A Demand Forecasting Methodology for Land-Based Ports of Entry

Dr. J.M. Kosior P. Eng., Senior Transportation Planner
Systems Planning Branch, Manitoba Infrastructure and Transportation

D. E. Lettner, BA, MPA, MCIP, Senior Transportation Planner
Systems Planning Branch., Manitoba Infrastructure and Transportation

Paper prepared for presentation
at the Transportation Planning session

Of the 2013 Conference of the Transportation Association of Canada
Winnipeg, Manitoba

ABSTRACT

Transportation infrastructure is essential for economic development and typically dependent on significant public sector investment. However, fiscal limitations impact the capacity of governments to fund these investments. These countervailing forces necessitate a policy-level approach to better justify and secure resources for key transportation infrastructure investments.

In a 2012 study of the Pembina-Emerson port of entry (POE), two planning methodologies were modified to better assess policy-level considerations related to POE transportation infrastructure. This paper addresses demand forecasting methodologies and is a precursor to the level of service (LOS) framework paper presented in these TAC sessions. Average annual daily traffic projections (AADT and AADTT) are insufficient for determining peaking patterns and assessing future infrastructure requirements at POE's. A new approach for forecasting vehicle demand at POE's was required to more effectively assess demand-capacity issues. Using historical arrival data, custom expansion factors were developed for forecast algorithms that replicated POE peaking characteristics and converted annual forecasts for vehicle categories to meaningful hourly arrival rates. These hourly forecast values were critical to run traffic simulation models and test the 30th highest hour design as well as populating the LOS framework that provides sensitivity analysis for assessing various infrastructure, phasing and service level scenarios.

1.0 Introduction

Land-based ports of entry (POE's) are key elements of the transportation network connecting two countries. Bottlenecks, delay and congestion at POE's add supply chain costs (time, financial, environmental) and have potential negative impacts on economic growth. The relative importance of land-based POE's are often expressed through trade figures and vehicle movements, which are generally accepted transportation industry metrics. For example, in 2010 the top 6 Canada-United States POE's accounted for $237 billion in two-way truck-based trade and more than 7 million annual truck movements. (Table 1).

Table 1: Top Six Canada – United States POE's (2010)

United States	Canada	Trade ($ B)	Two-Way Truck Traffic
Detroit	Windsor	91.7	2,620,000
Buffalo	Fort Erie	56.2	1,180,000
Port Huron	Sarnia	42.7	1,540,000
Champlain	Lacolle	18.4	620,000
Pembina	Emerson	14.3	370,000
Blaine	Surrey	13.9	700,000
TOTALS		237.2	7,030,000

POE delay typically occurs when vehicle arrivals exceed processing capacity (infrastructure or staffing levels). Insofar as delay is concerned, the main issue is the wide range and high variability of delay rather than average measures of delay. Wait times at POE's have been responsible for increasing production costs of a new vehicle in North America by $800 Cdn in the past decade. Ford Motor Company claims delay costs of $200 per hour per truck at POE crossings. More significantly, a delayed shipment can prevent the delivery of key components and shut down an entire production line. For the automotive industry, estimated costs of production down time range as high as $13,000 per minute (Anderson, 2012).

The bi-national *Beyond the Border* declaration (February 4, 2011) signed by President Obama and Prime Minister Harper provides the over arching policy framework for moving toward "a shared vision for perimeter security and economic competitiveness" in North America. The *Beyond the Border* declaration recognizes the critical importance of land-based POE's in their dual role of sovereign security and North American supply chain efficiency.

The *2012 Beyond the Border Implementation Report* notes that "efficient ports of entry are essential to the economic well-being of both Canada and the United States. An integrated bilateral approach to investment in infrastructure and technology is critical to maximizing the potential benefits of our shared economic space and to ensuring that we have the capacity to support the current and future volumes of commercial and passenger traffic that are critical to economic growth and job creation." A major output of the Beyond the Border process is to develop a five-year joint Border Infrastructure Investment Plan covering coordinated upgrades such as customs plaza replacement and redevelopment, additional primary and secondary lanes and booths, and expanded or new connecting roads and highway interchanges. (Ref. 2)

In a decision-making environment that is increasingly influenced by factors related to fiscal restraint, the competition for scarce resources to improve transportation infrastructure requires appropriate merit based justifications to illustrate the case for making multi-million dollar strategic investments. Furthermore, in the case of POE infrastructure delivery, the bi-national decision making context requires a lead time of between 6 to 10 years to deliver a coordinated infrastructure solution involving as many as 6 federal, state and provincial agencies. When planning for projects that must meet the needs for 20+ years and can take over a decade to implement, defensible forecasts of traffic projections are vital to justify proposed investments.

The applicability of a new forecasting methodology for POE's as articulated in this paper is that, once developed and fully operational, the methodology can be adapted to any major POE. In this regard, there are 120 land-based Canada-United States POE's and 44 land-based Mexico-United States POE's. In practical terms, the top 20 POE's along the Canada-United States and Mexico-United States could benefit from the application of this methodology.

A common economic metric in justifying infrastructure projects is the benefit-cost analysis approach, based on ratio of user benefits to capital costs over at a minimum of 20 years. A predominant metric is the reduction in wait times on a per vehicle basis. Therefore, any analysis requires vehicle arrival forecasts at a granular level down to the hour for each day of every year out to the planning horizon (typically 20 years).

The purpose of this paper is to illustrate the importance of developing precision forecasts of hourly vehicle arrivals (by vehicle category) as a basis for evaluating, planning and constructing merit-based infrastructure improvements at a land-based POE. A recently completed conceptual planning study for the Pembina-Emerson POE (2013) was used as the case study for this paper. This paper also relates to the companion paper entitled, "Developing and Applying a Level-of-Service Framework to Port-of-Entry Infrastructure Planning" presented at this TAC conference.

2.0 Methodology Integration

The Pembina-Emerson POE study is referenced as a case study in this paper to illustrate the critical importance of developing accurate hourly forecasts of vehicle arrivals at POE's. The accuracy of the forecast inputs drive the precision of the demand-capacity analysis and simulation models which are used as a basis for formulating various POE improvement scenarios. Forecast inputs are used to calibrate traffic simulation models to determine critical infrastructure requirements, based on 30th highest hour design, as well as generate output for an innovative Level-of-Service (LOS) framework for evaluating POE performance. Manitoba Infrastructure and Transportation (MIT) developed the forecast methodology and LOS framework for the Pembina Emerson study. Figure 1 illustrates the relationship between forecast development, simulation models and LOS analysis.

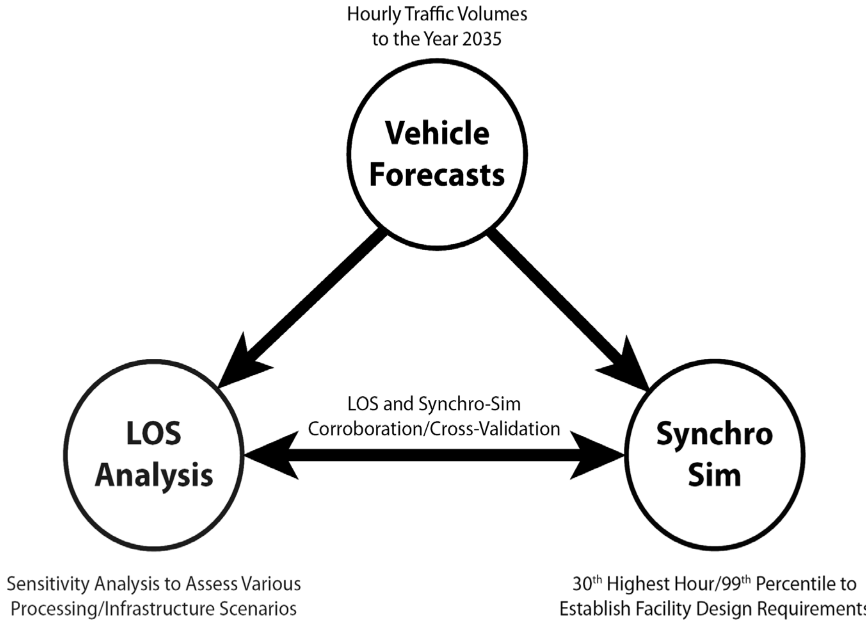

Figure 1: Methodology Relationships

3.0 Inadequacy of Contemporary Demand Forecasting for POE Applications

For the Pembina-Emerson study, demand forecasts to 2035 by direction and vehicle type (autos, trucks) were required. Bus activity was removed from the forecasts at Pembina-Emerson because it only accounts for 0.02% of total traffic. The standard engineering approach for road corridor design is to use average annual daily traffic (AADT) multiplied by several sets of expansion factors for each of the two vehicle classes to calculate the desired level of granularity (monthly, weekly, daily, hourly). These techniques are described in the 2010 Highway Capacity Manual (HCM), the 2005 National Cooperative Highway Research Program (NCHRP) Report 538, and the 2010 Institute of Transportation Engineers (ITE) Transportation Planning Handbook. Forecasts are crucial to determine the investment required in accommodating future traffic demands and when to expand networks to accommodate incremental volume growth (ie: when to add more lanes, etc.).

Table 2 shows the standard industry nomenclature of expansion factors from the 2010 HCM, Volume 1: *Concepts* is applicable to this study. These factors are derived from permanent counting station recordings for 24 hours of every day in a year, or 8,760 hours of annual data. Only vehicle volumes by the two main classes (cars, trucks) are needed for customs plaza performance measurement.

Initial scoping for the Pembina-Emerson POE study suggested that the standard HCM forecast methodology would suffice. For both autos and trucks, expansion factors were developed from vehicle count estimates at Manitoba Highway permanent counting station 31, two kilometres north of the border as a proxy for the POE. Figure 2 shows the AADT and AADTT temporal distribution for both total traffic and the proportion of truck traffic at station 31.

Table 2: Nomenclature used in Traffic Demand Forecasting

Term	Short Description	Long description and purpose
AADT	Average Annual Daily Traffic	The average annual daily traffic is expressed as the total vehicle traffic passing a station divided by 365, expressed as vehicles per day in both directions.
MDT	Monthly Daily Traffic	The percent of AADT that occurs in a day in a particular month.
AADW	Annual Average Day of the Week	The percent of AADT occurring on each day of the week.
DHV	Design Hourly Volume	Relating to traffic volume for a specific hour of the day
DDHV (or D)	Directional Design Hourly Volume	Refers to percent of traffic volume in the hour by direction (noted by some agencies and literature as simply D for direction). The opposing direction is (1-D) and both add up to 100%. Also changes by time of day.
T	Truck percent	The volume of trucks in the traffic stream, usually expressed as percent used in pavement design.
K	K factor	K refers to the traffic peak hour of the day with the hour defined as the high 15 minute volume in that hour. Often substituted for DHV or specific hourly counts.

Source: 2010 Highway Capacity Manual, Volume 1 *Concepts*

An example best illustrates how the HCM-based expansion factors are applied, using Station 31 data to calculate southbound auto traffic on a Friday in August 2011 at 6:00 pm:

AADT (2011) = 3,260
MDT (August) = 1.34
AADW (Friday) = 1.15
DHV (6:00 pm) = .069
T (truck %) = .324
DDHV (southbound) = .51

Hourly Southbound Auto Traffic = AADT x MDT x AADW x DHV x DDHV = 120

This example illustrates that 120 autos per hour are forecasted in the southbound direction for this year, month, day and time of day, whereas the typical southbound auto traffic on Fridays at 6:00 pm in August at the Pembina-Emerson POE ranges from 170 to 270 with the latter being a peak hour for August Long weekend. While the HCM forecast distribution approach seemed logical, it failed to replicate field observations where peak period delays for a similar date were in excess of 2 hours with queue lengths over a mile long.

Furthermore, when hourly forecast for future years was inputted to the traffic simulation software, it failed to produce queue lengths during known peak periods. As such, it was determined that the HCM-based approach for developing hourly forecast data for the Pembina-Emerson POE did not have any validity. The next two sections summarize an alternative approach developed by MIT for generating hourly forecast data (both autos and trucks) which were validated by ground truth observations and historical data.

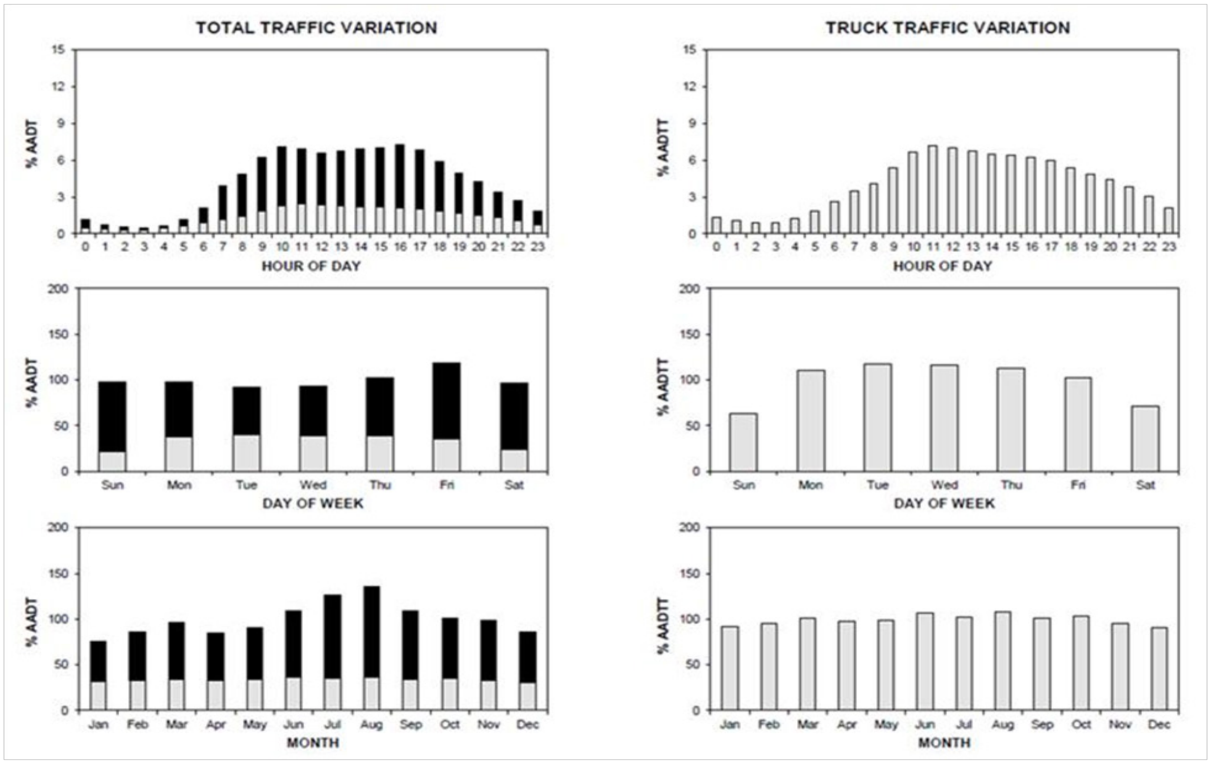

Figure 2: Pembina-Emerson POE AADT Expansion
Factors

3.1 Aggregate Auto Volume Forecasting

Recent studies in travel demand forecasting (Ref. 7,8) attempt to link land use activity, exchange rates, fuel prices, demographics, traveler choice behaviour and other characteristics as parameters in trip generation forecasting. Although these techniques provide insights on how trips are generated, they are static models based on trip generating factors for a defined region and are not directly applicable to regions as large as continental North America. Fuel prices and exchange rates do affect travel, but not to the extent that is suggested in other papers (Ref. 2,6). Pembina-Emerson POE traffic showed consistent growth as these two variables had a relatively in-elastistic effect (up to a certain point). For exchange rates, if the Canadian dollar drops below 85 cents relative to the U.S. dollar, then exports began to increase. For travelers, this doesn't affect it until this threshold was reached as well, Travel is influenced more by trip purpose, or a desire for a particular vacation destination. In the long run, these two variables tend to "wash" each other out, and are both difficult to predict in the future. Developing a function in the context of sensitivity analysis would show the effects of these variables, but for long run trends Pembina-Emerson historical traffic growth correlated well with population growth.

Therefore, standard regression analysis for auto trips that correlates to population growth was used to generate future AADT, with high-low projections at 1 percent each side of the average. For Pembina-Emerson auto traffic growth has been steady over the past 15 years at 2.6 percent. Bi-direction growth projections with high-low ranges are shown in figure 3.

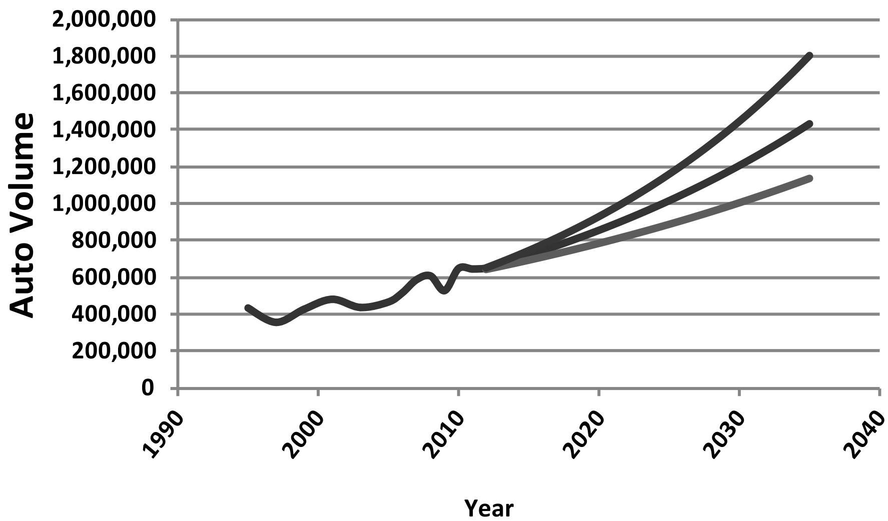

Figure 3: Pembina-Emerson Port of Entry Bi-Directional Auto Volume Growth with High-Low Ranges

3.2 Aggregate Truck Volume Forecasts

Truck forecasts were based on forecast commodity figures for the Pembina-Emerson POE extracted from the 2009 National Commodity and Trade Flow Survey commissioned by Transport Canada. A total of 30 commodity groups were forecasted in the study based on a North American production-consumption model. MIT obtained the southbound and northbound annual commodity tonnages for the Pembina-Emerson POE and converted this data to bi-direction annual truck flows using techniques in appendix A and B of NCHRP report 538, namely:

- Annual truck loads by commodity group estimated according to net cargo weights by GVW,
- GVW of I-29 and I-94 in U.S. used to determine weighted average GVW,
- Net cargo weights calculated by subtracting truck tare from GVW used in commodity industry,
- Empty backhauls by percent and direction were used to calibrate aggregate truck flows.

Bi-directional aggregate truck traffic future forecasts were calibrated by "backward" forecasting into historical data and using a *Microsoft Solver* ™ model to calculate the direction percent

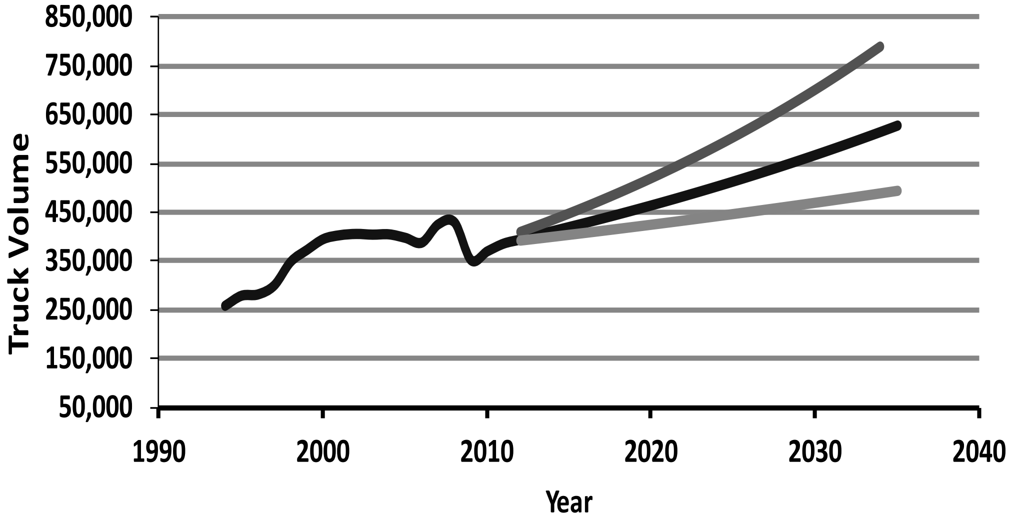

Figure 4: Pembina-Emerson POE Bi-Directional Truck Volume Growth with High-Low Ranges

aggregate annual growth. The aggregate forecasted truck traffic is a combination of loaded and empty moves by direction, as shown in figure 4.

4.0 Pattern Recognition in Revising Expansion Factors

For the Pembina-Emerson study historical hourly vehicle arrival rates for a 5 year historical period were obtained from US Customs and Border Protection (CBP) for the southbound direction of travel and Canada Border Services Agency (CBSA) for the northbound direction of travel. This consisted of Primary Inspection Lane (PIL) booth counts (autos and trucks) by each agency for each hour of every day of the year. The data revealed POE arrival rates with wide ranges, not unlike AADT patterns at permanent counting stations. Figure 5 illustrates a sample

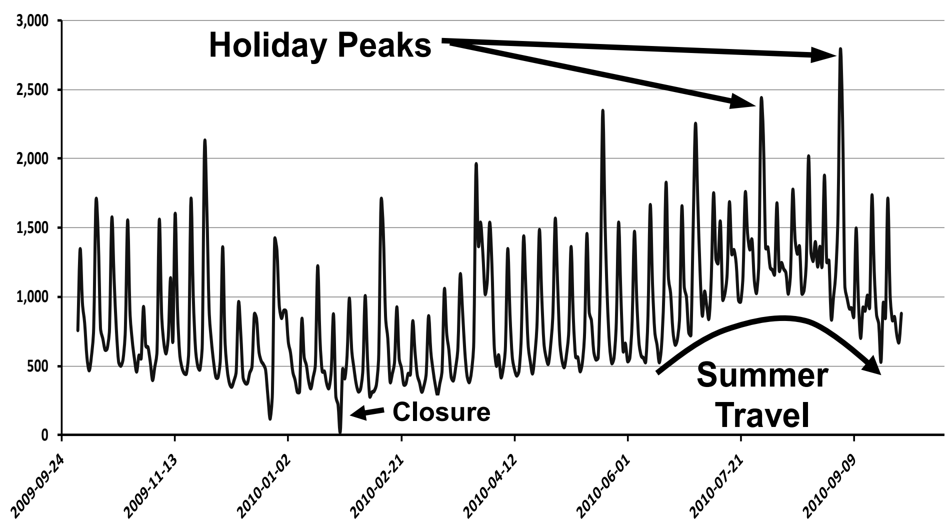

Figure 5: Sample Pembina-Emerson Southbound Auto Arrival Pattern

of southbound data that reflects these arrival patterns. However, use of general expansion factors as prescribed in the HCM has the effect of washing out the peaking patterns that occur when delays and queue lengths reach their maximum.

Several jurisdictions developed daily expansion factors for calendar days of the year where permanent counting station data exists and have proved to be extremely accurate in producing credible forecasts (References 9, 10). A requirement of this approach is "truth-in-data principle". The controlling truth-in-data principle for creating traffic forecasts is to precisely determine the accuracy sources and uncertainties of coefficients and growth to produce forecasts. This requires a clear statement of input assumptions and sources, defining known uncertainties, and providing the forecast in a form that a reviewer can understand and use. For the purposes of significant infrastructure investments based on forecasts, this principle underlies the need for a stable growth pattern with minimal statistical variation.

The major difference between using forecast data in engineering roadways as opposed to assessing customs plaza operations is that annual data for engineering is rank-ordered by magnitude as opposed to sequential hours used in simulation of queues at PIL booths. Furthermore, the 2010 HCM Volume 3, *Interrupted Flows* approach used for determining vehicle queues at signalized intersections and 4 way stops is not readily applicable due to differences in operational characteristics, notably platooning effects.

A more applicable approach for customs plazas is similar to queuing theory used in modeling service industries such as fast food outlets, bank tellers and other counter service business. Therefore, determining the sequential magnitude and pattern recognition characteristics in auto and truck arrivals was a crucial step in producing more credible forecasts to properly analyze the impact in traffic growth on infrastructure requirements and facility re-design. Developing custom expansion factors requires expert interpretation of historical arrivals data to understand the patterns and the unique peaking characteristics associated with each POE. The objective was to develop a methodology that would replicate the pattern shown in figure 5 as consistently as possible. Unlike a vehicle volume rank-order approach in engineered roadways, queues at customs plazas take time to dissipate below capacity and therefore have a greater proportion level of service hours in lower ranked categories.

Activity based trip generation models are not suitable as these involved too many parameters that, when combined, decrease the reliability of results and requires maintaining an information system on all facets for large regions. MIT obtained 5-7 years of historical hourly arrival data from both CBSA and CBP. The underlying vehicle arrival patterns at the Pembina-Emerson POE revealed several unique characteristics of auto and truck traffic, namely:

- Both southbound and northbound auto and truck traffic had very different hourly arrivals by time of day, day of week and even by month. For example, southbound autos on a Friday had a peak period between 4:00 pm and 7:00 pm, whereas on Sundays, the northbound auto peak was between 3:00 pm to 10:00 pm. This is reflective of weekend travelers from Manitoba to North Dakota departing after work on Fridays and returning under a more leisurely pace on Sundays. Also, Friday arrivals in May were different from a Friday in August and so forth.

- There was no uniformity in weekly arrival patterns by direction, nor within the two main vehicle classes. Weekly patterns varied not only within each month, but more so around cultural events such as religious holidays and civic holidays, when schools ended, for example. The week after schools let out tended to double normal values as families began vacations. Weekly averages mask these occurrences.

- Holidays such as Victoria Day and Black Friday had peaking patterns that were quadruple normal arrivals. Christmas Day for example, was consistent at about 1 percent or less of normal. In one year, only 5 autos southbound were recorded for the day as compared to a daily auto average of 925.

- The Easter period, which fluctuates between March and April, can often occur during the school spring break period and create a pattern of arrivals that varies year by year. This requires several sets of expansion factors to account for the proximity of these events.

- Holidays with fixed dates that move through the days of the week had different expansion values according to the day of the week. When the holiday occurred on a Friday or a Monday, producing a three day weekend, expansion values were doubled or more over normal.

When it became apparent that general travel behaviour patterns according to the aforementioned observations occurred with regularity, the following approach and rules in developing custom expansion factors and forecasts were formulated and applied:

- There was sufficient information to develop custom factors for *each individual day of the year*, that resulted in a 365 x 7 array of expansion factors, and,

- These custom expansion factors were separated by *auto and truck, by direction*, and

- Special expansion factors were developed for both vehicle classes, *for each Canadian and American holiday*, by day of the week, and,

- Hourly expansion factors were developed for *each hour for each day by direction*.

This approach is similar to that used by other jurisdictions where year round permanent counting station data existed (references 9, 10). However, the MIT approach enhanced the accuracy of forecasts by developing an algorithm that provided the logic "switch" to special expansion factors when holidays or special events occurred.

Figure 6 illustrates a three dimensional representation of these expansion factors. Figure 6 illustrates that when permanent counting station data that is relatively stable with minimal variability, it is possible to produce a 3 dimensional cube of expansion factors with calendar date, day of the week and hour of the day on each axis. This results in 61,320 individual factors for each hour of each day of the year and only requires multiplication by AADT. Forecasts for autos and trucks by direction were done separately and then aggregated, resulting in 4.9 million total calculated forecast hours.

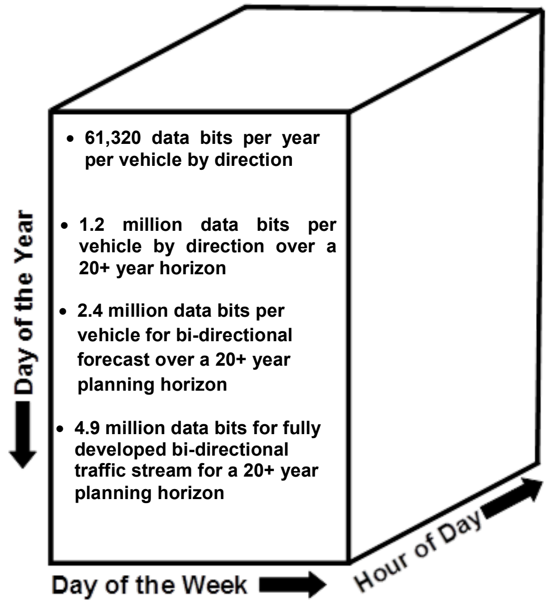

Figure 6: Three Dimensional Relationship Structure of expansion factors for Permanent Counting Stations

Tables 3, 4 and 5 shows samples of the expansion factor tables produced by MIT for vehicle arrivals in a two dimensional tabular format. Table 3 is for general days of the year that are not influenced by holidays, table 4 are special values to cover actual holidays and the days adjacent, and table 5 are hourly factors for each day of the week. These are remarkably consistent through 5 years of data, particularly for trucks, with only slight variations in magnitude.

Figure 7 shows a simplified approach to calculating hourly forecasts, taking into account the day of the year, whether it is a holiday and the hourly factor. The accuracy is improved as factors for each day of the year are produced, eliminating variability in monthly, weekly and any seasonal trends. The only special condition is the holiday factor. The HCM-based formula in section 3.0 for the northbound hourly auto example is thereby revised as follows:

Hourly Southbound Auto Traffic = AADT x MDT x AADW x DHV x DDHV

(MIT) Hourly Auto Traffic = AADT x DEF x DHV

The daily expansion factors (DEF) for each day of the year, as shown in table 3, replaces the monthly and weekly factors. While the DHV remains the same in the equation, the detailed border arrival counts were used to improve the precision of factors. When fully developed into a three dimensional expansion factor database structure, the formula for hourly vehicle arrivals is reduced to the following:

$$(\boldsymbol{MIT})\ \boldsymbol{Hourly\ Auto\ Traffic} = \boldsymbol{AADT\ x\ H}[\ \boldsymbol{HEF}^{\boldsymbol{G}}_{\boldsymbol{X,Y,Z}}\ |\ \boldsymbol{HEF}^{\boldsymbol{S}}_{\boldsymbol{X,Y,Z}}\ ]$$

Where AADT = average annual daily traffic
HEF = Hourly expansion factor (x,y,z)

H = Heaviside unit step function
G = General expansion factor set
S = Special holiday factor set
X = calendar day of the year
Y = day of the week
Z = hour of day

Table 3: Sample of Southbound Auto daily expansion factors

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
01-Jan	1.14	0.57	0.48	0.76	0.86	0.57	1.33
02-Jan	1.33	0.67	0.57	0.67	1.00	0.57	1.33
03-Jan	1.43	0.57	0.48	0.48	1.71	0.52	0.62
04-Jan	1.43	0.57	0.48	0.86	1.71	0.52	0.62
05-Jan	1.43	0.43	0.33	0.67	1.71	0.52	1.33
06-Jan	1.24	0.43	0.33	0.67	1.71	0.52	1.24
07-Jan	1.24	0.43	0.33	0.67	1.62	0.48	1.14
08-Jan	0.51	0.44	0.49	0.65	1.20	0.73	0.60
09-Jan	0.51	0.44	0.49	0.65	1.20	0.73	0.60
10-Jan	0.51	0.44	0.49	0.65	1.20	0.73	0.60
11-Jan	0.51	0.44	0.49	0.65	1.20	0.73	0.60

Table 4: Southbound Autos Special holiday expansion factors

Holiday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Louis Riel Day	0.98	0.49	0.59	0.99	2.16	2.11	1.35
Spring Break (week 1)	1.54	1.36	1.47	1.82	2.48	2.11	1.91
Spring Break (Week 2)	1.54	1.36	1.47	1.82	1.84	0.83	0.64
Easter	0.52	1.00	1.00	1.00	0.71	0.52	0.44
Victoria Day	0.82	1.00	1.00	1.33	2.95	2.11	1.32
July 1st	1.19	1.24	1.62	2.61	3.09	1.51	1.17
August Long	1.50	1.00	1.00	1.00	2.95	2.61	1.60
Labour Day	1.15	1.00	1.00	2.14	3.56	2.67	1.43
Thanksgiving	1.02	1.00	1.00	1.24	2.52	2.06	1.30
Rememberance Day	1.09	1.19	1.19	3.18	3.56	1.19	0.81
Black Friday	1.00	1.00	1.00	2.96	1.85	0.90	0.77

Table 5: Sample of Southbound Autos hourly factors

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
2	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
3	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
4	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
5	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
6	0.75%	0.75%	0.75%	0.75%	0.75%	1.50%	0.75%
7	1.00%	1.00%	1.00%	1.00%	1.00%	3.50%	1.00%
8	1.50%	1.50%	1.50%	1.50%	1.50%	5.50%	1.50%
9	3.00%	3.00%	3.00%	3.00%	3.00%	7.50%	3.00%
10	5.50%	5.50%	5.50%	5.50%	4.00%	11.50%	5.50%

The Heaviside unit step function is used in electrical engineering to represent the binary logic switch in circuits, and for this purpose, mathematically represents the IF and THEN command in the spreadsheet macro coding to indicate when to use the special expansion factors when a day falls on a holiday. The three axis locations (x,y,z) points to the precise hourly factor in each three dimensional set. An example if August 10 (x) in a future year falls on a Tuesday (y) at 6:00 pm (z).

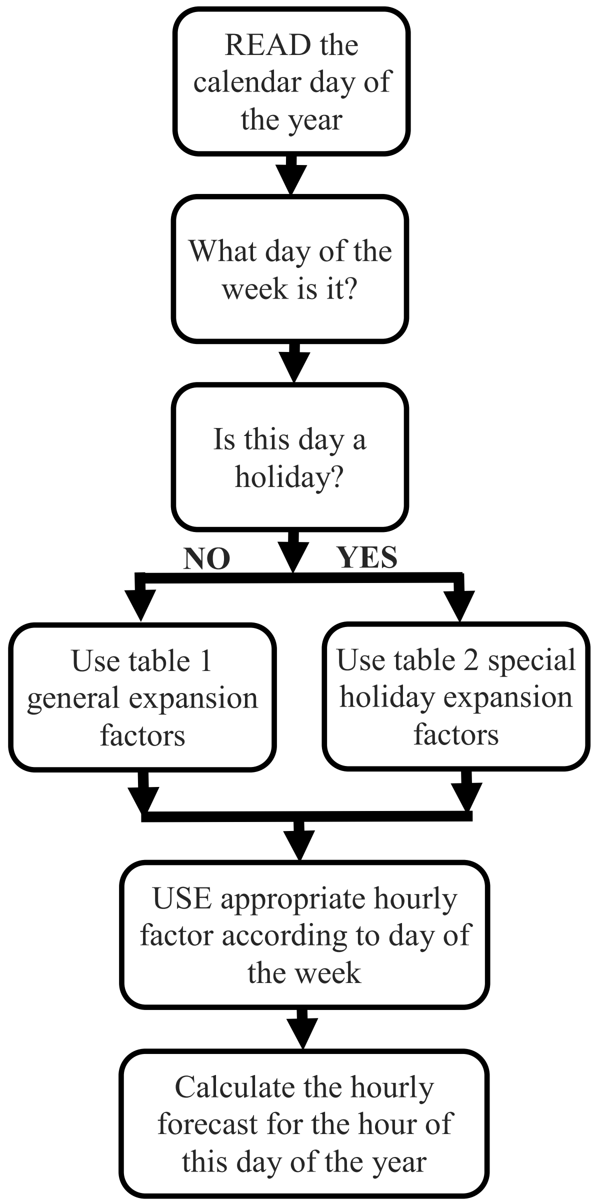

Figure 7: Decision Flowchart for Algorithm Used to Generate Vehicle Forecasts at Pembina-Emerson POE

5.0 Comparison of Original versus Revised Forecast Methods

The MIT forecast methodology proved to be superior to the standard HCM approach for several reasons. Table 6 provides a comparison between the HCM methodology example used in section 3 and the MIT methodology developed for the Pembina-Emerson POE study as presented in section 4. The HCM methodology produced a result of 120 autos per hour southbound on Fridays in August 2011. The methodology developed by MIT predicted auto arrivals of 307 for August long weekend and 248 for regular Fridays for the same day / time with the actual count being 295 and 251 respectively. As such, the HCM methodology understated actual arrivals by 206% whereas the MIT methodology reflected a 5 to 7 % variance from actual counts. Clearly, the MIT methodology more precisely reflected observed arrivals.

Table 6: Auto Arrival Forecasting Method Comparison	
Southbound Autos – Fridays, August , 6:00 pm 2011	
Auto Arrivals	Forecast Method
120	2010 HCM, NCHRP 538 (Original)
307 [a], 248 [b]	MIT forecast methodology
295, 251	Actual Counts from Border Data

a = August long weekend, b = regular Friday

Further validation of the MIT methodology occurred in 2012 when actual arrival data for the first quarter was obtained. This data was used to assess the accuracy of the forecasts for the same period to determine the variance between forecast values and observed arrivals. Figure 8 illustrates HCM forecast, MIT forecast and actual data for the first quarter of 2012. The HCM forecast line shows how the general average method fails to capture arrival peaks. The MIT forecast methodology closely approximated the observed oscillations of vehicle arrivals and was able to predict the pattern of vehicle arrivals during regular weekly periods as well as the more unique holiday peaking.

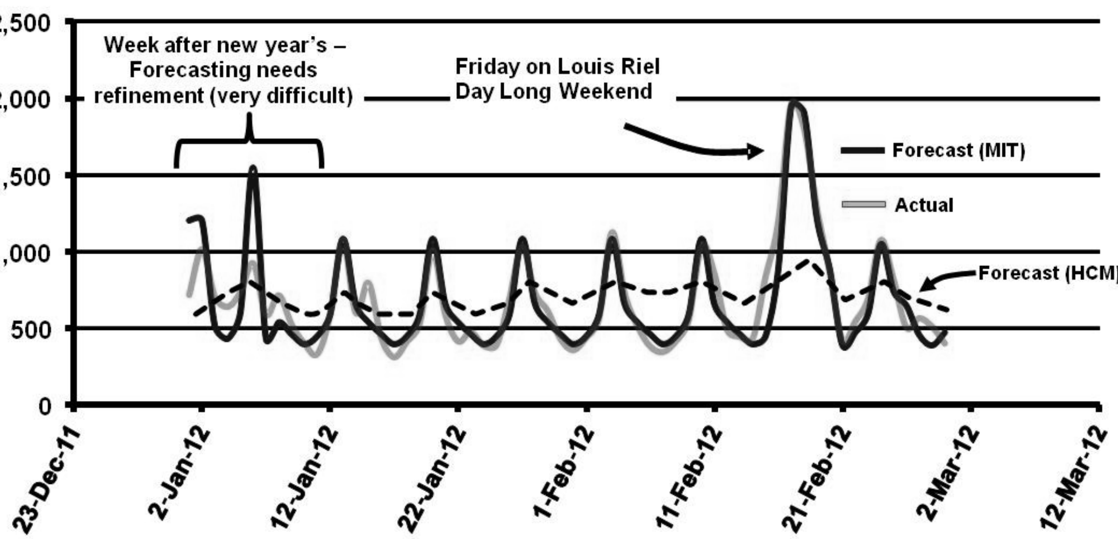

Figure 8: Comparison of Forecast Methods to Actual 2012 Southbound Auto Arrivals

The MIT methodology still requires some refinement to capture all the peaking anomalies. The one period of the year subject to further refinement is between Christmas and New Year, as evidenced in figure 8. The historical data showed great inconsistency from year to year during this period. There were some very weak patterns that were observed, for example if New Year's Day fell on a weekday as opposed to a weekend. The same observation would apply to Christmas day. Vehicle flows at the POE during the interim period showed a weak correlation to when both dates fell on weekend dates. However, these minor inconsistencies do not skew simulation results, LOS analysis, infrastructure assessments or trigger points for improvements.

6.0 Conclusions

The importance of an accurate traffic forecasting methodology, as described in this paper, has high-level policy implications regarding POE infrastructure investment decisions. Sound forecast data is of paramount importance in any POE planning process given that the cost of recommended infrastructure improvements are typically quite high. For example, all Detroit River International Crossing (DRIC) components are estimated to exceed $2 billion.

In the Pembina - Emerson study, full build-out for all elements of the recommended alternative is expected to be in the order of $60 million. However, the southbound and northbound improvements can become operational with an investment closer to $20 million. Furthermore, an investment of $20 million will return the full $355 million in benefits southbound and $222 million in benefits northbound attributed to reduced fuel consumption and emission reductions to the year 2035. Although a $20 million investment for a top 5 POE seems reasonable, particularly when those costs are distributed between four implementing agencies and the benefits are substantial, competition for merit-based funding in a fiscally restrained decision-making environment remains a reality. This is discussed further in the companion paper "*Developing and Applying a Level-of-Service Framework to Port-of-Entry Infrastructure Plannin*g".

As such, highly accurate forecasting for POE's on an hourly level allows for greater levels of confidence in applying the methodologies that are necessary to develop the engineering design (30th highest hour), evaluate POE performance (LOS analysis) and justify merit-based investments. Furthermore, without highly reliable forecasts on an hourly level, it was demonstrated that traffic simulation models were incapable of capturing historical peaking patterns and producing meaningful results to generate appropriate design alternatives. In applying the MIT forecast methodology to other POE's, accurate historical, port-specific, hourly data is a prerequisite for customizing expansion factors to the unique characteristics of that port.

Notwithstanding the fact that all historical based forecasting techniques assume minimal change in the structure of the economy that produces traffic demand, any significant departure in the production-consumption of national economies warrants revisiting the model for recalibration. Even sophisticated production-consumption models cannot escape this reality. In view of these considerations the costs to government of investing in the ongoing maintenance of effective data bases necessary to undertake appropriate analysis is also a long-term consideration.

Acknowledgments:

Transport Canada: Provided 2009 National Commodity and Trade Flow Survey data and major funding partner for the Pembina-Emerson study

Gannett Fleming: Conducted simulation modelling for the Pembina-Emerson POE and prepared the final study report

CBSA / CBP: Provided Pembina-Emerson POE historical arrival data

References:

1. Moens, A and N. Gabler (2012), "*Measuring the Costs of the Canada – US Border*", Studies in Canada-US Relations, Report by the Fraser Institute, Vancouver B.C., www.fraserinstitute.org
2. (2012) "*Beyond the Border Implementation Report*", http://actionplan.gc.ca/en/page/bbg-tpf/2012-beyond-border-implementation-report
3. (2010),`*Uninterupted Flows*``, Highway Capacity Manual, Vol. 2, Transportation Research Board, Washington, D.C.
4. (2005) "*Traffic Data Collection, Analysis, and Forecasting for Mechanistic Pavement Design*", Report 538, National Cooperative Highway Research Program Report (NCHRP).
5. (2010), ``*Transportation Planning Handbook*``, 6th Edition, Institute of Transportation Engineers, Washington D.C.
6. Anderson, W. (2012) "*The Border and the Ontario Economy*", Cross-Border Transportation Center, University of Windsor.
7. (2012) "*Travel Demand Forecasting: Parameters and Techniques*", Report 716, National Cooperative Highway Research Program, Transportation Research Board.
8. (2006) "*Innovations in Travel Demand Forecasting*", Conference Proceedings Vol. 2, Transportation Research Board, Austin, Texas.
9. (2012) Traffic Forecasting Guidelines, Nevada Department of Transportation, http://nevadadot.com/uploadedFiles/NDOT/Documents/Traffic%20Forecasting%20Guidelines%2012_2012.pdf
10. (2002) Project Traffic Forecasting Handbook, Florida Department of Transportation, http://www.dot.state.fl.us/planning/statistics/trafficdata/ptf.pdf