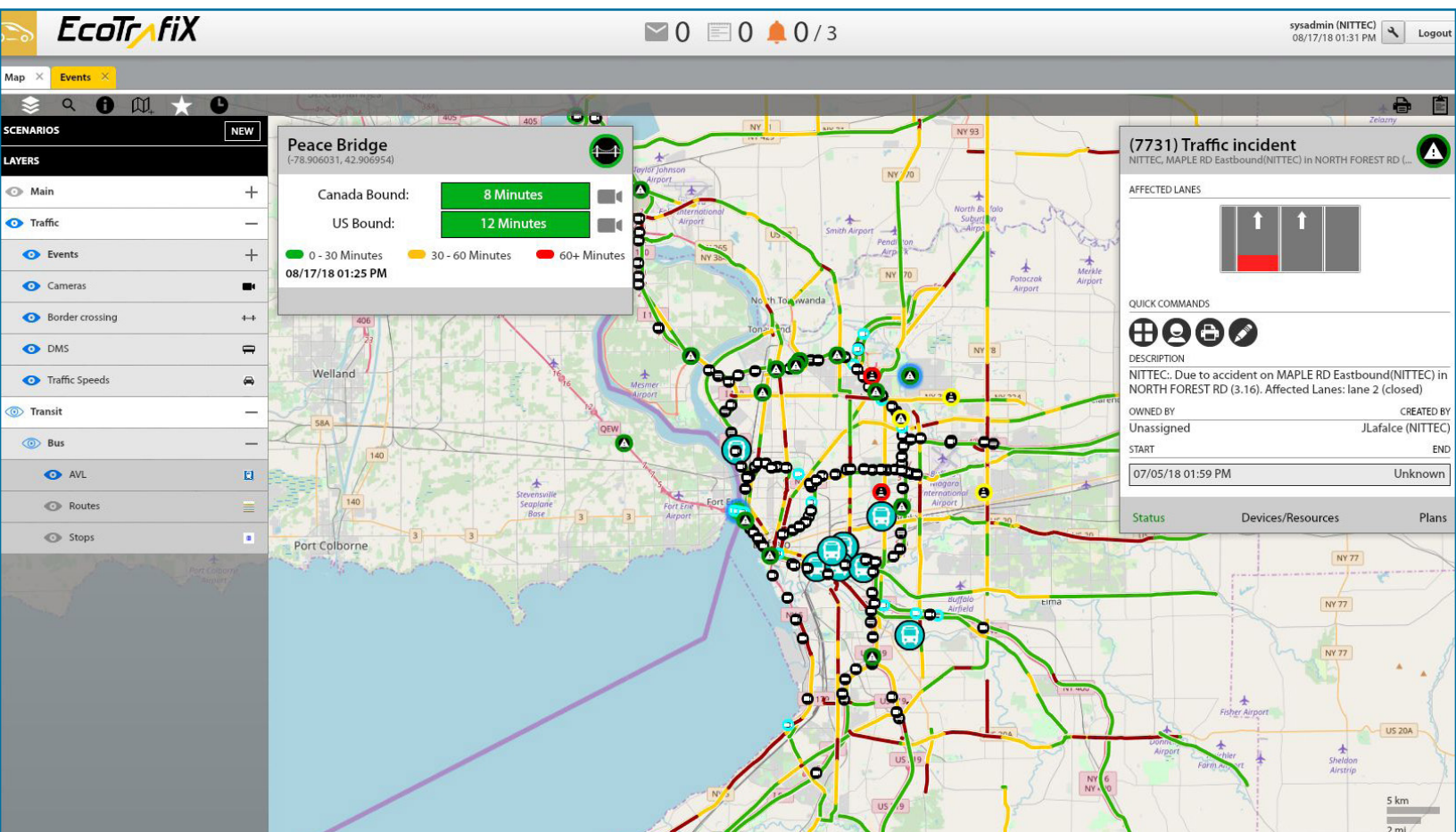# EcoTrafiX™ Platform Deployment for Niagara International Transportation Technology Coalition (NITTEC)

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EcoTrafiX™ Platform Deployment for Niagara International Transportation Technology Coalition (NITTEC)

Final Report

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16. Abstract

This document is the Final Report that describes the process and results of integrating various regional transportation data into the EcoTrafiX ATMS platform deployment in the Buffalo/Niagara region to facilitate the coordination of operational activities and events in the region and serve as a potential future platform for Integrated Corridor Management initiatives in the region.

The goal of the EcoTrafiX platform deployment is to provide pertinent, real-time transportation information to NITTEC operational staff to help improve mobility for the traveling public and the movement of goods. This will include benefits in terms of traffic management performance improvements, collaboration among partner agencies, and potential reductions in energy and greenhouse gas emissions.

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Table of Contents

List of Figures

Summary

This document represents the final report for NYSDOT Task Assignment No. C-15-09 and NYSERDA Agreement No. 83175, EcoTrafiX Platform Deployment for Niagara International Transportation Technology Coalition (NITTEC). It describes the process and results of integrating various regional transportation data into the EcoTrafiX Advanced Transportation Management System (ATMS) platform deployed in the Buffalo/Niagara region to facilitate the coordination of operational activities and events in the region and serve as a potential future platform for Integrated Corridor Management initiatives in the region.

The goal of the project was to deploy Kapsch TrafficCom's EcoTrafiX platform to provide pertinent, real-time transportation information to NITTEC operational staff to help improve mobility for the traveling public and the movement of goods. This includes benefits in terms of traffic management performance improvements, collaboration among partner agencies, and potential reductions in energy and greenhouse gas emissions.

The EcoTrafiX platform provides a user-customizable map that allows for accurate geographic display of all participating agencies' static Intelligent Transportation Systems (ITS) objects including Variable Message Signs (VMS), traffic sensors, Closed Circuit Television (CCTV), as well as dynamic data in the system in one central location.

S.1   System Development Process

A structured system development process was used to develop the system for this project. The first step was to define a set of technical requirements for the system to be developed and maintained during the course of the project. The goal of this effort was to ensure a common understanding between all parties `on the expected functionality of the resulting system.

The next step was to design the system. The Kapsch team produced various design documentation pertaining to the system architecture and methodologies for data collection, data integration, and data dissemination.

Development of the system proceeded in accordance with the functional requirements specifications and system design elements. Although most of the development focused on new system functionality, there were opportunities to utilize existing system tools. For example, Kapsch deployed its existing EcoTrafiX Commercial off the Shelf (COTS) software, thereby minimizing new development time, relying more on configuration to deploy the system. The TRANSCOM Data Interface work was also done in both New York State Department of Transportation (NYSDOT) Region 5 (Buffalo) and in Region 11 (New York City), so development time was reduced, and more time was allowed for data integration.

Testing resulting applications was conducted in multiple phases. In the first phase (unit testing), each component was individually tested to ensure independent functionality was operating properly, e.g., to test the retrieval of link speeds and travel times from the TRANSCOM travel time server system or simulated Automatic Vehicle Location (AVL) data from the Niagara Frontier Transportation Authority (NFTA) system.

The second testing phase (integration/system testing) was performed against a fully integrated, pre-production system to verify that interactions between all system components operated properly.

The final phase of testing, System Acceptance Testing (SAT), was based on the development of a Test Plan that defined the plans and a set of procedures used to verify the integration of data from the external sources into the EcoTrafiX system platform discussed in this report complied with the functional system requirements defined in the requirements specification document.

S.2   System Description

The EcoTrafiX system consists of several data interfaces that were developed to collect and integrate data from the data sources identified during the scope definition phase of the project delivery. The following data sources and data types were identified for integration into the NITTEC EcoTrafiX system.

- NYSDOT Linear Reference System Roadway Network: The roadway network data serves as the basis for the Geographic Information System (GIS) roadway network to properly geo-reference event data being collected by the various data source systems.
- NFTA Static Transit Data: This includes static transit route, stop, and schedule data.
- ITS Device Static Data: Static information for each of the CCTV and VMS devices includes device ID, owner name, device name, and location.
- Crossroads Data: Active incidents, construction events, CCTV status and video snapshots, VMS status and messages, and Border Crossing wait time data available in NITTEC's existing traffic management system (Crossroads) is collected from Crossroads data feeds.

- NFTA Data: Real-time AVL and departure information from the field is collected on regular polling intervals, and the estimated/scheduled departure times are processed into the EcoTrafiX fusion database.
- TRANSCOM Data: This includes static roadway link inventory data and real-time link speed and travel time information from the TRANSCOM travel time server.

The data collected for the NITTEC EcoTrafiX project is disseminated through various mechanisms, as follows:

- EcoTrafiX Graphical User Interface (GUI): The EcoTrafiX GUI is the main graphical component of the NITTEC deployment and contains a graphical representation of all data that is collected and fused for dissemination. The following data types are represented.

  o Active incidents and construction events are shown through the EcoTrafiX map and event list.
  o The status of each CCTV and VMS device is shown on the EcoTrafiX map with pop-ups for CCTV video snapshots and VMS messages.
  o Detailed border crossing wait times are shown via the EcoTrafiX map.
  o Roadway links on the EcoTrafiX map are colored to represent roadway speed with pop-ups for detailed speed and travel time information.
  o Transit vehicle location, departure time, and route data are shown on the EcoTrafiX map.

- Data Mart Web Services: The Data Mart Web Services enable data sharing allowing third parties the ability to consume the collected and fused data from the EcoTrafiX platform. Authorized third-party consumers must authenticate with the Web Services by providing a username and encrypted password to obtain access to the data.
- Custom Reporting: In addition to standard reports that ship as part of every EcoTrafiX deployment, custom reports were developed as part of the project delivery. Kapsch worked with NITTEC to identify a list of Key Performance Indicators (KPI's) to be included in the reporting metrics.

S.3   System Evaluation

Evaluation of the resulting system followed immediately upon completion of System Acceptance Testing and continued through project completion. As the system was deployed at the NITTEC Traffic Management Center (TMC) in Buffalo, NY, NITTEC operations staff evaluated the EcoTrafiX system and provided feedback. The evaluation process consisted of exchanges of observations and feedback through e-mail and teleconferences after the system was fully deployed.

NITTEC operations staff provided feedback to Kapsch staff over several months. To date, very few issues have been reported, and those were resolved in a timely manner. As issues were reported, Kapsch staff fielded the issue reports, assessed the magnitude of the issue, and resolved the issue where possible.

As part of the evaluation process, the Kapsch team documented several areas for improvement and potential expansion. These include usage of the system by additional agencies in the region, improvements to the static roadway network, integration of additional data sources, completion of additional custom reports, integration of Performance Measures dashboards, and integration of an Integrated Corridor Management System (ICMS) component.

A set of lessons learned and strategies for addressing them have also been developed that could be applied to future deliveries. These include methods for improving the implementation of the roadway network, transit data integration strategies, custom reporting development and estimation, and methods to streamline certain project deliverables.

1   Introduction

1.1   Project Background

The Niagara International Transportation Technology Coalition (NITTEC) is comprised of 14 transportation and international border crossing agencies and 17 additional affiliate agencies in Western New York and Southern Ontario working to coordinate facilities and operations. The member agencies have discussed the need for a system that can integrate transit and construction information, be accessed and updated in real time by all partners and run reports. Kapsch TrafficCom developed an integrated operations management platform that improves regional mobility through coordination and situational awareness.

The objective of this project was to deploy Kapsch TrafficCom's EcoTrafiX™ Platform with NITTEC and its partner agencies to coordinate operational activities and events in the region and serve as a potential future platform for their Integrated Corridor Management (ICM) initiatives. The platform provides a user-customizable map that allows for accurate geographic display of all participating agencies' static Intelligent Transportation Systems (ITS) objects including Variable Message Signs (VMS), traffic sensors, Closed Circuit television (CCTV), and detectors, as well as dynamic data in the system in one central location.

Anticipated benefits include the following:

- Performance improvements for event management and response, including alarm and incident detection, and the status of action/response plans.
- Collaborative traffic management to increase the speed of event clearance, better traffic mitigation and recovery, and the potential to more easily make changes to construction plans that involve lane closures.
- Potential for energy and greenhouse gas emission reductions from increased mobility and promotion of public transportation services.

2   System Development Methodology

This section provides an overview of the methodology used to develop the system created for this project. The system was developed using a structured systems engineering approach based on the following sub-tasks:

- System Requirements Analysis
- System Design
- System Development and Integration
- System Testing and Rollout

2.1   System Requirements Analysis

The first step in the project was to define a set of technical functional requirements for the system to be developed and maintained during the project. The goal of this effort was to ensure a common understanding between all parties on the expected functionality of the resulting system. The requirements were gathered from the original request for proposals for the project, Kapsch's proposal, and additions and clarifications based on discussions between the NITTEC and Kapsch project teams.

Each requirement was tracked during the course of the project, and any changes were documented and submitted for approval by NITTEC. Technical requirements were traced through system design, development, and testing to ensure that each requirement was adequately addressed through the associated project deliverables.

System/functional requirements were defined covering the following areas:

- EcoTrafiX fully integrated system functionality
- Data sources to be used (e.g., Crossroads, TRANSCOM, and NFTA)
- Types of data collected from each data source (e.g., events, VMS, CCTV, border crossings, roadway link speeds and travel times, and static and real-time transit data)
- Data dissemination mechanisms (e.g., EcoTrafiX GUI, Custom EcoTrafiX Reports, and Data Mart Web Services)

The detailed requirements can be found in the project functional requirements document. These functional requirements served as the basis for the design of the system.

2.2   System Design

The next step in the system development lifecycle was to design the system. Although a detailed design document was not a project deliverable for this project, the Kapsch team produced the following information:

- System Architecture
    - The following were discussed in the project implementation and equipment disposition plan:
        - Architecture diagrams
        - Networking parameters
        - Security methods
        - Hardware and Commercial off the Shelf (COTS) software platforms
    - The following were discussed in the Functional Requirements Document:
        - Definition of system components
        - External site connectivity mechanisms
- Data Collection
    - Setup of project roadway segments and data points
    - Data translation for mapping with external data sources
    - Quality control checks
    - Thresholds for alerts to be disseminated
    - Data update frequencies
- Data Integration
    - The following were discussed in the functional requirements document:
        - Details on data interfaces to dissemination systems (data content, formats, refresh cycles)
        - Sample outputs
        - Data categorization and prioritization
        - Error handling
- Data Dissemination
    - EcoTrafiX website user interface (map display) and functionality
    - Data Mart Web Services

Full SAT was performed in a pre-production environment to ensure that all identified requirements were fully covered.

2.3   System Development and Integration

Development of the system proceeded in accordance with the functional requirements specifications and system design elements. Although most of the development focused on new system functionality, there were opportunities to utilize existing system tools. For example, Kapsch deployed its existing EcoTrafiX COTS software, thereby minimizing new development time, relying much on configuration to deploy the system. The TRANSCOM Data Interface work was also done in both Region 5 (Buffalo) and in Region 11 (New York City), so development time was reduced, and more time was allowed for data integration.

System development and integration included the following tasks:

- Establish agreement terms with TRANSCOM to access its Travel Time Server Application Programming Interface.
- Setup and configure pre-production and production environments for later deployments of all software packages.
- Collect and fuse the NYSDOT Linear Referencing System (LRS) roadway network data.
- Collect, fuse, and map the TRANSCOM roadway network data.
- Collect, fuse, and map the Crossroads roadway network data.
- Develop Crossroads Data Interface to collect event, VMS, CCTV, and border crossing data.
- Develop TRANSCOM Data Interface to collect roadway link speed and travel time data.
- Obtain File Transfer Protocol over Secure Sockets Layer (FTPS) connectivity to NFTA File Transfer Protocol (FTP) server to allow for collection of NFTA static and dynamic data over secure FTP connection.
- Collect and fuse the NFTA transit network data.
- Develop NFTA Data Interface to collect real-time Automatic Vehicle Location (AVL) and departure information from NFTA.
- Deploy and configure the EcoTrafiX core components.
- Develop Border Crossing component and AVL component and integrate into the EcoTrafiX GUI.
- Develop Data Mart Web Services to provide third-party consumption of data integrated into the NITTEC EcoTrafiX package.
- Define and develop customized reports based on NITTEC requirements and integrate into the EcoTrafiX platform.
- Develop a SAT plan to ensure the system, as delivered, meets the functional requirements.

2.4 System Testing and Rollout

Testing of the resulting applications was conducted in multiple phases. In the first phase (unit testing, typically performed by the developers in their local development environments), each component was individually tested to ensure independent functionality was operating properly (e.g., to test the retrieval of link speeds and travel times from the TRANSCOM travel time server system, or simulated AVL data from the NFTA system).

The second testing phase (integration/system testing) was performed against a fully integrated, pre-production system to verify that interactions between all system components operated properly. For example, tests were conducted to ensure that the data retrieved from the Crossroads system was validated, then passed through the Data Interface to the EcoTrafiX pre-production platform, and then properly displayed on the EcoTrafiX pre-production website map and in the pre-production Data Mart Extensible Markup Language (XML) Web Services feeds. Integration/system testing was conducted on the EcoTrafiX pre-production platform to identify any potential problems with the system configuration and confirm operation in the destination environment.

To perform these tests, various test scripts were developed to exercise each system function. Both simulated and actual data were used to validate the system under different scenarios.

The final phase of testing, System Acceptance Testing (SAT), was based on the development of a test plan that defines the plans and a set of procedures used to verify that the integration of data from the external sources into the EcoTrafiX system platform discussed in this report complies with the functional system requirements defined in the requirements specification document. These tests use a technique in which satisfaction of a requirement is verified by the use of a series of steps to test a component of the system.

The following summarizes the primary areas of focus for the SAT verifications:

- Ingest Crossroads, TRANSCOM, and NFTA data into the EcoTrafiX data fusion platform and perform data quality checks.
- Integrate the data from the external sources into the EcoTrafiX data fusion platform and disseminate the information via EcoTrafiX application and Data Mart Web Services.
- Provide ingested and fused data to third-party consumers via the Data Mart Web Services to facilitate data sharing.
- Verify full system functionality of the EcoTrafiX GUI application to provide the following functions:

- EcoTrafiX user administration
- EcoTrafiX GIS based map functionality
- Event management
- Device management
- Customized reports
- Alarms and device alerts

System Acceptance Testing was conducted in two rounds in the presence of NITTEC and NFTA (second round only) representatives according to the procedures in the approved Test Plan using the operational system on the EcoTrafiX pre-production platform. Signoff by NITTEC on each test procedure signified formal acceptance of the system.

Upon acceptance of the system, an evaluation phase was conducted to operate the system and determine its effectiveness and to perform a shakeout of any potential bugs or inconsistencies in the system functionality. Any problems identified during this phase were continuously addressed and tested by the Kapsch team according to the development and testing methodology previously discussed.

2.5   Project Timeline

The project was contracted in April 2016 with work beginning in late June 2016. It was originally scheduled to be completed in April 2017, but several delays occurred that extended the overall project timeline, including the following:

- Delays in receiving information on NFTA transit data needs in order to finalize the requirements and begin development of the transit AVL data interface. NITTEC arranged meetings between NFTA and Kapsch staff to collaborate on AVL data needs, availability/sharing, and integration to minimize the delays where possible. It was determined to be more cost efficient to extend the project schedule to accommodate the integration of the NFTA transit data into a single overall system deployment as opposed to a separate future deployment just for the transit data integration.
- Incorrect/inconsistent map/roadway data requiring unanticipated changes to the EcoTrafiX map/GIS, including corrections to the roadway link shapes, due to issues with the source data from the NYSDOT linear referencing system.
- Issues with using General Transit Feed Specification (GTFS) AVL data for developing arrival time predictions for NFTA. This required changing the way static NFTA transit data gets imported into EcoTrafiX to enable NFTA arrival time predictions.
- Hardware/COTS software procurement delays.

Once the issues were resolved, system acceptance testing was scheduled for June 2017. However, because access to the NFTA data did not become available until July 2017, the system acceptance test was completed in two rounds. The first round of system acceptance testing occurred in June 2017, but this round did not include any of the test scripts that involved testing the data from NFTA.

Several issues were discovered with the NFTA transit AVL data interface that required additional coordination with NFTA and subsequent system changes resulting in the second round of system acceptance testing being performed in December 2017. Issues were found during this second round pertaining to the display of AVL data from NFTA on the EcoTrafiX map, and one script was deemed to be failed. After investigating the issue and working with NFTA, it was determined that the AVL data was in fact displayed on the map correctly as received from NFTA, and the ruling was overturned. System acceptance test signoff was executed in February 2018.

3   System Description

A description of the system that was developed for the NITTEC EcoTrafiX project is provided in this section. It defines the different components of the system and how they interact. The system description is organized as follows:
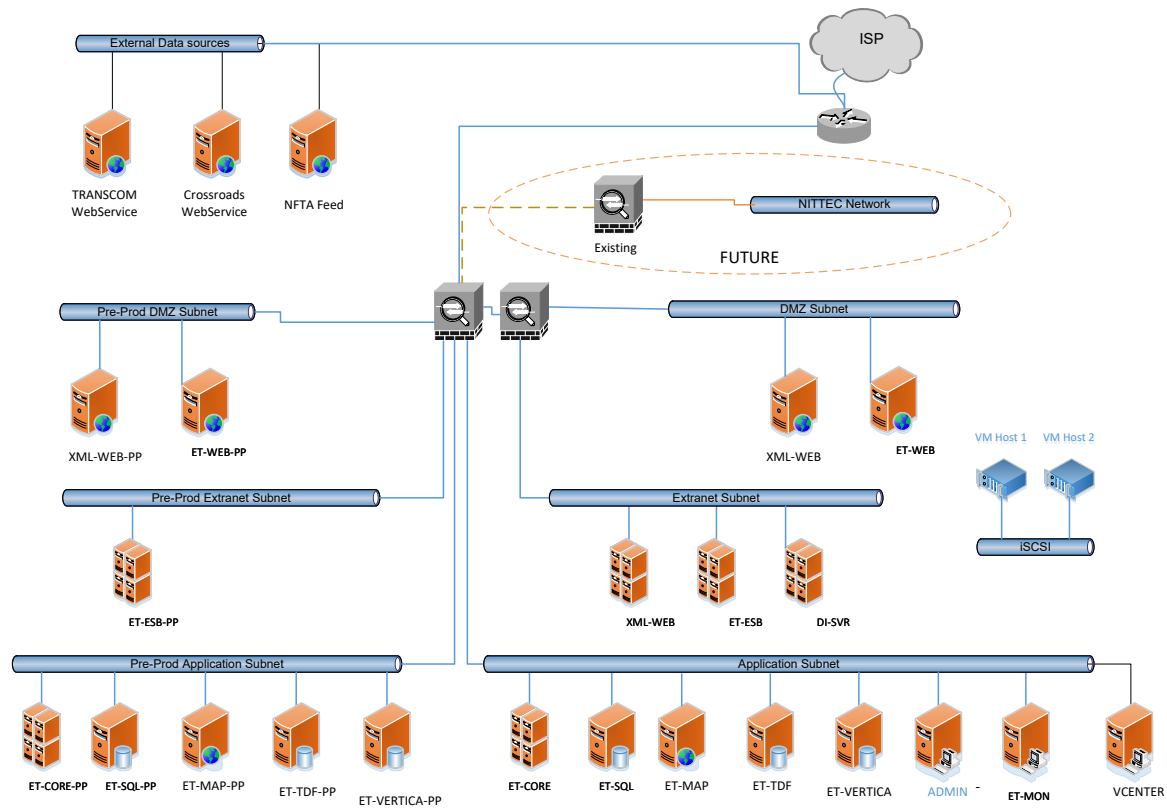
- System Architecture
- Data Collection
- Data Integration
- Data Dissemination

3.1   System Architecture

The following network diagram provides the EcoTrafiX network topology. The EcoTrafiX system architecture includes a preproduction environment to facilitate full system integration testing in an environment that closely mimics the actual production environment. Therefore, all software developed for the project can be deployed into the preproduction environment, configured, and then fully tested to ensure the software works as designed and meets all functional requirements prior to deploying into production. In addition, the preproduction environment also serves as the environment used to perform system acceptance testing to ensure that the delivered system met all functional requirements agreed to during the requirements definition phase.
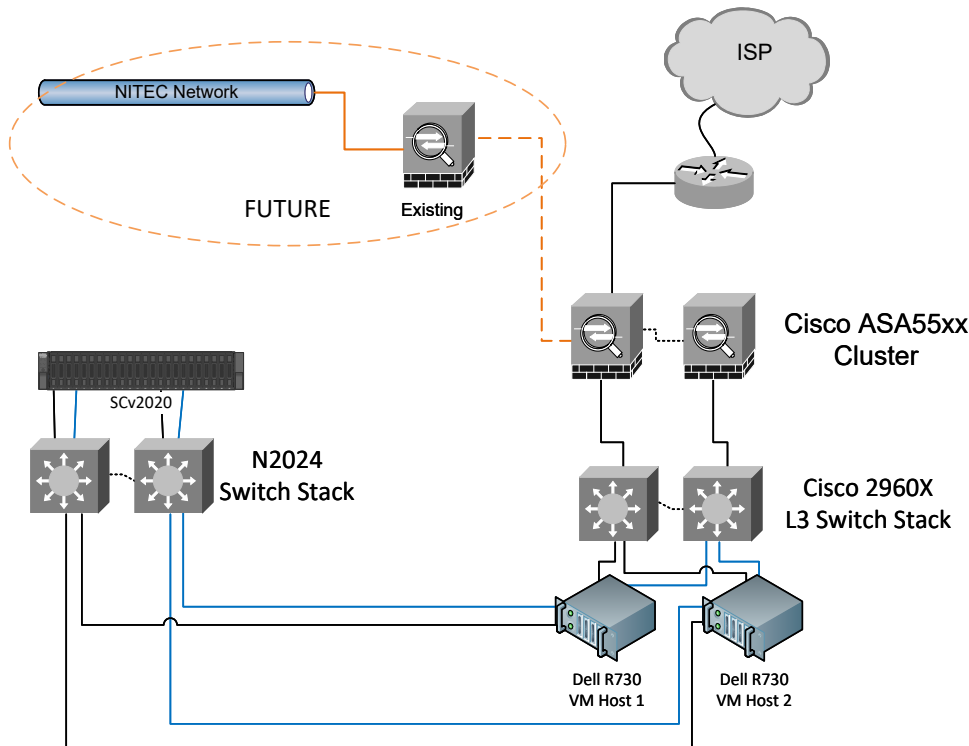
Figure 1. EcoTrafiX Network Topology

(Source: Kapsch TrafficCom)

The following diagram depicts the EcoTrafiX physical network architecture for deployment.

Figure 2. EcoTrafiX Physical Network Architecture

(Source: Kapsch TrafficCom)

The NITTEC EcoTrafiX platform is divided into multiple subnets, each representing a functional group, responsible for handling the data collection, data fusion (or integration), and data dissemination, discussed in further detail in the following sections. The functional groups are configured as such to provide a logical architecture for the distribution of platform functionality, as well as to maintain a secure environment, appropriate for the collection and dissemination of stakeholder information and data.

The network architecture includes the following three subnets or functional groups. Each group's functional purpose is also defined.

- Extranet: The extranet subnet hosts servers that terminate connections to the external data sources, specifically the Crossroads, TRANSCOM, and NFTA data feeds. Access to servers from external sources are typically restricted through firewall access control lists defining local and remote IP addresses and the associated IP ports required for proper operation of the connection. Access lists are also implemented to restrict access from servers in the extranet to servers located on higher security subnets.

- DMZ: The DMZ subnet hosts the web servers responsible for providing the EcoTrafiX Graphical User Interface and XML Web Services where access to the platform is necessary from outside consumers.
- Inside: The inside subnet is the most secure and hosts all database and core application servers responsible for storing data and providing core system functionality.

A logical data flow diagram of the NITTEC EcoTrafiX System is provided below and includes the data collection, data fusion, and data dissemination groups and identifies the flow of data between the groups.

Figure 3. EcoTrafiX System Data Flow Diagram

(Source: Kapsch TrafficCom)
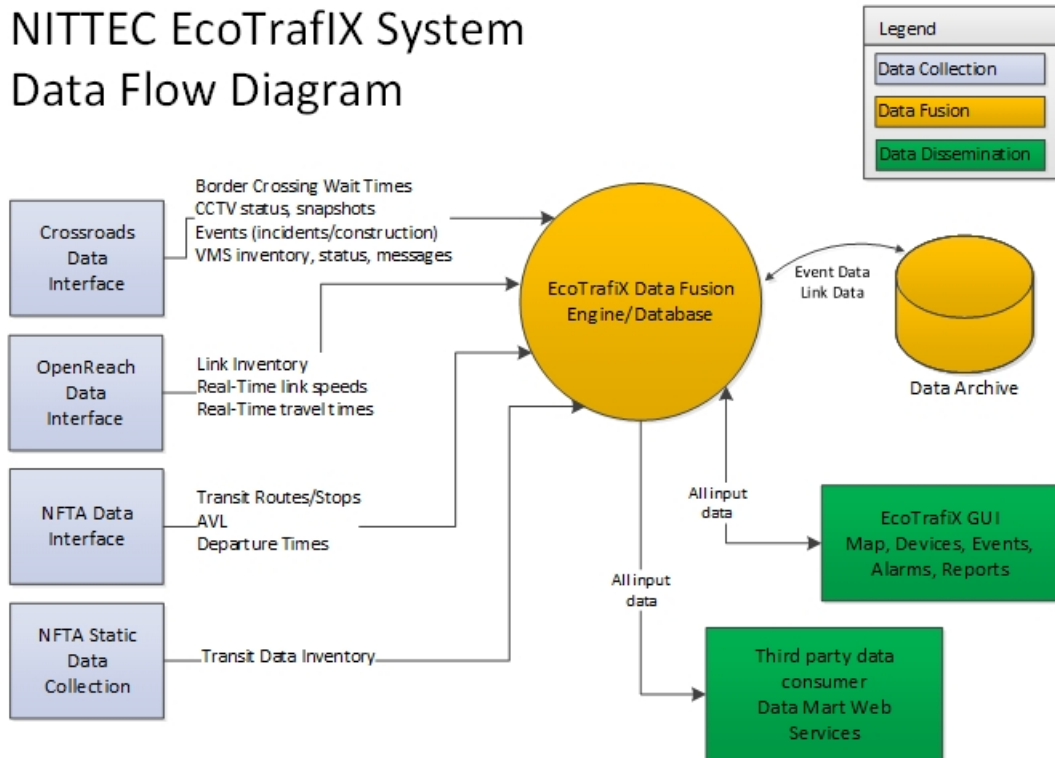
3.2 Data Collection

Data collection is typically done within the extranet. Data interfaces were developed to collect data from the data sources that were identified for integration during the Scope Definition phase of the project delivery. The following data sources and data types were identified for integration into the NITTEC EcoTrafiX system.

3.2.1 NYSDOT Linear Reference System Roadway Network Data Collection

Prior to implementation, Kapsch worked with NYSDOT to collect the static roadway network necessary to provide the underlying roadway network data for the EcoTrafiX platform. At the time of this publication, NYSDOT is currently developing a Statewide GIS Linear Referencing System (LRS) that was provided to Kapsch for processing and integration into the Kapsch Data Fusion database. This roadway network data serves as the basis for the GIS roadway network currently being used to properly geo-reference event data that is being collected by the systems identified below.

3.2.2 Niagara Frontier Transportation Authority (NFTA) Static Transit Data Collection

Prior to collecting the real-time AVL data which provides real-time Global Positioning System (GPS) locations of the vehicles in the field, static transit route, stop, and schedule data were collected, transformed and fused into the EcoTrafiX data fusion platform. The static transit network definition data had to be integrated into the EcoTrafiX database before proper translation of AVL objects could be processed properly. Therefore, Kapsch worked with NFTA to collect its static transit definition data, in flat file format, and process the data into the EcoTrafiX transit database tables.

3.2.3 ITS Device Data Collection (CCTV/VMS)

Prior to implementation, Kapsch worked with NITTEC to obtain a list of the static data associated with the ITS devices available in the region. The static device information was collected from NITTEC from the NITTEC ITS Device XML feed. This XML based list contains static information for each of the device types to allow for the inclusion of the device data in the EcoTrafiX System. This static data includes device ID, owner name, device name, and lat/lon. In the case of CCTV's, Kapsch worked to locate a URL for each individual camera to allow for the display of video snapshots in EcoTrafiX.

3.2.4 Crossroads Data Interface

Event, CCTV, VMS, and border crossing data available in NITTEC's existing traffic management system (Crossroads) were collected from the Crossroads XML feeds. Data made available in the Crossroads feed are collected on regular polling intervals for integration into the EcoTrafiX platform. The following data types were from Crossroads:

- Events
  - Active incidents
  - Active construction events

- CCTV
    - Real-time CCTV status
- VMS
    - Real-time VMS messages
    - Real-time VMS status
- Border crossings
    - Real-time border crossing wait times at the following three locations:
        - Lewiston-Queenston Bridge
        - Peace Bridge
        - Rainbow Bridge

3.2.5 NFTA Data Interface

Real-time Automated Vehicle Location (AVL) and departure information from the field is currently being collected by a data interface developed to consume real-time data from the NFTA. Real-time AVL information is collected on regular polling intervals and the estimated/scheduled departure times are processed into the fusion database for later dissemination.

3.2.6 TRANSCOM Data Interface

A data interface was developed to collect real-time roadway link speed and travel time information from the TRANSCOM travel time server. Prior to deploying the data interface into the pre-production/production systems, the TRANSCOM static link data definition was collected from TRANSCOM and a mapping was done from the TRANSCOM roadway network to the EcoTrafiX roadway network so that real-time link speeds and travel times can be appropriately assigned to the corresponding links in the EcoTrafiX platform. More information on the integration is provided below in the data integration section.

3.3 Data Integration

All data collected from the external sources described above was fused into the EcoTrafiX Data Fusion platform as shown in the data flow diagram. The following data types were integrated into the EcoTrafiX platform and disseminated as discussed in the data dissemination section below.

3.3.1 Crossroads Data

As discussed in the data collection section of this document, a data interface was developed to collect data from the Crossroads XML feeds on regular interval polling intervals. The XML feeds are consumed by the data interface where each type of data (as discussed previously) is translated so that it can be fused into the EcoTrafiX database. The following sections describe the logical flow of how each individual type of data is integrated into the EcoTrafiX database.

3.3.1.1 Events

Active incidents and construction events are collected from a Crossroads XML feed via the URL shown in Appendix A. All new and updated events that are made available in the feed are analyzed for correct schema and any missing information. The Crossroads events are then translated into the EcoTrafiX event data format, and then fused into the EcoTrafiX database. Any events found to be either in the incorrect format, missing data, stale, etc. are discarded and logged. Events fused into the EcoTrafiX data fusion database are also then stored in the archive database for later analytics and/or inclusion ad hoc or in scheduled reports on key performance indicators such as incident duration, etc.

3.3.1.2 CCTV

Dynamic CCTV status data is collected from a Crossroads XML feed via the URL shown in Appendix A. As described earlier, at the onset of the project, the static CCTV data was collected and fused into the EcoTrafiX database. As the CCTV dynamic status data is collected from the XML feeds in near real time, any updates to the individual CCTV devices are integrated into the EcoTrafiX database and then provided later to the data dissemination mechanisms.

3.3.2 VMS

Dynamic VMS status data is collected from a Crossroads XML feed via the URL shown in Appendix A. As described earlier, at the onset of the project, the static VMS data was collected and fused into the EcoTrafiX database. As the VMS dynamic messages and status data are collected from the XML feeds in near real time, any updates to the individual VMS devices are integrated into the EcoTrafiX database and then provided later to the data dissemination mechanisms.

3.3.2.1 Border Crossings

Dynamic border crossing wait time data is collected from a Crossroads XML feed via the URL shown in Appendix A. For each available border crossing (including Lewiston-Queenston Bridge, Peace Bridge, and Rainbow Bridge), live wait times from each side of the border (U.S. side and Canada side) are collected from the XML feed and integrated into the EcoTrafiX database and then provided later to the data dissemination mechanisms described below.

3.3.3 TRANSCOM Data

As discussed in the data collection section of this document, Kapsch worked to process the TRANSCOM static link inventory data into the EcoTrafiX database and created a cross reference translation table to map TRANSCOM roadway link segments to the EcoTrafiX link segments in the EcoTrafiX roadway network. The TRANSCOM Data Interface, also previously discussed, polls the TRANSCOM XML feed to collect the real-time link speed and travel time data from TRANSCOM and assigns the proper speeds and travel times to the mapped links in the EcoTrafiX database. This data is also aggregated and archived into the Kapsch data archive database as well as provided to the data dissemination mechanisms below. Link speed and travel times in the aggregated archive data are also then used to provide later analytics and/or inclusion in ad-hoc or scheduled reports on key performance indicators such as travel time index, historical link speeds, and travel times, etc.

3.3.4 NFTA Data

As discussed in the data collection section of this document, Kapsch worked to process the NFTA static transit inventory data into the EcoTrafiX database after receiving the NFTA data in flat file format. The NFTA Data Interface, also previously discussed, polls the NFTA FTP site to collect the real-time AVL and departure time information from NFTA. This data is then provided to the data dissemination mechanisms below.

3.4   Data Dissemination

The data collected for the NITTEC EcoTrafiX project is disseminated through various mechanisms. The following sections describe the data dissemination mechanisms and include graphical representations of the data dissemination outputs where applicable.

3.4.1 EcoTrafiX GUI

The EcoTrafiX GUI is the main graphical component of the NITTEC deployment and contains a graphical representation of all data that has been collected and fused for this project delivery. The following data types are currently being represented within the EcoTrafiX GUI, and associated screenshots of the live system are included.

3.4.1.1 Crossroads Event Data

As discussed previously, active incidents and construction events are currently being collected from the Crossroads XML feed, integrated and disseminated via the EcoTrafiX map and event list.

The following images depict graphical representations of the incidents and construction data from Crossroads, in both map and list format, existing in the production EcoTrafiX deployment.

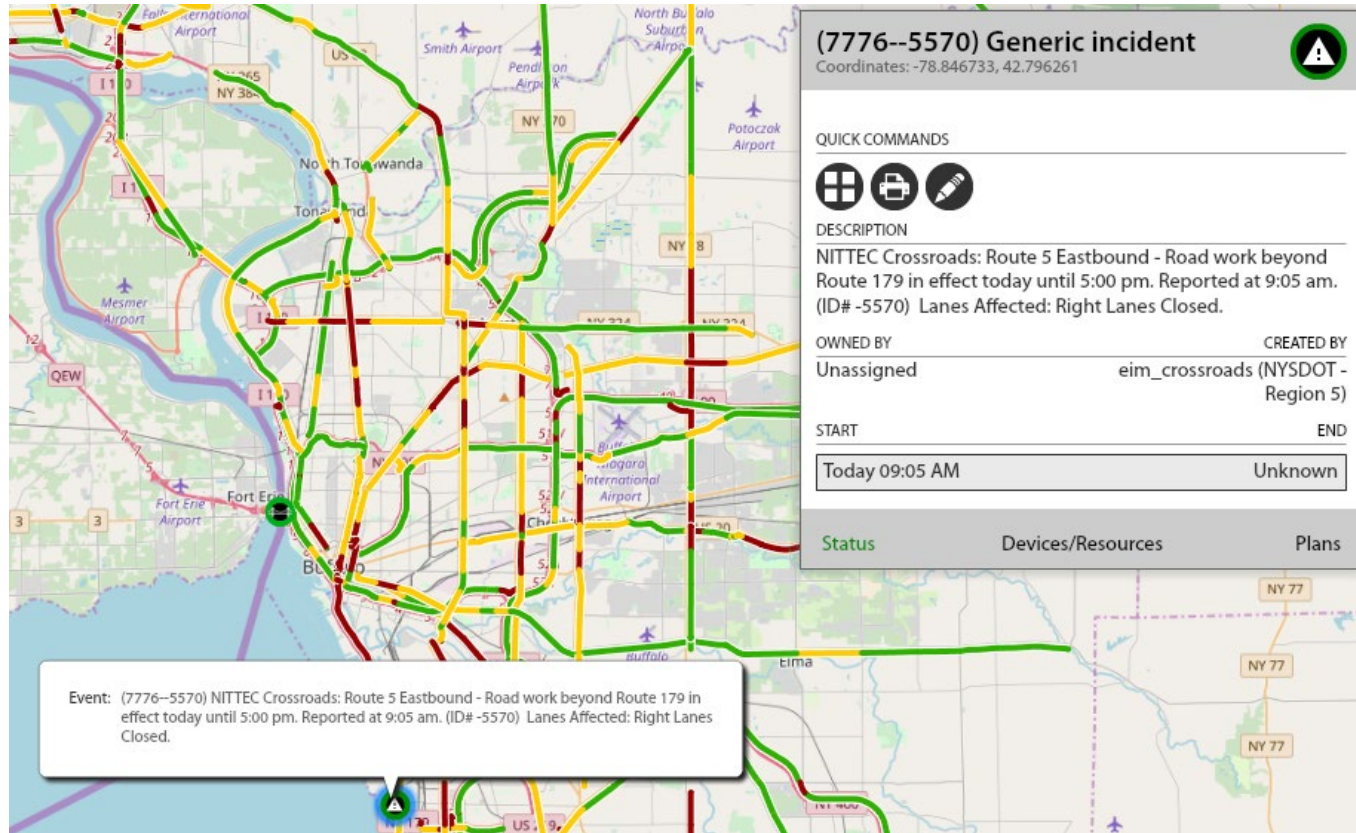**Figure 4. EcoTrafiX Map – Crossroads Incident**

(Source: Kapsch TrafficCom)

Figure 5. EcoTrafiX Event List – Crossroads Incident

(Source: Kapsch TrafficCom)

Figure 6. EcoTrafiX Map – Crossroads Construction Event

(Source: Kapsch TrafficCom)
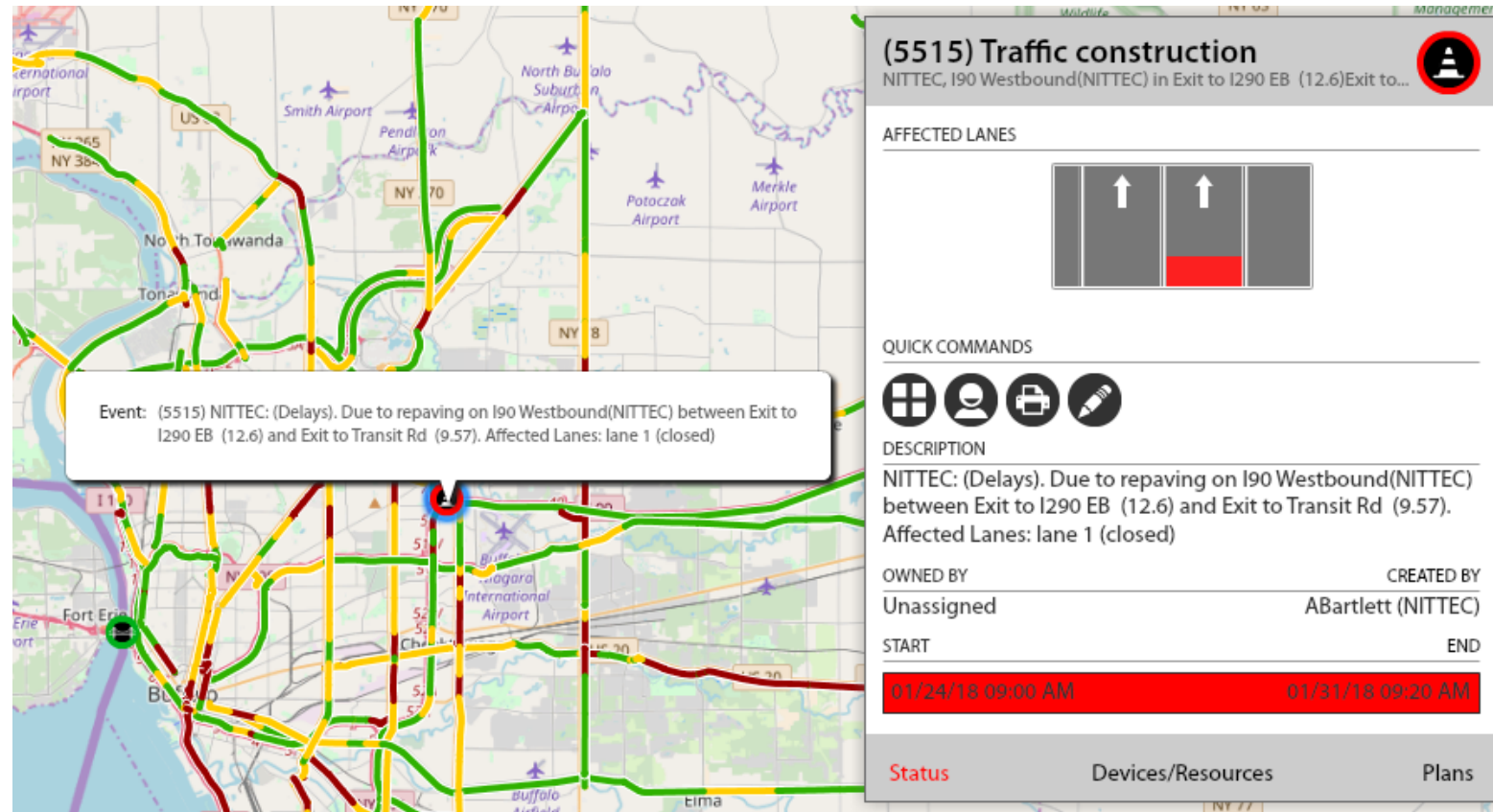
Figure 7. EcoTrafiX Event List – Crossroads Construction Event
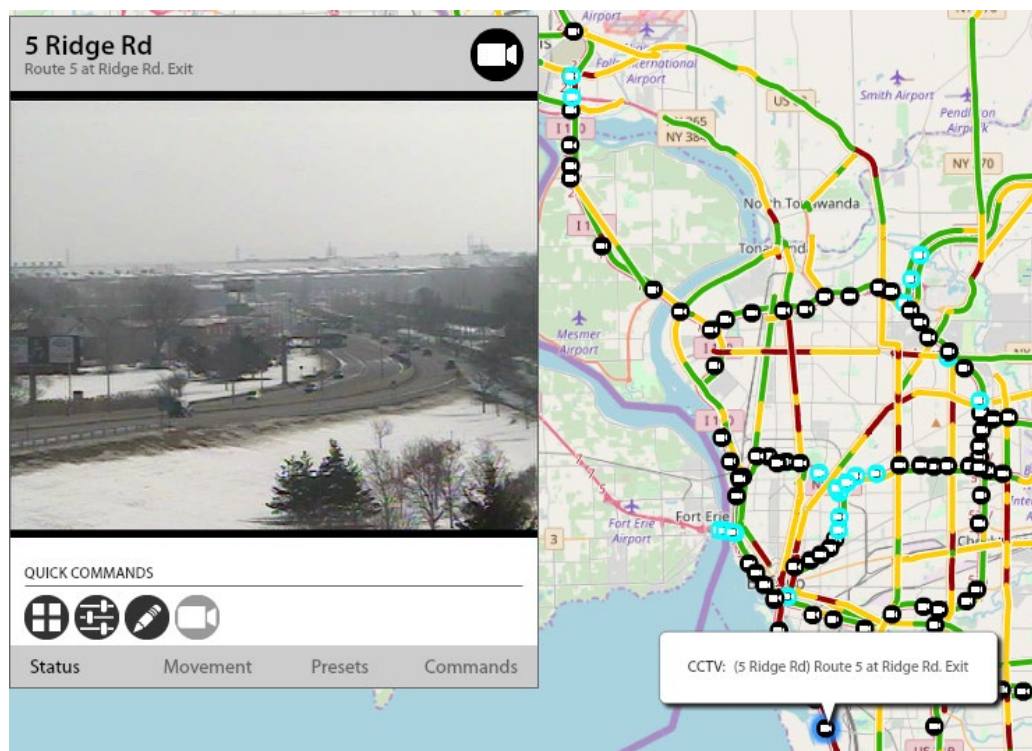
(Source: Kapsch TrafficCom)

3.4.1.2 Crossroads CCTV Data

CCTV status is collected from the Crossroads XML feed, integrated and disseminated via the EcoTrafiX map. In addition, CCTV snapshots are available to facilitate the viewing of camera images from the region's roadways.

The following images depict graphical representations of the CCTV snapshots and status data from Crossroads, on the map, existing in the production EcoTrafiX deployment.

Figure 8. EcoTrafiX Map – CCTV Status and Snapshot
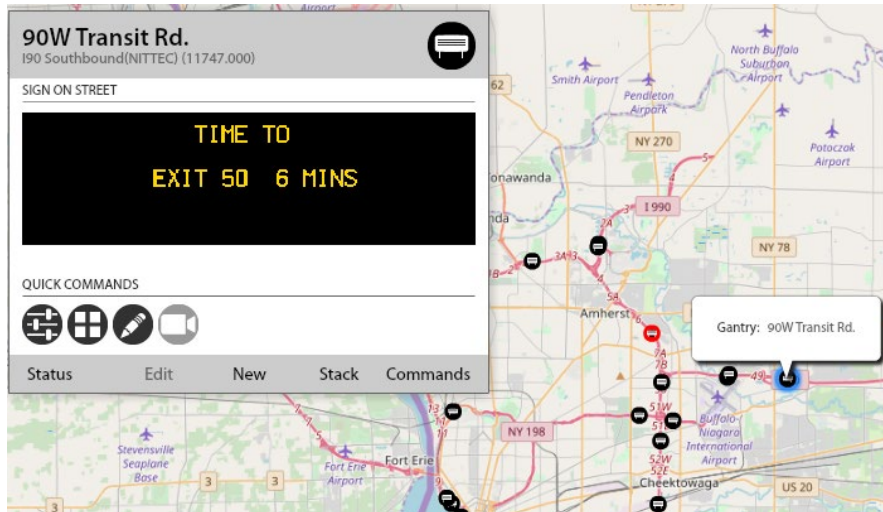
(Source: Kapsch TrafficCom)

3.4.2 Crossroads VMS Data

VMS status and dynamic messages are currently being collected from the Crossroads XML feed, integrated and disseminated via the EcoTrafiX map.

The following images depict graphical representations of the VMS messages and status data from Crossroads, on the map, existing in the production EcoTrafiX deployment.

Figure 9. EcoTrafiX Map – VMS Status and Dynamic Message

(Source: Kapsch TrafficCom)

3.4.2.1 Crossroads Border Crossing Data
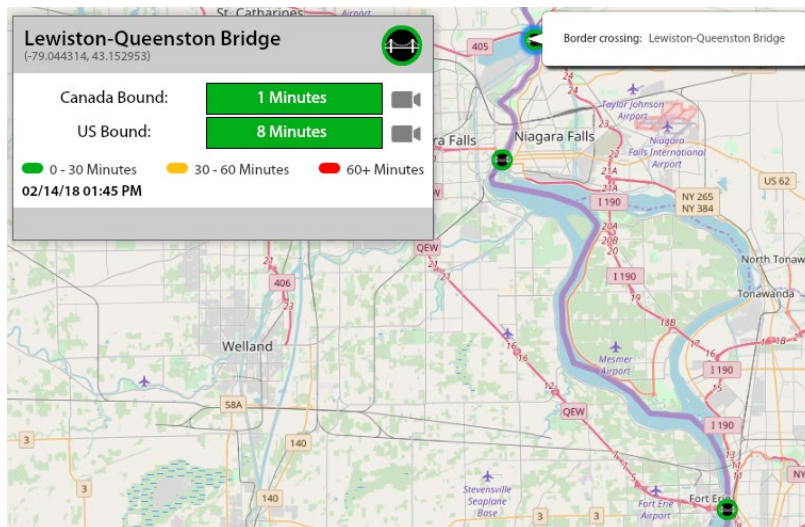
Border crossing wait times are collected from the Crossroads XML feed, integrated and disseminated via the EcoTrafiX map.

The following image depicts graphical representations of the Border Crossing wait times from Crossroads, on the map, existing in the production EcoTrafiX deployment.

Figure 10. EcoTrafiX Map – Border Crossing Wait Times

(Source: Kapsch TrafficCom)

3.4.2.2 TRANSCOM Link Speed and Travel Time Data

Roadway link speed and travel times are collected from the TRANSCOM travel time server, integrated and disseminated via the EcoTrafiX map.

The following image depicts graphical representations of the link speeds and travel times from TRANSCOM, on the map, existing in the production EcoTrafiX deployment.

Figure 11. EcoTrafiX Map – TRANSCOM Link Speed and Travel Time

(Source: Kapsch TrafficCom)
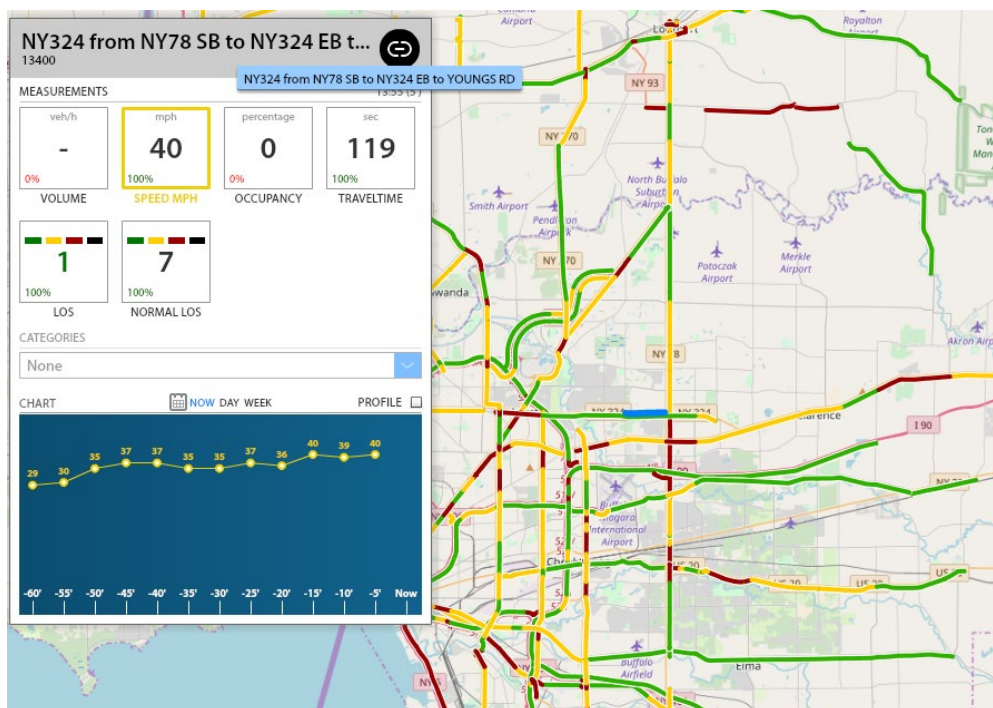
3.4.2.3 NFTA AVL Data

AVL and departure time data is collected from the NFTA, integrated and disseminated via the EcoTrafiX map.

The following images depict graphical representations of the AVL and departure time data from NFTA, on the map, existing in the production EcoTrafiX deployment.

Figure 12. EcoTrafiX Map – NFTA AVL and Departure Time Data

(Source: Kapsch TrafficCom)
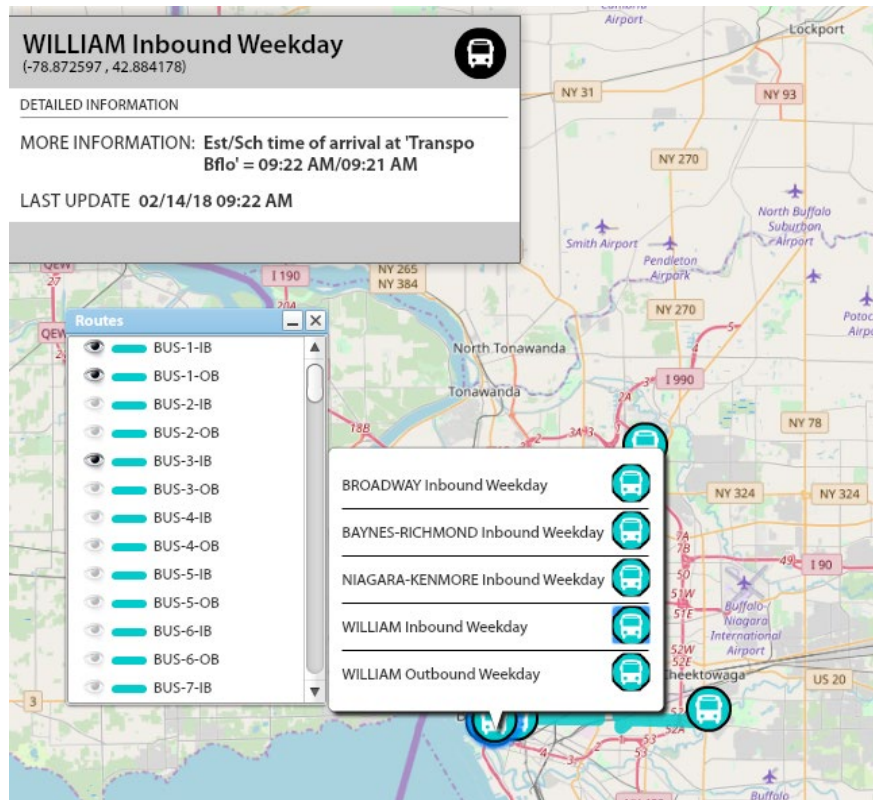
3.4.3 Data Mart Web Services

The Data Mart Web Services are a critical component in data dissemination and enable data sharing allowing third parties the ability to consume the collected and fused data from the EcoTrafiX platform. Authorized third-party consumers must authenticate with the web services by providing a username and encrypted password to receive an authentication token. That token can then be used on subsequent requests so the user does not need to authenticate for each web service call.

Integrated into the Data Mart Web Services is the ability to filter the data being presented in the XML response by user. It may be desired to limit a particular user's resultant dataset to a certain subset of the data, so the web services have been designed to allow for dynamic filtering of the content that is returned to a user when the user authenticates. These filters are all configurable and can be changed at any time.

All the previously mentioned data is being made available from the NITTEC Data Mart Web Services. Specifically, the following data types (available at the corresponding web service methods) are included in the web services and can be accessed via URL at the following location.

Table 1. EcoTrafiX Data Mart Web Services Data Types

(Source: Kapsch TrafficCom)

Data Type	Web Service Method
Border crossing wait times	getBorderCrossings
CCTV status	getCCTVs
CCTV snapshots	getCCTVs
VMS status	getDMSs
VMS messages	getDMSs
Active construction events	getEvents
Active incidents	getEvents
Link speeds and travel times	getLinkStatus
Transit departure times by stop	getTransitPredictionsByStop
Transit route shapes	getTransitRouteShapes
Transit routes	getTransitRoutes
Transit stops	getTransitStops
Transit vehicle locations	getTransitVehicleLocations

The web services are a powerful way to facilitate data sharing among project stakeholders and between applications. As more data is integrated into the EcoTrafiX platform, that data can be made available via the web services at any time in the future.

3.4.4 Custom Reporting

In addition to standard reports that ship as part of every EcoTrafiX deployment, custom reports were developed as part of the project delivery. Prior to developing custom reports, Kapsch worked with NITTEC to identify a list of Key Performance Indicators (KPI's) to be included in the reporting metrics. The following reports and KPI's were included in the project delivery.

1. DMS Report – EcoTrafiX Standard Report
   o Detailed report that provides Dynamic Message Sign (DMS) information such as device status and other static information such as location, model, etc.
2. CCTV Report – EcoTrafiX Standard Report
   o Provides status and snapshot reports for CCTV devices

3. Travel Times Report – Custom Report

   o Provides travel time and travel time index
   o Provides 95th percentile travel time and travel time index

4. Incident Management Report – Custom Report

   o Provides number of incidents categorized as minor, intermediate, or major in severity
   o Provides number of incidents that are cleared in less than 30 minutes, between 60 and 120 minutes, and more than 120 minutes
   o Provides average detection to arrival time
   o Provides average detection to lane clearance time
   o Provides average detection to return to normal conditions time

5. TOC Events Report – Custom Report

   o Provides summary report of the number of events of each type
   o Provides the number of secondary events
   o Provides summary report of the total number of events of any type

6. Event List Report – Custom Report

   o Provides detected time, scene arrival time, departure time, and return to normal conditions time
   o The following two reports were originally included in the functional requirements, but not delivered due to budgetary constraints; however, the reports can be delivered at a later date.

7. Event Detail Report – Custom Report

   o Provides event related DMS messages, and concurrent speed data
   o Provides all event related DMS messages and speeds during the life cycle of the relevant event

8. Systems Reliability Report – Custom Report

   o Provides percent uptime for devices (DMS/CCTV)

4   Documentation and Training

As a part of the system deployment and integration process, Kapsch provided several documents in addition to on-site and remote training for operations staff and Systems Engineers. The following documents/training items were delivered as a part of the implementation.

Documentation:

- Functional Requirements Document
- System Acceptance Test Plan
- Project Implementation Plan
- Host Site Agreement
- EcoTrafiX Software License Agreement
- Hardware/COTS Software Specifications
- Hardware/COTS Software Inventory
- Equipment Disposition Plan
- Data Mart Data Dictionary
- EcoTrafiX User Guide/Operator Training Material
- EcoTrafiX System Administrator Manual/Training Material
- EcoTrafiX Systems Engineer Guide
- Custom Reports mockups for evaluation prior to implementation
- Quarterly status reports
- System Administrator Training Guide
- Operations Training Guide

Training:

- On-site Systems Engineer training – 1 session
- On-site Operations Staff training – 1 session
- Remote Systems Engineer training

5   Findings and Conclusions

5.1   Evaluation Process

Evaluation of the resulting system followed immediately upon completion of the first round of System Acceptance Testing in June 2017 and continued through project completion. As the system was deployed at the NITTEC Traffic Management Center (TMC) in Buffalo, NY, NITTEC operations staff evaluated the EcoTrafiX system and provided feedback as discussed in the Observations/Results section below. The evaluation process consisted of exchanges of observations and feedback through e-mail and teleconferences after the system was fully deployed.

5.2   Observation and Results

NITTEC operations staff provided feedback to Kapsch staff over several months. To date, very few issues have been reported. As issues were reported, Kapsch staff fielded the issue reports, assessed the magnitude of the issue, and resolved the issue where possible. If any issues were found with the core software itself, Kapsch staff notified NITTEC that these issues, depending on magnitude, could be potentially addressed in the future with subsequent software builds.

The following issues were reported by NITTEC staff, along with their resolutions, or responses:

1. Issue: Traffic speeds were not appearing.
    Status: Resolved.
    Cause: Kapsch support team needed to perform a restart of Mule services.
    Follow up action: Kapsch staff trained the NITTEC Systems Engineer in accessing the system and performing the restarts if needed in the future. In addition, systems engineering documentation was provided as well.
2. Issue: Old events remaining in the system.
    Status: Resolved.
    Cause: Due to a possible power outage in the NITTEC facility, the Crossroads data interface temporarily lost connectivity to the Crossroads XML Feed and event closures were missed.
    Follow up action: Kapsch reviewed the system to ensure there were no longer any "stuck" events in the system and closed those that were missed due to the outage.
3. Issue: Event entry issue. In all secondary tabs within EcoTrafiX, creation and editing abilities are grayed out.
    Status: Resolved.
    Cause: This is by design. An event needs to be confirmed prior to being able to edit the information in the tabs. An operator cannot edit these fields while the event is in draft mode
    Follow up action: Kapsch can provide additional training where needed.

4. Issue: Automated event descriptions sometimes unclear.
   Status: Resolved.
   Cause: This is by design. This is a function of the core software and cannot easily be changed. However, there is an alternative. As an operator is creating an event, if the operator would like to modify the event description, they have the option to do so. The operator can simply check the "manual description editing" checkbox at the bottom of the event create form to manually alter the text in the event description.

5.3   Potential Areas for Improvement and Expansion

Now that the EcoTrafiX system has been deployed at NITTEC, there are several areas for potential improvement and expansion. The following is a list of potential items that can be looked at to improve system functionality and expand the system that is already available to NITTEC staff.

1. Expand usage of the EcoTrafiX system to additional agencies in and around the region to encourage interagency awareness.
2. Improvements to static roadway network.
   Kapsch used the DOT LRS, as previously described, to populate the EcoTrafiX roadway network. Much research has been done to evaluate the dataset and it has been determined the LRS can be made more granular by increasing the number of nodes/intersections along a link segment on the roadway. This will aid in the ability to more accurately map Crossroads incidents and construction events to the EcoTrafiX roadway network.
3. Integration of additional data sources. Examples include:

   o   Waze
   o   TRANSCOM OpenReach Events
   o   511NY
   o   Ministry of Transportation of Ontario Compass
   o   HERE data
   o   DTN Weather data
   o   NYSDOT RWIS data
   o   City of Buffalo Signal Systems
   o   NYSDOT Signal Systems
   o   Streetline Parking Data
   o   Connected Vehicle Data
   o   IIMS Data
   o   I3B Data

4. Completion of additional custom reports.
   As previously discussed, due to budgetary constraints, two reports were not completed. Potential expansion would include the addition of the reports that could not be completed.

5. Integration of Performance Measures dashboards.
    Kapsch has developed graphical Performance Measures (PM) dashboards to allow for historical data analysis, and KPI analytics. As a potential expansion activity, Kapsch could deploy its PM dashboards into the existing platform to allow NITTEC and project stakeholders access to intuitive graphical dashboards to assist in analysis of the performance of the Region's transportation network.
6. Upgrade the existing EcoTrafiX platform to the latest version of EcoTrafiX. This will allow NITTEC to utilize the most current version of the software, which includes key new features such as a simplified event entry screen that eases the process of creating an event in the EcoTrafiX software.
7. Integration of an Integrated Corridor Management System (ICMS) component to include decision support, support for connected vehicles, and an enhanced data fusion architecture that will allow for additional situation awareness at the border crossings and approaches, thereby aiming to ease operations for emergency service providers, freight carriers, travelers, and commuters in the region.
8. Integration of additional parking information to assist truckers in the region to find areas to park if wait times at the boarders are excessive.
9. Identify and integrate additional sources of transit data.

5.4   Lessons Learned

Over the course of the project delivery, lessons were learned that can be applied to future deliveries.

The following includes lessons learned and strategies taken to address them.

1. The roadway network data was challenging to process into the EcoTrafiX platform. With every project deployment, the static roadway network data always presents challenges when the data is in a format new to the Kapsch deployments. Kapsch learned, once the data was processed, that the NYSDOT LRS data is not as granular as the Crossroads intersection data, and therefore, did not have full one-to-one node mapping. Going forward, Kapsch now has processes to fuse the NYSDOT LRS dataset as a result of this deployment, and additional roadway network changes will require less time. Kapsch also now has processes to address the granularity issue with the LRS data and can apply that to future updates.
2. Kapsch assumed the GTFS data could be used for the NFTA data integration. However, after attempting to process the NFTA GTFS data, it was discovered the GTFS dataset was not sufficient for providing departure times to the EcoTrafiX platform. Therefore, Kapsch needed to work with NFTA to consume their proprietary data to provide departure times in the application. As a result, the overall project timeline was extended.
3. Also, with respect to NFTA, Kapsch struggled to pull the real-time NFTA data from their system as NFTA provides this information over FTPS. Kapsch's source code was not developed to utilize the FTPS protocol, so development was delayed until a workaround was found.

4. Significant effort was spent in developing the custom reports for the system, and it was agreed with NITTEC to place the two remaining reports on hold due to funding concerns. Kapsch fully understands the challenges with developing the more complicated reports and will estimate additional development time in the future for the reports that could pose a more challenging task.

5. Finalization of the Host Site Agreement deliverable required 12 months from January 2017 to December 2017 and seven draft iterations. This effort was complicated due to the varying requirements and responsibilities among the different organizations involved (Kapsch, NYSERDA, NITTEC, NFTA, and NYSDOT) and signatures required as it was considered a legal document. In the future, it may be advisable to not make this type of deliverable a legal document as its purpose is to document the deployment and operation of the EcoTrafiX system and the responsibilities of Kapsch and NITTEC in doing so.

6   Statement on Implementation

6.1   Next Steps

Kapsch is committed to supporting the EcoTrafiX deployment and NITTEC and will work with NITTEC to identify any of the items listed above in the areas for potential improvements and expansion that NITTEC would consider for the system. All items listed above would only improve the system that is already deployed and provide NITTEC with a set of tools that can further improve operations in the TMC and for any other project stakeholder.

Appendix A: URLs for Crossroads Data

The following URLs are used to access the Crossroads XML feeds that supply various data to the NITTEC EcoTrafiX system.

Incidents and Construction Events
http://www.nittec.org/content/xml/ActiveEvents.xml

CCTV Status Data
http://www.nittec.org/content/xml/CctvStatus.xml.

VMS Status Data
http://www.nittec.org/content/xml/VmsStatus.xml

Dynamic Border Crossing Wait Time Data
http://www.nittec.org/content/xml/bwt5min.xml

Appendix B: References

There are several project documents that define management processes and other technical aspects of the system created for this project. Relevant documents include:

- Kapsch Proposal Response to PON 3090, Integrated Mobility Solutions for Smarter Cities and Communities – Kapsch, July 29, 2015
- EcoTrafiX Platform Deployment for NITTEC, NYSERDA Agreement No. 83175, Statement of Work, Schedule and Budget – Kapsch, June 2016
- EcoTrafiX Operations manual – Kapsch, September 7, 2016
- EcoTrafiX Platform Deployment for NITTEC, EcoTrafiX Asset Inventory – Kapsch, March 31, 2017
- EcoTrafiX Platform Deployment for NITTEC, Project Implementation and Equipment Disposition Plan, Version 1.2 – Kapsch, April 7, 2017
- EcoTrafiX Platform Deployment for NITTEC, Functional Requirements, Version 1.5 – Kapsch, April 27, 2017
- EcoTrafiX Operator Training Presentation – Kapsch, May 19, 2017
- EcoTrafiX System Administrator Training Presentation – Kapsch, May 19, 2017
- EcoTrafiX Platform Deployment for NITTEC, System Acceptance Test Plan, Version 1.1 – Kapsch, December 15, 2017
- EcoTrafiX Platform Deployment for NITTEC, Host Site Agreement – Kapsch/NITTEC, December 15, 2017
- EcoTrafiX Software License Agreement – Kapsch, December 5, 2017

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