

2018 Association of Canadian Consulting Engineers Award Submission

# Toronto Transit Commision Line 1 Subway Extension



Joint Submission by:

**AECOM** **ARUP** **HATCH**



**PARSONS**



# Summary

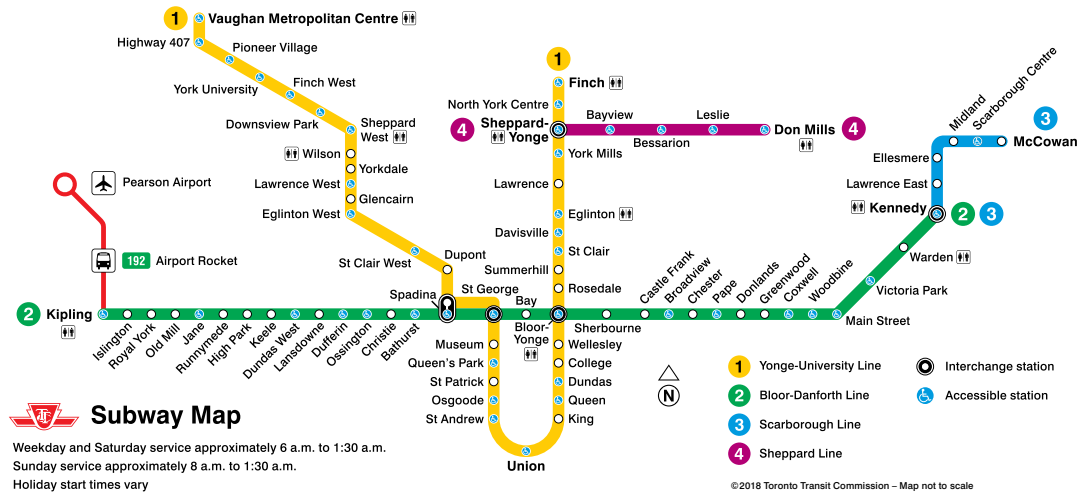
The project, costing \$3.18 billion and funded by all 3 levels of Government, is an 8.6 kilometre extension of the TTC's Line 1 Subway system, with 6 new state of the art Subway stations: Downsview Park, Finch West, York University, Pioneer Village, Highway 407 and Vaughan Metropolitan Centre. It also features 3 new bus terminals, 3 new commuter parking lots containing 3000 parking spaces, a regional GO train station at Downsview Park and provides seamless connections to other transit and commercial developments.

The alignment construction features 6.2 kilometres of twin tunnels installed using tunnel boring machines (TBM's), a triple track cross-over structure installed through the sequential excavation method (SEM), with the stations constructed using the 'cut and cover' method. There were 5 new electrical power sub-stations built as part of the project and a major extension to the

Wilson Yard Train Storage facility to accommodate the new trains running on the alignment.

The project has delivered on its objectives, providing a high-capacity, fast, convenient, modern and integrated subway system that will serve Toronto and York Region residents for generations to come. The Line 1 extension is projected to carry more than 80,000 riders every day and will reduce greenhouse gas emissions, stimulate economic development in the corridor, support transit oriented development, reduce the environmental impacts of projected growth, and improve the economic competitiveness of the GTA.

The applicants together completed station/tunnel/ systems design, project/construction management, testing and commissioning.



# Innovation

Numerous innovations were incorporated into the Project's design, during construction and testing & commissioning, the delivery of which has demonstrated exemplary implementation of best practice engineering principles. Some of the more notable innovations from the Project are highlighted below.

## Mining Under Major Pipeline and Hydro Corridor

The design called for use of Sequential Excavation Method (SEM) mining to construct the triple-track crossover structure under a major hydro/pipeline corridor, north of Finch West station. This is the first time the SEM method was used as part of the construction of a major transit facility in Canada. This methodology was employed to ensure no impact on major oil, gas and power transmission utilities during tunneling and minimized further surface disruptions.



## A Modern Subway Extension

The Project provides for modern amenities including wifi in stations and tunnels, implementation of new train signalling system (Automatic Train Control), modern fare gates (PRESTO fare card enabled), and stations built with integrated customer connections to a broad range of other transit services such as GO bus & rail, YRT bus rapidways and future LRTs.





# Innovation (cont'd)

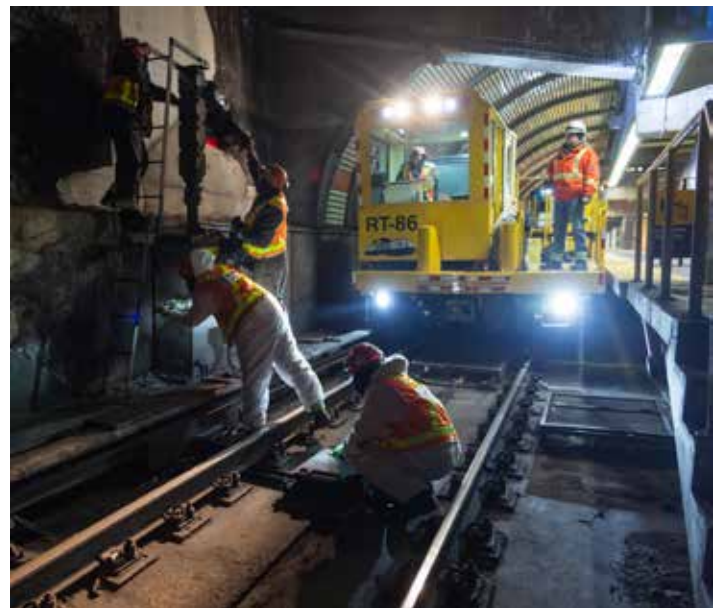
## Modern Systems Design – Fiber Optics

Thousands of metres of fibre-optic cable were installed in tunnels and stations providing a self-healing loop backbone to connect to TTC's various subway communications systems; SCADA (supervisory control and Data Acquisition), fire, IT network, radio, public address, passenger assistance alarms and CCTV (closed circuit television). The new fibre-optic network included a quadrupling of TTC's typical transmission capacity. All of these additions and system upgrades were integrated with TTC's Transit Control Centre systems as part of the Project.



## Automatic Train Control (ATC) Signalling System

First of its kind in Canada, the project opened using the TTC's new modern signalling system. TTC's new ATC system uses Communication Based Train Control (CBTC) that allows for the exact position of the train to be known, increasing subway system capacity and passenger safety. The Line 1 Extension project opened using the new ATC signalling system exclusively, as the second phase in TTC's Line 1 signal modernization project.



# Innovation (cont'd)

## Direct Fixation for Special Track Installations

The Project initiated a design for the special trackwork, at crossovers and in the triple track structure, to be placed on isolated track slabs using direct fixation – a first for TTC. A noise and vibration analysis determined the size of slabs and elastomers required. The TTC designed the structural slabs including the use of self-leveling concrete. Under management of the project team, the Contractor developed the process to construct the slabs, suspend the special trackwork and pour the concrete to complete the assembly.



## Incorporating Functional Art within Station Architecture

The Project design innovatively incorporates public art into all stations, most often in a functional as well as artistic capacity, with much of the art imbedded in the structural geometry of the stations including major elements that draw natural light deep into the stations.





# Complexity

Projects of this complexity, with multi-stakeholder involvement and expectations, are certainly not immune to challenges during the design, funding and execution phases. This project had challenges at each stage. However, what was promised has been delivered; a modern, seamlessly integrated subway system that supports economic growth and will provide sustainable transportation options for many generations in the future.

Some of the more complex aspects of the project during both the design and construction phase include:

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## High Water Table/ Buoyancy

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The Project required the construction of deep box stations, with 110 linear kilometres of caisson piling installed, requiring sophisticated support of excavation systems in a very high water table environment. Each station was designed to use a different method to counteract buoyancy including micropiles in the station base slab, backfilled toe slab and tension piles.




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## Logistics of Major Concrete Pours

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Complex station architecture required extensive coordination and logistics to accommodate numerous and major concrete pours to form unusual geometry. Two of the largest continuous pours on the Project occurred in 2015 as shown below.



York University Station – 2800 cubic metres over 15 hours



Vaughan Metropolitan Centre Station – 2250 cubic metres over 30 hours

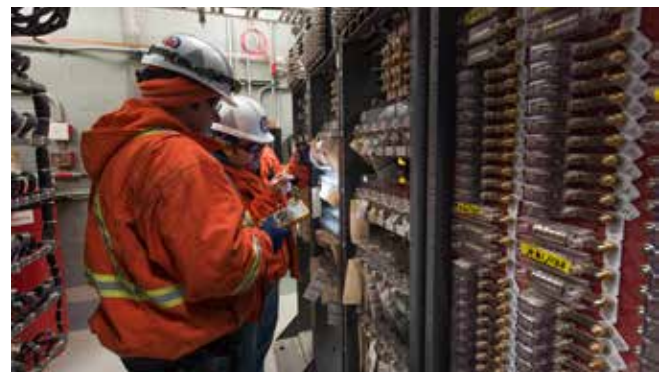
## Constructing an Elevated Traction Power Sub-Station (Second Floor of a Bus Terminal)

The Project constructed five traction power substations to provide electricity to stations for lighting, ventilation, escalators, elevators, and fare equipment, among other station systems, and to the tunnels for traction power (for train operation). Significant work coordination challenges were experienced to ensure the elevated Finch West traction power fully commissioned on time for full subway traction power testing and train operations.



## Testing and Commissioning

This nine month process involved thousands of person-hours of testing and commissioning of individual subway systems components, individual systems and finally the new subway project, through a comprehensive three level process to gain approvals from external agencies and TTC safety certification. An extensive training program was undertaken as part of the commissioning process, involving both internal staff groups and external agencies. Emergency response protocols were tested through two major subway evacuation simulation exercises – the largest undertaken by TTC to date.





# Social and Economic Benefit

The Project brings a rapid, convenient, high-capacity and reliable transit service to the NW quadrant of Toronto and beyond City limits into York Region, an area that previously was not serviced by rapid transit. It provides for a new regional connection with the GO Barrie Line at Downview Park, and easy access into the new park lands. For the densely populated Keele/ Finch neighbourhood, the subway provides excellent access into the York University campus, to the new VMC hub and much improved access to the array of employment, commerce, educational and social activities that downtown Toronto has to offer.

The Project serves York University with two new stations (approximately 60,000 full-time and part-time students), and in the process is removing 1800 buses a day from the campus. It has created 3000 new commuter parking

spaces, affording people who previously drove access to high-end transit for the first time, thus easing congestion on the surrounding highways. It provides opportunities for transit-oriented redevelopment at re-zoned high density development nodes along the route including at Downsview Park, Keele/Finch neighbourhood, around Pioneer Village Station, and at the new Vaughan Metropolitan Centre (VMC).

The transformation of the VMC area has already begun with direct connections made to the first office development into the subway station, and additional connections to York Region transit services: Viva BRT on Highway 7, and the YRT Bus terminal on Millway Ave.

Ridership on the whole line is expected to reach 26 million riders in 2018.





# Environmental/Sustainability

Few developments come close to being as sustainable as a subway project, which relieves urban sprawl (i.e. unsustainable development), road congestion, and associated air pollution, thereby allowing the City to grow in a sustainable manner. Subscribing to sustainable design principles, the Project adopted the Toronto Green Standard in its design, including the Wet Weather Flow Guidelines, Bird Friendly Guidelines, Green Roof By-law, and Greening of Parking Lots Guidelines. All stations meet AODA requirements and follow TTC standards for accessibility and wayfinding.

Cool or green roofs are features at all of the new stations. Green or vegetated roofs are located at Downsview Park and at the two TTC bus terminals. Station designs were developed to maximize available sunlight with the incorporation of Skylights, light wells and large voids allowing daylight to penetrate to the subterranean concourse and platform levels, thereby reducing energy consumption.

All stations and bus terminals feature “fritted” bird-friendly glass windows. The “frit” is a permanent dotted pattern applied to glass that helps our bird friends distinguish the glass as something to avoid.

Wherever possible, naturalized sustainable landscapes with storm-water processing and featuring increased biodiversity were incorporated into designs to reduce impacts. At Highway 407 Station, Black Creek was re-routed to facilitate station work. Working with the TRCA, and DFO, a design for the Creek’s re-routing was developed that would meet aquatic habitat objectives. The Creek was dammed, the water rerouted through the new channel, and more than 650 fish were captured and released downstream.



# Meeting Client's Needs

The client's project goals were numerous and varied, with key goals to:

- Provide a fast, safe, high-capacity, six station subway with new bus terminals, commuter parking and seamless connections to local and regional transit systems;
- Deliver high quality architecture and urban design with bright open spaces and daylight penetrating deep into the stations;
- Build barrier-free AODA compliant transit facilities to provide fully accessible system;
- Integrate public art into stations to enhance aesthetics of the stations, creating cultural amenities;
- Support transit-oriented development through installation of development connections and municipal services within new public streets; and
- Create improved pedestrian and cycling amenities and attractive streetscapes.

These client objectives were met with the design, construction and delivery of the the Project. The Project, which includes three bus terminals, a regional GO train connection, 3000 commuter car parking spaces & seamless connections to other transit services. It has already succeeded in attracting many new customers, and has a direct connection to a new office tower at VMC station. The landmark new state-of-the-art subway project provides options for future transit and development connections, has been built for the long term, with a 100 year life of stations/tunnels. Consultant Engineers played a crucial role in achieving client goals; ensuring the Project was designed and managed to the highest engineering standards.





*“This isn’t just any subway extension. This will be a Wi-Fi-, PRESTO-, Automatic-Train-Controlled subway extension. It really will be state of the art from day one.*

*– Andy Byford, TTC CEO  
(March 2017)*

