# *Manitoba Highway Traffic Information System Development*

Marina Melchiorre, EIT
Graduate Student

Luis Escobar, EIT
Transportation Consultant

Alan Clayton, P.Eng.
Professor

***University of Manitoba Transport Information Group***
Department of Civil Engineering
Rm.342 Engineering Building
15 Gillson Street
Winnipeg, Manitoba
R3T 5V6
umtig.mgmt.umanitoba.ca

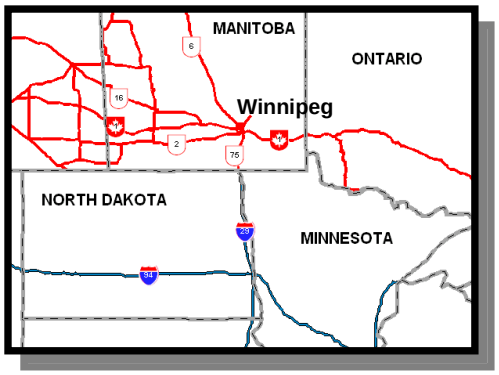
## *Introduction*

This paper describes the development and implementation of a traffic monitoring system for provincial highways in Manitoba, formally named the Manitoba Highway Traffic Information System (MHTIS). Established in 1994, the MHTIS is a partnership between Manitoba Highways and Transportation (MHT) and the University of Manitoba Transport Information Group for the collection, analysis, and dissemination of information about traffic movement on Manitoba highways. The combination of MHT's technical expertise in traffic data collection along with university students and faculty's developmental research focus has created an innovative traffic information system that continues to evolve.

First, this paper will discuss the development, operations, and methodologies of the MHTIS including: (1) the partnership between MHT and the University of Manitoba; (2) MHTIS responsibilities pertaining to traffic information delivery; and (3) MHTIS data analysis principles and techniques for Average Annual Daily Traffic (AADT) estimates from permanent counting stations and the expansion of short-period volume counts. Secondly, this paper will present current enhancements to the MHTIS in the areas of AADT estimation methodologies, quality control techniques, and truck information data collection. This paper will demonstrate the developments and current work conducted by UMTIG in the area of traffic monitoring and transportation system analysis.

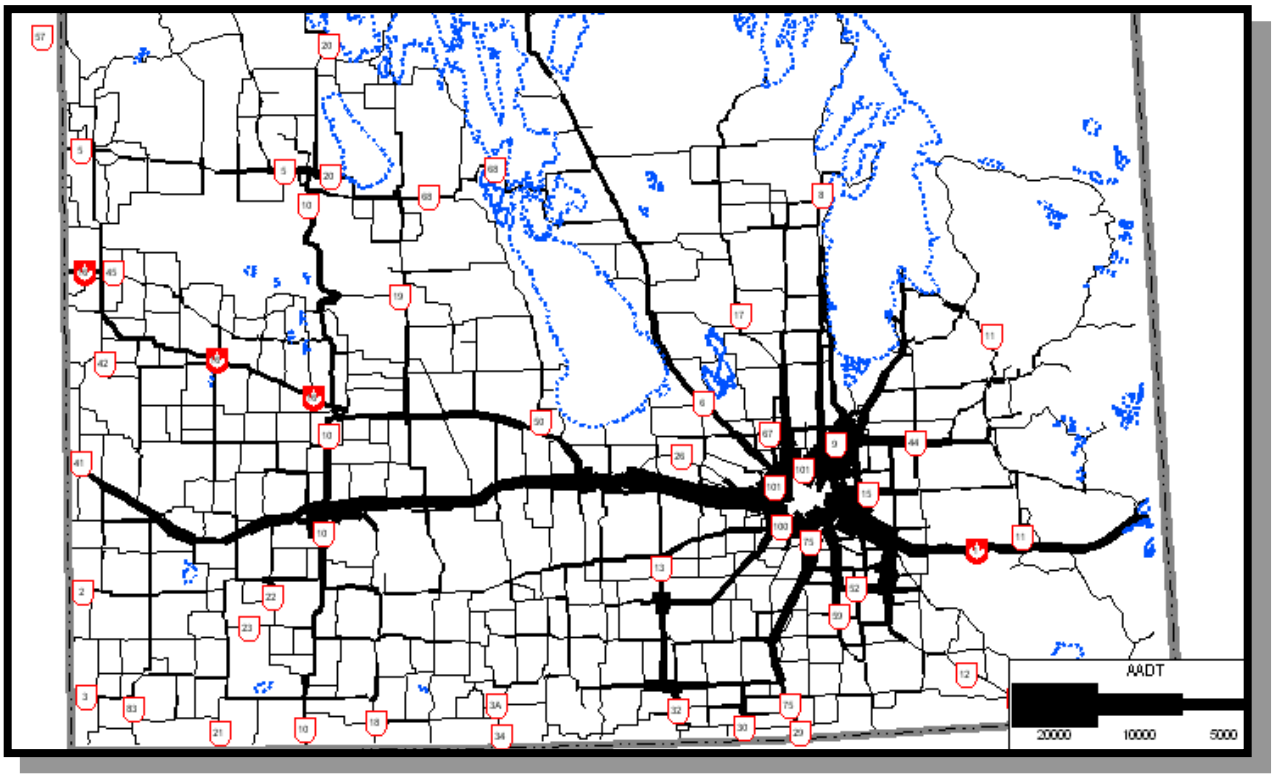
## *Characteristics of the Manitoba Highway Network*

The Province of Manitoba is located in the prairie region of Western Canada. Manitoba has population of one million, with nearly three-quarters of the population located in and around the region surrounding the City of Winnipeg. Manitoba's highway network consists of 17,400 kilometers of provincial trunk highways and provincial roads with the majority located in the southern part of the province.




***The Prairie Region*** encompasses the provinces of Saskatchewan and Manitoba along with North Dakota and Minnesota States.

Manitoba's highways are generally considered to be low volume roads with the exception of major routes such as the Trans-Canada, Yellow Head, and Perimeter highways. Notably, half of Manitoba's highways have average traffic volumes of less than 400 vehicles per day.



## *Background*

### *The University of Manitoba Transport Information Group*

The University of Manitoba Transport Information Group (UMTIG) is a team whose primary objective is to adopt information technology for transportation analyses. UMTIG continues to develop its expertise in traffic data processing and building transport databases in a GIS environment to provide meaningful information to transportation planning professionals. Over the past five years, UMTIG has employed more than fifteen graduate and undergraduate students in various capacities. UMTIG has worked for the US Federal Highway Administration, Transport Canada, City of Winnipeg, private consulting firms, and various trucking organizations in addition to MHT.

### *MHT -UMTIG Partnership*[1]

The MHT-UMTIG partnership is the result of a process that began, when the University of Manitoba Transport Institute was commissioned in the fall of 1991 to design a traffic monitoring system to service the needs of Manitoba Highways and Transportation. MHT was concerned about costly and inflexible mainframe-based data processing procedures, accuracy, and reliability of data summaries, long lag-time between data collection and the availability of reports, and isolation from MHT's traffic data needs. The resulting document, "Design, Development, and Implementation of a Traffic Monitoring System for Manitoba Highways and Transportation" was submitted making 51 recommendations towards creating an effective traffic information system.

Further discussions between MHT and the University of Manitoba led to the submission of a conceptual outline in which a co-operative venture to operate a new traffic information system was proposed. The University brought its strong knowledge base, analytical capability, and innovative thinking while MHT contributed its expertise in data collection, system management, and administration. The University would be responsible for data analysis, preparation of annual reports, and assessing data needs, while MHT would remain responsible for overall management, setting policy, and data collection.

[1] Lucas, Brian. "Design, Development, and Implementation of the Manitoba Highway Traffic Information System". M. Sc. Thesis, University of Manitoba, October. 1996.

***MHT Benefits:***

- State-of-the-art traffic information system
- Greater depth and detail in the analysis of traffic data
- Lower costs
- Development of well-trained future personnel
- Staffing and program flexibility

***University of Manitoba Benefits:***

- Excellent data source for research
- Excellent training ground for students
- Funds to assist graduate and undergraduate students
- Professional development opportunities

---

The detailed proposal document, "System Specifications", was accepted by MHT resulting in an agreement between MHT and the University signed in August 1994. Development of the MHTIS proceeded over the following months. The first annual report, "Traffic on Manitoba Highways 1994", was produced in July 1995 with subsequent annual reports completed yearly. Other special reports on vehicle-kilometers of travel and truck traffic were also produced to complement the annual reports.

## *Information Delivery Principles*[2]

The most important component of the MHTIS is the information delivery to the users. The fundamental principle of the MHTIS is that the entire system must be user-driven. That is, the system must be responsive to the user's needs. This means that the content of all reports produced by the MHTIS must meet the user's information requirements, and also that the reports are easily accessible to all users who require them, in an easy-to-use format, and are available in a timely manner.

All reports follow the principles of responsiveness to need, truth in data, and consistent practice while maintaining base data integrity.

---

***Responsive to need:***

- Provide information required by users
- Follow convenient, easy to use format that meets users' needs
- Handle requests for information quickly
- Provide timely information (i.e. not outdated)

***Truth-in-data:***

- Document and disclose methods used for data sampling and expansion
- Describe the methods used to collect and process the information presented
- Provide estimates of the accuracy of all statistics

***Consistent practice:***

- Adopt standard methods or press for standards to be established
- Conform to standard practice (AASHTO, ASTM, FHWA standards)

***Base data integrity:***

- Screen raw data for errors and anomalies
- Data may be accepted or rejected but not adjusted

---

[2] Clayton, Lucas, and Alam. "System Specifications". University of Manitoba Transport Information Group, August 1994.

## *Reporting Methods*

### *Help Desk*

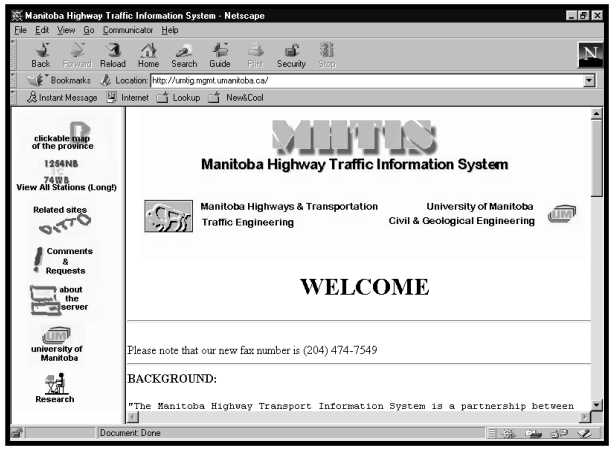
The UMTIG Help Desk assists users who do not have Internet access or who need assistance using it. Help Desk staff generate and send copies of raw data and tabulated data via fax or mail. The Help Desk services requests from MHT staff, engineering consultants, and the general public.

### *Annual Reports*

The annual publication, "Traffic on Manitoba Highways", provides historical statistics and analysis for the entire province. The report presents detailed information about traffic volumes at all permanent counter stations in the province including graphs depicting average hourly, monthly, and yearly variations. Summarized by highway, estimates of basic traffic statistics--Average Annual Daily Traffic, Average Summer Daily Traffic, 30th Highest Hour, and percentages of trucks--for locations across the province based on short-term counts. The report documents all methodologies and includes raw data from short-period counts.

### *Internet-Online Traffic Report System*

All information can be accessed through the Internet. The MHTIS Online Traffic Report System on the Internet has provided detailed traffic statistics for each station and tabular data to users since 1995. Presently, users can request information by specifying a station number or by selecting a location by clicking an on-screen highway map. Continuing upgrading includes the current development of a geographic information system interface to allow users to query traffic information by a number of location search engines and to produce user-defined thematic maps.




***The MHTIS Online Traffic Report System*** can be accessed at: umtig.mgmt.umanitoba.ca

### *Geographic Information Systems (GIS)*

Customized traffic flow maps are provided to users for specific areas of interest. Since its inception, the MHTIS has maintained all traffic information on a GIS platform where transportation analysis is facilitated.

## *AADT Estimation*[3]

Average Annual Daily Traffic (AADT) estimates are estimated at approximately 2000 location on provincial highways and roads using a variety of equipment. Of these locations, 57 are permanent count stations (PCS) that monitor traffic volumes year-round. At the rest of the sites, portable "coverage counters" are used to take short-term samples to produce estimates of traffic statistics. Most sites are surveyed on a two-year or longer cycle. Short-term count stations are generally surveyed twice for 48 hours each time in the year that they are counted.

AADT at permanent counter stations is estimated using the method specified by "ASTM Standard Practice for Highway-Traffic Monitoring, section 6.3". AADT at short-term counts is determined using a “factorless expansion method” that directly compares the short-term observed volume with the hourly data from the station's volume control station or Traffic Pattern Group (TPG). The method used for expanding traffic short-term counts is an extension of the "operational analysis" concept proposed in the AASHTO Guidelines.

A control station is a PCS that is believed to exhibit similar traffic flow patterns as that of the short-term count site. If data for the control station is not available, or is deemed to be inappropriate for expanding the short-term count, then the short-term count is expanded based on a traffic pattern group. A TPG is a group of permanent counters that exhibit similar temporal traffic characteristics. The expansion method assumes that traffic volumes at the permanent counter or TPG are proportional to those observed at the short-term count site for the same time period. This relationship is defined by the following equation:

$$\frac{AADT_{\text{Short-Term SIte}}}{VOLUME_{\text{Short-Term SIte}}} = \frac{AADT_{\text{Control Station}}}{VOLUME_{\text{Control Station}}}$$

Since the traffic pattern at a short-term count is unknown, the short-term count must be related to a TPG or a PCS to estimate the AADT from the short-term count. The assignment of both the TPG and PCS is based on the knowledge of the activity system surrounding the short-term count site. The assignment of the short-term count location to a certain TPG and PCS is empirical in nature and requires a great deal of knowledge of the activity system surrounding the short-term site.

[3] Clayton, Alam, Lucas, et al. "Design Development, and Implementation of a Traffic Monitoring System for Manitoba Highways and Transportation". University of Manitoba Transport Institute, April 1993.

## *Recent Enhancements*

### *Traffic Pattern Group Definition*[4]

To improve the representation of provincial highway TPGs, a new methodology of defining and assigning TPGs was developed by using an expanded study region consisting of Manitoba and Saskatchewan. This inter-provincial cooperation allowed the transportation system to be better characterized resulting in improved AADT estimates for Manitoba's short-term count sites. This development was an encouraging step in the cooperation and data-sharing policies between jurisdictions. This method also presented a new 'transparent' methodology for assigning short-term count sites to appropriate TPGs and control stations.

The quality of the AADT estimate depends on the quality of the TPG to which the short-term count site is assigned. A TPG which does not reflect the actual traffic pattern at the short-term count site to which it is assigned will result in AADT estimates which are inaccurate. The region consisting of Manitoba and Saskatchewan was selected because the two prairie provinces share many highways at the provincial border and the traffic patterns on these and many other highways in the region care likely similar. As well, the traffic monitoring practices of the two jurisdictions are comparable. However, traffic data was not previously exchanged.

The traffic patterns on highways in the region are examined to develop TPGs. The data from each permanent counter in Manitoba and Saskatchewan was summarized into seasonal (monthly) and average hourly traffic variations at permanent counter sites from 1995 and 1996. Groups were first developed based on the seasonal variations at each permanent counter site, and then further defined by sub-dividing each group.

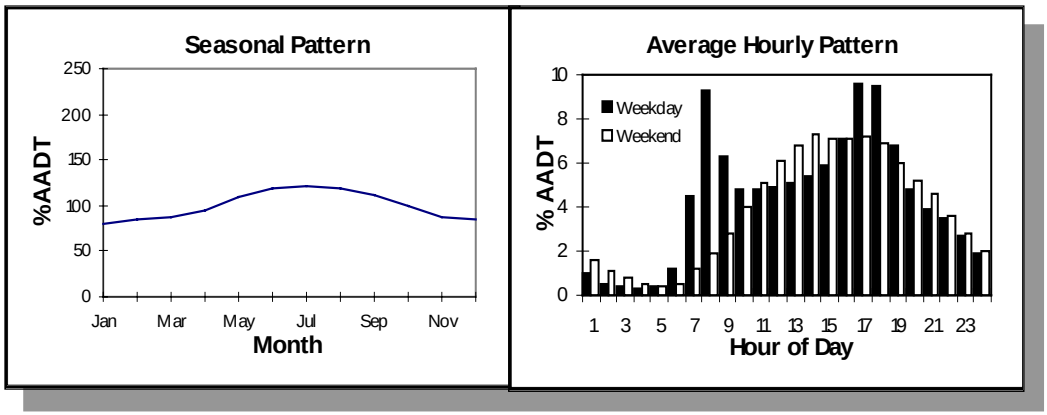
Permanent counters with similar seasonal traffic patterns are grouped using the Cluster analysis. Five seasonal counter groups were determined by comparing the mean monthly factors of each group using Tukey multiple means test. The five seasonal groups were further sub-divided based on the average weekday and weekend hourly traffic patterns to produce seven major TPGs. The groups are named Prairie Groups because of the region in which they are located.

Once the new Prairie Groups were determined, a new method of assigning TPGs to both PCS and short-term count sites was specified by examining the traffic patterns with respect to geographic characteristics of the permanent counting stations. This assignment process is customized for the prairie region and has been used since 1996. During the annual estimation process, if AADT estimates seem unreasonable TPG assignments are re-evaluated with changes appropriately documented.

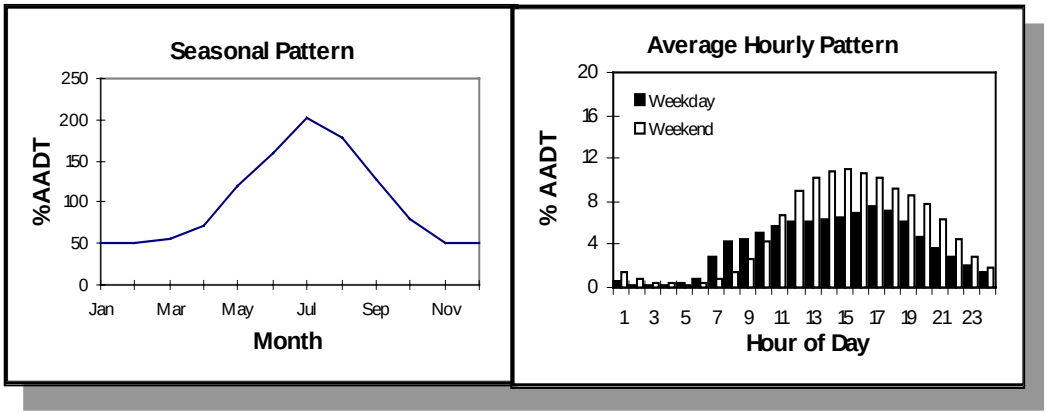
---

[4] Yeow, Jessie. "Enhancing Estimates of Annual Average Daily Traffic on Manitoba Provincial Highways". M. Sc. Thesis, University of Manitoba, March 1997.

***Prairie Group 1*** routes are located in or near a major urban center such as Winnipeg. These sites show very high morning and afternoon peaks during the weekdays with relatively little seasonal variation.




***Prairie Group 6*** routes serve areas where the traffic is almost exclusively seasonal recreational. The hourly pattern shows very high weekend traffic peaks compared to weekday traffic while exhibiting very high summer volumes.




## *Continuing development…*

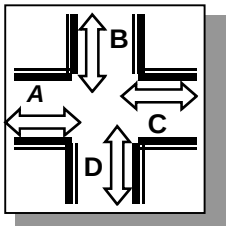
- Historical traffic data from 1997 permanent count stations is currently being used to evaluate the TPGs using a neural network.
- Efforts are being made to analyze the entire prairie region, consisting of Manitoba, Saskatchewan, North Dakota, and Minnesota, as a single transportation activity area. This analysis is based on the assumption that provincial and state highways will exhibit similar traffic characteristics.
- UMTIG is now developing a traffic monitoring program for the City of Winnipeg. The integration of both Winnipeg street and Manitoba highway traffic information will provide excellent coverage for regional analysis.

## *Quality-Control of AADT Estimates*[5]

One of the objectives of on-going development of MHTIS is to enhance the quality-control evaluation of its products, chiefly the AADT estimates of the system. The methodology used in the MHTIS process is fully documented and allows for the reproduction of estimates that are finally made. The current methodology uses human intervention for evaluating data input into the system. The raw data is screened and verified before being accepted into the database.

A new method was developed in 1997 to systematically evaluate combined AADT estimates by evaluating the conservation of flow at intersections while treating AADT point estimates as traffic flow along continuous links. Running on a GIS, this "intersection-balancing" technique identifies potential errors in AADT estimates of an "imbalanced" intersection and methodologically seeks to isolate potential sources of error.

A principal characteristic of flow in a network is that it is conserved at a single node, or in this case, an intersection. The method evaluates the conservation of flow by equating the flows entering the node to the flows leaving the node for each possible flow scenario. If the equation is satisfied, then the flow is conserved, and the node is said to be "balanced". Conversely, if the equation is not satisfied, conservation of flow is not achieved, and the node is said to be "imbalanced".




Each rule is applied to each intersection in the system. The volume difference between the flow entering and leaving the node is quantified by "balancing rules". This difference termed the "measure of imbalance". In short, it is the deficit or surplus in traffic needed to conserve flow at that intersection.

The measure of imbalance of each intersection cannot be compared directly because each intersection has a different amount of total activity. For example, consider two different AADT estimates, one of 5000 vehicles per day and another 500 vehicles per day. If a surplus of 100 vehicles per day results at both sites, the percent difference for the high volume count would only be 2 percent compared to the 20 percent for the low volume count. For this reason, volume differences of all intersections in Manitoba cannot be compared directly to one another.

The volume difference is normalized according to total traffic entering and leaving an intersection using the "Imbalance-Activity Ratio". The Imbalance-Activity Ratio is the imbalance expressed as a percentage of the total activity.

$$\text{IMBALANCE-ACTIVITY RATIO} = \frac{\text{Imbalance}}{\text{Total Activity}}$$

[5] Melchiorre, Marina. "Automated Quality-Control Evaluation of Traffic Volume Estimates for Manitoba Highways". B.Sc. Thesis, University of Manitoba, April 1997.

The total activity at an intersection is taken as the sum of the AADT estimates of each link connecting at that node. The Imbalance-Activity Ratio as a function of the total activity at an intersection forms the basis of determining which intersections are poorly balanced.

The last step in the quality-control method is to evaluate the individual AADT estimates of the links of imbalanced intersections. First, the relationship between imbalanced intersections in the system is established succeeded by investigating the potential sources of error. The link evaluation attempts to explain the imbalance at the intersection due to a poor AADT estimate, then to recommend measures that may improve the estimate in the future. Note that this method never alters an AADT estimate.

---

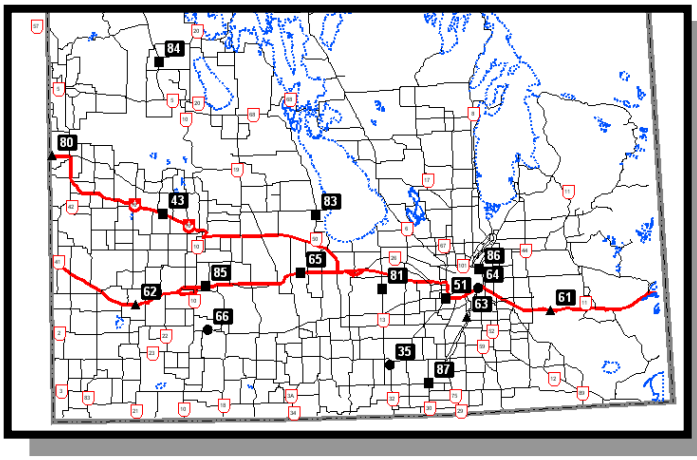
***Continuing development…***

- Using the same approach, further development of automated quality-control techniques based on network principles are being developed. These include a route-consistency method that would treat AADT estimates as continuum of traffic flow from one link to the next. Adjacent AADT estimates that have differing magnitudes beyond that expected would be investigated. This system could incorporate the knowledge of historical traffic patterns and demographic changes so that large differences in volumes from previous years could be identified and accounted for.

---

## *Truck Traffic Information System*

Many planning, engineering, and management issues facing MHT are dependent on the knowledge about past, present and future truck volumes and characteristics. UMTIG is currently developing a new Truck Traffic Information System (T-TIS) to monitor and classify truck traffic flows on low volume highways in Manitoba. At this time, nine automatic vehicle classifiers (AVCs) and eight weigh-in-motion devices (WIM) act as permanent count stations. As well, manual percent truck surveys and special surveys produce truck-related data on an "as-needed basis".




***WIM and AVC sites*** are located at test sites for the Strategic Highway Research Program Long Term Pavement Performance Project (SHRP/LTPP) and the Canadian SHRP.

The T-TIS will expand MHT's knowledge base by designing, implementing and operating a core program of monitoring and classifying truck traffic flows on each highway link. To produce truck volume estimates, the T-TIS must create appropriate adjustment factors for converting short-term truck traffic counts to annual averages similar to the method used for AADT expansion. This method requires the assignment of each highway link to an appropriate "Truck TPG" and permanent truck observation site such as a WIM or an AVC sites. This newly acquired information can then be used in to estimate axle weights for major truck classes.

To complement the T-TIS, UMTIG is proceeding with the automatic collection of truck - related information at Manitoba's ten permanent weigh scales. Truck weigh scales and mobile inspection stations observe, but do not retain a wealth of truck data. The information is only retained in special conditions such as an overweight vehicle. The potential knowledge to be gained from the weigh scales is large, and the inherent human intervention at the weigh scales and mobile stations will provide accurate and reliable data. Truck configurations, axle weights, gross vehicle weights, compliance levels (oversize and overweight), body types, and axle spreads are examples of data that is observed at each weigh scale. This data collection effort will be designed as an addition to the normal conduct of the truck weight enforcement program administered by MHT at static weigh scales and mobile inspection stations throughout Manitoba. The level of technology deployment, from data collection through data transfer, will be mainly dictated by truck traffic levels and weigh scale operational characteristics.

## *Summary*

The MHTIS continues to evolve in response to users' needs. The basic MHTIS framework was created as an 'open architecture' permitting on-going research and development. The result is many enhancements and complementing modules. The system demonstrates the partnership between a government agency and university that combined in-field experience with research and development to create a successful traffic information system.