A MODIFIED VERSION OF THE GTAMODEL TRAVEL DEMAND FORECASTING MODEL SYSTEM

QUEST PROJECT

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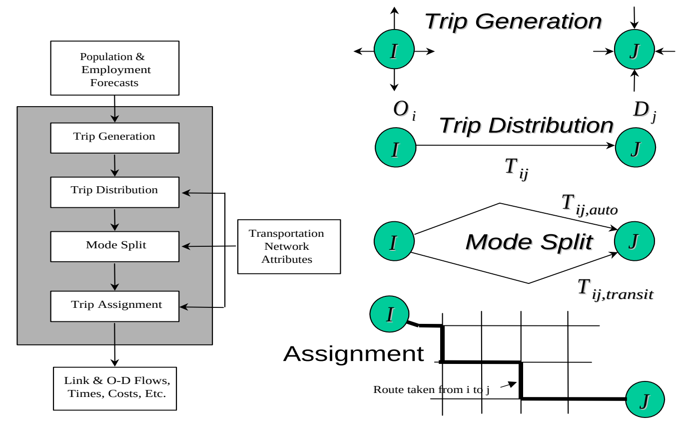
OVERVIEW OF THE TRAVEL DEMAND MODEL SYSTEM USED FOR THE QUEST PROJECT

A modified version of the GTAModel travel demand forecasting model system was used in the QUEST project. GTAModel was developed by Prof. Eric Miller at the University of Toronto and is used in operational regional planning practice by the City of Toronto, the Cities of Mississauga and Brampton, and the Regional Municipality of Durham. It also provides the conceptual framework for the Greater Golden Horseshoe Model (GGHM) used by the Ontario Ministry of Transportation and Metrolinx for transportation planning analysis in the Greater Toronto-Hamilton Area (GTHA).



(a) Model System Flowchart **(b) Trip Components by Model Stage**

Figure 1
The Four-Stage Urban Transportation Model System
(Source: Meyer & Miller, 2001)

GTAModel is in many respects a conventional four-step model system in which population and employment forecasts for each traffic zone in an urban region, combined with projected road and transit networks for the region for the forecast year are the primary inputs. Figure 1 depicts the standard four-step approach, in which travel demand is projected in four sequential stages:

- ***Trip generation***, in which the number of trips originating from each traffic zone i (O_i) and destined to each traffic zone j (D_j) are predicted as a function of zonal population and employment.
- ***Trip distribution***, in which the origin and destination "trip ends" are linked together to determine the "trip flows" from each origin zone i to each destination zone j (T_{ij}). The probability of a trip going from zone i to zone j depends upon the number of trips originating in zone i (O_i), the number of trips destined for zone j (D_j) and the ease/difficulty of travel between i and j, given the travel times and costs of feasible travel modes between the two zones.
- ***Mode split***, in which trip origin-destination (O-D) flows are "split" between feasible travel modes (auto, transit, etc.), yielding O-D flows by mode. Mode choices for each O-

D trip depend on the relative travel times and costs of the competing modes, as well as the modal preferences of the trip-makers (which vary with the socio-economic attributes of the trip-makers).

- ***Trip assignment***, in which auto and transit O-D trips are "assigned" to explicit paths through the road and transit networks, yielding for each road link in the system link flows, travel times, volume-to-capacity ratios, etc., and for each transit line in the system total passenger boardings and alightings, etc. "User-equilibrium" assignment methods are used, in which it is assumed that each trip-maker chooses the path through the road or transit network that minimizes their overall weighted travel time, taking into account congestion effects in the road network and walk, wait and transfer times within the transit network. The EMME/2 commercial network modelling package is used to perform road and transit assignments, with EMME/2 "macros" (scripts for running EMME/2) being integrated within the GTAModel software system.

Trips are divided into four trip purposes, with separate generation, distribution and mode split models for each trip purpose. Trip purposes used in GTAModel are:

- ***Home-to-work (HW).*** HW trips are further sub-divided by four occupation groups and by employment status (full-time and part-time workers). Separate generation and distribution models are used for each of the eight occupation-employment status groups; separate mode split models are used for each of the four occupation groups.
- ***Home-to-school (HS)***. HS trips are further sub-divided by three age groups, which act as proxies for school level (elementary, secondary and post-secondary). Separate models are used for each education group.
- ***Home-to-other (HO).*** HO trips are generated separately for workers, students and non-work. Single distribution and mode split models are then applied to all generated HO trips.
- ***Non-home-based (NHB).*** All trips not beginning at home are included in this trip category.

In addition to population and employment by traffic zone and the road and transit networks, important inputs to GTAModel include:

- Trip generation rates for each trip purpose and purpose sub-category. For the GTHA case, these trip rates are derived from 2006 Transportation Tomorrow Survey (TTS) data.
- Parameters for each trip distribution and mode choice model used. These parameters are statistically estimated using 2006 TTS observed data.
- Assumed distributions for:
  - Person age.
  - Person labour force participation (by occupation and employment status).
  - Person education participation.
  - Person possession of driver's licence.
  - Household auto ownership levels.
  - Employment by occupation.

  For the GTHA case, the default distributions are derived from 2006 TTS data.
- Average daily parking charges by traffic zone.
- Average auto operating cost ($/km).
- Transit fares by transit operator.

- Road tolls (where these exist; e.g., Highway 407 in the GTHA).

Standard outputs from GTAModel include:

- Origin-destination trips by traffic zone by trip purpose and by mode of travel.
- Origin-destination travel times and costs for auto and transit trips.
- Origin-destination mode shares by trip purpose.
- For each road link:
  - Travel time.
  - Average speed.
  - Volume.
  - Volume-to-capacity ratio.
  - Greenhouse gas and criteria pollutant emissions.
- For each transit line:
  - Total boardings
  - Total alightings
  - Peak load
  - Average load
  - Average route travel time
- Vehicle kilometres travelled (VKT) on the road system.
- Person kilometres travelled (PKT) by mode of travel.

Key features that differentiate GTAModel from conventional 4-step models include:

- HW and HS distributions are determined in a first instance as place-of-residence-place of work (PORPOW) and place-of-residence-place-of-school (PORPOS) linkages. That is, the fundamental relationship between where people live and work (or attend school) is directly modelled. These linkages are then subsequently turned into trips by applying an appropriate trip rate to these linkages. This approach eliminates the "noise" of variations in day-to-day trip-making from the estimation of these very important spatial relationships. It also facilitates the modelling of work and school trip making by time of day and the modelling of the "reverse" work-to-home and school-to-home" trips, since these all depend on the same base PORPOW/S linkages.
- Considerable care and detail is used in modelling mode choice by trip purposes. Sophisticated "nested logit" models are used to model mode choices in considerable detail. This includes the detailed modelling of auto access to subway and commuter rail modes, differentiating between auto-drivers and auto-passengers within the model, and the explicit modelling of walk, bicycle and (for school trips) school bus modes.
- A "population synthesis" procedure is implemented within the model system that takes total population per residential zone and synthesizes persons by age category, employment status, occupation group (for employed persons), student status, driver's licence possession and household auto ownership level. These synthesized persons are then used to model trip-making. This is an essential step in the modelling process, since trip generation, distribution and modal choice all depend critically upon these socio-economic attributes.

GTAModel is implemented within the eXtensible Travel Model Framework (XTMF), also developed at the University of Toronto, which is a software system that supports the rapid development of travel demand model systems. The standard GTAModel system was developed to model the typical weekday morning (AM) peak period in the GTHA. This AM-peak GTHA model system was extended within XTMF for the QUEST project in the following ways:

- Afternoon (PM) peak period and off-peak travel models were added to the model system so that 24-hour weekday trip-making could be modelled. These models simply applied the AM-peak model structure to the other time periods with time period specific new trip generation rates being used.
- Work-to-home and school-to-home trip purposes were added to the model system for the PM-peak and off-peak time periods.
- An endogenous daily parking price model was added to the model system. This model predicts zonal parking prices as a function of zonal employment density and can be "turned on" at the user's discretion to allow parking prices to vary in response to changes in urban form / density. Parking price is an important variable within the model system in explaining trip-makers' mode choices. This model was constructed using observed 2006 average daily parking prices for the GTHA. Appendix II provides details concerning this model.
- An endogenous household auto ownership model was added to the model system. This model predicts the distribution of zero-, one- and two-or-more-car households for each residential traffic zone as a function of zonal household density. Similar to the parking price model, it can be "turned on" to allow household auto ownership levels to vary in response to changes in urban form / density. Auto ownership is a very important variable within the model system in explaining trip-makers' mode choices. This model was constructed using historical data for the GTHA derived from TTS. It is documented in Appendix III.
- A new VKT/PKT report generator was added to the model system to export the VKT/PKT data required by the CIMS model system.

For further, more detailed, documentation of GTAModel and XTMF, see Miller (2007a-e).

To apply this modified GTAModel to the Winnipeg, Dawson Creek and Fort McMurray cases, the following assumptions were made:

- 2006 Winnipeg Area Travel Survey (WATS) data were used to construct Winnipeg specific trip rates and socio-economic distributions. These replaced the GTHA inputs in the Winnipeg trip generation and population synthesis procedures.
- In the absence of any travel survey data for either Dawson Creek or Fort McMurray, the Winnipeg trip rates and socio-economic distributions where used for both of these cases.
- GTHA trip distribution and mode choice model parameters were applied to the Winnipeg, Dawson Creek and Fort McMurray cases.
- For the Winnipeg case, the GTHA mode choice model alternative-specific constants were adjusted so that the model reproduced the aggregate morning peak-period mode choices observed in the 2006 WATS as best as possible. Table 1 presents 2006 morning peak-period WATS mode shares, original mode shares generated by GTAModel prior to adjusting the modal constants, and the final mode shares with the adjusted constants. The final adjusted mode shares reproduce the observed Winnipeg mode shares well for both the morning peak period and the 24-hour, all-day totals. These adjusted mode choice parameters were also used for the Dawson Creek and Fort McMurray cases.

Table 1: 2006 Winnipeg Aggregate Mode Shares: Observed and Predicted

Morning Peak-Period		**GTAModel**	
WORK	**WATS**	**Unadjusted**	**Adjusted**
Auto drive + passenger	84.0%	57.1%	82.7%
Transit	9.0%	30.1%	9.1%
Walkbike	7.0%	12.8%	8.2%
SCHOOL	**WATS**	**Unadjusted**	**Adjusted**
Auto drive + passenger	44.9%	44.8%	48.4%
Transit	23.5%	21.0%	21.7%
Walkbike	31.6%	34.3%	30.0%
HOME-BASED OTHER	**WATS**	**Unadjusted**	**Adjusted**
Auto drive + passenger	89.0%	92.6%	90.4%
Transit	4.0%	4.8%	4.5%
Walkbike	6.0%	2.6%	5.1%
NON-HOME-BASED	**WATS**	**Unadjusted**	**Adjusted**
Auto drive + passenger	90.0%	97.1%	90.4%
Transit	1.0%	1.7%	1.5%
Walkbike	9.0%	1.2%	8.0%
ALL TRIPS	**WATS**	**Unadjusted**	**Adjusted**
Auto drive + passenger	75.0%	63.5%	76.6%
Transit	10.9%	23.1%	10.9%
Walkbike	14.1%	13.4%	12.5%
Morning Peak-Period		**GTAModel**	
ALL TRIPS	**WATS**	**Unadjusted**	**Adjusted**
Auto drive + passenger	82.4%	77.9%	83.7%
Transit	7.9%	14.5%	8.0%
Walkbike	9.7%	7.5%	8.3%

TRANSPORTATION ANALYSIS OF QUEST SCENARIOS

For each of the four archetype urban areas (the Greater Toronto Area (GTA),[1] Winnipeg, Dawson Creek and Fort McMurray) seven GTAModel model system runs were undertaken, one for each of the seven scenarios under consideration:

- 2006 base case;
- 2030 trend, moderate and aggressive land uses; and
- 2050 trend, moderate and aggressive land uses.

For each land use scenario for each urban area three combined road and transit network scenarios were created in EMME/2 corresponding to the AM-peak, PM-peak and off-peak time periods. This permitted the road and transit assignment results to be stored for each time period for each land use scenario for each urban area. All road and transit network scenarios were coded according the 2001 network coding standard for the GTHA (DMG, 2004), incorporating GTAModel extensions (Miller, 2007c). The 2030 and 2050 trend networks were simply the 2006 base networks applied to the future year cases; i.e., no improvements in the road and transit

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[1] Although GTAModel was developed for the GTHA, and all model runs undertaken with the QUEST project included the effects of Hamilton-based trips on GTHA travel patterns, congestion levels, etc., only GTA-specific results were included in the outputs provided to the QUEST project team. That is, trips with origins and/or destinations with the City of Hamilton are not included in the reported QUEST results.

networks were assumed, except in a few cases where new growth within the urban area required extending the base road network to "connect" the new growth areas to the existing urban network. For the moderate and aggressive land use scenarios, 2030 and 2050 road networks were constructed that have the following attributes:

- They are as consistent as possible with current plans for transportation network expansion within each case study region, especially with respect to transit improvements.
- Especially for the aggressive land use scenarios, they are as aggressive as can be reasonably assumed with respect to transit service improvements.
- They are as consistent as possible with the assumed land use distributions in each scenario (e.g., transit services are improved in high-density corridors, etc.).

In all scenarios, auto fuel prices and tolls and transit fares were held fixed in constant 2006 dollar terms. The key drivers of the predicted travel behaviour in each scenario are thus the assumed population and employment distributions and the assumed transportation networks (especially the assumed transit networks). Table 2 summarizes the key transportation-related assumptions for each land use scenario analyzed in this study..

Table 2: Summary of Transportation Policy Assumptions

	LAND USE SCENARIO		
Service Attribute	**Trend**	**Moderate**	**Aggressive**
Auto operating costs	Fixed, 2006 levels	Fixed, 2006 levels	Fixed, 2006 levels
Road tolls	Fixed, 2006 levels	Fixed, 2006 levels	Fixed, 2006 levels
Transit fares	Fixed, 2006 levels	Fixed, 2006 levels	Fixed, 2006 levels
Daily parking charges	Fixed, 2006 levels	Varies with emp. density	Varies with emp. density
Hosuehold auto ownership levels	Fixed, 2006 levels	Varies with res. density	Varies with res. density
Transit service frequencies	Fixed, 2006 levels	Aggressive increases	Aggressive increases
Transit in-vehicle travel times	Fixed, 2006 levels	10% reduction relative to 2006	10% reduction relative to 2006
Use of higher order transit (BRT/LRT)	Fixed, 2006 levels	Some new BRT; limited LRT	More BRT; much more LRT

DISCUSSION OF TRANSPORTATION MODEL SYSTEM RUN RESULTS

While GTAModel generates large volumes of detailed data, only relatively aggregate travel-related outputs were required for input into the CIMS model system. These consisted of:

- VKT/PKT by mode.
- Total trips and mode shares by mode.

These summary statistics were generated for each land use scenario for each urban area and provided to the QUEST project team in a summary spreadsheet. Summary tables for the four case study urban areas are presented in Appendix I.

In all four case study urban areas, similar patterns in run results were obtained. Figures 2, 3 and 4 present summary results for the case of the GTA. Points to note include

- The "business as usual" trend scenarios consistently result in very significant increases in auto usage and vehicle kilometres travelled (VKT) and associated declines in transit mode shares.
- The moderate land use scenarios, combined with significant improvements in transit network coverage and service levels, reduces auto VKT and increases transit (and walk/bike) mode shares.

- The aggressive land use scenarios, again combined with major, aggressive transit improvements, much more significantly reduce auto VKT and increases transit and non-motorized mode shares, relative to both the trend and the moderate scenarios.

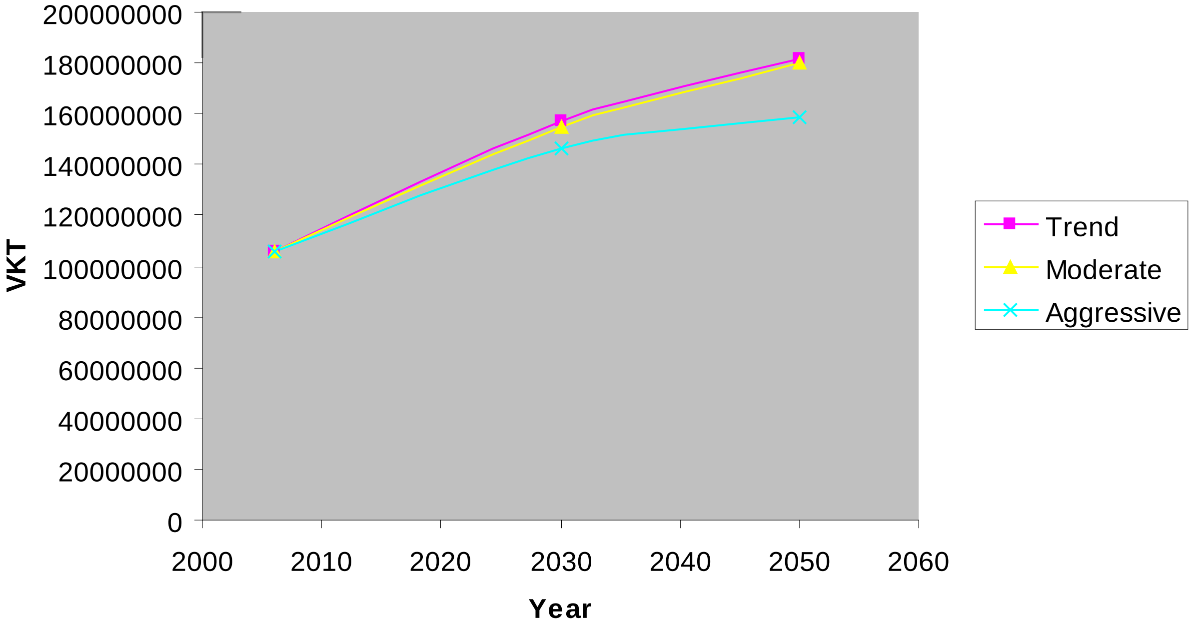
Figure 2
Auto VKT by Year & Scenario for the Greater Toronto Area

Table 3 summarizes changes in auto VKT, transit trips and auto trips and mode shares for the four study areas, comparing the trend and aggressive scenarios. While some scatter exists due to unavoidable vagaries in assumptions concerning land use and transit network improvements across the case studies, in general, the following points can be noted:

- Transit ridership impacts tend to be greatest in larger urban regions where greater scope for economies of scale in constructing cost-effective, comprehensive, high quality transit service exist.
- While auto trip and VKT reductions are naturally greatest in absolute terms in larger cities, on a percentage change basis the greatest reductions tend to occur in smaller areas.
- Conversely, a greater reduction in auto mode share tends to occur in larger areas, where greater opportunities for shifting to transit and non-motorized modes exist. This result also implies that in smaller cities a greater proportion of VKT reductions occur due to shortening of auto trip lengths rather than trip mode shifts, relative to the larger city case.
- Under all scenarios, auto travel remains a major mode of travel. Given the complex and dispersed nature of urban activity/travel patterns, even under the most aggressive of land use and transportation scenarios, the car will remain a primary mode of travel, especially for off-peak non-work/school trip-making.

Figure 3
Transit & Non-Motorized Trips by Year & Scenario
for the Greater Toronto Area

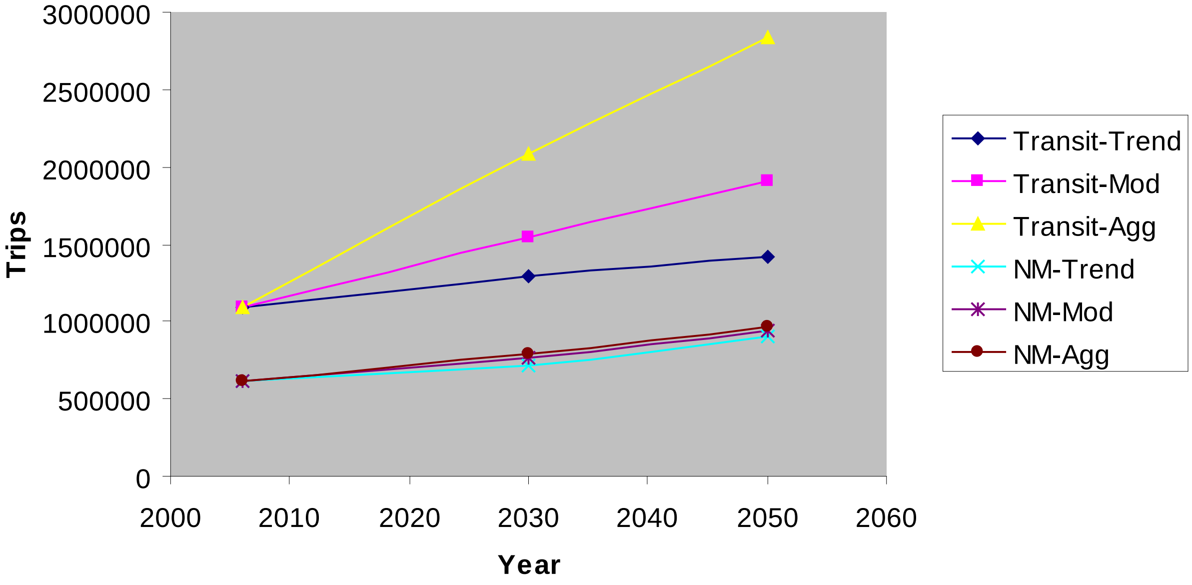

Figure 4
Transit & Non-Motorized Mode Shares by Year & Scenario
for the Greater Toronto Area

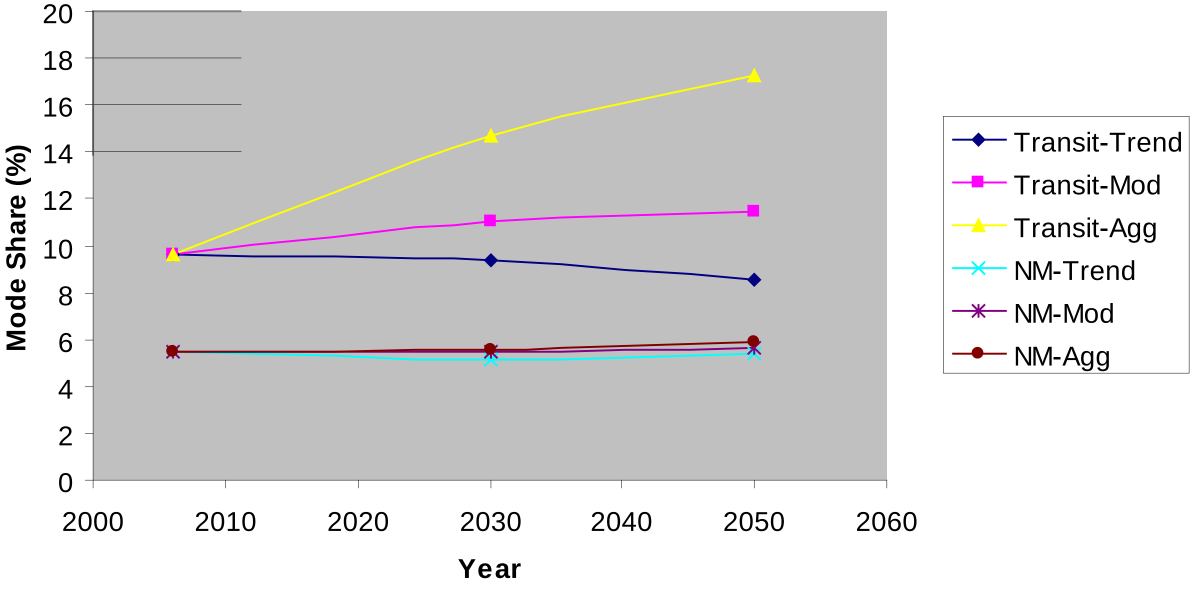

Table 3: Summary Statistics, Base, Trend and Aggressive Scenarios, All Cities

Auto VKT	**Future - Base**		**% Change from Base**		**Aggressive**	**% Change**
Year: 2030	**Trend**	**Aggressive**	**Trend**	**Aggressive**	**- Trend**	**from Trend**
Dawson Creek	37352	17760	56.3%	26.8%	-19592	-18.9%
Fort McMurray	1251718	974330	366.8%	285.5%	-277388	-17.4%
Winnipeg	-980017	-3459434	-6.8%	-24.0%	-2479417	-18.5%
GTA	51008880	40245680	48.2%	38.0%	-10763200	-6.9%
Auto VKT	**Future - Base**		**% Change from Base**		**Aggressive**	**% Change**
Year: 2050	**Trend**	**Aggressive**	**Trend**	**Aggressive**	**- Trend**	**from Trend**
Dawson Creek	82835	25720	124.8%	38.7%	-57115	-38.3%
Fort McMurray	1820001	1142315	533.3%	334.7%	-677686	-31.4%
Winnipeg	3108908	-293446	21.6%	-2.0%	-3402354	-19.4%
GTA	75530144	52822592	71.3%	49.9%	-22707552	-12.5%

Transit Trips	**Future - Base**		**% Change from Base**		**Aggressive**	**% Change**
Year: 2030	**Trend**	**Aggressive**	**Trend**	**Aggressive**	**- Trend**	**from Trend**
Dawson Creek	79	183	28.7%	66.5%	104	29.4%
Fort McMurray	3480	9307	86.6%	231.5%	5827	77.7%
Winnipeg	18289	99529	12.9%	70.4%	81240	50.9%
GTA	209484	998999	19.3%	91.8%	789515	60.9%
Transit Trips	**Future - Base**		**% Change from Base**		**Aggressive**	**% Change**
Year: 2050	**Trend**	**Aggressive**	**Trend**	**Aggressive**	**- Trend**	**from Trend**
Dawson Creek	164	362	59.6%	131.6%	198	45.1%
Fort McMurray	4651	15265	115.7%	379.7%	10614	122.4%
Winnipeg	58223	142547	41.2%	100.9%	84324	42.3%
GTA	334878	1742979	30.8%	160.2%	1408101	99.0%

Auto-Drive Trips	**Trips**			**Mode Share**		
Year: 2030	**Base**	**Trend**	**Aggressive**	**Base**	**Trend**	**Aggressive**
Dawson Creek	15477	20889	19844	67.37	67.35	64.32
Fort McMurray	79010	193457	175351	73.05	64.82	58.87
Winnipeg	1216020	1159663	1049752	68.51	69.65	62.94
GTA	8356430	10315262	9798607	74.16	74.29	69.14
Auto-Drive Trips	**Trips**			**Mode Share**		
Year: 2050	**Base**	**Trend**	**Aggressive**	**Base**	**Trend**	**Aggressive**
Dawson Creek	15477	26201	23200	67.37	67.2	62.13
Fort McMurray	79010	240855	199581	73.05	66.21	55.89
Winnipeg	1216020	1411194	1268823	68.51	69.65	62.46
GTA	8356430	12470382	10895992	74.16	74.69	66.39

POLICY IMPLICATIONS

From a policy perspective, the first key point to note is that, in the absence of very large increases in the real cost of auto travel, the auto remains the most attractive mode of travel for many trips, especially for off-peak non-work/school purposes. This is a reality of modern urban life that needs to be recognized in any policy discussion. In the model runs undertaken in this study, auto fuel prices (and, in the case of Toronto, road tolls) were kept fixed in real dollar terms, reflecting the assumption that changing vehicle technology would offset increasing fuel prices. Other assumptions, of course, are testable. It should be noted, however, that auto usage (and travel in general) historically has been quite cost inelastic; very significant increases in the real cost of auto travel would be required to significantly change the results presented here (cf. among others, Soberman and Miller, 1999).

In the scenarios analyzed the combined effects of:
- denser urban form and increased mixed uses of land;
- improved transit networks and services;
- reduced auto ownership levels (in response to higher densities and improved transit); and
- increased parking charges

were investigated. Points to note concerning each of these policy elements include the following.

- Parking charges were allowed to change within the moderate and aggressive land use scenarios in response to increasing employment densities.[2] Although not shown explicitly in this report, allowing parking charge to increase with density increases had significant impacts on reducing auto VKT and increasing transit usage. This is consistent with previous findings, in which it has been found that, contrary to auto fuel prices, auto usage is quite elastic with respect to parking prices and availability (cf. Miller, 1993). In general, parking pricing and supply represent extremely important policy levers for reducing auto usage, *providing that viable transit alternatives to the car exist*.
- Household vehicle ownership rates were allowed to change within the moderate and aggressive land use scenarios in response to increasing residential densities. This also had a significant impact on reducing auto VKT and increasing transit usage. This result is consistent with our understanding of travel behaviour: household auto ownership is obviously a major determinant of auto usage. A neglected aspect of many transportation policy discussions is the issue of reducing household auto ownership levels, in particular reducing the number of households owning two or more cars. In order to achieve reduced household auto ownership levels, both local neighbourhood design, which encourages non-motorized (walk/bike) trip-making, and comprehensive transit systems that provide attractive alternatives to the private car are required to provide a viable alternative to high levels of auto ownership. The current analysis most likely is conservative (i.e., underestimates) the impact of aggressive land use and transit network design on household auto ownership, since it only adjusted vehicle ownership rates as a simple function of neighbourhood residential densities. A more complete analysis would involve explicitly modelling household ownership levels as a function of household attributes, travel patterns, modal service levels, etc. While such models exist (e.g., Berkowitz, *et al*., 1987, 1990; Mohammadian and Miller, 2002; Roorda, *et al*., 2009), they are not currently operational within the GTAModel system (nor do such operational models exist within Canada) and so could not be used within this study.
- The combination of higher density, well designed, transit-oriented urban form with improved, high quality transit networks is essential to promoting increased transit usage. Higher densities in the absence of high quality transit will simply generate greater roadway congestion and will not be attractive to either households or firms. Improved transit without transit-supportive land uses will fail to attract sufficient patronage to be either a cost-effective investment or a viable alternative to the car. As demonstrated in

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[2] See Appendix II for a discussion of the model used to generate future year parking charges.

this study's results, strong investment in transit *combined with* significant improvements in transit-oriented urban form can yield significant improvements in transit usage. Key elements for such a strategy include:
  - Increased residential *and* employment densities. Concentration of employment within centres and along corridors that can be well served by transit is particularly important. Much of the planning debate tends to focus on residential densification. While residential densities are important, employment concentration is probably even more critical, since it is often the inability to access the "non-home" end of the trip that is the primary barrier to transit use.
  - Transit *network* design is critical to transit usage. A single transit line, no matter how good it's level of service (frequency, speed, reliability) can only serve a relatively small number of regional trips. A comprehensive network must exist that supports a wide variety of trip ends, both in terms of providing convenient (short walk) access to and egress from the transit system and in terms of providing comprehensive connectivity across the urban activity space. Transit networks must also be hierarchical in nature, with local "feeder" services providing fine-grained access to trip origins and destinations and connecting to higher-level "trunk" lines that can carry large volumes of people cost-effectively with high quality of service.
  - While not explicitly shown within this report, transit service levels are also critical to transit usage. Transit must be competitive with auto in terms of travel times, costs and reliability. Significant increases in transit usage were observed in model runs with increased transit frequencies and reduced transit in-vehicle travel times. In the results presented in this report, aggressive frequencies and transit travel times are assumed for the moderate and aggressive land use scenarios.
- Non-motorized (walk and bicycle) trip-making is another important alternative to the private car. While rather complex interactions between non-motorized and transit trip-making can occur as densities increase and transit systems are improved, usage of non-motorized modes generally increased in the moderate and aggressive land use scenarios in response to the residential and employment density increases assumed. Non-motorized trip-making is very sensitive to a variety of urban form factors, including:
  - Residential and employment densities.
  - The *mix* of uses within walking distance. Mono-use neighbourhoods will generate little non-motorized trip-making since there is "no place to go". A mixture of residential, commercial, public and other uses will encourage short-distance trip-making that can be accomplished by walking or biking.
  - The neighbourhood street layout and streetscape greatly influence non-motorized trip making. It must be feasible, safe and attractive for people to walk or bike.

  The analysis in this study may under-estimate the impact of urban densification on non-motorized travel within the case study cities. The current model does not take into account neighbourhood design details, nor the presence/absence of bike lanes.

While increased parking prices, reduced auto ownership levels and improved transit services are all important components of a more sustainable urban transportation system, the most crucial requirement is an urban form that significantly reduces auto dependency (in terms of both the number of auto trips and auto trip lengths) and that correspondingly increases transit ridership and usage of non-motorized modes of travel. In the presence of a supportive urban form, transit and non-motorized modes can provide attractive alternatives to the private car; in the absence of such an urban form, policies to significantly alter auto-based travel patterns are doomed to failure.

Creating the conditions for the emergence over time of such a sustainable urban form is, of course, not an easy task, especially given the advanced state of the auto-oriented urban form throughout Canadian cities. Possible policies to support sustainable urban form development might include the following.

- Zoning reform to permit and encourage medium/high density, mixed-use development. In many cases this requires removing zoning restrictions on mixed-use development and increased densities. It also requires rethinking green space requirements to ensure both that the resulting neighbourhood gross densities are transit/walk supportive and that the green spaces provided are actively usable and not just "wasted space" that reduces neighbourhood density without substantively improving neighbourhood amenities.
- Providing incentives to developers and land owners to undertake mixed-use, higher density development.
- Working actively with developers to improve their site plans. This can include emphasizing transit access/orientation and walkability in the site plan, as well as de-emphasizing auto-orientation (e.g., parking lots should be at the rear of the site, or underground, not fronting the street). Developers generally have standard templates/models for site development with which they are comfortable. In order to break the continuing recycling of unsustainable design practice, planning agencies need to pro-actively promote new, more sustainable models and they must be work with developers to get these new models applied in practice, first through "pilot tests" and then increasingly as new standard practice. This proactive, site-by-site improvement in design practice is critical in all situations, but particularly so with respect to:
    - Redevelopment of shopping centres and other major suburban activity centres. Many such sites are likely to undergo major redevelopment in the coming decade and beyond. These represent very important opportunities to improve suburban densities and transit-orientation.
    - Redevelopment of industrial brown field sites, both within central and suburban areas.
    - New green field development, which are currently exacerbating the problem by continuously adding low density, single use development to the urban fringe even as planners debate more sustainable planning principles.
- Recognizing the critical importance of employment density/concentration in the development of transit-supportive land use. The scattering of retail and office employment in dispersed patterns throughout suburban regions simply must be replaced by a more rational placement of commercial buildings in a manner that can be well served by transit. Zoning, incentives and education of both developers and businesses of the transportation implications of their location choices all can play role in this process.[3]

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[3] E.g., businesses often display a shocking lack of concern for the transportation accessibility of their employees in their firm location decision-making. Many anecdotal examples exist of firms relocating to a suburban location and only subsequently realizing that the new location is not accessible by transit.

- As illustrated in this study, parking policy plays a significant role in determining mode choice and auto usage. Desirable parking policies include:
    - Reducing/eliminating minimum parking requirements.
    - Where feasible, implementing maximum parking regulations.
    - Eliminating wherever possible free public parking.
    - Treating free parking at employment locations as a taxable benefit.
    - Changing property tax rules so that they no longer encourage the replacement of buildings with surface parking lots.
- Pro-active provision of public transit to both guide urban form development and to make feasible higher density development. Clear definition of high volume transit corridors and major transit-based "mobility hubs" are essential to provide the frame upon which higher density, mixed-use development can be built. Where possible, transit should "lead" land development so as to provide these necessary conditions for sustainable urban form development.

The urban form must be such that coherent, efficient transit networks can be cost-effectively constructed and operated, and so that efficient, transit-oriented travel patterns emerge. Travel patterns are self-organizing, emergent phenomena that are a function both of the spatial distribution of people and jobs/activities and the transportation networks and services connecting this spatial distribution. No matter how mixed-use and dense a neighbourhood may be, many people will continue to travel "out of neighbourhood" to jobs, schools, stores, etc. Thus, the overall urban form must be one that keeps the overall pattern of trip-making within "reasonable" bounds with respect to trip-lengths, auto usage, etc.

Sustainable planning must pro-actively occur at all levels of spatial scale: the region, the neighbourhood and the site. Not every site (or even neighbourhood) needs to be (or can be) mixed-use, high-density, etc. What is required in the first instance is an overall plan for how the urban region as a whole can sustainably function and evolve that provides a clear framework within each more micro-level plan and development can proceed. Without a clear master plan and firm guidelines, site-level decision-making will inevitably be ad hoc and result in very sub-optimal development patterns. That is, local concerns will over-whelm global ones, if the global concerns are not well and clearly articulated and enforced.

At the same time, however, the urban area evolves one site development project at a time: site by site the urban region develops and redevelops. Thus, site-by-site implementation of sustainable design principles and site-by-site assessment of the incremental contribution (positive or negative) to overall urban sustainability are required if sustainability is ever to be achieved on the ground within the realized, built city. To this end, it is arguable that every development/redevelopment project of any significant scope should be required to demonstrate the extent to which it will <u>reduce</u> auto VKT and <u>increase</u> transit (and/or non-motorized) modal share before it is approved. Similarly, it is arguable that the funding of transit (and possibly other infrastructure investments) by provincial and federal governments should be directly tied to on-the-ground development policies, plans and implementations that are verifiably transit-supportive and hence ensuring the effectiveness of the investment.

Without such explicit ties between development/investment on the one hand and verifiable sustainability improvements on the other, it is very possible (indeed, probably very likely) that our urban areas will continue to incrementally move away from sustainable urban form, rather than towards it. Certainly, this tends to be the case today in most Canadian urban regions, in which continuing low-density, single use development at the urban fringe, big-box, auto-oriented suburban retail complexes, migration of office floorspace from the urban centre to scattered suburban locations, and failure to invest effectively in dramatically improved transit services is all too often the norm.

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APPENDIX I

SUMMARY TRANSPORTATION MODEL SYSTEM RUN RESULTS

Table I.1: Summary Transportation Model System Run Results, Greater Toronto Area

Total Kilometres Travelled by Scenario

	Total VKT/PKT							Change from 2006						Change from Trend				Change from MOD	
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-Drive VKT	105870384	156879264	181400528	155127968	179716256	146116064	158692976	51008880	75530144	49257584	73845872	40245680	52822592	-1751296	-1684272	-10763200	-22707552	-9011904	-21023280
PKT: Local Bus	4496790	6881778	8675924	7554375	10706045	11341036	17318428	2384988	4179134	3057585	6209255	6844246	12821638	672597	2030121	4459258	8642504	3786661	6612383
PKT: Commuter Bus	268876	1237106	1703702	253175	385134	680612	905372	968230	1434826	-15701	116258	411736	636496	-983931	-1318568	-556494	-798330	427437	520238
PKT: Streetcar/LRT	513705	501926	531604	5487113	7481234	6048189	8964082	-11779	17899	4973408	6967529	5534484	8450377	4985187	6949630	5546263	8432478	561076	1482848
PKT: Subway	2905321	4257480	4319514	4947934	5842252	5287781	7062430	1352159	1414193	2042613	2936931	2382460	4157109	690454	1522738	1030301	2742916	339847	1220178
PKT: Commuter Rail	8367988	9072821	9632345	8225724	10198975	11495260	16450920	704833	1264357	-142264	1830987	3127272	8082932	-847097	566630	2422439	6818575	3269536	6251945
Walk WKT	742495	1096505	1595075	1116955	1499607	978611	1156789	354010	852580	374460	757112	236116	414294	20450	-95468	-117894	-438286	-138344	-342818
Bicycle BKT	125484	159983	316617	168807	231516	160241	204659	34499	191133	43323	106032	34757	79175	8824	-85101	258	-111958	-8566	-26857
Auto-Passenger VKT	5720506	7791960	9138825	8366456	10252780	7603285	8861624	2071454	3418319	2645950	4532274	1882779	3141118	574496	1113955	-188675	-277201	-763171	-1391156

	Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-Drive VKT	48.2%	71.3%	46.5%	69.8%	38.0%	49.9%	-1.1%	-0.9%	-6.9%	-12.5%	-5.8%	-11.7%
PKT: Local Bus	53.0%	92.9%	68.0%	138.1%	152.2%	285.1%	9.8%	23.4%	64.8%	99.6%	50.1%	61.8%
PKT: Commuter Bus	360.1%	533.6%	-5.8%	43.2%	153.1%	236.7%	-79.5%	-77.4%	-45.0%	-46.9%	168.8%	135.1%
PKT: Streetcar/LRT	-2.3%	3.5%	968.1%	1356.3%	1077.4%	1645.0%	993.2%	1307.3%	1105.0%	1586.2%	10.2%	19.8%
PKT: Subway	46.5%	48.7%	70.3%	101.1%	82.0%	143.1%	16.2%	35.3%	24.2%	63.5%	6.9%	20.9%
PKT: Commuter Rail	8.4%	15.1%	-1.7%	21.9%	37.4%	96.6%	-9.3%	5.9%	26.7%	70.8%	39.7%	61.3%
Walk WKT	47.7%	114.8%	50.4%	102.0%	31.8%	55.8%	1.9%	-6.0%	-10.8%	-27.5%	-12.4%	-22.9%
Bicycle BKT	27.5%	152.3%	34.5%	84.5%	27.7%	63.1%	5.5%	-26.9%	0.2%	-35.4%	-5.1%	-11.6%
Auto-Passenger VKT	36.2%	59.8%	46.3%	79.2%	32.9%	54.9%	7.4%	12.2%	-2.4%	-3.0%	-9.1%	-13.6%

Total Trips by Mode by Scenario

	24-Hour Trips							Change from 2006						Change from Trend				Change from MOD	
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	8356430	10315262	12470382	10101905	11953264	9798607	10895992	1958832	4113952	1745475	3596834	1442177	2539562	-213357	-517118	-516655	-1574390	-303298	-1057272
Auto-passenger	1009265	1244103	1449317	1251272	1484260	1212881	1385429	234838	440052	242007	474995	203616	376164	7169	34943	-31222	-63888	-38391	-98831
Transit-local	876368	1062472	1165257	1361646	1684592	1758263	2360442	186104	288889	485278	808224	881895	1484074	299174	519335	695791	1195185	396617	675850
Transit-prem	12831	36894	51449	12627	18136	11669	15330	24063	38618	-204	5305	-1162	2499	-24267	-33313	-25225	-36119	-958	-2806
GO-walk access	10389	7312	8991	30631	36508	215273	316497	-3077	-1398	20242	26119	204884	306108	23319	27517	207961	307506	184642	279989
Subway-auto	33222	37002	34363	38878	42161	51156	67035	3780	1141	5656	8939	17934	33813	1876	7798	14154	32672	12278	24874
GO-auto access	154953	153567	162581	105400	124468	50401	71438	-1386	7628	-49553	-30485	-104552	-83515	-48167	-38113	-103166	-91143	-54999	-53030
Walk	569520	661515	824912	713581	863880	732641	893692	91995	255392	144061	294360	163121	324172	52066	38968	71126	68780	19060	29812
Bicycle	45352	52277	80052	56635	72743	57611	73358	6925	34700	11283	27391	12259	28006	4358	-7309	5334	-6694	976	615
School bus	199947	314878	449746	316823	422966	283410	332614	114931	249799	116876	223019	83463	132667	1945	-26780	-31468	-117132	-33413	-90352
Total	11268277	13885282	16697050	13989398	16702978	14171912	16411827	2617005	5428773	2721121	5434701	2903635	5143550	104116	5928	286630	-285223	182514	-291151

	Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	23.4%	49.2%	20.9%	43.0%	17.3%	30.4%	-2.1%	-4.1%	-5.0%	-12.6%	-3.0%	-8.8%
Auto-passenger	23.3%	43.6%	24.0%	47.1%	20.2%	37.3%	0.6%	2.4%	-2.5%	-4.4%	-3.1%	-6.7%
Transit-local	21.2%	33.0%	55.4%	92.2%	100.6%	169.3%	28.2%	44.6%	65.5%	102.6%	29.1%	40.1%
Transit-prem	187.5%	301.0%	-1.6%	41.3%	-9.1%	19.5%	-65.8%	-64.7%	-68.4%	-70.2%	-7.6%	-15.5%
GO-walk access	-29.6%	-13.5%	194.8%	251.4%	1972.1%	2946.5%	318.9%	306.1%	2844.1%	3420.2%	602.8%	766.9%
Subway-auto	11.4%	3.4%	17.0%	26.9%	54.0%	101.8%	5.1%	22.7%	38.3%	95.1%	31.6%	59.0%
GO-auto access	-0.9%	4.9%	-32.0%	-19.7%	-67.5%	-53.9%	-31.4%	-23.4%	-67.2%	-56.1%	-52.2%	-42.6%
Walk	16.2%	44.8%	25.3%	51.7%	28.6%	56.9%	7.9%	4.7%	10.8%	8.3%	2.7%	3.5%
Bicycle	15.3%	76.5%	24.9%	60.4%	27.0%	61.8%	8.3%	-9.1%	10.2%	-8.4%	1.7%	0.8%
School bus	57.5%	124.9%	58.5%	111.5%	41.7%	66.4%	0.6%	-6.0%	-10.0%	-26.0%	-10.5%	-21.4%
Total	23.2%	48.2%	24.1%	48.2%	25.8%	45.6%	0.7%	0.0%	2.1%	-1.7%	1.3%	-1.7%

Overall Mode Shares (%) by Scenario

	24-Hour Mode Shares (%)							Change from 2006						Change from Trend				Change from MOD	
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	74.16	74.29	74.69	72.21	71.56	69.14	66.39	0.13	0.53	-1.95	-2.6	-5.02	-7.77	-2.08	-3.13	-5.15	-8.3	-3.07	-5.17
Auto-passenger	8.96	8.96	8.68	8.94	8.89	8.56	8.44	0	-0.28	-0.02	-0.07	-0.4	-0.52	-0.02	0.21	-0.4	-0.24	-0.38	-0.45
Transit-local	7.78	7.65	6.98	9.73	10.09	12.41	14.38	-0.13	-0.8	1.95	2.31	4.63	6.6	2.08	3.11	4.76	7.4	2.68	4.29
Transit-prem	0.11	0.27	0.31	0.09	0.11	0.08	0.09	0.16	0.2	-0.02	0	-0.03	-0.02	-0.18	-0.2	-0.19	-0.22	-0.01	-0.02
GO-walk access	0.09	0.05	0.05	0.22	0.22	1.52	1.93	-0.04	-0.04	0.13	0.13	1.43	1.84	0.17	0.17	1.47	1.88	1.3	1.71
Subway-auto	0.29	0.27	0.21	0.28	0.25	0.36	0.41	-0.02	-0.08	-0.01	-0.04	0.07	0.12	0.01	0.04	0.09	0.2	0.08	0.16
GO-auto access	1.38	1.11	0.97	0.75	0.75	0.36	0.44	-0.27	-0.41	-0.63	-0.63	-1.02	-0.94	-0.36	-0.22	-0.75	-0.53	-0.39	-0.31
Walk	5.05	4.76	4.94	5.1	5.17	5.17	5.45	-0.29	-0.11	0.05	0.12	0.12	0.4	0.34	0.23	0.41	0.51	0.07	0.28
Bicycle	0.4	0.38	0.48	0.4	0.44	0.41	0.45	-0.02	0.08	0	0.04	0.01	0.05	0.02	-0.04	0.03	-0.03	0.01	0.01
School bus	1.77	2.27	2.69	2.26	2.53	2	2.03	0.5	0.92	0.49	0.76	0.23	0.26	-0.01	-0.16	-0.27	-0.66	-0.26	-0.5

Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
2030TR	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
0.2%	0.7%	-2.6%	-3.5%	-6.8%	-10.5%	-2.8%	-4.2%	-6.9%	-11.1%	-4.3%	-7.2%
0.0%	-3.1%	-0.2%	-0.8%	-4.5%	-5.8%	-0.2%	2.4%	-4.5%	-2.8%	-4.3%	-5.1%
-1.7%	-10.3%	25.1%	29.7%	59.5%	84.8%	27.2%	44.6%	62.2%	106.0%	27.5%	42.5%
145.5%	181.8%	-18.2%	0.0%	-27.3%	-18.2%	-66.7%	-64.5%	-70.4%	-71.0%	-11.1%	-18.2%
-44.4%	-44.4%	144.4%	144.4%	1588.9%	2044.4%	340.0%	340.0%	2940.0%	3760.0%	590.9%	777.3%
-6.9%	-27.6%	-3.4%	-13.8%	24.1%	41.4%	3.7%	19.0%	33.3%	95.2%	28.6%	64.0%
-19.6%	-29.7%	-45.7%	-45.7%	-73.9%	-68.1%	-32.4%	-22.7%	-67.6%	-54.6%	-52.0%	-41.3%
-5.7%	-2.2%	1.0%	2.4%	2.4%	7.9%	7.1%	4.7%	8.6%	10.3%	1.4%	5.4%
-5.0%	20.0%	0.0%	10.0%	2.5%	12.5%	5.3%	-8.3%	7.9%	-6.2%	2.5%	2.3%
28.2%	52.0%	27.7%	42.9%	13.0%	14.7%	-0.4%	-5.9%	-11.9%	-24.5%	-11.5%	-19.8%

Table I.2: Summary Transportation Model System Run Results, Winnipeg

Total Kilometres Travelled by Scenario

	Total VKT/PKT						
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**
Auto-Drive VKT	14384636	13404619	17493544	12480839	15219845	10925202	14091190
PKT: Local Bus	1251487	1134935	1514914	1719222	2109882	1572729	1884603
PKT: Commuter Bus	0	0	0	0	0	0	0
PKT: Streetcar/LRT	0	0	0	0	0	14639	25545
PKT: Subway	0	0	0	0	0	0	0
PKT: Commuter Rail	0	0	0	0	0	0	0
Walk WKT	67958	80115	94017	104088	135111	117437	155766
Bicycle BKT	32466	39145	48067	53564	71158	60430	83777
Auto-Passenger VKT	3673929	1289588	1666130	1314486	1652292	1217816	1570106

	Change from 2006						Change from Trend				Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-Drive VKT	-980017	3108908	-1903797	835209	-3459434	-293446	-923780	-2273699	-2479417	-3402354	-1555637	-1128655
PKT: Local Bus	-116552	263427	467735	858395	321242	633116	584287	594968	437794	369689	-146493	-225279
PKT: Commuter Bus	0	0	0	0	0	0	0	0	0	0	0	0
PKT: Streetcar/LRT	0	0	0	0	14639	25545	0	0	14639	25545	14639	25545
PKT: Subway	0	0	0	0	0	0	0	0	0	0	0	0
PKT: Commuter Rail	0	0	0	0	0	0	0	0	0	0	0	0
Walk WKT	12157	26059	36130	67153	49479	87808	23973	41094	37322	61749	13349	20655
Bicycle BKT	6679	15601	21098	38692	27964	51311	14419	23091	21285	35710	6866	12619
Auto-Passenger VKT	-2384341	-2007799	-2359443	-2021637	-2456113	-2103823	24898	-13838	-71772	-96024	-96670	-82186

	Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-Drive VKT	-6.8%	21.6%	-13.2%	5.8%	-24.0%	-2.0%	-6.9%	-13.0%	-18.5%	-19.4%	-12.5%	-7.4%
PKT: Local Bus	-9.3%	21.0%	37.4%	68.6%	25.7%	50.6%	51.5%	39.3%	38.6%	24.4%	-8.5%	-10.7%
PKT: Commuter Bus	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PKT: Streetcar/LRT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PKT: Subway	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PKT: Commuter Rail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Walk WKT	17.9%	38.3%	53.2%	98.8%	72.8%	129.2%	29.9%	43.7%	46.6%	65.7%	12.8%	15.3%
Bicycle BKT	20.6%	48.1%	65.0%	119.2%	86.1%	158.0%	36.8%	48.0%	54.4%	74.3%	12.8%	17.7%
Auto-Passenger VKT	-64.9%	-54.6%	-64.2%	-55.0%	-66.9%	-57.3%	1.9%	-0.8%	-5.6%	-5.8%	-7.4%	-5.0%

Total Trips by Mode by Scenario

	24-Hour Trips						
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**
Auto-drive	1216020	1159663	1411194	1061178	1284515	1049752	1268823
Auto-passenger	270081	261637	317238	258386	317654	259259	327440
Transit-local	141292	159581	199515	240309	290630	240821	283839
Transit-prem	0	0	0	0	0	0	0
GO-walk access	0	0	0	0	0	0	0
Subway-auto	0	0	0	0	0	0	0
GO-auto access	0	0	0	0	0	0	0
Walk	131989	70374	81697	89474	110470	96894	122898
Bicycle	15550	13682	16427	18526	24293	21256	28537
School bus	0	0	0	0	0	0	0
Total	1774931	1664936	2026070	1667874	2027563	1667982	2031537

	Change from 2006						Change from Trend				Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	-56357	195174	-154842	68495	-166268	52803	-98485	-126679	-109911	-142371	-11426	-15692
Auto-passenger	-8444	47157	-11695	47573	-10822	57359	-3251	416	-2378	10202	873	9786
Transit-local	18289	58223	99017	149338	99529	142547	80728	91115	81240	84324	512	-6791
Transit-prem	0	0	0	0	0	0	0	0	0	0	0	0
GO-walk access	0	0	0	0	0	0	0	0	0	0	0	0
Subway-auto	0	0	0	0	0	0	0	0	0	0	0	0
GO-auto access	0	0	0	0	0	0	0	0	0	0	0	0
Walk	-61615	-50292	-42515	-21519	-35095	-9091	19100	28773	26520	41201	7420	12428
Bicycle	-1868	877	2976	8743	5706	12987	4844	7866	7574	12110	2730	4244
School bus	0	0	0	0	0	0	0	0	0	0	0	0
Total	-109995	251139	-107057	252632	-106949	256606	2938	1493	3046	5467	108	3974

	Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	-4.6%	16.1%	-12.7%	5.6%	-13.7%	4.3%	-8.5%	-9.0%	-9.5%	-10.1%	-1.1%	-1.2%
Auto-passenger	-3.1%	17.5%	-4.3%	17.6%	-4.0%	21.2%	-1.2%	0.1%	-0.9%	3.2%	0.3%	3.1%
Transit-local	12.9%	41.2%	70.1%	105.7%	70.4%	100.9%	50.6%	45.7%	50.9%	42.3%	0.2%	-2.3%
Transit-prem	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GO-walk access	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Subway-auto	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GO-auto access	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Walk	-46.7%	-38.1%	-32.2%	-16.3%	-26.6%	-6.9%	27.1%	35.2%	37.7%	50.4%	8.3%	11.3%
Bicycle	-12.0%	5.6%	19.1%	56.2%	36.7%	83.5%	35.4%	47.9%	55.4%	73.7%	14.7%	17.5%
School bus	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	-6.2%	14.1%	-6.0%	14.2%	-6.0%	14.5%	0.2%	0.1%	0.2%	0.3%	0.0%	0.2%

Overall Mode Shares (%) by Scenario

	24-Hour Mode Shares (%)						
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**
Auto-drive	68.51	69.65	69.65	63.62	63.35	62.94	62.46
Auto-passenger	15.22	15.71	15.66	15.49	15.67	15.54	16.12
Transit-local	7.96	9.58	9.85	14.41	14.33	14.44	13.97
Transit-prem	0	0	0	0	0	0	0
GO-walk access	0	0	0	0	0	0	0
Subway-auto	0	0	0	0	0	0	0
GO-auto access	0	0	0	0	0	0	0
Walk	7.44	4.23	4.03	5.36	5.45	5.81	6.05
Bicycle	0.88	0.82	0.81	1.11	1.2	1.27	1.4
School bus	0	0	0	0	0	0	0

	Change from 2006						Change from Trend				Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	1.14	1.14	-4.89	-5.16	-5.57	-6.05	-6.03	-6.3	-6.71	-7.19	-0.68	-0.89
Auto-passenger	0.49	0.44	0.27	0.45	0.32	0.9	-0.22	0.01	-0.17	0.46	0.05	0.45
Transit-local	1.62	1.89	6.45	6.37	6.48	6.01	4.83	4.48	4.86	4.12	0.03	-0.36
Transit-prem	0	0	0	0	0	0	0	0	0	0	0	0
GO-walk access	0	0	0	0	0	0	0	0	0	0	0	0
Subway-auto	0	0	0	0	0	0	0	0	0	0	0	0
GO-auto access	0	0	0	0	0	0	0	0	0	0	0	0
Walk	-3.21	-3.41	-2.08	-1.99	-1.63	-1.39	1.13	1.42	1.58	2.02	0.45	0.6
Bicycle	-0.06	-0.07	0.23	0.32	0.39	0.52	0.29	0.39	0.45	0.59	0.16	0.2
School bus	0	0	0	0	0	0	0	0	0	0	0	0

Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
2030TR	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
1.7%	1.7%	-7.1%	-7.5%	-8.1%	-8.8%	-8.7%	-9.0%	-9.6%	-10.3%	-1.1%	-1.4%
3.2%	2.9%	1.8%	3.0%	2.1%	5.9%	-1.4%	0.1%	-1.1%	2.9%	0.3%	2.9%
20.4%	23.7%	81.0%	80.0%	81.4%	75.5%	50.4%	45.5%	50.7%	41.8%	0.2%	-2.5%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
-43.1%	-45.8%	-28.0%	-26.7%	-21.9%	-18.7%	26.7%	35.2%	37.4%	50.1%	8.4%	11.0%
-6.8%	-8.0%	26.1%	36.4%	44.3%	59.1%	35.4%	48.1%	54.9%	72.8%	14.4%	16.7%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.3: Summary Transportation Model System Run Results, Dawson Creek

Total Kilometres Travelled by Scenario

	Total VKT/PKT							Change from 2006						Change from Trend				Change from MOD	
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-Drive VKT	66388	103740	149223	97718	127521	84148	92108	37352	82835	31330	61133	17760	25720	-6022	-21702	-19592	-57115	-13570	-35413
PKT: Local Bus	87	114	146	140	172	152	210	27	59	53	85	65	123	26	26	38	64	12	38
PKT: Commuter Bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PKT: Streetcar/LRT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PKT: Subway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PKT: Commuter Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walk WKT	1044	1372	1752	1618	2007	1623	2085	328	708	574	963	579	1041	246	255	251	333	5	78
Bicycle BKT	98	206	312	233	361	241	315	108	214	135	263	143	217	27	49	35	3	8	-46
Auto-Passenger VKT	900	4613	7860	4000	7249	3959	4404	3713	6960	3100	6349	3059	3504	-613	-611	-654	-3456	-41	-2845

	Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-Drive VKT	56.3%	124.8%	47.2%	92.1%	26.8%	38.7%	-5.8%	-14.5%	-18.9%	-38.3%	-13.9%	-27.8%
PKT: Local Bus	31.0%	67.8%	60.9%	97.7%	74.7%	141.4%	22.8%	17.8%	33.3%	43.8%	8.6%	22.1%
PKT: Commuter Bus	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PKT: Streetcar/LRT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PKT: Subway	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PKT: Commuter Rail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Walk WKT	31.4%	67.8%	55.0%	92.2%	55.5%	99.7%	17.9%	14.6%	18.3%	19.0%	0.3%	3.9%
Bicycle BKT	110.2%	218.4%	137.8%	268.4%	145.9%	221.4%	13.1%	15.7%	17.0%	1.0%	3.4%	-12.7%
Auto-Passenger VKT	412.6%	773.3%	344.4%	705.4%	339.9%	389.3%	-13.3%	-7.8%	-14.2%	-44.0%	-1.0%	-39.2%

Total Trips by Mode by Scenario

	24-Hour Trips							Change from 2006						Change from Trend				Change from MOD	
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	15477	20889	26201	20006	25057	19844	23200	5412	10724	4529	9580	4367	7723	-883	-1144	-1045	-3001	-162	-1857
Auto-passenger	2953	4244	5458	4128	5404	4168	5042	1291	2505	1175	2451	1215	2089	-116	-54	-76	-416	40	-362
Transit-local	275	354	439	423	522	458	637	79	164	148	247	183	362	69	83	104	198	35	115
Transit-prem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GO-walk access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subway-auto	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GO-auto access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walk	3966	5113	6361	5765	7277	5871	7765	1147	2395	1799	3311	1905	3799	652	916	758	1404	106	488
Bicycle	302	413	530	487	638	509	696	111	228	185	336	207	394	74	108	96	166	22	58
School bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	22971	31013	38989	30809	38897	30850	37339	8042	16018	7838	15926	7879	14368	-204	-92	-163	-1650	41	-1558

	Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	35.0%	69.3%	29.3%	61.9%	28.2%	49.9%	-4.2%	-4.4%	-5.0%	-11.5%	-0.8%	-7.4%
Auto-passenger	43.7%	84.8%	39.8%	83.0%	41.1%	70.7%	-2.7%	-1.0%	-1.8%	-7.6%	1.0%	-6.7%
Transit-local	28.7%	59.6%	53.8%	89.8%	66.5%	131.6%	19.5%	18.9%	29.4%	45.1%	8.3%	22.0%
Transit-prem	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GO-walk access	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Subway-auto	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GO-auto access	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Walk	28.9%	60.4%	45.4%	83.5%	48.0%	95.8%	12.8%	14.4%	14.8%	22.1%	1.8%	6.7%
Bicycle	36.8%	75.5%	61.3%	111.3%	68.5%	130.5%	17.9%	20.4%	23.2%	31.3%	4.5%	9.1%
School bus	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	35.0%	69.7%	34.1%	69.3%	34.3%	62.5%	-0.7%	-0.2%	-0.5%	-4.2%	0.1%	-4.0%

Overall Mode Shares (%) by Scenario

	24-Hour Mode Shares (%)							Change from 2006						Change from Trend				Change from MOD	
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	67.37	67.35	67.2	64.94	64.42	64.32	62.13	-0.02	-0.17	-2.43	-2.95	-3.05	-5.24	-2.41	-2.78	-3.03	-5.07	-0.62	-2.29
Auto-passenger	12.85	13.69	14	13.4	13.89	13.51	13.5	0.84	1.15	0.55	1.04	0.66	0.65	-0.29	-0.11	-0.18	-0.5	0.11	-0.39
Transit-local	1.2	1.14	1.13	1.37	1.34	1.48	1.7	-0.06	-0.07	0.17	0.14	0.28	0.5	0.23	0.21	0.34	0.57	0.11	0.36
Transit-prem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GO-walk access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subway-auto	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GO-auto access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walk	17.27	16.49	16.31	18.71	18.71	19.03	20.8	-0.78	-0.96	1.44	1.44	1.76	3.53	2.22	2.4	2.54	4.49	0.32	2.09
Bicycle	1.31	1.33	1.36	1.58	1.64	1.65	1.86	0.02	0.05	0.27	0.33	0.34	0.55	0.25	0.28	0.32	0.5	0.07	0.22
School bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
2030TR	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
0.0%	-0.3%	-3.6%	-4.4%	-4.5%	-7.8%	-3.6%	-4.1%	-4.5%	-7.5%	-1.0%	-3.6%
6.5%	8.9%	4.3%	8.1%	5.1%	5.1%	-2.1%	-0.8%	-1.3%	-3.6%	0.8%	-2.8%
-5.0%	-5.8%	14.2%	11.7%	23.3%	41.7%	20.2%	18.6%	29.8%	50.4%	8.0%	26.9%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
-4.5%	-5.6%	8.3%	8.3%	10.2%	20.4%	13.5%	14.7%	15.4%	27.5%	1.7%	11.2%
1.5%	3.8%	20.6%	25.2%	26.0%	42.0%	18.8%	20.6%	24.1%	36.8%	4.4%	13.4%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table I.4: Summary Transportation Model System Run Results, Fort McMurray

Total Kilometres Travelled by Scenario

	Total VKT/PKT							Change from 2006						Change from Trend				Change from MOD	
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-Drive VKT	341259	1592977	2161260	1376044	1849485	1315589	1483574	1251718	1820001	1034785	1508226	974330	1142315	-216933	-311775	-277388	-677686	-60455	-365911
PKT: Local Bus	14195	37987	43625	52187	60159	4504	7894	23792	29430	37992	45964	-9691	-6301	14200	16534	-33483	-35731	-47683	-52265
PKT: Commuter Bus	43770	53910	90639	48691	56689	42465	41834	10140	46869	4921	12919	-1305	-1936	-5219	-33950	-11445	-48805	-6226	-14855
PKT: Streetcar/LRT	0	0	0	0	0	56781	75888	0	0	0	0	56781	75888	0	0	56781	75888	56781	75888
PKT: Subway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PKT: Commuter Rail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walk WKT	6629	15043	15401	15181	18403	22592	30339	8414	8772	8552	11774	15963	23710	138	3002	7549	14938	7411	11936
Bicycle BKT	3450	99882	97690	94040	123421	112793	185133	96432	94240	90590	119971	109343	181683	-5842	25731	12911	87443	18753	61712
Auto-Passenger VKT	63657	140860	174502	159381	199876	134339	149577	77203	110845	95724	136219	70682	85920	18521	25374	-6521	-24925	-25042	-50299

	Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-Drive VKT	366.8%	533.3%	303.2%	442.0%	285.5%	334.7%	-13.6%	-14.4%	-17.4%	-31.4%	-4.4%	-19.8%
PKT: Local Bus	167.6%	207.3%	267.6%	323.8%	-68.3%	-44.4%	37.4%	37.9%	-88.1%	-81.9%	-91.4%	-86.9%
PKT: Commuter Bus	23.2%	107.1%	11.2%	29.5%	-3.0%	-4.4%	-9.7%	-37.5%	-21.2%	-53.8%	-12.8%	-26.2%
PKT: Streetcar/LRT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PKT: Subway	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PKT: Commuter Rail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Walk WKT	126.9%	132.3%	129.0%	177.6%	240.8%	357.7%	0.9%	19.5%	50.2%	97.0%	48.8%	64.9%
Bicycle BKT	2795.1%	2731.6%	2625.8%	3477.4%	3169.4%	5266.2%	-5.8%	26.3%	12.9%	89.5%	19.9%	50.0%
Auto-Passenger VKT	121.3%	174.1%	150.4%	214.0%	111.0%	135.0%	13.1%	14.5%	-4.6%	-14.3%	-15.7%	-25.2%

Total Trips by Mode by Scenario

	24-Hour Trips							Change from 2006						Change from Trend				Change from MOD	
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	79010	193457	240855	185651	223522	175351	199581	114447	161845	106641	144512	96341	120571	-7806	-17333	-18106	-41274	-10300	-23941
Auto-passenger	16683	41056	50255	41804	50462	40855	47688	24373	33572	25121	33779	24172	31005	748	207	-201	-2567	-949	-2774
Transit-local	4020	7500	8671	9848	12839	13327	19285	3480	4651	5828	8819	9307	15265	2348	4168	5827	10614	3479	6446
Transit-prem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GO-walk access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subway-auto	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GO-auto access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walk	7092	37668	44792	44044	53125	46461	58179	30576	37700	36952	46033	39369	51087	6376	8333	8793	13387	2417	5054
Bicycle	1354	18769	19191	18773	23997	21881	32337	17415	17837	17419	22643	20527	30983	4	4806	3112	13146	3108	8340
School bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	108159	298451	363764	300120	363945	297875	357069	190292	255605	191961	255786	189716	248910	1669	181	-576	-6695	-2245	-6876

	Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
Mode	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	144.9%	204.8%	135.0%	182.9%	121.9%	152.6%	-4.0%	-7.2%	-9.4%	-17.1%	-5.5%	-10.7%
Auto-passenger	146.1%	201.2%	150.6%	202.5%	144.9%	185.8%	1.8%	0.4%	-0.5%	-5.1%	-2.3%	-5.5%
Transit-local	86.6%	115.7%	145.0%	219.4%	231.5%	379.7%	31.3%	48.1%	77.7%	122.4%	35.3%	50.2%
Transit-prem	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GO-walk access	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Subway-auto	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GO-auto access	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Walk	431.1%	531.6%	521.0%	649.1%	555.1%	720.3%	16.9%	18.6%	23.3%	29.9%	5.5%	9.5%
Bicycle	1286.2%	1317.4%	1286.5%	1672.3%	1516.0%	2288.3%	0.0%	25.0%	16.6%	68.5%	16.6%	34.8%
School bus	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	175.9%	236.3%	177.5%	236.5%	175.4%	230.1%	0.6%	0.0%	-0.2%	-1.8%	-0.7%	-1.9%

Overall Mode Shares (%) by Scenario

	24-Hour Mode Shares (%)							Change from 2006						Change from Trend				Change from MOD	
Mode	**2006**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030TR**	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
Auto-drive	73.05	64.82	66.21	61.86	61.42	58.87	55.89	-8.23	-6.84	-11.19	-11.63	-14.18	-17.16	-2.96	-4.79	-5.95	-10.32	-2.99	-5.53
Auto-passenger	15.42	13.76	13.82	13.93	13.87	13.72	13.36	-1.66	-1.6	-1.49	-1.55	-1.7	-2.06	0.17	0.05	-0.04	-0.46	-0.21	-0.51
Transit-local	3.72	2.51	2.38	3.28	3.53	4.47	5.4	-1.21	-1.34	-0.44	-0.19	0.75	1.68	0.77	1.15	1.96	3.02	1.19	1.87
Transit-prem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GO-walk access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subway-auto	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GO-auto access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walk	6.56	12.62	12.31	14.68	14.6	15.6	16.29	6.06	5.75	8.12	8.04	9.04	9.73	2.06	2.29	2.98	3.98	0.92	1.69
Bicycle	1.25	6.29	5.28	6.26	6.59	7.35	9.06	5.04	4.03	5.01	5.34	6.1	7.81	-0.03	1.31	1.06	3.78	1.09	2.47
School bus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Per Cent Change from 2006						Per Cent Change from Trend				% Change from MOD	
2030TR	**2050TR**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030MOD**	**2050MOD**	**2030DG**	**2050DG**	**2030DG**	**2050DG**
-11.3%	-9.4%	-15.3%	-15.9%	-19.4%	-23.5%	-4.6%	-7.2%	-9.2%	-15.6%	-4.8%	-9.0%
-10.8%	-10.4%	-9.7%	-10.1%	-11.0%	-13.4%	1.2%	0.4%	-0.3%	-3.3%	-1.5%	-3.7%
-32.5%	-36.0%	-11.8%	-5.1%	20.2%	45.2%	30.7%	48.3%	78.1%	126.9%	36.3%	53.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
92.4%	87.7%	123.8%	122.6%	137.8%	148.3%	16.3%	18.6%	23.6%	32.3%	6.3%	11.6%
403.2%	322.4%	400.8%	427.2%	488.0%	624.8%	-0.5%	24.8%	16.9%	71.6%	17.4%	37.5%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

APPENDIX II

DAILY PARKING COST MODEL

In order to develop a simple model of average daily parking cost that incorporates sensitivity to land use assumptions, observed 2006 daily parking charges in the old City of Toronto were regressed versus a variety of density and other spatial variables. The overall best model found regressed the natural logarithm of average daily parking cost versus the natural logarithm of employment density and straight-line distance from the Central Business District (CBD) as explanatory variables:

$$\mathrm{lpkcst}(i) = 0.965 + 0.293*\mathrm{ledens}(i) + 0.00740*\mathrm{dist}(i) \tag{II.1}$$

where:
lpkcst(i) = Natural logarithm of average daily parking cost ($2006) in zone i
ledens(i) = natural logarithm of employment density (jobs/acre) in zone i
dist(i) = Straight-line distance (km) from the centroid of zone i to the CBD centroid

or,

$$\mathrm{pkcst}(i) = \exp(0.965 + 0.293*\mathrm{ledens}(i) + 0.00740*\mathrm{dist}(i)) \tag{II.2}$$

Table II.1: Parking Cost Model Regression

Regression Statistics	
Multiple R	0.652327195
R Square	0.425530769
Adjusted R	0.41232458
Standard E	0.354614505
Observatio	90

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regressior	2	8.103944174	4.051972087	32.22207122	3.37369E-11
Residual	87	10.94037591	0.125751447		
Total	89	19.04432008			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.964971262	0.185999874	5.188021041	1.37207E-06	0.595276379	1.334666145	0.595276379	1.334666145
ledens	0.293439537	0.043796099	6.700129529	1.97506E-09	0.206390049	0.380489024	0.206390049	0.380489024
dist	0.007395201	0.012688245	0.582838733	0.561509543	-0.01782406	0.032614461	-0.01782406	0.032614461

Table II.1 presents the regression parameter estimates and goodness-of-fit statistics. All parameters have the expected (positive) sign. The distance parameter is not statistically significant, but it is retained in the model both because theoretically it is expected that parking prices should decline as one moves away from the city centre and because the overall model performance appears to improve when it is retained in the equation. The goodness-of-fit of the model (adjusted $R^2 = 0.41$) is not exceptional, but acceptable given the simplicity of the model.

Figure II.1 presents residual and fit plots for each explanatory variable. These appear to be acceptable. Figure II.2 then plots observed versus predicted parking costs (i.e., using equation II.2 to compute predicted parking costs). While considerable scatter clearly exists in the data, the overall trend in parking costs is captured in a reasonable way by the model.

Figure II.1: Regression Residual and Fit Plots by Explanatory Variable

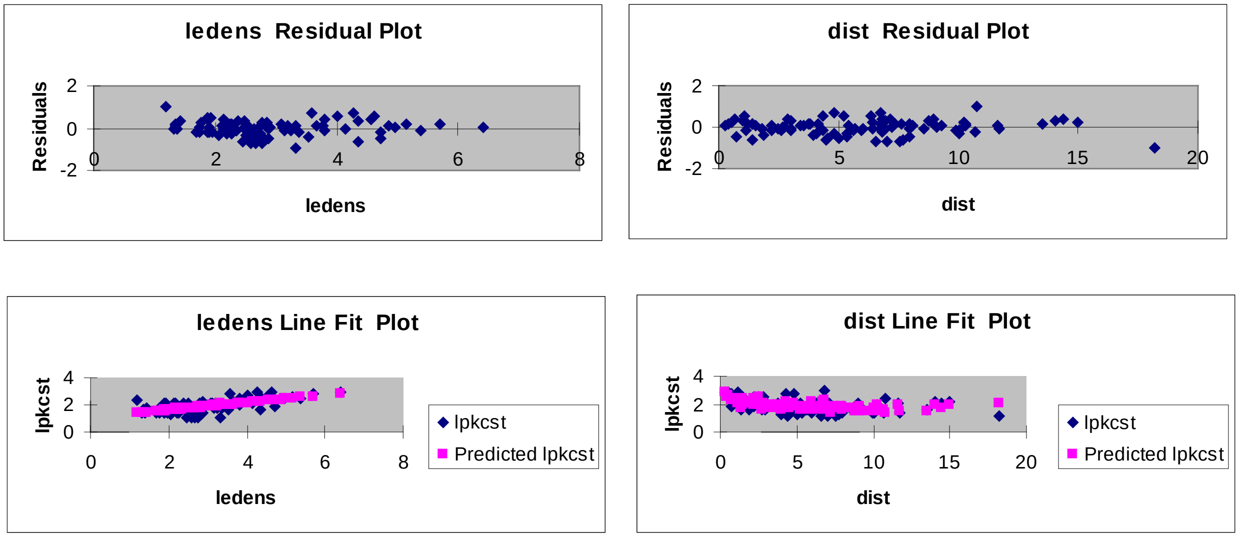
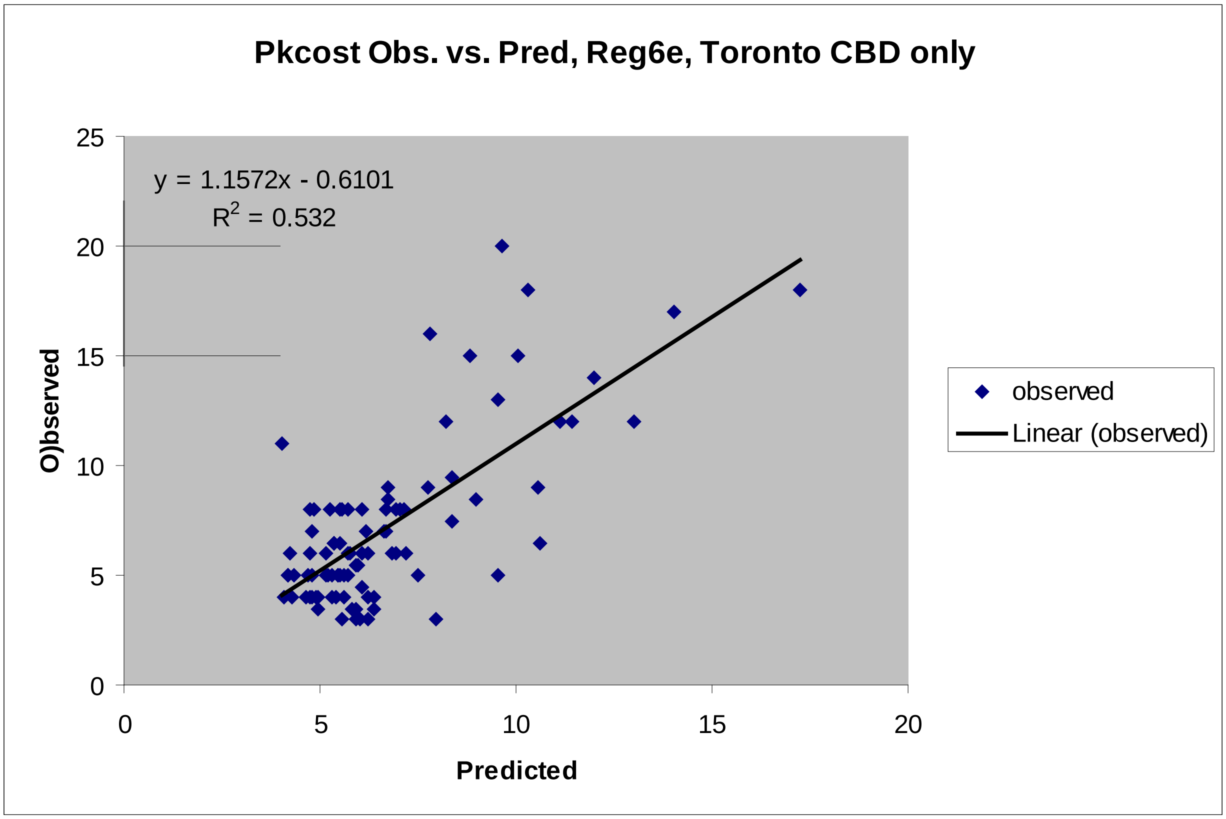


Figure II.2: Observed Versus Predicted Parking Costs



Clearly, the determination of zonal parking costs is a much more complicated function of supply, demand and regulation than is captured in this very simple model. What was desired for the purposes of this study, however, is a simple procedure for allowing parking costs to vary in a sensible way with changes in urban form/density. This model provides this capability.

In order to ensure that:

- Predicted parking costs did not exceed unreasonable minimum of maximum values, and
- Predicted parking costs were not less than base year values

the final algorithm used for computing parking costs is:

```
pknew(i) = exp(0.965 + 0.293*ledens(i) + 0.00740*dist(i))

if (pknew(i) > pkmax ) then
    pknew(i)= pkmax
else if (pknew(i) < pkmin) then
    Pknew(i) = pkmin

if (pknew(i) < pkold(i)) then
    pknew(i)= pkold(i)
```

where:

pknew(i) = New parking cost in zone i
pkold(i) = Base year parking cost in zone i
pkmax = Maximum allowed parking cost
pkmin = Minimim allowed parking cost

In all QUEST simulation runs, pkmax = $99.99 and pkmin = $2.00.

This parking cost model was applied to all moderate and aggressive scenarios in the four case study urban areas.

Table II.2 shows example summary results of applying this model for the GTA 2050 aggressive land use scenario run. As can be seen, it results in parking costs increasing significantly as a result of the urban density increases assumed within this scenario.

Table II.2: Summary Parking Model Results, GTA 2050 Aggressive Scenario

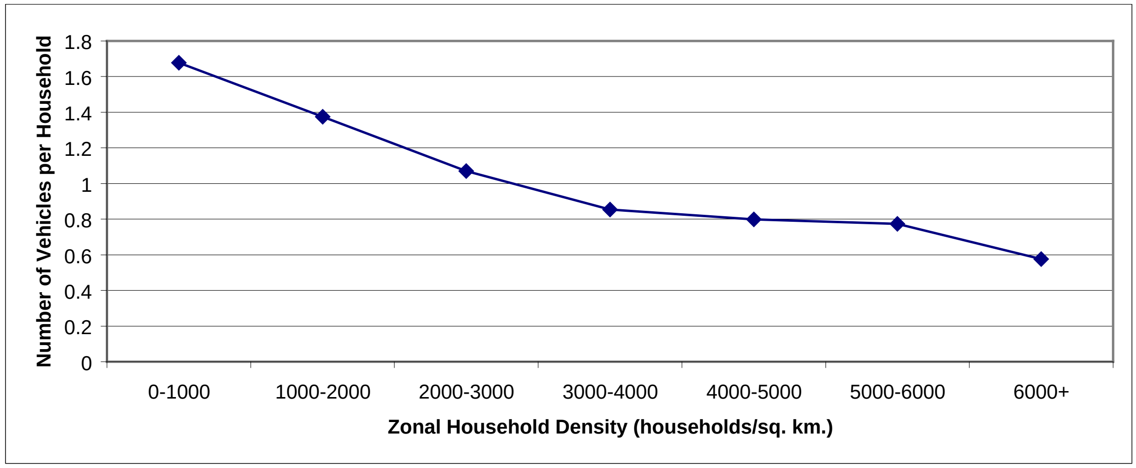
Zone Category	No. of Zones	Average Parking Cost ($)
Original AvgCost; pkcost > 0	132	6.4
New AvgCost; org. pkcost > 0	132	7.41
New AvgCost; org. pkcost = 0	1713	3.83
Original AvgCost; all zones	1845	0.46
New AvgCost; all zones	1845	4.09

APPENDIX III

HOUSEHOLD AUTO OWNERSHIP MODEL

In order to develop a simple model of household auto ownership levels that incorporates sensitivity to land use assumptions, the observed relationship between zonal average household auto ownership levels and household density levels in the GTA shown in Figure III.1.

Figure III.1: GTA Household Auto Ownership Levels versus Household Density



This graph suggests the following simple piece-wise linear relationship between household auto ownership and residential density:

$$n(d) = 1.84 - 0.283*d \qquad d \# 3.5 \qquad \text{(III.1a)}$$

$$= 1.03 - 0.050*d \qquad d > 3.5 \qquad \text{(III.1b)}$$

$n(d)$ = Zonal average vehicles per household
d = Zonal household density (10^3 households / km^2)

GTAModel, however, does not directly use average number of vehicles per household. Rather, what is required is the fraction of persons who belong to household with zero, one or two or more vehicles. Thus, a procedure to convert the zonal average number of cars per household into the zonal fractions of households with zero, one or two-plus cars is required. In order to construct such a procedure first define the following:

$n(t)$ = Average number of vehicles per household at time t in zone i (zonal subscript is suppressed for simplicity of presentation
$p_k(t)$= Probability or a household owning k cars at time t, k=0,1,2+
$d(t)$ = Zone density at time t (10^3 households / km^2)
x = Average number of cars in 2+ car households (based on TTS data, this is assumed to be 2.28 cars)

b = Base year (2006)
α = Slope in equation III.1= 0.283 if d(t) # 3.5; = 0.050 otherwise

Then equation III.1 can be rearranged to yield:

$$n(t) = n(b) - \alpha[d(t) - d(b)] \qquad \text{(III.2)}$$

Also n(t) must satisfy the constraint:

$$n(t) = p_1(t) + x\, p_2(t) \qquad \text{(III.3)}$$

If we assume that the ratio of zero-car to one-car households remains constant over time, then:

$$p_0(t)/ p_1(t) = p_0(b)/ p_1(b) \quad \forall\ t \qquad \text{(III.4a)}$$

$$\Psi \qquad p_0(t) = [p_0(b)/ p_1(b)]\, p_1(t)$$

$$p_0(t) = \beta\, p_1(t) \qquad \text{(III.4b)}$$

where β equals the base year ratio $[p_0(b)/ p_1(b)]$. By definition:

$$p_2(t) = 1 - p_0(t) - p_1(t) \qquad \text{(III.5)}$$

Substituting III.4b into III.5 yields (upon simplifying):

$$p_2(t) = 1 - (1+\beta)\, p_1(t) \qquad \text{(III.6)}$$

And substituting III.6 into III.3 and simplifying yields:

$$p_1(t) = [n(t) - x] / [1 - x(1+\beta)] \qquad \text{(III.7)}$$

Thus, given equations III.1 through III.7, the procedure for updating future year zonal auto ownership distributions given known base year distributions is as follows:

1. Compute the future year average cars per household using equation III.2.
2. Compute the future year distribution of zero-, one- and two-plus-car households given the future year average number of cars per household using equations III.7, III.6 and III.4b.[4]

Table III.1 illustrates the impact of the model by showing overall changes in average auto ownership levels for workers and non-workers for the 2050 aggressive land use scenarios for each of the four case study cities. As can be seen, significant decreases in average auto ownership is generated by the model in response to increased residential densities.

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[4] The actual algorithm is somewhat more complicated than this in that it must account for: (1) converting planning district auto ownership distributions to the zone level; (2) separate distributions are defined for workers and non-workers, further disaggregated by socio-economic attributes; and (3) various special cases that require special treatment.

Table III.1: Changes in Urban Area Wide Auto Ownership Levels for the 2050 Aggressive Land Use Scenarios

	Workers				Non-Workers			
Urban Region	**Base**	**2050DG**	**Delta**	**% Change**	**Base**	**2050DG**	**Delta**	**% Change**
Dawson Creek	1.41	1.19	-0.22	-15.6%	1.61	1.43	-0.19	-11.8%
Fort McMurray	1.41	1.17	-0.24	-17.0%	1.61	1.41	-0.2	-12.4%
Winnipeg	1.41	1.04	-0.37	-26.2%	1.61	1.27	-0.35	-21.7%
Toronto	1.45	1.11	-0.34	-23.4%	1.54	1.2	-0.34	-22.1%