Using Cloud-Computing to Promote Asset Management Best Practices – A Ministry of Transportation Ontario Case Study

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ABSTRACT

For many years, transportation agencies across Canada have been collecting roadway asset inventory and asset condition datasets across their networks with the aim of facilitating best practice in maintaining these assets at the highest levels of service and within budget. However these extensive datasets are often managed by only a few individuals responsible for developing high level work programs for the upcoming or future construction seasons.

With the advent of cloud computing, and its further development in recent years, a new interactive medium is now available for all agency staff, contractors, consultants, and end users to gain on-demand access to this highly valuable dataset, current and historic roadway asset attributes and conditions, in addition to roadway imagery. To demonstrate the many applications and benefits of a web-based medium for accessing these datasets and imagery, the Ministry of Transportation of Ontario's use of iVision is presented as a case study. Feedback received from key individuals in MTO during all phases of implementation of this web-based application and the statistics obtained through monitoring provide insight that other Canadian, State and Municipal agencies can benefit from. This paper explains how an accessible and interactive web application can promote best asset management practices for planning and day-to-day operations of roadway networks.

INTRODUCTION

Many transportation agencies spend significant financial and employee resources on an annual basis to measure the current and predicted conditions of many of their assets. Historically, responsibility for the collection and processing of this data has resided within pavement management group. High level reports describing network level conditions are created by the pavement management group to be distributed across and used by other government agencies and stakeholders. However, due to the sheer volume of the detailed performance data, many agencies lack the ability to distribute the information effectively. For example, Right of Way (ROW) images that are collected as a part of these surveys consume terabytes of computer storage space.

For most agencies the main focus in collection of roadway asset data is the pavement management system (PMS) budgeting and prioritization process. The true value is in optimization of the wealth of data to make detailed project level decisions. With advances in computer technology and improved capability of agency IT infrastructure, it is now possible to leverage web and cloud based systems to distribute and visualize the data. Internet based data viewers can be used to help QC results provided by collection vendors or to release information to all needed stake holders. The use of cloud technology is encouraged by governments, such as the United States, as an opportunity for agencies to focus on their core activities and mandates. (1)

The purpose of this paper is to provide an overview of what is possible with the availability of cloud-based tools. In 2012, the Ministry of Transportation (MTO) began the transition to web-based data viewing of their roadway assets using Fugro Roadware's iVision software. Using the MTO experience as a case study, this paper highlights some of the challenges and benefits realized as the new system was rolled out across the agency.

PAVEMENT DATA COLLECTION INFORMATION AVAILABLE

The MTO uses a high-speed inertial profiler to collect pavement condition and asset data. This profiler, called an ARAN and manufactured by Fugro Roadware, integrates high definition cameras, lasers and 3D sensors to capture a geocoded condition survey. Data processed from high-speed inertial profiler collection may include right-of-way images, pavement images, International Roughness Index (IRI), rutting, pavement distress indices, and road geometrics. All collected data is both geographically referenced using advanced GPS systems and linearly referenced to the MTO's road network. The primary destinations of network-level pavement and asset condition data are pavement and asset management systems that are used for modeling, prediction, utilization, project planning, and budgeting.

The development of a web-based viewing tool, having the capability to integrate and synchronize all data streams collected by the ARAN seamlessly, has created the means by which data can be readily accessed, shared and utilized by multiple users for multiple purposes.

CAPABILITIES OF WEB BASED DATA VIEWERS

The interface of a web-based data viewer generally includes:

- A geo-referenced window to house GIS basemaps and layers;
- Video stream players; and
- Linearly referenced tables with geocoded data.

With MTO's web based data viewer, all linearly referenced data published, such as video streams, data tables, and GPS traces are synchronized and can be viewed simultaneously. By streaming thumbnail images that are about 10% of the size of the full-size collected images very efficient playback can be achieved over a corporate intranet or even over the internet. Full size images are loaded automatically when video streaming is stopped.

The GIS enabled web map allows visualization of any linear position in reference to all basemaps and layers. Thematic maps created using the data published in tables (IRI, rutting, etc.) can also be displayed (Figure 1). Asset inventories can be imported as shape files and displayed.

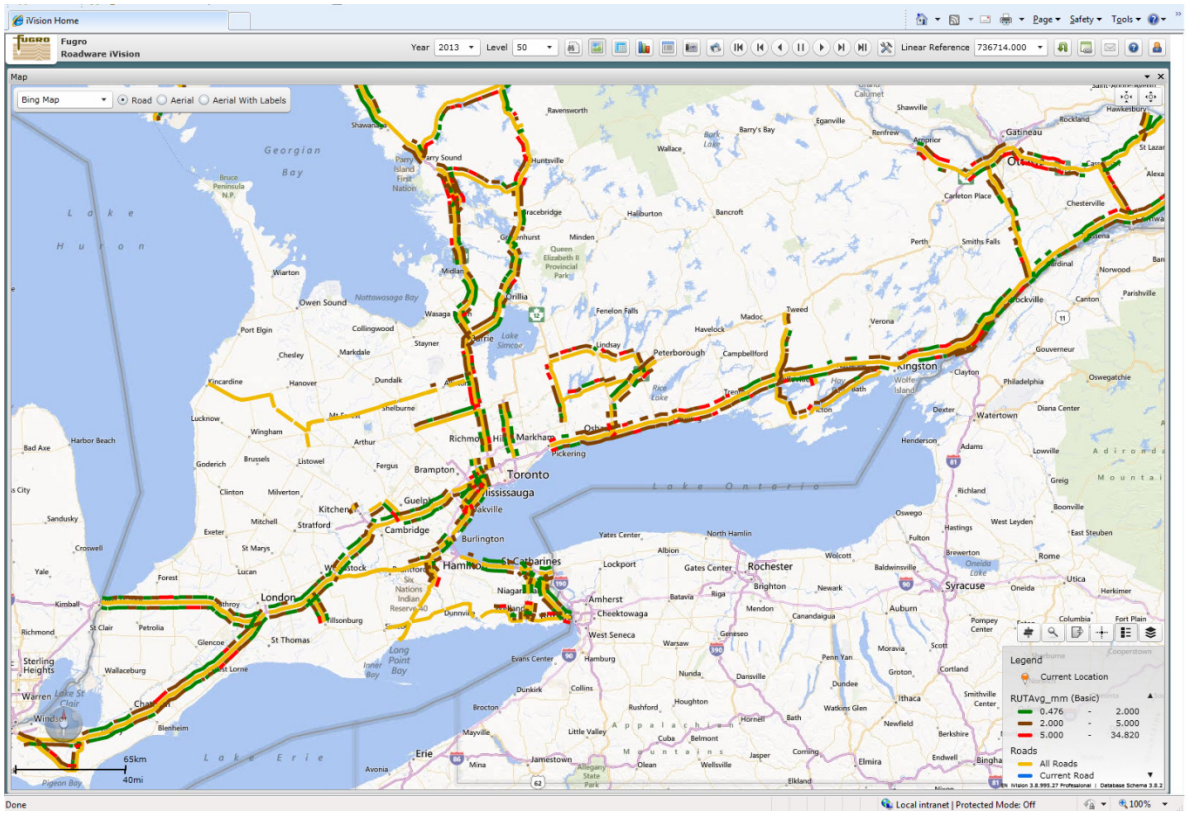

Figure 1. Typical Map Display for Web Based Pavement Condition Data

MTO's web based data viewer is an application that provides accessibility of all collected videolog information and images to a widespread audience. A sample of the right of way images can is provided in Figure 2. Ensuring data accessibility and usefulness, especially for audiences who do not traditionally work with pavement condition and asset data, is dependent upon the ease of finding the specific data a user is looking for and the synchronization of all data streams linearly and geographically.

Figure 2. Sample Right of Way Images Available

The ability to search for and locate specific pieces of data effectively allows pavement condition and asset data to be utilized by a diverse group of users. The MTO's iVision instance allows users to navigate to the section they want to see by:

- Using a geographically referenced web map;
- Using imported linearly referenced data tables; or

- Filtering or querying from pre-defined locators in pull down menus. MTO's iVision uses: region, district, highway name, direction, facility and collection type as locators.
- Viewing detailed distress data, including crack maps. (2)

A sample screen shot of MTO's iVision is seen in Figure 3.

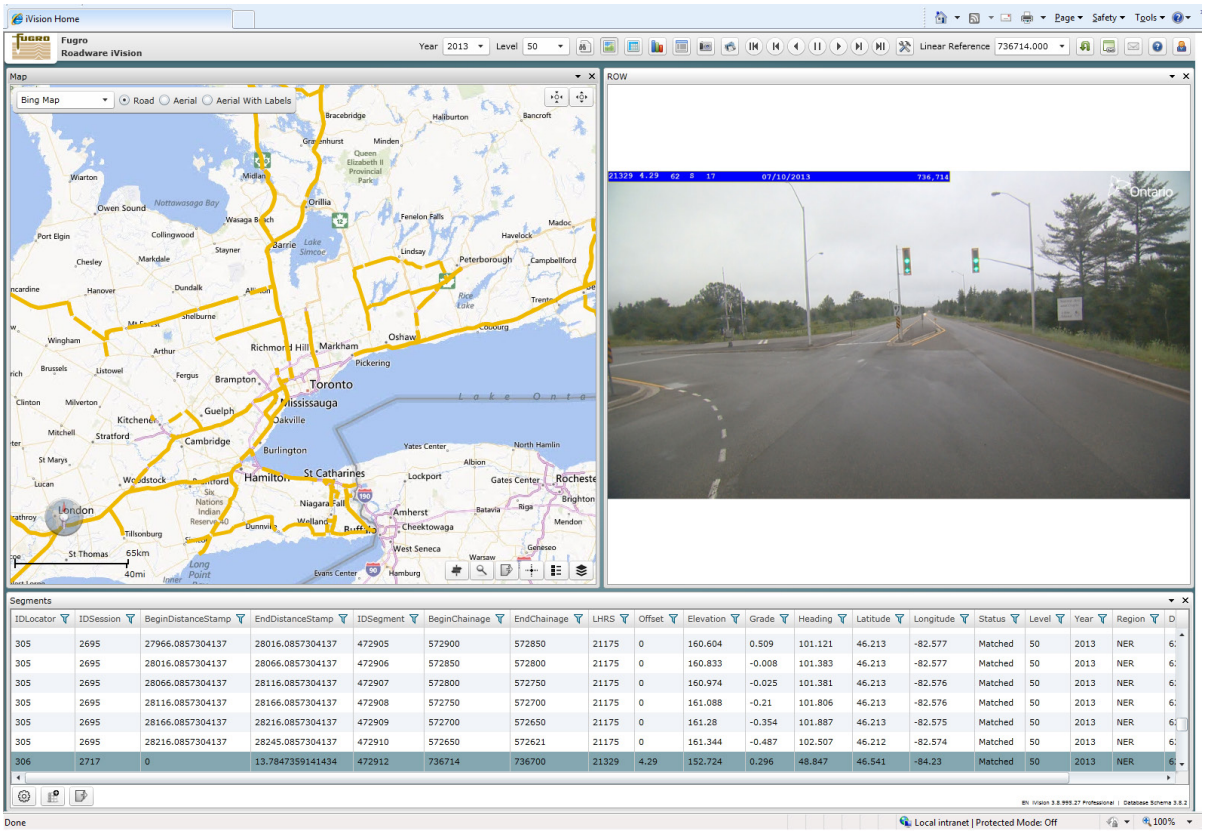

Figure 3. Sample Display from Web Based Display

SETTING UP AND PUBLISHING OF DATA

Data publishing protocols are developed and followed to ensure the complete publishing of all data and to verify that the performance of the application meets the needs of the end users. Within MTO, this process consists of publishing a test database that can be viewed and tested by the staff dedicated to this responsibility.

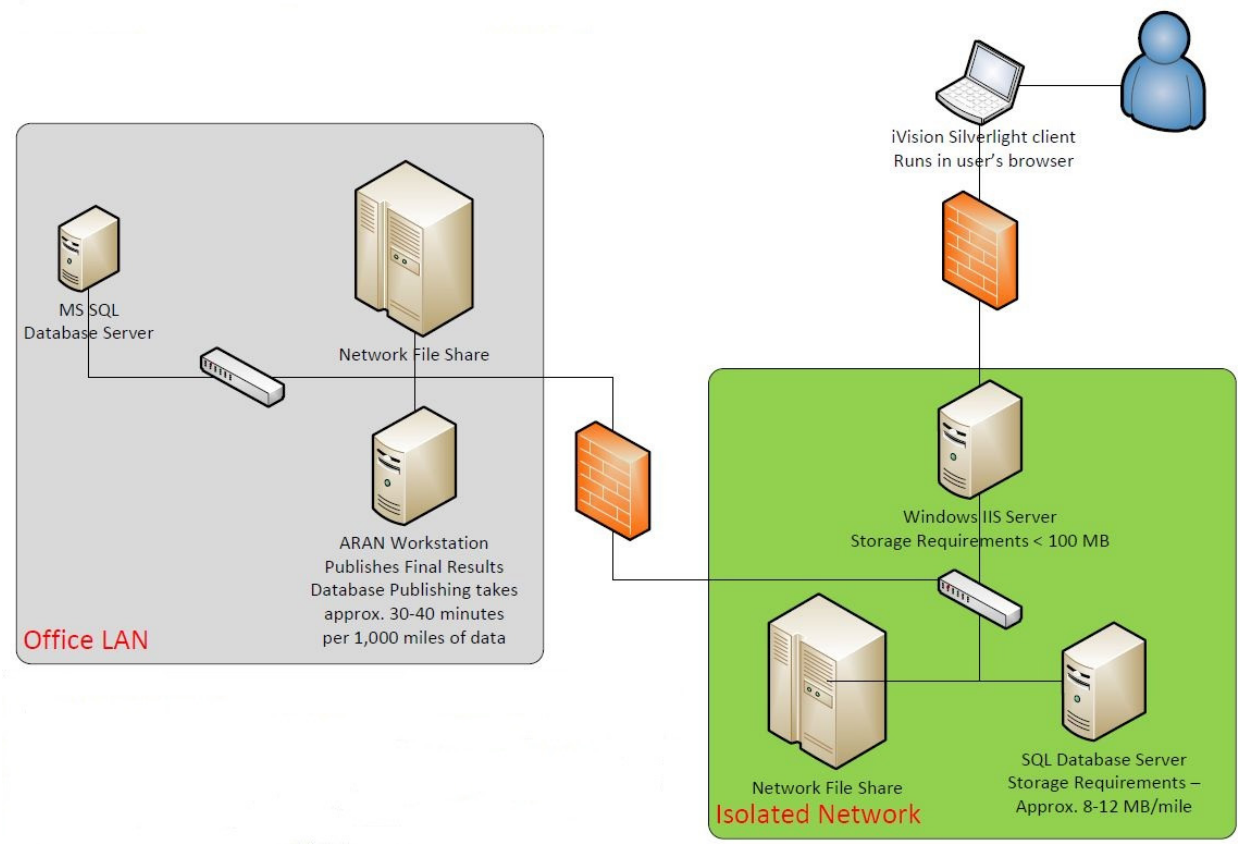

Figure 4. Network Diagram for Hosting and Publishing of a Web Based Solution

Once the data is ready for publishing, the information is submitted to the office responsible for data upload to the production environment. Images are uploaded onto the file share server for long term storage, maintenance, and backup, while the database is sent to database administrators for upload.

Configuration of the web application is then completed to ensure that access is available to both the database and the image and file storage location. The application can then be put online for users to access.

User access control is one of the bigger efforts that must be completed for agencies that wish to roll out the tool to a large number of users. A list of users is established in advance and uploaded into the system with pre-established access rights and controls. User administration capabilities and abilities for users to manage their individual accounts can then be accomplished through the software's user interface.

Software upgrades are done at the server level. In some cases, the core software files are simply replaced on the server while maintaining the software configuration information, database, and images. If database updates are required for additional functionality, automated tools are available to adjust the database as necessary to maintain functionality with the least impact on the end users.

AGENCY CHALLENGES AND SOLUTIONS

When implementing the iVision solution at MTO, numerous challenges and hurdles were encountered and overcome. The process is not simply a software installation, but requires that both parties understand the full scope of the project. A dedicated team is essential to manage

all aspects of the assignment in order to achieve a complete solution that includes full scale roll out to users.

Information Technology Planning

One of the most critical lessons learned through the roll out at MTO was the importance of getting early consultation with internal information technology (IT) staff. Launching cloud based solutions are often greatly influenced by IT policies and procedures. Initial discussions will help determine whether the information should be maintained on government controlled computers or on other cloud storage sources.

For data hosted by the agency, careful consideration should be given to the magnitude of data that is to be hosted. Many IT departments need substantial lead-in times for planning when data requirements exceed of 20TB. Concerns about access for data upload and frequency of backups and software upgrades also need to be considered and planned for.

Data Publishing Challenges

Challenges identified while publishing data are highlighted below:

- Tasks within the data publishing process described previously were found to have a steep learning curve, but can move much quicker once a clear process is established. Staff members responsible for publishing are more effective when given administrative rights to all necessary systems.
- Many agencies process, or review, the collected field data in an office that is in a different location or city than many of the IT resources available for publishing. One of the first challenges is to determine the best way to transfer the initial data upload to the hosting location. Some agencies may not prefer to transfer terabytes of data over the internet and may choose to ship computer hard drives between offices.
- Most agencies have database servers available for use for hosting non-image pavement data. These servers are, however, often used for multiple purposes may contain non-related data or be used to run non-related processes. The use of non-dedicated servers for the hosting of a website my lead to performance or security issues depending on the what non-related processes are being run and who has access to all of the data.
- There are some challenges in performing updates on systems that are actively being used. Depending on the size of the database, the process of updating, copying, and testing can take hours, if not days. Also, any changes made on the production system during this time may not be reflected in the copy that is being used for testing. These changes to user settings can be frustrating if not properly addressed or considered.

Training of End Users

While the software is designed to be as intuitive as possible, educating users about the capability of the system and providing training on how to use advanced features is a necessary part of the process.

The MTO hosted two iVision training sessions introduce the software and show how it can be used. The training sessions were interactive and used a screen sharing application to allow all trainees to gain hands on experience. Additional training was done on an as needed basis, and manuals specific to MTO's needs were provided to the users.

It was determined over time that there are two types of users for MTO's web based data viewer. Casual users have sporadic usage and tend to focus primarily on map and image data. A relatively small number of professional users are expected to make up the majority of traffic on the site. They are looking at detailed conditions or larger geographic areas and tend to be the most vocal with feedback and requests for modifications to both the data and the software.

USER BENEFITS

The road data collected by agencies has different value to different people within an organization. The data once collected can be used by a range of other departments within a transportation agency, as well as by other government agencies, private companies under contract with the government, and potentially to the travelling public.

For the pavement management group within a transportation agency, the benefits of having roadway asset and condition data readily available are relatively easy to quantify. For agencies that collect their own data, such as the MTO, the data can be quickly viewed by all members of the team and high level statistics and maps can be created. Once the annual road survey is complete, the data can be quickly imported and used into a range of PMS functions for the long term forecasting of conditions, budgets, and creation of maintenance plans. These results can then be updated in the cloud to ensure that all stake holders are aware of the plans and expectations for future conditions.

One of the significant advantages of a web-based application is it accessibility. Requests for pavement management data used to be time consuming efforts to assemble historic data for specific locations. Users can now retrieve data for themselves and access the information that they need. For example, access to GPS and video data is helpful for groups within agencies such as construction groups who will be responsible for setting up lane closures and adjusting their processes to deal with current conditions and any other unusual field conditions. Detailed images and mapping can prevent over half of the necessary trips to some remote sites to get a better understanding of what needs to be accomplished.

With many agencies outsourcing aspects of highway design, construction, and maintenance it is important to ensure that all individuals who need access to information can get access. Many agencies, such as the MTO, offer access to agency systems through a Virtual Private Network (VPN) or other mechanism. By ensuring the data is secure, many of the privacy concerns and distribution limitations can be addressed. Other government agencies, not responsible for transportation are often also interested in roadway asset data. For example, the MTO vehicle is equipped with a right-facing camera to capture video images of roadside assets. Land use and topographic details can also be viewed from the images. This provides a data source not otherwise available to other government ministries.

As more users are using the software, more feedback will be received and it is expected that the capabilities and usage of the software will increase over time. As data accumulates a historic archive, users will be better able to track site specific trends and defects that have occurred giving more insight into root causes of deterioration to better select pavement preservation and rehabilitation treatments. Right of way data can be used to show changes in the environment, roadside assets, traffic conditions, and many other potential factors. As more users are added to the system, more feedback on its use and future development will hopefully inspire increase functionality which will lead to a constructive cycle of further use.

POTENTIAL FUTURE DEVELOPMENTS

The advantage of having remote hosted applications is that they are easy to update. A web server can be updated with new software and it is instantly rolled our to thousands of users. As such, there is great potential for frequent and rapid updates. As we get into a positive spiral of increased use and increased functionality, we can expand the capabilities of the tool to include many potential future developments.

Faster turnaround of data is becoming more important. Annual data collection cycles have historically taken months to process and delivery to the people who need the data. With web based data, since the data is located in a central location, it has the potential to be edited while displayed. This would allow preliminary data and images to get posted immediately after testing and for the results to be updated and refined over time. This can provide updated images and data months earlier to those who may not need information such as pavement distress processing.

Most of the existing tools are based solely on the data collected in the field. As such, it is not always convenient for direct comparison of multiple years of data for the same location. Moving forward, the direct comparison of data from year to year will be a clear display to allow for rapid QC of data collection and development of performance trends on a project by project basis.

Other data sources and information will be combined for users. Many agencies are working on a range of web and cloud based systems for many of their different systems. The end goal however is not to have a range of systems, but a single flexible system for all users to connect to and get the information they need. This saves time and resources as well as provides a stable platform that more information can be provided in.

While the data is readily available in many standard computer browsers, the clear direction is to get the information onto a mobile platform. This will allow the information about condition to be made available while on site for maintenance crews and detailed site investigations. This can allow individual cracks identified on network level surveys to be reviewed on site, repaired, and monitored. By getting into the field with the full data source, root problems will be easier to identify for factors such as causes of roughness or localized deterioration that may not be readily available from the initial data collection effort.

Social networking and media has changed many ways in which we collect data today. Given the number of users (both within the agency and in the general public) that use the infrastructure on a daily basis, cloud based information can help get more information in real time from end users. But allowing agency officials, and potentially the general public, to identify problems and provide comments and feedback, information on problems and what is required can be obtained. This means that minor problems can be identified, and repaired, before they get a chance to deteriorate and require more expensive action. (3)

CONCLUSIONS AND RECOMMENDATIONS

Through the use of web based applications and cloud computing, the MTO has created a technological infrastructure to help distribute and visualize transportation asset data. With the implementation of MTO's web based viewer, data is now available for all agency staff, contractors, consultants, and end users to gain on-demand access to this highly valuable dataset, current and historic roadway asset attributes and conditions, in addition to roadway imagery. Feedback received from key individuals in MTO during all phases of implementation of this web-based application and the statistics obtained through monitoring provide insight that other Canadian, State and Municipal agencies can benefit from.

With many agencies outsourcing aspects of highway design, construction, and maintenance it is important to ensure that all individuals who need access to information can get access. Many agencies, such as the MTO, offer access to agency systems through a Virtual Private Network (VPN) or other mechanism. By ensuring the data is secure, many of the privacy concerns and distribution limitations can be addressed.

As more users are using the software, more feedback will be received and it is expected that the capabilities and usage of the software will increase over time. As more users are added to the system, more feedback on its use and future development will hopefully inspire increase functionality which will lead to a constructive cycle of further use.

It is recommended that agencies get the most out of the data that they already own and ensure that as many people can use the data as possible. This helps place the focus on the importance of this information and may lead to opportunities for multiple agencies within a government agency to share the data and potentially the cost. By tracking a cloud-based system's usage and monitoring feedback, governmental agencies are provided with data revealing what departments are using the data and for what reason. The possession of this data also helps to quantify the return on investment that the agency obtains from the collection of asset infrastructure data and sharing it online.

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