

The Road Less Travelled The Ministry Reduces Operational Costs by Improving Traffic Signal Monitoring at Major Highway Intersections

The Ministry of Transportation (MTO) continually seeks to improve traffic safety and reduce operational costs.

To this end, in 2011 the ministry implemented wireless technology to monitor traffic signal operations at all provincially-owned highway intersections. This new system provides ministry staff with faster access to traffic information, improves system reliability and increases traffic safety.

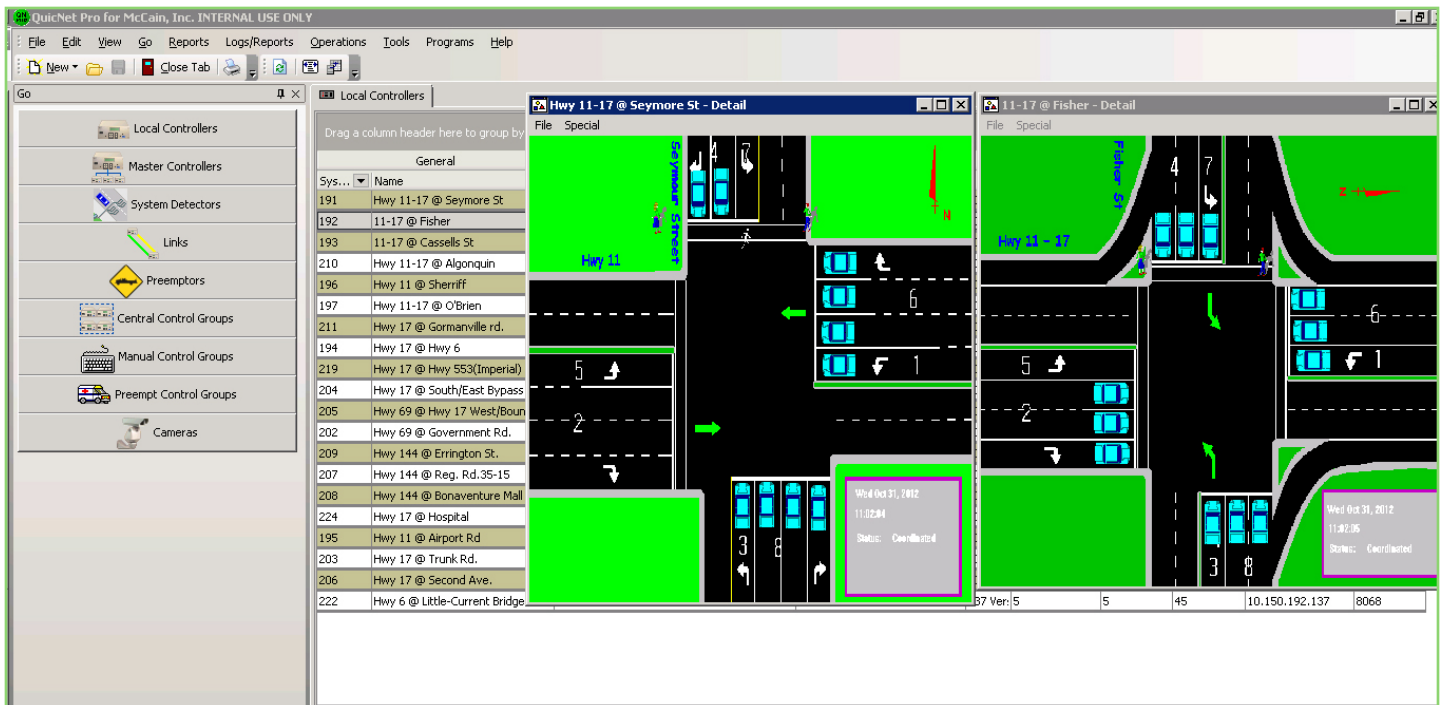
With QuickNet Pro software, which provides wireless services over MTO's existing communications network, the ministry is capable of remotely accessing information for multiple traffic signals throughout the province. This makes it possible for ministry staff and contractors to monitor and control intersection operations in real-time regardless of location. The system operates over a virtual private cellular network ensuring security and reliability of the entire operation.

QuickNet Pro provides more versatility by offering traffic signal malfunction diagnostics to ministry staff and contractors through their computers. This allows for swifter response to technical difficulties and traffic device malfunction.

Prior to the implementation of the wireless network, the ministry monitored traffic signals by physically patrolling highways or through feedback from citizens and police officers who identified local problems. Once aware of a traffic signal issue, ministry staff or contractors were deployed to investigate and resolve the problem. In remote locations, this could take several hours or up to half a day.

The dial-up system only allowed the ministry to access information for one traffic signal at a time. It was slow and costly. Based on the location of an intersection, long-distance charges would apply when communicating to remote intersection devices. Operational costs of the new wireless system are on average fifty per cent lower than the dial-up system. The cost of upgrading to the new technology is expected to be recovered within the first year of operation.

Ministry staff that monitor traffic signals are delighted with the new technology. Tim Edmonds, who is an Electrical Coordinator in West Region reports, "...a great improvement over the old analog system; I can check for signal failures on >



Computer screen shot showing images of two separate intersections being monitored on Highway 11. The background depicts Quicknet Pro's listing of intersections for that area.

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the laptop from my car or any other location. The new system allows us or our contractor to react quicker to issues with signal operation or timing in a reliable manner.”

“With this new digital system we are able to respond to public inquiries quicker as well as communicate with other peripheral

“...a great improvement over the old analog system; I can check for signal failures on the laptop from my car or any other location. ”

devices at the intersection. Definitely this new digital system will save us time and resources.” states Paul Webster, ministry Traffic Supervisor.

And finally, Paul Cayen, MTO Electrical Coordinator in Sudbury says, “The new central access has enabled us to implement coordination on the North-Bay bypass and also has enabled me to monitor my traffic signal intersections in the Northeastern area. This is very helpful considering I have intersections that are up to eight hours of driving apart, for instance, from Deep River to Sault-Ste-Marie.

It has proven itself to be very dependable.” Remote monitoring has improved

operations by reducing the number field visits to distant locations to check traffic signal and sensor failures, which allows the ministry to resolve traffic signal related issues sooner, saving time and money. Given the potential for additional future uses such as enhanced intersection monitoring, QuickNet continues to support the ministry’s efforts in safer, less costly operations. ●

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Structural Health Monitoring *Monitoring Ontario's Bridges*

Aging infrastructure and the increase of commercial transport vehicle weights contribute to the strain on bridge structures across North America and around the world. In Ontario, the Ministry of Transportation inspects its bridges every two years, either by in-house staff or through consultants. After reviewing all bridge conditions and considering each structure's age and design, the ministry determines which bridges require additional investigations to confirm structural integrity. Follow up investigations involve a detailed structural evaluation or for a more accurate assessment of the structural behaviour, a load test. Depending on the results, it may be necessary to limit the vehicle loads or re-route heavy transports.

The ministry is one of the few organizations in North America that performs its own detailed load testing for determining the structural response of the bridge to vehicle loads. To conduct this load test, the ministry installs strain gauges on bridge components (Fig. 1), to monitor the deflections, strains and tension on various structural components. Then two test trucks, each loaded incrementally with up to 72-one tonne concrete blocks (Fig. 2), are driven slowly across the bridge while the various gauges monitor and record strains in the bridge members. The results are compared to the theoretical values determined during a structural evaluation. This comparison of results can help to determine the true maximum load carrying capacity of the bridge.

The ministry completes about five load tests per year. In 2007, load testing on the Mattawishkwia River Bridge confirmed that the bridge could continue to support full highway loads until it was replaced in 2011. A load test was also undertaken on a bridge in the highway 401/404 interchange after the bridge was damaged by a truck collision and fire. In this case, testing confirmed the extent of repair required to restore the bridge to full traffic loads.

The ministry also uses remote monitoring to track the behaviour of bridges. After completing the evaluation and load testing, gauges are installed at critical areas of the bridge to determine the stresses in specific bridge components. The data, which is recorded and stored at the site using solar powered, portable computing equipment, is sent wirelessly to ministry computers, where gauge readings can be continuously monitored remotely from the office while under real-life conditions. One structure presently being remotely monitored by the ministry is the Grand River Bridge on Highway 3 in Cayuga, Ontario. Built in 1924, the Grand River Bridge carries two lanes of traffic across a 188.7 metre long, five-span steel through-truss bridge. A previous load test and evaluation determined that a load restriction was required for the bridge. On-going monitoring ensures that the bridge provides safe passage.

The ministry continues to monitor its bridges by conducting investigations and implementing weight restrictions when necessary to ensure structural integrity. ●

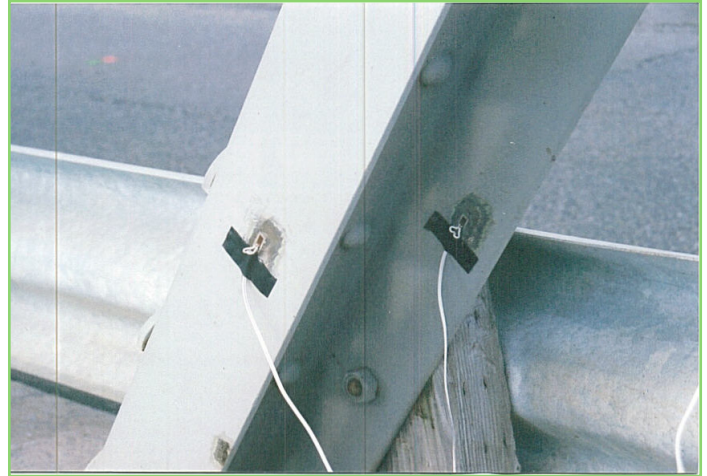


Figure 1: Strain gauges installed on a member



Figure 2: Test trucks on bridge

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A New Tool for Engineering Surveys Mobile Terrestrial LiDAR Scanning (MTLS)

In November 2001, Road Talk published *"A Light unto My Path"* (Vol. 7, Issue 4) featuring the emerging technology of Airborne LiDAR (Light Detection And Ranging) and its use at the Ministry of Transportation (MTO). In the intervening years, Airborne LiDAR has been used for developing Digital Elevation Models across a broad spectrum of applications including route planning and preliminary highway design.

Now another advanced LiDAR technology is emerging – Mobile Terrestrial LiDAR Scanning (MTLS), which collects more accurate topographic data with a higher resolution than data collected by an Airborne platform.

What is LiDAR?

LiDAR is a remote measurement tool that integrates lasers, Global Positioning Systems (GPS), and Inertial Navigation Systems (INS) into a single system that can create a "point cloud". A point cloud is a highly accurate set of three-dimensional (3D) geo-referenced points that is representative of a terrestrial or built surface.

The principle behind LiDAR is really quite simple: shine a focused light beam at a surface and measure the time it takes the reflected signal to return to its source. Distance = (Speed of Light x Time of Flight) / 2. This is similar to total station technology, the traditional survey instrument used for conducting topographic surveys. See Figure 4.

As light travels at a speed of about 300,000 km/s, the equipment taking measurements needs to operate extremely fast. Only with advancements in modern computing technology has this become possible. The LiDAR instrument sends up to 500,000 pulses of laser light per second at a surface to obtain three dimensional data of the surface it is measuring. This data is used to create survey products such as digital terrain models and engineering (topographic) plans of the earth's features.

When LiDAR sensors are mounted on mobile platforms such as airplanes or automobiles, the absolute position and orientation of the sensors must be determined. Global Positioning Systems (GPS) provide accurate geographical positioning of the sensor and Inertial Navigation Systems (INS) record the sensor's precise orientation at that location. These two devices provide the method for translating LiDAR data into geographically coordinated points. LiDAR sensors, coupled with GPS and INS, are able to geo-reference objects to centimetre-level accuracy.

MTLS systems are normally mounted on the roof of a vehicle (see Figures 1a and 1b) and operate with two high frequency lasers combining to take up to one million measurements per second. Mobile LiDAR systems can capture 360° coverage of a highway corridor to a radial distance of 100 metres or more while travelling



Figure 1a: Mobile LiDAR System



Figure 1b: Mobile LiDAR System Mounted on an SUV

at posted speed limits. The accuracy of the survey points degrade with distance due to the divergence of the laser light.

Transportation agencies in Canada, United States and Europe have tested mobile LiDAR data for transportation applications and several road authorities have performed demonstration and production projects. Some jurisdictions are moving toward using MTLS as a fully operational transportation engineering survey method.

Currently no national standards exist for the use of MTLS. A number of road authorities have developed their own MTLS standards and MTO is creating standards and best practices to provide consistency when using MTLS to collect survey data that will be used for detailed design purposes. >

Mobile Terrestrial LiDAR Scanning (MTLS), *continued*

Advantages, Considerations and Limitations of MTLS

Advantages of using mobile LiDAR for a transportation engineering survey include:

- Safety - LiDAR data is collected from a vehicle moving at highway speeds, keeping surveyors off the travelled lanes.
- Less disruptive – the mobile system does not require traffic control or lane closures.
- High accuracy – centimetre-level accuracies are possible on hard surfaces.
- Dense data sets - extremely dense topographic data sets, consisting of 1,000's of measurements per square metre, detail transportation features within the systems field of view. The data set can produce cross sections at any interval. Note however that the large quantity of LiDAR points also has drawbacks (discussed below).
- Rapid field data collection – mobile LiDAR survey data collection is significantly faster than conventional surveying methods.
- Imagery - digital geo-referenced imagery is collected simultaneously with the LiDAR data.

To ensure reliable results when conducting a MTLS survey close attention must be given to project control and targeting, data collection planning, data processing, quality assurance and quality control.

MTLS has limitations that must be considered prior to use on a specific project. These systems rely on “line of sight”, meaning they can only collect data from surfaces on which the laser beam can land and reflect back. Challenges arise when data isn't captured because features such as culverts, ditch bottoms, and back sides of slopes are obstructed from the laser's direct view. Areas of tall, dense grasses or shrubs can also prohibit the laser from reaching the ground. Since infrared light tends to be absorbed by water, drainage features, for example ditches, streams, and their underlying ground surfaces are not collected properly by MTLS. All obstructed features missed by the LiDAR system must be captured by conventional field surveying techniques.

LiDAR systems are reliant on GPS and the INS for positional accuracy. However additional ground control points must be incorporated to achieve the high level of accuracy the ministry requires for hard surface features such as pavement. Ground control points are locations that have been surveyed to establish their three-dimensional position (latitude, longitude, elevation) on the earth. Typically photo-identifiable control points that can be seen in the LiDAR point cloud must be manually set at regular intervals along the paved shoulders or median. Additional control points may also be needed where GPS signals are intermittently blocked, such as by tree canopy or overpasses.

A typical MTLS collects billions of three dimensional survey points, creating large data sets that require significant data storage capacity and specialized processing software. Typically the end user requires far less survey points than collected by MTLS, so the

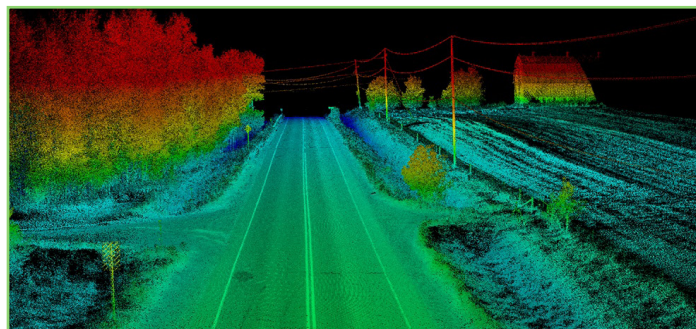


Figure 2a: LiDAR Point Cloud of Highway 594, west of Dryden



Figure 2b: Google Image of Highway 594, west of Dryden

data must be heavily reduced in order to be suitable for further use in standard survey and design software packages.

The topographic features such as pavement edge, curb, asphalt edge, original ground, or rock are not specifically identified at the time of LiDAR data collection so considerable hands on data processing is required. At the office, an operator must use the LiDAR point cloud and imagery to manually extract the features required for subsequent survey and design work. Once final plans are produced a field inspection is required to verify the feature extraction and check that all relevant features and breaklines have been collected.

Although overall MTLS field data acquisition is much faster than conventional surveying, processing the data takes significantly longer and still relies on some traditional field surveying and data verification.

Recent use of MTLS at MTO

Six MTO Engineering Survey projects in Northwestern Region have been conducted by Tulloch Mapping Solutions using MTLS. In all, over 130 kilometres of highway has been surveyed with MTLS on Highway 17 (Kenora, Ignace, Borups Corners), Highway 11 (Fort Frances, Beardmore) and Highways 502, 594 and 601 (Dryden). Sample data are shown in Figures 2a and 2b. A hybrid approach of combining MTLS with conventional GPS, levelling and Total Station surveys was required to deliver results that meet MTO Engineering Survey specifications. In the end, standard MTO engineering survey products were prepared, >

Mobile Terrestrial LiDAR Scanning (MTLS), continued

including a Digital Terrain Model (DTM), B plans (topographic detail and alignment) and C plans (profiles). See Figures 3a and 3b.

Results to date are encouraging. Mobile LiDAR is able to meet MTO Engineering Survey accuracy requirements for hard surface data collection of the road bed and shoulders, provided appropriate procedures are followed. Key factors include proper mission planning, good GPS satellite coverage, GPS base stations on site, and sufficient photo-identifiable ground control. Along with the augmentation by conventional ground survey beyond the road bed, complete projects can be performed where Mobile Terrestrial LiDAR Scanning plays an important role. •



Figure 3a: MTO B-Plan (topographic detail and alignment)

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For related articles, please see [“A Light unto My Path”](#) (Vol. 7, Issue 4)

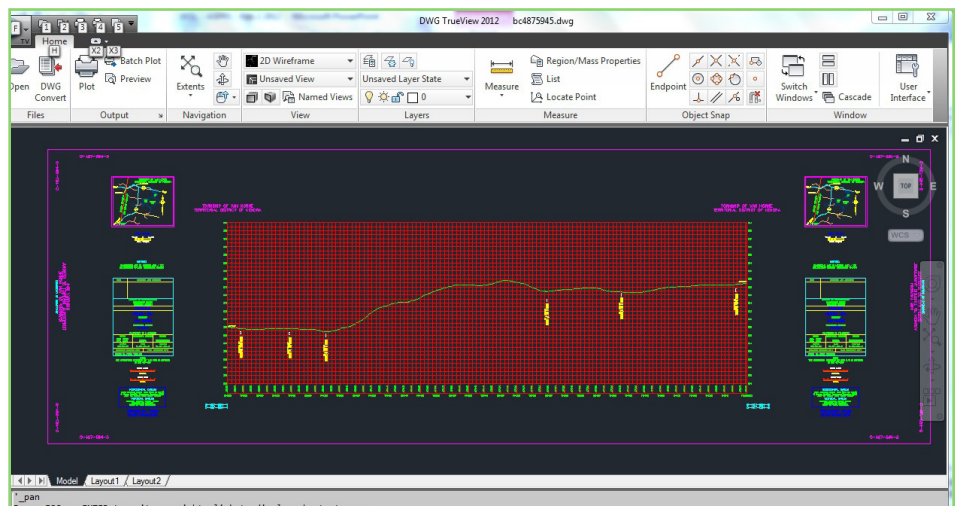


Figure 3b: MTO C-Plan (profile)



Figure 4: A Total Station is the traditional survey instrument used for conducting topographic surveys.