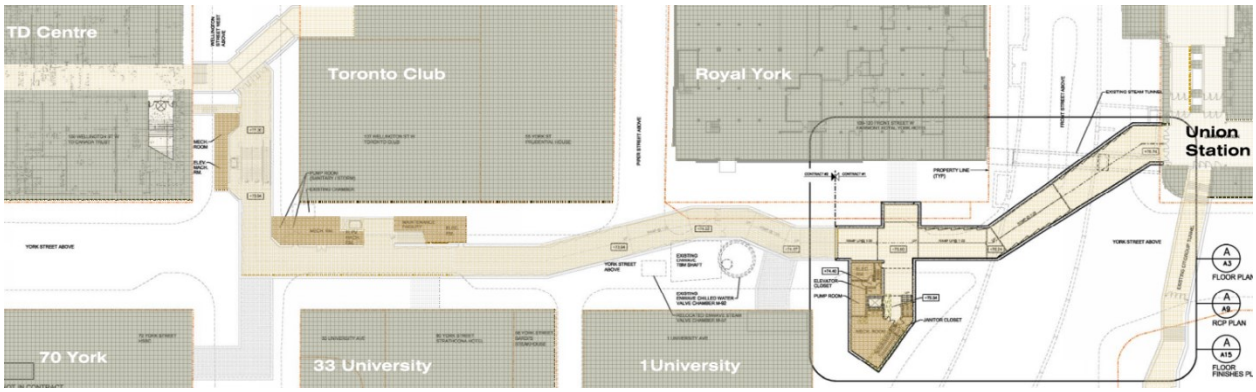
Project Description

The City of Toronto is carrying out major restorative work on the century old Union Station, Canada's busiest multi-modal transportation hub[1] as part of an overall $1B initiative supported by investment from all levels of government.

More people pass through Union Station every day than Toronto's international airport, and this number is expected to double by 2020[2]. The Northwest PATH Pedestrian Tunnel (PATH) project is a subset of this larger revitalization program.

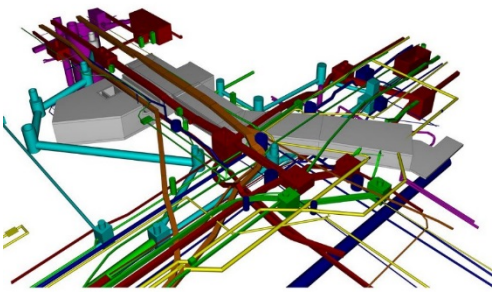


PATH Alignment

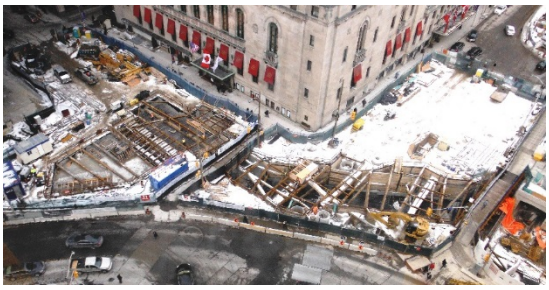
Toronto's PATH system is the world's largest pedestrian tunnel network, connecting more than 50 office towers through 27km of shopping arcades. Pedestrians have long used this network to escape the worst of the Canadian winter, to quickly get around the downtown core and to shop. Union Station is presently connected to the PATH system on the east side of the station only— a connection that is very congested with existing passenger volumes. To facilitate both current and expected volumes, the City requires a "passenger relief valve" on the west side of the station.

This vital addition to the network will provide a faster and safer means of crossing a very busy intersection, reduce congestion, improve pedestrian flows and travel times, and improve access to the buildings and businesses throughout the tunnel network.

Hatch (formerly Hatch Mott MacDonald Canada), in association with NORR Ltd., was the prime consultant working for the City of Toronto, providing both design and construction management services.



3D Model of Proposed Utility Relocations



Construction of Proposed Utility Relocations

Design Innovation

The PATH tunnel is a 200m cut-and-cover tunnel that will extend from Union Station and connect to the existing tunnel network. The first phase of the PATH tunnel alignment, which opened to the public in April 2015, successfully pushed a tunnel through one of the most utility and transit congested intersections in the City of Toronto. This took place in the middle of one of the city's busiest traffic intersections and surrounded by prominent stakeholders in the financial district.

Supporting Utilities During Construction

In addition to the tunnel structure, the project includes the construction of two steel/glass surface buildings for stair/elevator access, road restoration, demolition and rebuilding of a fan shaft for the subway system, and full architectural and mechanical/electrical system installations integrated into the control systems of Union Station.

Extensive 3D modelling of the spatial relationship between the utilities and tunnel structure was used to develop custom solutions to unique utility relocations (i.e. noncircular sewer siphons) and overcome discovered existing conditions which rendered the original reference design unbuildable.

Using a combination of MicroStation and InRoads, a detailed 3D model of the existing and proposed conditions was developed to illustrate the project challenges and develop solutions. Careful modelling of the utilities and tunnel structure provided the following benefits:

- Resolution of conflict between the utilities and the structure in both the design and construction phases;
- Dynamic updating of design drawings throughout the design phase greatly reducing CAD efforts;
- Allowed the scale and complexity of the utility relocations to be effectively communicated to stakeholders in ways not possible by 2D black and white drawings;
- In the field, the 3D models were updated with survey data which helped site and office teams to rapidly understand conflicts and generate options to solve them.

The creation of 3D digital prototypes of the new construction in the context of the existing conditions allowed us to truly visualize and understand the utility/structural conflicts with a level of confidence that 2D drawing extractions (elevations, sections, profiles, plans) wouldn't permit. To produce the contract drawings for construction, the necessary detailed plans, elevations and cross sections were generated directly from the model, saving time and improving the quality of drawings compared to traditional 2D CAD methods.

Sewers are the most unforgiving of utilities to relocate because they rely on gravity to function. One of our greatest challenges was to relocate a sewer whose existing profile went directly through the new tunnel. By using 3D modelling, we were able to geometrically design custom utility solutions with accuracy and confidence.

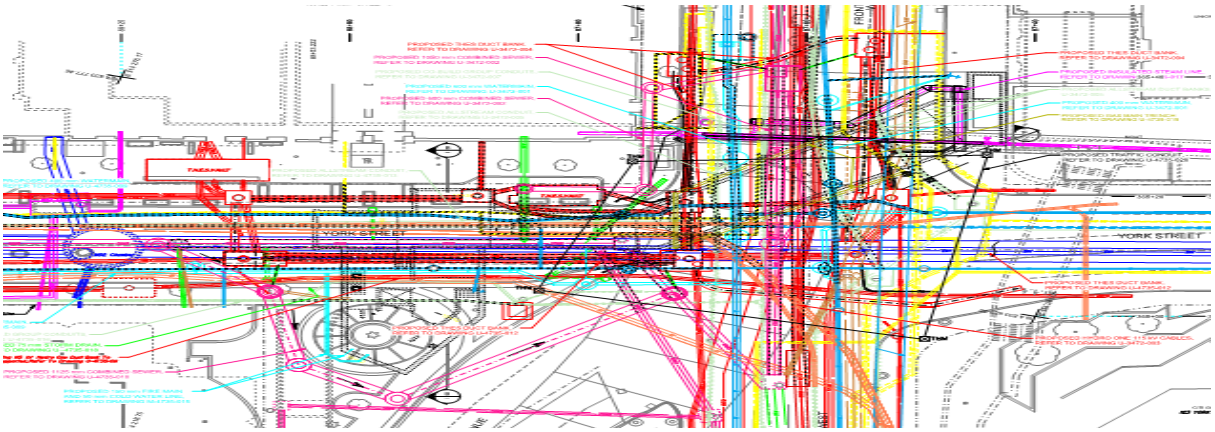
The design response was to create a siphon underneath the tunnel, directly between the new tunnel's floor slab and the existing subway system's roof slab. There was insufficient space between the structures to accommodate a circular sewer, so we designed transitions from a circular cross section to a rectangular equivalent and back again, with only 50mm clearance between the siphon and the tunnel structure. The siphon was made of 6mm thick stainless steel, with all field welds subject to strict verification, due to the City's concerns about maintaining a difficult-to-reach sewer between two structures.

Complexity

As the demand for transit infrastructure in Canada grows navigating the unseen world of urban utilities becomes a critical skill for transportation projects. Although PATH is often referred to as a "tunnel project", from an engineering standpoint it is primarily a utility relocation project due to the extent of utility congestion under one of Toronto's most complex and hectic urban intersections.

On this project we relocated almost every public and private utility present in the city (12 utility owners and 25 different utilities). The utility congestion was exacerbated by the fact that Toronto's shallow subway system passes through the intersection, causing the utilities to be sandwiched tightly between the road and the subway. Clearances were so tight in places that the new tunnel structure was constructed almost directly on top of the subway. In some areas, the relocated utilities were built between the new tunnel and the subway.

The relocated power and fiber optic networks were not only extensive in terms of size and number, but their criticality came into focus due to their location in the heart of Toronto's financial district, as they serve all of



Existing Utilities in 2D

Canada's major financial institutions. The 3D model also facilitated coordination between design disciplines, utility owners and other stakeholders, and allowed the scale and complexity of the utility relocations to be effectively communicated.

The relocated power and fiber optic networks were not only extensive in terms of size and number, but their criticality came into focus due to their location in the heart of Toronto's financial district, as they serve all of Canada's major financial institutions. Performing investigative boreholes in this area was a stressful business! The complexities and stakeholder management requirements went far beyond the norm for a project of this size ($35M for the first phase), due to its location and the large number of third party owners. The job site was in a critical intersection, adjacent to two large concurrent construction projects, and surrounded by heritage buildings and prominent stakeholders in the financial district. The 3D model became an important communication tool with stakeholders, ranging from the City to utility owners and local businesses. It allowed us to visually convey to

adjacent property owners the challenges involved in relocating this infrastructure and why a critical intersection needs to be closed for an extended period of time. A picture may be worth a thousand words, but when we rotated our 3D model of the utility conflicts in this intersection, stakeholders' eyes widen and their jaws drop!

Another significant challenge was getting approval to relocate the utilities of 12 different utility companies, each with different standards, operating procedures, physical clearance requirements, approval processes and financial concerns. The 3D model was key to illustrating the relocation challenges by allowing each utility company to see the constraints each utility imposed on the project. We often found that utility owners became more flexible to work with once they realized the extent and scale of the relocations required for the project to work, and that they weren't the only ones affected by the construction.

Freezing of Hydro One Transmission Circuit with Nitro Glycerin

Support of Live Utilities

Construction Management

The Construction Management of this project was a true team effort. Each member's unique strengths contributed to a team that was stronger than the sum of its parts. Combining key members of the design team with seasoned Construction Management leadership and keen young inspectors allowed a highly competent and tightly knit group to emerge. The team was able to not only weather, but to deliver under budget an extremely difficult and challenging project without formal claims from the Contractor or liquidated damages applied by the Owner.

The team's ability to maintain a positive and collaborative project environment cannot be overstated. Conflict was a daily occurrence on this complex and aggressively scheduled project. Constant contractual change from differing site conditions coupled with construction difficulties in a challenging and congested environment meant that the team had to work hard to maintain good working relationships with all stakeholders.

Rather than take a purely contractual and rigid approach to construction management the team's leadership fostered an open and cooperative style with the Contractor and Owner, earning the trust of both parties. Assistance was continually provided to the Contractor to overcome differing existing conditions to keep the project moving, engendering Contractor's cooperation for the duration of the project and ultimately a negotiated settlement at the end.

With close to 1000 Contractor submittals and shop drawings required to assure a quality project it would have been very easy to lose track of them all. The team tracked submittals very closely ensuring the Contractor provided all the required documentation.

Field staff maintained quality through a proactive "Don't Walk By" approach. This included diligent inspection aided by quality checklists as part of our Quality Control Inspection Reports, independent testing and close coordination with Contractor staff to identify issues before construction, not after. Even when mistakes occurred, the Team worked closely with the Contractor to provide design solutions to keep the project moving forward.

While faced with more than 100 contract changes the Team managed to contain costs and schedule claims while maintaining a high level of Owner satisfaction.

Safety

Both Hatch and the Contractor were 2014 Silver Recipients Award winners from Canada's Safest Employers. The project's excellent health and safety record was the product of a joint effort between the Construction Management Team and the Contractor. Any project with this level of utility congestion must take health and safety very seriously.

Safety was the first topic of every progress meeting ensuring it received the time it deserved.

Joint safety walkthroughs were carried out weekly by safety officers from both parties ensuring safety issues both large and small were identified and addressed before they had a chance to cause serious injury. Field staff participated in the Contractor's "Don't Walk By" program which encouraged all workers to proactively identify safety issues.

Specific safety hazards such as working on live power utilities or abating asbestos were managed by ensuring the Contractor was working to approved safe working procedures.

The result of this safe working culture is demonstrated by **not having a single lost time incident (LTI) in more than 125,000 man-hours worked**. This is well below the heavy civil industry average of 1.18 LTIs per 200,000 man-hours worked[3].

Social and/or Economic Benefits

The ongoing expansion of the GO commuter rail service at Union Station is expected to see passenger throughput double by 2020. The North West PATH tunnel will help facilitate this increase in ridership by permitting passengers to enter the PATH tunnel network from the west side of Union Station, greatly reducing congestion on the east side of the station.

By helping to foster and sustain increased usage of public transit within Toronto's downtown core the project:

- Reduces vehicle emissions;
- Reduces vehicular and pedestrian traffic congestion on the surface and underground.

The PATH network is home to hundreds of businesses and provides access to over 50 office buildings in the downtown core. This new link in the pedestrian tunnel system will have a positive impact on the downtown community through:

- A safer and faster means of crossing one of Toronto's largest and most congested intersections.
- Reduced pedestrian travel times and traffic congestion within the PATH network;

- Improved commercial health by providing better access for shoppers to the businesses within the PATH network;
- Improved access to all the businesses and offices that are connected to the network throughout the year, but particularly in the winter months.

Environmental Benefits

- As a key element in the plans to revitalize and expand the Union Station, the North West PATH Tunnel will facilitate the increased ridership on the GO Transit Network by helping to reduce traffic congestion and associated vehicle emissions.
- This tunnel provides an important new link in the PATH pedestrian tunnel network, connecting previously unconnected portions of the network directly to Union Station. This will not only provide a direct walking connection but will also redistribute pedestrian traffic in the network easing congestion in key areas, encouraging people to walk to and from the station to the downtown core and making the network's capacity more sustainable in the long term.
- Due to the sensitivity of the downtown core to construction, the team recognized the need to ensure the new infrastructure was as durable as possible, minimizing future maintenance and rehabilitation. When a sewer was built between the subway and the tunnel floor slab, it was designed in 6mm thick stainless steel to maximize its working life and minimize maintenance.
- The reinforcement of the tunnel structure itself was designed with stainless steel rebar to ensure durability of the structure and to minimize disruptive rehabilitation works in the intersection.

Meeting Client Needs

1. Tunnel Construction on Budget

With a finite budget and no access to more funds in this budget cycle, it was important to the client that the tunnel construction costs were contained within budget.

The project's budget was tracked in detail permitting monthly and on-demand client reporting on commercial exposure, allowing informed decisions. Each contract change pricing proposal from the Contractor was rigorously reviewed to ensure the terms of the contract were met and the Owner received fair value through the performance of parallel cost estimates.

Upon receipt of a schedule claim the team utilized their detailed project records to perform a forensic level schedule analysis which allowed fair apportionment of both Owner and Contractor delay. This ultimately lead to the successful brokering of a negotiated settlement between both parties avoiding any formal claims which would have led to costly dispute resolution by third parties or the courts.

As a result, the project was brought in approximately $2M (>5%) under budget.

2. Tunnel Construction on Schedule

With Toronto hosting the 2015 Pan American Games it was critical that all surface construction be completed before this immovable deadline. The Construction Management Team worked proactively and closely with the Contractor to resolve construction issues before they became problems, not afterwards, ensuring that construction work critical to restoring the streetscape were prioritized. The tunnel was opened to the public in concert with the opening of the York St. GO Transit Concourse in April 2015, well ahead of the Games.

3. Accessible and Barrier Free Path of Travel

The client required that the tunnel be accessible to people with all levels of mobility. The tunnel alignment was developed specifically with this in mind, making use of the 3D models developed to:

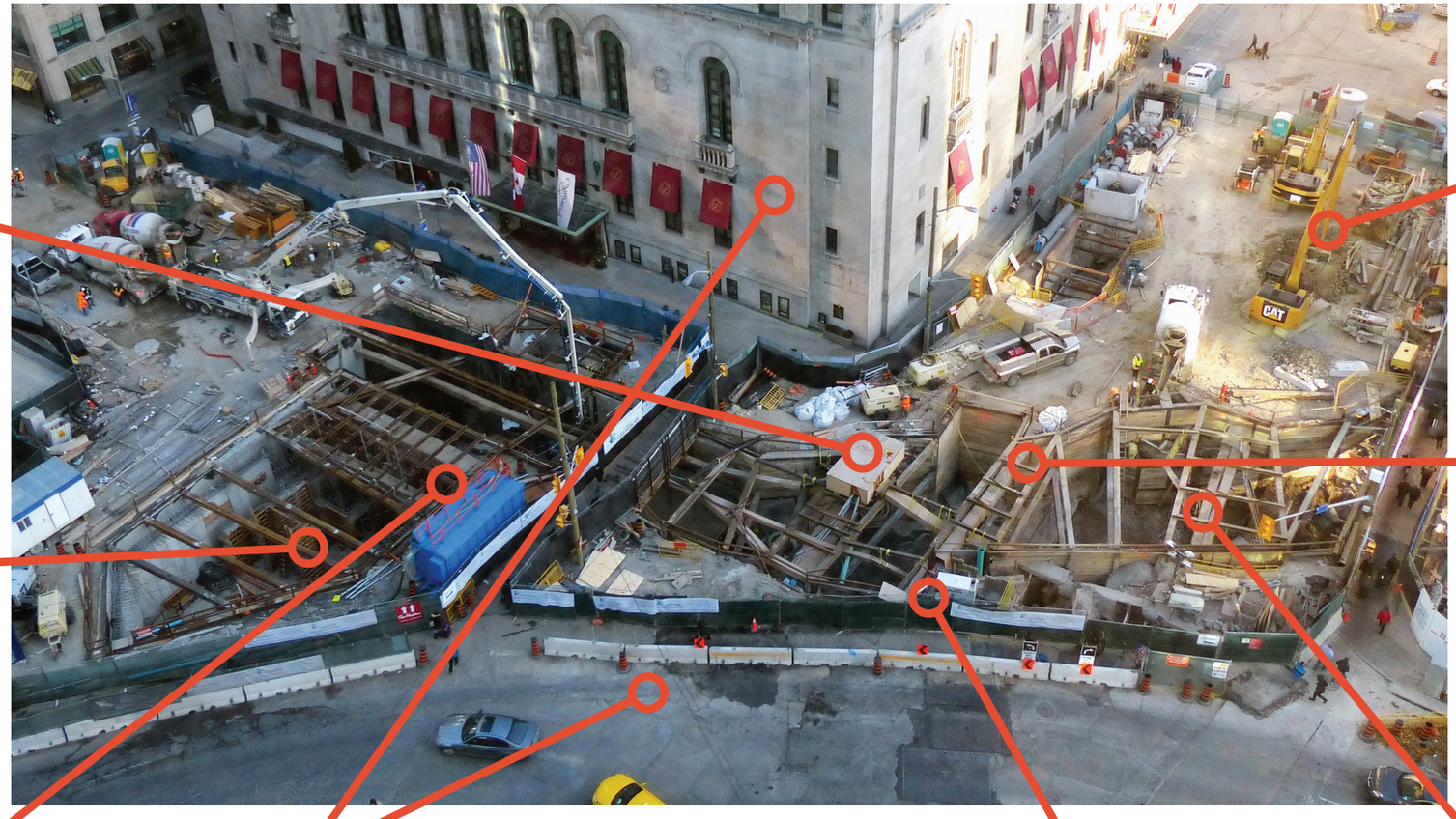
- Assess multiple alignments and their impacts on accessibility
- Ensure accessible tunnel floor and sidewalk gradients were maintained
- Assess the impacts on the surrounding utilities
- Ensure pedestrian egress/ingress structures (staircase and elevator) were to code

References

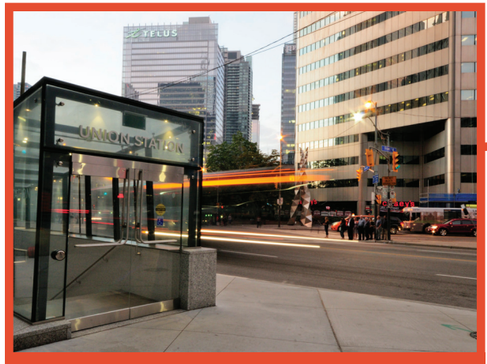
1. City of Toronto, Sites & Venues, Union Station, www.toronto.ca
2. GO Transit, GO News Special Edition 2009-2010, www.gotransit.com
3. Infrastructure Health & Safety Association – Rate Group 732 – Heavy Civil Construction – Member Firm Injury Performance 2013

NORTH WEST PATH
Pedestrian Tunnel

Complex Utilities

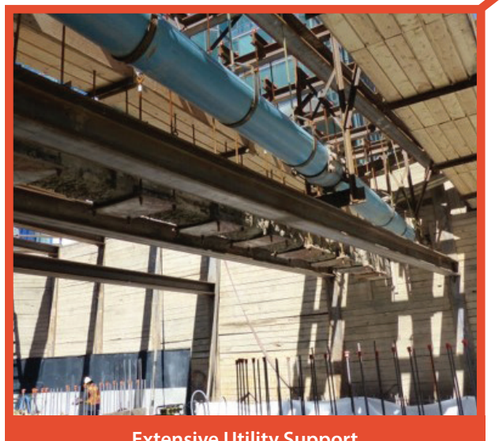


Cutting Edge Utility Relocations



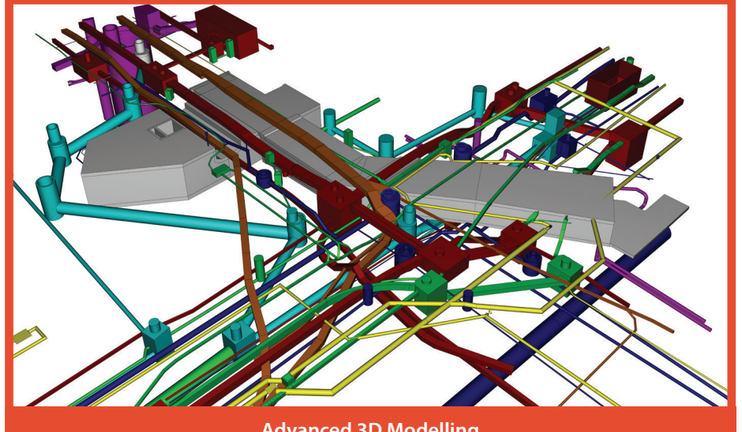
New Access to Union Station

Custom Utility Solutions



Extensive Utility Support

Congested Urban Environment with Prominent Stakeholders



Advanced 3D Modelling

High Quality Pedestrian Environment