

Innovative Approaches to Pedestrian Planning at Toronto's Union Station

Jeff Bateman, Senior Transportation Planner
Transportation Planning, City of Toronto
Metro Hall, 22nd Floor, Station 1220
55 John Street
Toronto, Ontario, M5V 3C6
jbatema@toronto.ca

Tim Laspa, Program Manager
Transportation Planning, City of Toronto
Metro Hall, 22nd Floor, Station 1220
55 John Street
Toronto, Ontario M5V 3C6
tlaspa@toronto.ca

Erin Morrow, Senior Transportation Analyst,
Arup
901 Market St., Suite 260
San Francisco, CA 94130
erin.morrow@arup.com

Abstract

Union Station is the most important transportation hub serving the Greater Toronto Area. The revitalization of Union Station is intended to improve the delivery of local, regional and national rail passenger services. The revitalization process is being facilitated by the City of Toronto and other parties that have an interest in Union Station. These parties are working together to coordinate transportation and pedestrian planning initiatives that are intended to respond to anticipated increases in transit rider ship over the next 20 to 30 years and to address the constraints that this growth will place upon the existing infrastructure. Given the growth expected, there is a need to consider existing and future pedestrian movements and interactions both inside and outside of the station building and understand how these movements tie into the urban fabric of the downtown business district and waterfront. Specifically, there is a need to address the permeability of pedestrian flows within the station building and from the station onto the public sidewalks.

The Union Station Master Plan (2004) and Union Station District Plan (2006) advocate strong pedestrian connections leading to, through and from the Station. They define parameters for specific studies that have been undertaken to help improve the overall pedestrian amenities within and in the vicinity of the Station. Since the adoption by city council of the Master Plan for station redevelopment the Transportation Planning Department has commissioned Arup to undertake two studies of pedestrian movement in and around Union Station.. The Union Station Area Pedestrian Study identified present and future pedestrian conditions in the vicinity of Union Station and developed measures and infrastructure requirements needed to address increasing demands and improve the overall quality of the pedestrian environment at below and at-grade locations in the vicinity of Union Station. The Union Station Internal Pedestrian Circulation Study included an analysis of forecast pedestrian volumes and levels of service to confirm the adequacy of planned facilities at Union Station. The intent of this work has been to provide greater insight into the existing and future operation of Union Station from a pedestrian flow perspective and to refine concepts for the layout of retail, commercial and transit-related components.

This paper examines the policy foundation for pedestrian planning at Union Station and the approach the City of Toronto and Arup have developed for ensuring that redevelopment plans for the station facilities meet policy objectives.

Presenters

Tim Laspa – City of Toronto

Tim Laspa has over 25 years of experience in the field of transportation planning and has been with the City and Metro Toronto for more than 15 years. He is currently a Program Manager in the Transportation Planning Section of the City Planning Division, responsible for transportation planning in the Toronto/East York District which includes the City's Central Area and waterfront. Recently, this has included overseeing all City transportation planning aspects related to Union Station revitalization including managing various Master Plan and pedestrian planning initiatives.

Tim and his staff are also responsible for co-ordinating the City's transportation planning issues at Union Station with a number of key stakeholders including the Union Station Public Advisory Group and the Station Operators including GO Transit, TTC and VIA. Tim holds an honours diploma in Civil Engineering (Transportation Planning) from Mohawk College of Applied Arts and Technology (1977-1980)

Jeff Bateman – City of Toronto

Jeff Bateman is a Senior Transportation Planner with the City of Toronto City Planning Division He has worked in the field of Transportation Planning in both the private and public sector and has a wide-range of experience in conducting research and developing transportation policies, plans and priorities at both the City and Regional level.

Jeff joined the City of Toronto in August 1999 and was actively involved in the consultation and development of the transportation directions outlined in the new Toronto Official Plan. Most recently Jeff has been an integral part of the City of Toronto staff team overseeing the revitalization of Union Station. Jeff holds a Bachelor of Applied Arts from Ryerson Polytechnical Institute (1986 – 1990).

Erin Morrow – Arup

Erin Morrow is a planning specialist with exceptional expertise in three dimensional problem solving and simulation of complex systems. Projects he has contributed to have included museums, stadiums, airports, and mass-transit systems. He has developed a unique expertise in combining architecture, computer science, and planning to document and project patterns of behavior in large-scale transport systems and urban planning contexts. Since 2003, Erin has been researching and developing tools for the simulation of complex pedestrian environments. He is currently responsible for pedestrian planning and simulation in Arup's Toronto and San Francisco offices. Erin studied architecture at the University of Waterloo (1995-2000).

Innovative Approaches to Pedestrian Planning at Toronto's Union Station

Walk21 International Conference
Toronto, October 2007



Jeff Bateman, Senior Transportation Planner
Transportation Planning, City of Toronto
Metro Hall, 22nd Floor, Station 1220
55 John Street
Toronto, Ontario
M5V 3C6

Tim Laspa, Program Manager
Transportation Planning, City of Toronto
Metro Hall, 22nd Floor, Station 1220
55 John Street
Toronto, Ontario
M5V 3C6

Erin Morrow, Senior Transportation Analyst
Arup
901 Market St., Suite 260
San Francisco, CA 94130

Introduction - Union Station, Toronto

Union Station functions as Toronto's primary transportation hub for commuters on GO Transit regional rail and bus services and the Toronto Transit Commission (TTC) subway and Harbourfront Light Rail Transit (HLRT). The station is also used by VIA Rail, Amtrak, and Ontario Northlander passenger rail services. Every year, Union Station handles more passengers than all three terminals at Pearson International Airport, Canada's busiest airport. As of 2006, the station handled:

- 49 million GO Transit rail and bus passengers
- 20 million TTC subway passengers
- 2.3 million VIA Rail passengers

Every business day, Union Station serves more than 145,000 GO Transit rail passengers and 30,000 bus passengers. This number is expected to double over the next 20 years as GO Transit's expansion programs are realized.

Enhancement of Union Station's public transportation attributes is a priority for the City of Toronto. Revitalization and expansion of this historic facility to accommodate increased usage and enhance pedestrian connections and amenities will continue to be coordinated with the station operators, their ongoing expansion programs, and population and employment increases in the downtown area.

Pedestrian Policy, Principles, and Objectives

Considering that all transit passengers are ultimately pedestrians, appropriate pedestrian planning principles and objectives were developed at the outset of the latest revitalization initiative to ensure that pedestrian circulation is maintained or improved to accommodate current and projected flows in a safe and efficient manner. In consultation with a Station Operator's Committee (comprising GO Transit, VIA Rail and the TTC) and the Union Station Revitalization Public Advisory Group (USRPEG) a document outlining the existing policy directions, principles and objectives was produced as a background document for the Union Station Master Plan. The Pedestrian Planning Policy and Objectives document brings together a cohesive policy framework for pedestrian planning and provides specific principles and objectives for the station building and for the immediate area surrounding the station.

The higher level policy directions are derived from the City of Toronto Official Plan (November 2002) and the Toronto Pedestrian Charter (May 2002) and provide general guidance to the development of the station as a pedestrian facility:

- Union Station will be refurbished and its passenger handling capacity expanded;
- A program of street improvements will be developed to enhance the pedestrian environment and measures undertaken to make it safer to walk and cycle in Downtown;
- An urban environment and infrastructure will be created that encourages and supports walking throughout the City through policies and practices that ensure safe, direct, comfortable, attractive and convenient pedestrian conditions.

In addition, the USRPAG noted the connection between economic vitality and walking and suggested the development of a "Pedestrian Sensitive Area" to underline the importance of pedestrian activities in the vicinity of the station.

It should be noted that the new Toronto Official Plan has had an important influence on how transportation planning matters are approached within the City. One of the main objectives of the Official Plan is to take a more comprehensive approach that links land use and transportation planning policies to create an effective strategy for accommodating the City's future trip growth in a way that reduces auto-dependency by making transit, cycling and walking more attractive alternatives. This new approach is increasingly reflected in the City's guidelines, programs and practices which promotes walking as a mode that encourages both health and transportation benefits – cornerstones of comprehensive City building.

The Union Station Master Plan



Figure 1 - Proposed Front St. Configuration

Toronto City Council adopted the Union Station Master Plan in December 2004. The Master Plan is a bold, visionary roadmap for the restoration, revitalization and operation of the Union Station complex. As a high-level policy document it is intended to direct decision making for Union Station as it continues to evolve.

The Union Station Master Plan advocates for strong pedestrian connections leading to, through and from the Station. The Master Plan effectively reiterates and reorganizes a number of the existing policy directions and objectives as outlined above and includes input received from the USRPAG and others during the consultation process of developing the Master Plan. The Master Plan also defines the need for additional studies that are to be undertaken to help improve the overall pedestrian conditions /amenities both within the station and its environs.

The Union Station District Plan



Figure 2 - Proposed Configuration of Bay St. & York St. Intersection

Toronto City Council adopted the Union Station District Plan in May 2006. The District plan provides an opportunity to advance pedestrian issues in the vicinity of Union Station. The Plan makes several recommendations and pushes the pedestrian agenda in ways that are positive and proactive – and new - for the City of Toronto.

The District Plan provides a vision for Union Station that integrates the historic character of the area while allowing the district to thrive as a multi-modal transportation hub. The Plan acts as a catalyst for urban improvement by:

- Delineating a Union Station Heritage Conservation District – clear guidelines for preserving and enhancing the historic character of the area
- Developing an improved public realm – shifts the design focus to the pedestrian sphere; and
- Enhancing connections and flow – acknowledges the multi modal and multi-directional “hub” that Union Station has become.

The District Plan sets out a number of guiding principles for the public realm that are intended to enhance and improve the pedestrian environment and better integrate the heritage and transportation requirements into the fabric of the downtown by improving pedestrian connectivity, enhancing pedestrian crossings and improving north-west PATH connectivity.

One of the most important recommendations of the District Plan is the consideration for the creation of a pedestrian priority zone, which means that an area covering several City blocks around the Station would be designed and operated in a manner that signals to drivers that they are passing through a primarily pedestrian realm. The priority zone would include pedestrian infrastructure elements, amenities and treatments that would give higher measure of awareness, and signal to drivers that they should be prepared to slow down or stop for pedestrians in this area – this type of zone does not necessarily segregate motor vehicles and pedestrians.

The District Plan will be the driver that leads to the implementation of new pedestrian infrastructure and urban design considerations that, once implemented could be used as an example or model of pedestrian planning directly applicable to other areas of the City, including possible future extensions to Toronto’s waterfront areas.

Assessing Pedestrian Demand – Phase 1

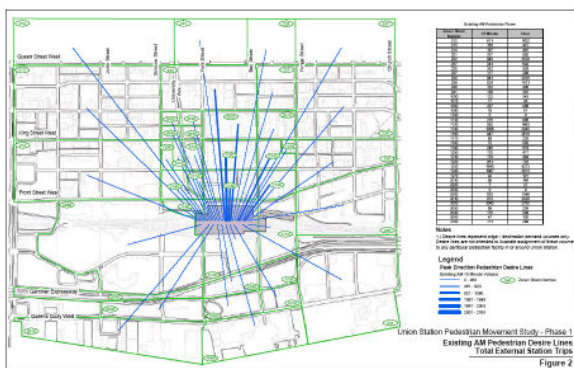


Figure 3 - Mapping of Existing AM Peak External Station Trips

As noted above, the Union Station Master Plan recommended that a number of studies be initiated to better identify present and future pedestrian conditions. The primary objective of Part 1 of this study was to develop a quantitative picture of peak pedestrian flow conditions in and around Union Station, for both current and future forecast conditions, and to identify potential constraints impacting pedestrian flows associated with proposed concept plans for the Union Station revitalization. It was also intended that the data collected and generated would be sufficient to support more detailed flow analysis, through simulations and other analytical tools in a future Phase 2 of the study. The phase 1 work was also intended to support decision making, design efforts and operational planning for the revitalization of Union Station and the surrounding area.

The study was completed for two principal time frames, base (2003) conditions and projected 2021 conditions, corresponding to forecast horizons for the various transportation providers and the City of Toronto’s employment and residential population data. A third 2011 condition was also documented on the basis of a straight line interpolation between 2003 and 2021. The analysis focuses on peak hour and peak 15 minute pedestrian movement volumes for the morning peak, the afternoon peak, Air Canada Centre special events, and Roger’s Centre special events.

The final report summarized a number of opportunities and constraints. This includes issues identified by the City of Toronto, agencies and public stakeholders. The issues identified were also used to assist in defining the scope and focus of subsequent Phase 2 pedestrian movement analysis and other related studies.

The Phase 1 Pedestrian Study highlights/supports the opportunity for:

- Providing additional linkages to the street and PATH network to ensure appropriate levels of pedestrian capacity, and further disperse pedestrian movement related to the Station
- Further planning and review of the Union Station Front Street Plaza and other areas external to the Station in the context of the Station Master Plan

- Further consideration of enhancing the porosity of the Station consistent with the Master Plan and the overall objective of minimizing bottlenecks and pedestrian congestion (eg. vertical transfers to the teamways from station platforms)

The Phase 1 Pedestrian Study highlighted the following constraints:

- There will continue to be a very heavy orientation of pedestrian flow between the Station and the downtown core, resulting in increasing congestion on the existing above and below grade pedestrian network. This is likely going to require the introduction of several mitigating measures to improve (or at least not further degrade) future above and below grade pedestrian conditions;
- The entry/exit points to the Station (TTC station access and York Street exit in particular) represent the most critical points of potential congestion. (Further simulation analysis and sensitivity testing is required to verify that vertical circulation and other corridors and spaces will operate at a satisfactory LOS). Methods of metering flows further up stream may need consideration.

Simulation of Pedestrian Circulation – Phase 2



Figure 4 - Simulation Environment (2021)

The intent of the Phase 2 study was to provide greater insight into the existing and future operation of Union Station from a pedestrian flow perspective and to refine concepts for the layout of retail, commercial and transit-related components within Union Station. This work was coordinated with other transportation planning elements (e.g. loading, servicing, taxi stands) and other initiatives in the immediate area. The work undertaken by Arup in Phase 2 was intended to answer four fundamental questions:

- How would the proposed Concept Plan support or otherwise impact pedestrian flow patterns?
- Was the Union Station Concept Plan appropriate from a pedestrian flow perspective?
- What are the internal and external congestion points, and what conditions may be causing congestion?
- Where are areas of flexibility that provide opportunities for other Precinct and Station revitalization initiatives?

Phase 2 of the Planning Study involved the creation of “agent based” simulation models of the facility. To accomplish this objective the first task was to improve the resolution of the information that was produced during Phase 1. Using a series of statistical methods, cross-checks, and operator approved assumptions, Arup was able to produce a minute by minute breakdown of the where pedestrians would enter the study area (origin) and where they be going (destination) both in 2003 and in 2021.

Union Station is an environment with complex route choices and very high volumes of pedestrian traffic, particularly during the morning rush hour. The challenge was to develop an approach to modeling the pedestrian traffic at the station in a way that would allow accurate calibration of the model inputs without overly prescribing the detailed behaviour of pedestrians within the station. To do this, Arup applied MassMotion a leading edge approach based on intelligent agents, a full 3D model of the environment, and John Fruin’s industry standard planning and design guidelines for pedestrian behaviour.

The primary differentiator of MassMotion compared to other pedestrian simulation tools is that it actually models pedestrian behaviour rather than testing a user’s preconceptions about pedestrian behaviour. For example, if a room has doors on all four sides, other pedestrian simulation tools require the user to input what percentage of the room’s population will use each door.

In a MassMotion simulation each agent decides which door to use based on what it knows about the distance to its goal from each door and how long the queue is for each door. There are two noteworthy advantages to such a system. The first is that in MassMotion an agent only needs to be assigned an end goal to navigate through an environment while other models require the user to input percentage splits at all potential branching points and for all sub groups within a simulated population. Clearly a MassMotion model requires far less time to setup or to modify and scales much more efficiently as the complexity of the simulation environment increases. The second advantage is that MassMotion actually predicts how rational pedestrians will navigate through an environment and how they will respond dynamically to constantly evolving situations. Other tools (as a result of the static route assignment approach) are not able to predict how pedestrian congestion and route choice will evolve throughout the course of simulation.

For these reasons MassMotion was therefore an ideal choice to model a future scenario at Union Station that had both a reconfigured layout and doubling of current pedestrian volumes. Once the variables that govern how Toronto commuter agents behave were calibrated against existing survey data this behavioural profile could be applied to a the future scenario with confidence.

After extensive simulation of the proposed Concept Plan, Arup concluded that the Concept Plan in its current configuration would support the estimated pedestrian volumes for 2021. The layout of the station in the Concept Plan is appropriate from a pedestrian flow perspective.

While there are some internal areas which experience high densities of commuters during the morning peak 15 minutes, the flow of traffic is consistent and does not degrade to conditions of static congestion. The external pedestrian routes at Union Station provide adequate capacity for demand at all areas except for the sidewalks and crosswalks at corners of Front & Bay St. and the corner of Front & York St.

In addition to the overall success of the Concept Plan with regard to the pedestrian traffic associated with the morning peak, Arup identified the proposed GO West Concourse and the Bay St. West and the York St. East teamways as underutilized areas. With further examination and testing of platform staircase locations and retail or other service layouts in these areas there may be significant gains to be had in terms of balancing passenger flow patterns and improving the user experience.

Phase 2 focused on three distinct configurations for the station and surrounding environment, Current Configuration (2003), Future Concept Plan (2021), and Future Concept Plan (2021) with a new Northwest PATH connection.

All configurations were simulated with the pedestrian volume forecasts for the a.m. peak 15 minutes and the statistical outputs of these simulations defined in the final Arup report.

It will be possible in the future to build on this Phase 2 work and consider other configurations and traffic conditions such as afternoon peaks and special events using the existing simulation models.

Lessons Learned



Figure 5 - Predicted pedestrian volume in Bay St. Concourse (2021)

The pedestrian planning initiatives at Union Station have broken new ground for the way the City will plan for pedestrian activities in the future. A number of lessons have been learned through the process. Despite the over-riding policy directions and city building objectives of the City, there continues to be a need for more outreach with decision makers and members of the public who may still not be convinced of the merits of improving/prioritizing pedestrian environments. Focused consultation with the sub-groups of the USRPAG and Toronto Pedestrian Committee worked extremely well, particularly for the policy development/confirmation components and pedestrian model calibration. For other City of Toronto staff and staff from the various operators, the pedestrian planning initiatives have been an education that is paying off.

From a modeling and simulation perspective, the Phase 2 study was an exceptional test of the MassMotion toolset that Arup has developed. The very high volumes of pedestrians being simulated in combination with the complex layout of the station facility demonstrated the usefulness of an agent based approach to pedestrian simulation and analysis.

During the calibration phase of the simulations a phenomena was observed which has had a significant impact on how the agent behaviours were designed. The original assumption about commuter behaviour was that they are focused on selecting the most efficient route to their destinations. In reality this is only partially true as even expert users of a facility will not have perfect awareness of distance and congestion on any given route. Furthermore individual assessments of route cost may include preferences for factors that are not captured within the range of variables in the software. As a result agents were permitted to select from a range of available routes that were within a specified deviation from the most efficient route. This had the effect of distributing the simulated pedestrian flows more smoothly throughout the model and also resulted in statistical results that were significantly better aligned survey data.

There is recognition that the model is a powerful tool that provides a very clear indication of how the station will be used and how passengers will move through the facility in the future.

The City of Toronto's pedestrian policies, principles and objectives have been instrumental in driving the pedestrian agenda and have lead to the council endorsed studies (e.g. Environmental Assessments fro the new Northwest PATH connection) and recommended actions to improve the pedestrian realm both within the station and its environs.

Arup has continued to develop MassMotion by improving the software based on lessons learned from the simulation work done for the City of Toronto at Union Station. User interface improvements have significantly reduced setup time and user input errors, while the way finding algorithms have been expanded to incorporate signage and signals.

The Way Forward



Figure 6 - Great Hall, Union Station

The pedestrian planning initiatives undertaken at Union Station to-date have been very successful. The process of policy development and confirmation involved a wide range of interest from the station operators, decision makers and the public. The importance of pedestrian activities at Union Station and its environs and the need to plan for and accommodate growth are clearly articulated in City policy and programs.

The pedestrian planning model developed by Arup (MassMotion) has proved to be an invaluable tool which visualizes pedestrian flows and identifies areas where further design refinements are required, particularly where pedestrian levels of service are deficient and /or need improvement. Importantly, it will be possible in the future to build on the Phase 2 work and consider other station configurations and traffic conditions.

The City of Toronto's Facilities and Real Estate Division and City Planning Division are currently considering options for Union Station Revitalization, including opportunities to reconfigure the internal Station layout and connections in a way that supports pedestrian movement and compliments the highest and best use of space within the building. Within this context, the City will continue to study pedestrian movements within and beyond the Station to increase the effectiveness of Union Station as a major transportation hub. GO Transit are also interested in ensuring optimum pedestrian conditions at Union Station in conjunction with their multi-year capital rail improvement program.

As the next step in the initiative (Phase 3), a forecast commuter weekday PM peak 15-minute modeling simulation is required similar to the AM peak 15-minute simulation developed in the Phase 2 study.

The model simulation and analysis envisioned in Phase 3 is intended to address the following questions:

- How will the proposed layout plan support or otherwise impact pedestrian flow and queuing/waiting patterns, particularly in the future pedestrian concourses;
- Are there other opportunities for pedestrian flow and station uses (e.g., should the extent of proposed retail/commercial area within the future pedestrian concourses, moats and teamways be reduced to better accommodate commuter needs, or is there opportunity for expansion of retail /commercial uses in these areas); and,
- Where are the internal and external congestion points, what conditions may be causing congestion, and what measures may be required to alleviate unacceptable levels of congestion.

The work plan envisioned for the next phase of pedestrian planning will apply the MassMotion model and City database for Union Station to the extent possible to create a simulation of current conditions, and forecast conditions (2021) for existing and future networks. The model will confirm anticipated levels of service for all key locations (i.e. doorways, stairs, ramps, escalators, corridors, etc.) within the Station and adjacent pedestrian areas, and provide visual pedestrian flow simulations within the three-dimensional environment.

Modeling efforts such as those developed for Union Station can be an important element of the "planner's toolbox", used to encourage and set in place the process to achieve sustainable transportation policy and objectives. As demonstrated in this paper, the MassMotion model represents an important "next generation" application that the City of Toronto Transportation Planning Division is able to employ to generate innovative solutions that are supported by technical and intuitive results - easily understood and able to address highly dynamic conditions.

As the cost of developing pedestrian modeling applications decreases, or as applications become more scalable and user friendly in nature, pedestrian modeling and simulation work is likely to become commonplace. In this context, an integrated planning approach that merges technology and the human experience will become increasingly important as the City tackles transportation challenges in the near future related to growth in its downtown, urban centres and the waterfront district.

References

- Arup Canada (2005). Union Station Pedestrian Movement Study - Phase 1
- Arup Canada (2006). Union Station Pedestrian Movement Study - Phase 2
- City of Toronto (2002a). Official Plan
- City of Toronto (2002b). Pedestrian Charter
- City of Toronto (2004a). Union Station Pedestrian Planning Principles and Objectives
- City of Toronto (2004b). Union Station Master Plan
- City of Toronto (2006). Union Station District Plan
- Fruin, J. ([1971] 1987). *Pedestrian Planning and Design, Revised Edition*. Mobile, AL: Elevator World