GTA A.M. PEAK HOUR NETWORK CODING STANDARD

Part I - Notation

May 1998

University of Toronto
Joint Program in Transportation
Data Management Group

Preface

In the trip assignment stage of a typical travel demand modelling process, an electronic representation of the transportation system is needed to determine vehicular and person travel paths for each trip interchange. Every significant component of the transportation system in the urban area of interest must be represented and each component consistently represented relative to the other components.

The network representation consists of nodes and links. Each entity correspondingly is defined by a set of attributes. A node represents a zone centroid, intersection of paths, a transit stop, a change in alignment of a path or a change in one or more of the characteristics of a link. A link represents a section of a travel path beginning and ending at a node. Examples of links include centroid connector, road segment, transit route segment and transfer link.

Through the joint efforts of transportation planning staff of the Regional Municipalities of York, Peel, Durham, Halton and Hamilton-Wentworth, the City of Toronto, Toronto Transit Commission, GO Transit, Ministry of Transportation and the Data Management Group, an EMME/2 version of the 1996 road and transit systems, sharing a common base, was developed. Prior to the actual creation of the network, a new network coding standard had to be developed. The same group of technical staff was instrumental in the creation of both. Through numerous long meetings, telephone conversations, and staff time spent, some of it being personal time, on researching and documenting the coding standard and the actual coding of the 1996 network, this technical group brought the two products to reality.

The GTA Integrated Network Coding Standard is documented in two parts: Notation and Coding Procedures. This report documents the notation part. Since EMME/2 is the transportation planning tool used by the majority of planning agencies in the GTA, EMME/2 network data terminology are used frequently in this document.

This Coding Standard and the 1996 GTA network are under the care of the Data Management Group, housed under the Joint Program in Transportation at the University of Toronto. All enquiries related to these should be directed to:

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1.0 Node Attributes

Basic network node attributes are node number and co-ordinate system. In addition, while not a node attribute, use of an appropriate spatial reference is very important in error checking of a network. Depending on the travel demand model, other nodal attributes may be needed. However, they are model-specific data and should be defined as part of the model documentation.

1.1 Node Numbers (i, j)

One, two, three and four digit node numbers are reserved for centroid nodes. Current travel demand models in the GTA uses centroid nodes for several purposes. In this standard, centroid numbers are categorised into three groups, as defined in Table 1.1.

Table 1.1
Centroid Number Categories

Centroid Type	Centroid Node Number Range
Traffic Zones	1 - 3,999
External GTA Zones	4,000 – 4,999
Durham	4,000 – 4,099
York	4,100 – 4,199
Peel	4,200 – 4,299
Halton	4,300 – 4,399
Hamilton-Wentworth	4,400 – 4,499
Spare	4,500 – 4,999
Stations	5,000 - 8,999
Dummy (Spare)	9,000 - 9,999

The traffic zone number range of 1 – 4,999 is further categorised by regional municipality to define a traffic zone system. The current GTA traffic zone system in use is the 1996 GTA Traffic Zone System although the 1991 GTA Traffic Zone System is still in use in certain applications. Appendix A lists the traffic zone number ranges for each of the region in the GTA for the 1996 and 1991 GTA Traffic Zone Systems.

Regular nodes in a network must use five digit node numbers. Their use are classified by the Regional Municipalities that they fall in within the Greater Toronto Area (GTA), as shown in Table 1.2.

Table 1.2
Regular Node Number Categories

Regional Municipality	Regular Nodes
Metro Toronto	10,000 - 29,999
Durham	30,000 - 39,999
York	40,000 - 49,999
Peel	50,000 - 59,999
Halton	60,000 - 69,999
Hamilton-Wentworth	70,000 - 79,999
External to GTA	80,000 - 89,999

The 10,000 node numbers designated for external GTA areas are further segmented by node range and area coverage as shown in Table 1.3.

Table 1.3
External GTA Node Number Categories

Regional Municipality	**Node Range**	**External GTA Areas**
Durham	80,000 – 81,999	Victoria, Peterborough and Northumberland Counties
York	82,000 – 83,999	Simcoe County
Peel	84,000 – 85,999	Dufferin and Wellington Counties
Halton	86,000 – 87,999	Waterloo County
Hamilton-Wentworth	88,000 – 89,999	Brant, Haldimand-Norfolk and Niagara Counties

Further, because of the nature of heavy and commuter rail services and, typically the need to model these services separately from other forms of transit, subways and commuter rail routes are given separate node number ranges to represent them. The are listed in Table 1.4 below.

Table 1.4
Node Numbers for Heavy Rail

Type of Rail Service	**Regular Nodes**
Subway or Metro	90,000 – 90,999
GO or Commuter	91,000 – 91,999

1.2 Coordinate System (x,y)

The coordinate system employed should be the Universal Transverse Mercator (UTM) 6 Degree System. In order to accommodate coordinates within 6-digit integer fields, the UTM zone number (always 17 for the GTA) and the first digit of the north coordinate (always 4 for the GTA) are omitted. 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.

1.3 Spatial Referencing

To ease error checking of the network, an accepted comprehensive spatial database such as Statistics Canada's Street Network File (SNF) or Ontario Base Maps (OBM) is recommended as the spatial base to code the network.

A fixed datum for the spatial reference database should always be used to maintain consistency with historical network data. As well, travel demand modelling requires the use of several other spatial data in addition to network data. It would be best if these various data sets are all spatially referenced to a common datum. That, however, is not always the case. Appendix B lists some of these data and the datum to which the data are referenced.

1.4 Metric System

The following table lists the units of measure used in this standard:

Table 1.5
Metric System

Measure	**Unit**
x, y co-ordinates	metres
Length	kilometres
Time	minutes
Speed	km/hr

2.0 Link Attributes

Spatially, a link is defined by a starting node and an ending node. Links have a set of basic network attributes and can have additional model-specific attributes as well. The basic link attributes as defined in this standard are mode, number of lanes, length, functional class, volume delay function, speed, lane capacity and spatial classification.

2.1 Mode (mod)

Only one mode is defined for each type of technology. There may be variations within each technology such as articulated bus. These variations are reflected in the transit vehicle definitions in Section 3.5. The following table lists the mode codes defined by the standard.

Table 2.1a
Mode Definition

Code	**Mode**	**Mode Type**
c	Personal vehicle - all occupancy	auto
h	HOV 2+ vehicle	auto
i	HOV 3+ vehicle	auto
b	Bus	transit
g	Highway coach bus	transit
m	Heavy rail	transit
l	LRT	transit
r	Commuter rail	transit
s	Streetcar	transit
w	Walk	transit
t	Transfer	transit
f	Heavy truck	auto

The following table provides more detailed descriptions of the various modes:

Table 2.1b
Mode Description

Mode	**Description**
Personal Vehicle	Personal vehicle with one or more occupants.
HOV 2+	Personal vehicle with 2 or more occupants.
HOV 3+	Personal vehicle with 3 or more occupants.
Bus	30 ft or 40 ft or articulated bus currently used for local transit service.
Highway coach bus	Highway coach bus. Commonly used for inter-city routes.
Streetcar	An electric-powered light-weight rail vehicle running almost exclusively in mixed traffic. Vehicles may be coupled together to form a maximum size “train” of two vehicles. Operation is not controlled, although traffic signal priority may be available. Stops may or may not have passenger platforms or “islands” in the road. Platforms are not full height (level access).
Light rail	An electric-powered rail vehicle of medium weight running primarily on a generally separate right-of-way. The right-of-way may have complete or partial physical separation from a road or crossroads. Operation may or may not be fully or partially controlled through signalling and/or communications links. Vehicles may operate singly, however the medium weight (greater impact strength) allows vehicles to be coupled together to form trains of any length. Stops always have passenger platforms. These may be full height (level access) or partial height.

Mode	Description
Heavy rail	An electric-powered rail vehicle made up into trains of various lengths, generally not less than three/four cars per train. The right-of-way is completely separate and exclusively used by the heavy rail trains. Operation is controlled through signalling and/or communications links. Stations provide stops with full height platforms. "Advanced Light Rail (ALR)" should also be classified in this category because it is always on a completely separate right-of-way, operation is always controlled, stops are always made in stations and platforms are always full height.
Commuter rail	Rail vehicles operating on "traditional mainline" or "inter-city" rail corridors, usually in mixed operation with freight trains and other passenger trains. Rail vehicles may be self-propelled cars labelled as diesel multiple units (DMU or "Budd car") or electric multiple units (EMU) which can operate singly or in trains. Rail vehicles may be locomotive-hauled by traditional diesel-electric units or electric units. Locomotive-hauled trains can be of various lengths, generally not less than three cars and may be up to fourteen cars. Operation is controlled through signalling and/or communications links. Stops are always made at stations, however platforms may vary from very low (asphalt pad) to full height.
Heavy truck	Trucks not classified under one of the personal vehicle modes.
Walk	Walking at a default speed of 5 km/hr.
Transfer	Special mode to represent the act of switching from one mode to another or from one transit line to another.

2.2 Link length (len)

Euclidean or straight-line distance, calculated from the co-ordinates of the connecting nodes, is to be used for all links, except mode t links, but including internal GTA zone centroid connectors.

2.3 Number of Lanes (lan)

The actual number of lanes available during the peak period should be represented, except for walk, transfer and centroid connector links where a standard 2-lane configuration is to be used.

2.4 Auto Link Speed (ul2)

In general, posted speed should be used. However, there may be circumstances where using a higher or lower value than the posted speed is more realistic. For instance, traffic on streets within a CBD area may actually travel at a much lower average speed than the posted speed due to the number of traffic lights/intersections, pedestrians, etc. In such a case, one may want to use a lower speed value. In other cases where very little "side friction" exist along the link and where traffic generally travel at an average speed that is higher than the posted speed, a higher link speed should be used. For example, on freeway, rural highway, urban highway and controlled access urban arterial links, the link speed should be posted speed plus 10 km/hr.

For centroid connectors, a link speed of 40 km/hr should be used.

2.5 Functional Class and Volume Delay Function Index (vdf)

In this standard, the link functional class defines the volume delay function applicable to that link. The functional form of the volume delay functions specific to a network is documented in a separate report. The standard functional classes are listed in Table 2.2.

The vdf index is a 2-digit field. The first digit is used for the functional class number and the second digit is used to refer to the administrative jurisdiction of the link. The jurisdictional codes are listed in Table 2.3.

Table 2.2
Link Functional Classification

Class No.	Functional Classification
1	Freeways
2	Freeway ramps
3	Controlled access or rural highways & arterial roads
4	High capacity urban arterial roads
5	Medium capacity urban arterial roads
6	CBD/minor arterial and collector roads
7	Auxiliary transit links (e.g. walk, transfer links)
8	Exclusive transit links (e.g. subway, GO Rail, ALRT)
9	Centroid connectors

Table 2.3
Jurisdictional Code

Code	Jurisdiction
1	Federal
2	Provincial
3	Regional
4	Area Municipal

2.6 Lane Capacity (ul3)

Lane capacity for a road link is defined as the a.m. peak hour service-capacity in auto vehicles per hour per lane. Empirical data should be used whenever they are available. Otherwise, the following classifications should be used:

Table 2.4
Lane Capacity

Road Classification	Lane Capacity (auto-veh/hr)
Freeways	1,800
Freeway ramps	1,400
Controlled access or rural highways & arterial roads	1,200
Rural highways or arterial roads	1,500
High capacity urban arterial roads	900
Medium capacity urban arterial roads	700
CBD arterial roads	500
Collector roads and local streets	400
Centroid connectors	9,999
Transfer links	0
Exclusive transit links	0

2.7 Spatial Classification (type)

The 3-digit link type code is used to classify links by their location based on Regional Municipality, and planning district/area. The first digit must be as follows:

Table 2.5
Regional Municipal Code

Code	Region
1	Metro (City of) Toronto
2	Durham
3	York
4	Peel
5	Halton
6	Hamilton-Wentworth
7	External GTA

The second and third digits are to be used for distinguishing planning districts/areas within each of the region. These planning area numeric codes are to be defined by the regions according to their individual needs. Planning areas with a numeric code of less than 10 would have a zero as the second digit so that, for example, a network link in planning area 3 in York Region would have a link type code of 303.

2.8 Numeric Screen Line Code

Screen lines are to be denoted using a 4-digit numeric code system as defined in Table 2.6.

Table 2.6
Definition of Numeric Screen Line Code

Digit	Description
1	Regional municipality (1-Toronto, 2-Durham, 3-York, 4-Peel, 5-Halton, 6-Hamilton-Wentworth)
2 - 3	Regional screen line code
4	Traffic flow direction across screen line (1-NB, 2-SB, 3-EB, 4-WB)

3.0 Transit Line Attributes

A transit line is defined through two components, a header section that defines attributes applied to the entire line, and a route itinerary section defined by a sequence of segments. Each segment is further defined by several attributes. The header attributes are line name, line description, headway and default operating speed. Each segment is defined by a *from* and a *to* node and a set of attributes including dwell time, layover time and transit time function.

3.1 Line Name (lin)

The line name field is used to distinguish transit lines and is a unique alpha-numeric identifier of up to 6 characters in length. The 6 characters are to be used as follows:

For TTC, GO Transit and non-municipal transit operators:

char.	value
1	T/G/O for Toronto/GO Transit/nOn-municipal transit
2-5	route number, including branch code (right justified, pad with zeros)
6	special code

For all other municipal agencies:

char.	value
1	D (Durham), Y (York), P (Peel), H (Halton), W (Hamilton-Wentworth)
2	municipal/transit property code (see table below)
3-5	route number (right justified, pad with zeros)
6	route branch code (alpha-numeric code, usually A-Z)

Table 3.1
Municipal Transit Agency Code

Region Code	Municipal Code	Transit Agency
D (Durham)	P	Pickering
	A	Ajax
	W	Whitby
	O	Oshawa
Y (York)	M	Markham
	V	Vaughan
	R	Richmond Hill
	A	Aurora
	N	Newmarket
P (Peel)	M	Mississauga
	B	Brampton
H (Halton)	O	Oakville
	M	Milton
	B	Burlington
W (Hamilton-Wentworth)	W	HSR

3.2 Line Description (descr)

A textual description, up to 20 characters, of the line/route is provided in this field.

3.3 Line Headway (hdw)

The line headway is the average time between buses or trains in the service schedule of the line for the AM peak period of 6 to 9 am. For lines with varying headways across the 3 hour peak period, a calculated "combined" headway would be used. For some routes, the headway of the peak hour service may be appropriate. "Effective headways" are to be used for transit routes with infrequent number of runs (<=6). The headways used for the different types of services are described below.

Local transit — The scheduled operating headway corresponding to the peak period is used.

GO Bus and GO Rail — Effective headways corresponding to the table below are used except for "Feeder Buses" which meet trains at departure or arrival. The headways of these feeder lines are set to 5 minutes.

Table 3.2
Effective Transit Line Headway

Number of Buses or Trains Between 6 and 9 am	Effective Headway (min)
1	30
2	30
3	20
4	15
5	12
6	10

3.4 Line Speed (spd)

Transit line speeds can be defined in two ways: the default operating speed for the entire line or segment speeds implied by transit time functions. The default speed is used to calculate the travel time between stops (nodes) for line segments where no transit time function (ttf) are defined. The transit time function, where it is defined, changes the default transit travel time for the current and following line segments.

For transit routes with exclusive right-of-way, the line segment user data 1 (us1) field is reserved for the segment speed. Therefore, such lines may be coded to use the default line speed or individual segment speeds.

Speed values are used to calculate segment travel times. With an integrated auto and transit network, auto link/segment travel times can also be used with the appropriate definition of transit time functions.

3.5 Transit Vehicle (veh)

Each transit line must be associated with a mode and transit vehicle type. Below is the list of transit vehicles in use in the GTA.

Table 3.3
Transit Vehicle Definition

Vehicle Type	Description	Mode	Seated Capacity	Total Capacity	Pass. Car Equiv.
1	GO Rail	r	1,600	2,000	
2	Subway	m	480	1200	
3	ALRT	m	120	280	
4	LRT – exclusive ROW	l	50	75	
5	Streetcar	s	50	75	*
6	Streetcar - articulated	s	60	110	*
7	Bus – articulated	b	60	90	*
8	Bus - 40 ft	b	40	60	2.5
9	Bus - 30 ft	b	30	40	2.5
10	Coach bus – GO Transit	g	49	60	2.5
11	Coach bus - private	g	49	49	2.5

* to be developed.

3.6 Line Segment Attributes

Line segments make up the transit line itinerary. Each segment may be described by some or all of the following attributes:

Table 3.4
Transit Line Segment Attribute Summary

Keyword	Description
Dwt	Dwell time per line segment (default 0.01)
Dwf	Dwell time factor in minutes per unit length
Ttf	Transit time function on both links and turns
Ttfl	Transit time function on links
Ttft	Transit time function on turns
us1, us2, us3	Segment user data. us1 contains segment speed.
Lay	Layover time (segment specific)
Tdwt	Temporary dwell time (segment specific)
tus1, tus2, tus3	Temporary segment user data 1, 2 , 3

The dwell time attributes (dwt, dwf, tdwt), may be marked with one or more of the following symbols:

- * dwell time factor
- < boarding only
- > alighting only
- # non-stop (no boarding and no alighting)
- + boarding and alighting are allowed

3.7 Transit Time Function Index

A separate index is given to each transit mode as shown below:

Table 3.5
Transit Time Function Index

Function Index	Mode
1	r
2	m
3	l
4	s
5	b
6	g

Appendix A

1996 and 1991 GTA Traffic Zone Systems

These zone systems were developed collectively by the six regions of the GTA to coincide with the conduct of the 1996 and 1991 Transportation Tomorrow Surveys. Data from the surveys were assigned and made available in these zone systems.

1996 GTA Traffic Zone System

Region	**Allotted Range**	**Highest Zone Number**	**Zone Count**
Metro Toronto	1 – 500	463	463
Durham	501 – 1000	765	265
York	1001 – 1500	1353	353
Peel	1501 – 2000	1749*	248
Halton	2001 – 2500	2179	179
Hamilton-Wentworth	2501 – 3000	2670**	169
GTA			**1677**

* skipped zone number 1716; ** skipped zone number 2657

1991 GTA Traffic Zone System

Region	**Allotted Range**	**Highest Zone Number**	**Zone Count**
Metro Toronto	1 – 500	460	460
Durham	501 – 800	710	210
York	801 – 1000	978	178
Peel	1101 – 1400	1325*	224
Halton	1401 – 1600	1563	163
Hamilton-Wentworth	1601 – 1900	1770**	169
GTA			**1404**

* skipped zone number 1316; ** skipped zone number 1757

Appendix B

Spatial Reference of Related GTA Databases

Travel demand modelling requires the use of several other spatial data in addition to network data. It would be best if these various data sets are all spatially referenced to a common datum. That, however, is not always the case. The table below lists some of these data and the datum to which the data are referenced.

Application	**Datum**
TTS 1986 & 1991	NAD 27
TTS 1996	NAD 27
EMME/2 Networks	NAD 27
1991 GTA Traffic Zone Boundaries	NAD 27
1996 GTA Traffic Zone Boundaries	NAD 27 & NAD 83