TRAVEL MODELLING GROUP

GTHA 2011 EMME NETWORK CODING STANDARD

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Travel Modelling Group Report No. 4

November, 2012

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1 INTRODUCTION

This report documents the 2011 EMME Network Coding Standard (NCS11) for the Greater Toronto-Hamilton Area (GTHA) as developed by the Travel Modelling Group (TMG) and its partners.[1] This coding standard will form the basis for all EMME-based network modelling undertaken by TMG, and the intent is that NCS11 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 macros, etc.) cannot be developed.

Ten years ago, the Data Management Group (DMG) developed a coding standard (DMG, 2004) for the 2001 base network which for some time provided such a common standard for network development within the GTHA. In this report this standard will be referred to as DMG01. In recent years, however, there has been a tendency for agencies and model developers to deviate from, and/or extend, DMG01 for a variety of reasons, with the result that currently no uniform standard for network development exists within the region.

The three most common coding conventions currently in use in the GTHA provide the starting point for the specification of NCS11. These are:

- DMG01.[2]
- GTAModel Version 3.0 (V3) extensions to DMG01 (Miller, 2007).[3]
- Greater Golden Horseshoe (GGH) Model (GGHM) (IBI, 2009).[4]

In developing a new coding standard, several criteria were considered:

- Maintaining wherever possible consistency with previous standards/conventions (especially DMG01) 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 DMG01 are required to properly support current regional modelling efforts.
- The standard should be complete in that it addresses all elements of network coding.

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

[2] DMG attempted an update of DMG01 in 2006 (DMG, 2006), but this update was never finalized. The work documented in DMG (2006) is included within NCS11.

[3] As with all versions of GTAModel, V3 takes DMG01 as its base and then adds a small number of extensions required to support GTAModel calculations. DMG01 can be considered a subset of V3's coding conventions.

[4] GGHM also takes DMG01 as its base, but incorporates a number of significant deviations, in addition to extensions, to DMG01, and so the GGHM coding conventions represent a fairly distinct alternative to DMG01 in a number of respects.

- 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".

This report loosely follows DMG (2004) in that it deals with each of the three primary network building blocks (nodes, links and transit lines) in Sections 3, 4 and 5, 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 NCS11. Table 2.1 defines the standard units of measurement used.

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, which continues to be the standard in NCS11. Previous years' EMME networks hosted by the DMG, 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
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 and BRT) as destinations/origins for access/egress trips to/from these stations by non-EROW modes (auto access to rail; transit/walk egress 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. Station centroids were not included in DMG01, but they are required by many regional model systems, notably both GTAModel and GGHM, and so they are included in NCS11.
- *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.

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

Table 3.1 Zone Numbering Ranges, Selected Systems

2001 DMG Coding Standard

	Used	**Reserved**
Internal GTA Zones	1-2670	1-3999
External GTA Zones	4000-4410	4000-4999
Spare		4500-8999
Dummy (Spare)		9000-9999

GTAModel Version 3

Same as the 2001DMG standard except:

Subway park & Ride stations	6000-6999
GO Rail stations	7000-7999

GGH Model

Census Division	**No. of Zones**	**Region code**	**From**	**To**
Toronto	568	10	1001	1568
Durham	215	20	2001	2215
York	429	30	3001	3429
Peel	305	40	4001	4305
Halton	200	50	5001	5200
Hamilton	227	60	6001	6227
Niagara	192	70	7001	7192
Wellington County	94	85-86	8501	8594
Dufferin Country	15	87	8701	8715
Simcoe County	120	88-89	8801	8920
Kawartha Lakes	25	90	9001	9025
Peterborough County	47	91-92	9101	9147
Waterloo	219	82-84	8201	8419
Haldimand-Norfolk	25	80	8001	8025
Brant County	44	81	8101	8144
Northumberland County	31	93	9301	9331
External zones or gateways[1]		94-95	9401	9413
Dummy park & ride zones[2]		96-98		

The zone centroids are four-digit numbers with the first two digits indicating the upper tier municipality of the zone

1. 94xx for Canada and 95xx for the U.S.
2. 96 for BRT/LRT, 97 for Subway and 98 for GO Rail

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 / country within the internal study area. These ranges should be clearly defined for each zone system used. Table 3.1 illustrates this criterion for the cases of DMG01, GTAModel V3 and GGHM.
- 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 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, NCS11 specifies the criteria (listed above) that a valid NCS11 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.

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.

For TMG base network development work, the zone numbering conventions adopted are detailed in Table 3.2.

Table 3.2 TMG Base Network Zone Conventions

Region	Zone Range
City of Toronto	0 - 1,000
Durham Region	1,001 - 2,000
York Region	2,001 - 3,000
Peel Region	3,001, - 4,000
Halton Region	4,001 - 5,000
City of Hamilton	5,001 - 6,000
External Zones	6,001 - 7,000
Subway Stations with parking	9,700 - 9,799
GO Train Stations	9,800 - 9,999

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 are adopted in NCS11. These are shown in Table 3.3.

3.3 Node Attributes

No node user fields (**ui1**, **ui2**, **ui3**) are specified in NCS11. The user is free to use these fields as required. Two node extra attributes are included in NCS11:

- **@pkcap**: The parking capacity for the zone or station. This is generally only useful for park-n-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.

Table 3.3 NCS11 Node Numbering Ranges

Region	Node Range
City of Toronto	10000-19999
Durham Region	20000-29999
York Region	30000-39999
Peel Region	40000-49999
Halton Region	50000-59999
City of Hamilton	60000-69999
Niagara Region	70000-79999
Wellington County	85001-86999
Dufferin County	87001-87999
Simcoe County	88001-89999
Kawartha Lakes Division	90001-90999

Region	Node Range
Peterborough County	91001-91999
Waterloo Region	82001-84999
Haldimand-Norfolk Region	80000-80999
Brant County	81001-81999
External zones/gateways, Canada	94001-94999
External zones/gateways, US	95001-95999
BRT/LRT nodes	96001-96999
Subway nodes	97001-97999
GO Rail nodes	98001-98999
HOV	900000-999999

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 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:

- *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).

4.1.1 Auxiliary Auto Models

Auxiliary auto modes include trucks and modes for the special treatment of HOV vehicles (e.g., to facilitate restricting HOV lane usage to HOV vehicles. NCS11 includes mode designations for light/medium and heavy trucks and HOV2+ (2 or more persons in the vehicle) and HOV3+

(3 or more persons in the vehicle). Note a separate mode is not included in the standard for medium trucks, since the primary use of these mode definitions is to determine what modes may by assigned to what links in the system. Heavy truck restrictions exist for many roadways and so it makes sense to differentiate between light/medium and heavy trucks. Similar restrictions for medium trucks generally do not exist and so the need for a separate mode for these vehicles is not compelling. Table 4.1 presents suggested definitions for light, medium and heavy trucks for network coding purposes.

Table 4.1 Suggested definitions for truck modes

Mode	Type	Description
d	Light truck	4-tire commercial vehicles, including delivery and service vehicles
e	Medium truck	Single unit trucks with 6 or more tires
f	Heavy truck	Combination trucks consisting of a power unit (truck or tractor) and one or more trailing units

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 in Section 0. NCS11 includes mode designations for the following transit modes:

- Local bus.
- Highway coach bus (GO Bus; intercity buses).
- LRT (light rail operated in exclusive right-of-way).
- Subway (heavy rail; not commuter rail).
- Premium bus service (not GO Bus or intercity).
- BRT (bus on exclusive right-of-way).
- Commuter rail.
- Streetcar (light rail operated in shared right-of-way).

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 to/from transit 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 NCS11 are:

- T: transfer between two transit lines for the same transit 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

Table 4.2 Mode Code Definitions

Code	Type	Description
C	*Auto*	Personal vehicle, any occupancy
E	*Auxilliary Auto*	Light/medium truck
F	*Auxiliary Auto*	Heavy truck
H	*Auxiliary Auto*	HOV2+ personal vehicle
I	*Auxiliary Auto*	HOV3+ personal vehicle
J	*Auxiliary Auto*	LOV (<2 or <3 depending on HOV definition used)
B	*Transit*	Local bus: 9m, 12m or articulated bus
G	*Transit*	Highway coach bus: GO Buses and intercity buses
L	*Transit*	LRT (light rail operated in exclusive right-of-way)
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 (light rail operated in shared right-of-way)
A	*Auxiliary Transit*	Auto access to transit
K	*Auxiliary Transit*	Bicycle
T	*Auxiliary Transit*	Transfer between two lines for the same transit agency
U	*Auxiliary Transit*	Transfer between two transit agencies
V	*Auxiliary Transit*	Walk mode on centroid connector
W	*Auxiliary Transit*	Walk mode on road network link
Y	*Auxiliary Transit*	Walk from park & ride lot to transit station
X	*Unassigned*	Reserved for internal use

Currently unassigned: D,N,O,Z

"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 (T-link) and between the subway and GO Train stations at Union Station.

"U" are also required if "fare-based" transit assignment is required, since these transfer links are then coded with a time-equivalent of the transfer fare. In this case, however, an automated macro exists to create these links and modify transit line coding accordingly. Thus, this case does not require extra effort on the part of network coders; i.e., these links do not need to be included in base networks unless so desired.

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.

Finally, the ‘Y’ auxiliary transit mode is used to indicate links connecting station centroids to their respective transit services. For stations where both GO and the TTC have parking lots (e.g., Kipling Station), ‘Y’ links connect the GO station centroid to both the GO rail node *and* the subway node. This permits ‘transit-access-GO’ trips. Subway station centroids need only to connect to their respective subway node.

In addition to these pedestrian-based auxiliary transit modes, two vehicular “auxiliary transit” modes are defined in NCS11:

- Mode A is available for model systems in which auto access to transit is represented as a high-speed auxiliary transit mode.
- Mode K represents the bicycle mode, either as a transit access mode or as a regular mode of travel.

Table 4.2 summarizes the modes supported within NCS11.

4.2 Link Length

Euclidean (straight-line) distances, calculated from the co-ordinates of the link nodes, are used for all links, except for the standard exceptions shown in Table 4.3. 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. Note that the EMME3 Network Editor can handle the link shape by adding vertices and calculate the shape length. The link shape may be applied to the network where it is needed.

Table 4.3 Link Length Defintions: 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. 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 being modelled.

Table 4.4 Number of Lanes Definitions: Special Cases

Link Type	No. of Lanes
Centroid Connectors	2
Mode = L,M,R*	0
Mode = T,U	0

* or any other transit-only link.

4.4 FUNCTIONAL CLASS & VOLUME DELAY FUNCTION INDICES[5]

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 NCS11 VDF definitions draw heavily on GGHM practice and represent a change in practice from DMG01.

[5] EMME Attribute `vdf`

Table 4.5 contains the VDF definitions and codes used in NCS11.

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 is not assigned a fixed purpose in NCS11 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. The so-called "tangent function" is used in many regional modelling systems, including GTAModel and GGH Model. Appendix A presents a list of tangent VDFs for the set of VDFs listed in

Table 4.5.

Table 4.5 Link Functional Class & VDF Definitions

Area	Functional Classification	Classification for Capacity	Adjacent Land Use	Other Factors Affecting Capacity and Speed	Lane Capacity (Autos/Hr)	VDF
N/A	Freeways/Expressways	Freeways	N/A		1,800	11
		Urban expressways			1,800	12
		Freeway ramps			1,400	13
		Toll highway			1,800	14
		Toll highway ramps			1,400	15
		Freeway/expressway HOV			1,800	16
		Freeway/expressway HOV ramp			1,400	17
		Freeway/expressway truck only				
Rural		Two-lane undivided highways/arterial roads	Roads through mostly vacant / farm lands		1,000	20
	Principal/Major Arterials	Multi-lane highways/arterial roads			1,100	21
		Two-lane undivided collector roads			500	22
Urban	Collector Roads	Principal urban arterials	Low density residential/ commercial development with no direct accesses	Long signal spacing and good signal coordination/rogression	900	30
	Principal/Major Arterials	Major urban arterials	Low/medium density residential or commercial with some accesses	Closer signal spacing, lower level of signal coordination and greentime allocation	800	40
		Major urban arterial HOV			800	41
	Major Urban Arterials	Minor urban arterials	Low/medium density residential or commercial with direct accesses	Close signal spacing, occassional illegal parking causing interference	700	42
			Industrial area		???	43
	Minor Urban Arterials	Downtown/city centre roads	Roads in high density office/commercial (CBD) with high pedestrian activity, parking, etc.	Presence of street cars and cyclists	600	50
	Downtown/City Centre Roads	Collector roads	Roads providing access to local streets	All-way stops, traffic calming measures	500	51
	Local Streets	Centroid connectors	Centroid connectors		9,999	90

4.5 LINK SPEED[6]

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 currently 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 4.8, 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[7]

Link user attribute **ul3** is reserved the for 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, NCS11 defines an extra attribute, **@lkcap** (see Section 4.8), 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

The 3-digit link type attribute is used to classify links by their municipality. For links within the GTHA, the first digit of the type code indicates the regional municipality, while 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 first two digits are region/county code defined in Table 3.1, followed by a zero for the third digit. Thus, for example, links in Wellington County have link type 850.

Codes 940-999 are reserved for custom use.

[6] EMME Attribute `ul2`
[7] EMME Attribute `ul3`

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 Toronto, while the southbound links are coded as belonging to York Region.

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 York Region, while eastbound links are coded as belonging to the City of Toronto.

4.8 OTHER LINK ATTRIBUTES

Link user field **ul1** is not assigned within NCS11 and may be used by the user as needed.

Link extra attributes maintained within NCS11 network scenarios are:

- **@lkcap**: Link nominal capacity (veh/hr/lane).
- **@lkcst**: Personal vehicle link travel cost (excluding tolls) ($).
- **@lkspd**: Link posted speed (km/hr).
- **@slc**: Link screenline code.
- **@toll**: Link toll charge ($).
- **@tvaeq**: Passenger car equivalents of transit vehicles using the link (pcu)

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 5.5, 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).

- All lines <u>must</u> be coded as one-way routes. EMME transit assignment results can often be unreliable if two-way routes are used. Thus, routes with terminals at each end must have layovers coded at each end, and looped routes must be broken at an appropriate point with an inserted layover.

5.1 TRANSIT LINE NAME & DESCRIPTION[8]

Each transit line has a unique 6-character alphanumeric line name. Table 5.1 provides the line name coding conventions used in NCS11. In addition to its name, each line has a text description of up to 20 characters to further identify the line

Table 5.1 Transit Line Name Codes

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		
		All Durham (DRT)	R		
H	Halton	Oakville	O		
		Milton	M		
		Burlington	B		
P	Peel	Mississauga	M		
		Brampton	B		
W	Hamilton	HSR	W		
Y	York	Markham	M		
		Vaughan	V		
		Richmond Hill	R		
		Aurora	A		
		Newmarket	N		
		Regular route	R		
		Viva route	V		
T	Toronto	TTC	-		
G	-	GO	-		
		Other non-municipal transit	-	Last char: Special code	

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

DRT code (2006 and after)

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

Post-Viva codes (2006 and after)

[8] EMME Attributes `line` and `descr`

5.2 LINE HEADWAY

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. At least two approaches are possible:

- Currently most model systems assume that if more than one run occurs during the analysis period the average time between runs is used (rules for how to handle runs that either start before the time period or end after the time period but that do operate for part of the time period need to be established). For example, a route that operates two trains half an hour apart has an assigned headway of 30 minutes. If only one run occurs during the analysis period, a maximum headway of 60 minutes is used. Note that in such cases, the user should make appropriate assumptions concerning average wait times for riders using these services. This approach has the potential to seriously over-estimate service frequencies when multiple lines converge on a trunk segment (as often happens with GO Bus lines). It may also over-estimate the "scheduling convenience" on the individual lines of the limited service.
- Simply define the headway as the service period (e.g., typically 180 minutes for the morning peak-period) divided by the number of runs occurring during this period. This approach solves the overlapping line problem described above but it does lead to very large (and unrealistic) average wait times for the route. This approach would likely require the use of node-specific wait time factors (or some other mechanism) to generate more reasonable wait times for these routes.

Both of these approaches really represent modelling assumptions rather than "base data". In keeping with NCS11 philosophy of not embedding modelling assumptions into base networks, but rather only incorporating actual service attributes, in NCS11 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 new recommended approach to link speeds and capacities).

5.3 LINE SPEED

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 (subway and GO Rail) 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 NCS11:

- When segment-based speeds are used for a line **spd** = 99 for this line.
- When average line speeds are used, **us1** = 99 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 exclude end-of-line terminal and recovery times.

Table 5.2 NCS11 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	-
-	4	Subway (4-car, T1)	Sub4carT1	m	260	670	-
2	5	Subway (6-car, T1)	Sub6carT1	m	400	1,000	-
-	6	Subway (6-car, Rocket)	Sub6carRkt	m	400	1,100	-
4	7	Streetcar CLRV (16m) in excl. ROW	SCxROW	l	45	75	-
-	8	*Light rail vehicle (currently unused)*	LRV	l	*Reserved for future expansion*		
5	9	Streetcar CLRV (16m)	CLRV16	s	45	75	3.0
6	10	Streetcar ALRV (23m)	ALRV23	s	60	110	3.5
-	11	Streetcar LFLRV (30m)	LFLRV30	s	70	130	3.5
9	12	Bus (30ft / 9m)	Bus9	b	25	40	2.5
8	13	Bus (40ft / 12m)	Bus12	b	35	55	2.5
-	14	Deluxe bus (40ft / 12m)	Deluxe12	b	35	45	2.5
-	15	Deluxe bus (60ft / 18m)	Deluxe18	b	55	70	3.0
7	16	Articulated bus (60ft / 18m)	Bus18	b	55	85	3.0
-	17	*BRT bus (currently unused)*	BRT	q	*Reserved for future expansion*		
10	18	Coach bus	GoBus	g	55	55	2.5
-	19	Double-decker coach bus	DblDeckBus	g	80	80	2.5

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).

Vehicle capacity is included as an attribute, however EMME's standard transit assignment algorithm does not simulate any impedance from over-capacity vehicles (although so-called 'congested transit assignment' algorithms have been written). Instead the capacity attribute supports analysis of overall line capacities.

NCS11 vehicle capacities are based on typical loading standards set by the TTC and by 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 5.2 lists the vehicle definitions supported in NCS11. 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.

5.5 TRANSIT LINE & SEGMENT ATTRIBUTES

Transit line user field **ut1** is used to store a transit line operator code, see Table 5.3. 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.

As discussed in Section 5.2, one transit line extra attribute is included in NCS11:

- **@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.

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 5.4. 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 5.3 Transit Line Operator Code (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	
DR	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	
YA	Aurora	79	Pre-Viva codes (i.e., 2001 and earlier)
YM	Markham	72	
YN	Newmarket	78	
YR	Richmond Hill	78	
YV	Vaughan	74	
Y	YRT	70	Post-Viva codes (2006 and after)

Table 5.4 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 (2004) *GTA Network Coding Standard, 2001 A.M. Peak EMME/2 Integrated Road and Transit Network, Release 1.0/1.1*, Toronto: Joint Program in Transportation, September.

DMG (2006) *2006 GTHA Network – Version I*, working paper, Toronto: Joint Program in Transportation, February 25.

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

IBI (2009) *TPM for Multi-Modal Transportation Forecasting Tools for the Greater Golden Horseshoe: Networks*, report to the Ontario Ministry of Transportation, Toronto: IBI Group, March.

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APPENDIX A

Link volume-delay functions: Mathematical structure

$$TT_{a,f} = \begin{cases} \left(\frac{length_a * 60}{speed_a}\right) * \left(\frac{1 + volau_a}{lanes_a * cap_a}\right)^{exp_f}, & if\ \frac{volau_a}{lanes_a * cap_a} < 1.0 \\ \alpha_f * \frac{volau_a}{lanes_a * cap_a} - \beta_f\ , & otherwise \end{cases}$$

where:

$TT_{a,f}$	=	Travel time, in minutes, on link *a*, for function *f*.
$length_a$	=	The length, in km, on link *a*.
$speed_a$	=	The speed limit, or freeflow speed, in km/hr, on link *a*.
$volau_a$	=	The auto volume, in vehicles per hour, on link *a*.
$lanes_a$	=	The number of lanes on link *a*.
cap_a	=	The capacity, in vehicles per hour per lane per direction (less trucks on highways), on link *a*.
exp_f	=	The exponent for function *f*.
α_f	=	Linear decay rate parameter for function *f*.
β_f	=	Linear decay constant parameter for function *f*.

Parameter sets:

exp_f	α_f	β_f	Criteria
6	*6*	*4*	All major highways
4	*4*	*2*	All other roads