DS-12 PEDESTRIAN FLOW MODELLING DESIGN STANDARD

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AMENDMENT RECORD

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PREFACE

The design of pedestrian and passenger facilities involves the application of traffic engineering, environmental design, and user experience principles to accommodate the widest variety and number of customers. By applying quantitative and qualitative passenger flow principles and adopting a user-centered approach, Metrolinx strives for ease of movement for all customers at all facilities under various operating conditions.

PURPOSE

The purpose of this Standard is to bring consistency to the user experience, maximize independent access and increase safety for all customers. The consistent application of the Passenger Flow Design Standard to the design of stations, terminals, and customer-facing facilities will allow Metrolinx to elevate the customer experience, remove barriers, and promote a seamless transit experience for all.

REGULATORY REQUIREMENTS

The Passenger Flow Design Standard is not meant to replace or supersede regulatory codes or standards, including the Ontario Building Code (OBC) or other regulatory requirements such as NFPA 130.

Should the requirements stipulated in regulatory codes or standards be more stringent than the Passenger Flow Design Standard, those requirements shall take precedence in the planning and design of facilities.

RELATIONSHIP TO OTHER METROLINX STANDARDS

The Pedestrian Flow Modelling Design Standard is intended to support other standards published by Metrolinx which stipulate other specific requirements. Metrolinx Standards that shall be adhered to include, but not limited to:

- GO Design Requirements Manual (DRM)
- Design Standards (DS-00)
- GO Station Architectural Design Standard (DS-04)
- Subway Station Architectural Design Standard (DS-09)
- Light Rail Transit (LRT) Architecture Design Standard (DS-13)
- Bus Rapid Transit (BRT) Architectural Design Standard (DS-27)

EXTERNAL REFERENCE DOCUMENTS

For additional information regarding the concepts outlined in this Standard, the following reference documents should be reviewed:

- Transit Capacity and Quality of Service Manual (TCRP Report 165), Transportation Research Board, 2017
- Designing For Pedestrians: A Level of Service Concept, John J Fruin, 1971
- Standard for Fixed Guideway Transit and Passenger Rail Systems (NFPA130), National Fire Protection Association, 2020
- Station Planning Standard (S1371), London Underground, 2016
- Station Capacity Planning Guidance, Network Rail, 2016
- Fundamental Diagram of Pedestrian Flow Including Wheelchair Users in Straight Corridors, Journal of Statistical Mechanics: Theory and Experiment, 2021
- How People with Disabilities Influence Crowd Dynamics of Pedestrian Movement Through Bottlenecks, Science Journal, 2022
- Vertical Circulation Design Manual (NR/GN/CIV200/05), Network Rail, 2022
- Guide D: Transportation Systems in Buildings, Chartered Institution of Building Services Engineers (CIBSE), 2015

1.0
Introduction

1 INTRODUCTION

1.1 CONTEXT & OVERVIEW

The Pedestrian Flow Modelling Design Standard is a document that outlines the standard requirements and technical details to analyze and plan for pedestrian circulation within all Metrolinx owned or sponsored stations, terminals, and facilities. It is applicable to all categories of these facilities.

These requirements promote a consistent approach to pedestrian capacity analysis in the planning and design of public areas in buildings and stations, particularly for key elements such as platforms, walkways, footbridges, tunnels, and potential areas of congestion along customer access paths.

These requirements provide:

a) A standard approach to station capacity analysis and assessments

b) Station planning and design standards

c) Space requirements for public areas in stations; and

d) The opportunity for consistent validation of station design using the appropriate pedestrian modelling technique when warranted.

1.2 METROLINX DESIGN PRINCIPLES

The six Design Principles below are overarching values that inform and guide the development of the Metrolinx Design Standards (DS-00) and strive to integrate the physical, digital and human aspects of the end-to-end customer journey. They are as follows:

a) Seamless

b) Intuitive

c) Inclusive

d) Safe

e) Reliable

f) Thoughtful

These Principles apply largely to customer-facing elements and touchpoints (for instance payment, transfer, etc.) while taking into account spatial adjacencies and sensory aspects of back-of-house elements, such as noise, smells and sight lines, which affect customer experience. Safety of customers and operatives is a prerequisite.

The Design Principles are underpinned by safety and making all Metrolinx customer journeys as safe as possible.

Beyond these Design Principles, to support the safety and comfort of passengers, space for normal operations in the GO Stations, Terminals and Facilities shall be planned to:

g) Optimize passenger comfort, satisfaction and safety;

h) Minimize congestion;

i) Be resilient to fluctuations in passenger demand and service disruptions; and

j) Provide enhanced integration and connections to broader multi-modal transportation networks and partner transit services.

1.3 APPLICATION OF THE DESIGN STANDARD

This standard clarifies the requirements for pedestrian modelling analysis to support effective and suitable design for pedestrian infrastructure for all Metrolinx stations, terminals, stops and customer-facing facilities. It is to be used to varying degrees for all upcoming and existing Metrolinx projects so that the design for pedestrian circulation can be assessed using the same parameters and criteria. This allows a consistent approach to analysis across the network.

The Pedestrian Flow Modelling Design Standard is:

a) Mandatory for the design of new construction and redevelopment of existing stations, terminals, stops and customer-facing facilities.

b) Intended to be applied to the greatest extent possible for retrofit, and state of good repair capital infrastructure programs to existing stations, terminals, stops and customer-facing facilities.

c) May apply to temporary infrastructure, depending on scope, please read in conjunction with the Temporary Construction and Customer Experience Requirements for GO Facilities

d) Shall include early consultation with Metrolinx to ensure alignment with project requirements and priorities.

1.4 STATION PLANNING CONSIDERATIONS

Station planning is a critical part of the design and operation of new and existing stations. It relates to three critical aspects – safety, access, and comfort. For new stations, or stations that are being upgraded, planning and analysis shall be undertaken at every step of the project life cycle:

a) Initially, station planning and analysis shall be undertaken to determine the functional requirements of the station.

b) During the design phase, analysis and modelling shall be undertaken to demonstrate that the designs meet the functional requirements.

c) During construction at active stations, analysis and modelling shall be undertaken when changes to access or station elements are made, to understand how the potential impacts construction activities may have within the station or wider area.

The application of station planning principles continues once the station is operational:

d) Ongoing monitoring of the station performance is required to ensure that the infrastructure remains fit for purpose.

e) Operational planning is undertaken at a regular basis, if applicable, to understand how the station is likely to operate as demand or service patterns change.

2.0

Station Elements

2 STATION ELEMENTS

The Pedestrian Flow Modelling Design Standard focuses on the space within buildings and key station elements that directly impact the customer journey. It also applies to space immediately outside of stations, and in locations of transfer/ interchange between modes.

This Standard covers the following station elements:

a) Walkways

b) Platforms

c) Queuing Areas (on concourses and for elevators)

d) Vertical Circulation including Stairways, Ramps, Escalators and Elevators

e) Doorways

f) Fare Gates

g) Self-Serve Hubs

Depending on site specific requirements, additional station elements may be identified and included based on consultation with Metrolinx.

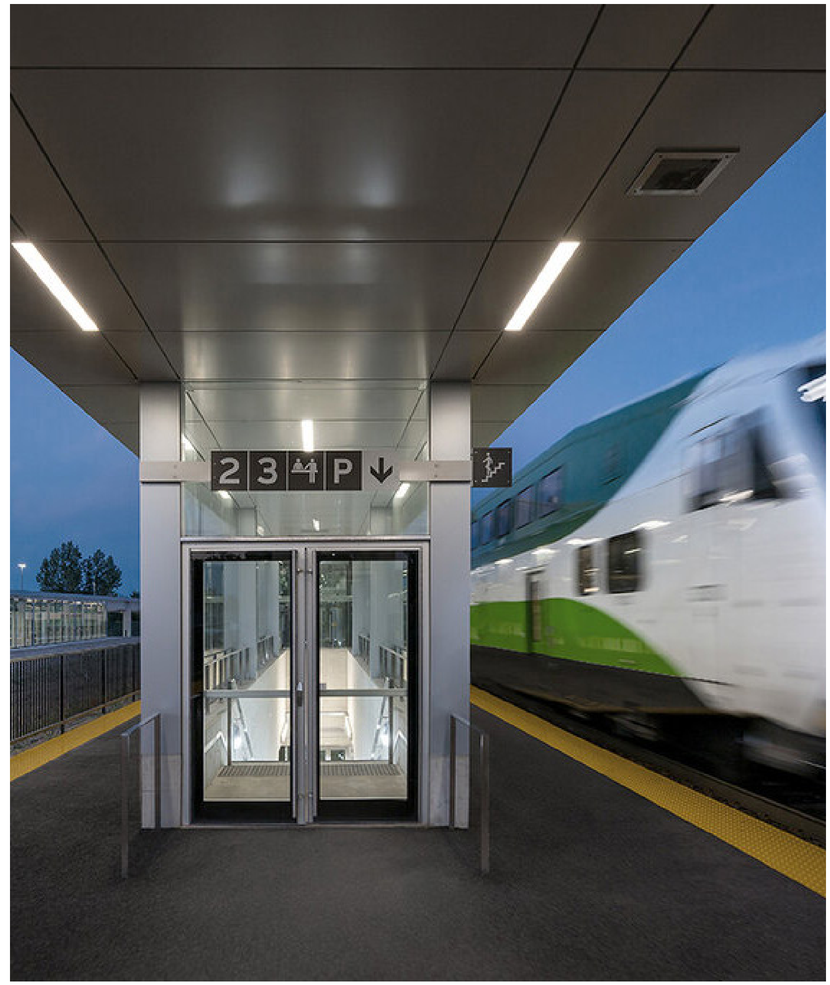


Figure 1: Typical Platform - Guildwood GO Station

3.0
Passenger Flow & Level of Service Principles

3 PASSENGER FLOW & LEVEL OF SERVICE PRINCIPLES

3.1 LEVELS OF SERVICE

The Levels of Service specified in this Standard aim to meet the Metrolinx Design Principles and provide an adequate level of comfort for customers without making stations uneconomically large.

Passenger movement through a station is complex. Multiple activities happen concurrently, often in a restricted space. In order to understand the performance of a station environment, individual areas are evaluated using two main criteria:

a) **Passenger Density** – for areas of the station where accumulation takes place (typically waiting areas including platforms and elevator lobbies). Passenger density is expressed in terms of passengers per square meter (pax/m^2).

b) **Passenger Flow** – for areas of circulation within the station, typically walkways or vertical circulation elements (VCE) that include ramps, stairways, escalators, and elevators. Passenger flow rate is expressed in terms of passengers per meter width per minute (pax/m/min).

In order to simplify interpretation of these densities and flow rates, the Level of Service (LOS) concept is often used.

A variety of ways of quantifying LOS have been documented in academic and industry literature, however the majority are based on the three concepts developed by Professor John J Fruin in “Designing for Pedestrians: A Level of Service Concept” (1971).

3.2 PASSENGER SPEEDS AND TYPES

Metrolinx passengers have different needs and behave differently within any given station environment resulting in a range of walk speeds between 0.6 and 2.0m/s. For example, an adult that does not have a disability may walk at a speed of 1.5 m/s or above on flat surfaces in normal conditions. In crowded conditions however, walking speeds are significantly lower.

Metrolinx has a large number of customer types all of which have slightly different requirements. Each of these groups can have varying familiarity with our systems:

a) **Commuters** are normally traveling to and from work, schools, or higher education and are familiar with the station layout and train services. At most stations, a large proportion of passengers during the peak periods are regular commuters.

b) **Leisure travelers** are infrequent users of the service; they may require assistance in terms of wayfinding and service information. They generally tend to arrive at stations earlier, and therefore dwell longer in comparison with regular commuters. At some stations, a large proportion of users can be leisure travelers on a Friday afternoon, weekends or during special events, or late afternoon/weekday evening (e.g. sporting events). Leisure travelers may also carry some form of luggage.

c) **Passengers with reduced mobility** may have a physical or cognitive condition which affects their ability to navigate within a station environment. Passengers with reduced mobility require more space, time and may require assistance from staff. This may include passengers in wheelchairs who need step free access and may require assistance in accessing train services or other facilities at a station, as well as passengers with temporary reduced mobility (e.g. crutches).

   It has been determined that the presence of persons with disabilities (PWD) has influenced the behaviour of persons without disabilities in a crowd, particularly at bottlenecks. For instance, the speed of persons without disabilities was adapted to the speed of the PWD, passing was observed less frequently, and the interactions between participants to self-organize movement in front of the bottleneck increased. This should be taken into account when reconciling passenger speeds and types.

d) **Passengers with luggage or sporting equipment** require more space depending on the size and shape of luggage they are carrying. This includes passengers carrying small backpacks, large shopping bags, large musical instruments, regular or fold-up bikes and large suitcases.

e) **Passengers with young children** and infants in strollers may be slow-moving and prefer to remain in groups.

3.3 WALKWAYS

Walkways are corridors where pedestrians walk, typically defined by either movement in a single direction or in both directions at the same grade, or with only minor grade differences from one end to the other. They can operate with a mixture of mobility elements including moving walkways, or commercial/retail space along a corridor.

Walkway capacity is influenced by the following factors:

a) Pedestrian walking speed

b) Pedestrian density

c) Pedestrian characteristics, including the presence of luggage, strollers, bicycles, use of mobility aid devices, or digital signage

d) Effective width of the walkway at its narrowest point

e) Moving walkway speed (where applicable)

Level of Service (LOS) for walkways is expressed in both density: the number of customers within a given area, as well as flow: the number of customers passing through a walkway per minute.

LOS ratings range from LOS A, where pedestrian comfort and level of service is high, through to LOS F, where pedestrian movement and comfort breakdown:

LOS A allows pedestrians to move freely through areas.

LOS B allows pedestrians to move at "normal speeds". Contraflow movements will cause minor conflicts and slightly lowered speed and flow.

LOS C restricts the ability to overtake others and select walking speed. Multi-directional flow will cause conflicts.

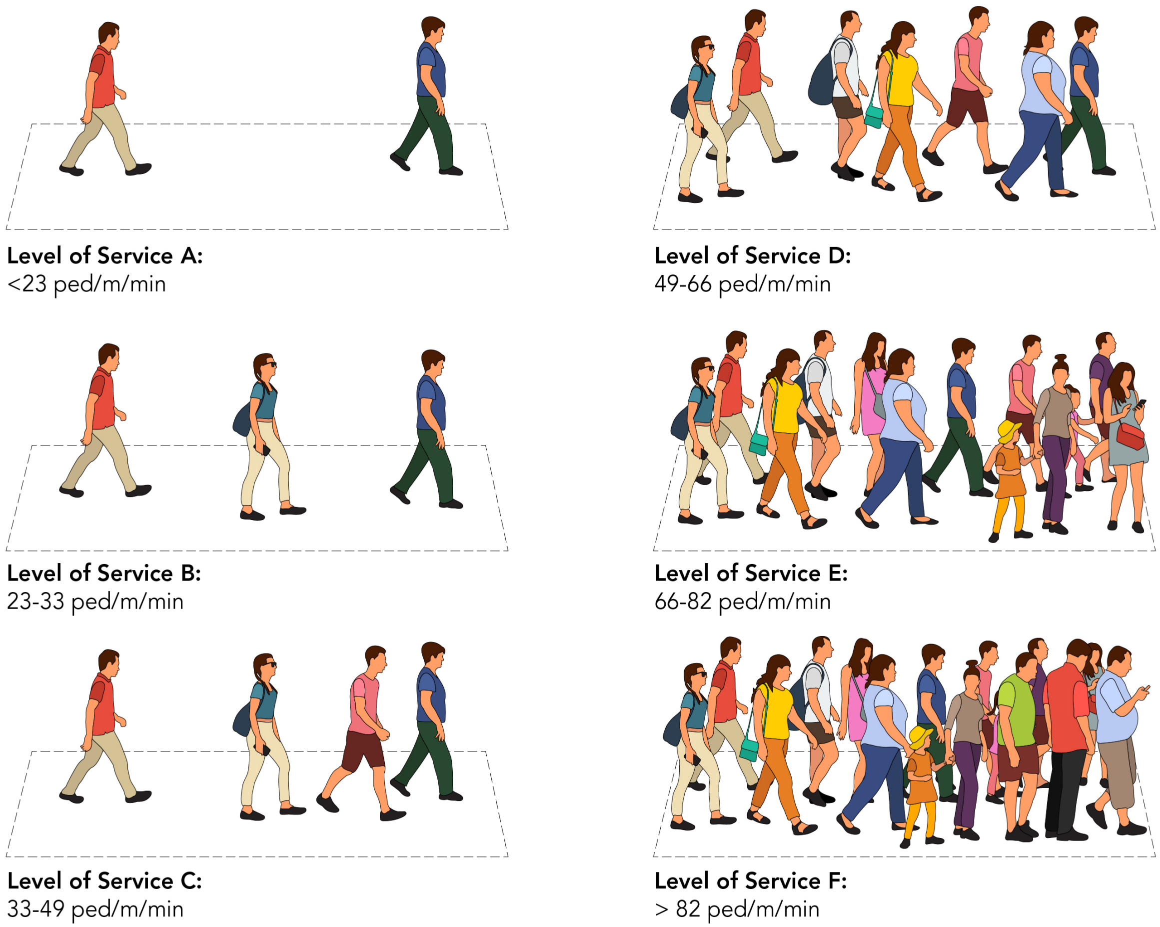
LOS D restricts the walking speed of most people. It is very difficult to overtake and avoid conflicts. Contraflow movements are severely impeded. There is some probability of start-stop movement.

LOS E causes all pedestrians to have their speed restricted. The speed of the crowd fluctuates requiring individuals to frequently adjust their pace.

LOS F results in significant flow breakdown. Walkways at this density range function more like queuing areas.

LOS	Density (m^2/ person)			Flow (people /m/ minute)		
A	3.25	+			<	23
B	2.32	-	3.25	23	-	33
C	1.39	-	2.32	33	-	49
D	0.93	-	1.39	49	-	66
E	0.46	-	0.93	66	-	82
F		<	0.46		>	82

Table 1: Walkway Level of Service



Level of Service for Walkways

Pedestrian per metre per minute (ped/m/min)

Figure 2: Walkway Level of Service

3.4 PLATFORMS & QUEUING AREAS

Queuing areas are areas where passengers will queue and will tolerate closer levels of proximity from other passengers. Areas where this happens include:

a) Platforms

b) Fare Gates

c) Areas in front of passenger information screens

d) Elevator Queuing Areas

e) Retail Space Queuing Areas

f) Ticket Vending Machines Queuing Areas

g) Bus Stops

There are a number of different factors that go into determining the size of a queuing area. For platforms, the majority of the platform area can be considered. For fare gates, the size of queuing area depends on the number of gates available and passenger demands by direction. Generally, larger areas are required for queuing when passengers are leaving the station as arrival to the station is usually staggered when compared to passengers alighting trains. Passenger crowding at platforms directly impacts boarding and alighting time and as a result may affect safety.

When sizing queuing areas, consideration must be made to interfacing walkways in order to avoid queuing congestion impacts to passenger circulation. Level of Service (LOS) for platforms and queuing areas is expressed in terms of density: the number of customers within a given area. LOS ratings range from LOS A, where pedestrian comfort and level of service is high through to LOS F, where pedestrian movements breakdown.

Queuing areas, such as platforms, shall be assessed using the queuing level of service thresholds shown.

LOS A allows enough space for free circulation within queuing area.

LOS B allows space for restricted circulation without disturbing others.

LOS C involves disturbing others for restricted circulation although people maintain their comfort zones.

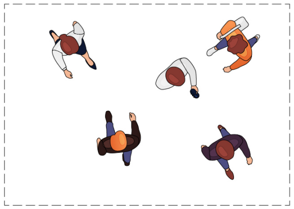
LOS D represents a severely restricted queuing environment. There is enough space for people to stand without touching each other. It is not recommended for long-term waiting.

LOS E represents a severely restricted queuing environment that is only recommended for elevators. There is barely enough space to stand, and contact is unavoidable.

LOS F involves people standing within very close proximity and could create an environment leading to panic in large crowds.

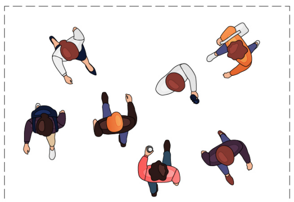
LOS	Density (m^2/ person)			Description
A	1.21	+		Free Circulation Zone
B	0.93	-	1.21	Restricted Circulation Zone
C	0.65	-	0.93	Personal Comfort Zone
D	0.28	-	0.65	No Touch Zone
E	0.19	-	0.28	Touch Zone
F		<	0.19	The Body Ellipse

Table 2: Platform and Queuing Level of Service



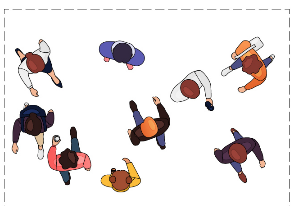
Standing and free circulation through the queuing area possible without disturbing others within the queue.

Level of Service A:
> 1.2 m² per pedestrian



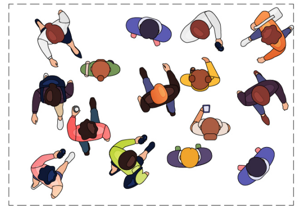
Standing and partially restricted circulation to avoid disturbing others within the queue is possible.

Level of Service B:
0.9 - 1.2 m² per pedestrian



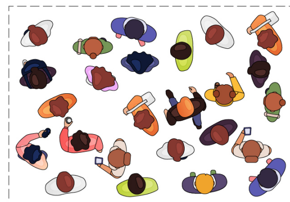
Standing and restricted circulation through the queuing area by distributing others is possible; this density is within the rannge of personal comfort.

Level of Service C:
0.7 - 0.9 m² per pedestrian



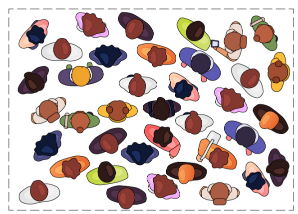
Standing without touching is impossible; circulation is severely restricted within the queue and forward movement is only possible as a group; long-term waiting at this density is discomforting.

Level of Service D:
0.3 - 0.7 m² per pedestrian



Standing in physical contact with others is unavoidable; circulation within the queue is not possible;queuing at this density can only be sustained for a short period without serious discomfort.

Level of Service E:
0.2 - 0.3 m² per pedestrian



Virtually all persons within the queue are standing in direct physical contact with others; this density is extremely discomforting; no movements is possible within the queue; the potential for pushing and panic exists.

Level of Service F:
< 0.2 m² per pedestrian

Level of Service for Queuing Areas

Figure 3: Platform and Queuing Level of Service

3.5 VERTICAL CIRCULATION

Vertical circulation encompasses stairways, ramps, elevators, and escalators. The design of these shall account for station depth, human limitations, and provide sufficient capacity for train service perturbation and maintenance activities. As per AODA requirements and Metrolinx DS-02 Universal Design Standard, all Metrolinx stations require the inclusion of one or more of these elements when level changes are required to access or move within a station.

There are multiple mechanisms for achieving changes in level and they can be considered as constituting a primary or secondary option. Table 3 demonstrates where different options must be adopted depending on the change in level.

A **Primary vertical** transport option represents the key option of choice for the majority of passengers.

A **Secondary** vertical transport option represents an alternative option. Principally for passengers with mobility needs at heights differences of up to 6m, these secondary vertical transportation options become more important as height difference increases (exception: stations where elevators are provided as the primary means of vertical transport, in which case a staircase shall be provided).

Step free access shall be provided to accommodate a proportion of the demand. This proportion will be determined using observed data or in consultation with Metrolinx. In the absence of an alternative assumption, 8% of passenger demand should be assumed to use the step free route (based on Transport for London research, 2008)

Consideration for run off and run on space without overlap is required for surge demand at stairway and escalator space entrances, a minimum length of 5m for stairways, 5m for escalators, and 3m for elevators shall be provided at vertical circulation entry and exit points.

As height differences required to be negotiated in accessing service become greater, customers tend to rely more heavily on mechanical means (i.e. escalators and elevators). It is important to consider this in the evaluation of a station, along with other specific design factors. While public stairs and emergency stairs will always be required, Table 3 provides criteria that speak to depth as related to elevators, escalators, sloped walkways and ramps.

Table 3: Vertical Circulation Criteria

Change in Level	Primary Means	Secondary Means
<0.5m	Sloped Walkway	Ramp
0.5m to 2.5m	Stairway or Sloped Walkway	Ramp or Elevator
2.5m to 6m	Stairway or Escalator (if applicable)	Elevator
>6m	Escalator or Elevator (if applicable)	Elevator and Stairway (if applicable)

NOTE 1: Sloped Walkways with an incline of less than 5% are preferred. Ramps should only be used if Sloped Walkways cannot be accommodated due to constraints.

NOTE 2: GO Stations use stairways as the primary means of vertical transport for customers who do not have mobility disabilities.

NOTE 3: Stairways shall be provided in accordance with OBC, and other applicable project standards or requirements, to meet public access and emergency egress requirements. This table illustrates the vertical circulation elements that are required for passenger comfort. Escalators may be best suited as Primary Means for a change in level of 6m or greater.

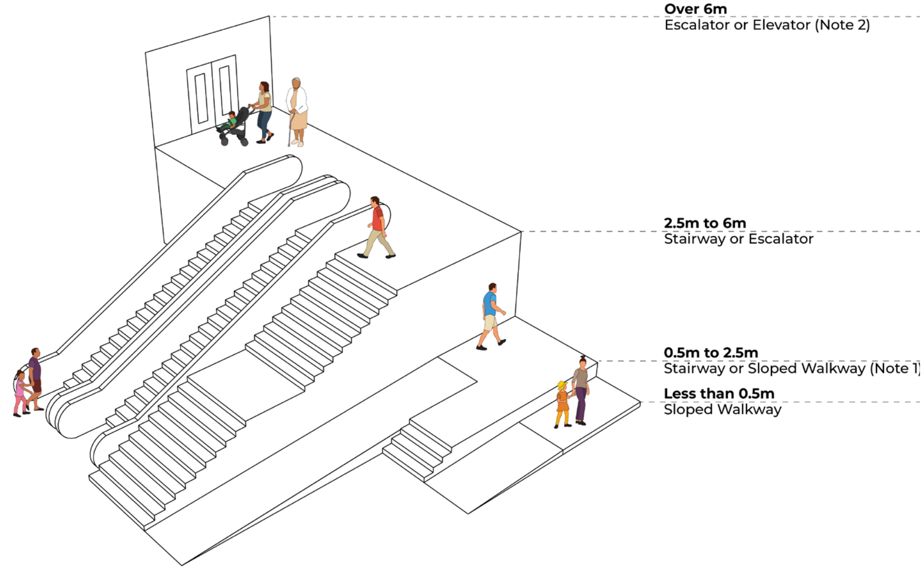


Figure 4: **Primary Means of Vertical Circulation**

3.5.1 STAIRWAYS

Stairways are defined as one or more flights of stairs usually with landings to pass from one level to another. The two directions of travel include upwards and downwards and can operate in either a single direction or both. They are typically the primary vertical pedestrian movement system in transit facilities depending on the station configuration, layout and station depth.

The capacity of a stairway is largely governed by the stairway width. Unlike walking on a level surface, people tend to walk in lines or lanes when traversing stairs. The stairway width determines both the number of distinct lines of people who can traverse the stair and the side-to-side spacing between people. Intermediate handrails also plays a role in dividing ascending and descending flows of traffic.

This affects pedestrians' ability to pass slower-moving pedestrians and the level of interference between adjacent lines of people. The consequences are that increases in capacity are not directly proportional to the width but occur in increments. Unlike on walkways, a minor pedestrian flow in the opposing direction on a stairway can result in a capacity reduction disproportionate to the magnitude of the reverse flow.

Level of Service (LOS) for stairways is expressed in both density: the number of customers within a given area, as well as flow: the number of customers passing through a walkway per minute.

LOS ratings range from LOS A, where pedestrian comfort and level of service is high through to LOS F, where pedestrian movements breakdown:

LOS A allows pedestrians complete freedom of movement and the ability to choose their own speed without impacting others.

LOS B challenging for fast moving pedestrians to overtake slower movers.

LOS C and **LOS D** pedestrian speed is further restricted by the inability to overtake slower movers.

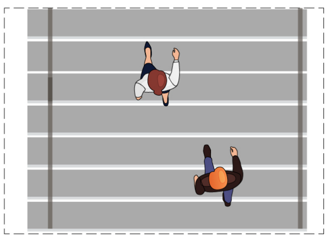
LOS E operates with speed further restricted by limited tread space.

LOS F corresponds with complete flow breakdown.

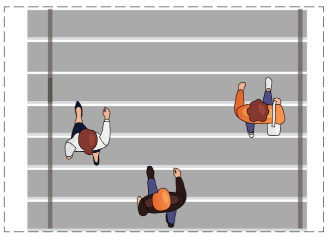
LOS	Density (m^2/ person)			Flow (people /m/ minute)		
A	1.86	+			<	16
B	1.39	-	1.86	16	-	23
C	0.93	-	1.39	23	-	33
D	0.65	-	0.93	33	-	43
E	0.37	-	0.65	43	-	56
F		<	0.37		>	56

Table 4: Stairway Level of Service

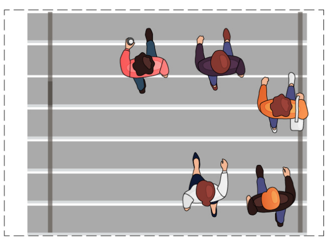
Note: Flow is defined as people per meter width of stairways (m), per minute.



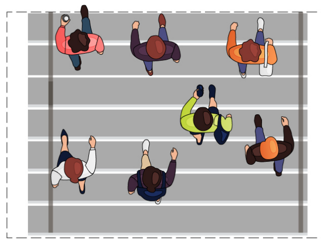
Level of Service A:
< 16 ped/m/min



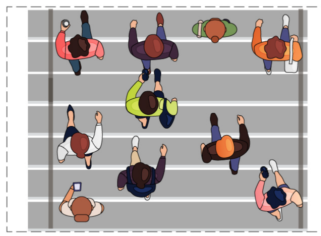
Level of Service B:
16-23 ped/m/min



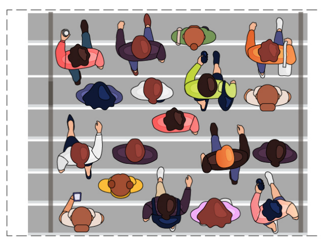
Level of Service C:
23-33 ped/m/min



Level of Service D:
33-43 ped/m/min



Level of Service E:
43-56 ped/m/min



Level of Service F:
>56 ped/m/min

Level of Service for Stairways
Pedestrian per metre per minute (ped/m/min)

Figure 5: Stairway Level of Service

3.5.2 ESCALATORS

Escalators are mechanical stairs to transport pedestrians between different levels of a station and can provide movement both upwards and downwards, but each escalator is confined to a single direction. They are often installed in pairs where there are grade separations between platforms, other areas of the station, or outside areas. Escalators are used to efficiently move large volumes of people. Escalators can supplement stairways and, in many cases, escalators and stairways are located adjacent to one another as part of the combined pedestrian flow strategy. Escalators can function as stairways when they are not powered, allowing for passengers to climb and descend levels manually. However, escalators that are off are not a comfortable means of replacing stairs. Especially at large heights, with unequal steps and without landings, escalators that are not powered on create hazardous conditions.

The capacity of an escalator is dependent upon:

a) Entry width

b) Operating speed

The standard capacity of a 1m wide escalator is 100 passengers per minute based on an assumed speed of 0.5 m/s.

Stations should consider the value of escalators for user experience, with the number of escalators calculated based on passenger demands, number of elevators available, and change in level.

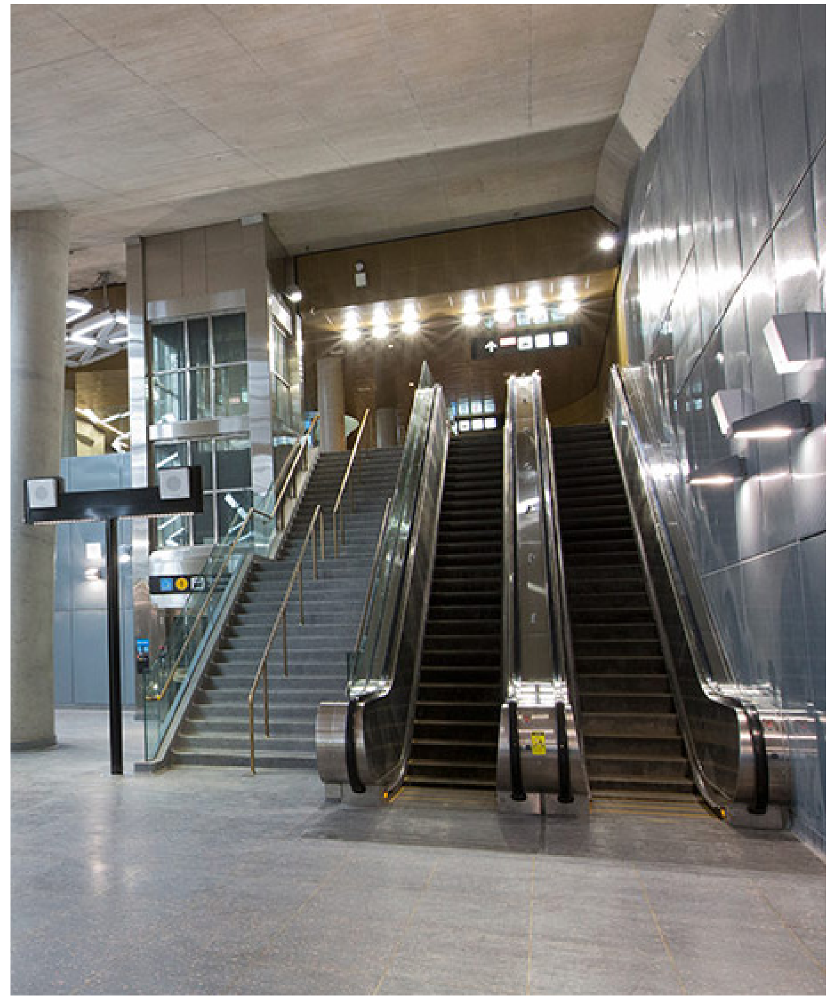


Figure 6: Typical Escalator - TTC Pioneer Village

3.5.3 ELEVATORS

Elevators are a platform or compartment housed in a shaft for raising and lowering pedestrians to different floors and levels. Whereas an escalator, ramp, or lift is confined to serving a specific start and end point. Elevators typically occupy the smallest footprint required to transport pedestrians to multiple levels or floors. Benefits of elevators, escalators and stairs are divers and require a comprehensive design investigation.

The capacity of an elevator is dependent upon:

a) Elevator cab size

b) Entry width

c) Operating speed

d) Trip characteristics (where an elevator serves multiple different levels).

e) Weight Capacity

Figure 7: Typical Elevator - TTC Pioneer Village

3.5.4 SLOPED WALKWAYS AND RAMPS

Sloped walkways and ramps may be designed for general customer use in place of stairs or steps. Used as an alternative to elevators, they have the advantage of requiring minimal maintenance, have no operating cost, and are available to a broader spectrum of passengers who may choose them. Sloped walkways have a grade of 5% or less, while ramps generally have an incline that is greater than 5%.

Alternatively, sloped walkways and ramps may also provide a secondary pedestrian flow purpose for persons with mobility constraints, and are also useful to passengers with strollers, wheeled luggage, or heavy packages.

Sloped walkways and ramps will require sufficient horizontal distance, known as run, to achieve the necessary grade change. In situations where sloped walkways and ramps are not feasible due to space constraints, other vertical systems such as elevators, can be used to accommodate vertical level change, particularly for passengers with mobility aid devices.

Ramps are permitted to negotiate a height difference of up to 2.5m.

Figure 8: Typical Ramp - Ajax GO Station

3.6 DOORWAYS

Doorways limit the capacity of a walkway by imposing restricted lateral spacing. Because of this restriction on capacity, doorways will impact the overall capacity of a pedestrian walkway within a transit station, and therefore will require additional design considerations. Another consideration that impacts doorway capacity is the spacing between doorways, commonly referred to as a vestibule. The size of vestibules can either assist or be detrimental to pedestrian flow and must be taken into consideration.

The effect of doorways on pedestrian flow will depend on the headway (time) between pedestrians. When a pedestrian reaches a doorway, there must be sufficient time-headway separation to allow that pedestrian to pass through the doorway before the next pedestrian arrives. If time-headways between successive pedestrians are too close, a pedestrian queue will develop. The capacity of a doorway is therefore determined by the minimum time required by each pedestrian to pass through the entrance.

There are typically two types of doorway entrances used within transit stations: Free-Swinging and Revolving.

Type of Doorway	Observed Average Headway(s) (Minutes)	Equivalent Pedestrian Volume (pax/min)
Free- Swinging	1.0 - 1.5	40 - 60
Revolving per direction	1.7 - 2.4	25 - 35

Table 5: Doorway Capacities

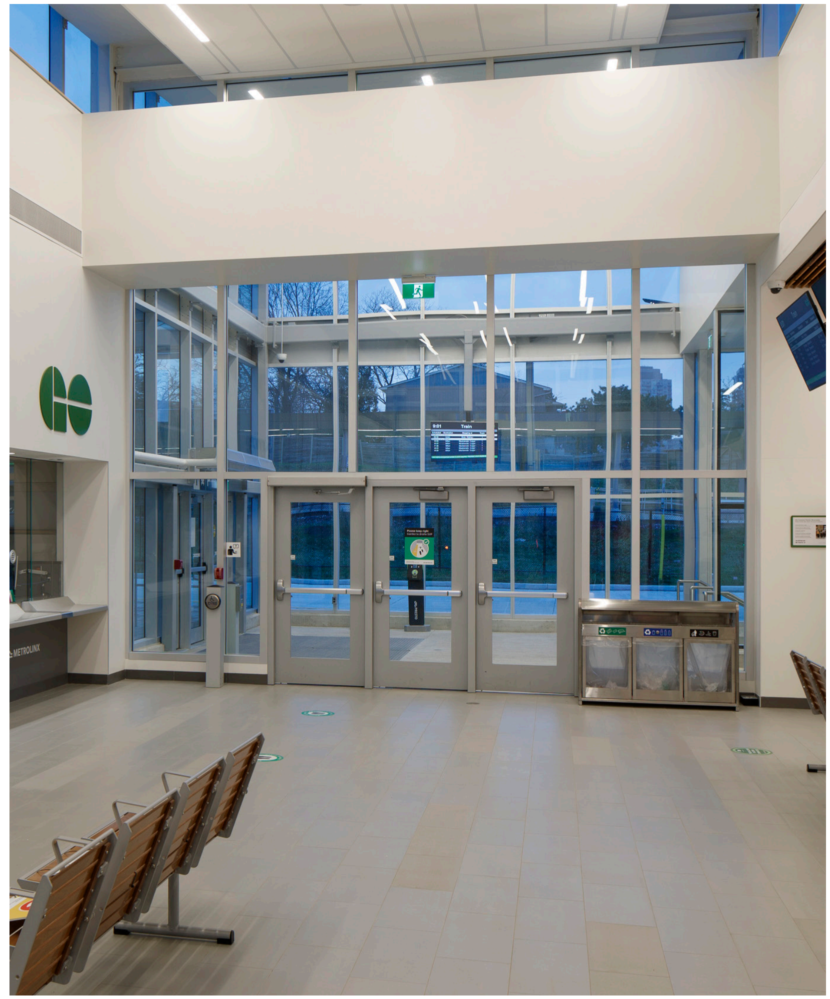


Figure 9: Typical Station Doorway - Cooksville GO Station

3.7 FARE GATES

Fare gates limit the capacity of a circulation route by imposing restricted lateral spacing and by requiring pedestrians to perform an activity that consumes additional time. Within the Metrolinx transit network automated fare gates, leveraging contact-less fare-cards, are typically provided within rapid subway or grade separated light rail transit stations, while the heavy rail network uses a barrier-free tap on and off system with contact-less fare cards.

The effect of fare gates on pedestrian flow will depend on the headway between pedestrians. When a pedestrian reaches a fare gate, there must be sufficient time separation to allow that pedestrian to pass through the fare gate before the next pedestrian arrives. If the times between successive pedestrians are too close, a pedestrian queue will develop. The capacity of a fare gate is therefore determined by the minimum time required by each pedestrian to pass through.

Type of Fare Gates	Observed average headway(s) (Minutes)	Equivalent Pedestrian Volume (pax/min)
Free Admission (barrier only)	1.0 - 1.5	40 - 60
PRESTO Card + High Bi-Leaf Gate	2.4	25
Exit Gate, 0.9m wide	0.8	75
Exit Gate, 1.2m wide	0.6	100
Exit Gate, 1.5m wide	0.5	125

Table 6: Fare Gates Capacities

Figure 10: Typical Fare Gate - TTC Union Station

4.0
Operational Scenarios

4 OPERATIONAL SCENARIOS

This section of the Standard outlines some of the operational scenarios that shall be considered when planning and designing transit facilities.

4.1 REGULAR OPERATIONS

A regular (or normal) operations analysis may include examining the following:

a) Morning and evening weekday peak periods for stations that correspond with residential and office developments.

b) Retail developments weeknight or weekend peak periods.

c) Specific generators such as large institutions or other site-specific conditions.

4.2 SERVICE DISRUPTIONS

Service disruptions can lead to additional queuing requirements and more concentrated arrival patterns. Analysis of service disruption periods may be necessary for stations where queuing space in the station or on station approaches is limited. The typical measure of effectiveness would be per-person space in queuing areas inside and outside the station. The analysis may include an assessment of maximum queuing capacity, and the length of service disturbance before that queuing space is attained. Additional mitigation strategies for off-site queuing may also be useful to review.

Service disruption scenarios will vary by station and analysis tests will need to be defined on a station-by-station basis. At a minimum, service disruption evaluations are required for three scenarios:

a) **Missed Headway** scenario, where the busiest train in the peak period is canceled resulting in increased on-train and on-platform loads.

b) **Evacuation Scenario**, where a full train is evacuated out of a station (Refer to Section 4.3 Emergency Operations); and

c) **Demand Surge Across the Network** (Events Scenario), which serves as a stress test of a station's ability to handle surges in passenger flows such as during major events (Refer to Section 4.4 Special Events)

Additional service disruption scenarios will vary by station and analysis tests will need to be defined on a station by station basis. Other scenarios may be necessary depending on station typology, passenger demands, train service characteristics and the purpose of pedestrian flow modeling. Additional service disruption scenarios may include multiple missed headways, reduced platform width due to construction, reduced off platform capacity such as the closure of station entrances or vertical circulation systems, partial service disruptions to one more modes at multi-modal transfer stations, and turn back capacity at turn back stations.

Typical Service Disruption Scenarios to be Analyzed	
Required	
1.	Missed Headway (Peak Hour)
2.	Evacuation Scenarios (Train on fire/ Station on fire)
3.	Demand Surge Across the Network (Event Scenarios)
As applicable to each Station	
4.	Multiple Missed Headways (i.e. complete cessation of services for 30/60 minutes)
5.	Reduced Platform Width (e.g. O&M related, construction or other reason)
6.	Reduced Circulation Capacity (e.g. closure of one or more station entrances, stairways, elevators, and escalators. This is particularly important for deep stations)
7.	Multi-Modal Stations: Partial Service Disruption (i.e. rail down + normal bus service)
8.	At turn-back stations, accommodating a full train returning

Table 7: Typical Service Disruption Scenarios

4.3 EMERGENCY OPERATIONS

An emergency scenario analysis can help identify mitigation strategies to address a worst-case egress scenario. Emergency scenarios include station evacuation, and they may include scenarios where the station itself is used to evacuate an adjacent site, resulting in higher than normal demand at the station. The goal of these analyses is to identify operational strategies to accommodate an egress condition – for example, additional staff, signage, and pedestrian management strategies.

Evacuation assessments must be undertaken in line with Ontario OBC and NFPA130 requirements and are undertaken using passenger demand derived under a service disruption scenario (i.e. accounting for a missed headway).

Emergency scenarios must take into account individuals with disabilities and those customers who cannot evacuate through non-accessible routes. Identification of the evacuation and protection plan for individuals who aren't using stairs should be evaluated under the pedestrian flow design standard.

4.4 SPECIAL EVENTS

A special event analysis is typical for stations near major event venues. At these locations, the post-event egress period is typically analyzed. This includes an assessment of event-generated demand for a weeknight or weekend condition. An analysis of weeknight event ingress is also recommended because it would reflect the overlap of event ingress demand with weeknight commuter peak demand. The analysis criteria are typically relaxed – for example, instead of looking at the peak 15-minutes, it may be more suitable to evaluate a 30-minute period, and one of the metrics may be time to clear. This analysis type must also account for higher event-related transit service frequency.

4.5 CONSTRUCTION

During periods of construction, pedestrian flow and/or vertical circulation elements may be impacted. An analysis of construction conditions is typically outside the scope of a pedestrian study. If requested, the metrics for evaluation would be a critical element analysis, where platform access is evaluated with the loss of one or more vertical circulation elements, for example, or pedestrian queuing space is assessed with an area reserved for construction. Operating condition benchmarks may be relaxed from normal operating conditions. The goal would be to identify the worst-case conditions, and those that may operate at failing conditions or put pedestrians at risk.

If construction affects the accessible paths of travel, analysis should take into consideration the impact and delay to persons who require a step-free route.

5.0 Customer Level of Service Standards

5 CUSTOMER LEVEL OF SERVICE STANDARDS

This section sets out the Level of Service standards to be applied in the planning and design of new and existing stations. The descriptions provided relate to regular operations, but the tables also provide the standards as they relate to other operational scenarios.

Customer Level of Service standards are defined separately for GO Service and Subway/Rapid Transit facilities.

The Level of Service standards for GO Service are set for stations and facilities with lower service frequencies that are peak-period focused. These facilities typically accommodate the majority of passenger demands during the morning and afternoon commuter periods.

Subway/Rapid Transit standards are set for stations and facilities that typically provide more frequent, all-day service with higher passenger demands throughout the day.

The customer Level of Service standards takes into account these subtle differences in order to ensure that stations and facilities are not over or under designed.

5.1 WALKWAYS

For GO Service and Subway / Rapid Transit facilities, walkways shall be designed to meet the following LOS standard:

a) Walkways (One Way): **LOS D** (50 pax/m/min)

b) Walkways (Two Way): **LOS C** (40 pax/m/min)

To determine the required walkway width, where width is defined as the minimum width along the walkway accounting for finishes and localized obstructions, a 0.3m buffer must be taken into account for the "friction effect" of walkway walls which causes pedestrians to move more slowly in the area immediately adjacent to solid objects.

The following walkway width equations, which include an allowance of 0.3m buffer, shall be used to determine the required width of walkways under regular operations:

c) $$\text{One - Way Walkway Width} = \left(\frac{\text{Peak Minute Flow}}{50} + (2 \times 0.3) \right) \text{m}$$

d) $$\text{Two - Way Walkway Width} = \left(\frac{\text{Peak Minute Flow}}{40} + (2 \times 0.3) \right) \text{m}$$

Notes:

- Where central barriers are provided in walkways to divide passenger flows, 0.3m shall be added to the walkway width.
- The minimum width of a walkway shall be 1.6 m between finishes.
- Where a central barrier is fitted, the minimum width either side of a central barrier shall be 1.6m between barrier and wall finishes.
- The width of a walkway between walkway junctions or other station elements shall be consistent along its entire length.

Station Element	Regular Operations		Special Event	Service Disruption and Construction	Emergency
	GO Service	Subway/ Rapid Transit			
Walkways – One way	50 pax/m/min (LOS D)	50 pax/m/min (LOS D)	80 pax/m/min (LOS E)	65 pax/m/min (LOS D)	80 pax/m/min (LOS E)
Walkways – Two way	40 pax/m/min (LOS C)	40 pax/m/min (LOS C)	65 pax/m/min (LOS D)	50 pax/m/min (LOS D)	80 pax/m/min (LOS E)

Table 8: **Level of Service Standard (Walkways)**

5.2 PLATFORMS & QUEUING AREAS

a) For GO Service facilities, platforms and queuing areas shall be designed to meet the following LOS standard:

LOS B (0.93m^2 per customer)

b) For Subway, Bus and Rapid Transit facilities, platforms and queuing areas shall be designed to meet the following LOS standard:

LOS C (0.80 m^2 per customer)

c) Platforms are represented as queuing areas within a static analysis and will therefore be assessed using the queuing density thresholds.

d) When assessing the performance of a platform, it is important to consider the following:

1. **Platform Length** – capacity assessments shall only take into account the "effective length of the platform", defined as the length of the platform that trains stop at. In other words, the platform shall only be considered as long as the train service it.

2. **Platform Width** – typically platforms have variable width (allowing for structures, furniture and tapering). Variable platform width needs to be considered when considering platform performance. Platform width also needs to account for a "safety zone " of 0.61m at the edge of the platform where passengers will not be waiting.

3. **Platform Waiting Distribution** – waiting behaviour on a platform varies considerably depending on platform length, available width, location of access points, extent/presence of a canopy and the weather. These elements will need to be considered on a case by case basis when undertaking an assessment of platform performance.

Station Element	Regular Operations		Special Event	Service Disruption and Construction	Emergency
	GO Service	Subway/ Rapid Transit			
Platforms	0.93m^2 per person (LOS B)	0.80m^2 per person (LOS C)	0.28m^2 per person (LOS E)	0.45m^2 per person (LOS D)	80 pax/m/min (as passageway) 0.40m^2 per person (as queuing area)

Table 9: Level of Service Standard (Platforms)

e) The LOS analysis of platforms shall follow the following process:

1. Determine peak boarding load using the calculations outlined in **Appendix B**.
2. Determine corresponding alighting load.
3. Divide the platform length into train car length segments (for a typical twelve car, the platform shall be divided into twelve equal segments or "blocks"). Calculate the effective area of each block (block length multiplied by effective block width, where effective block width is the minimum width of each block minus the 0.61m safety zone).
4. Allocate boarding and alighting demand to each platform block based on an observed distribution. If an observed platform distribution is not available, an assumed distribution must be agreed with Metrolinx prior to undertaking the analysis. Platform distribution, as discussed above, is very variable and shall be considered and agreed on a station by station basis.
5. Determine passenger density per block by dividing peak platform load per block by effective block area. This can be used to derive a level of service.

5.2.1 PLATFORM ACCESS ROUTES

The location of platform access routes has a significant bearing on platform performance as they influence the platform clearance times and platform distribution. Platform access routes shall be designed to achieve as even a distribution as possible (see separate note about end loaded platforms).

The minimum width of a platform access route shall be 2.0m.

End Loaded Platforms

Long platforms that are end loaded create particular challenges relating to platform distribution. This standard doesn't restrict the ability to implement end loaded platforms as it is acknowledged that spatial constraints sometimes mean that this is the only practical way to deliver a station. However, should an end loaded platform design be required, additional analysis shall be undertaken to demonstrate that the design can operate safely and efficiently.

In the absence of observed platform loading distributions and/or site specific platform assumptions, 75% of boarding and alighting shall be assumed to take place within 50% of the platform closest to the access route.

5.2.2 PLATFORM CLEARANCE TIMES

Platform clearance times under normal operations are a key metric to understand the performance of the station during all categories of operation. There are two main aspects of platform clearance to be considered:

a) **Safety** – the platform must be cleared between train arrivals. If exiting passengers remain on the platform when the following train arrives there is increased risk of adverse safety outcomes.

b) **Comfort** – long platform clearance times result in frustration and poor levels of passenger comfort. This may result in missed connections, or reduced performance of other downstream station elements.

Minimum platform clearance times shall be either equivalent to the minimum feasible train headway, or four minutes (whichever is lower).

Platform clearance time is a function of the peak train alighting load and the capacity of the exit routes off the platform. Peak train alighting load (for both base and future demand scenarios) shall be assigned to each of the exit routes from the platform based on proportions agreed with Metrolinx. Exit routes from the platform are typically either walkways or means of vertical circulation.

NOTE: Emergency clearance times for platforms shall conform with the requirements outlined in the Ontario Building Code (OBC) and NFPA 130.

The capacity of these routes shall be calculated using the planning criteria shown in **Table 8.**

Platform clearance time shall be calculated separately for each exit route using the following two equations:

c) $$\text{Clearance time (1)} = \text{Time for first arrival} + \frac{\text{Total demand for route}}{\text{route capacity}}$$

d) $$\text{Clearance time (2)} = \text{Time for last arrival}$$

Where "time for first arrival" is the time it takes for the first person to arrive at the exit route following the arrival of the train. This can be calculated by dividing the distance between the closest train door and the exit route by 1.5 (where 1.5 m/s is assumed to be the walking speed of the alighting passenger).

Time for last arrival is the time it takes for the last person to arrive at the exit route following the arrival of the train. This can be calculated by dividing the distance between the furthest train door and the exit route by 1.5 (where 1.5 m/s is assumed to be the walking speed of the alighting passenger).

The highest value of clearance time (1) and clearance time (2) shall be used as the clearance time for each exit route. The highest clearance time for any individual exit route shall be used as the overall platform clearance time.

5.3 STAIRWAYS

For GO Service facilities, stairways shall be designed to meet the following LOS standard:

a) Stairways (One Way): **LOS D** (35 pax/m/min)

b) Stairways (Two Way): **LOS C** (28 pax/m/min)

For Subway and Rapid Transit facilities, platforms and queuing areas shall be designed to meet the following LOS standard:

c) Stairways (One Way): **LOS E** (56 pax/m/min)

d) Stairways (Two Way): **LOS D** (35 pax/m/min)

To determine stairway width (where width is the minimum width along the walkway accounting for handrails) the peak minute flow using each staircase shall be determined. Consideration for run off and run on space is required for surge demand at stairway, a minimum length of 5m at top and bottom of stairs shall be provided at vertical circulation entry and exit points.

There is no need to subtract 0.3m from each side of the width to calculate the effective width as people are assumed to walk comfortable using the entire width between handrails. A minimum stairway width of 2.0m shall be provided (including handrails).

The following equations can be applied to determine the required stairway width to meet anticipated customer demands.

GO Facilities:

e) $$\text{One - Way Staircase Width} = \left(\frac{\text{Peak Minute Flow}}{35}\right) \text{m}$$

f) $$\text{Two - Way Staircase Width} = \left(\frac{\text{Peak Minute Flow}}{28}\right) \text{m}$$

Subway / Rapid Transit Facilities:

g) $$\text{One - Way Staircase Width} = \left(\frac{\text{Peak Minute Flow}}{56}\right) \text{m}$$

h) $$\text{Two - Way Staircase Width} = \left(\frac{\text{Peak Minute Flow}}{35}\right) \text{m}$$

Station Element	Regular Operations		Special Event	Service Disruption and Construction	Emergency
	GO Service	Subway/ Rapid Transit			
Stairways – One way	35 pax/m/min (LOS D)	56 pax/m/min (LOS E)	56 pax/m/min (LOS E)	56 pax/m/min (LOS E)	56 pax/m/min (LOS E)
Stairways – Two way	28 pax/m/min (LOS C)	35 pax/m/min (LOS D)	35 pax/m/min (LOS D)	35 pax/m/min (LOS D)	56 pax/m/min (LOS E)

Table 10: **Level of Service Standard (Stairways)**

5.4 ESCALATORS

Escalators and moving walkways shall be designed to meet the following LOS standard:

a) Escalators: accommodate 100 customers / escalator / minute

The following equation can be applied to determine the number of escalators that are required for any one direction, if under consideration:

b) Number of Escalators = $\left(\frac{\text{Peak Minute One Way Flow}}{100}\right)$

For the purposes of calculation, this standard reflects industry standard width of 1000mm (1 meter) wide escalators with a speed of 0.5 m/s. The calculated speed of 0.5 m/s. The calculated number of escalators shall be rounded to the next whole number if the number after the decimal point is more than 2. Otherwise, the number of required escalators shall be rounded down. For example, an assumed peak passenger flow of 215 customers would yield 2.15 requiring 2 escalators to service peak demands.

An acceptable level of queuing at escalators is 0-15 seconds on a concourse and 0-30 seconds on a platform. Consideration for run off and run on space is required for surge demand at escalator space entrances, a minimum length of 5m at top and bottom for escalators shall be provided at vertical circulation entry and exit points, without overlapping other runoff spaces or clearances. Runoff distances are minimum and additional runoff shall be determined based on passenger demands and achieving level of service criteria.

To establish the number of escalators needed for a station, the following considerations must be taken into account:

c) Overall height difference of level change. As height difference increases, a larger proportion of customers rely on elevators.

d) Number of available escalators needed during peak periods when an escalator is down due to malfunction or maintenance.

e) Availability of adequate alternatives to elevators, particularly as station depth increases. This supports Crime Prevention Through Environmental Design (CPTED) principles, and provides improved access to passengers that require step free access.

f) It should be noted that other design considerations for deep stations, which are beyond the scope of the DS-12 Pedestrian Flow Modeling Standard, should be considered.

5.5 SLOPE WALKWAYS AND RAMPS

For GO Service and Subway / Rapid Transit facilities, sloped walkways with an incline that is less 5% shall be designed to meet the following LOS standard:

a) Sloped Walkway (< 5% - One Way): **LOS D** (50 pax/m/min)

b) Sloped Walkway (< 5% - Two Way): **LOS C** (40 pax/m/min)

Ramps with an incline that is greater than 5% shall be designed to meet the following LOS standard:

c) Ramps (> 5% - One Way): **LOS D** (45 pax/m/min)

d) Ramps (> 5% - Two Way): **LOS C** (36 pax/m/min)

Station Element	Regular Operations		Special Event	Service Disruption and Construction	Emergency
	GO Service	Subway/ Rapid Transit			
Sloped Walkways <5% - One way	50 pax/m/min (LOS D)	50 pax/m/min (LOS D)	80 pax/m/min (LOS E)	65 pax/m/min (LOS D)	80 pax/m/min (LOS E)
Sloped Walkways <5% - Two way	40 pax/m/min (LOS C)	40 pax/m/min (LOS C)	65 pax/m/min (LOS D)	50 pax/m/min (LOS D)	80 pax/m/min (LOS E)
Ramps >5% - One way	45 pax/m/min (LOS C)	45 pax/m/min (LOS C)	72 pax/m/min (LOS D)	59 pax/m/min (LOS D)	55 pax/m/min (LOS E)
Ramps >5% - Two way	36 pax/m/min (LOS C)	36 pax/m/min (LOS C)	59 pax/m/min (LOS D)	45 pax/m/min (LOS D)	55 pax/m/min (LOS E)

Table 11: Level of Service Standard (Sloped Walkways and Ramps)

5.6 ELEVATORS

The Level of Service for elevators is evaluated based on passenger wait times and passenger crowding in elevator waiting areas. Under normal operating conditions, the typical tolerance for an acceptable waiting time for elevator service at transit facilities is approximately 30 seconds, but this depends on the vertical distance traveled, the travel speed of the elevator, the capacity of the elevator cabin, and the availability of secondary means for vertical circulation.

For GO Service and Subway / Rapid Transit facilities, the number of elevators provided, and designated elevator waiting areas shall be designed to meet the following LOS standard:

a) Regular Operations: LOS C (0.80 m^2 per person)

b) Special Events: LOS E (0.28 m^2 per person)

c) Service Disruption or Construction: LOS D (0.45 m^2 per person)

Elevators are not considered as part of an evacuation route, and as a result no level of service standard is identified for an Emergency scenario.

To evaluate the effective capacity of existing elevator systems, the following capacity assumptions shall be adopted:

d) Elevator Capacity (Primary): 70% of plated capacity

e) Elevator Capacity (Secondary) 25% of plated capacity

Where plated capacity is the rated elevator load in number of people accommodated per trip.

Alternatively, where plated capacity is not available, the following elevator passenger density assumptions shall be adopted:

f) Elevator Capacity (Primary): 4 passengers per m^2

g) Elevator Capacity (Secondary): 1 passenger per m^2

Station Element	Regular Operations		Special Event	Service Disruption and Construction	Emergency
	GO Service	Subway/ Rapid Transit			
Elevator Waiting Areas	0.80m^2 per person (LOS C)	0.80m^2 per person (LOS C)	0.28m^2 per person (LOS E)	0.45m^2 per person (LOS D)	n/a
Elevator Capacity (Primary)	70% of plated capacity or 4 pax / m^2	70% of plated capacity or 4 pax / m^2	70% of plated capacity or 4 pax / m^2	70% of plated capacity or 4 pax / m^2	n/a
Elevator Capacity (Secondary)	25% of plated capacity or 1 pax / m^2	25% of plated capacity or 1 pax / m^2	25% of plated capacity or 1 pax / m^2	25% of plated capacity or 1 pax / m^2	n/a

Table 12: **Level of Service Standard (Elevators)**

5.7 FARE GATES

Fare gates limit walkway capacity by restricting lateral spacing of walkways and requiring customers to perform a fare payment activity that takes additional time. Due to these factors, fare gates impact the overall capacity of walkway systems and therefore the number of fare gates provided and their placement must be considered.

For GO Service and Subway / Rapid Transit facilities, the number of fare gates provided shall be designed to meet the following LOS standard:

a) Fare Gate Capacity: 25 pax per gate per minute

b) Emergency Capacity (Open Gates): 45 pax per gate per minute

Station Element	Regular Operations		Special Event	Service Disruption and Construction	Emergency
	GO Service	Subway/ Rapid Transit			
Fare Gate	25 pax/gate/min	25 pax/gate/min	25 pax/gate/min	25 pax/gate/min	45 pax/gate/min (open)

Table 13: Level of Service Standard (Fare Gates)

5.8 DOORWAYS

Doorways limit capacity by restricting lateral spacing of walkways and requiring customers to pass through a doorway or entrance. Due to these factors, doorways impact the overall capacity of walkway systems and therefore the number of doorways provided and their placement must be considered.

For GO Service and Subway / Rapid Transit facilities, the following doorway capacities and LOS standards shall be adopted:

a) Regular Operations: LOS D (50 pax per door per minute)

b) Special Event: LOS E (80 pax per door per minute)

c) Service Disruption and Construction: LOS D (65 pax per door per minute)

d) Emergency: LOS E (80 pax per door per minute)

Station Element	Regular Operations		Special Event	Service Disruption and Construction	Emergency
	GO Service	Subway/ Rapid Transit			
Doorway (unidirectional)	50 pax/doorway/min (LOS D)	50 pax/doorway/min (LOS D)	80 pax/doorway/min (LOS E)	65 pax/doorway/min (LOS D)	Refer to OBC requirements

Table 14: **Level of Service Standard (Doorways)**

5.9 CUSTOMER LEVEL OF SERVICE STANDARD SUMMARY

Station Element	GO Service	Subway/ Rapid Transit	Special Event	Service Disruption and Construction	Emergency
Platforms	0.93m2 per person (LOS B)	0.8m2 per person (LOS C)	0.28m2 per person (LOS E)	0.45m2 per person (LOS D)	80 pax/m/min (as passageway) 0.40m2 per person (as queuing area)
Walkways – One way	50 pax/m/min (LOS D)	50 pax/m/min (LOS D)	80 pax/m/min (LOS E)	65 pax/m/min (LOS D)	80 pax/m/min (LOS E)
Walkways – Two way	40 pax/m/min (LOS C)	40 pax/m/min (LOS C)	65 pax/m/min (LOS D)	50 pax/m/min (LOS D)	80 pax/m/min (LOS E)
Stairways – One way	35 pax/m/min (LOS D)	56 pax/m/min (LOS E)	56 pax/m/min (LOS E)	56 pax/m/min (LOS E)	56 pax/m/min (LOS E)
Stairways – Two way	28 pax/m/min (LOS C)	35 pax/m/min (LOS D)	35 pax/m/min (LOS D)	35 pax/m/min (LOS D)	56 pax/m/min (LOS E)
Escalators and Moving Walkways	100 pax/min/escalator	100 pax/min/escalator	100 pax/min/escalator	100 pax/min/escalator	56 pax/m/min (stopped) 100 pax/min/escalator
Sloped Walkways <5% - One way	50 pax/m/min (LOS D)	50 pax/m/min (LOS D)	80 pax/m/min (LOS E)	65 pax/m/min (LOS D)	80 pax/m/min (LOS E)
Sloped Walkways <5% - Two way	40 pax/m/min (LOS C)	40 pax/m/min (LOS C)	65 pax/m/min (LOS D)	50 pax/m/min (LOS D)	80 pax/m/min (LOS E)
Ramps >5% - One way	45 pax/m/min (LOS C)	45 pax/m/min (LOS C)	72 pax/m/min (LOS D)	59 pax/m/min (LOS D)	55 pax/m/min (LOS E)
Ramps >5% - Two way	36 pax/m/min (LOS C)	36 pax/m/min (LOS C)	59 pax/m/min (LOS D)	45 pax/m/min (LOS D)	55 pax/m/min (LOS E)
Fare Gates	25 pax/gate/min	25 pax/gate/min	25 pax/gate/min	25 pax/gate/min	45 pax/gate/min (open)
Elevator Capacity (Primary)	70% of plated capacity or 4 pax/m2	70% of plated capacity or 4 pax/m2	70% of plated capacity or 4 pax/m2	70% of plated capacity or 4 pax/m2	n/a
Elevator Capacity (Secondary)	25% of plated capacity or 1 pax/m2	25% of plated capacity or 1 pax/m2	25% of plated capacity or 1 pax/m2	25% of plated capacity or 1 pax/m2	n/a
Doorways (unidirectional)	50 pax/doorway/min (LOS D)	50 pax/doorway/min (LOS D)	80 pax/doorway/min (LOS E)	65 pax/doorway/min (LOS D)	Refer to OBC requirements
Queuing Areas	0.80m2 per person (LOS C)	0.80m2 per person (LOS C)	0.28m2 per person (LOS E)	0.45m2 per person (LOS D)	n/a

Table 15: Customer Level of Service Standards

6.0

Station Capacity Assessment

6 STATION CAPACITY ASSESSMENT

6.1 OVERVIEW

Station capacity requirements and challenges vary depending on typology and the unique customer demands for each station. Despite this, all stations share basic fundamental design requirements that can be answered through the following questions:

a) Is there sufficient platform capacity?

b) Is there sufficient vertical circulation and access in terms of stairs, escalators, and elevators?

c) Is there sufficient space within the station for exiting and entering passengers under the worst-case condition?

d) Is there sufficient space if fare gates are being considered?

e) Is there sufficient space around any fare vending and fare payment machines?

f) Are internal walkways sufficiently sized for the estimated volumes of passengers?

g) Is there sufficient queuing space outside the station if there is a bus stop immediately adjacent or the station sits in an urban area?

h) Is there sufficient pedestrian spaces to accommodate emergency egress within the required clearance time?

i) For deep stations, are there sufficient escalators and elevators to enable vertical access by mechanical means?

j) For deep stations, is there sufficient vertical circulation and access capacity in the event of an inoperable escalator or elevator?

The goal of the assessment is to determine if there are any design issues that need to be addressed that have the potential to result in circulation issues or blockages in pedestrian flows. This assessment can start as a general flow map with volumes to create an understanding of the movements that will occur and possible areas of concern. Understanding passenger volumes and movements into and out of the station along with the pedestrian movements around the station entry points are a first set in the assessment.

Pedestrian flow capacity assessments can be conducted in one of two ways based on the size, scope, and complexity of the transit facility being assessed:

Static Capacity Assessment: a simplified, often spread-sheet based approach

Dynamic Capacity Assessment: a more detailed assessment requiring the use of specialized industry software.

6.2 DATA INPUTS

In broad terms, data needs can be categorized into several areas – pedestrian demand, pedestrian infrastructure, service frequency, station access, and adjacent developments. These inputs facilitate the development of an origin-destination matrix of movements, and a profile of arrivals. A Data Requirements checklist is provided in **Appendix A.**

a) **Peak Hours to Examine:** The peak hours of operation form the basis of a station capacity assessment and needs to be defined clearly. Typically, the Peak Hours of operations constitute the weekday AM and PM Peak commuter periods, but this can be influenced by a range of factors. For example, a new station near a university may be influenced by class schedules in the morning. For existing stations, data may be collected to confirm peak periods. For a proposed station, peak periods must be agreed to in consultation with Metrolinx Planning & Development.

b) **Arrival Flow and Directionality:** Observed arrival patterns and direction that people come to the station, will be used to understand the geographic distribution of ingress and egress flows to different entry and exit access points. The arrival flow and directionality may be restricted for individuals who cannot traverse steps and need an accessible route. This should be taken into consideration when assessing the geographic distribution of ingress and egress flows as it may impact the speed of the individuals using the accessible routes.

c) **Arrival Profile within the Peak Hour:** The arrival rate of passengers between trains, and the rate of people alighting off trains needs to be confirmed through data collection. This can be influenced by the headway between services, the surrounding business areas, proximity to residential communities, commercial offerings in the area, parking, arrival of transferring buses, and number of accessible trains provided to accommodate accessible alighting.

d) **Pedestrian Infrastructure:** Station infrastructure and design elements are documented in detailed and scaled station plans. The following aspects need to be considered:

1. Are the station elements shown on station plans representative of current site conditions?
2. Are there restrictions/barriers in peak time not shown on the station plan?
3. Are the effective widths of major vertical circulation elements clearly indicated?
4. Does the station plan indicate the location and dimensions of obstacles to pedestrian flow, such as benches, kiosks, or other architectural station elements?

5. Does the station plan show emergency egress locations?

6. Does the station plan clearly indicate the depth of stations and height of level change for all levels?

e) **Service Frequency:** Identify the arrival headways for each service line by direction. If possible, evaluate on-time performance and departure loads.

f) **Adjacent Developments:** Along with the areas within the station, it is important to consider external elements that will have an influence on station performance and background pedestrian demands. The following considerations must be made:

1. Identify adjacent and integrated developments

2. What are the major origins and destinations for passengers?

3. What are their operating parameters / peaking characteristics?

4. Are there any special events that will generate peak demand for the station?

5. What other modes of travel are available? (This will inform mode share)

6.3 PASSENGER DEMAND

A passenger flow assessment typically considers a range of passenger demand scenarios:

a) **Base Year Demand:** This typically represents the "current" year and reflects a year close to the present for which representative passenger demand data is available. An assessment of base year demand shall be undertaken to demonstrate that the assessment approach is able to reflect observed conditions.

b) **Future Year Demand – Scheme Opening Year:** A range of future year demand scenarios are developed. The first provides an understanding of the operation of the station in the opening year of the scheme. The purpose of this is to understand how the station will operate on "day 1". The following inputs must be assembled to provide input into the passenger demand forecasts:

1. Input from a regional travel demand model, to confirm future year station demand patterns.
2. Trip generation patterns and development densities of adjacent or integrated land uses, taking into account the fact that different land uses will have different trip patterns.
3. Trip distribution characteristics – arrival and departure percentages by service line and direction of travels.
4. Future service frequency, to understand arrival and departure headways.

These inputs can be used to define a future year demand matrix.

c) **Future Year Demand – Design Year:** In addition to the opening year assessment, a "design year" assessment shall be undertaken to demonstrate enduring benefits. This shall be based on regional travel demand model data. Where this isn't available, a growth assumption shall be agreed to by Metrolinx.

d) **Key Demand Concepts:** Assessments of station capacity typically draw on the following consistent concepts of demand so that the busiest periods are represented in the analysis. More detail is provided in **Appendix B**:

1. **Peak Period** – Typically the AM and PM commuter periods, the peak periods typically represent the two busiest periods of station operation throughout the day. Where available, these periods will be derived from observed data, making allowance for seasonality and weekly variability. In some cases (for example, for stations in the vicinity of stadia or other special event venues), the peak period of activity will occur outside of the commuter peaks. These will be identified and agreed in advance with Metrolinx prior to any analysis being undertaken.

2. **Peak Hour** – The busiest hour within the peak period. This typically becomes the focus of the analysis.
3. **Peak 15-Minutes** – The busiest 15-minute period within the peak hour. The peak 15-minute period is typically used for reporting purposes, particularly where dynamic modelling is undertaken. Outputs showing mean density typically reflect the peak 15-minute period
4. **Peak Minute** – The busiest minute within the peak fifteen minutes and typically coinciding with train arrival or departure events. This is used in many of the capacity calculations to determine infrastructure sizing requirements.
5. **Peak Train** – The busiest train for boarding and alighting activity during the peak period. The number of people boarding and alighting the peak train is used to determine platform requirements.
6. **Egress Load** – The total demand to be evacuated from a station during an evacuation event. This will be calculated using the OBC and NFPA130. Egress Load typically includes everyone within the station at the time of the evacuation, in addition to everyone on the train to be evacuated.
7. **Headway** – The gap (in minutes) between services, as derived from the operating train schedule or timetable. This is used to calculate platform accumulation.
8. **Missed Headway** – When a service is canceled resulting in a larger gap between services. This results in greater levels of platform accumulation and more significant off-train alighting loads. Missed headways are used in service disruption and emergency egress scenario tests.
9. **Passenger Makeup** – The types of customers using a station influence route choices and infrastructure requirements. This is particularly the case with step free routes. In the absence of any observed data, a minimum of 8% of passengers shall be assumed to use step free infrastructure. For deep stations, the proportion of passengers using elevators may increase.

In the absence of any observed data, a minimum 8% of passengers shall be assumed to use step free infrastructure.

6.4 STATIC CAPACITY ASSESSMENT

a) **Description:** A simplified, often spreadsheet-based, numerical investigation used to assess the functionality of a station through the application of mathematical formulae derived from industry planning standards. Historically, static analyses were used in the absence of advanced computer modelling programs. Static capacity assessments continue to be useful and offer a quick method of evaluating anticipated performance of station elements. Within the context of the Pedestrian Flow Design Standard, static capacity assessments shall be used as the default form of pedestrian flow capacity assessments, even if dynamic analysis is to be undertaken as well. This section documents the approach for undertaking a static analysis.

b) **Purpose:** A static analysis can provide either a preliminary analysis of a scheme to determine whether it meets the appropriate planning standards or whether further analysis is required to address constraints, such as dynamic modelling. If it is agreed that dynamic modelling is required, a spreadsheet-based capacity assessment shall also be carried out to provide an initial high-level analysis of performance, to determine any obvious and extreme failings in a design or proposed scheme prior to dynamic modelling, and to provide a sense-check of the dynamic modelling outputs.

6.4.1 STATIC ASSESSMENT METHODOLOGY

This process is intended as a guide to undertaking spreadsheet-based LOS capacity assessments for stations across the Metrolinx network. More detail on this methodology is provided within **Appendix D.**

a) **Step 1 – Define the Station Area:** Existing and Future (if applicable) station areas and elements shall be clearly summarized and documented. This includes but is not limited to: the number and location of access points and doorways, walkways, fare gates, fare ticket dispensing machines, vertical circulation elements and associated landing areas, queuing areas, and platforms. This information shall also include station element dimensions and gross floor areas (GFA), as applicable. Service information at the station shall be provided and is to include but is not limited to: service schedules, rolling stock and vehicle type, dwell times, vehicle door numbers and stop positions.

b) **Step 2 – Quantify Passenger Demand:** Base year and, if applicable, future station passenger demand data for the busiest hours of station operation shall be summarized. The selection of a future horizon year shall be done in consultation with Metrolinx and shall include , at a minimum the build-out year and build-out plus 5-year horizons. Typically, stations will be assessed for AM and PM weekday peak periods as these tend to be the busiest periods of station operation, however stations in proximity to major recreational or special event centres may require a weekday evening and/or weekend peak period assessment. Demand data shall be provided in the form of boarding and alighting demand for all transit platforms during each peak hour to be assessed. Where this data is not available, assumptions will need to be agreed upon in advance with Metrolinx.

c) **Step 3 – Quantify Passenger Flows:** Existing, and if applicable, future station movement patterns and routes shall be summarized for the agreed upon peak periods to be assessed. A matrix of origin - destination movements within the station shall be developed based on the passenger demand quantified in Step 2 and visualized in diagram format to show pedestrian volumes by study period and study horizon year. Although this information will vary on a station by station basis, complex stations will typically require information on the use of different entry and exit points, platform to platform interchange, use of alternative forms of vertical transportation (escalators, stairs and elevators) and the use of alternative circulation routes. These volumes will be used to assess capacity of key station elements. These elements shall be analyzed using spreadsheet calculations as described in subsequent steps.

d) **Step 4 – Assigning Passenger Flows:** Where determining escalators are the primary means of vertical circulation, the number of escalators should be determined using the equation in Section 5.4b while assuming 100% of passengers use the escalators in each direction. Assignment of passenger flows in a static assessment should first use available escalator capacity up to the defined flow rate and subsequently assign any remaining passenger demands to use stairs.

e) **Step 5 – Capacity Assessment:** A capacity assessment shall be conducted for each study period and horizon year. The results shall be summarized in tabular format and any elements exceeding the LOS service standard criteria summarized in Section 5 (Customer Level of Service Standards) shall be identified with appropriate mitigation measures developed and tested in consultation with Metrolinx. Where capacity constraints cannot be alleviated, a dynamic model shall be considered at the discretion of Metrolinx.

f) **Step 6 – Evacuation Assessment:** where appropriate an assessment of evacuation capacity shall be undertaken for two scenarios as described in Section 4.3 of this document:

1. Train on Fire
2. Station on Fire

Evacuation assessment parameters must comply with Ontario Building Code, NFPA 130, and other regulatory requirements.

g) **Step 7 - Result Documentation:** Documentation must include the methodology followed, all assumptions made in the process of carrying out a static analysis, calculations, and results. Access points, locations of assessment areas, and other critical points shall be clearly marked and documented in a graphic illustration of the study area. The spreadsheet used to carry out the analysis must be submitted and be sufficiently labeled to be self-explanatory. Static analysis must be verified. Outputs shall be reviewed by the consultants carrying out the assessment (i.e. internal QA/QC review). The report shall clearly identify if the proposed design is compliant or non-complaint with the passenger flow design standards. If station elements are deemed non-complaint to the standard, the magnitude of non-compliance shall be specified in the report. If applicable, if non-compliance is identified, design modifications and/or measures to achieve compliance or mitigate risks must be identified.

6.5 DYNAMIC CAPACITY ASSESSMENT

a) **Description:** A more detailed analysis to supplement the high-level appraisal static analysis provides. The advantage of dynamic passenger flow modelling is that it generally treats all the physical elements that constitute a station environment (or sub-section) as well as the passenger activities and behaviour patterns as a single system and is therefore able to capture the interaction between these various elements and activities. It is also able to reflect the dynamic nature of passenger flows, and in the case of microscopic models, the interaction between individual pedestrians.

Dynamic models generally provide a richer, more detailed level of analysis, which in turn provides a better understanding and more accurate view of pedestrian circulation performance. The visual nature of these models also provides a good communication tool, particularly when presenting to non-technical audiences. A Level of Service (LOS) capacity assessment (often referred to as a static analysis) is a numerical investigation used to assess the functionality of a station through the application of mathematical formulae derived from industry planning standards.

b) **Purpose:** A dynamic capacity assessment can be undertaken by developing a new passenger flow computer-based model, or adopting and updating an existing one. Dynamic capacity models can simulate various scenarios and evaluate passenger flow performance for the entire customer journey. Dynamic models can also be used to verify capacity constraints identified under static capacity assessments.

The key distinction between dynamic and static models lie in the degree of detail: dynamic capacity models provide a holistic evaluation of the pedestrian environment within a station, whereas static capacity models evaluate station performance at the individual station element level.

6.5.1 DYNAMIC ASSESSMENT METHODOLOGY

This process is intended as a guide to undertaking dynamic modelling capacity assessments for all customer-facing stations and facilities across the Metrolinx network. More detail on specific inputs, assumptions and parameters associated with this methodology are provided within **Appendix E.**

a) **Step 1 – Data Collection and Preparation:** Establish the availability and suitability of any existing data, and if necessary, plan and carry out station surveys to collect any additional or missing data required to undertake a dynamic model. The modelling input requirements are covered in Appendix A and Appendix E. Any station surveys shall be planned in consultation with Metrolinx. This step also involves preparing and formatting the data according to the requirements of the modelling package being used.

b) **Step 2 – Modelling Assumptions:** Determine and document the relevant modelling assumptions as set out in Appendix E. This may involve site visits and consultation with the relevant representative from the Metrolinx team (or other agencies as discussed with Metrolinx).

c) **Step 3 – Model Plan:** Develop a Model Plan in accordance with this guidance and in discussion with Metrolinx. This document shall document all modelling inputs and assumptions and set out the approach to developing the model.

d) **Step 4 – Data Inputs, Assumptions and Plan:** Before proceeding with the model development, the initial Model Plan must be reviewed with Metrolinx to confirm modelling input data and assumptions, and to ensure that model development will be in accordance with Metrolinx recommended approach.

e) **Step 5 – Base Year Model Development:** Unless otherwise agreed with Metrolinx, the first stage of model development involves building a Base Year Model (current year or earlier, depending on availability of data) in accordance with the Model Plan. This document does not provide technical guidance on how to build a model. This will depend on the modelling software being used, and it is expected that the consultant appointed to undertake the modelling will have the relevant expertise and experience to use the selected software in the appropriate manner.

f) **Step 6 – Base Year Model Validation:** The next stage in the model development is the validation of the Base Year model. Model validation is covered in Section 6.7, and the Base Year model can be considered validated if the variations between the modelled outputs and the corresponding validation data are less than 15%. If the variations are greater than 15%, the reasons for the variations must be investigated to facilitate improved validation. As noted in Section 6.7 Model Validation, route choice and queuing should be checked against site observations and/or video evidence for existing stations. This includes the utilization and choice of stairs versus escalators. Where no localized data is available, default software parameters of time & distance generalized costs should be used for dynamic route choice, reflecting the effort and attractiveness to use stairs, escalators, and elevators for vertical change in height.

g) **Step 7 – Base Year Model Audit:** Metrolinx requires that, before continuing with the scenario testing, the validated Base Year model is audited to confirm it is fit for purpose. This audit shall be carried out by a qualified person who is independent of the model development process (i.e. who has not worked on the same project). Metrolinx reserves the right, at its discretion, to appoint an independent auditor to perform a technical review on behalf of Metrolinx.

h) **Step 8 – Scenario Modelling:** Using the Base Year model as a reference model on which to base the scenario testing, the scenarios identified for the project are modelled. This may be an iterative process, depending on the results of the scenario testing and whether the model outputs are used to inform any design or operational changes. In addition to modeling peak period conditions, scenario modeling includes the Service Disruption scenarios outlined in Table 7.

i) **Step 9 – Model Outputs and Analysis:** The generation of model outputs and the analysis of results shall be carried out in response to the objectives of the study and must demonstrate whether the performance of the station meets the planning standards. The outputs and analysis must also provide additional information and understanding of the performance of the station or areas with respect to passenger circulation and crowding. The outputs required also depend on whether a business case is needed or not. Refer to Appendix E for more information.

j) **Step 10 – Reporting:** The results of the analyses shall be documented in a report. Commentary on the functionality of the station under peak travel and service disruption scenarios shall be provided including the role that entrances, corridors, platforms, and vertical circulation elements (i.e. stairways, escalators, elevators) will provide for modeled scenarios. The report shall clearly identify if the proposed design is compliant or non-complaint with the pedestrian flow design standards. If station elements are deemed non-complaint to the standard, the magnitude of non-compliance shall be specified in the report. If applicable, if non-compliance is identified, design modifications and/or measures to achieve compliance or mitigate risks.

Where applicable, the reporting must provide professional judgment as to the implications and potential sensitivity of design or operational changes, with the appropriate conclusions and recommendations.

For stations with a height difference of 6m or higher, a commentary as to the functionality of the station in peak and service disruption scenarios shall be added including the role of stairs, escalators and elevators will play in these scenarios.

6.6 CAPACITY ASSESSMENT SELECTION

Prior to conducting a pedestrian flow assessment, a terms of reference shall be submitted to Metrolinx for review; identifying the following key attributes of the study area:

a) Description of the station typology, study area, and purpose

b) Study area site plan with access points under consideration

c) Gross Floor Area (GFA) and the Gross Walkable Floor Area (GWFA) of the transit station

d) Existing and, if applicable, Future transit ridership demand by Peak Hour

Appendix C outlines the elements to research prior to undertaking a capacity assessment.

A static model assessment will always be required regardless of the study area; however, a dynamic assessment is generally conducted based on the criteria shown in the **Dynamic Modelling Needs Checklist.**

The Dynamic Modelling Needs Checklist identifies the analysis conditions that warrant a dynamic assessment based on station typology, access arrangements, passenger demands, or operational scenarios. **The Dynamic Modelling Needs Checklist shall be used to determine if a dynamic model assessment is warranted.**

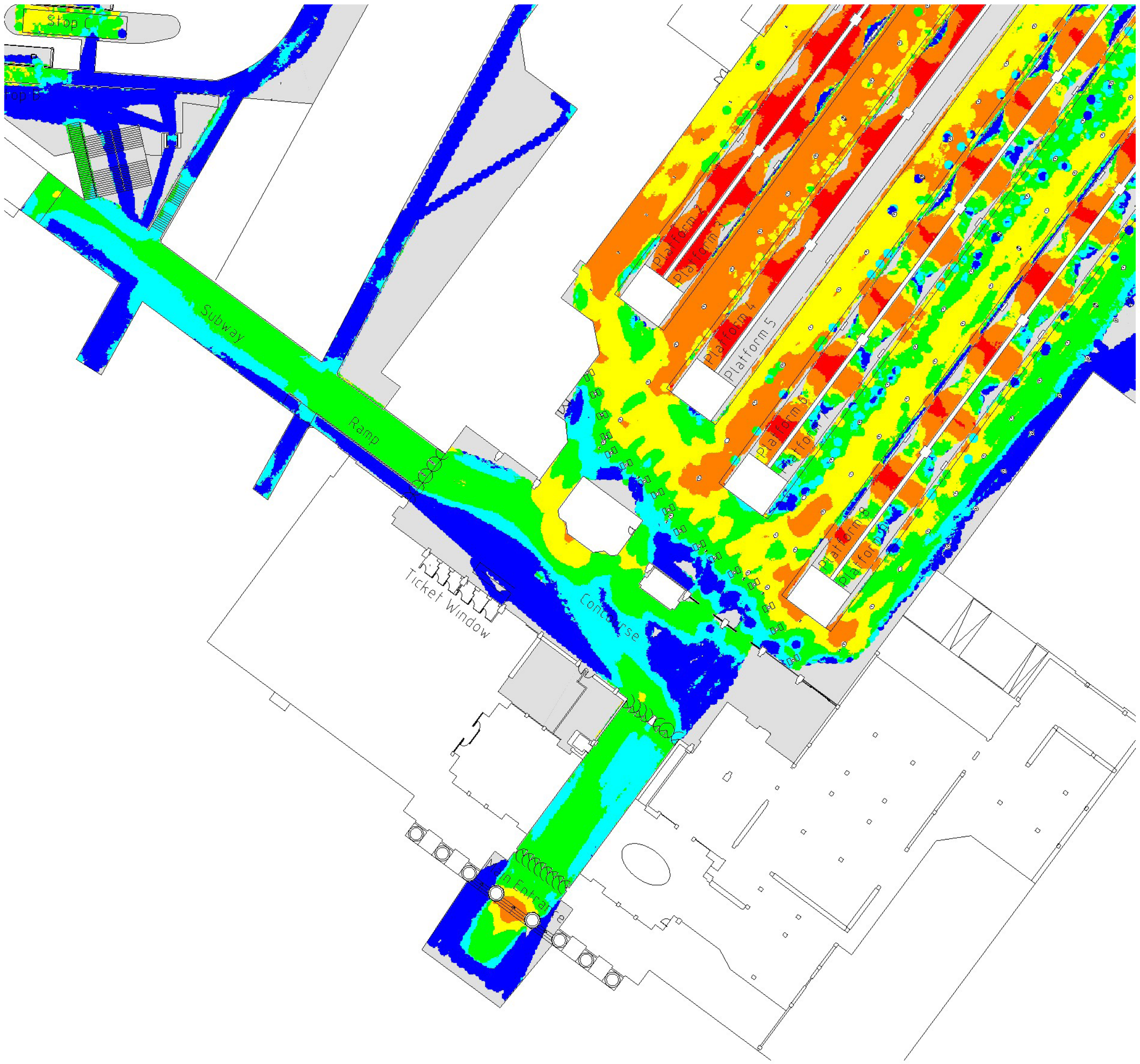


Figure 11: Dynamic Modelling Output Example (LEGION Software Package)

6.7 MODEL VALIDATION, AUDITING, AND PEER REVIEW

When validating the dynamic model, the following items can be checked against site observations/video evidence to confirm the model accurately reflects reality.

a) Fare gates queuing

b) Route choice and travel time where multiple routes exist

c) Locations of queuing and their associated behaviour (bus stops, platforms, or elevator lobby)

When auditing a model or carrying out a peer review, the following information must be checked within the model output file:

d) Follow the flow of entities through the model and confirm that the behaviour looks correct. Examples of including verifying that passenger movements seem natural and are not back tracking, and ensuring that model entities are not stuck in the model (i.e. - congregation of entities at model corners).

e) Do queuing and waiting areas reflect likely or observed behaviour?

f) Do route choices and assumptions match the model assumptions?

g) Is the model output Origin-Destination matrix similar to the input Origin-Destination matrix?

Dynamic Modelling Needs Checklist

A dynamic pedestrian flow model is required if any of these conditions apply:

- ✓ New stations
- ✓ Subway stations
- ✓ Where a dynamic model has been previously developed
- ✓ Stations with a single point of access
- ✓ Station with high transfer passenger volumes **≥ 1000 passengers / hour**
- ✓ Stations with peak hour ridership **≥ 2500 passengers / hour**
- ✓ Where the Static Analysis method indicates that two or more station elements (i.e. vertical circulation, platform, walkway, doorway elements) are projected to operate at **≥ 90% of Flow Rate and Density Service Standard Levels**
- ✓ Construction activities and stations where change in service, demands, or construction activities are expected to influence station performance
- ✓ Where Metrolinx determines that a dynamic analysis is warranted

h) Are the assumed proportion assignments for the use of stairways, elevators, and escalators appropriate to the station depth?

6.8 REPORTING

When reporting the outcomes of modelling, the sections and content identified in **Table 16**, below, needs to be documented. This will inform stakeholders and assist with any further modelling.

The report shall clearly identify if assessed station elements Meet or Do No Meet the required Level of Service standards. If station elements Do Not Meet the standards and are deemed non-complaint, the magnitude of non-compliance shall be specified in the report. If applicable, if non-compliance is identified, design modifications and/or measures to achieve compliance or mitigate risks must be identified.

This general reporting outline can be used for both static and dynamic modelling studies. The distinction is that under the results section details on the dynamic model development and results would be documented under Other Modelling Results, if required. It is expected that dynamic modelling inputs and assumptions would be included under the inputs and assumptions sections, respectively.

Pedestrian modeling reports, models and native files are to be submitted to Metrolinx with final Report submission.

APPENDICES

APPENDIX A: DATA COLLECTION CHECKLIST

The following datasets shall be sourced prior to commencing a passenger capacity assessment, if applicable:

a) Drawings of the existing and proposed station layout to a level of quality/accuracy that will enable accurate dimensions to be determined. Ideally these will be in CAD (.dwg, .dgn, .dxf) format as this will facilitate any future dynamic analysis that may be required. If CAD format files are not available, PDF format drawings may be acceptable for a static analysis. Dimensions must be verified by Metrolinx or through on-site measurements.

b) Base year train passenger demand data for all time periods to be assessed. The base year shall be agreed in advance with Metrolinx. Static analysis shall be undertaken for the busiest hours of station operation. Typically, stations will be assessed for AM and PM weekday peak periods as these tend to be the busiest periods of station operation. However, this shall be confirmed with Metrolinx prior to commencing the analysis. Demand data shall be provided in the form of boarding and alighting demand for all trains during

Report Section	Required Content
1.0 Introduction	Introduce the study area and the purpose of the modelling.
2.0 Methodology	This section will include sub sections outlining how the modelling was done.
2.1 Inputs	This section lists the inputs provided and sourced and documents any site visits that took place and outlines key observations.
2.2 Assumptions	This section lists any assumptions that are required to be made that cannot be quantified with any readily available data.
3.0 Results	This section summarizes all the results from the modelling.
3.1 Base Modelling Results	This section lists the base modelling results that the model is built upon. This section must highlight any areas of concern in each peak, if applicable.
3.2 Other Modelling Results (if Dynamic)	This section and subsequent sections detail the results and effects of changes to demand, operations or layout for each of the peak periods.
4.0 Conclusions/Recommendations	This section summarizes the key findings from the results and must clearly identify if assessed station elements Meet or Do Not Meet the standards. If non-compliance is identified, design modifications and/or measures to achieve compliance or mitigate risks must be identified.

Table 16: General Reporting Sections and Required Content

each peak hour to be assessed. This will include trains serving non-peak direction platforms.

c) Base year non-train passenger demand data for all time periods to be assessed. In some cases, stations serve to cater for people who are not traveling by train. There may be a bus interchange facility, or the station functions as a pedestrian route. This data will need to be assembled for the same time periods as the train passenger demand data and disaggregated into 15-minute time slices.

d) Train (and bus) service information. In addition to the demand data, a significant amount of information is required regarding the base year train (and bus) services at the station. This must include schedules, dwell times, rolling stock/vehicle types, door numbers and positions, and stopping positions. In addition to this, it may be a requirement to understand train/bus loading on arrival at the station as this is needed for certain types of analysis. For platforms with multiple service patterns, information on the destination of boarding passengers will also be required as some passengers may not board the first service.

e) Platform loading profiles. The distribution of people along the platform needs to be determined. In the absence of observed data, distribution data will need to be agreed with Metrolinx.

f) Station movement patterns and routes. A matrix of origin to destination movements within the station needs to be developed based on the demand information described above. Information shall be provided to enable this task to be completed. Although this information will vary on a station by station basis, complex stations will typically require information on the use of different entry and exit points, platform to platform interchange, use of alternative forms of vertical transportation (escalators, stairs and elevators) and the use of alternative circulation routes.

g) Information on other in-station activities. In addition to boarding and alighting trains, a range of other activities take place within a station. Again, this information will vary on a station by station basis, but will typically include retail activity, ticket sales, and revenue protection activities.

h) Future year information. In order to assess the performance of the station in future years, the above data will also have to be collated for the future year to be assessed. Where this data is not available, assumptions will need to be agreed in advance with Metrolinx. All input data must be recorded and, with the exception of the CAD data, collated into a single spreadsheet that will be used for the static analysis.

Observed data is collected from existing stations to fulfill this Data Collection Checklist:

- Where the station already exits, surveys should be undertaken at the station to understand the passenger demand and patterns of passenger movements (both temporal and geographic).
- For new stations representative data should be obtained

from either existing adjacent stations, or a station on the network deemed to have similar characteristics.

- As deep underground stations are relatively new to the Greater Toronto and Hamilton Area, data may be referenced from international precedents with similar station designs, service delivery, and customer experience expectations.

In the absence of observed data Appendix B provides default generic factors which can be used to calculate peak periods.

APPENDIX B:
DEMAND CONCEPTS

a) **Peak Period** – Typically the AM and PM commuter periods, the peak periods represent the busiest three hour periods of station operation throughout the day. Where available, these periods will be derived from observed data, making allowance for seasonality and weekly variability. In some cases (for example, for stations in the vicinity of stadia or other special event venues), the peak period of activity will occur outside of the commuter peaks. These will be identified and agreed in advance with Metrolinx prior to any analysis being undertaken.

b) **Peak Hour** – The busiest hour within the peak period. This typically becomes the focus of the analysis. Observed data shall be used to derive the peak hour. Where observed data is not available, the following factors should be used (Source: London Underground S1371):

1. AM Peak Hour = 45% of AM Peak Period
2. PM Peak Hour = 41% of PM Peak Period

c) **Peak 15-Minutes** – The busiest fifteen-minute period within the peak hour. The peak 15-minute period is typically used for reporting purposes, particularly where dynamic modelling is undertaken. Outputs showing mean density typically reflect the peak fifteen-minute period. Where observed 15-minute data is not available, the peak 15-minute period can be derived by dividing the peak hour by four.

d) **Peak Minute** – The busiest minute within the peak fifteen minutes and typically coinciding with train arrival or departure events. This is used in many of the capacity calculations to determine infrastructure sizing requirements. In the absence of observed data, a factor of 11% of the peak 15 minutes may be used to derive the peak minute to reflect a peak time "surge factor" (source: London Underground S1371)

e) **Peak Train** – The busiest train for boarding and alighting activity during the peak period. The number of people boarding and alighting the peak train is used to determine platform requirements. In the absence of observed peak train boarding and alighting data, the peak train load can be estimated by multiplying the peak minute by the peak headway

f) **Egress Load** – The total demand to be evacuated from a station during an evacuation event. This will be calculated using the OBC and NFPA130 and typically includes everyone within the station at the time of the evacuation along with everyone on the train to be evacuated. The egress load is significantly larger than the normal station load as it incorporates a missed headway. In most cases, this will result in the evacuation of a crush loaded train as well as double the normal station occupancy.

APPENDIX C: PRE-ANALYSIS RESEARCH CHECKLIST

Prior to undertaking a passenger flow analysis a desk top assessment of design drawings and other relevant documentation must be undertaken. Through this the analyst will gain an understanding of the study area. Some points for consideration when researching the station:

a) Has any previous work been undertaken? Is it possible to obtain previous reports, studies and surveys or even models? Previous studies must be acknowledged in the static analysis report.

b) From drawings, study the layout of the station; number of platforms, entrances, staircases and elevators, waiting areas, emergency exit locations. A simple diagrammatic representation of the station must be developed and included (either within the analysis spreadsheet or using a specialist design package) showing key station elements to be assessed.

c) Understand the current station and its problems (possibly by talking to station management and site observations) and anticipate what passenger flow issues there might be in future; identify likely routes pedestrians will take between origins and destinations, existing and potential conflicts. The diagrammatic representation of the station must be augmented to show key pedestrian flow paths and dwelling areas.

d) Understand train services; how many trains operate during the peak periods, where people wait to board the services (and whether this changes according to the service, or the weather conditions), the distribution of alighting demand along the train (the percentage of people who alight from each train car), and the proportions of people who board each service type.

APPENDIX D: PEDESTRIAN FLOW ANALYSIS STEPS

a) **Step 1 - Define the Station Area:** The model extents need to be defined. This will need to include information on existing and future train (and bus) service information, schedules, dwell times, rolling stock/vehicle types, door numbers and positions, and stopping positions. For platforms with multiple service patterns, information on the destination of boarding passengers will also be required as some passengers may not board the first service. Before undertaking capacity assessment, it is important to agree with Metrolinx in advance which station elements are to be assessed. This should reflect the depth of station. Therefore step one will also include sourcing information on different components of the station and their associated GFA, fare gate/fare control/ fare vending locations, non travel related activities (retail, food and beverage, washrooms).

b) **Step 2 – Quantify Passenger Demand:** Base year and, if applicable, future station passenger demand data for the busiest hours of station operation shall be summarized. The selection of a future horizon year shall be done through consultation with Metrolinx and must include at least the build-out year and an additional five (5)-year horizon. Typically, stations will be assessed for AM and PM weekday peak periods as these tend to be the busiest periods of station operation, however stations in proximity to major recreational or special event centres may require a weekend peak period assessment. However, this shall be confirmed with Metrolinx prior to commencing the analysis. Demand data shall be provided in the form of boarding and alighting demand for all transit platforms during each peak hour to be assessed. Where this data is not available, assumptions will need to be agreed upon in advance with Metrolinx.

c) **Step 3 – Quantify Passenger Flows:** Existing, and if applicable, future station movement patterns and routes shall be summarized for the agreed upon peak periods to be assessed. A matrix of origin to destination movements within the station shall be developed based on the passenger demand quantified in Step 2 and visualized in diagram format to show pedestrian volumes by study period and study horizon year. These volumes will be used to assess capacity of key station elements.

d) **Step 4 – Capacity Assessment:** A capacity assessment shall be conducted for each study period and horizon year. The results shall be summarized in tabular format and any elements exceeding the agreed planning criteria shall be identified with appropriate mitigation measures developed and tested in consultation with Metrolinx. Where capacity constraints cannot be alleviated, a dynamic model shall be considered at the discretion of Metrolinx.

e) **Step 5 – Evacuation Assessment**; where appropriate an assessment of evacuation capacity shall be undertaken for two scenarios: Train on Fire and Station on Fire.

f) **Step 6 – Service Disruption**: An assessment of service distribution scenarios must be carried out in accordance with Table 7.

g) **Step 7 – Reporting:** Result documentation shall include the methodology followed, all assumptions made in the process of carrying out the analysis, calculations, and results. Locations of assessment areas shall be clearly marked on an illustration of the study area. The spreadsheet used to carry out the analysis must be submitted and be labeled to be self-explanatory. Any analysis must be verified, and outputs reviewed by the consultants carrying out the assessment (internal review).

APPENDIX E: DYNAMIC MODELLING

In addition to the data inputs shown in **Appendix A**, the following represents a list of requirements for a dynamic pedestrian model:

a) In addition to the station CAD file, a CAD representation of any vehicles (trains or buses) to be modelled as these facilitate an improved representation of passenger arrivals onto a platform.

b) Station demand for the peak period to be modelled in origin-destination format.

c) Demand profiles for the period to be modelled to show the rate of arrivals at each entry point. A profile can be specified to any level of disaggregation depending on data availability. Best practice dictates that:

   1. Street entrance arrival profiles be disaggregated into 5 minute time increments

   2. Train/Bus arrival profiles be based on operating schedules such that alighting demand is placed in the model at the point at which the service arrives at the station

d) According to the *Fundamental diagram of pedestrian flow including wheelchair users in straight corridors*, published in the *Journal of Statistical Mechanics: Theory and Experiment*, 2021, persons without disabilities have demonstrated an "unimpeded speed and relaxation time that is 38.9% higher and 24.5% shorter than those of persons using wheelchairs, respectively. The presence of wheelchair users makes the pedestrian flow have a smaller density range (0.59–4.17 m−2) and flow rate (1.49 ± 0.21 (m s)−1). The critical headway and safe response time (reciprocal of the proportionality constant of the headway–speed relation) are 11.76% and 20.93% longer, respectively."

e) Coding assumptions that allow elements within the station to operate in accordance with this standard. Using a well established and industry validated pedestrian modelling tool provides confidence that station areas such as passageways, stairway and platforms will be represented accurately, however capacity assumptions will have to be made for the following elements based on site specific parameters:

   1. Elevators (e.g. - travel time based on vertical distance traveled, size of elevator, etc).

   2. Escalators (e.g. - width, speed, and vertical distance traveled)

   3. Ticket Gates (number and throughput capacity)

f) Typically outputs will consist of:

Density/Level of Service plots (mean density over the peak 15 minutes, maximum density, length of time for which a particular density threshold is exceeded – time in excess of a given LOS, for example)

1. Flow rates for key station elements
2. Travel times between key origins and destinations within the station
3. Platform clearance times
4. Station egress times

g) Typical validation checks may consist of:

1. Site visual inspection of operations for existing stations.
2. Travel times. This will help to demonstrate whether the model is accurately reflecting passenger journeys through the station and may require a journey time survey to be undertaken, if applicable (only for existing stations).
3. Flow rates. This will help to demonstrate that the model is accurately representing route choice within the station and will require some internal counts to be collected. This type of validation is often undertaken at fare gates of at changes of level.
4. Matrix assessment. Dynamic modelling tools allow the input matrix to be compared against the output matrix (the number of people who move between each origin and each destination within the simulation). This will help understand whether the demand is being assigned correctly and that passengers are completing their journeys within the model.

LIST OF FIGURES AND TABLES