7. PLANNING AND DESIGN PARAMETERS

7.1 RAPID TRANSIT DESIGN OBJECTIVES

Rapid transit services and infrastructure in the Highway 7 Corridor and Vaughan North-South Link Transitway will be designed to provide the essential features for its role as an important new member of the family of transit services available to the Region's communities, as defined in the Transportation Master Plan. This family is intended to comprise:

- Local services through neighbourhoods and business districts using conventional buses of various sizes;
- Rapid Transit service operating on a regional network fed by local services and inter-connected with commuter services and rapid transit in Toronto and adjacent regions; and
- Long distance inter-regional commuter service provided by GO Transit buses and trains.

The primary objectives in designing the rapid transit infrastructure and service are to achieve the following:

- A flexible, permanently integrated high-performance system with a strong customer-oriented identity;
- An integrated assembly of elements appropriate to urban environment for current and future market(s) to be served;
- High service speeds offering superior travel times competitive with those of the private automobile;
- Demonstrated service reliability providing high frequency (an average wait of 5 minutes) and a high degree of on-time performance;
- Comfort and convenience by providing a smooth ride, level boarding in a user-friendly, quality station environment, easy transfers between systems and innovative fare pre-payment and passenger information services; and
- Environmental compatibility manifested by reductions in energy use, pollution, noise and visual intrusion as well as environmentally sensitive urban design.

The key components of the ultimate Highway 7 Corridor and Vaughan North-South Link Transitway are as follows:

- An exclusive two-lane, at-grade transitway that uses the centre median of the existing Highway 7 and other routing streets rights-of-way to enable operation of surface rapid transit services (BRT or LRT) with no loss of current traffic capacity;
- High-frequency BRT service of 3-minute headway or less during peak travel periods;
- Transit signal priority to speed the movement of transit vehicles through busy intersections and limited stops (approximately 1-kilometre station spacing) to improve overall travel times;
- Attractive rapid transit stations, designed and landscaped for integration with the surrounding communities (the Transitway alignment includes high-density commercial and residential nodes, and a commercial heritage district);
- Access facilities at stations to encourage and support pedestrian and bicycle modes of transportation;
- Proof-of-payment fare policy and systems to speed passenger boarding and facilitate "smart card" technology;
- "Real-time" passenger information displays at stations and on-board vehicles;
- Intelligent Transportation Systems (ITS) technology to track vehicles and interface with transit priority measures for reliable service;
- Integrated communications to increase public awareness and overall ridership with a corresponding decrease in automobile use; and
- In the case of the Vaughan North-South Link, an extension of the Toronto Spadina Subway line from Steeles Avenue to Highway 7 in the VCC.

7.2 DESIGN CRITERIA

In the York Region network, surface rapid transit facilities will initially use BRT technology and convert to LRT technology at such time when BRT service reliability can no longer be assured or the use of LRT will result in operating cost benefits or attract greater transit oriented development.

This section outlines the basic criteria adopted for the planning and design of the main components of the facilities for each technology.

Transitway alignment geometry will influence the system riding quality, especially for standing passengers. The design aims to provide alignments which reduce sags, crests and directional changes to a minimum, consistent with reasonable economy. In developing the rapid transit alignment, consideration must be given to the following:

- Safety;
- Alignment standards;
- Sight distance and visibility;
- General appearance;
- Passenger comfort;
- Impact on at-grade Crossings;
- Intended operating and service plan;
- Adjacent roadways and railways;
- Vehicle performance;
- Impact on adjacent property;
- Underground and overhead utilities;
- Cost-effectiveness;
- Horizontal and vertical clearances;
- Type of construction; and
- Future LRT Horizontal and Vertical Alignment standards and clearances.

7.2.1 Bus Rapid Transit (BRT)

The BRT system is one in which predominantly exclusive rights-of-way with on-line stations are provided for the use of the rubber-tired vehicles delivering the service. These rapid transit vehicles can operate on and off the rapid transit right-of-way and therefore offer the opportunity to link certain feeder and line haul express services to reduce the need for passengers to transfer. In the early stages of system development, BRT services may be provided by buses operating in exclusive bus or HOV lanes in streets or even in mixed traffic.

Wherever practical, BRT station design will allow vehicles to pass other vehicles that are picking up and dropping off passengers. This means that skip stop and express services can be combined with local stopping services in the same ROW. The typical BRT operating configuration consists of a high frequency service running the full length of the corridor and stopping at each station. It provides a service not unlike that of LRT except the vehicle used is rubber tired (usually articulated for greater capacity). On top of this service various express services can be overlain and, where appropriate, services can be started or terminated off of the transitway.

Passengers access the service as they would to an LRT service by walking or cycling to the stations, transferring from feeder buses and by using park-and-ride and pick-up/drop-off facilities where provided. In addition, some trips could be made without a transfer.

BRT Design Criteria

Table 7.2-1 summarizes the principal BRT running way design criteria adopted for the development of alternative designs for transitway facilities. These criteria have been developed with possible future conversion to LRT in mind.

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Table 7.2-1
Summary of BRT Geometric Design Criteria

CRITERIA		Preferred	Absolute
Design Speed – Transitway between stations (Generally follows the existing local traffic speeds)		90 km/h	40 km/h
Design Speed – Station and Business Dist. Areas		-	50 km/h
Design Speed - Arterial Ramps and Access Roads		-	40 km/h
Stopping Sight Distance:	90 km/h design speed 60 km/h design speed	- -	236 m 84 m
Minimum Horizontal Curve Radius, Transitway		200 m	50 m
Minimum Horizontal Curve Radius, Stations and CBD		120 m	50 m
Minimum Horizontal Curve Radius, Access Ramps		-	45 m
Minimum Turning Radii at Intersections		25 m	15 m
Maximum Transitway Superelevation (above 50 km/h)		-	7%
Maximum Superelevation at Stations		-	- 2% (fall to centre)
Minimum Tangent at end of Station Platforms		20 m	14 m
Maximum Grade of Transitway		3%	7%
Minimum Transitway Grade between Stations		0.5%	0.35%
Maximum Grade in Stations		0.5%	4%
Transitway Grade: Access Roads and Ramps		6%	10%
Minimum Grade in Stations		0.5%	0.3%
Minimum Crest Curves: (Passenger Comfort)	90 km/h design speed 60 km/h design speed	K=65 K=17	- -
Minimum Sag Curves: (Passenger Comfort)	90 km/h design speed 60 km/h design speed	K=59 K=17	- -
Transitway Lane Width		3.50 m	3.40 m
Streetscape Median		4.00 m	-
Raised Median		1.00 m	-
Rumble Strip		-	0.3 m

Note: CBD – Central Business District
K – Parabolic Vertical Curve Parameter

7.2.2 Light Rail Transit (LRT)

Light rail transit is a flexible, rail-based transit mode that can operate in a variety of urban ROW settings. Depending on the degree of segregation of the right-of-way, it is a relatively low cost form of rail technology and is usually electrically propelled, obtaining power from overhead catenary wires.

LRT can provide a broad range of passenger capacities due to its ability to use coupled vehicles. It can operate in exclusive or semi-exclusive lanes or in mixed traffic on tracks embedded in the street.

The overhead power supply feature allows LRT systems to interface safely with other at-grade transportation modes and with pedestrians.

The electrically powered vehicles are virtually pollution free (a major benefit for a region with air quality concerns) although the primary power generating source may produce some pollution. Vehicles are generally bi-directional, low-floor and articulated with multiple doors on both sides. LRT has the ability to be placed into built-up urban areas and is designed to operate harmoniously with vehicular and pedestrian traffic. It is possible for light rail vehicles to share a transitway with buses operating in a BRT service as the vehicle dynamic envelope is similar to a BRT lane width. Also, LRT vehicles can be operated on existing railway tracks assuming compatible facilities and temporal separation of service from freight operations.

LRT Design Criteria

Table 7.2-2 provides a summary of the LRT geometric design criteria.

Table 7.2-2
Summary of LRT Geometric Design Criteria

CRITERIA		Preferred	Absolute
Maximum In-service Speed (Generally follows the existing local traffic speeds)		100 km/h	-
Minimum Horizontal Curves Radius:	On Running Line In Stations In Yards	250 m Tangent 50 m	100 m 800 m 35 m
Minimum Length of horizontal curves		Design Speed / 2	35 m
Minimum length of spiral curves, the greater of the following: - considering roll rate; or - considering vehicle torsion; or - considering lateral acceleration		 $8.75E_a \times V$ $400E_a$ $6.45E_a \times V$	 14 m 14 m 14 m
Minimum Length of tangent between spiral curves		100 m	25 m
Minimum Length of tangent track preceding a point of switch		15 m	10 m
Minimum Length of tangent beyond the ends of platforms		20 m	15 m
Maximum Gradient:	On running line In Stations	4.5% 0.3%	6.0% 0.5%
Minimum Grade on running lane		0.3%	0.0%
Minimum Length of vertical curves		100 m	60 m
Maximum Length of vertical curves		-	200 m
Minimum Length of constant grade between vertical curves		100 m	80 m
Maximum applied superelevation on running track		110 mm	130 mm
Maximum Unbalanced E_u:	On running line In turnouts	75 mm	100 mm 90 mm
Transitway Lane Width		3.50 m	3.40 m
Streetscape Median		4.00 m	-
Raised Median		1.00 m	-
Rumble Strip		-	0.3 m

Note: E_a – LRT superelevation
E_u – Unbalanced superelevation

7.2.3 Subway

Subway Design Criteria

The fundamental design criteria (related to both track and station requirements) employed in the development of each alternative were established based on the Toronto Transit Commission's Design Manual. A summary of these design criteria is presented in **Table 7.2-3**.

Table 7.2-3
Summary of Subway Geometric Design Criteria

Horizontal Criteria		
absolute minimum horizontal curve radius (used only with TTC approval in special circumstances)		300 m
desired minimum horizontal curve radius		600 m
minimum length of tangent section		150 m
minimum length of circular curve		23 m
minimum length of constant profile grade		150 m
Station ROW	centre platform	26 m x 150 m long
	side platform	26 m x 150 m long
tangent section ROW		26 m
tail track ROW	centre platform station	26 m x 257 m long
crossover track ROW		26 m x 172 m long[3]
Vertical Criteria		
maximum gradient of main-line track		± 3.5%
minimum gradient of main-line track (for drainage purposes)		± 0.3%
gradient through stations		± 0.3%
tunnel diameter	inside	5.2 m
	outside	5.65 m
minimum depth of cover	top of box structure to grade	3.0 m
	top of station structure to grade	3.0 m
	top of tunnel to grade	1.5-2 tunnel diameter
	top of tunnel to grade	~ 8 m

To facilitate fast and efficient operation of the subway train, the largest horizontal radii and flattest grades feasible should be employed. However, given physical constraints and/or property restrictions, these were often not feasible and/or optimal. As suggested by TTC staff, the twin box configuration and centre platform stations were assumed to provide maximum flexibility in the construction methodology (i.e. these represent the greatest requirements).

Standard subway stations were located on a tangent section (i.e. straight section) with a grade of 0.3% to facilitate drainage and ease of mobility for passengers on the platform. Typical stations were assumed to have a platform length of 150 metres; beyond this, the station right-of-way (26 metres) was extended a further 25 metres at either end to accommodate service rooms, ventilation equipment, etc. To maximize the catchment areas and integration with street bus services, subway stations were typically located in close proximity to major intersections.

At terminal stations, including interim terminal stations (i.e. stations that will act as terminal stations during the phased construction of the line) provisions for necessary tail track and crossover track were assumed to be required. Both of these were located on tangent sections with a constant grade. The "worst case" scenario has been assumed for the following requirements as some basic information has not been available. A 172 metre crossover track, located prior to the station, was assumed with a maximum grade of ±3.5% (although it is preferred to use ±0.3% to match that of the station). The tail track, located beyond the station, for the storage of disable trains whilst ensuring the continued operations of the station and both tracks required a length of 257 metres based on the following:

- 90 metres for overshoot protection beyond the end of the station;
- 150 metres for storage (6 car train); and
- 17 metres for bumping post and stopping distance.

7.2.4 Roadway

The insertion of the exclusive transitway ROW in the median of Highway 7 and other routing streets requires widening of these streets in order to maintain the existing number of traffic lanes and to meet the traffic demands. In addition, a section of Highway 7 in Markham requires widening from existing four lanes to future six lanes during the interim stage of transit implementation. To ensure the safety and driver's comfort, the design criteria of these streets is generally conformed to the Geometric Design Standards for Ontario Highways (MTO, 1994) and with reference to Geometric Design Guide for Canadian Roads (TAC, 1999) and respective municipality design guidelines currently in use.

Roadway Design Criteria

Table 7.2-4 provides a summary of the roadway geometric design criteria.

Table 7.2-4
Summary of Roadway Geometric Design Criteria

Table 7.2-4
Summary of Roadway Geometric Design Criteria

CRITERIA		Preferred	Absolute
Design Speeds (Retains existing traffic speeds)		-	50 - 90 km/h
Minimum Stopping Sight Distance:	50 km/h	-	65 m
	60 km/h	-	85 m
	70 km/h	-	110 m
	80 km/h	-	135 m
	90 km/h	-	160 m
Minimum Horizontal Curves Radius/ Spiral (A):	50 km/h	-	90 m/ 79
	60 km/h	-	130 m/ 99
	70 km/h	-	200 m/ 125
	80 km/h	-	250 m/ 149
	90 km/h	-	340 m/ 180
Maximum Deflection Angle without Curve		-	$0^{o}30'$
Superelevation		6%	-
Maximum Grade		6%	12.0%
Minimum Crest Vertical Curves (K):	50 km/h	8	-
	60 km/h	15	-
	70 km/h	25	-
	80 km/h	35	-
	90 km/h	50	-
Minimum Sag Vertical Curves (K):	50 km/h	12	-
	60 km/h	18	-
	70 km/h	25	-
	80 km/h	30	-
	90 km/h	40	-
Lane Width		3.50 m	3.40 m
Curb Lane Width		3.75m	-
Left Turn Deceleration Parallel Lane/ Taper Length:	50 km/h	20 m/ 85 m	-
	60 km/h	30 m/ 100 m	-
	70 km/h	40 m/ 115 m	-
	80 km/h	50 m/ 130 m	-
	90 km/h	60 m/ 145 m	-
Right Turn Deceleration Parallel Lane/ Taper Length:	50 km/h	20 m/ 40 m	-
	60 km/h	30 m/ 50 m	-
	70 km/h	45 m/ 60 m	-
	80 km/h	60 m/ 70 m	-
	90 km/h	70 m/ 75 m	-
Minimum Turning Radii at Intersections		18 m	15 m
Intersection Angle		-	< 70^{o} (> 110^{o})

Reference: Geometric Design Standards for Ontario Highways (MTO, 1994)
Geometric Design Guide for Canadian Roads (TAC, 1999)
Note: A – Spiral Parameter

7.3 SURFACE STATION DESIGN FEATURES

The stations are normally unattended and their design will stress passenger safety, convenience, comfort, low maintenance and accessibility. The station location and layout will facilitate convenient transfer between the Rapid Transit service and local service and also to any pick-up/drop-off facility, where provided. Stations will be fully accessible to persons with disabilities and configured to allow convenient access by pedestrians and cyclists. Pedestrians from local services or travelling by foot, as well as cyclists will access the station platforms at the signalized intersections where all the stations are conveniently located. Space for bike lockers will be identified adjacent to sidewalks near most stations.

Stations are normally spaced such that the majority of walk-in passengers walk less than 400 m to and from the station; however, some passengers can be expected to walk up to 600 m. This provision results in station spacing between 0.8 and 1.5 km.

The preferred station layout consists of two parallel side-loading platforms preferably offset head-to-head on either side of an intersection or mid-block pedestrian crossing as illustrated in **Figure 7.3-1**. Through major stations with high passenger volumes, the transitway is widened to four lanes with a central fenced median to allow buses to bypass and pull out around stopped buses. Where hourly one-way bus volumes are less than the maximum capacity, a reduced space station configuration is recommended as illustrated.

Passenger shelters, benches, system maps, real-time passenger information and other amenities are provided on each platform. All designs emphasize durability and minimal ongoing maintenance needs.

7.4 FARE COLLECTION

The facilities provided at the stations will be those required for a fare system based on the off-board purchase of passes and tickets. Provision for pass and ticket dispensing machines and sufficient space for totally off-board fare collection in a protected environment wherever practical is a requirement of the station design.

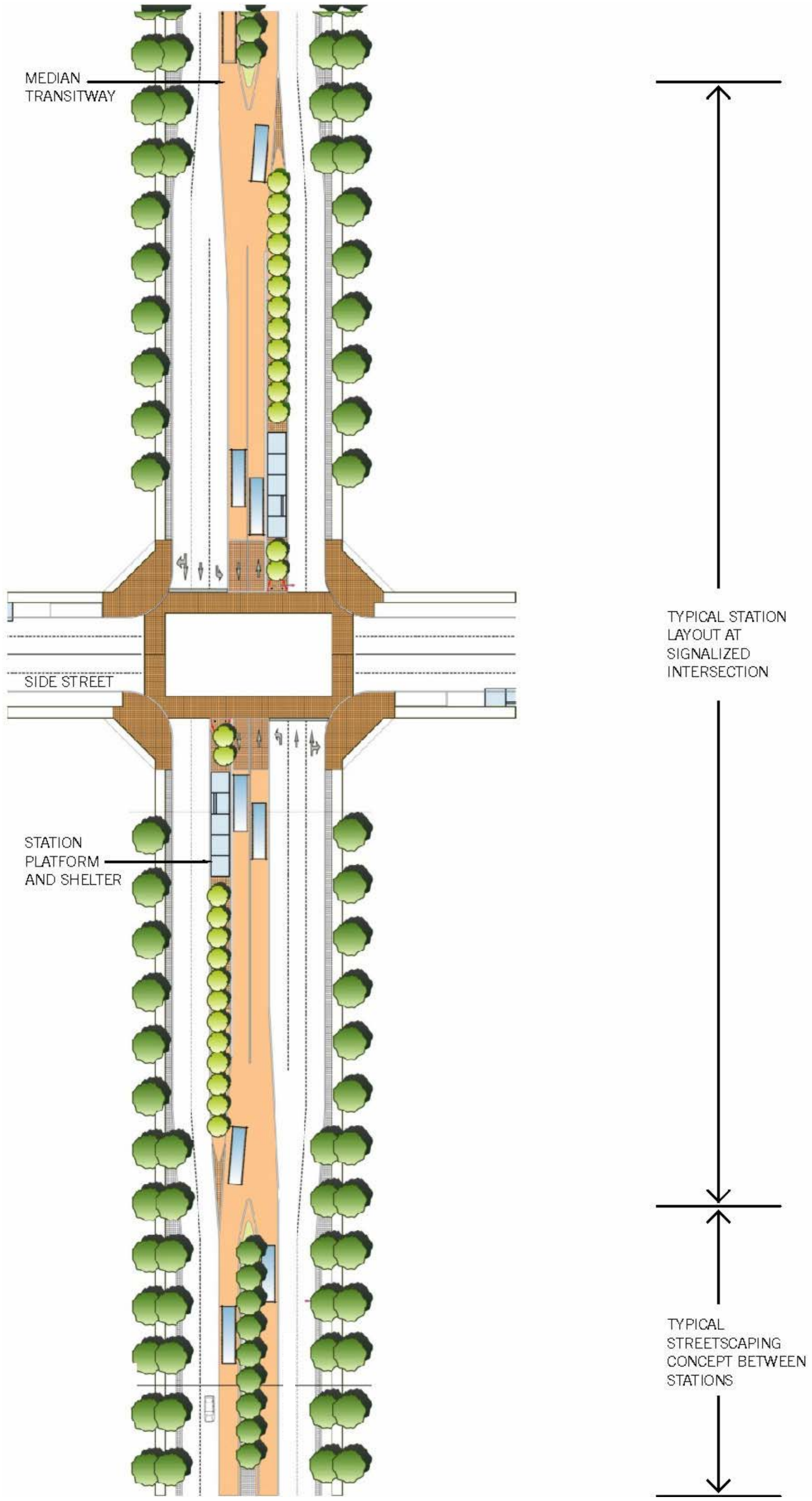

Figure 7.3-1
Typical Station Layout at street intersection

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