above PED (m)	Perforated Breakaway Panels required
Bathurst	1	1	3	3.47	3	Terrazzo	Concrete	Yes	Yes	0	0.296	Yes
Bay	4a	1	3	2.1	2.85	Terrazzo	Concrete	Yes	Yes	1	N/A Open	Yes
Bloor-Yonge	4a	2	3	2.1	2.87	Terrazzo	Ceiling Slats/ Concrete	Yes	Yes	1	N/A Open	Yes
Broadview	1	1	3	3.5	3	Terrazzo	Concrete	Yes	No	0	0.296	Yes
Castle Frank	1	1	3	3.48	3	Terrazzo	Concrete	Yes	No	0	0.296	Yes
Chester	1	1	3	3.5	3	Terrazzo	Concrete	Yes	Yes	0	0.296	Yes
Christie	1	1	3	3.48	3	Terrazzo	Concrete	Yes	Yes	0	0.296	Yes
Coxwell	1	1	3	2.88	3	Terrazzo	Concrete	Yes	Yes	0	0.296	Yes
Donlands	1	1	3	3.5	3	Terrazzo	Concrete	Yes	Yes	0	0.296	Yes
Dufferin	1	1	3	3.48	2.99	Terrazzo	Concrete	Yes	No	0	N/A Open	Yes
Dundas West	1	2	3	3.49	2.97	Terrazzo	Concrete	Yes	Yes	0	N/A Open	Yes
Greenwood	1	1	3	3.5	3	Terrazzo	Concrete	Yes	Yes	0	0.296	Yes
High Park	3	5	1	3.49	3	Terrazzo	Concrete	Yes	No	0	0.296	Yes
Islington	4a	1	3	2.09	2.86	Terrazzo	Concrete	Yes	Yes	1	N/A Open	Yes
Jane	1	2	3	3.49	3	Terrazzo	Ceiling Slats/ Concrete	Yes	No	0	0.296	Yes
Keele	3	1	1	2.78	3.62	Terrazzo	Concrete	Yes	Yes	1	0.75	Yes
Kennedy	4a	1	3	1.97	3.3	Tile	Ceiling Slats/ Concrete	Yes	No	0	0.596	Yes
Kipling	5	1	1	2.04	2.74	Tile	Ceiling Slats/ Concrete	Yes	No	2	N/A Open	Yes
Lansdowne	1	1	3	3.48	2.98	Terrazzo	Concrete	Yes	Yes	0	N/A Open	Yes
Main Street	1	1	3	3.5	3	Terrazzo	Concrete/ Cement Board	Yes	Yes	0	0.296	Yes
Old Mill	3	5	1	3.5	2.97	Terrazzo	Steel Deck	Yes	Yes	0	N/A Open	Yes
Ossington	1	1	3	3.49	2.99	Terrazzo	Concrete	Yes	No	0	N/A Open	Yes
Pape	1	1	3	3.45	3	Terrazzo	Concrete	Yes	No	0	0.296	Yes
Royal York	1	1	3	3.5	2.98	Terrazzo	Concrete	Yes	No	0	N/A Open	Yes
Runnymede	1	1	3	3.47	3	Terrazzo	Concrete/ Cement Board	Yes	Yes	0	0.296	Yes
Sherbourne	1	1	3	3.5	2.97	Terrazzo	Concrete	Yes	Yes	0	N/A Open	Yes
Spadina	1	1	3	3.49	3	Terrazzo	Concrete	Yes	Yes	0	0.296	Yes
St George	4a	1	3	2.15	3.21	Terrazzo	Concrete	Yes	Yes	1	0.506	Yes
Victoria Park	2	2	1	3.5	3.75	Terrazzo	Concrete	Yes	No	1	0.75	No
Warden	5	2	1	2.5	3.35	Terrazzo	Concrete	Yes	No	1	0.646	Yes
Woodbine	1	1	3	3.5	3	Terrazzo	Concrete	Yes	No	0	0.296	Yes

Line 4 Stations

Station Group	
1	Underground Station with Side Platform
2	Station at Grade with Side Platform
3	Elevated Station with Side Platform
4	Underground Station with Center Platform w/ Conc Box
5	Station at Grade with Center Platform
6	Elevated Station with Center Platform

Station Structure	
1	Concrete Slab
2	Concrete Slab & Beams
3	Concrete Cantilever
4	Cast Iron Tunnel
5	Steel Frame

	Count
Stations Ready for PEDs	0
Stations That Require Platform Edge Support	5
Stations With Platform Depth Less Than 1800	0
New Stations	0

Station Name	Station Group	Station Structure	Structural Option	Platform Depth	Ceiling Height	Floor Material	Ceiling Material	Platform Lighting to Be Removed/Replaced	Signs in Conflict to be Removed/Replaced	Number of Conduits Above Platform Edge	Height of Louvre Above PED (m)	Perforated Breakaway Panels required
Bayview	4a	1	3	2.5	3.5	Terrazzo	Ceiling Slats/ Concrete	No	Yes	0	0.75	No
Bessarion	4a	2	3	2.5	3.69	Terrazzo	Ceiling Slats/ Concrete	No	Yes	0	0.75	No
Don Mills	4a	2	3	2.5	3.5	Terrazzo	Alum Panel/ Concrete	No	Yes	0	0.75	No
Leslie	4a	2	3	2.91	3.33	Terrazzo	Ceiling Slats/ Concrete	No	Yes	0	0.626	No
Sheppard-Yonge	1	2	3	3.65	3.71	Terrazzo	Ceiling Slats/ Concrete	No	Yes	0	0.75	No

Appendix D

Safety Certification Plan

Safety Certification Plan – Above Grade Stations

Attachment 1

Scope of Facilities Safety Activities for Platform Edge Door Study			Potential Hazards												Facilities Safety Assurance						Facilities Design									Facilities Construction						Commissioning			Certification
Element	Sub-Elements		Fire	Collision	Derailment	Electric Shock	Electrical & Magnetic Interference	Air Pressure	Power Failure	Failure in Emergency	Water ingress	Flood	Trips and Falls	Pinch Points	Safety Assurance Plan	Safety Specification	Reliability Specification	Safety Assurance Report	Reliability Assurance Report	Reliability Demonstration	Design Contract Number	Proj. Engineering Co-ord	Design Support	Design Report (30%)	Design Report (60%)	Design Report (90%)	Design Report (100%)	Statement of Conformity	Confirmed Deliverables	Construction Package	Resident Superintendent	Construction Records	Installation Records	PICO Report	As-Built Drawings	Integration Test Report	Acceptance Test Report	Pre-Service Test Report	Compliance Certificate
Platform Edge Door Study	Emergency Ventilation Equipment	SHWS-1.1	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Provision for Platform Edge Doors	SHWS-1.2	None	None	None	None	None	X	X	X	None	None	X	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Ventilation Barriers - Sliding Glass Doors	SHWS-1.3	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Submersible Pump Room	SHWS-1.4	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Elevator and Escalator Room	SHWS-1.5	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Communications Room	SHWS-1.6	X	None	None	X	X	None	None	None	X	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Battery Room	SHWS-1.7	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Power Equipment Room	SHWS-1.8	X	None	None	X	None	None	None	None	X	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Power Substation	SHWS-1.9	X	None	None	X	X	None	X	X	X	X	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Fare Collection space	SHWS-1.10	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Signals Room	SHWS-1.11	None	None	None	X	None	None	None	None	X	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Cables and Conduits	SHWS-1.12	X	None	None	X	X	None	None	X	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Station Platforms	SHWS-2.1	X	X	None	None	None	None	None	None	X	None	X	X	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Station Stairs	SHWS-2.2	None	None	None	None	None	None	None	None	None	None	X	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Elevators	SHWS-3	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Escalators	SHWS-4	None	None	None	None	None	None	None	None	None	None	X	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Emergency Vent. System Power Supply	SHWS-5.1	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Passenger Station Power	SHWS-5.2	X	None	None	None	X	None	X	X	None	X	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Lighting	SHWS-6	X	None	None	X	None	None	X	X	X	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Fireman's Access Shaft	SHWS-7.1	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
	Fire Alarm and Suppression Systems	SHWS-7.2	X	None	None	None	X	None	None	X	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
All Stations	Submersible Pump Systems and	SPSC-1	None	None	None	None	None	None	None	None	None	None	None	None	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7

X Sub-Elements may contribute to, or mitigate against, the hazard
1. System Safety Assurance
2. Section Designer
3. Commissioning Team
4. TTC Operations
5. Resident Superintendant
6. Architect
7. Facilities Contractor

CERTIFICATE NO. (SHWS 1.2)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.2 Provisions for Platform Edge Doors	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. PED location and dimensions

   Applicable Codes, Standards and Design Manual References

   TYSSE Guidelines for the Provisions of Platform Edge Doors (PEDs), 04SEP2009

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Air pressure

   Applicable Codes, Standards and Design Manual References

   TTC DM-0601-02, Articles 1.2.1 and 1.4.2

   Documentation Provided

   Not applicable to Drawings and Specifications

2. Fire suppression and/or sprinklers

   Applicable Codes, Standards and Design Manual References

   OBC-3.2.3 Spatial Separation and Exposure Protection
   OBC-3.2.5 Provisions for Fire Fighting
   TYSSE Guidelines for the Provision of Platform Edge Doors (PEDs) September 04, 2009

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Power

   Applicable Codes, Standards and Design Manual References

   TYSSE-GUIDELINES for the Provision of PLATFORM EDGE DOORS (PEDs)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Detection

   Applicable Codes, Standards and Design Manual References

   TYSSE-GUIDELINES for the Provision of PLATFORM EDGE DOORS (PEDs)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Grounding

   Applicable Codes, Standards and Design Manual References

   Ontario Electrical Safety Code, Chapter 10

   Documentation Provided

   Not Applicable, Insert Design Document References Here

4. Lighting

   Applicable Codes, Standards and Design Manual References

   TYSSE-GUIDELINES for the Provision of PLATFORM EDGE DOORS (PEDs)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

5. Conduits

   Applicable Codes, Standards and Design Manual References

TYSSE-GUIDELINES for the Provision of PLATFORM EDGE DOORS (PEDs)

Documentation Provided

Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 1.6)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.6 Communications Room	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. <u>Room Location and Dimensions</u>

   Applicable Codes, Standards and Design Manual References

   TTC DM-0402-04, Article 3.4.6 (Communications Equipment Room)
   TTC Directive Drawing 0803-01.01, Communications Equipment Room Space Envolope

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. <u>Fire Barriers</u>

   Applicable Codes, Standards and Design Manual References

   Communication Equipment Room

Walls 2 hr rating	OBC 3.13.2.1(3) Ground Level
Floor 2 hr rating	OBC 3.13.2.1(3) Ground Level
Ceiling Structure 1 hr rating	OBC 3.13.2.1(3) Roof Level

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. <u>Fire Protection</u>

   Applicable Codes, Standards and Design Manual References

   OBC-3.2 Building Fire Safety

TTC DM-0102-02, Table 1 Extinguisher CO2, Extinguisher ABC, Wet Standpipe

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Grounding (shock prevention)

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-10, Article 2.5

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Detection

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Article 2.7 Smoke Detection

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 1.8)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.8 Power Equipment Rooms	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Room Location and Dimensions

   Applicable Codes, Standards and Design Manual References

   TTC DM-0402-04, Article 3.4.1 (AC Switchboard Room)
   TTC DM-0402-04, Article 3.4.2 (AC Switchgear Room)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Walls 1 hr rating	OBC 3.13.2.1(3) Ground Level
Floor N/A	
Ceiling Structure 1 hr rating	OBC 3.13.2.1(3) Roof Level

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Fire Protection

   Applicable Codes, Standards and Design Manual References

   OBC-3.2 Building Fire Safety
   TTC DM-0102-02, Table 1 Extinguisher CO2, Extinguisher ABC, Wet Standpipe

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Grounding (shock prevention)

   Applicable Codes, Standards and Design Manual References

TTC-DM-0701-10, 2.5.3	Ground Bus
TTC-DM-0701-12, 1.10	Grounding

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Detection

   Applicable Codes, Standards and Design Manual References

TTC-DM-0102-02, Table 1	Smoke Detection

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above:	Accepted:
(System Safety Engineer)	(Operations)

CERTIFICATE NO. (SHWS 1.9)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.9 Power Substation	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Room Location and Dimensions

   Applicable Codes, Standards and Design Manual References

TTC DM-0402-04, Article 3.8.1	Hydro Incoming Metering
TTC DM-0402-04, Article 3.8.2	Control Room
TTC DM-0402-04, Article 3.8.7	Rectifier Room
TTC DM-0402-04, Article 3.8.8	Transformer Yard
TTC DM-0804-06	Electrical Substations
TTC DM-0804-01, Article 3.6.1	Substation Location and Arrangement

   TTC DM-0402-04, Article 3.4.2 (AC Switchgear Room)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Substation Rooms	
Walls 2 hr rating	OBC 3.13.2.1(3) Ground Level
Floor N/A	
Ceiling Structure 1 hr rating	OBC 3.13.2.1(3) Roof Level

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Flood Prevention

Applicable Codes, Standards and Design Manual References

TTC-DM-0804-06, Article 3.1.8 Raised Door Sill

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Fire Protection

Applicable Codes, Standards and Design Manual References

OBC, 7.4.2.1. Connections to Sanitary Drainage Systems
OBC-3.2 Building Fire Safety
TTC DM-0102-02, Table 1 Extinguisher CO2, Extinguisher ABC, Fire Hydrant

Documentation Provided

Not Applicable, Insert Design Document References Here

2. Yard Drainage

Applicable Codes, Standards and Design Manual References

TTC DM-0804-06, Article 4.1.2 Transformer Yard Drainage

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Grounding (shock prevention)

Applicable Codes, Standards and Design Manual References

Ontario Electrical Safety Code, Section 36-300
TTC-DM-0804-08, 4.2, 4.1.5, 4.5.1

Documentation Provided

Not Applicable, Insert Design Document References Here

2. Power Failure / Redundancy

Applicable Codes, Standards and Design Manual References

TTC-DM-0804-01, 3.3.1

Documentation Provided

Not Applicable, Insert Design Document References Here

3. Fire Detection

Applicable Codes, Standards and Design Manual References

TTC-DM-0102-02, Table 1 Smoke Detection

Documentation Provided

Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 1.11)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.11 Signals Room	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Room Location and Dimensions

   Applicable Codes, Standards and Design Manual References

   TTC DM-0402-04, Article 3.7.3 — Signal Power Supply Room

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Walls 3 hr rating	OBC 3.13.2.1(3)
Floor 2 hr rating	OBC 3.13.2.1(3)
Ceiling Structure 2 hr rating	OBC 3.13.2.1(3)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Fire Protection

   Applicable Codes, Standards and Design Manual References

   OBC 3.13.3 Safety Requirements Within Stations
   OBC 3.6.2.7 Electrical Equipment Vaults
   OBC 3.5.3 Fire Separations
   OBC 3.6.3 Vertical Service Spaces and Service Facilities

TTC DM-0102-02, Table 1 Extinguisher CO2, Extinguisher ABC, Wet Standpipe

Documentation Provided

Not Applicable, Insert Design Document References Here

2. Eye Wash

   Applicable Codes, Standards and Design Manual References

   OBC 7.4.2.1 Connections to Sanitary Drainage Systems
   TTC DM-0402-04, Article 3.7.3 Signal Power Supply Room

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Grounding (shock prevention)

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-10, Article 2.5

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Detection

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Table 1 Smoke Detection

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above:	Accepted:
(System Safety Engineer)	(Operations)

CERTIFICATE NO. (SHWS 1.12)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.12 Cables and Conduits	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION – ELECTRICAL

1. Fire Protection

   Applicable Codes, Standards and Design Manual References

   Ontario Electrical Safety Code
   TTC-DM-0701-12, Article 1.3.1
   NFPA 130, Chapter 7

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Grounding (shock prevention)

   Applicable Codes, Standards and Design Manual References

   Ontario Electrical Safety Code, Section 10
   TTC-DM-0701-12, Article 1.10

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above:	Accepted:
(System Safety Engineer)	(Operations)

CERTIFICATE NO. (SHWS 2.1)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-2.1 Station Platforms	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Walls N/A to platform	
Floor 2 hr rating	OBC 3.13.2.1(3)
Ceiling Structure 2 hr rating	OBC 3.13.2.1(3)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Pedestrian Circulation Requirements

   Applicable Codes, Standards and Design Manual References

TTC-DM-0402-04, Article 2.0	Platform Occupant Load
TTC-DM-0402-06, Articles 2.0, 4.0, 6.0	Station Planning, Pedestrian Circulation
OBC 3.13.4.1	Occupant Load

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Barrier Free Access – Trips and Falls

   Applicable Codes, Standards and Design Manual References

TTC-DM-0405-00	Barrier Free Access
TTC-DM-0402-06, Articles 6.0	Station Planning, Pedestrian Circulation
OBC 3.8.1.1, 3.13.8.4	Barrier Free Design

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION - Structural

1. <u>Collision Prevention</u>

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0205-01, Vehicle Clearance Envelope
   TTC-DM-0205-01, Fig 2.2.2
   TYSSE Design Guideline (Sep 04 2009), Guidelines for the Provision of Platform Edge Doors (PEDs)
   OBC 4.1.5.15, Crowd horizontal live load
   TTC-DM-0301-02, Article 3.3.4, Train Piston Effect
   TTC-DM-0301-02, Article 3.2.11, Floor and Miscellaneous Live Load

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. <u>Water Ingress</u>

   Applicable Codes, Standards and Design Manual References

   DI-009, Measures to Minimize Concrete Cracking and Prevent Water

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. <u>Ventilation</u>

   Applicable Codes, Standards and Design Manual References

   OBC 6.2.2 Ventilation
   TTC-DM-0102-02 Fire/Safety, Article 3.0 Ventilation
   TTC-DM-0601-02 Ventilation, Articles 1.2.1, Internal Ambient Design Conditions, 1.4.2.1, Public and Tunnel Areas
   TTC DM-0601-03 Ventilation, Article 1.2. Station and Tunnel Design Conditions

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. <u>Drainage</u>

Applicable Codes, Standards and Design Manual References

OBC 7.4.2.1 Connections to Sanitary Drainage Systems
TTC DM-0602-03, Article 1.5.4

Documentation Provided

Not Applicable, Insert Design Document References Here

3. Fire Protection

Applicable Codes, Standards and Design Manual References

OBC 3.2 Building Fire Safety
TTC DM-0102-02 Table 1 Wet Standpipe, Extinguisher ABC, Extinguisher Water

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Fire Detection

Applicable Codes, Standards and Design Manual References

TTC-DM-0102-02, Table 1

Documentation Provided

Not Applicable, Insert Design Document References Here

2. Lighting

Applicable Codes, Standards and Design Manual References

OBC 3.13.3.7
TTC-DM-0701-05, Articles 2.5.3, 2.5.4, 2.5.6, 2.5.7, 2.10.2

Documentation Provided

Not Applicable, Insert Design Document References Here

Complies with above:	Accepted:
(System Safety Engineer)	(Operations)

CERTIFICATE NO. (SHWS 2.2)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-2.2 Station Stairs	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Fire Barriers

Applicable Codes, Standards and Design Manual References

Walls 2 hr rating	OBC 3.13.2.1(3)
Floor 2 hr rating	OBC 3.13.2.1(3)
Ceiling Structure 2 hr rating	OBC 3.13.2.1(3)

Documentation Provided

Not Applicable, Insert Design Document References Here

2. Pedestrian Circulation Requirements

Applicable Codes, Standards and Design Manual References

TTC-DM-0402-04, Article 2.0	Platform Occupant Load
TTC-DM-0402-05	Level of Service
TTC-DM-0402-06, Article 3.0	Vertical Circulation
TTC-DM-0402-06, Article 4.0	Surge Spaces, Queuing and Runoff
TCC-DM-0402-06, Article 6.0	Provisions for Means of Escape
TTC-DM-0402-08	Stairs and Stair Platform Lifts
OBC 3.13.2.1(3) and (5), 3.13.4.1	Building Classifications and Occupant Loads
OBC 3.13.4.3	Means of Egress
OBC 3.13.4.4, 3.13.4.5	Egress Capacity

Documentation Provided

Not Applicable, Insert Design Document References Here

3. Barrier Free Access – Trips and Falls

Applicable Codes, Standards and Design Manual References

TTC-DM-0405-00	Barrier Free Access
TTC-DM-0402-06, Articles 6.0	Station Planning, Pedestrian Circulation
OBC 3.8.1.1, 3.13.8.4	Barrier Free Design

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Drainage

   Applicable Codes, Standards and Design Manual References

   OBC 7.4.2.1 Connections to Sanitary Drainage Systems
   TTC DM-0602-03 1.5.5 ad Table 1 Staircases

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Protection

   Applicable Codes, Standards and Design Manual References

   OBC 3.2 Building Fire Safety
   TTC DM-0102-02 Table 1 Wet Standpipe, Extinguisher ABC, Extinguisher Water

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Fire Detection

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Table 1

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 4)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-4 Escalators	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Pedestrian Circulation Requirements

   Applicable Codes, Standards and Design Manual References

TTC-DM-0402-06, Article 3.0	Vertical Circulation
TTC-DM-0402-06, Article 4.0	Surge Spaces, Queuing and Runoff
TCC-DM-0402-06, Article 6.0	Provisions for Means of Escape
TTC-DM-0402-07, Articles 1.2, 1.4	General location and capacity
OBC 3.13.4.3	Means of Egress
OBC 3.13.4.4, 3.13.4.5	Egress Capacity

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Barrier Free Access – Trips and Falls

   Applicable Codes, Standards and Design Manual References

TTC-DM-0405-00	Barrier Free Access
TTC-DM-0402-06, Articles 3.0	Station Planning, Pedestrian Circulation
TTC-DM-0603-03, Article 1.1.4	Smooth Emergency Stop
TTC-DM-0603-03, Article 1.2.2	Safety and Security
TTC-Dm-0603-03, Article 1.2.7.1	Passenger emergency stop buttons

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Drainage

Applicable Codes, Standards and Design Manual References

OBC 7.4.2.1 Connections to Sanitary Drainage Systems
TTC-DM-0402-07, Article 1.5.3 Escalator Pit Drain
TTC DM-0602-03 1.5.1 and Table 1 Escalator Bottom Pit

Documentation Provided

Not Applicable, Insert Design Document References Here

2. <u>Fire Protection</u>

Applicable Codes, Standards and Design Manual References

OBC 3.5.3 Fire Separations
OBC 3.6.3 Vertical service Spaces and Service Facilities
TTC-DM-0402-07, Article 1.5.1 Support Truss Sprinklers
TTC DM-0102-02 Table 1 Escalator Truss, Wet Standpipe, Sprinklers, Extinguisher ABC

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. <u>Power Failure</u>

Applicable Codes, Standards and Design Manual References

TTC-DM-0603-03, Article 1.2.4.7 Hand cranking for emergency at pit

Documentation Provided

Not Applicable, Insert Design Document References Here

2. <u>Power Failure</u>

Applicable Codes, Standards and Design Manual References

TTC-DM-0603-03, Article 1.1.4 Smooth emergency Stop
TTC-DM-0603-03, Article 1.2.2 Safety and security
NFPA 130 Soft Stop Braking

Documentation Provided

Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 5.2)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-5.2 Passenger Station Power	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION – ELECTRICAL

1. <u>Fire Rating / Protection</u>

   Applicable Codes, Standards and Design Manual References

   NFPA 130, Article 7.7 Wiring requirements of Fire Ventilation System
   TTC-DM-0701-10, Article 2.4.9 Penetration of fire rated separations
   TTC-DM-0701-12, Article 1.3.1 Penetration of fire rated assemblies
   TTC-DM-0804-07 02, Article 3.1, 4.1.6 Cable Requirements

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. <u>Power Failure / Redundancy</u>

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-02, Fig 1.3A Passenger Station Fed from Local Traction Power Substation Simplified Block Diagram

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. <u>Failure in Emergency</u>

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-02, Article 2.1

   Documentation Provided

Not Applicable, Insert Design Document References Here

4. Water Ingress Protection

Applicable Codes, Standards and Design Manual References

D1-002, Measures to Prevent Water Ingress Into Electrical Conduits

Documentation Provided

Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 6)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-6 Lighting	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION – ELECTRICAL

1. Grounding

   Applicable Codes, Standards and Design Manual References

   Ontario Electrical Safety Code, 30-110

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Power Failure / Redundancy

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Article 6.0 Emergency Lighting
   TTC-DM-0701-05, Articles 2.5.7, 2.8.5, 2.9.2, 2.10 Emergency Lighting

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Failure in Emergency

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-05, Article 2.10 Emergency Lighting

   Documentation Provided

   Not Applicable, Insert Design Document References Here

4. Water Ingress Protection

Applicable Codes, Standards and Design Manual References D1-002, Measures to Prevent Water Ingress Into Electrical Conduits Documentation Provided *Not Applicable, Insert Design Document References Here*	
Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 7.2)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-7.2 Fire Alarm and Suppression Systems	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION – Mechanical

1. Fire Protection

   Applicable Codes, Standards and Design Manual References

   OBC 3.2 Building Fire Safety
   TTC-DM-0102-02 Fire/Life Safety

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Fire Rating

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-10, Article 2.3.2 Fire Alarm Cables
   TTC-DM-0701-12, Article 1.3.1 Penetration of Fire Rated Assemblies

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Failure in Emergency

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Article 4.2 Normal/Emergency Power Feed

   Documentation Provided

Not Applicable, Insert Design Document References Here	
Complies with above: (System Safety Engineer)	Accepted: (Operations)

Safety Certification Plan – Below Grade Stations

Attachment 1

Scope of Facilities Safety Activities for Platform Edge Door Study			Potential Hazards											
Element	Sub-Elements		Fire	Collision	Derailment	Electric Shock	Electrical & Magnetic Interference	Air Pressure	Power Failure	Failure in Emergency	Water ingress	Flood	Trips and Falls	Pinch Points
Platform Edge Door Study	Emergency Ventilation Equipment	SHWS-1.1	X	None	None	None	None	X	None	None	None	None	None	None
	Provision for Platform Edge Doors	SHWS-1.2	None	None	None	None	None	X	X	X	None	None	X	None
	Ventilation Barriers - Sliding Glass Doors	SHWS-1.3	None	None	None	X	None	X	None	X	None	None	None	X
	Submersible Pump Room	SHWS-1.4	None	None	None	None	None	None	None	None	None	None	None	None
	Elevator and Escalator Room	SHWS-1.5	None	None	None	None	None	None	None	None	None	None	None	None
	Communications Room	SHWS-1.6	X	None	None	X	X	None	None	None	X	None	None	None
	Battery Room	SHWS-1.7	None	None	None	None	None	None	None	None	None	None	None	None
	Power Equipment Room	SHWS-1.8	X	None	None	X	None	None	None	None	X	None	None	None
	Power Substation	SHWS-1.9	X	None	None	X	X	None	X	X	X	X	None	None
	Fare Collection space	SHWS-1.10	None	None	None	None	None	None	None	None	None	None	None	None
	Signals Room	SHWS-1.11	None	None	None	X	None	None	None	None	X	None	None	None
	Cables and Conduits	SHWS-1.12	X	None	None	X	X	None	None	X	None	None	None	None
	Station Platforms	SHWS-2.1	X	X	None	None	None	None	None	None	X	None	X	X
	Station Stairs	SHWS-2.2	None	None	None	None	None	None	None	None	None	None	X	None
	Elevators	SHWS-3	None	None	None	None	None	None	None	None	None	None	None	None
	Escalators	SHWS-4	None	None	None	None	None	None	None	None	None	None	X	None
	Emergency Vent. System Power Supply	SHWS-5.1	None	None	None	X	X	None	None	X	None	None	None	None
	Passenger Station Power	SHWS-5.2	X	None	None	None	X	None	X	X	None	X	None	None
	Lighting	SHWS-6	X	None	None	X	None	None	X	X	X	None	None	None
	Fireman's Access Shaft	SHWS-7.1	None	None	None	None	None	None	None	None	None	None	None	None
	Fire Alarm and Suppression Systems	SHWS-7.2	X	None	None	None	X	None	None	X	None	None	None	None
All Stations	Submersible Pump Systems and	SPSC-1	None	None	None	None	None	None	None	None	None	None	None	None

	Facilities Safety Assurance						Facilities Design									Facilities Construction						Commissioning			Certification
Sub-Elements	Safety Assurance Plan	Safety Specification	Reliability Specification	Safety Assurance Report	Reliability Assurance Report	Reliability Demonstration	Design Contract Number	Proj. Engineering Co-ord	Design Support	Design Report (30%)	Design Report (60%)	Design Report (90%)	Design Report (100%)	Statement of Conformity	Confirmed Deliverables	Construction Package	Resident Superintendent	Construction Records	Installation Records	PICO Report	As-Built Drawings	Integration Test Report	Acceptance Test Report	Pre-Service Test Report	Compliance Certificate
Emergency Ventilation Equipment	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Provision for Platform Edge Doors	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Ventilation Barriers - Sliding Glass Doors	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Submersible Pump Room	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Elevator and Escalator Room	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Communications Room	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Battery Room	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Power Equipment Room	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Power Substation	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Fare Collection space	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Signals Room	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Cables and Conduits	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Station Platforms	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Station Stairs	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Elevators	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Escalators	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Emergency Vent. System Power Supply	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Passenger Station Power	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Lighting	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Fireman's Access Shaft	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Fire Alarm and Suppression Systems	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2+6	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7
Submersible Pump Systems and	1+2	1+2	1+2	1+2	1+2	1+2			2+4	2	2	2	2	2	2			5+7	5+7	5+7	2+5+7	3	3	3+4	!+2+3+4+5+6+7

X Sub-Elements may contribute to, or mitigate against, the hazard
1. System Safety Assurance
2. Section Designer
3. Commissioning Team
4. TTC Operations
5. Resident Superintendant
6. Architect
7. Facilities Contractor

CERTIFICATE NO. (SHWS 1.1)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.1 Emergency Ventilation Equipment	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Room Location and Dimensions

   Applicable Codes, Standards and Design Manual References

   TTC DM-0402-04, Article 3.6.15

   Documentation Provided

   Insert Design Document References Here

2. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Walls 2-hr rating	OBC 3.13.2.1.(3)
Floors 2-hr rating	OBC 3.13.2.1.(3)
Ceiling structure 2-hr rating	OBC 3.13.2.1.(3)
General Requirements	OBC 3.13.7
General Requirements	NFPA 130

   Documentation Provided

   Insert Design Document References Here

3. Door Details

Applicable Codes, Standards and Design Manual References

Door 1.5-hr rating OBC 3.13.3.1.(2)

Documentation Provided

Insert Design Document References Here

VERIFICATION – MECHANICAL

1. Air Pressure

Applicable Codes, Standards and Design Manual References

OBC 6.2.2 Ventilation
TTC DM-0601-02, Article 1.2 Ambient Design Conditions
TTC DM-601-03 Ventilation

Documentation Provided

Insert Design Document References Here

2. Fire Suppression and/or sprinklers

Applicable Codes, Standards and Design Manual References

OBC 3.2 Building Fire Safety
TTC DM-0102-02 Fire/Life Safety

Documentation Provided

Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Power

Applicable Codes, Standards and Design Manual References

Ontario electrical Safety Code 2009
TTC DM-0701-40 articles 2.1.3, 2.2.1

NFPA-130 Articles 7.7

Documentation Provided

Insert Design Document References Here

2. Grounding

   Applicable Codes, Standards and Design Manual References

   Ontario electrical Safety Code 2009, Section 10
   TTC DM-0804-08 Articles 3.0, 4.1

   Documentation Provided

   Insert Design Document References Here

3. Lighting

   Applicable Codes, Standards and Design Manual References

   TTC DM-701-05

   Documentation Provided

   Insert Design Document References Here

4. Fire Detection

   Applicable Codes, Standards and Design Manual References

   TTC DM-102-02 Article 2.7

   Documentation Provided

   Insert Design Document References Here

5. Control

   Applicable Codes, Standards and Design Manual References

   TTC DM-102-05 Article 3.2

   Documentation Provided

   Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 1.2)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.2 Provisions for Platform Edge Doors	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. PED location and dimensions

   Applicable Codes, Standards and Design Manual References

   TYSSE Guidelines for the Provisions of Platform Edge Doors (PEDs), 04SEP2009

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Air pressure

   Applicable Codes, Standards and Design Manual References

   TTC DM-0601-02, Articles 1.2.1 and 1.4.2

   Documentation Provided

   Not applicable to Drawings and Specifications

2. Fire suppression and/or sprinklers

   Applicable Codes, Standards and Design Manual References

   OBC-3.2.3 Spatial Separation and Exposure Protection
   OBC-3.2.5 Provisions for Fire Fighting
   TYSSE Guidelines for the Provision of Platform Edge Doors (PEDs) September 04, 2009

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Power

   Applicable Codes, Standards and Design Manual References

   TYSSE-GUIDELINES for the Provision of PLATFORM EDGE DOORS (PEDs)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Detection

   Applicable Codes, Standards and Design Manual References

   TYSSE-GUIDELINES for the Provision of PLATFORM EDGE DOORS (PEDs)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Grounding

   Applicable Codes, Standards and Design Manual References

   Ontario Electrical Safety Code, Chapter 10

   Documentation Provided

   Not Applicable, Insert Design Document References Here

4. Lighting

   Applicable Codes, Standards and Design Manual References

   TYSSE-GUIDELINES for the Provision of PLATFORM EDGE DOORS (PEDs)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

5. Conduits

   Applicable Codes, Standards and Design Manual References

TYSSE-GUIDELINES for the Provision of PLATFORM EDGE DOORS (PEDs) Documentation Provided *Not Applicable, Insert Design Document References Here*	
Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 1.3)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.3 Ventilation Barriers – Sliding Glass Doors	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. <u>Door Location and Dimensions (related to egress only)</u>

   Applicable Codes, Standards and Design Manual References

   TTC DM-0402-06, Article 7

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. <u>Runoff (queuing for egress only) Space</u>

   Applicable Codes, Standards and Design Manual References

   TTC DM-0402-06, Article 7

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. <u>Emergency or Power Failure Operation</u>

   Applicable Codes, Standards and Design Manual References

Barrier Free	OBC 3.8.1.1, 3.13.8.4
Emergency Power	OBC 3.13.5.7

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Air pressure

   Applicable Codes, Standards and Design Manual References

   OBC 6.2.2 Ventilation
   TTC DM-0601-02, Articles 1.4.1 and 1.4.2

   Documentation Provided

   Not applicable to Drawings and Specifications

2. Fire suppression

   Applicable Codes, Standards and Design Manual References

   OBC-3.2
   TTC DM-0102-02 Fire/Life Safety

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Power

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-06, Article 1.3

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Power Failure

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-02, Article 5.1.4

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Grounding

   Applicable Codes, Standards and Design Manual References

Ontario Electrical Safety Code, Chapter 10 Documentation Provided *Not Applicable, Insert Design Document References Here*	
Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 1.6)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.6 Communications Room	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Room Location and Dimensions

   Applicable Codes, Standards and Design Manual References

   TTC DM-0402-04, Article 3.4.6 (Communications Equipment Room)
   TTC Directive Drawing 0803-01.01, Communications Equipment Room Space Envolope

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Barriers

   Applicable Codes, Standards and Design Manual References

   Communication Equipment Room

Walls 2 hr rating	OBC 3.13.2.1(3) Ground Level
Floor 2 hr rating	OBC 3.13.2.1(3) Ground Level
Ceiling Structure 1 hr rating	OBC 3.13.2.1(3) Roof Level

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Fire Protection

   Applicable Codes, Standards and Design Manual References

   OBC-3.2 Building Fire Safety

TTC DM-0102-02, Table 1 Extinguisher CO2, Extinguisher ABC, Wet Standpipe

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Grounding (shock prevention)

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-10, Article 2.5

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Detection

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Article 2.7 Smoke Detection

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 1.8)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.8 Power Equipment Rooms	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Room Location and Dimensions

   Applicable Codes, Standards and Design Manual References

   TTC DM-0402-04, Article 3.4.1 (AC Switchboard Room)
   TTC DM-0402-04, Article 3.4.2 (AC Switchgear Room)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Walls 1 hr rating	OBC 3.13.2.1(3) Ground Level
Floor N/A	
Ceiling Structure 1 hr rating	OBC 3.13.2.1(3) Roof Level

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Fire Protection

   Applicable Codes, Standards and Design Manual References

   OBC-3.2 Building Fire Safety
   TTC DM-0102-02, Table 1 Extinguisher CO2, Extinguisher ABC, Wet Standpipe

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Grounding (shock prevention)

   Applicable Codes, Standards and Design Manual References

TTC-DM-0701-10, 2.5.3	Ground Bus
TTC-DM-0701-12, 1.10	Grounding

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Detection

   Applicable Codes, Standards and Design Manual References

TTC-DM-0102-02, Table 1	Smoke Detection

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above:	Accepted:
(System Safety Engineer)	(Operations)

CERTIFICATE NO. (SHWS 1.9)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.9 Power Substation	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Room Location and Dimensions

   Applicable Codes, Standards and Design Manual References

TTC DM-0402-04, Article 3.8.1	Hydro Incoming Metering
TTC DM-0402-04, Article 3.8.2	Control Room
TTC DM-0402-04, Article 3.8.7	Rectifier Room
TTC DM-0402-04, Article 3.8.8	Transformer Yard
TTC DM-0804-06	Electrical Substations
TTC DM-0804-01, Article 3.6.1	Substation Location and Arrangement

   TTC DM-0402-04, Article 3.4.2 (AC Switchgear Room)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Substation Rooms	
Walls 2 hr rating	OBC 3.13.2.1(3) Ground Level
Floor N/A	
Ceiling Structure 1 hr rating	OBC 3.13.2.1(3) Roof Level

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. <u>Flood Prevention</u>

Applicable Codes, Standards and Design Manual References

TTC-DM-0804-06, Article 3.1.8 Raised Door Sill

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. <u>Fire Protection</u>

Applicable Codes, Standards and Design Manual References

OBC, 7.4.2.1. Connections to Sanitary Drainage Systems
OBC-3.2 Building Fire Safety
TTC DM-0102-02, Table 1 Extinguisher CO2, Extinguisher ABC, Fire Hydrant

Documentation Provided

Not Applicable, Insert Design Document References Here

2. <u>Yard Drainage</u>

Applicable Codes, Standards and Design Manual References

TTC DM-0804-06, Article 4.1.2 Transformer Yard Drainage

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. <u>Grounding (shock prevention)</u>

Applicable Codes, Standards and Design Manual References

Ontario Electrical Safety Code, Section 36-300
TTC-DM-0804-08, 4.2, 4.1.5, 4.5.1

Documentation Provided

Not Applicable, Insert Design Document References Here

2. <u>Power Failure / Redundancy</u>

Applicable Codes, Standards and Design Manual References

TTC-DM-0804-01, 3.3.1

Documentation Provided

Not Applicable, Insert Design Document References Here

3. <u>Fire Detection</u>

Applicable Codes, Standards and Design Manual References

TTC-DM-0102-02, Table 1	Smoke Detection

Documentation Provided

Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 1.11)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.11 Signals Room	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Room Location and Dimensions

   Applicable Codes, Standards and Design Manual References

   TTC DM-0402-04, Article 3.7.3 — Signal Power Supply Room

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Walls 3 hr rating	OBC 3.13.2.1(3)
Floor 2 hr rating	OBC 3.13.2.1(3)
Ceiling Structure 2 hr rating	OBC 3.13.2.1(3)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Fire Protection

   Applicable Codes, Standards and Design Manual References

   OBC 3.13.3 Safety Requirements Within Stations
   OBC 3.6.2.7 Electrical Equipment Vaults
   OBC 3.5.3 Fire Separations
   OBC 3.6.3 Vertical Service Spaces and Service Facilities

TTC DM-0102-02, Table 1 Extinguisher CO2, Extinguisher ABC, Wet Standpipe

Documentation Provided

Not Applicable, Insert Design Document References Here

2. Eye Wash

   Applicable Codes, Standards and Design Manual References

   OBC 7.4.2.1 Connections to Sanitary Drainage Systems
   TTC DM-0402-04, Article 3.7.3 Signal Power Supply Room

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Grounding (shock prevention)

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-10, Article 2.5

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Detection

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Table 1 Smoke Detection

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above:	Accepted:
(System Safety Engineer)	(Operations)

CERTIFICATE NO. (SHWS 1.12)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-1.12 Cables and Conduits	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION – ELECTRICAL

1. <u>Fire Protection</u>

   Applicable Codes, Standards and Design Manual References

   Ontario Electrical Safety Code
   TTC-DM-0701-12, Article 1.3.1
   NFPA 130, Chapter 7

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. <u>Grounding (shock prevention)</u>

   Applicable Codes, Standards and Design Manual References

   Ontario Electrical Safety Code, Section 10
   TTC-DM-0701-12, Article 1.10

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above:	Accepted:
(System Safety Engineer)	(Operations)

CERTIFICATE NO. (SHWS 2.1)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-2.1 Station Platforms	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Walls N/A to platform	
Floor 2 hr rating	OBC 3.13.2.1(3)
Ceiling Structure 2 hr rating	OBC 3.13.2.1(3)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Pedestrian Circulation Requirements

   Applicable Codes, Standards and Design Manual References

TTC-DM-0402-04, Article 2.0	Platform Occupant Load
TTC-DM-0402-06, Articles 2.0, 4.0, 6.0	Station Planning, Pedestrian Circulation
OBC 3.13.4.1	Occupant Load

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Barrier Free Access – Trips and Falls

   Applicable Codes, Standards and Design Manual References

TTC-DM-0405-00	Barrier Free Access
TTC-DM-0402-06, Articles 6.0	Station Planning, Pedestrian Circulation
OBC 3.8.1.1, 3.13.8.4	Barrier Free Design

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION - Structural

1. Collision Prevention

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0205-01, Vehicle Clearance Envelope
   TTC-DM-0205-01, Fig 2.2.2
   TYSSE Design Guideline (Sep 04 2009), Guidelines for the Provision of Platform Edge Doors (PEDs)
   OBC 4.1.5.15, Crowd horizontal live load
   TTC-DM-0301-02, Article 3.3.4, Train Piston Effect
   TTC-DM-0301-02, Article 3.2.11, Floor and Miscellaneous Live Load

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Water Ingress

   Applicable Codes, Standards and Design Manual References

   DI-009, Measures to Minimize Concrete Cracking and Prevent Water

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Ventilation

   Applicable Codes, Standards and Design Manual References

   OBC 6.2.2 Ventilation
   TTC-DM-0102-02 Fire/Safety, Article 3.0 Ventilation
   TTC-DM-0601-02 Ventilation, Articles 1.2.1, Internal Ambient Design Conditions, 1.4.2.1, Public and Tunnel Areas
   TTC DM-0601-03 Ventilation, Article 1.2. Station and Tunnel Design Conditions

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Drainage

Applicable Codes, Standards and Design Manual References

OBC 7.4.2.1 Connections to Sanitary Drainage Systems
TTC DM-0602-03, Article 1.5.4

Documentation Provided

Not Applicable, Insert Design Document References Here

3. Fire Protection

Applicable Codes, Standards and Design Manual References

OBC 3.2 Building Fire Safety
TTC DM-0102-02 Table 1 Wet Standpipe, Extinguisher ABC, Extinguisher Water

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Fire Detection

Applicable Codes, Standards and Design Manual References

TTC-DM-0102-02, Table 1

Documentation Provided

Not Applicable, Insert Design Document References Here

2. Lighting

Applicable Codes, Standards and Design Manual References

OBC 3.13.3.7
TTC-DM-0701-05, Articles 2.5.3, 2.5.4, 2.5.6, 2.5.7, 2.10.2

Documentation Provided

Not Applicable, Insert Design Document References Here

Complies with above:	Accepted:
(System Safety Engineer)	(Operations)

CERTIFICATE NO. (SHWS 2.2)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-2.2 Station Stairs	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Fire Barriers

   Applicable Codes, Standards and Design Manual References

Walls 2 hr rating	OBC 3.13.2.1(3)
Floor 2 hr rating	OBC 3.13.2.1(3)
Ceiling Structure 2 hr rating	OBC 3.13.2.1(3)

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Pedestrian Circulation Requirements

   Applicable Codes, Standards and Design Manual References

TTC-DM-0402-04, Article 2.0	Platform Occupant Load
TTC-DM-0402-05	Level of Service
TTC-DM-0402-06, Article 3.0	Vertical Circulation
TTC-DM-0402-06, Article 4.0	Surge Spaces, Queuing and Runoff
TCC-DM-0402-06, Article 6.0	Provisions for Means of Escape
TTC-DM-0402-08	Stairs and Stair Platform Lifts
OBC 3.13.2.1(3) and (5), 3.13.4.1	Building Classifications and Occupant Loads
OBC 3.13.4.3	Means of Egress
OBC 3.13.4.4, 3.13.4.5	Egress Capacity

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Barrier Free Access – Trips and Falls

Applicable Codes, Standards and Design Manual References

TTC-DM-0405-00	Barrier Free Access
TTC-DM-0402-06, Articles 6.0	Station Planning, Pedestrian Circulation
OBC 3.8.1.1, 3.13.8.4	Barrier Free Design

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Drainage

   Applicable Codes, Standards and Design Manual References

   OBC 7.4.2.1 Connections to Sanitary Drainage Systems
   TTC DM-0602-03 1.5.5 ad Table 1 Staircases

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Fire Protection

   Applicable Codes, Standards and Design Manual References

   OBC 3.2 Building Fire Safety
   TTC DM-0102-02 Table 1 Wet Standpipe, Extinguisher ABC, Extinguisher Water

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Fire Detection

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Table 1

   Documentation Provided

   Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 4)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-4 Escalators	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION - ARCHITECTURAL

1. Pedestrian Circulation Requirements

   Applicable Codes, Standards and Design Manual References

TTC-DM-0402-06, Article 3.0	Vertical Circulation
TTC-DM-0402-06, Article 4.0	Surge Spaces, Queuing and Runoff
TCC-DM-0402-06, Article 6.0	Provisions for Means of Escape
TTC-DM-0402-07, Articles 1.2, 1.4	General location and capacity
OBC 3.13.4.3	Means of Egress
OBC 3.13.4.4, 3.13.4.5	Egress Capacity

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Barrier Free Access – Trips and Falls

   Applicable Codes, Standards and Design Manual References

TTC-DM-0405-00	Barrier Free Access
TTC-DM-0402-06, Articles 3.0	Station Planning, Pedestrian Circulation
TTC-DM-0603-03, Article 1.1.4	Smooth Emergency Stop
TTC-DM-0603-03, Article 1.2.2	Safety and Security
TTC-Dm-0603-03, Article 1.2.7.1	Passenger emergency stop buttons

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION - MECHANICAL

1. Drainage

Applicable Codes, Standards and Design Manual References

OBC 7.4.2.1 Connections to Sanitary Drainage Systems
TTC-DM-0402-07, Article 1.5.3 Escalator Pit Drain
TTC DM-0602-03 1.5.1 and Table 1 Escalator Bottom Pit

Documentation Provided

Not Applicable, Insert Design Document References Here

2. <u>Fire Protection</u>

Applicable Codes, Standards and Design Manual References

OBC 3.5.3 Fire Separations
OBC 3.6.3 Vertical service Spaces and Service Facilities
TTC-DM-0402-07, Article 1.5.1 Support Truss Sprinklers
TTC DM-0102-02 Table 1 Escalator Truss, Wet Standpipe, Sprinklers, Extinguisher ABC

Documentation Provided

Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. <u>Power Failure</u>

Applicable Codes, Standards and Design Manual References

TTC-DM-0603-03, Article 1.2.4.7 Hand cranking for emergency at pit

Documentation Provided

Not Applicable, Insert Design Document References Here

2. <u>Power Failure</u>

Applicable Codes, Standards and Design Manual References

TTC-DM-0603-03, Article 1.1.4 Smooth emergency Stop
TTC-DM-0603-03, Article 1.2.2 Safety and security
NFPA 130 Soft Stop Braking

Documentation Provided

Not Applicable, Insert Design Document References Here

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 5.1)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-5.1 Power Supply Equipment for Emergency Ventilation System	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION – ELECTRICAL

1. <u>Grounding (shock prevention)</u>

   Applicable Codes, Standards and Design Manual References

TTC-DM-0701-10, 2.5.3	Ground Bus
TTC-DM-0701-12, 1.10	Grounding

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. <u>Emergency Operation</u>

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Article 4.1 Alternate Power Feeds

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. <u>Power Supply</u>

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Article 4.1 Alternate Power Feeds

   Documentation Provided

   Not Applicable, Insert Design Document References Here

4. <u>Control Panel</u>

Applicable Codes, Standards and Design Manual References TTC-DM-0102-05, Article 3.2 Emergency Fan Control Panel Documentation Provided *Not Applicable, Insert Design Document References Here*	
Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 5.2)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-5.2 Passenger Station Power	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION – ELECTRICAL

1. Fire Rating / Protection

   Applicable Codes, Standards and Design Manual References

   NFPA 130, Article 7.7 Wiring requirements of Fire Ventilation System
   TTC-DM-0701-10, Article 2.4.9 Penetration of fire rated separations
   TTC-DM-0701-12, Article 1.3.1 Penetration of fire rated assemblies
   TTC-DM-0804-07 02, Article 3.1, 4.1.6 Cable Requirements

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Power Failure / Redundancy

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-02, Fig 1.3A Passenger Station Fed from Local Traction Power Substation Simplified Block Diagram

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Failure in Emergency

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-02, Article 2.1

   Documentation Provided

Not Applicable, Insert Design Document References Here 4. <u>Water Ingress Protection</u> Applicable Codes, Standards and Design Manual References D1-002, Measures to Prevent Water Ingress Into Electrical Conduits Documentation Provided *Not Applicable, Insert Design Document References Here*	
Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 6)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-6 Lighting	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION – ELECTRICAL

1. Grounding

   Applicable Codes, Standards and Design Manual References

   Ontario Electrical Safety Code, 30-110

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Power Failure / Redundancy

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Article 6.0 Emergency Lighting
   TTC-DM-0701-05, Articles 2.5.7, 2.8.5, 2.9.2, 2.10 Emergency Lighting

   Documentation Provided

   Not Applicable, Insert Design Document References Here

3. Failure in Emergency

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-05, Article 2.10 Emergency Lighting

   Documentation Provided

   Not Applicable, Insert Design Document References Here

4. Water Ingress Protection

Applicable Codes, Standards and Design Manual References D1-002, Measures to Prevent Water Ingress Into Electrical Conduits Documentation Provided *Not Applicable, Insert Design Document References Here*

Complies with above: (System Safety Engineer)	Accepted: (Operations)

CERTIFICATE NO. (SHWS 7.2)

TORONTO TRANSIT COMMISSION
SAFETY CERTIFICATION
CERTIFICATE OF COMPLIANCE

Completion of this permit indicates that the certifiable element described below complies with all applicable TTC safety criteria for public use.

CERTIFIABLE ELEMENT NUMBER & NAME: SHWS-7.2 Fire Alarm and Suppression Systems	DATE OF PERMIT:

RESTRICTIONS STATUS & CLOSURE REQUIREMENTS:

None

VERIFICATION – Mechanical

1. Fire Protection

   Applicable Codes, Standards and Design Manual References

   OBC 3.2 Building Fire Safety
   TTC-DM-0102-02 Fire/Life Safety

   Documentation Provided

   Not Applicable, Insert Design Document References Here

VERIFICATION – ELECTRICAL

1. Fire Rating

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0701-10, Article 2.3.2 Fire Alarm Cables
   TTC-DM-0701-12, Article 1.3.1 Penetration of Fire Rated Assemblies

   Documentation Provided

   Not Applicable, Insert Design Document References Here

2. Failure in Emergency

   Applicable Codes, Standards and Design Manual References

   TTC-DM-0102-02, Article 4.2 Normal/Emergency Power Feed

   Documentation Provided

Not Applicable, Insert Design Document References Here	
Complies with above: (System Safety Engineer)	Accepted: (Operations)

Appendix F

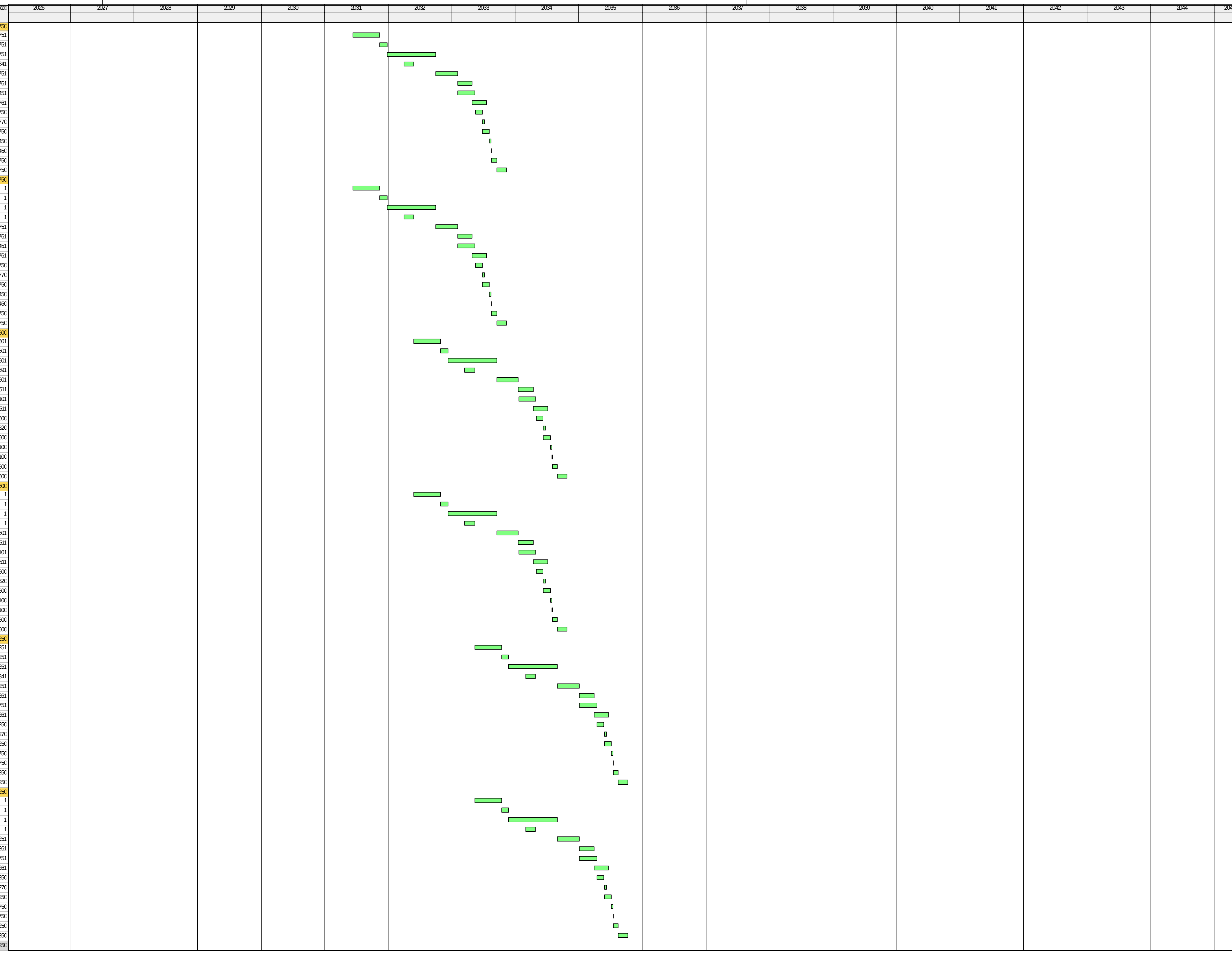
Construction Schedule

Activity ID	Activity Name	Original Duration	Start	Finish	Total Float
PEDs-4station		3801	01-Jan-26	26-Jul-40	0
PEDs Program (Line 1, 2 & 4) High Level Plan - Design Build		3801	01-Jan-26	26-Jul-40	0
Milestones		3801	01-Jan-26	26-Jul-40	0
M-1000	Phase 1- PED Pilot Start	0	01-Jan-26		3801
M-1040	Phase 1- PED Pilot Completion	0		12-Jul-29*	1035
M-1060	Phase 2 -Line 1 Start	0	12-Jul-29		2880
M-1010	Phase 3 -Line 2 Start	0	27-Apr-34		1630
M-1080	Phase 2 -Line 1 Completion	0		11-Oct-35	1250
M-1050	Phase 4 -Line 4 Start	0	25-Feb-38		630
M-1030	Phase 3 -Line 2 Completion	0		11-Aug-39	250
M-1070	Phase 4 -Line 4 Completion	0		26-Jul-40	0
Phase 1 -PED Pilot		921	01-Jan-26	12-Jul-29	2880
PED-1000	Planning / Preliminary Design of PED Pilot	110	01-Jan-26	03-Jun-26	3
PED-1010	Tendering PED Pilot	122	04-Jun-26	20-Nov-26	3
PED-1011	NTP-Design Build	30	23-Nov-26	01-Jan-27	3
PED-1020	Design of PED Pilot	200	04-Jan-27	08-Oct-27	3
PED-1021	Shop Drawings	40	12-Apr-27	04-Jun-27	3
PED-1022	One-Time Qualification Testing	124	07-Jun-27	25-Nov-27	3
PED-1024	Electrical Door & Exciting Sighage Rough-In	90	30-Aug-27	31-Dec-27	94
PED-1022-1	Manufacturing	90	26-Nov-27	30-Mar-28	3
PED-1026	Relocate Excisting Sighage & Lighting to Accomodate PED	55	03-Jan-28	17-Mar-28	3224
PED-1025	Instal PED Controlers in Electrical Room & Energize	40	28-Jan-28	23-Mar-28	75
PED-1050	Factory Acceptance Testing	7	31-Mar-28	10-Apr-28	3
PED-1023	Platform Structural Improvments	100	31-Mar-28	08-Jul-28	4401
PED-1060	Packaging / Shipping to Site	60	11-Apr-28	03-Jul-28	3
PED-1027	Instal PED Panels	8	04-Jul-28	11-Jul-28	3
PED-1028	Terminate PED Electical Connections	3	12-Jul-28	14-Jul-28	3
PED-1070	Component System Testing	80	14-Jul-28	03-Nov-28	1
PED-1080	Site Acceptance Testing	50	03-Nov-28	12-Jan-29	1
PED-1075	Commissioning	21	03-Nov-28	04-Dec-28	3038
PED-1090	Pilot Review-Lessons learned	129	12-Jan-29	12-Jul-29	1
Phase 2- Line 1		1630	12-Jul-29	11-Oct-35	1250
Package 2A		630	12-Jul-29	11-Dec-31	2250
P-2A-1010	Primerely Design, Tendering- PED Package 2A	110	12-Jul-29	13-Dec-29	2251
P-2A-1020	NTP-Design Build	30	13-Dec-29	24-Jan-30	2251
P-2A-1030	Design of PED Package 2A	200	24-Jan-30	31-Oct-30	2251
P-2A-1040	Shop Drawings	40	02-May-30	27-Jun-30	2341
P-2A-1041	Manufacturing	90	31-Oct-30	06-Mar-31	2251
P-2A-1080	Factory Acceptance Testing	60	06-Mar-31	29-May-31	2261
P-2A-1050	Platform Stractural Improvments	100	07-Mar-31	14-Jun-31	3151
P-2A-1090	Packaging / Shipping to Site	60	29-May-31	21-Aug-31	2261
P-2A-1060	Electrical Door & Exciting Sighnage Rough-In	30	16-Jun-31	25-Jul-31	2250
P-2A-1061	Instal PED Controlers in Electrical Room & Energize	10	28-Jul-31	08-Aug-31	2270
P-2A-1062	Relocate Excisting Sighage & Lightning to Accomodate PED	30	28-Jul-31	05-Sep-31	2250
P-2A-1063	Instal PED Panels	10	06-Sep-31	15-Sep-31	3150
P-2A-1064	Terminate PED Electrical Connections	3	16-Sep-31	18-Sep-31	3150
P-2A-1100	Commissioning	20	18-Sep-31	16-Oct-31	2250
P-2A-1110	Site Acceptance Testing	40	16-Oct-31	11-Dec-31	2250
Package 2B		630	12-Jul-29	11-Dec-31	2250
P-2B-1570	Primerely Design, Tendering- PED Package 2B	110	12-Jul-29	13-Dec-29	1
P-2B-1580	NTP-Design Build	30	13-Dec-29	24-Jan-30	1
P-2B-1590	Design of PED Package 2B	200	24-Jan-30	31-Oct-30	1
P-2B-1600	Shop Drawings	40	02-May-30	27-Jun-30	1
P-2B-1610	Manufacturing	90	31-Oct-30	06-Mar-31	2251
P-2B-1680	Factory Acceptance Testing	60	06-Mar-31	29-May-31	2261
P-2B-1620	Platform Stractural Improvments	100	07-Mar-31	14-Jun-31	3151
P-2B-1690	Packaging / Shipping to Site	60	29-May-31	21-Aug-31	2261
P-2B-1630	Electrical Door & Exciting Sighnage Rough-In	30	16-Jun-31	25-Jul-31	2250
P-2B-1640	Instal PED Controlers in Electrical Room & Energize	10	28-Jul-31	08-Aug-31	2270
P-2B-1650	Relocate Excisting Sighage & Lightning to Accomodate PED	30	28-Jul-31	05-Sep-31	2250
P-2B-1660	Instal PED Panels	10	06-Sep-31	15-Sep-31	3150
P-2B-1670	Terminate PED Electrical Connections	3	16-Sep-31	18-Sep-31	3150
P-2B-1700	Commissioning	20	18-Sep-31	16-Oct-31	2250
P-2B-1710	Site Acceptance Testing	40	16-Oct-31	11-Dec-31	2250
Package 3A		630	27-Jun-30	25-Nov-32	2000
P-3A-1420	Primerely Design, Tendering- PED Package 3A	110	27-Jun-30	28-Nov-30	1
P-3A-1430	NTP-Design Build	30	28-Nov-30	09-Jan-31	1
P-3A-1440	Design of PED Package 3A	200	09-Jan-31	16-Oct-31	1
P-3A-1450	Shop Drawings	40	17-Apr-31	12-Jun-31	1
P-3A-1460	Manufacturing	90	16-Oct-31	19-Feb-32	2001
P-3A-1530	Factory Acceptance Testing	60	19-Feb-32	13-May-32	2011
P-3A-1470	Platform Stractural Improvments	100	20-Feb-32	29-May-32	2801
P-3A-1540	Packaging / Shipping to Site	60	13-May-32	05-Aug-32	2011
P-3A-1480	Electrical Door & Exciting Sighnage Rough-In	30	31-May-32	09-Jul-32	2000
P-3A-1490	Instal PED Controlers in Electrical Room & Energize	10	12-Jul-32	23-Jul-32	2020
P-3A-1500	Relocate Excisting Sighage & Lightning to Accomodate PED	30	12-Jul-32	20-Aug-32	2000
P-3A-1510	Instal PED Panels	10	21-Aug-32	30-Aug-32	2800
P-3A-1520	Terminate PED Electrical Connections	3	31-Aug-32	02-Sep-32	2800
P-3A-1550	Commissioning	20	02-Sep-32	30-Sep-32	2000
P-3A-1560	Site Acceptance Testing	40	30-Sep-32	25-Nov-32	2000
Package 3B		630	27-Jun-30	25-Nov-32	2000
P-3B-1420	Primerely Design, Tendering- PED Package 3B	110	27-Jun-30	28-Nov-30	2001
P-3B-1430	NTP-Design Build	30	28-Nov-30	09-Jan-31	2001
P-3B-1440	Design of PED Package 3B	200	09-Jan-31	16-Oct-31	2001
P-3B-1450	Shop Drawings	40	17-Apr-31	12-Jun-31	2091
P-3B-1460	Manufacturing	90	16-Oct-31	19-Feb-32	2001
P-3B-1530	Factory Acceptance Testing	60	19-Feb-32	13-May-32	2011
P-3B-1470	Platform Stractural Improvments	100	20-Feb-32	29-May-32	2801
P-3B-1540	Packaging / Shipping to Site	60	13-May-32	05-Aug-32	2011
P-3B-1480	Electrical Door & Exciting Sighnage Rough-In	30	31-May-32	09-Jul-32	2000
P-3B-1490	Instal PED Controlers in Electrical Room & Energize	10	12-Jul-32	23-Jul-32	2020
P-3B-1500	Relocate Excisting Sighage & Lightning to Accomodate PED	30	12-Jul-32	20-Aug-32	2000
P-3B-1510	Instal PED Panels	10	21-Aug-32	30-Aug-32	2800
P-3B-1520	Terminate PED Electrical Connections	3	31-Aug-32	02-Sep-32	2800
P-3B-1550	Commissioning	20	02-Sep-32	30-Sep-32	2000
P-3B-1560	Site Acceptance Testing	40	30-Sep-32	25-Nov-32	2000

Remaining Level of Effort | Actual Level of Effort | Remaining Work
WBS Summary | Actual Work | Critical Remaining Work

TASK filter: All Activities

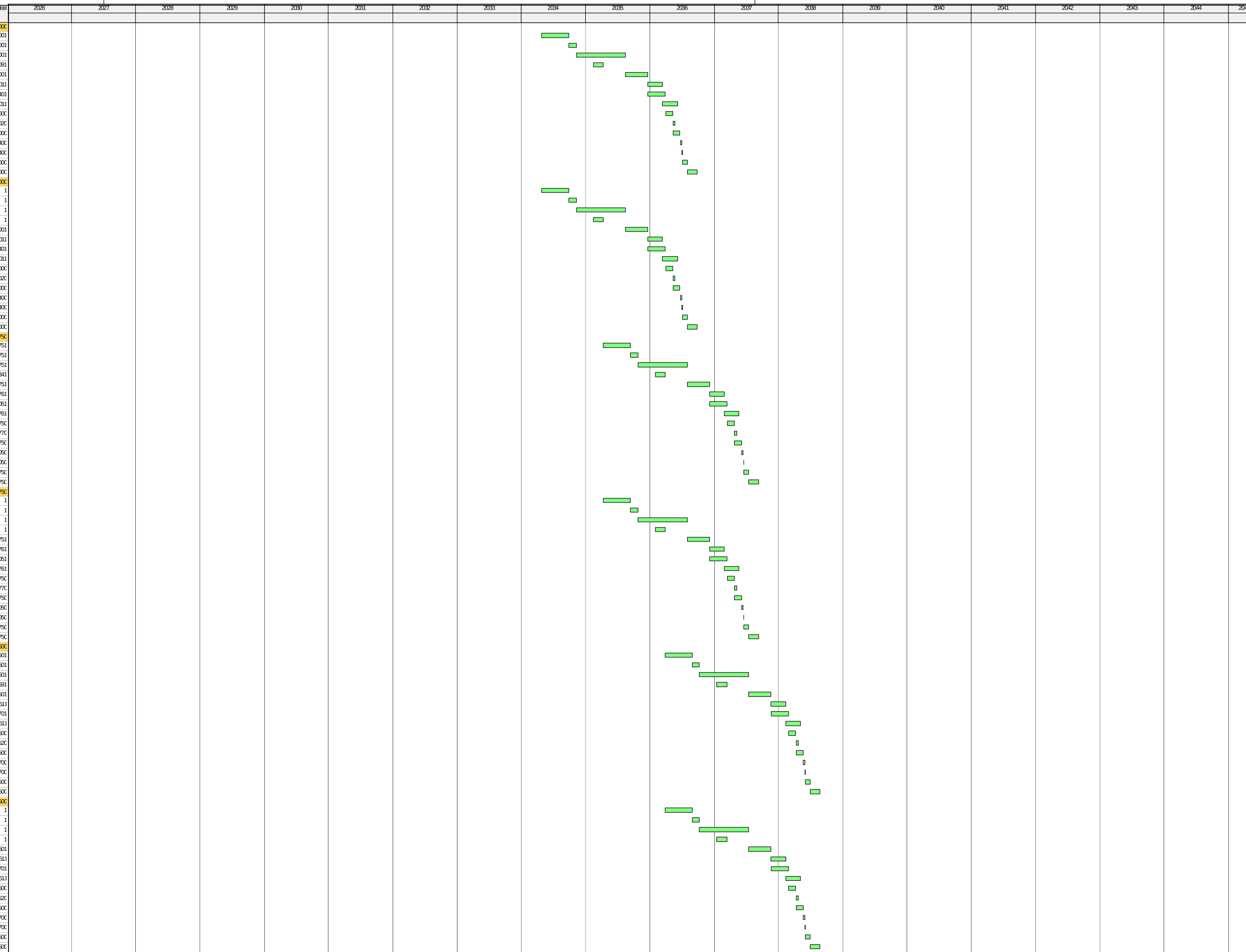
Activity ID	Activity Name	Original Duration	Start	Finish	Total Float
Package 4A		630	12-Jun-31	10-Nov-33	1750
P-4A-1280	Primerely Design, Tendering- PED Package 4A	110	12-Jun-31	13-Nov-31	1751
P-4A-1290	NTP-Design Bulid	30	13-Nov-31	25-Dec-31	1751
P-4A-1300	Design of PED Package 4A	200	25-Dec-31	30-Sep-32	1751
P-4A-1310	Shop Drawings	40	01-Apr-32	27-May-32	1841
P-4A-1320	Manufacturing	90	30-Sep-32	03-Feb-33	1751
P-4A-1390	Factory Acceptance Testing	60	03-Feb-33	28-Apr-33	1761
P-4A-1330	Platform Stractural Improvments	100	04-Feb-33	14-May-33	2451
P-4A-1400	Packaging / Shipping to Site	60	28-Apr-33	21-Jul-33	1761
P-4A-1340	Electrical Door & Exciting Sighnage Rough-In	30	16-May-33	24-Jun-33	1750
P-4A-1350	Instal PED Controlers in Electrical Room & Energize	10	27-Jun-33	08-Jul-33	1770
P-4A-1360	Relocate Excisting Sighage & Lightning to Accomodate PED	30	27-Jun-33	05-Aug-33	1750
P-4A-1370	Instal PED Panels	10	06-Aug-33	15-Aug-33	2450
P-4A-1380	Terminate PED Electrical Connections	3	16-Aug-33	18-Aug-33	2450
P-4A-1410	Commissioning	20	18-Aug-33	15-Sep-33	1750
P-4A-1420	Site Acceptance Testing	40	15-Sep-33	10-Nov-33	1750
Package 4B		630	12-Jun-31	10-Nov-33	1750
P-4B-1280	Primerely Design, Tendering- PED Package 4B	110	12-Jun-31	13-Nov-31	1
P-4B-1290	NTP-Design Bulid	30	13-Nov-31	25-Dec-31	1
P-4B-1300	Design of PED Package 4B	200	25-Dec-31	30-Sep-32	1
P-4B-1310	Shop Drawings	40	01-Apr-32	27-May-32	1
P-4B-1320	Manufacturing	90	30-Sep-32	03-Feb-33	1751
P-4B-1390	Factory Acceptance Testing	60	03-Feb-33	28-Apr-33	1761
P-4B-1330	Platform Stractural Improvments	100	04-Feb-33	14-May-33	2451
P-4B-1400	Packaging / Shipping to Site	60	28-Apr-33	21-Jul-33	1761
P-4B-1340	Electrical Door & Exciting Sighnage Rough-In	30	16-May-33	24-Jun-33	1750
P-4B-1350	Instal PED Controlers in Electrical Room & Energize	10	27-Jun-33	08-Jul-33	1770
P-4B-1360	Relocate Excisting Sighage & Lightning to Accomodate PED	30	27-Jun-33	05-Aug-33	1750
P-4B-1370	Instal PED Panels	10	06-Aug-33	15-Aug-33	2450
P-4B-1380	Terminate PED Electrical Connections	3	16-Aug-33	18-Aug-33	2450
P-4B-1410	Commissioning	20	18-Aug-33	15-Sep-33	1750
P-4B-1420	Site Acceptance Testing	40	15-Sep-33	10-Nov-33	1750
Package 5A		630	27-May-32	26-Oct-34	1500
P-5A-1280	Primerely Design, Tendering- PED Package 5A	110	27-May-32	28-Oct-32	1501
P-5A-1290	NTP-Design Bulid	30	28-Oct-32	09-Dec-32	1501
P-5A-1300	Design of PED Package 5A	200	09-Dec-32	15-Sep-33	1501
P-5A-1310	Shop Drawings	40	17-Mar-33	12-May-33	1591
P-5A-1320	Manufacturing	90	15-Sep-33	19-Jan-34	1501
P-5A-1390	Factory Acceptance Testing	60	19-Jan-34	13-Apr-34	1511
P-5A-1330	Platform Stractural Improvments	100	20-Jan-34	29-Apr-34	2101
P-5A-1400	Packaging / Shipping to Site	60	13-Apr-34	06-Jul-34	1511
P-5A-1340	Electrical Door & Exciting Sighnage Rough-In	30	01-May-34	09-Jun-34	1500
P-5A-1350	Instal PED Controlers in Electrical Room & Energize	10	12-Jun-34	23-Jun-34	1520
P-5A-1360	Relocate Excisting Sighage & Lightning to Accomodate PED	30	12-Jun-34	21-Jul-34	1500
P-5A-1370	Instal PED Panels	10	22-Jul-34	31-Jul-34	2100
P-5A-1380	Terminate PED Electrical Connections	3	01-Aug-34	03-Aug-34	2100
P-5A-1410	Commissioning	20	03-Aug-34	31-Aug-34	1500
P-5A-1420	Site Acceptance Testing	40	31-Aug-34	26-Oct-34	1500
Package 5B		630	27-May-32	26-Oct-34	1500
P-5B-1280	Primerely Design, Tendering- PED Package 5B	110	27-May-32	28-Oct-32	1
P-5B-1290	NTP-Design Bulid	30	28-Oct-32	09-Dec-32	1
P-5B-1300	Design of PED Package 5B	200	09-Dec-32	15-Sep-33	1
P-5B-1310	Shop Drawings	40	17-Mar-33	12-May-33	1
P-5B-1320	Manufacturing	90	15-Sep-33	19-Jan-34	1501
P-5B-1390	Factory Acceptance Testing	60	19-Jan-34	13-Apr-34	1511
P-5B-1330	Platform Stractural Improvments	100	20-Jan-34	29-Apr-34	2101
P-5B-1400	Packaging / Shipping to Site	60	13-Apr-34	06-Jul-34	1511
P-5B-1340	Electrical Door & Exciting Sighnage Rough-In	30	01-May-34	09-Jun-34	1500
P-5B-1350	Instal PED Controlers in Electrical Room & Energize	10	12-Jun-34	23-Jun-34	1520
P-5B-1360	Relocate Excisting Sighage & Lightning to Accomodate PED	30	12-Jun-34	21-Jul-34	1500
P-5B-1370	Instal PED Panels	10	22-Jul-34	31-Jul-34	2100
P-5B-1380	Terminate PED Electrical Connections	3	01-Aug-34	03-Aug-34	2100
P-5B-1410	Commissioning	20	03-Aug-34	31-Aug-34	1500
P-5B-1420	Site Acceptance Testing	40	31-Aug-34	26-Oct-34	1500
Package 6A		630	12-May-33	11-Oct-35	1250
P-6A-1430	Primerely Design, Tendering- PED Package 6A	110	12-May-33	13-Oct-33	1251
P-6A-1440	NTP-Design Bulid	30	13-Oct-33	24-Nov-33	1251
P-6A-1450	Design of PED Package 6A	200	24-Nov-33	31-Aug-34	1251
P-6A-1460	Shop Drawings	40	02-Mar-34	27-Apr-34	1341
P-6A-1470	Manufacturing	90	31-Aug-34	04-Jan-35	1251
P-6A-1540	Factory Acceptance Testing	60	04-Jan-35	29-Mar-35	1261
P-6A-1480	Platform Stractural Improvments	100	05-Jan-35	14-Apr-35	1751
P-6A-1550	Packaging / Shipping to Site	60	29-Mar-35	21-Jun-35	1261
P-6A-1490	Electrical Door & Exciting Sighnage Rough-In	30	16-Apr-35	25-May-35	1250
P-6A-1500	Instal PED Controlers in Electrical Room & Energize	10	28-May-35	08-Jun-35	1270
P-6A-1510	Relocate Excisting Sighage & Lightning to Accomodate PED	30	28-May-35	06-Jul-35	1250
P-6A-1520	Instal PED Panels	10	07-Jul-35	16-Jul-35	1750
P-6A-1530	Terminate PED Electrical Connections	3	17-Jul-35	19-Jul-35	1750
P-6A-1560	Commissioning	20	19-Jul-35	16-Aug-35	1250
P-6A-1570	Site Acceptance Testing	40	16-Aug-35	11-Oct-35	1250
Package 6B		630	12-May-33	11-Oct-35	1250
P-6B-1280	Primerely Design, Tendering- PED Package 6B	110	12-May-33	13-Oct-33	1
P-6B-1290	NTP-Design Bulid	30	13-Oct-33	24-Nov-33	1
P-6B-1300	Design of PED Package 6B	200	24-Nov-33	31-Aug-34	1
P-6B-1310	Shop Drawings	40	02-Mar-34	27-Apr-34	1
P-6B-1320	Manufacturing	90	31-Aug-34	04-Jan-35	1251
P-6B-1390	Factory Acceptance Testing	60	04-Jan-35	29-Mar-35	1261
P-6B-1330	Platform Stractural Improvments	100	05-Jan-35	14-Apr-35	1751
P-6B-1400	Packaging / Shipping to Site	60	29-Mar-35	21-Jun-35	1261
P-6B-1340	Electrical Door & Exciting Sighnage Rough-In	30	16-Apr-35	25-May-35	1250
P-6B-1350	Instal PED Controlers in Electrical Room & Energize	10	28-May-35	08-Jun-35	1270
P-6B-1360	Relocate Excisting Sighage & Lightning to Accomodate PED	30	28-May-35	06-Jul-35	1250
P-6B-1370	Instal PED Panels	10	07-Jul-35	16-Jul-35	1750
P-6B-1380	Terminate PED Electrical Connections	3	17-Jul-35	19-Jul-35	1750
P-6B-1410	Commissioning	20	19-Jul-35	16-Aug-35	1250
P-6B-1420	Site Acceptance Testing	40	16-Aug-35	11-Oct-35	1250
Phase 3- Line 2		1380	27-Apr-34	11-Aug-39	250



Remaining Level of Effort
Actual Level of Effort
Remaining Work
WBS Summary
Actual Work
Critical Remaining Work

TASK filter: All Activities

Activity ID	Activity Name	Original Duration	Start	Finish	Total Float
Package 8A		630	27-Apr-34	25-Sep-36	1000
P-8A-1010	Primerely Design, Tendering- PED Package 8A	110	27-Apr-34	28-Sep-34	1001
P-8A-1020	NTP-Design Bulid	30	28-Sep-34	09-Nov-34	1001
P-8A-1030	Design of PED Package 8A	200	09-Nov-34	16-Aug-35	1001
P-8A-1040	Shop Drawings	40	15-Feb-35	12-Apr-35	1091
P-8A-1050	Manufacturing	90	16-Aug-35	20-Dec-35	1001
P-8A-1120	Factory Acceptance Testing	60	20-Dec-35	13-Mar-36	1011
P-8A-1060	Platform Stractural Improvments	100	21-Dec-35	29-Mar-36	1401
P-8A-1130	Packaging / Shipping to Site	60	13-Mar-36	05-Jun-36	1011
P-8A-1070	Electrical Door & Exciting Sighnage Rough-In	30	31-Mar-36	09-May-36	1000
P-8A-1080	Instal PED Controlers in Electrical Room & Energize	10	12-May-36	23-May-36	1020
P-8A-1090	Relocate Excisting Sighage & Lightning to Accomodate PED	30	12-May-36	20-Jun-36	1000
P-8A-1100	Instal PED Panels	10	21-Jun-36	30-Jun-36	1400
P-8A-1110	Terminate PED Electrical Connections	3	01-Jul-36	03-Jul-36	1400
P-8A-1140	Commissioning	20	03-Jul-36	31-Jul-36	1000
P-8A-1150	Site Acceptance Testing	40	31-Jul-36	25-Sep-36	1000
Package 8B		630	27-Apr-34	25-Sep-36	1000
P-8B-1010	Primerely Design, Tendering- PED Package 8B	110	27-Apr-34	28-Sep-34	1
P-8B-1020	NTP-Design Bulid	30	28-Sep-34	09-Nov-34	1
P-8B-1030	Design of PED Package 8B	200	09-Nov-34	16-Aug-35	1
P-8B-1040	Shop Drawings	40	15-Feb-35	12-Apr-35	1
P-8B-1050	Manufacturing	90	16-Aug-35	20-Dec-35	1001
P-8B-1120	Factory Acceptance Testing	60	20-Dec-35	13-Mar-36	1011
P-8B-1060	Platform Stractural Improvments	100	21-Dec-35	29-Mar-36	1401
P-8B-1130	Packaging / Shipping to Site	60	13-Mar-36	05-Jun-36	1011
P-8B-1070	Electrical Door & Exciting Sighnage Rough-In	30	31-Mar-36	09-May-36	1000
P-8B-1080	Instal PED Controlers in Electrical Room & Energize	10	12-May-36	23-May-36	1020
P-8B-1090	Relocate Excisting Sighage & Lightning to Accomodate PED	30	12-May-36	20-Jun-36	1000
P-8B-1100	Instal PED Panels	10	21-Jun-36	30-Jun-36	1400
P-8B-1110	Terminate PED Electrical Connections	3	01-Jul-36	03-Jul-36	1400
P-8B-1140	Commissioning	20	03-Jul-36	31-Jul-36	1000
P-8B-1150	Site Acceptance Testing	40	31-Jul-36	25-Sep-36	1000
Package 9A		630	12-Apr-35	10-Sep-37	750
P-9A-1010	Primerely Design, Tendering- PED Package 9A	110	12-Apr-35	13-Sep-35	751
P-9A-1020	NTP-Design Bulid	30	13-Sep-35	25-Oct-35	751
P-9A-1030	Design of PED Package 9A	200	25-Oct-35	31-Jul-36	751
P-9A-1040	Shop Drawings	40	31-Jan-36	27-Mar-36	841
P-9A-1050	Manufacturing	90	31-Jul-36	04-Dec-36	751
P-9A-1120	Factory Acceptance Testing	60	04-Dec-36	26-Feb-37	761
P-9A-1060	Platform Stractural Improvments	100	05-Dec-36	14-Mar-37	1051
P-9A-1130	Packaging / Shipping to Site	60	26-Feb-37	21-May-37	761
P-9A-1070	Electrical Door & Exciting Sighnage Rough-In	30	16-Mar-37	24-Apr-37	750
P-9A-1080	Instal PED Controlers in Electrical Room & Energize	10	27-Apr-37	08-May-37	770
P-9A-1090	Relocate Excisting Sighage & Lightning to Accomodate PED	30	27-Apr-37	05-Jun-37	750
P-9A-1100	Instal PED Panels	10	06-Jun-37	15-Jun-37	1050
P-9A-1110	Terminate PED Electrical Connections	3	16-Jun-37	18-Jun-37	1050
P-9A-1140	Commissioning	20	18-Jun-37	16-Jul-37	750
P-9A-1150	Site Acceptance Testing	40	16-Jul-37	10-Sep-37	750
Package 9B		630	12-Apr-35	10-Sep-37	750
P-9B-1010	Primerely Design, Tendering- PED Package 9B	110	12-Apr-35	13-Sep-35	1
P-9B-1020	NTP-Design Bulid	30	13-Sep-35	25-Oct-35	1
P-9B-1030	Design of PED Package 9B	200	25-Oct-35	31-Jul-36	1
P-9B-1040	Shop Drawings	40	31-Jan-36	27-Mar-36	1
P-9B-1050	Manufacturing	90	31-Jul-36	04-Dec-36	751
P-9B-1120	Factory Acceptance Testing	60	04-Dec-36	26-Feb-37	761
P-9B-1060	Platform Stractural Improvments	100	05-Dec-36	14-Mar-37	1051
P-9B-1130	Packaging / Shipping to Site	60	26-Feb-37	21-May-37	761
P-9B-1070	Electrical Door & Exciting Sighnage Rough-In	30	16-Mar-37	24-Apr-37	750
P-9B-1080	Instal PED Controlers in Electrical Room & Energize	10	27-Apr-37	08-May-37	770
P-9B-1090	Relocate Excisting Sighage & Lightning to Accomodate PED	30	27-Apr-37	05-Jun-37	750
P-9B-1100	Instal PED Panels	10	06-Jun-37	15-Jun-37	1050
P-9B-1110	Terminate PED Electrical Connections	3	16-Jun-37	18-Jun-37	1050
P-9B-1140	Commissioning	20	18-Jun-37	16-Jul-37	750
P-9B-1150	Site Acceptance Testing	40	16-Jul-37	10-Sep-37	750
Package 10A		630	27-Mar-36	26-Aug-38	500
P-10A-1010	Primerely Design, Tendering- PED Package 10A	110	27-Mar-36	28-Aug-36	501
P-10A-1020	NTP-Design Bulid	30	28-Aug-36	09-Oct-36	501
P-10A-1030	Design of PED Package 10A	200	09-Oct-36	16-Jul-37	501
P-10A-1040	Shop Drawings	40	15-Jan-37	12-Mar-37	591
P-10A-1050	Manufacturing	90	16-Jul-37	19-Nov-37	501
P-10A-1120	Factory Acceptance Testing	60	19-Nov-37	11-Feb-38	511
P-10A-1060	Platform Stractural Improvments	100	20-Nov-37	27-Feb-38	701
P-10A-1130	Packaging / Shipping to Site	60	11-Feb-38	06-May-38	511
P-10A-1070	Electrical Door & Exciting Sighnage Rough-In	30	01-Mar-38	09-Apr-38	500
P-10A-1080	Instal PED Controlers in Electrical Room & Energize	10	12-Apr-38	23-Apr-38	520
P-10A-1090	Relocate Excisting Sighage & Lightning to Accomodate PED	30	12-Apr-38	21-May-38	500
P-10A-1100	Instal PED Panels	10	22-May-38	31-May-38	700
P-10A-1110	Terminate PED Electrical Connections	3	01-Jun-38	03-Jun-38	700
P-10A-1140	Commissioning	20	03-Jun-38	01-Jul-38	500
P-10A-1150	Site Acceptance Testing	40	01-Jul-38	26-Aug-38	500
Package 10B		630	27-Mar-36	26-Aug-38	500
P-10B-1010	Primerely Design, Tendering- PED Package 10B	110	27-Mar-36	28-Aug-36	1
P-10B-1020	NTP-Design Bulid	30	28-Aug-36	09-Oct-36	1
P-10B-1030	Design of PED Package 10B	200	09-Oct-36	16-Jul-37	1
P-10B-1040	Shop Drawings	40	15-Jan-37	12-Mar-37	1
P-10B-1050	Manufacturing	90	16-Jul-37	19-Nov-37	501
P-10B-1120	Factory Acceptance Testing	60	19-Nov-37	11-Feb-38	511
P-10B-1060	Platform Stractural Improvments	100	20-Nov-37	27-Feb-38	701
P-10B-1130	Packaging / Shipping to Site	60	11-Feb-38	06-May-38	511
P-10B-1070	Electrical Door & Exciting Sighnage Rough-In	30	01-Mar-38	09-Apr-38	500
P-10B-1080	Instal PED Controlers in Electrical Room & Energize	10	12-Apr-38	23-Apr-38	520
P-10B-1090	Relocate Excisting Sighage & Lightning to Accomodate PED	30	12-Apr-38	21-May-38	500
P-10B-1100	Instal PED Panels	10	22-May-38	31-May-38	700
P-10B-1110	Terminate PED Electrical Connections	3	01-Jun-38	03-Jun-38	700
P-10B-1140	Commissioning	20	03-Jun-38	01-Jul-38	500
P-10B-1150	Site Acceptance Testing	40	01-Jul-38	26-Aug-38	500
Package 11A		630	12-Mar-37	11-Aug-39	250



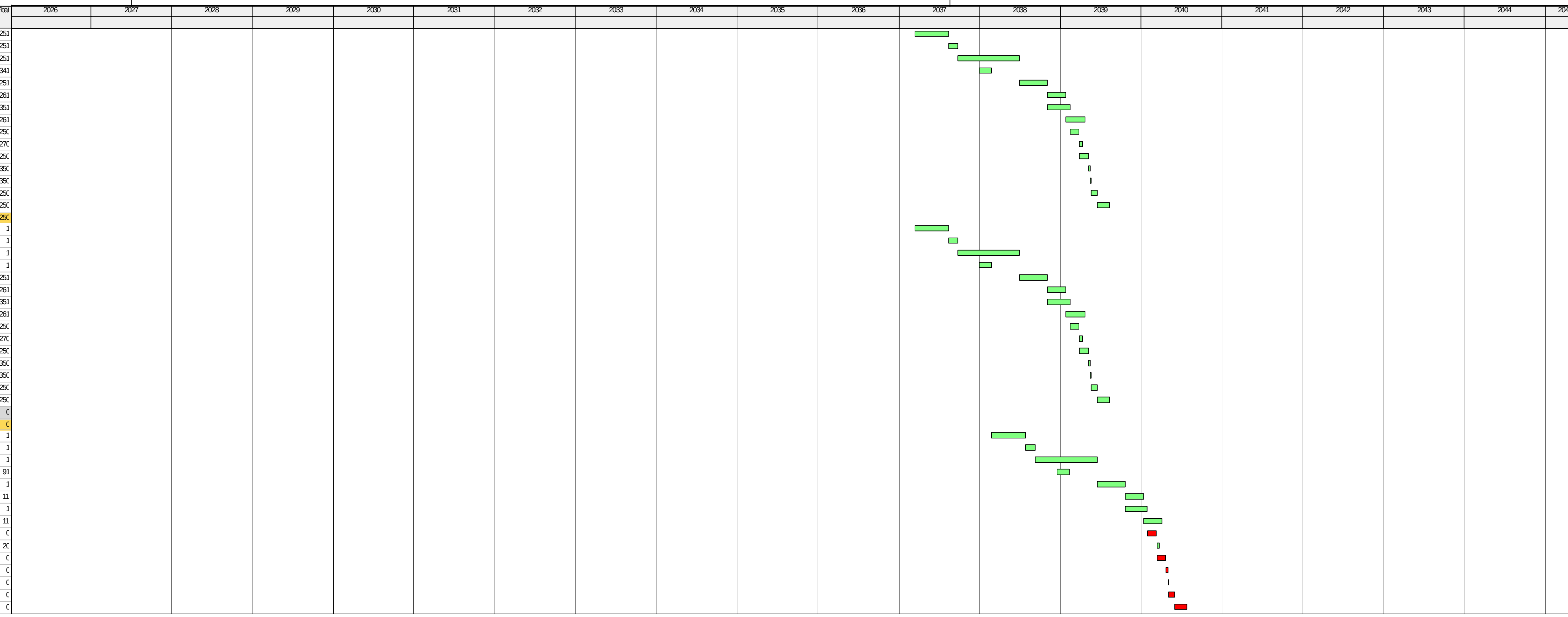
Remaining Level of Effort
Actual Level of Effort
Remaining Work
WBS Summary
Actual Work
Critical Remaining Work

TASK filter: All Activities

PEDs Program (Line 1, 2 & 4) High Level Plan - Design Build
4 Stations

Printed on: 24-Oct-23

Activity ID	Activity Name	Original Duration	Start	Finish	Total Float
P-11A-1010	Primerely Design, Tendering- PED Package 11A	110	12-Mar-37	13-Aug-37	251
P-11A-1020	NTP-Design Buid	30	13-Aug-37	24-Sep-37	251
P-11A-1030	Design of PED Package 11A	200	24-Sep-37	01-Jul-38	251
P-11A-1040	Shop Drawings	40	31-Dec-37	25-Feb-38	341
P-11A-1050	Manufacturing	90	01-Jul-38	04-Nov-38	251
P-11A-1120	Factory Acceptance Testing	60	04-Nov-38	27-Jan-39	261
P-11A-1060	Platform Stractural Improvments	100	05-Nov-38	12-Feb-39	351
P-11A-1130	Packaging / Shipping to Site	60	27-Jan-39	21-Apr-39	261
P-11A-1070	Electrical Door & Exciting Sighnage Rough-In	30	14-Feb-39	25-Mar-39	250
P-11A-1080	Instal PED Controlers in Electrical Room & Energize	10	28-Mar-39	08-Apr-39	270
P-11A-1090	Relocate Excisting Sighage & Lightning to Accomodate PED	30	28-Mar-39	06-May-39	250
P-11A-1100	Instal PED Panels	10	07-May-39	16-May-39	350
P-11A-1110	Terminate PED Electrical Connections	3	17-May-39	19-May-39	350
P-11A-1140	Commissioning	20	19-May-39	16-Jun-39	250
P-11A-1150	Site Acceptance Testing	40	16-Jun-39	11-Aug-39	250
Package 11B		630	12-Mar-37	11-Aug-39	250
P-11B-1010	Primerely Design, Tendering- PED Package 11B	110	12-Mar-37	13-Aug-37	1
P-11B-1020	NTP-Design Buid	30	13-Aug-37	24-Sep-37	1
P-11B-1030	Design of PED Package 11B	200	24-Sep-37	01-Jul-38	1
P-11B-1040	Shop Drawings	40	31-Dec-37	25-Feb-38	1
P-11B-1050	Manufacturing	90	01-Jul-38	04-Nov-38	251
P-11B-1120	Factory Acceptance Testing	60	04-Nov-38	27-Jan-39	261
P-11B-1060	Platform Stractural Improvments	100	05-Nov-38	12-Feb-39	351
P-11B-1130	Packaging / Shipping to Site	60	27-Jan-39	21-Apr-39	261
P-11B-1070	Electrical Door & Exciting Sighnage Rough-In	30	14-Feb-39	25-Mar-39	250
P-11B-1080	Instal PED Controlers in Electrical Room & Energize	10	28-Mar-39	08-Apr-39	270
P-11B-1090	Relocate Excisting Sighage & Lightning to Accomodate PED	30	28-Mar-39	06-May-39	250
P-11B-1100	Instal PED Panels	10	07-May-39	16-May-39	350
P-11B-1110	Terminate PED Electrical Connections	3	17-May-39	19-May-39	350
P-11B-1140	Commissioning	20	19-May-39	16-Jun-39	250
P-11B-1150	Site Acceptance Testing	40	16-Jun-39	11-Aug-39	250
Phase 4- Line 4		630	25-Feb-38	26-Jul-40	0
Package 7A		630	25-Feb-38	26-Jul-40	0
P-7A-1010	Primerely Design, Tendering- PED Package 7A	110	25-Feb-38	29-Jul-38	1
P-7A-1020	NTP-Design Buid	30	29-Jul-38	09-Sep-38	1
P-7A-1030	Design of PED Package 7A	200	09-Sep-38	16-Jun-39	1
P-7A-1040	Shop Drawings	40	16-Dec-38	10-Feb-39	91
P-7A-1050	Manufacturing	90	16-Jun-39	20-Oct-39	1
P-7A-1120	Factory Acceptance Testing	60	20-Oct-39	12-Jan-40	11
P-7A-1060	Platform Stractural Improvments	100	21-Oct-39	28-Jan-40	1
P-7A-1130	Packaging / Shipping to Site	60	12-Jan-40	05-Apr-40	11
P-7A-1070	Electrical Door & Exciting Sighnage Rough-In	30	30-Jan-40	09-Mar-40	0
P-7A-1080	Instal PED Controlers in Electrical Room & Energize	10	12-Mar-40	23-Mar-40	20
P-7A-1090	Relocate Excisting Sighage & Lightning to Accomodate PED	30	12-Mar-40	20-Apr-40	0
P-7A-1100	Instal PED Panels	10	21-Apr-40	30-Apr-40	0
P-7A-1110	Terminate PED Electrical Connections	3	01-May-40	03-May-40	0
P-7A-1140	Commissioning	20	03-May-40	31-May-40	0
P-7A-1150	Site Acceptance Testing	40	31-May-40	26-Jul-40	0



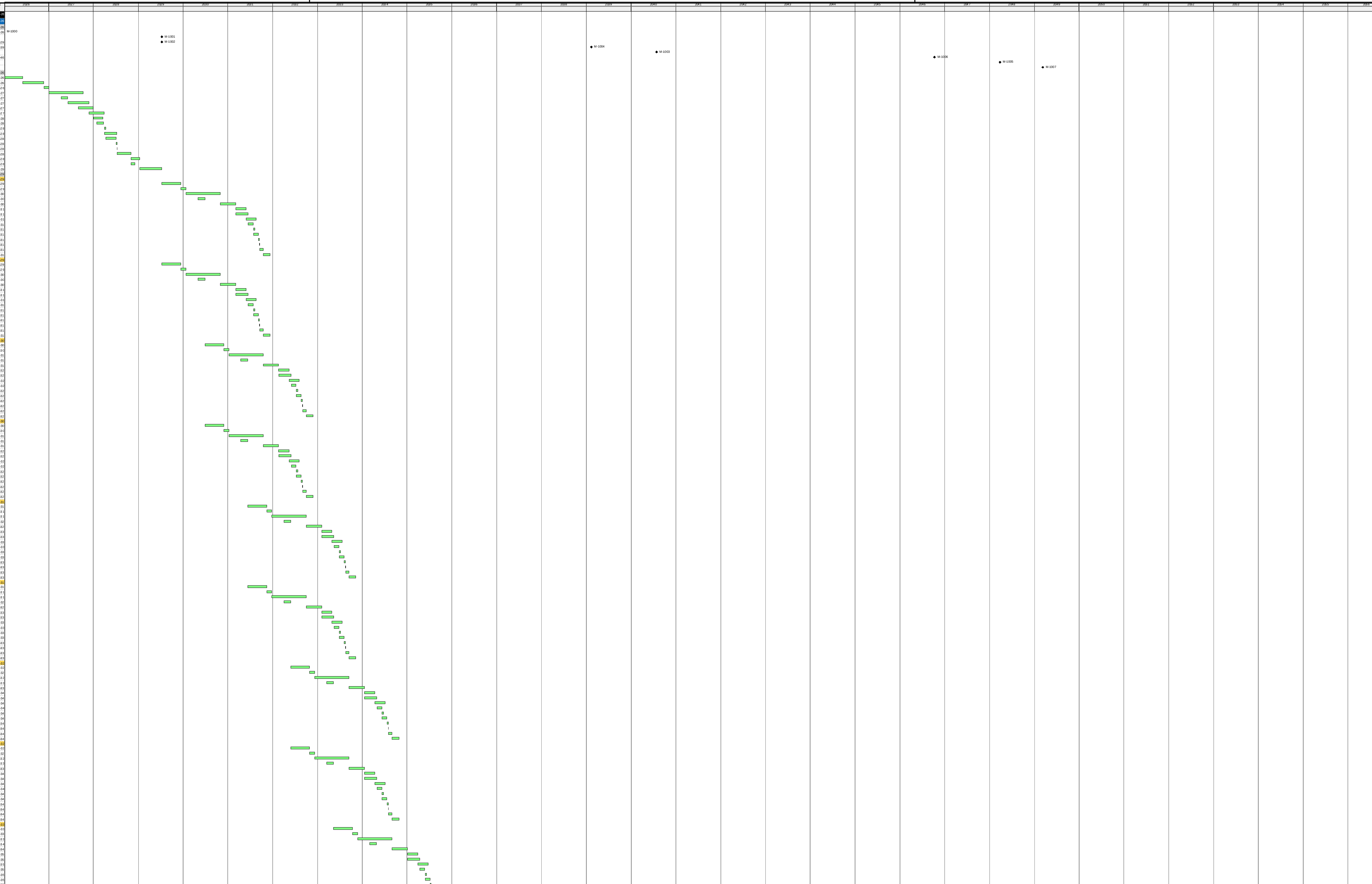
Remaining Level of Effort | Actual Level of Effort | Remaining Work
WBS Summary | Actual Work | Critical Remaining Work

TASK filter: All Activities

AECOM

PEDs Program (Line 1, 2 & 4) High Level Plan - Design Build
2 Stations

Activity ID	Activity Name	Original Duration	Start
PEDs-2station		6051	01-Jan-26
PEDs Program (Line 1, 2 & 4) High Level Plan - Design Buil		6051	1-Jan-26
Milestones		6051	1-Jan-26
M-1000	Phase 1 - PED Pilot Start	0	1-Jan-26
M-1001	Phase 1 - PED Pilot Completion	0	
M-1002	Phase 2 - Line 1 Start	0	12-Jul-29
M-1004	Phase 3 - Line 2 Start	0	0-Feb-39
M-1003	Phase 2 - Line 1 Completion	0	
M-1006	Phase 4 - Line 4 Start	0	1-Oct-46
M-1005	Phase 3 - Line 2 Completion	0	
M-1007	Phase 4 - Line 4 Completion	0	
Phase 1- PED Pilot		921	1-Jan-26
PED-1000	Planning / Preliminary Design of PED Pilot	110	1-Jan-26
PED-1010	Tendering PED Pilot	122	4-Jun-26
PED-1011	NTP-Design Bulid	30	3-Nov-26
PED-1020	Design of PED Pilot	200	4-Jan-27
PED-1021	Shop Drawings	40	2-Apr-27
PED-1022	One-Time Qualification Testing	124	7-Jun-27
PED-1024	Electrical Door & Exciting Sighage Rough-In	90	0-Aug-27
PED-1022-1	Manufacturing	90	6-Nov-27
PED-1026	Relocate Excisting Sighage & Lighting to Accomodate	55	3-Jan-28
PED-1025	Install PED Controllers in Electrical Room & Energize	40	8-Jan-28
PED-1050	Factory Acceptance Testing	7	1-Mar-28
PED-1023	Platform Structural Improvments	100	1-Mar-28
PED-1060	Packaging / Shipping to Site	60	1-Apr-28
PED-1027	Install PED Panels	8	04-Jul-28
PED-1028	Terminate PED Electical Connections	3	12-Jul-28
PED-1070	Component System Testing	80	14-Jul-28
PED-1080	Site Acceptance Tesing	50	3-Nov-28
PED-1075	Commissioning	21	3-Nov-28
PED-1090	Pilot Review-Lessons learned	129	2-Jan-29
Phase 2- Line 1		2880	12-Jul-29
Package 2A		630	12-Jul-29
P-2A-1010	Primerely Design, Tendering - PED Package 2A	110	12-Jul-29
P-2A-1020	NTP-Design Bulid	30	3-Dec-29
P-2A-1030	Design of PED Package 2A	200	4-Jan-30
P-2A-1040	Shop Drawings	40	2-May-30
P-2A-1041	Manufacturing	90	1-Oct-30
P-2A-1080	Factory Acceptance Testing	60	6-Mar-31
P-2A-1050	Platform Stractural Improvments	100	7-Mar-31
P-2A-1090	Packaging / Shipping to Site	60	9-May-31
P-2A-1060	Electrical Door & Exciting Sighnage Rough-In	30	6-Jun-31
P-2A-1061	Install PED Controllers in Electrical Room & Energize	10	28-Jul-31
P-2A-1062	Relocate Excisting Sighage & Lightning to Accomodat	30	28-Jul-31
P-2A-1063	Install PED Panels	10	6-Sep-31
P-2A-1064	Terminate PED Electrical Connections	3	6-Sep-31
P-2A-1100	Commissioning	20	8-Sep-31
P-2A-1110	Site Acceptance Tesing	40	6-Oct-31
Package 2B		630	12-Jul-29
P-2B-1570	Primerely Design, Tendering - PED Package 2B	110	12-Jul-29
P-2B-1580	NTP-Design Bulid	30	3-Dec-29
P-2B-1590	Design of PED Package 2B	200	4-Jan-30
P-2B-1600	Shop Drawings	40	2-May-30
P-2B-1610	Manufacturing	90	1-Oct-30
P-2B-1680	Factory Acceptance Testing	60	6-Mar-31
P-2B-1620	Platform Stractural Improvments	100	7-Mar-31
P-2B-1690	Packaging / Shipping to Site	60	9-May-31
P-2B-1630	Electrical Door & Exciting Sighnage Rough-In	30	6-Jun-31
P-2B-1640	Install PED Controllers in Electrical Room & Energize	10	28-Jul-31
P-2B-1650	Relocate Excisting Sighage & Lightning to Accomodat	30	28-Jul-31
P-2B-1660	Install PED Panels	10	6-Sep-31
P-2B-1670	Terminate PED Electrical Connections	3	6-Sep-31
P-2B-1700	Commissioning	20	8-Sep-31
P-2B-1710	Site Acceptance Tesing	40	6-Oct-31
Package 2C		630	7-Jun-30
P-2C-1000	Primerely Design, Tendering - PED Package 2C	110	7-Jun-30
P-2C-1010	NTP-Design Bulid	30	8-Nov-30
P-2C-1020	Design of PED Package 2C	200	9-Jan-31
P-2C-1030	Shop Drawings	40	7-Apr-31
P-2C-1040	Manufacturing	90	6-Oct-31
P-2C-1110	Factory Acceptance Testing	60	9-Feb-32
P-2C-1050	Platform Stractural Improvments	100	0-Feb-32
P-2C-1120	Packaging / Shipping to Site	60	3-May-32
P-2C-1060	Electrical Door & Exciting Sighnage Rough-In	30	1-May-32
P-2C-1070	Install PED Controllers in Electrical Room & Energize	10	12-Jul-32
P-2C-1080	Relocate Excisting Sighage & Lightning to Accomodat	30	12-Jul-32
P-2C-1090	Install PED Panels	10	1-Aug-32
P-2C-1100	Terminate PED Electrical Connections	3	1-Aug-32
P-2C-1130	Commissioning	20	2-Sep-32
P-2C-1140	Site Acceptance Tesing	40	0-Sep-32
Package 2D		630	7-Jun-30
P-2D-1000	Primerely Design, Tendering - PED Package 2D	110	7-Jun-30
P-2D-1010	NTP-Design Bulid	30	8-Nov-30
P-2D-1020	Design of PED Package 2D	200	9-Jan-31
P-2D-1030	Shop Drawings	40	7-Apr-31
P-2D-1040	Manufacturing	90	6-Oct-31
P-2D-1110	Factory Acceptance Testing	60	9-Feb-32
P-2D-1050	Platform Stractural Improvments	100	0-Feb-32
P-2D-1120	Packaging / Shipping to Site	60	3-May-32
P-2D-1060	Electrical Door & Exciting Sighnage Rough-In	30	1-May-32
P-2D-1070	Install PED Controllers in Electrical Room & Energize	10	12-Jul-32
P-2D-1080	Relocate Excisting Sighage & Lightning to Accomodat	30	12-Jul-32
P-2D-1090	Install PED Panels	10	1-Aug-32
P-2D-1100	Terminate PED Electrical Connections	3	1-Aug-32
P-2D-1130	Commissioning	20	2-Sep-32
P-2D-1140	Site Acceptance Tesing	40	0-Sep-32
Package 3A		630	2-Jun-31
P-3A-1420	Primerely Design, Tendering - PED Package 3A	110	2-Jun-31
P-3A-1430	NTP-Design Bulid	30	3-Nov-31
P-3A-1440	Design of PED Package 3A	200	5-Dec-31
P-3A-1450	Shop Drawings	40	1-Apr-32
P-3A-1460	Manufacturing	90	0-Sep-32
P-3A-1530	Factory Acceptance Testing	60	3-Feb-33
P-3A-1470	Platform Stractural Improvments	100	4-Feb-33
P-3A-1540	Packaging / Shipping to Site	60	8-Apr-33
P-3A-1480	Electrical Door & Exciting Sighnage Rough-In	30	6-May-33
P-3A-1490	Install PED Controllers in Electrical Room & Energize	10	7-Jun-33
P-3A-1500	Relocate Excisting Sighage & Lightning to Accomodat	30	7-Jun-33
P-3A-1510	Install PED Panels	10	6-Aug-33
P-3A-1520	Terminate PED Electrical Connections	3	6-Aug-33
P-3A-1550	Commissioning	20	8-Aug-33
P-3A-1560	Site Acceptance Tesing	40	5-Sep-33
Package 3B		630	2-Jun-31
P-3B-1420	Primerely Design, Tendering - PED Package 3B	110	2-Jun-31
P-3B-1430	NTP-Design Bulid	30	3-Nov-31
P-3B-1440	Design of PED Package 3B	200	5-Dec-31
P-3B-1450	Shop Drawings	40	1-Apr-32
P-3B-1460	Manufacturing	90	0-Sep-32
P-3B-1530	Factory Acceptance Testing	60	3-Feb-33
P-3B-1470	Platform Stractural Improvments	100	4-Feb-33
P-3B-1540	Packaging / Shipping to Site	60	8-Apr-33
P-3B-1480	Electrical Door & Exciting Sighnage Rough-In	30	6-May-33
P-3B-1490	Install PED Controllers in Electrical Room & Energize	10	7-Jun-33
P-3B-1500	Relocate Excisting Sighage & Lightning to Accomodat	30	7-Jun-33
P-3B-1510	Install PED Panels	10	6-Aug-33
P-3B-1520	Terminate PED Electrical Connections	3	6-Aug-33
P-3B-1550	Commissioning	20	8-Aug-33
P-3B-1560	Site Acceptance Tesing	40	5-Sep-33
Package 3C		630	7-May-32
P-3C-1000	Primerely Design, Tendering - PED Package 3C	110	7-May-32
P-3C-1010	NTP-Design Bulid	30	8-Oct-32
P-3C-1020	Design of PED Package 3C	200	9-Dec-32
P-3C-1030	Shop Drawings	40	7-Mar-33
P-3C-1040	Manufacturing	90	5-Sep-33
P-3C-1110	Factory Acceptance Testing	60	9-Jan-34
P-3C-1050	Platform Stractural Improvments	100	0-Jan-34
P-3C-1120	Packaging / Shipping to Site	60	3-Apr-34
P-3C-1060	Electrical Door & Exciting Sighnage Rough-In	30	1-May-34
P-3C-1070	Install PED Controllers in Electrical Room & Energize	10	2-Jun-34
P-3C-1080	Relocate Excisting Sighage & Lightning to Accomodat	30	2-Jun-34
P-3C-1090	Install PED Panels	10	22-Jul-34
P-3C-1100	Terminate PED Electrical Connections	3	1-Aug-34
P-3C-1130	Commissioning	20	3-Aug-34
P-3C-1140	Site Acceptance Tesing	40	1-Aug-34
Package 3D		630	7-May-32
P-3D-1010	Primerely Design, Tendering - PED Package 3D	110	7-May-32
P-3D-1020	NTP-Design Bulid	30	8-Oct-32
P-3D-1030	Design of PED Package 3D	200	9-Dec-32
P-3D-1040	Shop Drawings	40	7-Mar-33
P-3D-1050	Manufacturing	90	5-Sep-33
P-3D-1120	Factory Acceptance Testing	60	9-Jan-34
P-3D-1060	Platform Stractural Improvments	100	0-Jan-34
P-3D-1130	Packaging / Shipping to Site	60	3-Apr-34
P-3D-1070	Electrical Door & Exciting Sighnage Rough-In	30	1-May-34
P-3D-1080	Install PED Controllers in Electrical Room & Energize	10	2-Jun-34
P-3D-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	2-Jun-34
P-3D-1100	Install PED Panels	10	22-Jul-34
P-3D-1110	Terminate PED Electrical Connections	3	1-Aug-34
P-3D-1140	Commissioning	20	3-Aug-34
P-3D-1150	Site Acceptance Tesing	40	1-Aug-34
Package 4A		630	2-May-33
P-4A-1280	Primerely Design, Tendering - PED Package 4A	110	2-May-33
P-4A-1290	NTP-Design Bulid	30	3-Oct-33
P-4A-1300	Design of PED Package 4A	200	4-Nov-33
P-4A-1310	Shop Drawings	40	2-Mar-34
P-4A-1320	Manufacturing	90	1-Aug-34
P-4A-1390	Factory Acceptance Testing	60	4-Jan-35
P-4A-1330	Platform Stractural Improvments	100	5-Jan-35
P-4A-1400	Packaging / Shipping to Site	60	9-Mar-35
P-4A-1340	Electrical Door & Exciting Sighnage Rough-In	30	6-Apr-35
P-4A-1350	Install PED Controllers in Electrical Room & Energize	10	8-May-35
P-4A-1360	Relocate Excisting Sighage & Lightning to Accomodat	30	8-May-35
P-4A-1370	Install PED Panels	10	07-Jul-35
P-4A-1380	Terminate PED Electrical Connections	3	17-Jul-35



Remaining Level of Effort | Actual Level of Effort | Remaining Work
WBS Summary | Actual Work | Critical Remaining Work

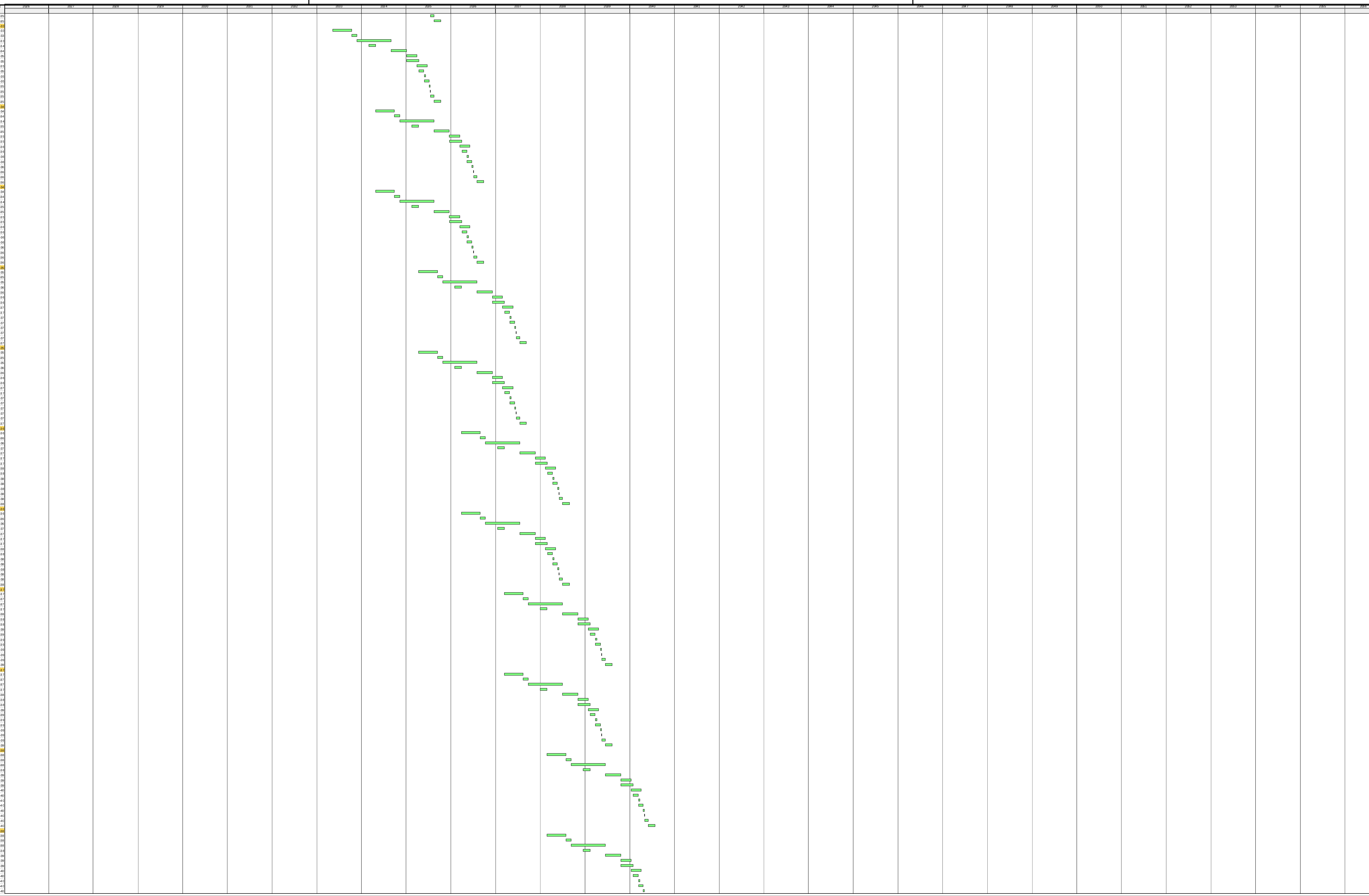
TASK filter: All Activities

AECOM

PEDs Program (Line 1, 2 & 4) High Level Plan - Design Build
2 Stations

Printed on: 24-Oct-23

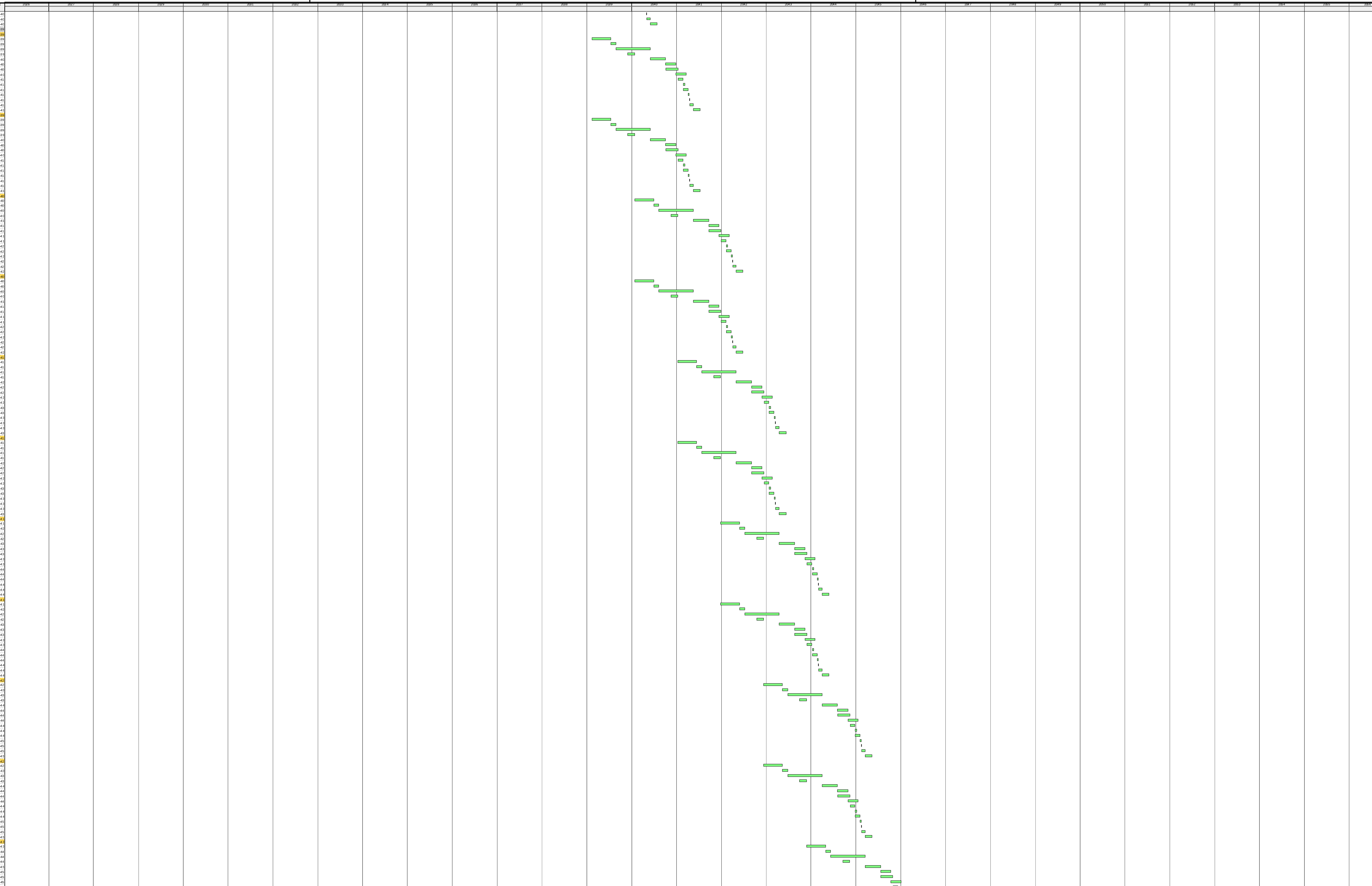
Activity ID	Activity Name	Original Duration	Start
P-4A-1410	Commissioning	20	19-Jul-35
P-4A-1420	Site Acceptance Testing	40	6-Aug-35
Package 4B		630	2-May-33
P-4B-1280	Primerely Design, Tendering - PED Package 4B	110	2-May-33
P-4B-1290	NTP-Design Bulid	30	3-Oct-33
P-4B-1300	Design of PED Package 4B	200	4-Nov-33
P-4B-1310	Shop Drawings	40	2-Mar-34
P-4B-1320	Manufacturing	90	1-Aug-34
P-4B-1390	Factory Acceptance Testing	60	4-Jan-35
P-4B-1330	Platform Stractural Improvments	100	5-Jan-35
P-4B-1400	Packaging / Shipping to Site	60	9-Mar-35
P-4B-1340	Electrical Door & Exciting Sighnage Rough-In	30	6-Apr-35
P-4B-1350	Install PED Controllers in Electrical Room & Energize	10	8-May-35
P-4B-1360	Relocate Excisting Sighage & Lightning to Accomodat	30	8-May-35
P-4B-1370	Install PED Panels	10	07-Jul-35
P-4B-1380	Terminate PED Electrical Connections	3	17-Jul-35
P-4B-1410	Commissioning	20	19-Jul-35
P-4B-1420	Site Acceptance Testing	40	6-Aug-35
Package 4C		630	7-Apr-34
P-4C-1010	Primerely Design, Tendering - PED Package 4C	110	7-Apr-34
P-4C-1020	NTP-Design Bulid	30	8-Sep-34
P-4C-1030	Design of PED Package 4C	200	9-Nov-34
P-4C-1040	Shop Drawings	40	5-Feb-35
P-4C-1050	Manufacturing	90	6-Aug-35
P-4C-1120	Factory Acceptance Testing	60	0-Dec-35
P-4C-1060	Platform Stractural Improvments	100	1-Dec-35
P-4C-1130	Packaging / Shipping to Site	60	3-Mar-36
P-4C-1070	Electrical Door & Exciting Sighnage Rough-In	30	1-Mar-36
P-4C-1080	Install PED Controllers in Electrical Room & Energize	10	2-May-36
P-4C-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	2-May-36
P-4C-1100	Install PED Panels	10	1-Jun-36
P-4C-1110	Terminate PED Electrical Connections	3	01-Jul-36
P-4C-1140	Commissioning	20	03-Jul-36
P-4C-1150	Site Acceptance Testing	40	31-Jul-36
Package 4D		630	7-Apr-34
P-4D-1010	Primerely Design, Tendering - PED Package 4D	110	7-Apr-34
P-4D-1020	NTP-Design Bulid	30	8-Sep-34
P-4D-1030	Design of PED Package 4D	200	9-Nov-34
P-4D-1040	Shop Drawings	40	5-Feb-35
P-4D-1050	Manufacturing	90	6-Aug-35
P-4D-1120	Factory Acceptance Testing	60	0-Dec-35
P-4D-1060	Platform Stractural Improvments	100	1-Dec-35
P-4D-1130	Packaging / Shipping to Site	60	3-Mar-36
P-4D-1070	Electrical Door & Exciting Sighnage Rough-In	30	1-Mar-36
P-4D-1080	Install PED Controllers in Electrical Room & Energize	10	2-May-36
P-4D-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	2-May-36
P-4D-1100	Install PED Panels	10	1-Jun-36
P-4D-1110	Terminate PED Electrical Connections	3	01-Jul-36
P-4D-1140	Commissioning	20	03-Jul-36
P-4D-1150	Site Acceptance Testing	40	31-Jul-36
Package 5A		630	2-Apr-35
P-5A-1280	Primerely Design, Tendering - PED Package 5A	110	2-Apr-35
P-5A-1290	NTP-Design Bulid	30	3-Sep-35
P-5A-1300	Design of PED Package 5A	200	5-Oct-35
P-5A-1310	Shop Drawings	40	1-Jan-36
P-5A-1320	Manufacturing	90	31-Jul-36
P-5A-1390	Factory Acceptance Testing	60	4-Dec-36
P-5A-1330	Platform Stractural Improvments	100	5-Dec-36
P-5A-1400	Packaging / Shipping to Site	60	6-Feb-37
P-5A-1340	Electrical Door & Exciting Sighnage Rough-In	30	6-Mar-37
P-5A-1350	Install PED Controllers in Electrical Room & Energize	10	7-Apr-37
P-5A-1360	Relocate Excisting Sighage & Lightning to Accomodat	30	7-Apr-37
P-5A-1370	Install PED Panels	10	6-Jun-37
P-5A-1380	Terminate PED Electrical Connections	3	6-Jun-37
P-5A-1410	Commissioning	20	8-Jun-37
P-5A-1420	Site Acceptance Testing	40	16-Jul-37
Package 5B		630	2-Apr-35
P-5B-1280	Primerely Design, Tendering - PED Package 5B	110	2-Apr-35
P-5B-1290	NTP-Design Bulid	30	3-Sep-35
P-5B-1300	Design of PED Package 5B	200	5-Oct-35
P-5B-1310	Shop Drawings	40	1-Jan-36
P-5B-1320	Manufacturing	90	31-Jul-36
P-5B-1390	Factory Acceptance Testing	60	4-Dec-36
P-5B-1330	Platform Stractural Improvments	100	5-Dec-36
P-5B-1400	Packaging / Shipping to Site	60	6-Feb-37
P-5B-1340	Electrical Door & Exciting Sighnage Rough-In	30	6-Mar-37
P-5B-1350	Install PED Controllers in Electrical Room & Energize	10	7-Apr-37
P-5B-1360	Relocate Excisting Sighage & Lightning to Accomodat	30	7-Apr-37
P-5B-1370	Install PED Panels	10	6-Jun-37
P-5B-1380	Terminate PED Electrical Connections	3	6-Jun-37
P-5B-1410	Commissioning	20	8-Jun-37
P-5B-1420	Site Acceptance Testing	40	16-Jul-37
Package 5C		630	7-Mar-36
P-5C-1010	Primerely Design, Tendering - PED Package 5C	110	7-Mar-36
P-5C-1020	NTP-Design Bulid	30	8-Aug-36
P-5C-1030	Design of PED Package 5C	200	9-Oct-36
P-5C-1040	Shop Drawings	40	5-Jan-37
P-5C-1050	Manufacturing	90	16-Jul-37
P-5C-1120	Factory Acceptance Testing	60	9-Nov-37
P-5C-1060	Platform Stractural Improvments	100	0-Nov-37
P-5C-1130	Packaging / Shipping to Site	60	1-Feb-38
P-5C-1070	Electrical Door & Exciting Sighnage Rough-In	30	1-Mar-38
P-5C-1080	Install PED Controllers in Electrical Room & Energize	10	2-Apr-38
P-5C-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	2-Apr-38
P-5C-1100	Install PED Panels	10	2-May-38
P-5C-1110	Terminate PED Electrical Connections	3	1-Jun-38
P-5C-1140	Commissioning	20	3-Jun-38
P-5C-1150	Site Acceptance Testing	40	01-Jul-38
Package 5D		630	7-Mar-36
P-5D-1150	Primerely Design, Tendering - PED Package 5D	110	7-Mar-36
P-5D-1160	NTP-Design Bulid	30	8-Aug-36
P-5D-1170	Design of PED Package 5D	200	9-Oct-36
P-5D-1180	Shop Drawings	40	5-Jan-37
P-5D-1190	Manufacturing	90	16-Jul-37
P-5D-1260	Factory Acceptance Testing	60	9-Nov-37
P-5D-1200	Platform Stractural Improvments	100	0-Nov-37
P-5D-1270	Packaging / Shipping to Site	60	1-Feb-38
P-5D-1210	Electrical Door & Exciting Sighnage Rough-In	30	1-Mar-38
P-5D-1220	Install PED Controllers in Electrical Room & Energize	10	2-Apr-38
P-5D-1230	Relocate Excisting Sighage & Lightning to Accomodat	30	2-Apr-38
P-5D-1240	Install PED Panels	10	2-May-38
P-5D-1250	Terminate PED Electrical Connections	3	1-Jun-38
P-5D-1280	Commissioning	20	3-Jun-38
P-5D-1290	Site Acceptance Testing	40	01-Jul-38
Package 6A		630	2-Mar-37
P-6A-1430	Primerely Design, Tendering - PED Package 6A	110	2-Mar-37
P-6A-1440	NTP-Design Bulid	30	3-Aug-37
P-6A-1450	Design of PED Package 6A	200	4-Sep-37
P-6A-1460	Shop Drawings	40	1-Dec-37
P-6A-1470	Manufacturing	90	01-Jul-38
P-6A-1540	Factory Acceptance Testing	60	4-Nov-38
P-6A-1480	Platform Stractural Improvments	100	5-Nov-38
P-6A-1550	Packaging / Shipping to Site	60	7-Jan-39
P-6A-1490	Electrical Door & Exciting Sighnage Rough-In	30	4-Feb-39
P-6A-1500	Install PED Controllers in Electrical Room & Energize	10	8-Mar-39
P-6A-1510	Relocate Excisting Sighage & Lightning to Accomodat	30	8-Mar-39
P-6A-1520	Install PED Panels	10	7-May-39
P-6A-1530	Terminate PED Electrical Connections	3	7-May-39
P-6A-1560	Commissioning	20	9-May-39
P-6A-1570	Site Acceptance Testing	40	6-Jun-39
Package 6B		630	2-Mar-37
P-6B-1280	Primerely Design, Tendering - PED Package 6B	110	2-Mar-37
P-6B-1290	NTP-Design Bulid	30	3-Aug-37
P-6B-1300	Design of PED Package 6B	200	4-Sep-37
P-6B-1310	Shop Drawings	40	1-Dec-37
P-6B-1320	Manufacturing	90	01-Jul-38
P-6B-1390	Factory Acceptance Testing	60	4-Nov-38
P-6B-1330	Platform Stractural Improvments	100	5-Nov-38
P-6B-1400	Packaging / Shipping to Site	60	7-Jan-39
P-6B-1340	Electrical Door & Exciting Sighnage Rough-In	30	4-Feb-39
P-6B-1350	Install PED Controllers in Electrical Room & Energize	10	8-Mar-39
P-6B-1360	Relocate Excisting Sighage & Lightning to Accomodat	30	8-Mar-39
P-6B-1370	Install PED Panels	10	7-May-39
P-6B-1380	Terminate PED Electrical Connections	3	7-May-39
P-6B-1410	Commissioning	20	9-May-39
P-6B-1420	Site Acceptance Testing	40	6-Jun-39
Package 6C		630	5-Feb-38
P-6C-1010	Primerely Design, Tendering - PED Package 6C	110	5-Feb-38
P-6C-1020	NTP-Design Bulid	30	29-Jul-38
P-6C-1030	Design of PED Package 6C	200	9-Sep-38
P-6C-1040	Shop Drawings	40	6-Dec-38
P-6C-1050	Manufacturing	90	6-Jun-39
P-6C-1120	Factory Acceptance Testing	60	0-Oct-39
P-6C-1060	Platform Stractural Improvments	100	1-Oct-39
P-6C-1130	Packaging / Shipping to Site	60	2-Jan-40
P-6C-1070	Electrical Door & Exciting Sighnage Rough-In	30	0-Jan-40
P-6C-1080	Install PED Controllers in Electrical Room & Energize	10	2-Mar-40
P-6C-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	2-Mar-40
P-6C-1100	Install PED Panels	10	1-Apr-40
P-6C-1110	Terminate PED Electrical Connections	3	1-May-40
P-6C-1140	Commissioning	20	3-May-40
P-6C-1150	Site Acceptance Testing	40	1-May-40
Package 6D		630	5-Feb-38
P-6D-1010	Primerely Design, Tendering - PED Package 6D	110	5-Feb-38
P-6D-1020	NTP-Design Bulid	30	29-Jul-38
P-6D-1030	Design of PED Package 6D	200	9-Sep-38
P-6D-1040	Shop Drawings	40	6-Dec-38
P-6D-1050	Manufacturing	90	6-Jun-39
P-6D-1120	Factory Acceptance Testing	60	0-Oct-39
P-6D-1060	Platform Stractural Improvments	100	1-Oct-39
P-6D-1130	Packaging / Shipping to Site	60	2-Jan-40
P-6D-1070	Electrical Door & Exciting Sighnage Rough-In	30	0-Jan-40
P-6D-1080	Install PED Controllers in Electrical Room & Energize	10	2-Mar-40
P-6D-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	2-Mar-40
P-6D-1100	Install PED Panels	10	1-Apr-40



Remaining Level of Effort | Actual Level of Effort | Remaining Work
WBS Summary | Actual Work | Critical Remaining Work

TASK filter: All Activities

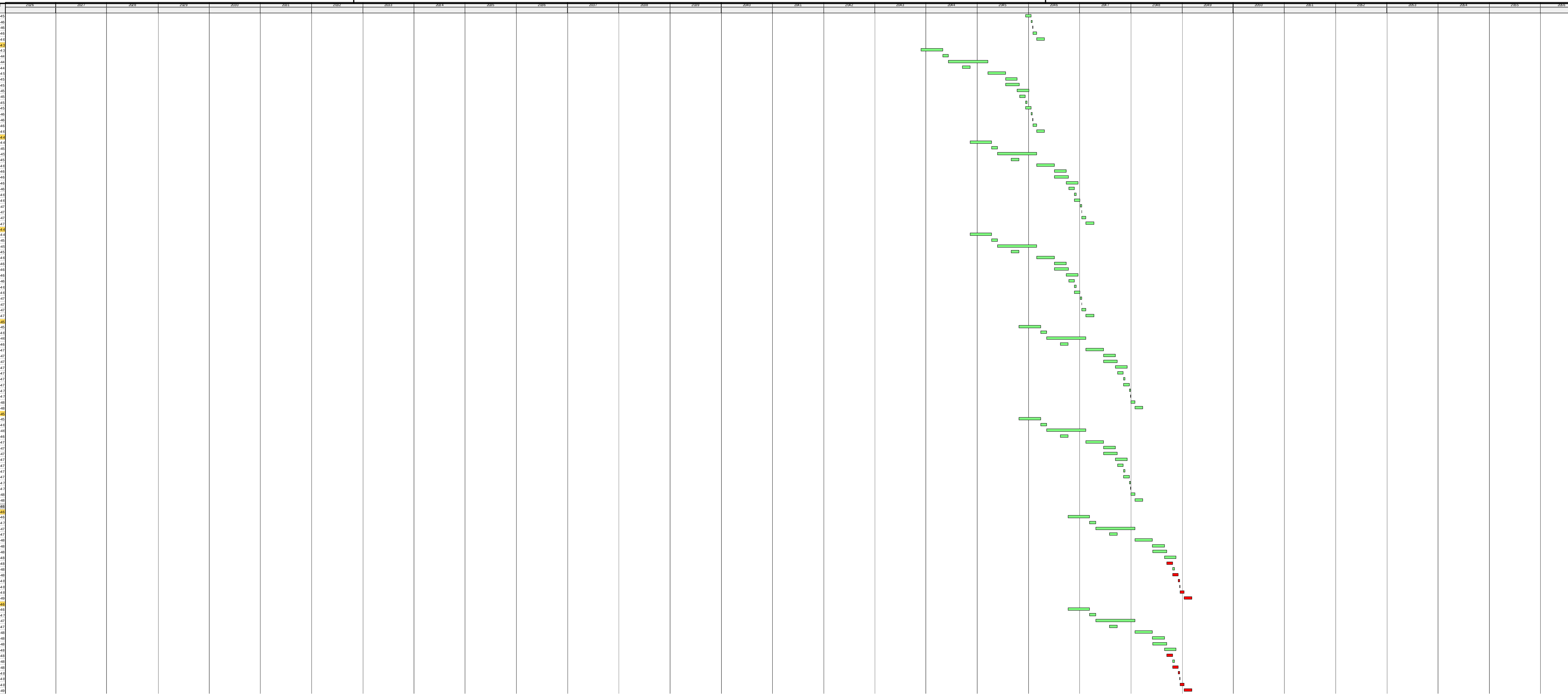
Activity ID	Activity Name	Original Duration	Start
P-6D-1110	Terminate PED Electrical Connections	3	1-May-40
P-6D-1140	Commissioning	20	3-May-40
P-6D-1150	Site Acceptance Testing	40	1-May-40
Phase 3-Line 2		2380	0-Feb-39
Package 8A		630	0-Feb-39
P-8A-1010	Primerely Design, Tendering - PED Package 8A	110	0-Feb-39
P-8A-1020	NTP-Design Bulid	30	14-Jul-39
P-8A-1030	Design of PED Package 8A	200	5-Aug-39
P-8A-1040	Shop Drawings	40	1-Dec-39
P-8A-1050	Manufacturing	90	1-May-40
P-8A-1120	Factory Acceptance Testing	60	4-Oct-40
P-8A-1060	Platform Stractural Improvments	100	5-Oct-40
P-8A-1130	Packaging / Shipping to Site	60	7-Dec-40
P-8A-1070	Electrical Door & Exciting Sighnage Rough-In	30	4-Jan-41
P-8A-1080	Install PED Controllers in Electrical Room & Energize	10	5-Feb-41
P-8A-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	5-Feb-41
P-8A-1100	Install PED Panels	10	6-Apr-41
P-8A-1110	Terminate PED Electrical Connections	3	6-Apr-41
P-8A-1140	Commissioning	20	8-Apr-41
P-8A-1150	Site Acceptance Testing	40	6-May-41
Package 8B		630	0-Feb-39
P-8B-1010	Primerely Design, Tendering - PED Package 8B	110	0-Feb-39
P-8B-1020	NTP-Design Bulid	30	14-Jul-39
P-8B-1030	Design of PED Package 8B	200	5-Aug-39
P-8B-1040	Shop Drawings	40	1-Dec-39
P-8B-1050	Manufacturing	90	1-May-40
P-8B-1120	Factory Acceptance Testing	60	4-Oct-40
P-8B-1060	Platform Stractural Improvments	100	5-Oct-40
P-8B-1130	Packaging / Shipping to Site	60	7-Dec-40
P-8B-1070	Electrical Door & Exciting Sighnage Rough-In	30	4-Jan-41
P-8B-1080	Install PED Controllers in Electrical Room & Energize	10	5-Feb-41
P-8B-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	5-Feb-41
P-8B-1100	Install PED Panels	10	6-Apr-41
P-8B-1110	Terminate PED Electrical Connections	3	6-Apr-41
P-8B-1140	Commissioning	20	8-Apr-41
P-8B-1150	Site Acceptance Testing	40	6-May-41
Package 8C		630	6-Jan-40
P-8C-1010	Primerely Design, Tendering - PED Package 8C	110	6-Jan-40
P-8C-1020	NTP-Design Bulid	30	8-Jun-40
P-8C-1030	Design of PED Package 8C	200	9-Aug-40
P-8C-1040	Shop Drawings	40	5-Nov-40
P-8C-1050	Manufacturing	90	6-May-41
P-8C-1120	Factory Acceptance Testing	60	9-Sep-41
P-8C-1060	Platform Stractural Improvments	100	0-Sep-41
P-8C-1130	Packaging / Shipping to Site	60	2-Dec-41
P-8C-1070	Electrical Door & Exciting Sighnage Rough-In	30	0-Dec-41
P-8C-1080	Install PED Controllers in Electrical Room & Energize	10	0-Feb-42
P-8C-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	0-Feb-42
P-8C-1100	Install PED Panels	10	2-Mar-42
P-8C-1110	Terminate PED Electrical Connections	3	1-Apr-42
P-8C-1140	Commissioning	20	3-Apr-42
P-8C-1150	Site Acceptance Testing	40	1-May-42
Package 8D		630	6-Jan-40
P-8D-1010	Primerely Design, Tendering - PED Package 8D	110	6-Jan-40
P-8D-1020	NTP-Design Bulid	30	8-Jun-40
P-8D-1030	Design of PED Package 8D	200	9-Aug-40
P-8D-1040	Shop Drawings	40	5-Nov-40
P-8D-1050	Manufacturing	90	6-May-41
P-8D-1120	Factory Acceptance Testing	60	9-Sep-41
P-8D-1060	Platform Stractural Improvments	100	0-Sep-41
P-8D-1130	Packaging / Shipping to Site	60	2-Dec-41
P-8D-1070	Electrical Door & Exciting Sighnage Rough-In	30	0-Dec-41
P-8D-1080	Install PED Controllers in Electrical Room & Energize	10	0-Feb-42
P-8D-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	0-Feb-42
P-8D-1100	Install PED Panels	10	2-Mar-42
P-8D-1110	Terminate PED Electrical Connections	3	1-Apr-42
P-8D-1140	Commissioning	20	3-Apr-42
P-8D-1150	Site Acceptance Testing	40	1-May-42
Package 9A		630	0-Jan-41
P-9A-1010	Primerely Design, Tendering - PED Package 9A	110	0-Jan-41
P-9A-1020	NTP-Design Bulid	30	3-Jun-41
P-9A-1030	Design of PED Package 9A	200	25-Jul-41
P-9A-1040	Shop Drawings	40	1-Oct-41
P-9A-1050	Manufacturing	90	1-May-42
P-9A-1120	Factory Acceptance Testing	60	4-Sep-42
P-9A-1060	Platform Stractural Improvments	100	5-Sep-42
P-9A-1130	Packaging / Shipping to Site	60	7-Nov-42
P-9A-1070	Electrical Door & Exciting Sighnage Rough-In	30	5-Dec-42
P-9A-1080	Install PED Controllers in Electrical Room & Energize	10	6-Jan-43
P-9A-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	6-Jan-43
P-9A-1100	Install PED Panels	10	7-Mar-43
P-9A-1110	Terminate PED Electrical Connections	3	7-Mar-43
P-9A-1140	Commissioning	20	9-Mar-43
P-9A-1150	Site Acceptance Testing	40	6-Apr-43
Package 9B		630	0-Jan-41
P-9B-1010	Primerely Design, Tendering - PED Package 9B	110	0-Jan-41
P-9B-1020	NTP-Design Bulid	30	3-Jun-41
P-9B-1030	Design of PED Package 9B	200	25-Jul-41
P-9B-1040	Shop Drawings	40	1-Oct-41
P-9B-1050	Manufacturing	90	1-May-42
P-9B-1120	Factory Acceptance Testing	60	4-Sep-42
P-9B-1060	Platform Stractural Improvments	100	5-Sep-42
P-9B-1130	Packaging / Shipping to Site	60	7-Nov-42
P-9B-1070	Electrical Door & Exciting Sighnage Rough-In	30	5-Dec-42
P-9B-1080	Install PED Controllers in Electrical Room & Energize	10	6-Jan-43
P-9B-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	6-Jan-43
P-9B-1100	Install PED Panels	10	7-Mar-43
P-9B-1110	Terminate PED Electrical Connections	3	7-Mar-43
P-9B-1140	Commissioning	20	9-Mar-43
P-9B-1150	Site Acceptance Testing	40	6-Apr-43
Package 9C		630	6-Dec-41
P-9C-1010	Primerely Design, Tendering - PED Package 9C	110	6-Dec-41
P-9C-1020	NTP-Design Bulid	30	9-May-42
P-9C-1030	Design of PED Package 9C	200	10-Jul-42
P-9C-1040	Shop Drawings	40	6-Oct-42
P-9C-1050	Manufacturing	90	6-Apr-43
P-9C-1120	Factory Acceptance Testing	60	0-Aug-43
P-9C-1060	Platform Stractural Improvments	100	1-Aug-43
P-9C-1130	Packaging / Shipping to Site	60	2-Nov-43
P-9C-1070	Electrical Door & Exciting Sighnage Rough-In	30	0-Nov-43
P-9C-1080	Install PED Controllers in Electrical Room & Energize	10	1-Jan-44
P-9C-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	1-Jan-44
P-9C-1100	Install PED Panels	10	0-Feb-44
P-9C-1110	Terminate PED Electrical Connections	3	1-Mar-44
P-9C-1140	Commissioning	20	3-Mar-44
P-9C-1150	Site Acceptance Testing	40	1-Mar-44
Package 9D		630	6-Dec-41
P-9D-1010	Primerely Design, Tendering - PED Package 9D	110	6-Dec-41
P-9D-1020	NTP-Design Bulid	30	9-May-42
P-9D-1030	Design of PED Package 9D	200	10-Jul-42
P-9D-1040	Shop Drawings	40	6-Oct-42
P-9D-1050	Manufacturing	90	6-Apr-43
P-9D-1120	Factory Acceptance Testing	60	0-Aug-43
P-9D-1060	Platform Stractural Improvments	100	1-Aug-43
P-9D-1130	Packaging / Shipping to Site	60	2-Nov-43
P-9D-1070	Electrical Door & Exciting Sighnage Rough-In	30	0-Nov-43
P-9D-1080	Install PED Controllers in Electrical Room & Energize	10	1-Jan-44
P-9D-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	1-Jan-44
P-9D-1100	Install PED Panels	10	0-Feb-44
P-9D-1110	Terminate PED Electrical Connections	3	1-Mar-44
P-9D-1140	Commissioning	20	3-Mar-44
P-9D-1150	Site Acceptance Testing	40	1-Mar-44
Package 10A		630	1-Dec-42
P-10A-1010	Primerely Design, Tendering - PED Package 10A	110	1-Dec-42
P-10A-1020	NTP-Design Bulid	30	4-May-43
P-10A-1030	Design of PED Package 10A	200	5-Jun-43
P-10A-1040	Shop Drawings	40	1-Oct-43
P-10A-1050	Manufacturing	90	1-Mar-44
P-10A-1120	Factory Acceptance Testing	60	4-Aug-44
P-10A-1060	Platform Stractural Improvments	100	5-Aug-44
P-10A-1130	Packaging / Shipping to Site	60	7-Oct-44
P-10A-1070	Electrical Door & Exciting Sighnage Rough-In	30	4-Nov-44
P-10A-1080	Install PED Controllers in Electrical Room & Energize	10	6-Dec-44
P-10A-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	6-Dec-44
P-10A-1100	Install PED Panels	10	4-Feb-45
P-10A-1110	Terminate PED Electrical Connections	3	4-Feb-45
P-10A-1140	Commissioning	20	6-Feb-45
P-10A-1150	Site Acceptance Testing	40	6-Mar-45
Package 10B		630	1-Dec-42
P-10B-1010	Primerely Design, Tendering - PED Package 10B	110	1-Dec-42
P-10B-1020	NTP-Design Bulid	30	4-May-43
P-10B-1030	Design of PED Package 10B	200	5-Jun-43
P-10B-1040	Shop Drawings	40	1-Oct-43
P-10B-1050	Manufacturing	90	1-Mar-44
P-10B-1120	Factory Acceptance Testing	60	4-Aug-44
P-10B-1060	Platform Stractural Improvments	100	5-Aug-44
P-10B-1130	Packaging / Shipping to Site	60	7-Oct-44
P-10B-1070	Electrical Door & Exciting Sighnage Rough-In	30	4-Nov-44
P-10B-1080	Install PED Controllers in Electrical Room & Energize	10	6-Dec-44
P-10B-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	6-Dec-44
P-10B-1100	Install PED Panels	10	4-Feb-45
P-10B-1110	Terminate PED Electrical Connections	3	4-Feb-45
P-10B-1140	Commissioning	20	6-Feb-45
P-10B-1150	Site Acceptance Testing	40	6-Mar-45
Package 10C		630	6-Nov-43
P-10C-1010	Primerely Design, Tendering - PED Package 10C	110	6-Nov-43
P-10C-1020	NTP-Design Bulid	30	8-Apr-44
P-10C-1030	Design of PED Package 10C	200	9-Jun-44
P-10C-1040	Shop Drawings	40	5-Sep-44
P-10C-1050	Manufacturing	90	6-Mar-45
P-10C-1120	Factory Acceptance Testing	60	20-Jul-45
P-10C-1060	Platform Stractural Improvments	100	21-Jul-45
P-10C-1130	Packaging / Shipping to Site	60	2-Oct-45
P-10C-1070	Electrical Door & Exciting Sighnage Rough-In	30	0-Oct-45
P-10C-1080	Install PED Controllers in Electrical Room & Energize	10	1-Dec-45



Remaining Level of Effort | Actual Level of Effort | Remaining Work
WBS Summary | Actual Work | Critical Remaining Work

TASK filter: All Activities

Activity ID	Activity Name	Original Duration	Start
P-10C-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	1-Dec-45
P-10C-1100	Install PED Panels	10	0-Jan-46
P-10C-1110	Terminate PED Electrical Connections	3	0-Jan-46
P-10C-1140	Commissioning	20	1-Feb-46
P-10C-1150	Site Acceptance Testing	40	1-Mar-46
Package 10D		630	6-Nov-43
P-10D-1010	Primerely Design, Tendering - PED Package 10D	110	6-Nov-43
P-10D-1020	NTP-Design Bulid	30	8-Apr-44
P-10D-1030	Design of PED Package 10D	200	9-Jun-44
P-10D-1040	Shop Drawings	40	5-Sep-44
P-10D-1050	Manufacturing	90	6-Mar-45
P-10D-1120	Factory Acceptance Testing	60	20-Jul-45
P-10D-1060	Platform Stractural Improvments	100	21-Jul-45
P-10D-1130	Packaging / Shipping to Site	60	2-Oct-45
P-10D-1070	Electrical Door & Exciting Sighnage Rough-In	30	0-Oct-45
P-10D-1080	Install PED Controllers in Electrical Room & Energize	10	1-Dec-45
P-10D-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	1-Dec-45
P-10D-1100	Install PED Panels	10	0-Jan-46
P-10D-1110	Terminate PED Electrical Connections	3	0-Jan-46
P-10D-1140	Commissioning	20	1-Feb-46
P-10D-1150	Site Acceptance Testing	40	1-Mar-46
Package 11A		630	0-Nov-44
P-11A-1010	Primerely Design, Tendering - PED Package 11A	110	0-Nov-44
P-11A-1020	NTP-Design Bulid	30	3-Apr-45
P-11A-1030	Design of PED Package 11A	200	5-May-45
P-11A-1040	Shop Drawings	40	1-Aug-45
P-11A-1050	Manufacturing	90	1-Mar-46
P-11A-1120	Factory Acceptance Testing	60	05-Jul-46
P-11A-1060	Platform Stractural Improvments	100	06-Jul-46
P-11A-1130	Packaging / Shipping to Site	60	7-Sep-46
P-11A-1070	Electrical Door & Exciting Sighnage Rough-In	30	5-Oct-46
P-11A-1080	Install PED Controllers in Electrical Room & Energize	10	6-Nov-46
P-11A-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	6-Nov-46
P-11A-1100	Install PED Panels	10	5-Jan-47
P-11A-1110	Terminate PED Electrical Connections	3	5-Jan-47
P-11A-1140	Commissioning	20	7-Jan-47
P-11A-1150	Site Acceptance Testing	40	4-Feb-47
Package 11B		630	0-Nov-44
P-11B-1010	Primerely Design, Tendering - PED Package 11B	110	0-Nov-44
P-11B-1020	NTP-Design Bulid	30	3-Apr-45
P-11B-1030	Design of PED Package 11B	200	5-May-45
P-11B-1040	Shop Drawings	40	1-Aug-45
P-11B-1050	Manufacturing	90	1-Mar-46
P-11B-1120	Factory Acceptance Testing	60	05-Jul-46
P-11B-1060	Platform Stractural Improvments	100	06-Jul-46
P-11B-1130	Packaging / Shipping to Site	60	7-Sep-46
P-11B-1070	Electrical Door & Exciting Sighnage Rough-In	30	5-Oct-46
P-11B-1080	Install PED Controllers in Electrical Room & Energize	10	6-Nov-46
P-11B-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	6-Nov-46
P-11B-1100	Install PED Panels	10	5-Jan-47
P-11B-1110	Terminate PED Electrical Connections	3	5-Jan-47
P-11B-1140	Commissioning	20	7-Jan-47
P-11B-1150	Site Acceptance Testing	40	4-Feb-47
Package 11C		630	6-Oct-45
P-11C-1000	Primerely Design, Tendering - PED Package 11C	110	6-Oct-45
P-11C-1010	NTP-Design Bulid	30	9-Mar-46
P-11C-1020	Design of PED Package 11C	200	0-May-46
P-11C-1030	Shop Drawings	40	6-Aug-46
P-11C-1040	Manufacturing	90	4-Feb-47
P-11C-1110	Factory Acceptance Testing	60	0-Jun-47
P-11C-1050	Platform Stractural Improvments	100	1-Jun-47
P-11C-1120	Packaging / Shipping to Site	60	2-Sep-47
P-11C-1060	Electrical Door & Exciting Sighnage Rough-In	30	0-Sep-47
P-11C-1070	Install PED Controllers in Electrical Room & Energize	10	1-Nov-47
P-11C-1080	Relocate Excisting Sighage & Lightning to Accomodat	30	1-Nov-47
P-11C-1090	Install PED Panels	10	1-Dec-47
P-11C-1100	Terminate PED Electrical Connections	3	1-Dec-47
P-11C-1130	Commissioning	20	2-Jan-48
P-11C-1140	Site Acceptance Testing	40	0-Jan-48
Package 11D		630	6-Oct-45
P-11D-1010	Primerely Design, Tendering - PED Package 11D	110	6-Oct-45
P-11D-1020	NTP-Design Bulid	30	9-Mar-46
P-11D-1030	Design of PED Package 11D	200	0-May-46
P-11D-1040	Shop Drawings	40	6-Aug-46
P-11D-1050	Manufacturing	90	4-Feb-47
P-11D-1120	Factory Acceptance Testing	60	0-Jun-47
P-11D-1060	Platform Stractural Improvments	100	1-Jun-47
P-11D-1130	Packaging / Shipping to Site	60	2-Sep-47
P-11D-1070	Electrical Door & Exciting Sighnage Rough-In	30	0-Sep-47
P-11D-1080	Install PED Controllers in Electrical Room & Energize	10	1-Nov-47
P-11D-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	1-Nov-47
P-11D-1100	Install PED Panels	10	1-Dec-47
P-11D-1110	Terminate PED Electrical Connections	3	1-Dec-47
P-11D-1140	Commissioning	20	2-Jan-48
P-11D-1150	Site Acceptance Testing	40	0-Jan-48
Phase 4-Line 4		630	1-Oct-46
Package 7A		630	1-Oct-46
P-7A-1010	Primerely Design, Tendering - PED Package 7A	110	1-Oct-46
P-7A-1020	NTP-Design Bulid	30	4-Mar-47
P-7A-1030	Design of PED Package 7A	200	5-Apr-47
P-7A-1040	Shop Drawings	40	1-Aug-47
P-7A-1050	Manufacturing	90	0-Jan-48
P-7A-1120	Factory Acceptance Testing	60	4-Jun-48
P-7A-1060	Platform Stractural Improvments	100	5-Jun-48
P-7A-1130	Packaging / Shipping to Site	60	7-Aug-48
P-7A-1070	Electrical Door & Exciting Sighnage Rough-In	30	4-Sep-48
P-7A-1080	Install PED Controllers in Electrical Room & Energize	10	6-Oct-48
P-7A-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	6-Oct-48
P-7A-1100	Install PED Panels	10	5-Dec-48
P-7A-1110	Terminate PED Electrical Connections	3	5-Dec-48
P-7A-1140	Commissioning	20	7-Dec-48
P-7A-1150	Site Acceptance Testing	40	4-Jan-49
Package 7B		630	1-Oct-46
P-7B-1010	Primerely Design, Tendering - PED Package 7B	110	1-Oct-46
P-7B-1020	NTP-Design Bulid	30	4-Mar-47
P-7B-1030	Design of PED Package 7B	200	5-Apr-47
P-7B-1040	Shop Drawings	40	1-Aug-47
P-7B-1050	Manufacturing	90	0-Jan-48
P-7B-1120	Factory Acceptance Testing	60	4-Jun-48
P-7B-1060	Platform Stractural Improvments	100	5-Jun-48
P-7B-1130	Packaging / Shipping to Site	60	7-Aug-48
P-7B-1070	Electrical Door & Exciting Sighnage Rough-In	30	4-Sep-48
P-7B-1080	Install PED Controllers in Electrical Room & Energize	10	6-Oct-48
P-7B-1090	Relocate Excisting Sighage & Lightning to Accomodat	30	6-Oct-48
P-7B-1100	Install PED Panels	10	5-Dec-48
P-7B-1110	Terminate PED Electrical Connections	3	5-Dec-48
P-7B-1140	Commissioning	20	7-Dec-48
P-7B-1150	Site Acceptance Testing	40	4-Jan-49



***Please note that the number of packages may need to be increased to 12 (from 6) for phases 2 & 3.**

Remaining Level of Effort
Actual Level of Effort
Remaining Work
WBS Summary
Actual Work
Critical Remaining Work

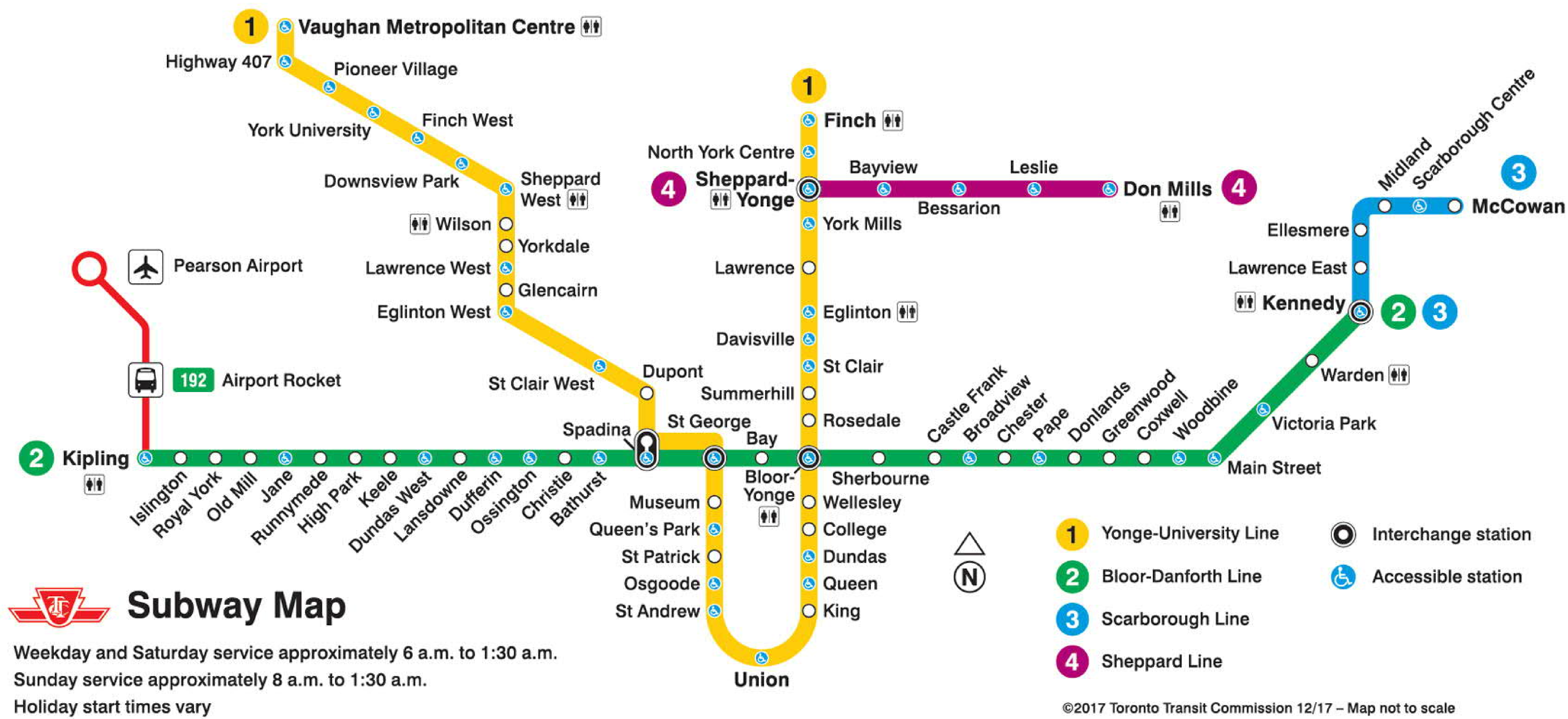
TASK filter: All Activities

Appendix G

Subway Map

-

Reference Table in section 2.6.1 for station packages



Appendix H

TTC Concept of Operations for PEDs

Toronto Transit Commission

Platform Edge Doors (PEDs)

High-Level Concept of Operations

Version 2

March 1, 2017

REVISION LOG

Version	Date	Comments
Version 1	Dec 7, 2016	Initial Release
Version 2	March 1, 2017	Updated based on comments received

TABLE OF CONTENTS

1. INTRODUCTION

This document is a high-level Concept of Operations (ConOps) for Platform Edge Doors (PEDs), as may be installed on current and/or future Toronto Transit Commission (TTC) subway lines.

1.1 BUSINESS OBJECTIVES

The business objectives for installing PEDs include the following:

1.1.1 *Safety*

- The primary safety objective is to improve passenger safety by preventing conflicts between passengers and moving trains, particularly on heavily crowded station platforms, and to reduce track related injuries and fatalities by preventing trespass from the station platform onto the trackway (for example to recover articles dropped onto the track);
- A secondary safety benefit is to reduce debris blown onto the tracks from station platforms, with associated reduction in track fires;
- In addition, any new hazards introduced by the presence of PEDs must be mitigated.

1.1.2 *Operations*

- Provide for high levels of operational availability of the PED system;
- Improve passenger boarding/alighting flow; and
- Creating a cleaner/quieter platform environment for passengers.

1.1.3 *Maintenance*

- PED system to be easily maintained from the station platform; and
- PED system design to allow access between the trackway and the station platform for maintenance of the right-of-way.

1.1.4 *Ventilation Systems Integration*

- For existing stations, PED system design to be integrated with the existing tunnel/ventilation systems; and
- For new stations, tunnel/ventilation system designs to be optimized based on the presence of PEDs.

1.1.5 *Business Case*

- PED system implementation strategy to be based on a cost/benefit analysis to ensure appropriate return on investment.

1.2 CONTEXT

The context for this ConOps is based on the following assumptions:

1) Certain stations on an existing or new TTC subway line may be PED-equipped, but other stations on that line may not be equipped with PEDs, depending on cost/benefit analysis, funding availability and the PED roll-out strategy; specific scope of PED deployment to be determined during Procurement stage;

2) All passenger trains operating on a subway line equipped with, or partially-equipped with, PEDs are assumed to be fixed length trains, either Toronto Rocket (TR) trains or future, similar, modern passenger trains of "walk-thru" design (i.e. not T1 trains); all trains (current or future) operating on a PED-equipped line would have to have compatible door configurations (locations of doors and door widths) and compatible dynamic envelopes (the same minimum and maximum gap between a closed PED and a train that is stationary at, or passing though, the PED-equipped station);
    a. Specifically, given the desirability for commonality between lines, current expectation is that T1 trains would <u>not</u> be used on the BD line (Line 2), if any BD stations were PED equipped;

3) One-Person Train Operation (OPTO) is the assumed operating concept for trains operating on a subway line equipped with, or partially-equipped with, PEDs;

4) The installation of PEDs on a given station platform will not be dependent upon permanently staffing that platform i.e. the installation of PEDS should not drive a mandatory requirement to permanently staff every platform; failure management to be train operator and on-call maintenance personnel as an extension of current practices to manage train door failures; and

5) A subway line equipped with, or partially-equipped with, PEDs would ideally also be equipped with an Automatic Train Control (ATC) system providing Automatic Train Protection (ATP) and Automatic Train Operation (ATO) functions; hence a preference to install PEDs on YUS (Line 1) first;
    a. ATC is however not a mandatory requirement for PEDs (for example, the initial installation of PEDs on the Jubilee Line Extension in London, and the installation of PEDs on the UP Express in Toronto); as such, this document also covers the potential scenario where a PED system may be required to operate in conjunction with the existing fixed block, track circuit-based, wayside signal/trip stop signalling system, with manual train operations.

1.3 ACRONYMS AND ABBREVIATIONS

ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
CABS	Cab-Signalling mode
EM	Emergency Manual mode
OPTO	One-Person Train Operation
TCC	Transit Control Centre
TR	Toronto Rocket (subway train)
TTC	Toronto Transit Commission

2. PED SYSTEM FUNCTIONAL DESCRIPTION

For the purposes of this ConOps, a PED System as installed on a typical TTC station platform is assumed to satisfy the high-level functional requirements listed below.

Requirement/design trade-offs may be required in the event of conflicts between these desired functional requirements and the business objectives listed in Section 1.1.

Any PED System will also require integration with, and modifications to, the platform infrastructure, the trains, the ATC/signalling/communication systems, and TTC's operating and maintenance practices. The nature and extent of these modifications will be dependent upon the specific design solution adopted.

- The PED System will create a continuous barrier between the platform and the trackway which isolates passengers from the trackway; this continuous barrier will consist of:
  - Automatically controlled bi-parting PEDs (for normal passenger transfer between trains/platforms);
  - A manually controlled crew door, aligned with the train cab door (to enable the train operator to access the station platform);
  - Emergency doorways (as may be required for emergency access to the station platform from the trackway);
  - Fixed panels; and
  - Alarmed trackway access doors (at the head-wall and tail-wall ends of the PED barrier).

- The PED System will be designed to withstand the maximum possible pressure loading that could be applied on a crowded platform;

- The PED System will include multiple PEDs. The number and location of the PEDs will correspond to the number and location of passenger doors on the fixed-length passenger train when the train is correctly berthed at that station platform;

- The PED design (specifically the door closing speed and force) will reduce the potential for an injury should a person be hit by a closing door (equivalent to the train door design);

- The emergency doorways and fixed panels will be configured to not only support emergency operating scenarios, but also to permit the required transfer of materials between the station platform and trackway for maintenance of the right-of-way;

- On an ATC-equipped line (with ATC-equipped passenger trains), the PEDs will be controlled and supervised by the ATC system in a similar fashion to the ATC system's control and supervision of train doors; specifically:
  - Train door and PED opening control protection interlocks will prevent train doors/PEDs opening unless the train is correctly berthed at the station platform; and
  - Train departure interlocks will prevent a train departing from a station platform unless all train doors/PEDs (as well as crew door and emergency doorways) are confirmed to be closed and locked; similarly, a train would be prevented from entering a station platform unless all PEDs (as well as crew door and emergency doorways) are confirmed to be closed and locked;

- Equivalent door opening protection and train departure/train arrival interlocks would also be provided on non-ATC lines (i.e. lines equipped with a wayside signal/trip-stop system only);

- PEDs will be fitted with open indicator lights and means to bypass local interlocks in the event of failure;

- The PED System design (specifically PED opening and closing times), and the PED/ATC/train interfaces will be such that the introduction of PEDs will not extend platform dwell times[1]; the PED control system will provide near simultaneous opening and closing of the train doors and PEDs;
    - With respect to door closure, it is desirable for the PEDs to commence closing ahead of the train doors.

- The PED System design (specifically PED door open width) will be consistent with the stopping accuracy that can be reliably achieved by the train/ATC system, when operating in ATO mode and with a stopping profile that does not significantly extending station run-in times;
    - On non-ATC lines, the achievable stopping accuracy, and impacts on train run-in times would have to reflect manual train operations/platform berthing;

- Train-borne CCTV and platform cameras will give the train operator a view of the platform and PEDs;

- PED status (open/closed/out-of-service) will be indicated to the train operator;
    - A bi-directional communication link of some form will be required between the train and PED systems to synchronize train door opening/closing with PED door opening/closing and to provide necessary safety interlocks; some changes to the existing TR trains will be required to accommodate PEDs;

- A PED System local control panel, on the platform head-wall, will be provided for failure management purposes and for PED maintenance; the local control panel will allow for the PEDs to be opened and closed locally and can also be used to lockout selected PEDs for maintenance or repair;

- Facilities will also be provided at the crew door, accessible to the train operator from the train cab, to allow the train operator to open and close the PEDs for failure management purposes;

- It will be possible to lock closed (i.e. take out-of-service) specific PEDs; a PED locked closed will (where practical) prevent a corresponding train door from opening; similarly, a train door locked closed (taken out-of-service) will (where practical) prevent a corresponding PED from opening;

- The PED design, and the gap between a PED and train door, will be limited such that a person (including a small child) cannot become trapped between a closed PED and a closed train door;

[1] *Research as shown that the presence of PEDs does not have a detrimental impact on the boarding and alighting time but does affect passenger behavior at the platform, inducing a more organized boarding and alighting process in which boarders wait beside the doors rather than in front of them and give way to alighters more often than without PEDs. (ref. "Impact of Platform Edge Doors on Passengers' Boarding and Alighting Time and Platform Behavior", Transportation Research Record: Journal of the Transportation Research Board Issue Number: 2540, 2016.)*

- The PED design will provide for the detection of, and response to, persons trapped between a closing PED, equivalent to that provided for train doors;
    - There are currently facilities on the TR train to recycle (re-open/re-close) train doors in the event of a train door blockage and equivalent facilities will need to be provided to also recycle (re-open/re-close) PED doors; it should be possible to recycle train doors and PED doors independently; specific details to be determined during design phase;

- It will be possible to open any PED or emergency doorway manually from the trackway.

3. NORMAL OPERATING SCENARIOS

3.1 ON ATC-EQUIPPED LINES

Under normal (non-failure) operating scenarios, an ATC-equipped train is assumed to be operating in ATO mode. Trains operating in CABS or EM mode are addressed in Section 4.1.

3.1.1 *Train Entering PED-equipped Station Platform*

The ATC system will prevent a train entering a PED-equipped station, in ATO mode, unless the PEDs are indicating closed and locked.

Subject to any ATP-imposed constraints, a train in ATO mode will be automatically controlled by the ATC system to a stop at the designated stopping point on the station platform. The ATO stopping profile will be such to provide the specified station stopping accuracy. The operating scenario where the train fails to stop within the specified station stopping accuracy is discussed in Section 4.2.

The ATC system will ensure that the train is properly berthed on the station platform and constrained against motion prior to enabling the opening of the train doors and PEDs.

The ATC system will automatically control the opening of the train doors and PEDs. The PEDs will be controlled as a set with the matching train doors such that the train and matching platform edge doors open together.

3.1.2 *Train Departing PED-equipped Station Platform*

The train operator will be responsible for initiating door closure upon expiry of the scheduled station dwell time and when safe to do so. The PEDs will be controlled as a set with the matching train doors such that the train and matching platform edge doors close together. If a PED/train door fails to close, the doors will be recycled. Intervention may be required to safely lockout a problem door (ref. Section 5.1).

The ATC system will prevent a stationary train from departing the station in ATO mode unless all train doors and PEDs are properly closed and locked.

3.2 ON WAYSIDE-SIGNALLED LINES

All trains operating on wayside signalled lines would be operating in manual mode.

3.2.1 *Train Entering PED-equipped Station Platform*

The wayside signal system will prevent a train entering a PED-equipped station unless the PEDs are indicating closed and locked.

Unless constrained by a restrictive wayside signal aspect, the train operator will manually control the train to a stop at the designated stopping point on the station platform. The train operator will be responsible for ensuring the train stops within the specified station stopping accuracy. Signage will be provided to assist the train operator.

The operating scenario where the train operator fails to stop within the specified station stopping accuracy is discussed in Section 4.2

Facilities will be provided to ensure that the train is properly berthed on the station platform and constrained against motion prior to enabling the opening of the train doors and PEDs.

The train operator will be responsible for opening the train doors and PEDs. Facilities will be provided to ensure the PEDs will be controlled as a set with the matching train doors such that the train and matching platform edge doors open together.

3.2.2 *Train Departing PED-equipped Station Platform*

The train operator will be responsible for initiating door closure upon expiry of the scheduled station dwell time and when safe to do so. The PEDs will be controlled as a set with the matching train doors such that the train and matching platform edge doors close together.

Facilities will be provided to prevent a stationary train from moving unless all train doors and PEDs are properly closed and locked.

4. ABNORMAL OPERATING SCENARIOS

4.1 OTHER PASSENGER TRAIN OPERATING MODES ON ATC-EQUIPPED LINES

4.1.1 *Train Entering Station Platform in CABS Mode*

The ATC system will prevent a train entering a PED-equipped station, in CABS mode, unless the PEDs are indicating closed and locked.

Subject to any ATP-imposed constraints, the train operator will manually control the train to a stop at the designated stopping point on the station platform. The train operator will be responsible for ensuring the train stops within the specified station stopping accuracy. Signage will be provided to assist the train operator.

The operating scenario where the train operator fails to stop the train within the specified station stopping accuracy is discussed in Section 4.2.

The ATC system will ensure that the train is properly berthed on the station platform and constrained against motion prior to enabling the opening of the train doors and PEDs.

The train operator will be responsible for opening the train doors and PEDs. The PEDs will be controlled as a set with the matching train doors such that the train and matching platform edge doors open together.

4.1.2 *Train Departing Station Platform in CABS Mode*

The train operator will be responsible for initiating door closure upon expiry of the scheduled station dwell time and when safe to do so. The PEDs will be controlled as a set with the matching train doors such that the train and matching platform edge doors close together.

The ATC system will prevent a stationary train from departing the station in CABS mode unless all train doors and PEDs are properly closed and locked.

4.1.3 *Train Entering Station Platform in EM Mode*

There will be no ATC system interlocks to prevent a train entering a PED-equipped station in EM mode.

The train operator will manually control the train to a stop at the designated stopping point on the station platform. The train operator will be responsible for ensuring the train stops within the specified station stopping accuracy.

For a train in EM mode, the opening of train doors and PEDs will be the responsibility of the train operator.

4.1.4 *Train Departing Station Platform in EM Mode*

For a train in EM mode, the closing of train doors and PEDs will be the responsibility of the train operator.

There will be no ATC system interlocks to prevent a train in EM mode departing a PED-equipped station.

4.2 PASSENGER TRAIN FAILS TO STOP WITHIN SPECIFIED STATION STOPPING ACCURACY

Should a train in ATO mode stop short of the desired platform stopping point, the train operator can select CABS mode in order to manually drive the train to the correct location.

Should the train stop (either in ATO or in a manual operating mode) outside the defined PED/train door alignment tolerance, but the PED/train door alignment will still allow passengers restricted train ingress/egress, the train operator will be able to override the door opening interlock and command the train doors and PEDs to open (utilizing in-cab facilities and facilities at the crew door in the PED barrier).

Should the train stop such that the PED/train door alignment will not allow passenger ingress/egress, the train operator will not be able to override the door opening interlocks and will have to proceed to the next station without allowing passengers to exit or enter the train at the current station. (Note: The PED system design should ensure this is an infrequent scenario such that operating impacts are acceptable. As such, adding additional design/operational complexities to shunt forward to another door set is not required.)

4.3 OPERATION OF WORK TRAINS

ATC-equipped work trains operating on ATC-equipped lines would normally be operating in CABS mode while moving to or from the work site. As such, the ATC system will prevent a work train entering or passing through a PED-equipped station, unless the PEDs are indicating closed and locked status (ref. Section 4.1.1). There will be no ability to open/close PEDs from a work train.

There will be no ATC system interlocks to prevent a work train entering or passing through a PED-equipped station if that work train is not ATC-equipped, or if that work train is operating in EM mode (ref. Section 4.1.3).

4.4 MAINTENANCE ACCESS BETWEEN STATION PLATFORM AND TRACKWAY

At a PED-equipped station, maintenance personnel at track level will be able to access a station platform (and vice versa) via the trackway access doors installed at each end of the PED barrier. Opening of these trackway access doors will be alarmed at the Transit Control Centre but will not inhibit a passenger train entering the station platform.

Individual PEDs and/or emergency access doorways can also be used by maintenance personal to transfer materials between the station platform and trackway for maintenance of the right-of-way.

5. DEGRADED OPERATING SCENARIOS

It is anticipated that management of PED failures, PED control system failures, and train door failures would be by the train operator and/or on-call maintenance personnel (or by mobile station staff), with no requirement to permanently staff all PED-equipped platforms.

General failure management concepts are summarized below. Specific details will be dependent on the specific PED design solution adopted.

5.1 PED SYSTEM FAILURES

5.1.1 *Failure of One or More PEDs*

If one or more PEDs fail to open or close, or fail to provide a “door closed” indication when closed and locked, then those doors can be taken out-of-service and locked in the closed position by means of local provisions such as facilities at each PED location, or at the PED System local control panel installed on the platform head-wall.

The fact that a specific PED is out-of-service would be indicated to passengers on the platform.

A PED out of service would also be alarmed at the Transit Control Centre.

If a specific PED is out-of-service, the corresponding train door would also be prevented from opening (where practical).

Prior to taking a failed PED out-of-service, the possibility exists that a train door will still open, but the corresponding PED will remain closed. Passengers will still have the ability to enter or exit the train through another door on the train, but at some increased inconvenience.

5.1.2 *Total Failure of the PED Control System*

The design of the PED system will be such that an inability to open/close all PEDs is an infrequent event.

Under this scenario, either manual intervention would be required (to manually open and close each passenger door), with associated service impacts, or trains will need to bypass that station until the failure is corrected.

5.2 TRAIN DOOR FAILURES

If a single train door fails to open or close, or fails to provide a "door closed" indication when closed and locked, then that door can be taken out of service and locked in the closed position in accordance with current practice.

Facilities will be provided to prevent the corresponding PED opening, with an indication provided to passengers on the platform (where practical).

Prior to taking a failed train door out-of-service, the possibility exists that a PED will open, but the corresponding train door will remain closed. Passengers will still have the ability to enter or exit the train through another PED, but at some increased inconvenience.

5.3 SIGNALLING SYSTEM FAILURES

5.3.1 *On ATC-equipped Lines*

In the event of a total failure of the train-borne ATC equipment, any movement of that train would be in EM mode (ref. Section 4.1.3) in accordance with defined operating procedures for the movement of EM trains. Under this scenario, there would be no ATC system interlocks to prevent an EM train entering or passing through a PED-equipped station and the opening of train doors/PEDs would have to be accomplished manually in accordance with operating procedures.

In the event of a total failure of the wayside equipment in the area of a PED-equipped station, any movement of any train in that area would also be in EM mode (ref. Section 4.1.3).

Similarly, a total failure of the interface between the ATC system and the PED System would also require trains to enter and pass through that station in EM mode (ref. Section 4.1,3).

5.3.2 *On Wayside Signalled Lines*

Wayside signalling failures may also require a train to enter and pass through a PED-equipped stations with PED System interlocks bypassed, depending on the specific design implementation.

5.4 PED SYSTEM MAINTENANCE

Proactive, condition-based, preventative maintenance will be planned and conducted such that the probability of a service-affecting PED system failure is reduced to acceptable levels.

The PED System will be designed to detect and react to PED equipment failures, with alarms to the Transit Control Centre (TCC). (Note: The method of communicating any PED status information to the TCC will be dependent upon the specific PED design solution adopted, but would likely be through an extension to the existing SCADA systems.)

The PED System will be designed such that all of the working components can be safely maintained, repaired or replaced from the platform side. Used of properly design safety barriers will permit maintenance of a PED to be accomplished during revenue service hours with no risk to passengers or staff.

A PED out-of-service for maintenance would be alarmed to the Transit Control Centre.

Cleaning of the track-side of the PED barrier would be limited to non-revenue hours.

(Note: The additional maintenance staff required, and the required maintenance qualifications, will depend on the number of PED-equipped stations, and the specific PED design solution adopted.)

6. EMERGENCY OPERATING SCENARIOS

6.1 PERSON ENTERS TRACKWAY

PEDs effectively eliminate the risk of a person intentionally or accidently entering the trackway.

6.2 PERSON TRAPPED BETWEEN CLOSED PED AND CLOSED TRAIN DOOR

The risk of a person being trapped between a PED and train door, and the train departs from the station, will be virtually eliminating by designing the PED/train interface such that the gap between a closed PED and closed train door is minimized. In addition, a person trapped between a closing PED and/or closing train door would be detected and the lack of PED/train door closed and locked status will prevent the train departing from the station platform. PED status indications would be designed in accordance with “fail safe” principles.

6.3 PASSENGER EVACUATION SCENARIOS

A situation could potentially arise where the PED barrier delays the emergency evacuation of a train in a station.

The PEDs will therefore include an emergency release to enable a PED to be opened from the trackside if the train doors open but the PEDs fail to open.

The emergency doorways would also enable passengers on a train to exit a train onto a station platform, if the train doors are not aligned with the PEDs.

Passengers in the trackway can also exit onto the platform via the trackway access doors at the end of each PED barrier.

(Note: Scenarios for evacuation passengers from a train, or the trackway, onto a station platform should be the same for both side and centre-platform stations.)

6.4 VENTILATION EMERGENCY

A train or tunnel fire would trigger the tunnel emergency ventilation system. Existing tunnel ventilation systems have been designed based on “open” platforms and this would likely preclude the use of full-height PEDs on existing station platforms. For future stations, an opportunity may exist to isolate the stations from the tunnel through full-height PEDs. Under this scenario, the additional PED costs could be more than offset by reductions in the tunnel ventilation system/infrastructure costs.