GTHA 2016 EMME Network Coding Standard

FINAL

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1 INTRODUCTION

This report documents the 2016 EMME Network Coding Standard (NCS16) for the Greater Toronto-Hamilton Area (GTHA) as developed by the Travel Modelling Group (TMG) and its partners.[1] This is an update of the 2011 coding standard (NCS11), which has been the basis for all EMME-based network modelling undertaken by TMG to date. The intent is that NCS16 will be the standard for all network development work moving forward by all participating agencies. The importance of a common network coding standard for regional travel demand modelling cannot be overstated. Without a common coding standard networks cannot be transferred or compared from one agency to another and common network modelling procedures (assignment modules, etc.) cannot be developed.

In developing this coding standard update, several criteria were considered:

- Maintaining wherever possible consistency with previous standards/conventions so as to minimize the need to recode legacy networks to the new standard. Limits obviously exist in terms of enforcing this criterion, since a number of extensions of / changes to NCS11 and other legacy standards are required to properly support current regional modelling efforts and practice.
- The standard should be complete in that it addresses all elements of network coding.
- The standard should provide flexibility to meet individual agency needs, providing that this flexibility does not compromise the basic commonality of regional networks for travel demand modelling purposes.
- The standard should avoid assumptions that reflect model design (e.g., how to account for truck movements and their effect on lane capacities) rather than network “base data”.

Sections 3, 4 and 5 of this report deal with each of the three primary network building blocks: nodes, links and transit lines, respectively. Prior to discussion of these components, Section 2 defines the units of measurement used within the standard.

2 UNITS OF MEASUREMENT

2.1 UNITS

Metric units are used throughout NCS16. Table 2.1 defines the standard units of measurement used.

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[1] TMG partners involved in developing this coding standard are: Metrolinx, Ontario Ministry of Transportation, the Cities of Toronto, Hamilton and Mississauga, and the Regional Municipalities of Halton, Peel, York and Durham.

Table 2.1 Units of Measurement

Measure	Unit
x,y coordinates	metres
Length	kilometres
Time	minutes
Speed	km/hr
Cost/fare	$
Energy	MJ

2.2 Coordinate System & Projection

The coordinate system used is the Universal Transverse Mercator (UTM) 6 Degree System. The origin point of the reference grid is 4,000 km north of the equator and 500 km west of longitude 81 degrees west. The vertical axis is parallel to the true north at longitude 81 degrees west. All units are in metres.

To maintain historical consistency, a fixed projection datum for the spatial reference database should be used. Since 2001 networks have been encoded using the NAD 83 projection, this continues to be the standard in NCS16. Previous years' EMME networks hosted by the DMG prior to TMG taking over base network development in 2011, however, were developed in the NAD 27 projection. Spatial references historically used are provided in Table 2.2.

All network X-Y coordinates should use the full set of UTM digits to facilitate interchanging EMME and GIS files.

Table 2.2 Spatial References for Selected GTHA Databases

Application	Datum
TTS 1986 and 1991	NAD 27
TTS 1996	NAD 27
TTS 2001	NAD 83
TTS 2006	NAD 83
TTS 2011	NAD 83
TTS 2016	NAD 83
Pre-2001 EMME/2 Networks	NAD 27
2001 EMME/2 Network	NAD 83
1991 GTA Traffic Zone Boundaries	NAD 27
1996 GTA Traffic Zone Boundaries	NAD 27 and NAD 83
2001 GTA Traffic Zone Boundaries	NAD 83
2006 GTA Traffic Zone Boundaries	NAD 83

3 NODES

Four major classes of nodes exist in any regional network model:

- Zone centroids for traffic zones that are internal to the region being modelled (*internal zones*).
- Centroids for *external zones* and/or *gateways* representing the interconnections between the region being modelled (e.g., the GTHA or the GGH) and the areas surrounding the region. These external centroids are required so that trips between these external areas and the internal study region can be modelled, usually using more simplified methods than used to model internal travel within the study region.
- *Station centroids*, which represent exclusive right-of-way (EROW) stations (for rail, BRT or any other EROW transit service) as destinations/origins for access/egress trips to/from these stations by non-EROW modes (auto access to rail; transit/walk access/egress to/from rail; etc.). These station centroids are required so that EMME can assign access/egress trips to/from these stations and are essential for all stations that have park-n-ride facilities. This station centroid concept can be extended to include stand-alone park & ride lots, etc. that define other types of transfer points (e.g., from SOV to HOV travel) for each a "trip link" may need to be explicitly assigned in the network.
- *Regular road and transit nodes*, which are the basic building blocks of the road and transit networks since they define the end points of the links within these networks.

In order to do certain forms of transit assignment a hypernetwork is sometimes generated (TMG, 2015). The hypernetwork consists of regular and transit nodes, but is labelled separately (Table 3.3). The labelling generally occurs automatically during hypernetwork generation.[2]

Sections 3.1 and 3.2 define centroid and regular node numbering conventions, respectively. Section 3.3 discusses node attributes.

3.1 CENTROID NUMBERS

Zone systems are increasingly difficult to standardize due to the desire of individual agencies to custom-design their zone system for their particular needs. Also given the flexibility of modelling software to accommodate a variety of (well-defined) zone systems, it is unclear that a standard zone system is essential for regional network modelling, providing that the following criteria are met:

- Clear, systematic, mutually exclusive ranges for centroid numbering are maintained for internal zones, external zones/gateways and station centroids, respectively. In addition, systematic, mutually exclusive numbering ranges must also be maintained for each regional municipality / county within the internal study area. These ranges should be clearly defined for each zone system used.
- The mapping of each zone system to standard regional aggregate zone systems is specified. At a minimum, these should include mappings to regional municipalities and TTS planning districts. To facilitate common modelling procedures, EMME zone

[2] See, for example, the TMG hypernetwork generation procedure used in GTAModel V4.0.

ensemble **gr** is reserved for regional municipalities and **gp** is reserved for planning districts. See DMG (2007), Exhibit 4, pages 8-10 for definitions of these two ensembles.
- All centroid numbers lie within the range 1-9,999 (i.e., 1-4 digits).

Thus, rather than pre-specifying a standard zone system, NCS16 specifies the criteria (listed above) that a valid NCS16 zone system must meet. This approach has the very strong advantage of permitting individual agencies to custom-tailor their zone systems to their individual needs. It does imply, however, the following requirements for modelling procedures in order to ensure their ability to handle user-customized zone systems:
- The software must be generic with respect to node numbering and ranges.
- Ideally, automated (or at least semi-automated) procedures exist for creating centroid connectors for custom zone systems so that networks can be converted from one zone system to another. TMG has developed an EMME module, CCGEN, for this purpose.

Also note that the lack of a universally adopted zone system may make exchange of data files challenging unless clear and unambiguous conversions from one zone system to another are available.

Three types of centroids are included in NCS16:
- "Regular" zone centroids. These, in turn, can be subdivided into zone centroids within the GTHA *per se* and centroids for "external" zones at the periphery of the GTHA that are included for modelling purposes.
- "Station" centroids representing (typically higher-order) transit stations/stops.
- "Parking lots", for carpool parking, and other major parking facilities not associated with transit park & ride stations. These are not typically used in current models, but allowance is made in NCS16 for their eventual use.

In all cases, centroids are necessary any time one wants to model trips to/from a point in the network, since only centroids (as opposed to "regular" network nodes) can be sources of and sinks for (producers/attractors, origin/destinations) of trips in EMME. In particular, this is the reason that station centroids are often included in the network: so that access/egress trips to/from transit stations can be explicitly modelled. At a minimum, station centroids will be required at all transit stations that have park & ride / kiss & ride facilities in any model in which auto access/egress station choice is being explicitly modelled.[3] More generally, if access/egress station mode choice is to be modelled then all stations will require station centroids.

For TMG base network development work, the zone numbering conventions adopted are detailed in Table 3.1.

[3] The primary alternative to this approach to modelling auto access to transit is to use auto auxiliary transit connectors from zone centroids directly to transit station nodes. This approach is rarely currently used in GTHA models and generally is not recommended.

Table 3.1 2016 TMG Base Network Zone Conventions

Region	Numbering Range[2]	
	Zone Centroids	Station Centroids
City of Toronto	0 - 1,000	8000-8499
Durham Region	1,001 - 2,000	8500-8749
York Region	2,001 - 3,000	8750-8999
Peel Region	3,001, - 4,000	9000-9249
Halton Region	4,001 - 5,000	9250-9499
City of Hamilton	5,001 - 6,000	9500-9749
External Zones	6,001 - 7,000	9750-9799
Car Pool Lots, Parking Lots, etc.[1]	9,800-9,999	

1. Can be used for any trip origin/destination location not covered by the other centroid categories.
2. Note that zone range 7001-7999 is not allocated to any particular use and so can be used if need be by an agency to deal with any special cases not covered by NCS16.

3.2 NODE NUMBERS

Similar to centroid numbering, the primary concern for non-centroid node numbering is that a clear, systematic numbering scheme is used that meets the following criteria:

- Exclusive right-of-way (EROW) transit lines (subway, GO Rail, LRT, BRT) are all coded with their own sets of nodes and links.
- High-occupancy vehicle (HOV) lanes similarly are all coded with their own sets of nodes and links.
- All other (i.e., non-EROW, non-HOV) nodes within a given regional municipality are grouped within a numbering range that is mutually exclusive from that used for other regional municipalities.
- Nodes that fall on the boundary between two municipalities need to be numbered in a consistent manner.

Unlike zone centroids, which inevitably will vary from one model system to another, however, network nodes should correspond to a standard numbering convention so as to facilitate the exchange and comparison of networks from one agency to another and to allow different model systems to readily operate on different networks. To this end, as the most comprehensive system currently available, the GGH Model system node numbering conventions form the basis of the NCS16 node numbering ranges. These are shown in Table 3.2. Note that "External Zones/Gateways" refer to network nodes within zones external to the TTS (GGH) study area. If flow is to be generated to/from these zones/gateways then external zone centroids need to be coded (see Table 3.1).

3.3 NODE ATTRIBUTES

No node user fields (**ui1**, **ui2**, **ui3**) are specified in NCS16. The user is free to use these fields as required. Two node extra attributes are included in NCS16:

- **@pkcap**: The parking capacity for the zone or station. This is generally only useful for park & ride stations. It should include both free and paid parking spaces in formal parking lots adjacent to the station.
- **@pkcst**: Average daily off-street parking cost ($) for the zone or station.
- **@stationlabel**: Defines what kind of station centroid it is. 0 is not a station centroid. The rest of the numbers use a flag system in binary with 4 digits. The first is the flag for GO train, the second is for GO Bus, the third is for local train, and the fourth is for local bus. Example: Kennedy Station has GO Trains, local trains, and local busses. It would be labelled as 1011

Table 3.2 NCS16 Node Numbering Ranges

Region	Node Range
City of Toronto	10,000-19,999
Durham Region	20,000-29,999
York Region	30,000-39,999
Peel Region	40,000-49,999
Halton Region	50,000-59,999
City of Hamilton	60,000-69,999
Niagara Region	70,000-79,999
Haldimand-Norfolk Region	80,000-80,999
Brant County	81,000-81,999
Waterloo Region	82,000-84,999
Wellington County	85,000-86,999
Dufferin County	87,000-87,999
Simcoe County	88,000-89,999
Kawartha Lakes Division	90,000-90,999
Peterborough County	91,000-91,999
External zones/gateways, Canada	94,000-94,999
External zones/gateways, US	95,000-95,999

EROW/HOV Type	Node Range
BRT/LRT nodes	96,000-96,999
Subway nodes	97,000-97,999
GO Rail nodes	98,000-98,999
HOV	900,000-999,999
Hypernetwork nodes	>100,000 & <900,000

4 LINKS

In EMME, links are defined by their starting and ending nodes and so do not have an identifying number/label. Link attributes discussed in the following sections are:

- Mode.
- Length.
- Number of lanes.
- Function class / volume delay function (VDF).
- Speed.
- Lane capacity.
- Type (spatial classification).

- Other attributes.

4.1 MODES

Modes are designated within EMME using a single-letter case-sensitive code. Each link must be coded with one or more mode codes, indicating what modes are permitted to use each link in the system. EMME supports four generic types of modes (Table 4.1):

- *Auto* (personal vehicles).
- *Auxiliary auto* (other vehicle categories, including HOV and trucks).
- *Transit* (public/common carrier services).
- *Auxiliary transit* (transit access/egress walk; more generally non-auto/transit modes).

Table 4.1 Mode Code Definitions

Code	Type	Description
c	*Auto*	Personal vehicle, any occupancy
C	*Auxiliary Auto*	Zero-occupancy autonomous vehicle
d	*Auxiliary Auto*	Light truck
e	*Auxiliary Auto*	Medium truck
f	*Auxiliary Auto*	Heavy truck
h	*Auxiliary Auto*	HOV2+ personal vehicle
H	*Auxiliary Auto*	HOV2+ autonomous vehicle
i	*Auxiliary Auto*	HOV3+ personal vehicle
I	*Auxiliary Auto*	HOV3+ autonomous vehicle
j	*Auxiliary Auto*	SOV personal vehicle
J	*Auxiliary Auto*	SOV autonomous vehicle
k	*Auxiliary Auto*	Bicycle
K	*Auxiliary Auto*	Motorcycle
b	*Transit*	Local bus: 9m, 12m or articulated bus
g	*Transit*	Highway coach bus: GO Buses and intercity buses
l	*Transit*	LRT
m	*Transit*	Subway
p	*Transit*	Premium bus service (not GO or intercity)
q	*Transit*	BRT (bus on exclusive right-of-way)
r	*Transit*	Commuter rail
s	*Transit*	Streetcar
t	*Auxiliary Transit*	Transfer between two transit lines for the same transit agency
u	*Auxiliary Transit*	Transfer between two different transit agencies
v	*Auxiliary Transit*	Walk mode on centroid connector
w	*Auxiliary Transit*	Walk mode on a regular street link
y	*Auxiliary Transit*	Walk between park & ride lot and a transit station
x	*Unassigned*	Reserved for internal use within model systems

Currently unassigned: a,n,o,z; and all upper-case letters other than C, H, I, J and K.

4.1.1 Auxiliary Auto Modes

There are four types of auxiliary auto modes in NCS16: truck modes, HOV modes, bicycles and motorcycles. Allowance for specific representation of autonomous vehicles is also included in NCS16.

Many roads have weight restrictions for vehicles heavier than 4.5 or 5 tonnes. Commercial vehicles that are lighter than these weight restrictions are classified as light trucks (Table 4.2). Medium or heavy trucks are vehicles that exceed the weight restriction. 4.5 tonnes has been used in this coding standard as the dividing line between light and other trucks, although it is noted that Highway 407 uses 5.0 tonnes in its definition.

Table 4.2 Suggested Definitions for Truck Modes

Mode	Type	Description
d	Light truck	Pickups and Trucks with a gross registered weight of less than 4,500 kg and used for commercial purpose.
e	Medium truck	Commercial vehicles with gross registered weight greater than 4,500 kg, and are single-unit vehicles of length not exceeding 12.5 metres.
f	Heavy Truck	Commercial vehicles with gross registered weight greater than 4,500 kg, and are multi-unit combination (tractor-trailer) vehicles of length exceeding 12.5 metres

High-occupancy lanes are only open to vehicles which have either 2+ or 3+ occupants. For this reason, NCS16 includes mode designations for HOV2+ (2 or more persons in the vehicle) and HOV3+ (3 or more persons in the vehicle).

Bicycles are included in the auxiliary auto (rather than transit) category since they are legally road vehicles, and, as more formal models of bicycle demand and performance possibly are developed within the region, they will likely be modelled in ways that are similar to cars and trucks. They are also subject to congestion in the same ways as cars and trucks rather than simply having a constant speed (as they would be under the auxiliary transit mode). Mode k represents the bicycle mode, either as a transit access mode or as a regular mode of travel. Mode K has been included to permit explicit modelling of motorcycles. Typical practice in the GTHA has been to include motorcycle trips with auto trips. While this practice is unlikely to change in the near future, mode K has been included in the coding standard to allow for this possibility.

4.1.2 Transit Modes

Transit mode codes are used to define primary transit technology-service categories. Additional detail concerning specific transit technologies (e.g., articulated bus versus regular bus) can be added through the vehicle definitions discussed Section 5.4. NCS16 includes mode designations for the following transit modes:

- Local bus.
- Highway coach bus (GO Bus; intercity buses).
- LRT.
- Subway (heavy rail; not commuter rail).
- Premium bus service (not GO Bus or intercity).

- BRT (bus on exclusive right-of-way).
- Commuter rail.
- Streetcar.

4.1.3 Auxiliary Transit Modes

Auxiliary transit modes in EMME are typically used to model pedestrian movements to/from transit, but they can also be used to model general walk movements and other-mode movements that are not otherwise explicitly handled by the other modes in the network. It is very useful to differentiate different types of pedestrian movements that may either have different attributes or be used for different purposes in network modelling. The pedestrian movements explicitly represented in NCS16 are:

- t: transfer between two transit lines for the same agency; no additional fare is required.
- u: transfer between two different transit agencies; an additional fare may apply.
- v: walk on centroid connector.
- w: walk on a regular street link.
- y: walk from park & ride lot to transit

"t" and "u" links should be included in the network whenever the transfer between two transit lines involves a significant walk (e.g., more than crossing a street or changing platform levels within a station). Typical examples where these transfer links should be used include the transfer between the Bloor-Danforth and University-Spadina subways at Spadina station and between the subway and GO Train stations at Union Station. The provision of two types of links – one for same-agency transfers (t) and one for between-agency transfers (u) facilitates fare-based transit assignments, in which between-agency transfers may incur an additional fare being charged. Two walk modes ("v" for centroid connectors and "w" for walk-on-road network) are included in the standard to facilitate fare-based network calculations (in which access fares may be coded into centroid connectors) as well as allow for the possibility of different speeds being used on the two types of links. Walk-on-road is included in the network so that transit users are not restricted to accessing transit nodes/lines that are directly connected to centroids via centroid connectors but can also "walk past" the closest transit service to access more distant, higher service lines. Note that one one-way road links (e.g., Adelaide or Richmond Streets in downtown Toronto) walking needs to be coded in both directions.

4.2 LINK LENGTH

"Actual" link lengths are used for all links, except for the standard exceptions shown in Table 4.3. The Table 4.3 lengths are suggested defaults, which should be replaced with more realistic lengths when the transfer distances are non-trivial. The impact of the 0.10km (100m) default on modelling results should be investigated in future work. Link lengths may also vary under very special circumstances, but these exceptions should be kept to a minimum and must be well documented whenever they occur.

Table 4.3 Link Length Definitions: Special Cases

Link Type	Length (km)
Mode = t	0.10
Mode = u	0.10

HOV Ramps	0.00

4.3 Number of Lanes

The actual number of lanes available during the time period being modelled is used for all links, except for the exceptions shown in Table 4.4. Exclusive left turn and centre turning lanes are usually not explicitly coded, but lane capacities on such links can be adjusted to reflect the capacity increases represented by these extra lanes.[4] The typical default time period is the morning peak period. Note that if multiple time periods are being modelled with differing lane availabilities, these will need to be coded into separate network scenarios for each time period.

Table 4.4 Number of Lanes Definitions: Special Cases

Link Type	**No. of Lanes**
Centroid Connectors	2
Only Transit Modes	0
Only Transfer Modes	0

4.4 Functional Class & Volume Delay Function Indices (*VDF*)

Volume delay functions (VDFs) are defined by a combination of link functional class and adjacent land uses (which can influence roadway performance). The **vdf** attribute, therefore, does double-duty as both the VDF index for link travel time calculations and as an indicator of link functional class. The NCS16 VDF definitions draw heavily on GGHM practice. Table 4.5 contains the VDF definitions and codes used in NCS16.

These definitions derived from a combination of sources, including from the previous version of the Network Coding Standard (NCS11), as well as the Geometric Design Guide and GGHMv4 VDF definitions. As the geometric design guide does not give lane capacities, the capacities have been updated from NCS11, where necessary, to be consistent with GGHMv4 standards.

Note that EMME VDFs must use link user fields as their arguments; they cannot use link extra attributes. As a result, key link attributes such as speed and capacity must be stored in user fields, as discussed in the following sections. Link user fields **ul2** and **ul3** are used for this purpose. Link user field ul1 is not assigned a fixed purpose in NCS16 and so may be used at the user's discretion. The specification of the actual mathematical functional forms that define the VDFs is a modelling matter that is left to the user to determine. GTAModel, for example, uses "tangent functions", whereas GGH Model V4 uses BPR functions.

[4] Since EMME does not explicitly model turning movements or split flows by lane, it is not appropriate to specifically code special turning lanes into the network.

Table 4.5 Link Functional Class & VDF Definitions

Area	Class	Subclass	Land use	Other Factors	Speed Range	Lane Capacity	VDF
N/A	Freeways	Freeway				1800	11
		Expressway				1800	12
		Freeway Ramp				1400	13
		Toll highway				1800	14
		Toll highway ramps				1400	15
		Freeway/expressway HOV				1800	16
		Freeway/expressway HOV ramp				1400	17
		Freeway/expressway truck only					
Rural	Arterials	Long Distance Arterials		Unsignalized long distance arterials	70-80	1400	20
		Major Country Roads		Major roads with a greater number of signals	60-90	1000	21
	Collector	Collector Road	Main Street or Collector Roads		40-60	500	22
Suburban	Arterials	Principal urban arterials	Low density residential/ commercial development with no direct accesses	Long signal spacing and good signal coordination/ progression	60-90	1000	30
	Collector	Suburban Collector Roads			40-60	500	31
Urban	Arterials	Major urban arterials	Low/medium density residential or commercial with some accesses	Longer signal spacing, good level of signal coordination and green-time allocation	50-80	800	40
		Major urban arterial HOV	Low/medium density residential or commercial with some accesses	Longer signal spacing, good level of signal coordination and green-time allocation	50-80	800	41
		Minor urban arterials	Low/medium density residential or commercial with direct accesses	Closer signal spacing, occasional illegal parking causing interference	50-80	700	42
	Collector	Downtown/city centre roads	Roads in high density office/commercial (CBD) with high pedestrian activity, parking, etc.	Presence of street cars and cyclists	40-60	600	50
		Collector Roads	Roads providing access to local streets	All-way stops, traffic calming measures	40-60	500	51
N/A	Local	Centroid Connectors	Local Streets		40	9999	90

4.5 LINK SPEED (*UL2*)

Link user attribute **ul2** is reserved for link free-flow speeds (km/hr) for use in VDF calculations. The definition of link free-flow speed is a modelling issue, and different assumptions are used in various regional modelling systems. For example, for arterial roads, GTAModel uses the posted speed limit, whereas GGH Model uses 75-80% of the posted speed. Both systems typically use the posted speed plus 10 km/hr for freeways. As is discussed further in Section 4.9, the extra attribute **@lkspd** contains the link posted speed. The freeflow speed used in **ul2** can then be computed based on the posted speed as required for a given model system.

For centroid connectors a uniform, non-congestion dependent speed of 40 km/hr is assumed.

4.6 LANE CAPACITY (*UL3*)

Link user attribute **ul3** is reserved for the lane capacities to be used in VDF calculations (autos/hr/lane). As in the case of link speeds, the definition of lane capacities typically involves modelling assumptions that may vary from one model system to another. Given this, NCS16 defines an extra attribute, **@lkcap** (see Section 4.9), that contains the calculated nominal link capacity, based on a defined set of rules. The assignment capacities used in **ul3** may then be computed by the user based in the user's model system assumptions.

Table 4.5 lists suggested nominal weekday morning peak-period lane capacities by link functional class for the case in which trucks are not explicitly assigned to the network and so freeway capacities are reduced by 10% to account for this omission (a common practice in current GTHA model systems). Note that if capacities change by the time period or day of the week being modelled (e.g., weekend versus weekday) then these will need to be coded into separate network scenarios for each time period or day being modelled (or stored in a user-defined extra attribute).

4.7 LINK TYPE (*TYPE*)

The 3-digit link type attribute is used to classify links by their municipality. The first digit indicates the jurisdictional and special code (Table 4.6). For links within the GTHA, the second and third digits define the planning district. See DMG (2007), Exhibit 4, pages 8-10 for the regional municipality and planning district codes. Note that for Planning Districts 1-9, the second digit in the type code is "0". For links outside the GTHA, the last two digits are the region/county code as defined in Table 4.7. Thus, for example, a regional road link in Wellington County would have link type 385.

For links that cross a municipal boundary the municipality within which the link's **i-node** is located defines the link's **type** value. Thus, for example, northbound links crossing Steeles Avenue are coded as belonging to the City of Mississauga, while the southbound links are coded as belonging to the City of Brampton.

For links that define the boundary between two municipalities, the roadway centreline is assumed to mark the actual boundary. Thus the link **type** value is defined by which side of the centreline the link lays. Thus, for example, along Steeles Avenue, westbound links are coded as belonging to the City of Brampton, while eastbound links are coded as belonging to the City of Mississauga.

Table 4.6 First Digit of Link Type Classification

First type digit	Classification
0	Centroid Connector
1	Federal
2	Provincial
3	Regional
4	Area Municipal
5	Private Sector
9	HOV ramp

Table 4.7 Region Codes

Census Division	Region Code
Niagara Region	70
Haldimand-Norfolk	80
Brant County	81
Waterloo	82-84
Wellington County	85-86
Dufferin Country	87
Simcoe County	88-89
Kawartha Lakes	90
Peterborough County	91-92
Northumberland County	93

4.8 SCREENLINE CODES

Links can correspond to one or more screenline. To identify them, the extra attributes @stn1 and @stn2 are used:

- **@stn1**: Screenline countpost flag attribute.
- **@stn2**: Screenline alternate flag attribute.

4.9 OTHER LINK ATTRIBUTES

Link user field **ul1** is not assigned within NCS16 and may be used by the user as needed.
Link extra attributes maintained within NCS16 network scenarios are:

- **@lkcap**: Link nominal capacity (veh/hr/lane).
- **@lkcst**: Personal vehicle link travel cost (excluding tolls) ($).
- **@lkspd**: Link posted speed (km/hr).
- **@toll**: Link toll charge ($).

5 TRANSIT LINES

Each transit line (route) is defined by two components:

- A *header section* which defines attributes that apply to the entire line. Sections 5.1 through 5.4 describe these attributes, which are:
    - Transit line name.
    - Transit line description.
    - Transit line headway.
    - Transit line speed.
    - Transit vehicle mode and type.
- A *route itinerary section* that defines the path of the transit line through the network as a sequence of transit line *segments*. Each segment is defined by a *from*-node and a *to*-node. As described in Section 5.4, each segment has a set of attributes that include dwell time, layover time and a transit time function.

Two important points to note when coding transit lines are:

- For routes with multiple branches, each branch must be coded as a separate transit line with a unique identifier (see Table 5.1).
- EMME, while allowing looped lines, still recommends lines be coded as two one-way routes. This allows for direction specific information. However, looped lines may be used as well, especially in cases of a pronounced "hammerhead" or “lollipop” shape. The extra transit line attribute @loop is used to determine what kind of line it is while the segment attribute @loopcut is used to show where the transit line was cut when converting from loop to one way routes. For more information please see Section 5.4

5.1 TRANSIT LINE NAME & DESCRIPTION (*LINE* & *DESCR*)

Each transit line has a unique 6-character alpha-numeric line name. Table 5.1 provides the line name coding conventions used in NCS16. In addition to its name, each line has a text description of up to 20 characters to further identify the line.

Table 5.2 provides the labelling conventions for building older networks in Durham and York Regions corresponding to points in time prior to the current period of consolidated services.

Table 5.1 Transit Line Name Codes

1st Char.	Region	Transit Agency	2nd Char.	Remaining Characters
D	Durham	Regional	N/A	Middle Characters: Digits of route number (right justified, padded with zeroes) Last character: Route branch code (usually A-Z) e.g. PM057b, G9001E, T501a
H	Halton	Oakville	O	
		Milton	M	
		Burlington	B	
M	Mississauga	Mississauga	N/A	
B	Brampton	Brampton	N/A	
W	Hamilton	HSR	N/A	
Y		Regular route	N/A	
		Viva route	V	
T	Toronto	TTC (Bus and Streetcar)	N/A	
		TTC Train	S	
G	-	GO Bus	B	
		Go Train	T	
		Other non-municipal transit	-	Last char: Special code

5.2 LINE HEADWAY (*HDWY*)

The line headway is generally defined as the average time between transit vehicle arrivals for the service period being modelled. Note that if multiple time periods are being modelled and if headways vary across time periods, then different network scenarios will be required (with appropriate headways coded into each scenario) for each time period (or, these headways could be stored in user-defined extra attributes).

No standard GTHA-wide definition of the morning peak period (or other service periods within the day) currently exists, with both 6:00-8:59 and 6:30-9:29 being used in various models. From a network coding standard point of view a standard set of operating period definitions is not essential. The exchange of data, models and network information among agencies, however, would certainly be facilitated if standard definitions were used.

For GO Transit (or any other transit service operating relatively infrequently), care must be taken to properly describe the service's "headway" for network assignment purposes so that the effect of the headway on transit line assignments is neither grossly over- or under-estimated

How headways are handled represent modelling assumptions rather than "base data". In keeping with the NCS16 philosophy of not embedding modelling assumptions into base networks, but rather only incorporating actual service attributes, in NCS16 an extra transit line attribute (**@trrun**, see Section 5.5) is used to store the number of runs in the period for each transit line, leaving it to the user to compute the "headway" as a modelling assumption (i.e., similar to the recommended approach to link speeds and capacities).

5.3 LINE SPEED (*SPD, TTF* & *US1*)

Transit line speeds may be defined in two ways. The first is to define a default operating speed for the entire line in the **spd** line attribute. These average line speeds are computed based on schedule data. The second method is to define speeds on a segment-by-segment basis using one or more transit time functions (TTF) (**ttf**, see Section 5.5). The line default speed is used for all segments that do not have a transit time function defined. The user segment field **us1** (see Section 5.5) is used to define segment-specific speeds that are used in the segment TTFs. Current GTHA practice tends to be to use TTFs for EROW rail links and average line speeds for surface transit routes. Firm rules concerning when to use TTFs are not included in this coding standard. To avoid inadvertent usage of incorrect data, however, the following conventions are explicitly introduced in NCS16:

- When segment-based speeds are used for a line, **spd** = 999 for this line.
- When average line speeds are used, **us1** = 999 for that line's segments.
- Average transit line speeds include dwell times and dwell times are set = 0.01.
- One-way average transit line speeds should <u>exclude</u> end-of-line terminal and recovery times.

Table 5.2 Historical Transit Line Names

1st Char.	Region	Transit Agency	2nd Char.	Remaining Characters	
D	Durham	Pickering	P	Middle Characters: Digits of route number (right justified, padded with zeroes) Last character: Route branch code (usually A-Z) e.g. PM057b, G9001E, T501a	
		Ajax	A		
		Whitby	W		
		Oshawa	O		
Y	York	Markham	M		
		Vaughan	V		
		Richmond Hill	R		
		Aurora	A		
		Newmarket	N		

Pre-DRT codes (i.e., 2001 and earlier)

Pre-Viva codes (i.e., 2001 and earlier)

5.4 Transit Vehicle & Mode

Each transit line must have a unique mode and transit vehicle type. Each vehicle type must have the following attributes:

- Vehicle type number.
- A 10-character code.
- Seated capacity (passengers).
- Total capacity (passengers)
- Auto equivalency factor (passenger car equivalents / vehicle).

NCS16 vehicle capacities are based on typical loading standards set by TTC and Metrolinx for service planning, rounded to the nearest 10 passengers for high-capacity modes and rounded to the nearest 5 for lower-capacity modes. Capacities for rapid-transit modes have been calculated from the following formulae:

Total capacity = seats + (allowed density) * (floor area of the vehicle)

where the allowed density for exclusive-ROW vehicles being 3.0 pass / m^2; and the density for mixed-ROW vehicles being 2.34 pass / m^2. Note that GO buses are not permitted standees due to safety restrictions and that GO rail services currently target a 100% seated load with zero standees.

Table 5.3 lists the vehicle definitions supported in NCS16. Some vehicle IDs have been 'reserved' for vehicles expected to enter into service in the next decade. Furthermore, note that more than one vehicle type may be associated with a given transit mode.

Table 5.3 NCS16 Transit Vehicle Definitions and Attributes

Old ID	New ID	Description	Code description	Mode	Seated Capacity	Total Capacity	Auto Equiv.
1	**1**	GO Train (10-car)	GoTrain10	r	1,600	1,600	-
-	**2**	GO Train (12-car)	GoTrain12	r	1,900	1,900	-
3	**3**	ICTS train (SRT)	SRT4car	m	120	220	-
2	**4**	Subway (4-car, T1)	Sub4carT1	m	260	670	-
-	**5**	Subway (6-car, T1)	Sub6carT1	m	400	1,000	-
-	**6**	Subway (6-car, Rocket)	Sub6carRkt	m	400	1,100	-
-	**7**	*Light rail vehicle (currently unused)*	LRV	l	*Reserved for future expansion*		
5	**8**	Streetcar CLRV (16m)	CLRV16	s	45	75	3.0
6	**9**	Streetcar ALRV (23m)	ALRV23	s	60	110	3.5
-	**10**	Streetcar LFLRV (30m)	LFLRV30	s	70	130	4.0
9	**11**	Bus (30ft / 9m)	Bus9	b	25	40	2.5
8	**12**	Bus (40ft / 12m)	Bus12	b	35	55	2.5
-	**13**	Deluxe bus (40ft / 12m)	Deluxe12	b	35	45	2.5
-	**14**	Deluxe bus (60ft / 18m)	Deluxe18	b	55	70	3.0
7	**15**	Articulated bus (60ft / 18m)	Bus18	b	55	85	3.0
-	**16**	*BRT bus (currently unused)*	BRT	q	*Reserved for future expansion*		
10	**17**	Coach bus	GoBus	g	55	55	2.5
-	**18**	Double-decker coach bus	DblDeckBus	g	80	80	2.5
-	**19**	Union Pearson Express (3-car)	UPX3car	r	173	173	-

5.5 TRANSIT LINE & SEGMENT ATTRIBUTES

Transit line user field **ut1** is used to store a transit line operator code, see Table 5.4. This code is useful for various operator-specific network calculations. **ut2** is available for user-defined purposes. **ut3** stores line-specific boarding penalties. This can be used to distinguish lines with quicker access (e.g., due to all-door boarding and off-board fare payment, such as Viva and Zum), or to penalize lines/services for which transfers carry a higher weight. Extra attributes for transit lines and segments are defined below:

- **@trrun**: Used to store the number of runs in the analysis time period for each transit line, leaving it to the user to compute the "headway" (attribute hdw) as a modelling assumption. This attribute only needs to be defined (i.e., non-zero) for low-frequency routes for which normal (actual) headway-based calculations are inappropriate (e.g., many GO Transit routes, other low-frequency express or special service routes, etc.). For these routes, **hdw** should be set equal to zero in the base network. Users can then define the **hdw** attribute for these routes as part of their modelling assumptions.
- **@loop**: A transit line extra attribute used to show what kind of line it is. When @loop is 0, it means the line is not looped. A value of 1 means that the line is looped and has been

modelled as looped while a value of 2 is when the line is looped but has been split into two one way routes.

- **@loopcut**: A transit segment attribute that is used to show the location of the split if the line has been split from a looped line to two one-way lines. This is to be used in conjunction with the @loop transit line attribute. The value of @loopcut is the J node of the segment at which point the line was split and 0 for all other segments.
- **@tstop**: A transit segment attribute that is used to show how many transit stops exist on that section. This is useful after removing cosmetic nodes in order to keep track of the stops that were eliminated. The surface transit speed updating procedure requires this to be defined.

Table 5.4 Transit Line Operator Code (ut1)

Transit line code	Transit agency	Code	
D	Durham (DRT)	80	DRT code (2006 and after)
G	GO Bus	65	
G	GO Rail	90	
HB	Burlington	46	
HM	Milton	44	
HO	Oakville	42	
PB	Brampton	24	
PM	Mississauga	20	
T	TTC	26	
WW	HSR	60	
Y	YRT and Viva	70	Post-Viva codes (2006 and after)

For building historical networks the labelling shown in Table 5.5 will apply as needed.

Table 5.5 Historical Transit Line Operator Codes (ut1)

Transit line code	Transit agency	Code	
DA	Ajax	84	Pre-DRT codes (i.e., 2001 and earlier)
DO	Oshawa	88	
DP	Pickering	82	
DW	Whitby	86	
YA	Aurora	79	Pre-Viva codes (i.e., 2001 and earlier)
YM	Markham	72	
YN	Newmarket	78	
YR	Richmond Hill	78	
YV	Vaughan	74	

Each transit line itinerary is made up line segments, with each segment between defined by two nodes in the itinerary list. Each segment may be described by some or all of the attributes listed in Table 5.6. Segment-specific attributes apply only to the segment immediately following the attribute specification in the itinerary definition, while other attributes continue to apply to all subsequent segments until they are redefined within the itinerary definition. See the EMME user's manual for further details.

Table 5.6 Transit Line Segment Attribute Summary

Keyword	Description	Default
dwt	Dwell time per line segment in minutes	0.01
dwf	Dwell time factor in minutes per length unit	Not used
path (yes or no)	Nodes on line can or cannot be omitted	Yes
ttf	Transit time function on links and turns	0 (use line speed)
ttfl	Transit time function on links only	0
ttft	Transit time function on turns only	0
us1	Exclusive right-of-way speed (kph)	0
us2, us3	Segment user data fields	Not used
lay	Layover time (segment specific, can be used for one intermediate segment)	0
tdwt	Temporary dwell time (segment specific)	0
tus1, tus2, tus3	Temporary segment user data storage (not used)	Not used

6 REFERENCES

DMG (2007) *Transportation Tomorrow Survey 2006 Version 0.1 Data Guide*, Toronto: Joint Program in Transportation, December.

TMG (2015) *Fare Based Transit Networks: Hyper-Network Generation Procedure and Specification.* Toronto: Joint Program in Transportation, June 10.