# Development Of A Province-Wide Strategic Highway Traffic Forecasting Tool For Ontario

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## Abstract

A consistent foundation for province-wide highway system analysis and forecasting is necessary to assess highway usage/deficiencies, service level indicators, and develop traffic forecasts to support transportation planning and infrastructure investment decisions. The level of data requirements and effort associated to develop and maintain a typical 4-step transportation demand forecasting model is challenging for applications in larger geographies. Provincial highway forecasts in Ontario typically carried out on a corridor or a project-specific area and there is a need to advance analysis by determining the impacts on system-wide performance on a consistent and regular basis.

The project goal was to develop a province-wide strategic highway traffic forecasting, system analysis and performance measurement tool for Ontario. A wide variety of data were gathered and harmonized, including network data such as auto and commercial traffic volume, highway infrastructure inventory and planned improvements. Demand data such as population, employment, financial and tourism forecasts from provincial and federal sources were also obtained and utilized. Various methods were investigated and employed in order to develop a provincial-level forecasting framework which can be applied to the entire network, or to criteria based subsets. This framework has the capability to carry out systematic province-wide forecasting of highway traffic and corresponding service level indicators, test different growth scenarios for determinants of traffic (commuter, tourism/recreational, commercial), and identify current and future highway system deficiencies and bottlenecks. The end product was to develop a user friendly desktop application to allow for multi-skilled users to produce relevant products including reports in the form of tables, charts, and GIS maps.

Although the tool focuses on inter-urban traffic, it is relevant to ‘best practices’ in urban transportation planning in two ways: [a] the tool complements and extends urban travel demand models by providing an integrated, holistic treatment of externally-based and through trips; and [b] the tool provides a practical approach for forecast development, using disparate data sources and GIS.

## 1.0 Introduction

The Ontario Ministry of Transportation (MTO) requires highway traffic forecasts at provincial level to support long range transportation planning, investment/capital planning, and policy/planning analysis. Historically, such forecasts were provided using a simplistic trend-line approach through which it was not possible to test alternatives, scenarios, or impacts of any policy/planning initiatives and improvement strategies (MTO, 2009).

There are new and emerging priorities for policy/planning analysis, such as long range corridor investment plans, Ontario-Quebec Continental Gateway Trade Corridor and others, which require provision of reasonable traffic forecasts warranting a sound system of forecasting methodology that is consistent for the entire province.

The MTO retained iTRANS Consulting Inc. (now HDR | iTRANS) to conduct the Provincial Highway System Traffic Forecasts project. The purpose of the project was to develop a strategic level tool to forecast provincial highway traffic volumes to support MTO's business needs. The focus was to develop the capability to produce traffic forecasts and corresponding service level indicators, and assess alternative traffic growth scenarios and future highway deficiencies, while using procedures with minimal turn-around time, and addressing the entire provincial highway network at the same base level of detail. The tool provides MTO with the ability to import available forecasts from other sources such as urban forecasting models and examine the performance of any or all parts of the provincial highway network on a systematic basis. The tool is based upon currently available data, but could be expanded in the future to incorporate new data.

## 2.0 Strategic Highway Forecasting at Provincial Level

The MTO manages about 16,500 kilometres of highway network worth $ 27 billion in highway assets. It is important to understand how this vast and expensive network of highway system is performing and what the future demands and deficiencies are in order to serve various highway planning and investment needs. A strategic highway forecasting tool at provincial level will provide current and future highway demands and related deficiencies, which in turn, help support transportation infrastructure decision-making on when, where, and how to invest.

A strategic highway forecasting tool provides decision makers, planners, and policy developers a consistent reference and framework to:

- identify bottlenecks for further detailed analysis;
- test different growth scenarios for determinant components of traffic (commuter, tourism/recreational and commercial);
- carry out systematic province-wide forecasting of highway traffic;
- provide a systematic framework to ensure that future highway / section needs are considered as part of the full system/network

## 3.0 Project Objectives and Parameters

The project objectives were to a) develop an integrated Ministry tool for strategic highway forecasting and system analysis; b) harmonize and assemble inventory, traffic, demand, and GIS data from various sources; and c) develop a consistent and user friendly interface without the dependency of specialized software installation.

In order to achieve the objectives, the study was divided in several tasks as summarized below:

1. Traffic Volume Forecasting: Examine and develop alternative methods of forecasting future traffic volumes at the strategic level without resorting to intensive traffic forecasting / modelling techniques, and evaluate them based on their suitability for inclusion in the strategic tool.
2. Performance Measures: Consider a range of highway performance measures to describe highway deficiencies for any horizon / intermediate years, and to perform a comparative analysis on various alternatives and scenarios using the strategic tool.
3. Database Development: Integrate various components of historical / existing data related to provincial highway system and available Ministry databases, traffic forecasts, and relevant studies / data sources.
4. Shell / User Interface Development: Develop a user-friendly shell / interface that utilizes a readily available database package and permits a full range of scenario testing, comparative analysis, and reporting.
5. GIS Data System Development: Integrate various geography descriptive layers, highway system database attributes, and other spatial elements to be mapped and present provincial highway system information and traffic forecast results.
6. Traffic Analysis: Consider the appropriate level of analysis required to address historical and existing traffic volume data.

Figure 1 shows the main components and capabilities of the tool that was delivered through this study.

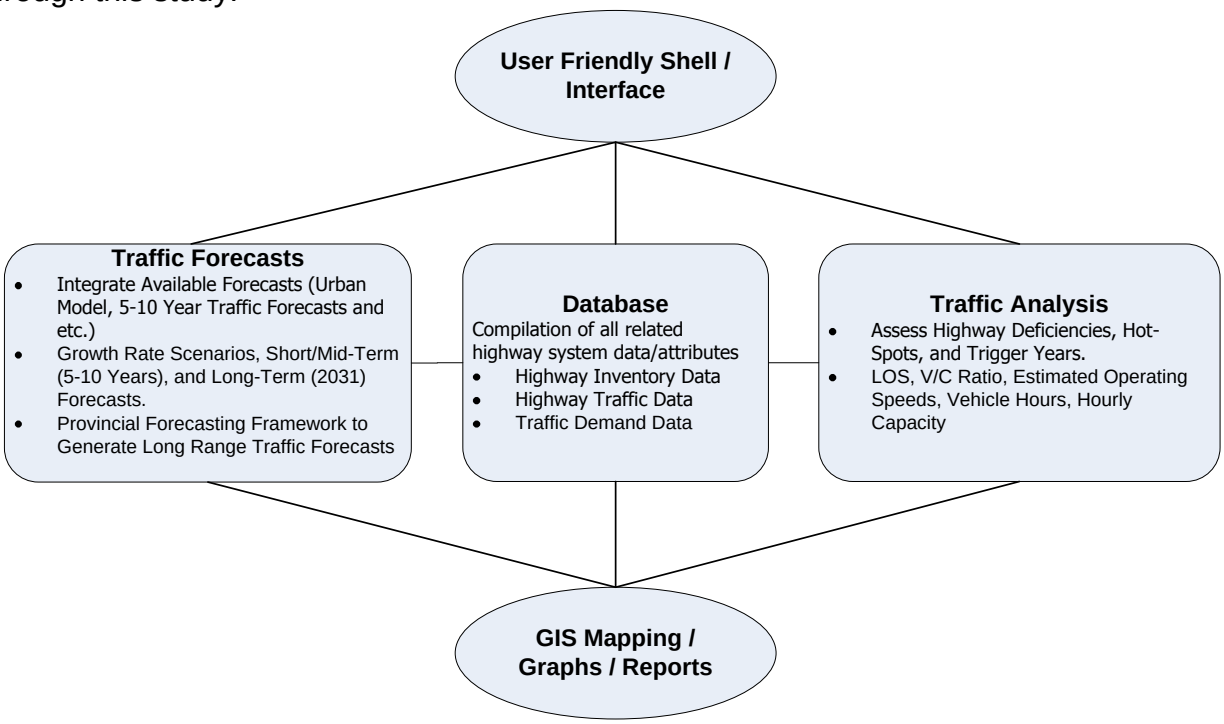


**Figure 1: General Structure of the PHFT**

## 4.0 Review of available data sources, constraints, and challenges

In the development of the PHFT, data had to be gathered from a variety of sources within and outside MTO, assembled into a cohesive database, processed to calculate forecast estimates and performance measures, and output in the form of tables, charts and maps. Through all of these stages many difficulties were encountered related to data gaps and integration. There were gaps in data availability as there are no sources of readily available travel and forecast data with a consistent base for the whole province. For example, Statistics Canada do collect journey to work information for the entire province on a 20% representation of population every Census year. However, this data set only covers information on trip linkages (not actual trips) for commuters between their place of work and place of residence, not providing insights on non-commuting and/or long distance trips that could be significant on some provincial facilities. Additionally, this study required harmonization and assembling of data from various sources that are collected and maintained on systems that are fundamentally different from each other. This caused significant data integration challenges that needed to be addressed in this study.

There were three key data components of the PHFT namely 1) network of highway segments, 2) travel demand, and 3) GIS based data systems. Many data sources were utilized in order to collect information for each of the three data components.

The highway network data included traffic volume and geometry information which was obtained from MTO's Traffic Volume Information System (TVIS) and Integrated Highway Information System (IHIS), respectively.

The MTO collects and maintains AADT traffic counts for its provincial facilities on an annual basis and this program is called the TVIS. Traffic volume information is stored in the traffic volume master spreadsheet and contains traffic attributes including section length, current and historical AADT (18 years available for most sections), % commercial vehicle, directional split, design hourly volume etc. This database is updated every few years through an involved process of sampling and validity review undertaken to prepare final results (TVIS, 2009).

The MTO also maintains an integrated database of network infrastructure inventories and conditions known as the IHIS (IHIS, 2009). The IHIS contains many attributes including number of lanes, shoulder widths, average highway speeds, percent passing sight distance, terrain class, etc that were utilized in this study. The conditions of these inventories are assessed annually to determine what is required in maintaining the roads network. Bridge, Pavement condition and Traffic data are copied into the system annually to provide base inventory / condition data for capital construction decision-making.

Both these key databases (TVIS and IHIS) use geographic location as the integrator across different business functions. Geographic location is defined by the Linear Highway Referencing System (LHRS) which is a link-node referencing system used to locate road sections and points on the provincial highway network. It uses a unique referencing number assigned in ascending order to key points along each highway, while less significant points are described by offsets from key points. Sections are defined between pairs of keypoint/offset location points.

Although the keypoints of the LHRS were fixed, the offsets assigned to the unique referencing number to the key points varied between TVIS and IHIS because these databases are maintained separately to serve different business needs. This complicated the linking of TVIS and IHIS data and as section definitions change from year to year and there was no simple way to connect the two. In this study, computation logic was developed to connect TVIS and IHIS data, which is described in section 5.

Moreover, there were network connectivity gaps in both TVIS and IHIS as both systems collect and maintain information for provincial facilities only and data regarding connecting links and intersections were not available. Considerable modifications to the network were made to address this issue, described in section 5.

Travel demand data was sub-categorized into commuter, tourism, and commercial data. Commuter data was obtained from Census Place of Work tables; tourism data was obtained from Ministry of Tourism and Statistics Canada; and commercial data was obtained from the 2006 Commercial Vehicle Survey program. Since the travel demand data was available at varying geographies (Census Metropolitan Area (CMA), Census

Agglomeration (CA), Census Division (CD), MTO Regions, etc) all information and geography was normalized at the CD level.

The PHFT's GIS based data system consisted of standard layers of geographic features such as various boundary files for highway network, cities, CD, CA/CMA, water bodies, lakes, MTO Regions, etc. The characteristics of PHFT's database elements are discussed in section 6.

## 5.0 Provincial Highway Forecasting Tool (PHFT) development process

The development of the PHFT comprised several stages as follows:

- development of automated assembly of base data from a variety of internal MTO as well as external sources (including developing data correction logic and default behaviours for key missing elements in each record);
- development of software to produce traffic forecasts through a variety of methods;
- development of software modules to implement capacity analysis and other measures of effectiveness;
- interfacing with Microsoft (MS) Excel for tabular and chart outputs, and;
- interfacing with TransCAD GIS for map output, including construction of a TransCAD mapping template to receive data through a connection to the MS Access database

This was the general order of the development. The database had to be completed first. The components such as forecasting options, analysis modules, and report generation that queried the database were developed next.

While these components are essentially independent, they are all built using MS Access and the VBA programming language. This was a deliberate decision intended to produce a tool that can be easily copied from one computer to another as a single file, together with its database, and does not require any involved installation, or any elevated desktop security privileges. This platform also permits system administrators to make changes to the tool readily, without needing anything more than MS Access installed, and no additional licence costs. Finally, since the database is built in, an advanced user is able to inspect, import/export and alter the database tables, which makes operations very open for examination and alteration, allowing a degree of freedom to experiment that some forecasters would value.

This MS Access approach was the appropriate first step for the development of PHFT as it provided a rather quick development cycle and a simplified environment that allows emphasis to be placed on function and correctness without distraction of sophisticated interface. Using MS Access, features from other MS products, such as regression modelling from MS Excel, can be easily called which provided a seamless and user friendly interface.

While no software development effort is completely straightforward, the components of this tool were generally not problematic with a few exceptions as follows:

- The process to merge the TVIS and IHIS databases took considerable time to develop due to the frequent differences in the segmentation of each network. For instance three segments of the IHIS data may span four segments of TVIS data (or visa-versa). Through several trials, a computational logic has been developed and implemented which uses the IHIS data segmentation as a reference, and assigns TVIS data to the IHIS segmentation by means of weighted averages by segment length.
- Many sections of roadway which are essential to complete paths between zones are not included in the database. There were just a few sections missing in error, but the vast majority the omission is intentional and systematic because such sections are not in MTO control (such as connecting links), or because they are major intersections and so not managed at a planning level in the same way as links. As a consequence, considerable modification to the network was necessary in order to provide the connectivity required to calculate minimum path trees for the O-D assignment forecast method.
- There were some data completeness and quality issues in the data sources utilized for this tool. For example, some highway segments had missing or inaccurate attribute data in TVIS and/or IHIS, which would impact forecasting and performance measure results. These needed to be dealt with individually by a reasonable logic in order to maximize the proportion of the highway network for which reasonable estimates of forecasts and performance measures could be prepared.

## 6.0 PHFT Design, Features and Capabilities

<u>Interface</u>

The interface is a built-in addition to the database. The purpose of the interface is to provide a user-friendly environment that facilitates scenario testing, comparative analysis, and data reporting. The interface comprises forms that allow the user to access the various options available in the database. The interface has been designed in such a way to permit users with MS Office experience and basic traffic analysis training to readily adapt to the environment and easily carry out standard tasks without the need to read the manual or follow step-by-step instructions. At the same time, advanced users have the capability to log in as administrators in order to perform tool maintenance/updates and other complex tasks. The user can store relevant details with the traffic, network, or demand data, such as dates, source details, scenario constraints etc. that will allow all users of the database to readily see, for example, the assumptions underlying a particular set of volume forecasts. The layout of the interface (Figure 2) serves as a map of the tool components. The left-hand column of buttons is for administrator use only and relate to setup and updating of the core database. The centre column is the entrypoint for the calculation components, broken down into those that produce link volume estimates, and those that calculate performance measures

based on link volumes. The right hand column is output alternatives, so in general the work flow generally goes from left to right.

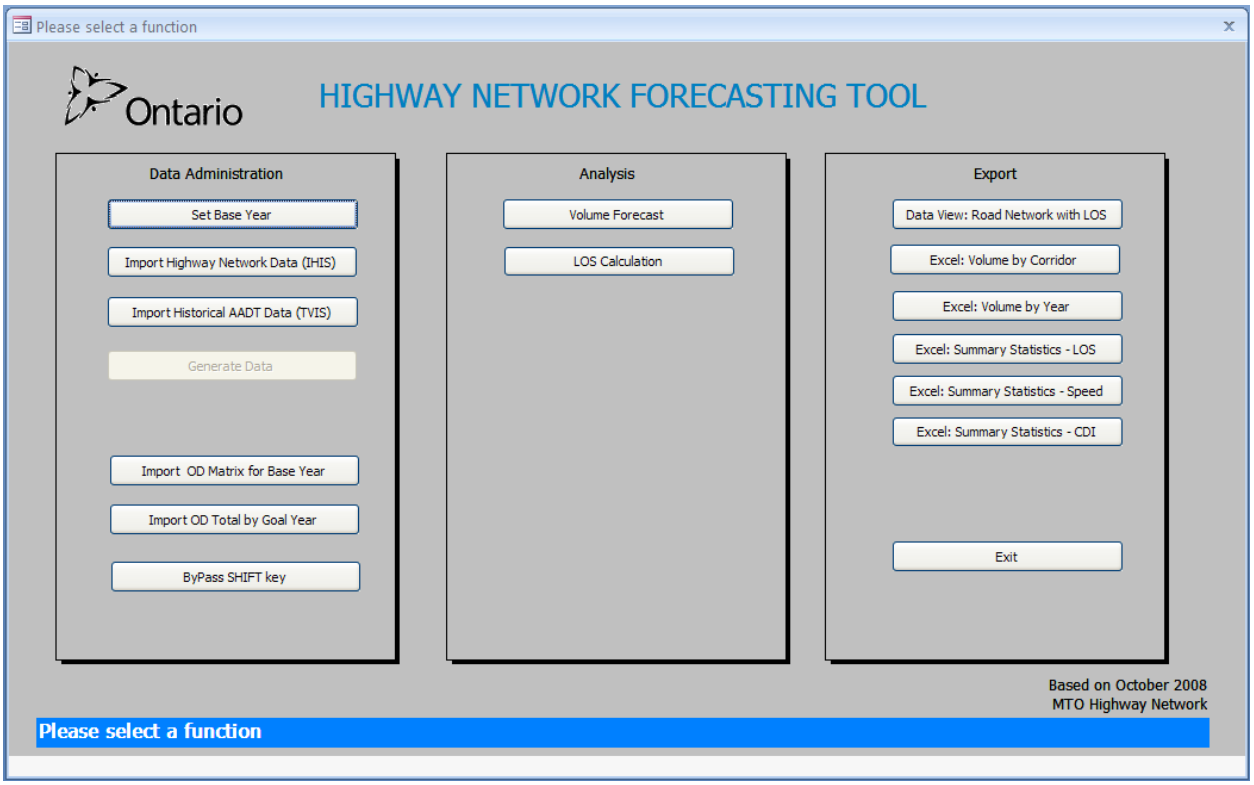


**Figure 2: Main screen of the PHFT**

<u>Database</u>

The core of PHFT is the database itself, consisting of two conceptual parts: the base data which is essentially existing facts of the network and corresponding demand, and forecasting and analytical scenarios created through manipulation of the base data by various modules. The base data is assembled by the tool using data from various input databases, the key ones being TVIS and IHIS. This database has limited access so that only certain users can alter the base data in the tool. While all users can construct forecast scenarios and execute queries on the database to produce a variety of outputs. The base data is required to be assembled on an annual basis to incorporate the latest editions of TVIS and IHIS databases. Figure 3 outlines the various components of the PHFT database structure.

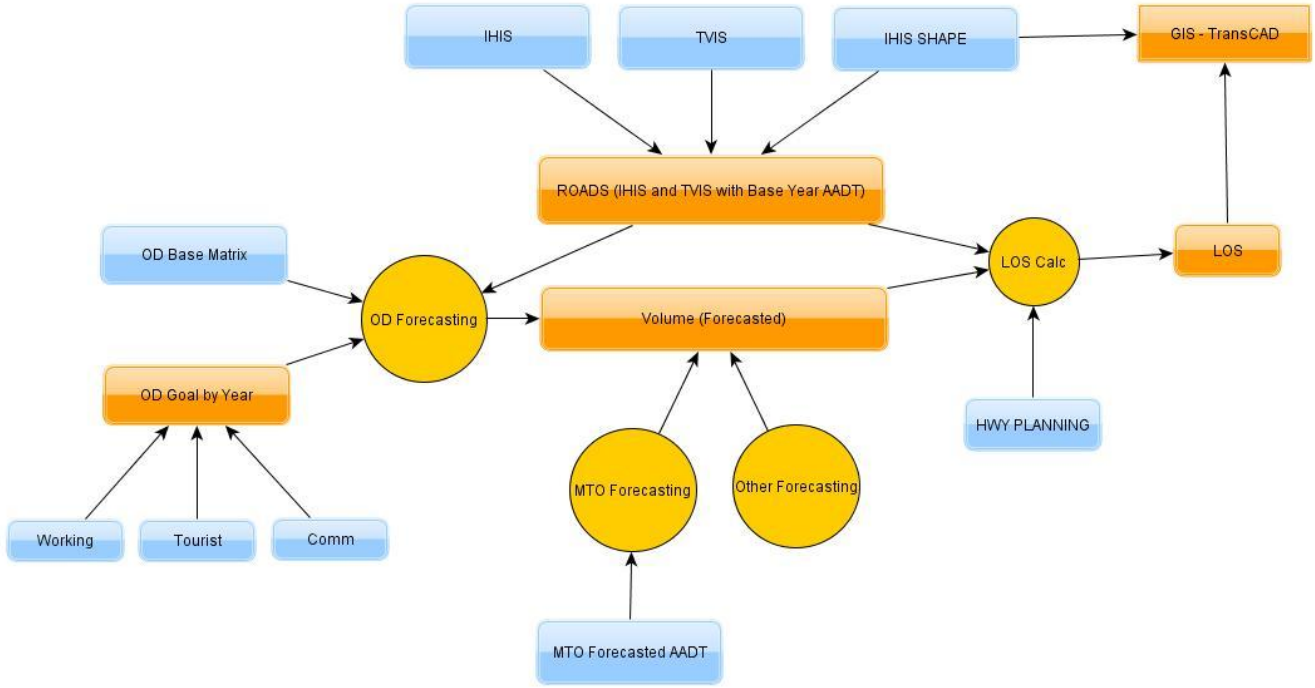


**Figure 3: The PHFT database structure**

<u>Traffic Forecasting</u>

The traffic forecasting module is the first step in the application of PHFT. This module manages sets of link volumes, which are created through a variety of methods for estimating future volumes including:

- Import AADTs – this allows direct importing from any external forecast source via an MS Excel spreadsheet table, so that where more detailed or more accurate forecasts are available (e.g. in a large urban area having a full modelling system) thus can be used in place of the simpler internal forecasts
- Import growth factors – similar to importing AADTs, this permits the import of an MS Excel table of link growth factors, so that an external tool can generate them on a link by link basis (e.g. through some combination of AM and PM peak hour model results)
- Simple Factor – e.g. multiply base volumes by 1.2 for 20% total growth
- Compound Growth – e.g. multiply base volumes by 1.02 for 2% annual growth
- Linear Trend Line – e.g. forecast 10 years into the future by linear extrapolation from the past 10 years of observations for each section
- Power Function – e.g. forecast 10 years into the future using a power model formulation based on the past 10 years at each location
- Origin-Destination (O-D) Based Growth by Goal – This generates forecast link volumes using a specified set of traffic zone O-D goals for each of commuter, tourist and commercial traffic types (more details below).

- Origin-Destination (O-D) Based Growth by Matrix – Similar to the O-Ds by Goal, this does an O-D table assignment to the network, but directly from an externally-provided table rather than using the internal OD table generation (more below).

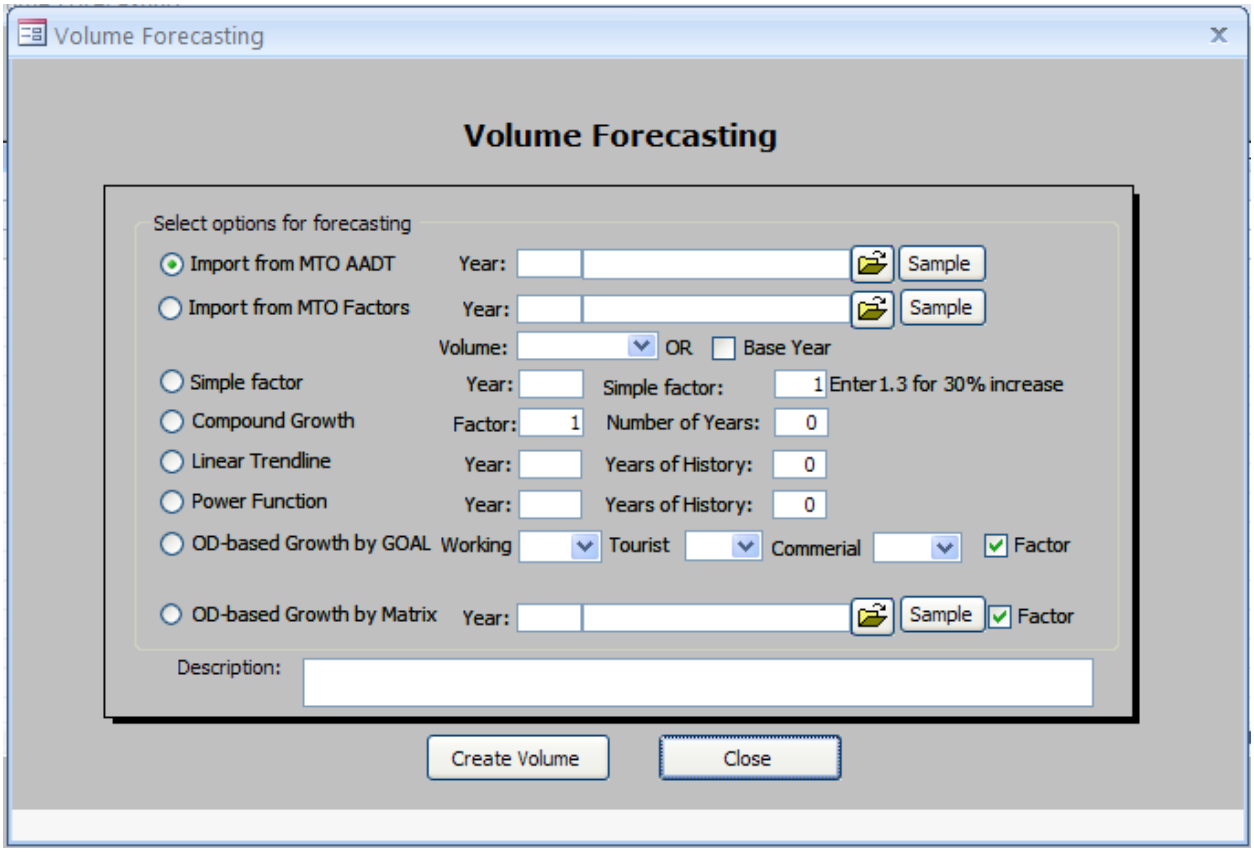


**Figure 4: The Volume Forecasting screen**

These forecasting methods (also shown in Figure 4) are all fairly self-explanatory and are based on some function of the existing and/or historical traffic data for each highway segment, independent of the other segments. This is a common approach for highway planning outside of urban areas, but it inherently relies on the assumption that future traffic on a link will follow similar trend from the past of the same link.

The O-D Based Growth method is distinctly different; it produces forecast flows between pairs of zones based on current O-D patterns as well as expected future trip growth in each zone. The process is illustrated schematically in Figure 5 and described as below

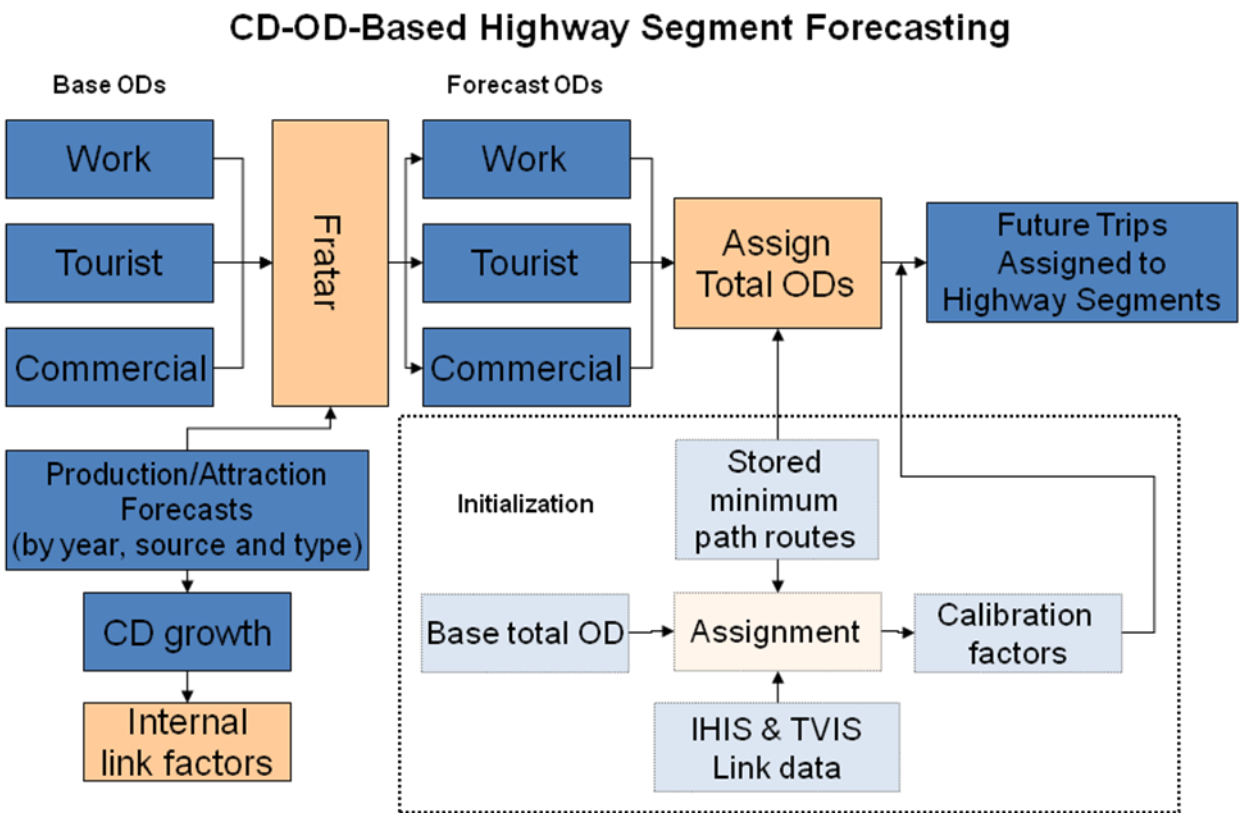


**Figure 5: Logic of the OD-Based Forecasting**

The following procedures were used to develop the O-D based traffic forecasting data:

- Define Study Area:
- Define Traffic Analysis Zones (TAZs)
- Superimpose Provincial Highway Network
- Derive Base Year O-D Trip Matrix
- Develop Forecast Trip Productions / Attractions
- Select Trip Distribution Method (Fratar Method)
- Develop Trip Assignment Method

The Census of Canada Census Division (CD) was used as the Traffic Analysis Zones (TAZs) for the O-D based forecast. The provincial highway network was superimposed on this network, and the minimum paths between each O-D pair were determined using GIS software. Additionally, the zone system and network was coded into EMME and a database table was output which lists the sequence of highway segments making up each minimum path between Origins and Destinations in the table. As described previously in section 4, a complete province-wide passenger O-D matrix does not exist, , so partial data sources had to be relied upon. A base year passenger O-D matrix was derived separately for work and tourist trips (with the capability to import third trip type such as commercial vehicle matrix) in order to provide the flexibility to input updated or

new data for each trip type separately as it would be available in the future. Forecast trip productions and attractions at the CD level were based on available population, employment, and tourism expenditure data obtained from the Ontario Ministries of Finance, and Tourism, and from the Census of Canada Journey to Work database (Ministry of Finance, 2009; Ministry of Tourism and Recreation, 2009; Statistics Canada, 2009).

The Fratar (growth factor) method was used to distribute trips between the various O-D pairs for the traffic forecast scenarios. Trip assignment to the provincial highway network used an all-or-nothing assignment of trips to the minimum paths between each O-D pair. Highway segments not included on a minimum path had their traffic volumes increased by a growth factor, which is ratio of the base and forecast trip totals for the CD in which the link is located. In addition, in order to compensate for the very coarse level of detail imposed by the broad strategic nature of the PHFT in both the zone system and the highway network, each assigned forecast segment volume was multiplied by a correction factor. This factor was calculated as the ratio of the base year observed AADT on the segment to the O-D assignment of the base year trip tables.

Finally, the assigned volumes were adjusted using a factor derived from the base year AADT and an assignment of the base O-D table. This step was employed to account for links running in parallel to the provincial highway network which would potentially take some (or all) of the future traffic growth.

The network assignment can be done in two ways. The simpler way is to import a finished O-D table from an external source and assign it to the paths as described above. The more complex method requires the user to supply origin and destination goal total vectors by trip type (commuter, tourist and commercial). Those are used to Fratar-factor their respective base O-D tables, which are then assembled, and again assigned as described above.

Performance Measures

Once volumes are generated for the links, the LOS Calculation module may be used to calculate performance measures for a specified forecast scenario. The bulk of this module is the implementation of the HCM 2000 LOS methodologies for 2-lane, multi-lane and freeway facilities (HCM, 2000). This produces design hour volume/capacity (v/c) ratio and Level-of-Service (LOS) for each link in the network. Additional calculations produce:

- average operating speed in the design hour, using the commonly referenced U.S. Bureau of Public Roads (BPR) formulation
- vehicle-hours – total time cost for road users in the design hour
- Congestion Duration Index (CDI) – Based on definition in the report “Multimodal Freight and Passenger Traffic Flows, and Infrastructure Study - Ontario-Québec Continental Gateway and Trade Corridor – Phase 1 Highway Mode Report” (prepared for Transport Canada by the Research and Traffic Group), this is an indication of the degree of congestion across the entire day, calculated as:

$CDI_i = AADT_i / C_i$, where *i* is the link in question, $AADT_i$ is the Average Annual Daily Traffic on that link and $C_i$ is the hourly capacity of the link. In other words, this is the number of hours of full capacity (v/c = 1.0) flow that would be required to serve the entire daily demand.

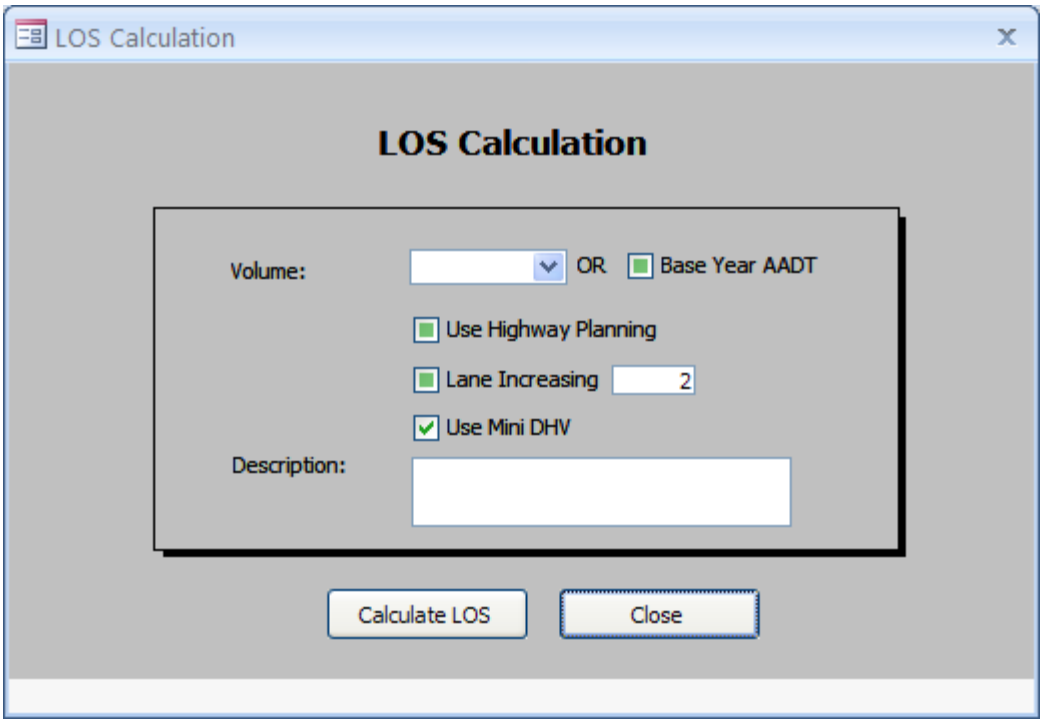


**Figure 6: LOS Calculation screen**

The PHFT also provides several options for calculation of performance measures (Figure 6). These are defined as follows:

- Volume: selects the volume scenario to use for the calculation, or optionally uses the base year volumes instead of a forecast
- Use Highway Planning: when checked, this option will adjust key highway parameters before calculating the performance measures, if the highway is scheduled to have been improved (or simply changed) before the indicated forecast year. To implement this feature, the PHFT administrator must populate a table in the database to indicate for each planned highway segment investment: the year of improvement, and new values for number of lanes, lane width, average highway speed, Design Hourly Volume percentage (DHV%), and optional comments to describe the planned project.
- Lane Increasing: this option was included for experimental purpose only and when checked, it simply adds the indicated number of lanes to every highway link system-wide before calculation of performance measures.
- Mini DHV: this option implements a simple measure to approximate the effect of peak spreading as demands increase over time and hit capacity limit, likely causing at least some road users to adjust their time of day to travel. To limit this

to realistic DHV values, the algorithm references a statistical analysis of DHV values categorised by the subject highway link's traffic pattern type, as follows:

- Determine the v/c ratio for highway segment i under forecast conditions:
  - If v/c ratio > 1.00, proceed to adjust DHV.
  - If v/c ratio ≤ 1.00, move on to next highway segment (i+1).
- Determine the PATTERN_TYPE classification for the highway segment i.
- Determine the 25$^{th}$ percentile DHV% for the PATTERN_TYPE classification:
  - If 25$^{th}$ percentile DHV% > base year DHV%, then set DHV% = 25$^{th}$ percentile DHV%.
  - If 25$^{th}$ percentile DHV% < base year DHV%, then retain base year DHV% (i.e. no peak spreading applied).
- Re-calculate performance measures based on the new DHV%.

The DHV reduction technique to simulate potential peak spreading is useful when assessing the impacts of change in travel pattern. For example, this feature could be used to assess a particular highway corridor that is currently utilized mainly for recreational and/or tourism trips with high DHV values and there is a potential for future urban development or land use change within that corridor.

GIS Data System

The purpose of the GIS data system is to integrate various geographical descriptive layers, highway system database attributes, and other spatial elements to be mapped to effectively present provincial highway system information and traffic forecast results. The TransCAD travel demand forecasting package was used for the GIS data system.

In order to facilitate the transfer of data between the database and the GIS data system, a TransCAD base map of Ontario was created. The source code of the database was written assuming that this base map is located in the same directory as the MS Access database file for the purpose of exporting data. However, the link between the PHFT and the TransCAD GIS map was designed in such a way that the user does not require access to the TransCAD GIS software in order to use the PHFT.

The PHFT was developed with the capability to export traffic analysis data directly to the provincial highway network layer in the TransCAD base map. It is also possible to join data from MS Excel spreadsheets to layers in the TransCAD base map directly, provided there is a common reference system used to identify specific highway segments, Census Divisions, etc. These data can then be displayed using the various thematic map displays that are available in the TransCAD software package.

Reporting of Results

The remaining section includes the generation of a range of tabular and graphical reports. This allows any user to extract forecasts and performance measures for any developed scenario. There are a number of options available (demonstrated later in this document) and they fall into several categories:

- Tables of link-by-link data exported to MS Excel
    - A subset of the entire database based on Territory, MTO Region, District, road class, number of lanes, highway number, corridor, and/or LOS,
    - Volumes along a specified corridor for one or more scenarios, allowing the comparison of volumes
    - Volumes by year for a single highway segment, for any number of scenarios. This produces for example the standard plot of historical observed AADTs, along with single year forecasts to show expected growth under a number of assumptions
    - Summary of LOS
        - By centreline-km, lane-km or AADT-km
        - By MTO Region or Census Division
    - Summary of speed:
        - Average operating speed or total vehicle hours
        - By MTO Region or Census Division
    - Summary of CDI by MTO Region or Census Division
- Line charts are automatically created in MS Excel for many of the tabular exports listed above, and since the are created alongside the tables, the results are easy to modify for later use in a presentation or report
- A special database table is populated to be reference by TransCAD so that users can perform GIS based analysis and mapping.

## 7.0 Integration of PHFT with urban forecasting models (GGH Model)

The PHFT has been designed to provide a consistent highway forecasting and system analysis framework for the entire province at the same base level of details. The PHFT's built-in OD based highway segment forecasting procedure is useful to determine inter regional, externally based and/or through trips to cover large areas of geography that otherwise couldn't reasonably be represented by urban models. At the same time, the PHFT has the capability to import traffic volumes or growth factors available from urban models at highway section level. These imported attributes can then be integrated within the tool's framework to produce forecasts and performance measures on selected highways or segments. This is an important feature towards developing a forecasting framework for large geographies which enables integration of relevant forecasts from external or discrete sources such as urban models. This approach permits the forecasting and performance assessment of the provincial highway system as a whole, addressing any spatial or temporal gaps between urban models of different areas and cities. Moreover, the PHFT has many built-in performance measures, especially the LOS computation module that utilizes HCM 2000 methodology by taking into consideration various highway geometric and traffic characteristics. Such performance measures would complement urban models by providing additional useful means to assess the highway system.

The Greater Golden Horseshoe Model (GGHM) is the modeling framework for the development of strategic transportation forecasts at MTO. The GGHM is a multimodal forecasting platform developed to support Ministry projects within the GGH area. The GGHM generates forecasts for auto, transit and commercial trucks under the same platform and provides the means to determine the interaction between different modes/users of the system (GGHM, 2009).

The PHFT is based upon uni-directional highway segments with AADT to represent daily average traffic. There is no differentiation of direction or two-way links that are required network attributes for the GGHM. Therefore, an equivalency file was created to link the GGHM network features with those of the PHFT. Traffic volumes for each direction and for each time period (AM and PM) were aggregated to compute representative daily growth factors at highway segment level. These growth factors were imported into the PHFT's framework in order to estimate the traffic forecasts within the Greater Golden Horseshoe area. Alternatively, forecast AADT volumes, instead of growth factors, generated from the GGHM could also be imported into the PHFT's framework. Similar procedure can be adopted for importing and utilizing forecasting results available from other models.

## 8.0 Selected Demonstration of Results

(Results are for demonstration purpose only and do not form any official position of the Ontario Ministry of Transportation)

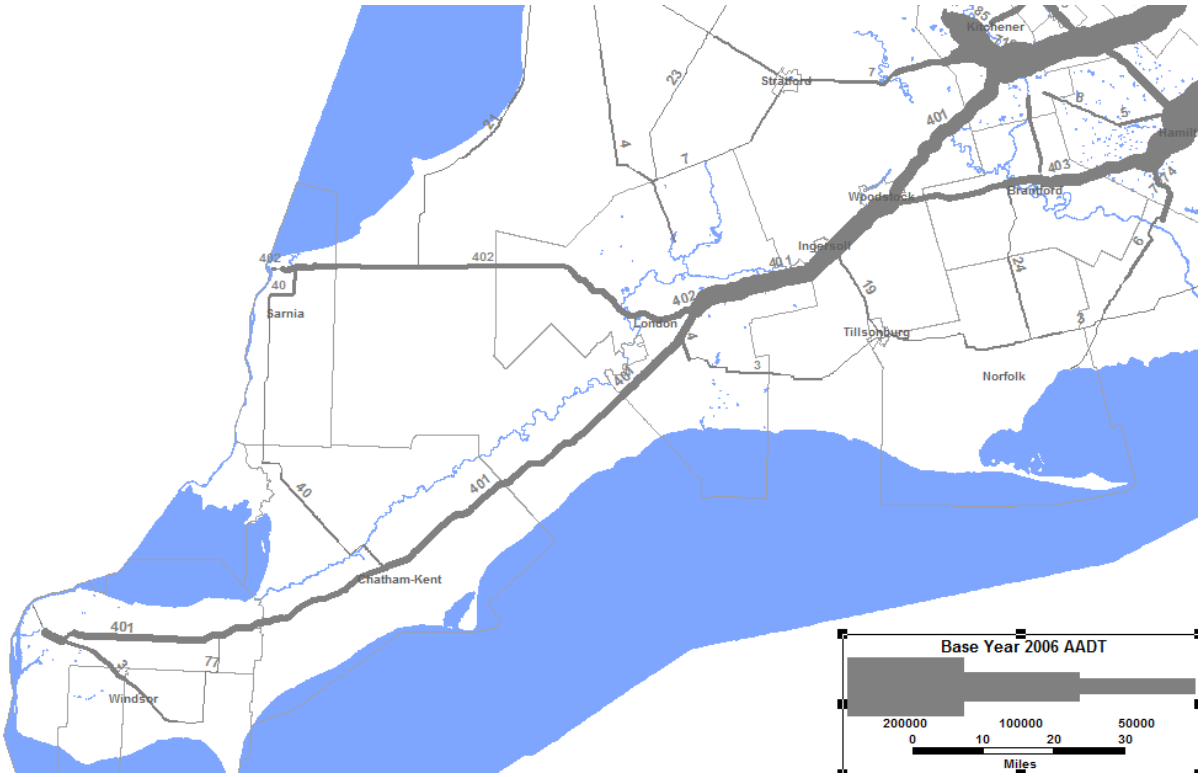


**Figure 7: Base Year AADT Volumes**

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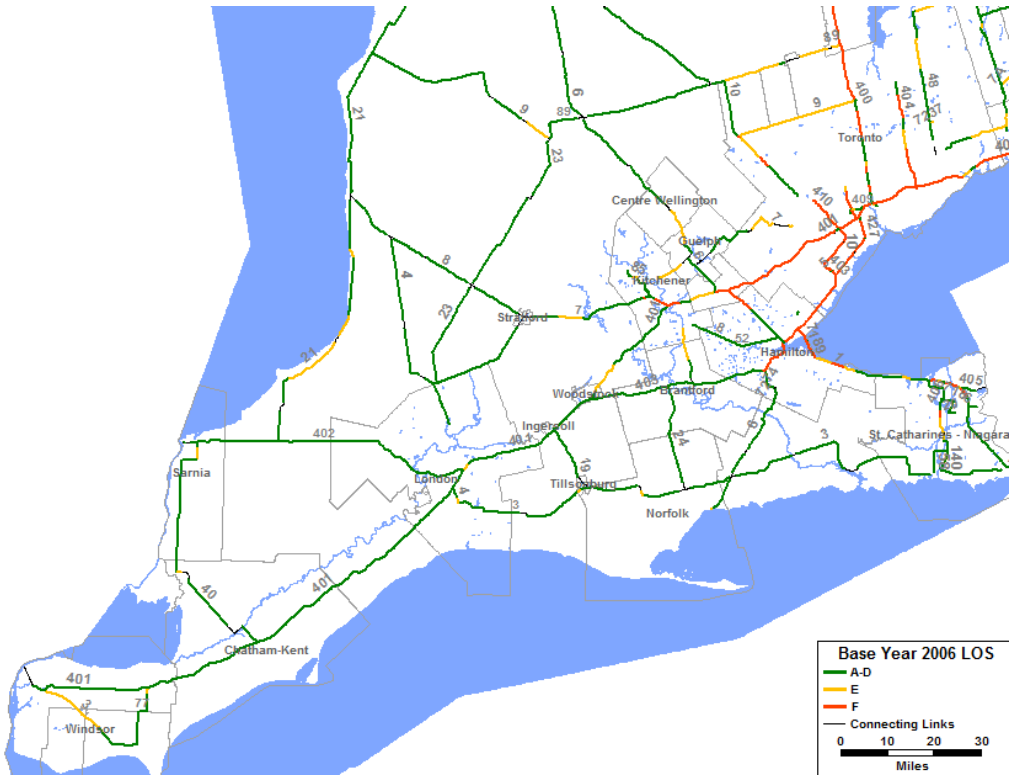
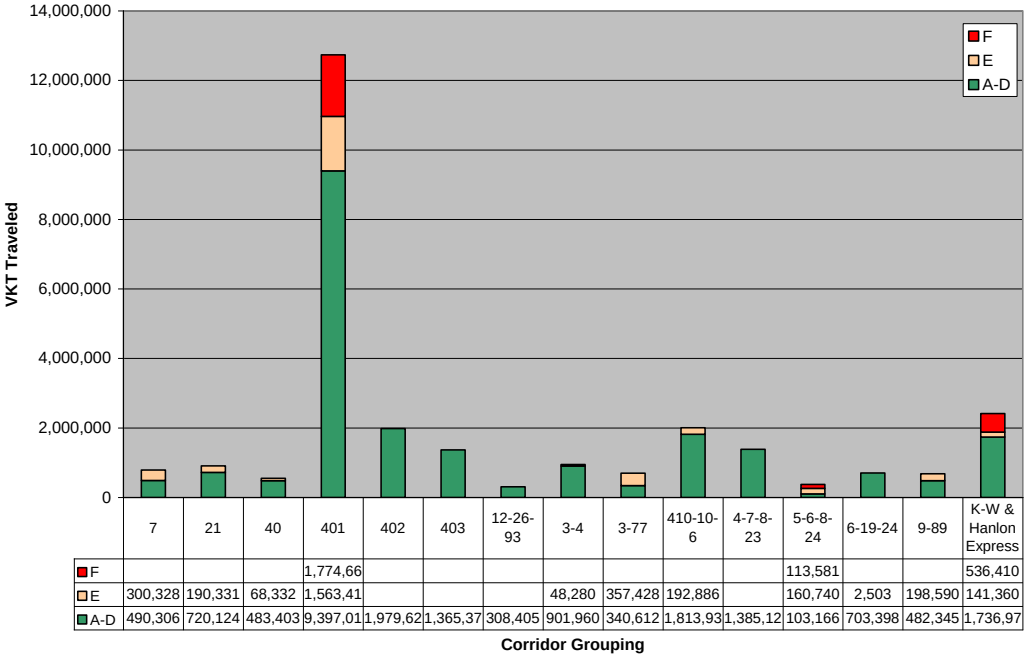



**Figure 8: Base Year Level of Service (LOS) Map**

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F | | | | 1,774,66 | | | | | | | | 113,581 | | | 536,410 |
| E | 300,328 | 190,331 | 68,332 | 1,563,41 | | | | 48,280 | 357,428 | 192,886 | | 160,740 | 2,503 | 198,590 | 141,360 |
| A-D | 490,306 | 720,124 | 483,403 | 9,397,01 | 1,979,62 | 1,365,37 | 308,405 | 901,960 | 340,612 | 1,813,93 | 1,385,12 | 103,166 | 703,398 | 482,345 | 1,736,97 |

**Figure 9: Base Year 2006 Corridor Usage – Vehicle KM Traveled Under LOS**

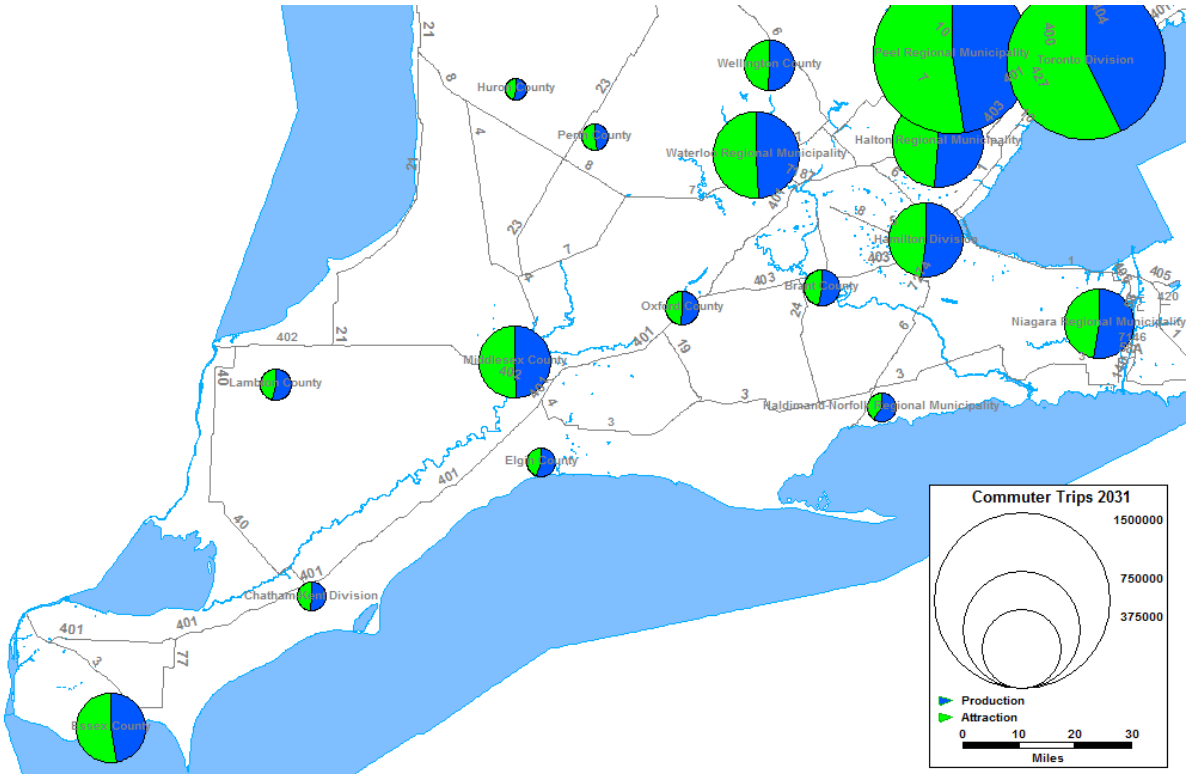



**Figure 10: Future Commuter Trip Production and Attraction, 2031**

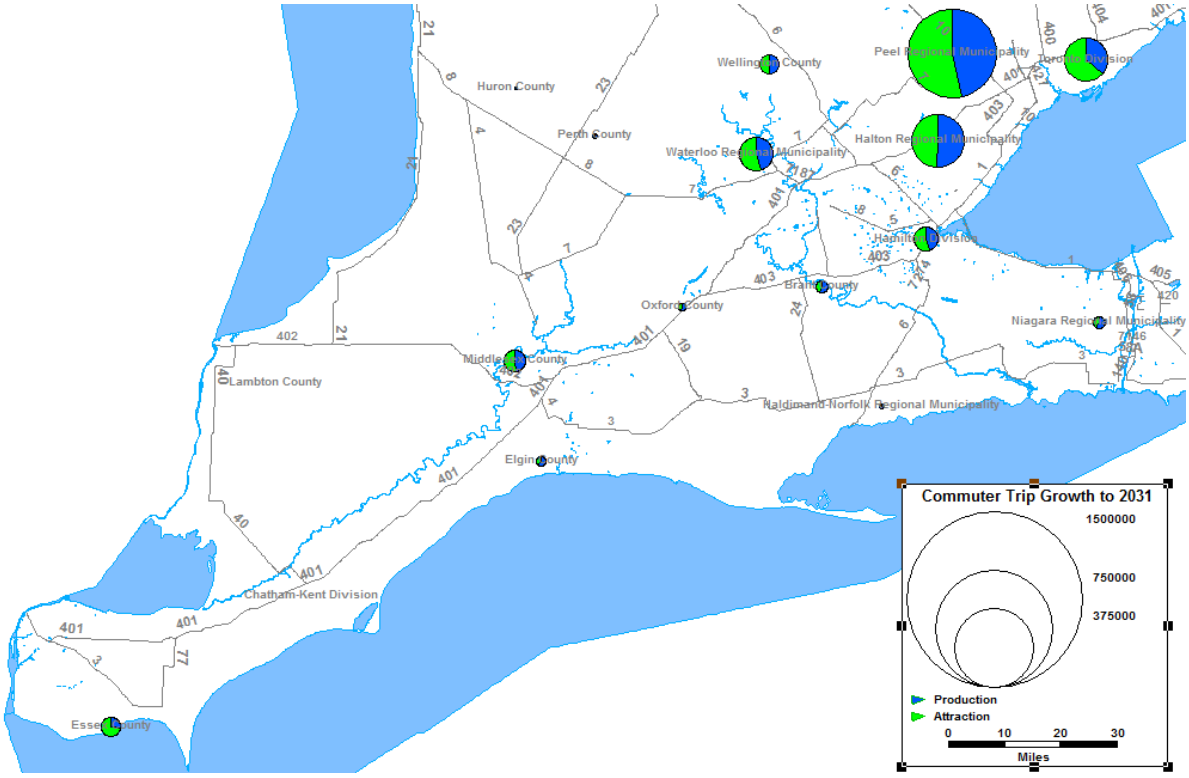



**Figure 11: Commuter Trip Growth, 2006-2031**

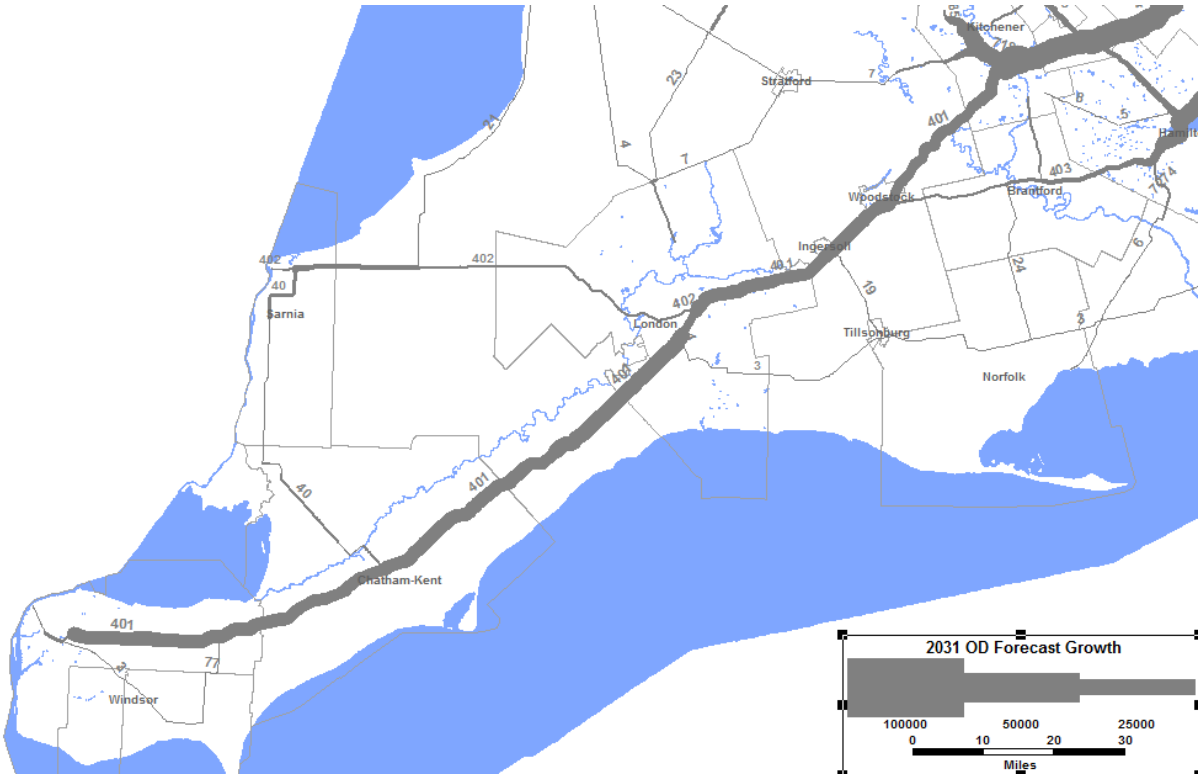



**Figure 12: Growth in AADT, 2006-2031**

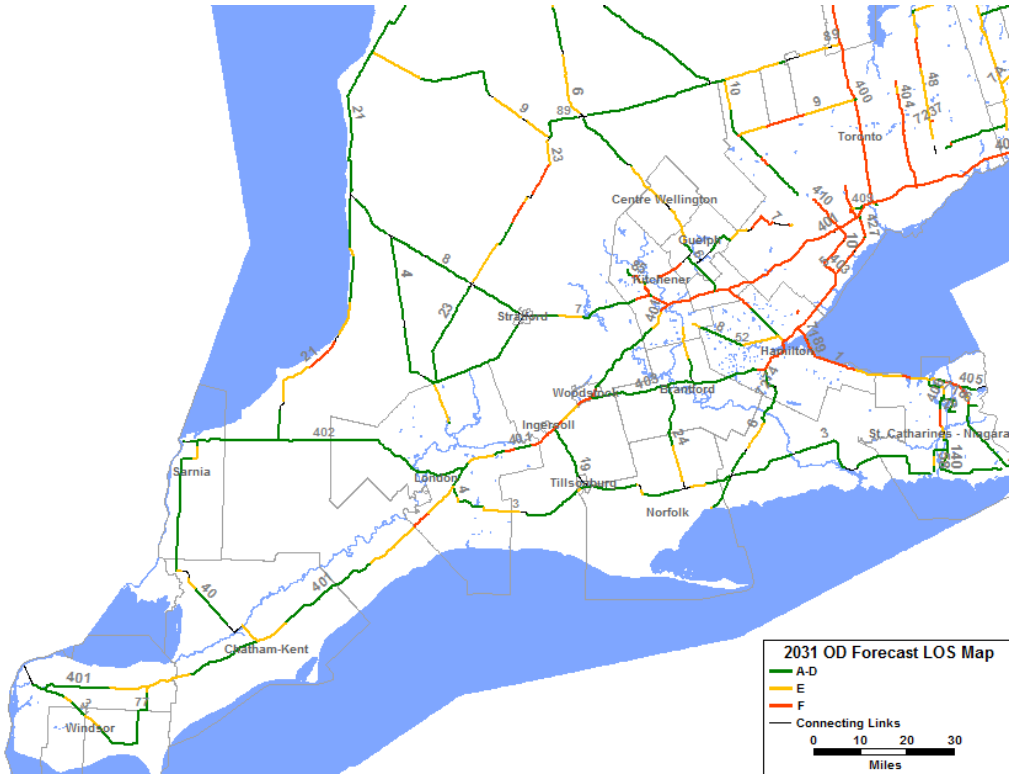
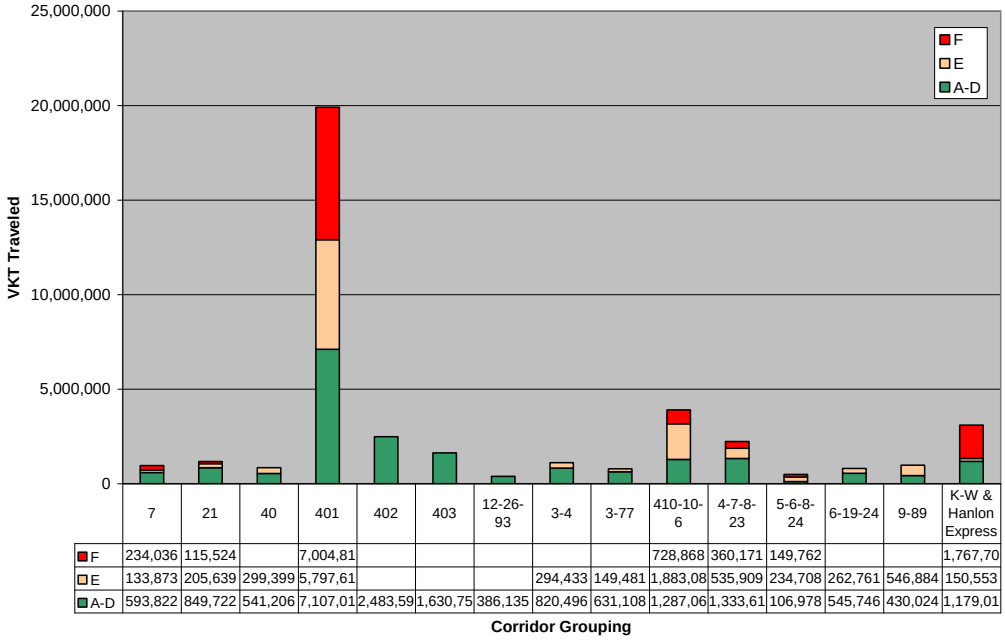



**Figure 13: Future LOS Map, 2031**




| | 7 | 21 | 40 | 401 | 402 | 403 | 12-26-93 | 3-4 | 3-77 | 410-10-6 | 4-7-8-23 | 5-6-8-24 | 6-19-24 | 9-89 | K-W & Hanlon Express |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F | 234,036 | 115,524 | | 7,004,81 | | | | | | 728,868 | 360,171 | 149,762 | | | 1,767,70 |
| E | 133,873 | 205,639 | 299,399 | 5,797,61 | | | | 294,433 | 149,481 | 1,883,08 | 535,909 | 234,708 | 262,761 | 546,884 | 150,553 |
| A-D | 593,822 | 849,722 | 541,206 | 7,107,01 | 2,483,59 | 1,630,75 | 386,135 | 820,496 | 631,108 | 1,287,06 | 1,333,61 | 106,978 | 545,746 | 430,024 | 1,179,01 |

**Figure 14: Future Year Corridor Usage, 2031 – Vehicle KM Traveled Under LOS**

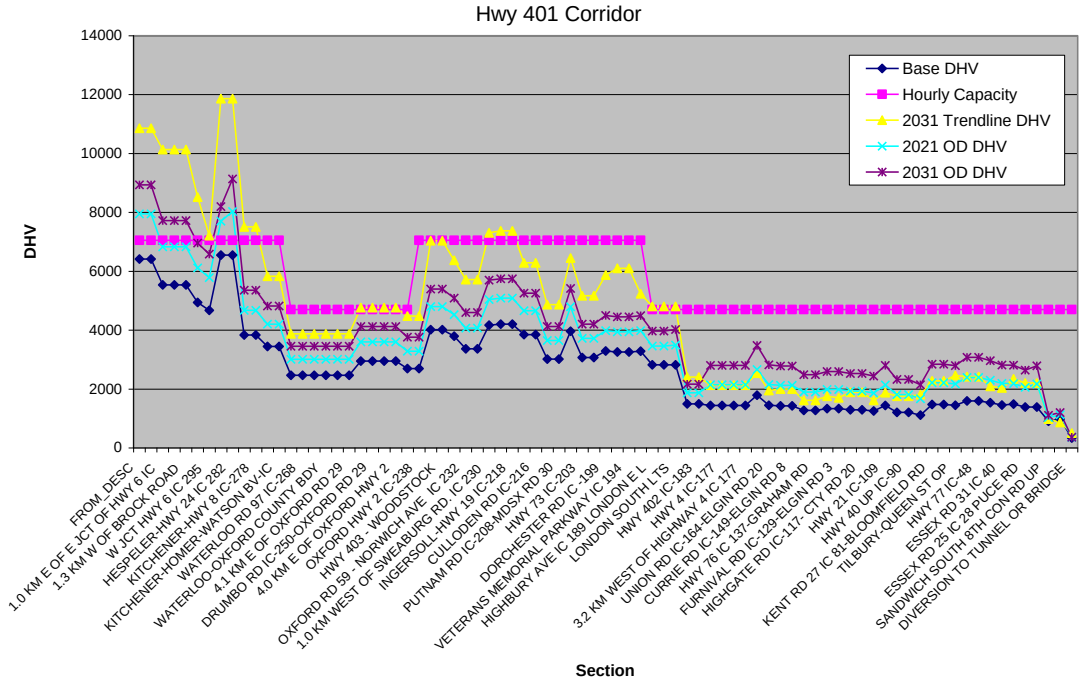



**Figure 15: Corridor Design Hour Volume (DHV) Analysis Results using various forecasting methodologies**

## 9.0 Summary and Conclusion

The current assignment was a first ever attempt to develop a strategic level tool to combine elements of MTO's traffic, inventory, demand, and GIS databases for highway deficiency analyses and forecasts. In this study, an integrated Ministry highway forecasting and system analysis tool, namely PHFT, was developed by harmonizing and assembling network, demand, and GIS data from various Ministry and external sources. This tool has various built-in forecasting methods and the capability to integrate and utilize forecasts available from other sources such as urban models. The interface is user friendly for easy database access, manipulation, analysis and reporting.

The PHFT is the first key step towards an "inclusive" forecasting framework which is designed for large geographies while enabling MTO to integrate relevant forecasts from urban models such as GGHM. This will permit the forecasting and performance assessment of the provincial highway system as a whole while addressing any spatial or temporal gaps between urban models of different areas and cities.

The MTO will utilize PHFT to develop long range traffic forecasts, test various growth scenarios, and identify current and future bottlenecks or deficiencies on its entire provincial highway system for further detailed analysis. The PHFT will also provide information to support MTO towards ranking of its provincial highway segments and corridors based on their usage levels, deficiencies and strategic needs.

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