Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program Final Report

Grant Award Recipient: Niagara Frontier Transportation Authority (NFTA)

Prepared by: Niagara International Transportation Technology Coalition (NITTEC)

Submitted to: Federal Highway Administration (FHWA)

Project Title: A Connected Region: Moving Technological Innovations Forward in the NITTEC Region

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1 PROJECT SUMMARY

1.1 Project Description

The Niagara International Transportation Technology Coalition's (NITTEC) mission is to "improve mobility, reliability and safety on the regional bi-national multimodal transportation network through information sharing and coordinated management of operations." The purpose of this project is to design, develop, implement, and maintain a system that supports the achievement of this mission. Components of the system include the following:

- A data hub and data mart to allow electronic collection and exchange of information between the various stakeholder traffic management systems, field, central and 3rd party data sources and field traffic management devices. A decision support system to automate and streamline coordinated responses across stakeholders to anomalous regional events.
- A performance measures module to monitor the performance of the various systems and provide reports and dashboards for use by stakeholder decision makers to determine the extent to which the various systems are meeting their objectives.

Prior to this project's implementation, NITTEC and its member agencies collected and used data independently of one another. Data sharing occurred sporadically upon request, requiring information to be manually exported from a given system and shared directly with the requesting party. These limitations resulted not only from the siloed nature of the data sources, but often also from a lack of awareness of which agencies were collecting this information at all.

The project is intended to deploy a multi-agency, technology enabled, integrated regional mobility management system that will enhance safety and mobility across the region. Key project goals from this effort are balancing multimodal demand across the Niagara Frontier border crossings, improving freight operations by providing targeted information to drivers, use of improved weather information in traffic management, improving regional mobility by expanding integrated corridor management activities and providing the benefits of multi-agency cooperation by creating real time interagency information sharing and collaboration.

1.2 Project Scope

The NITTEC Advanced Transportation Congestion Management Technology Deployment (ATCMTD) system includes, as subcomponents, an advanced regional mobility system that combines several data sources from external systems on a common data sharing and dissemination platform, an integrated decision support system, and an online microsimulation model to evaluate the efficacy of measures taken to balance traffic and respond to abnormal travel conditions. The data and decisions being collected and generated by the central system will also power key performance indicators at the regional level via advanced analytics and dashboards, providing insight into the performance of the road network, commercial vehicle operations and border crossing activities. The primary goal of the effort was to enhance safety and mobility across the Region through fulfillment of the following:

- Balancing Border Crossing Demand at the 4 border crossings
- Improving Freight Operations including Truck Traveler Information and Parking management systems
- Expand Regional Mobility
- Improved Weather Information
- Improve Incident Management
- Provide for Operational Integration within the Niagara Frontier Transportation Authority (NFTA) and with Regional Smart Mobility
- Interagency Information Sharing and Collaboration
- Enhanced Data Collection, Fusion Distribution and Archiving

This project includes a centralized ATCMTD system consisting of a core Decision Support System (DSS), Regional Smart Mobility Data Hub, and integration with external systems such as:

- Regional Central Advanced Traffic Management System (ATMS)
- I-190 Integrated Corridor Management (ICM)
- Vehicle-to-Infrastructure (V2I) and in-vehicle messaging
- Parking Management
- Weather forecasting and Road Weather Information System (RWIS)
- Big data, performance measurement and reporting
- Traveler Information dissemination

The system is accompanied by fully developed functional and technical documentation, including interface definition with other contractors and 3rd parties for finalizing any interface design requirements.

1.2.1 Modifications to Scope

As the project progressed, the scope remained largely unchanged. However, some facets of the project received greater or lesser focus depending on a variety of factors. The most prevalent of these was an inability to obtain datasets from some sources, due to either technical or institutional barriers outside of NITTEC's control. In these cases, is was ensured that the solutions developed in this project would be built to accept that data in the future, if it can be made available. It should be noted that performance metrics which had been previously identified related to these datasets can no longer be used to evaluate this project.

1.3 Project Timeline

- March 2016 – Notice of Funding Opportunity Issued for First Round of ATCMTD Grants
- June 2016 – NFTA/NITTEC Grant Application Submitted
- October 2016 – NFTA/NITTEC awarded $7,813,256 Grant to Improve Regional Smart Mobility
- December 2017 – Request for Proposals (RFP) for ATCMTD Project Issued
- March 2018 – Initial Consultant Selection and Subsequent Protest

- September 2018 – Per Federal Highway Administration (FHWA) Guidance, Cancelled Initial Selection and Restructure Project into Two Phases, Each with its own RFP
- June 2019 – RFP for Phase 1 (Planning) Issued
- January 2020 – Phase 1 Kick-Off
- April 2021 – Phase 1 Completed
- June 2021 – RFP for Phase 2 (Implementation) Issued
- March 2022 – Phase 2 Kick-Off
- June 2024 – ATCMTD System Go-Live
- December 2024 – End of Evaluation Period
- April 2025 – Project Completion

1.3.1 Project Schedule Deviations

In total, three project extensions were granted by FHWA. The first in 2020 allowed for additional time to make up for delays resulting from protests to the initial RFP and COVID-19 related factors. This extended the end of the project to December of 2023.

The second extension in 2023 allowed for additional time to make up for delays resulting from protests to the second RFP. This extended the end of the project to December of 2024.

The third and final extension in 2024 allowed for additional time to collect and analyze data for performance measures and create the final report. This extended the end of the project to April of 2025.

2 Performance Metrics, Evaluation Methods, and Data Sources

2.1 Project Goals

This project was designed around several goals, with an overarching focus on improving mobility through better access to and management of transportation data. The specific goals are outlined below, organized by the applicable ATCMTD grant goal areas.

2.1.1 Improved safety

- Provide truck parking management support to accommodate trucking and trucker needs.
- Improve coordination among responders by integrating with additional 911 Computer Aided Dispatch (CAD) systems and expanding the Regional information exchange network initial project to assure for a robust and timely exchange of information including incident location, response and incident status.
- Integrate with on-scene Emergency Management Service providers using the Integrated Incident Management System (IIMS) concept employed as a pilot project for the New York State Department of Transportation (NYSDOT).
- Improve NFTA transit incident management by integrating various steps and process within the agency and with various involved departments.

2.1.2 Reduced congestion and improved mobility

- Define operational performance goals for border crossing travel time and delay.
- Develop and implement strategies to balance border performance and travel time within the set thresholds.
- Upgrade municipal signal systems on potential alternate routes.

2.1.3 Improved system performance or optimized multimodal system performance

- Dynamically monitor border crossing operational status.
- Expand ICM to major highways in the Region, as well as the City of Buffalo main corridors and routes.
- Expand the I-190 ICM corridor from the east to Rochester and from the south to the Pennsylvania border via an expansion of the regional model.
- Upgrade the Regional ATMS to have a fully integrated Regional smart mobility system.
- Develop a dynamic Regional Decision Support System and performance measures application to ensure optimized operational level of service.
- Integrate NFTA operational data and systems within the Regional mobility concept.
- Offer transit as an alternative strategy to highways and vice versa.

2.1.4 *Effectiveness of providing integrated real-time transportation information to the public to make informed travel decisions*

- Provide in-vehicle real-time traffic, parking and weather information to commercial vehicles to facilitate trucks operations from the Pennsylvania border and the Rochester area into Buffalo and the border crossings.
- Deploy a parking management system downtown and/or around major trip generators, such as hospitals, stadiums, special events, downtown business areas and more.
- Implement a robust real-time and weather forecast and alert system to warn truckers and motorists of inclement weather and delays.
- Provide real-time transit information to the public via 511NY and other dissemination tools.
- Provide real-time and forecasted multi-modal, multi-agency transportation network information via 511NY and other applications.

2.1.5 *Improved inter-agency coordination*

- Integrate real-time and forecast weather information system and the alerting applications within the Region.
- Integrate with NYSDOT and New York State Thruway Authority (NYSTA) RWIS units currently in place and/or being expanded via the Mesonet project.
- Integrate various NFTA real-time data sources to improve operational efficiency.
- Enhance the ability to collect, fuse, distribute and archive available data for all manner of performance measures, performance management, real-time operations and real-time information.

2.2 Deployed Technologies and Goals

This section lists the deployments and services which were funded using the ATCMTD grant. Any systems or services shown in the System Context Diagram (Figure 1) which are not listed under sections 2.2.1, 2.2.2, or 2.2.3 are only included for reference and were not funded under this grant.

2.2.1 *ATCMTD Core System*

The system, called AllRoads, addresses some of the long-standing challenges experienced in the Buffalo Niagara Region. While Intelligent Transportation System (ITS) projects have been successfully deployed in the past, integrating them into traffic management operations, especially across agency jurisdictions, has proven difficult. NITTEC used this project as an opportunity to leverage the strong inter-agency collaboration it has built to create a new system, which addresses the needs of its stakeholder agencies, bringing together the previously siloed sources of traffic data into a single system.

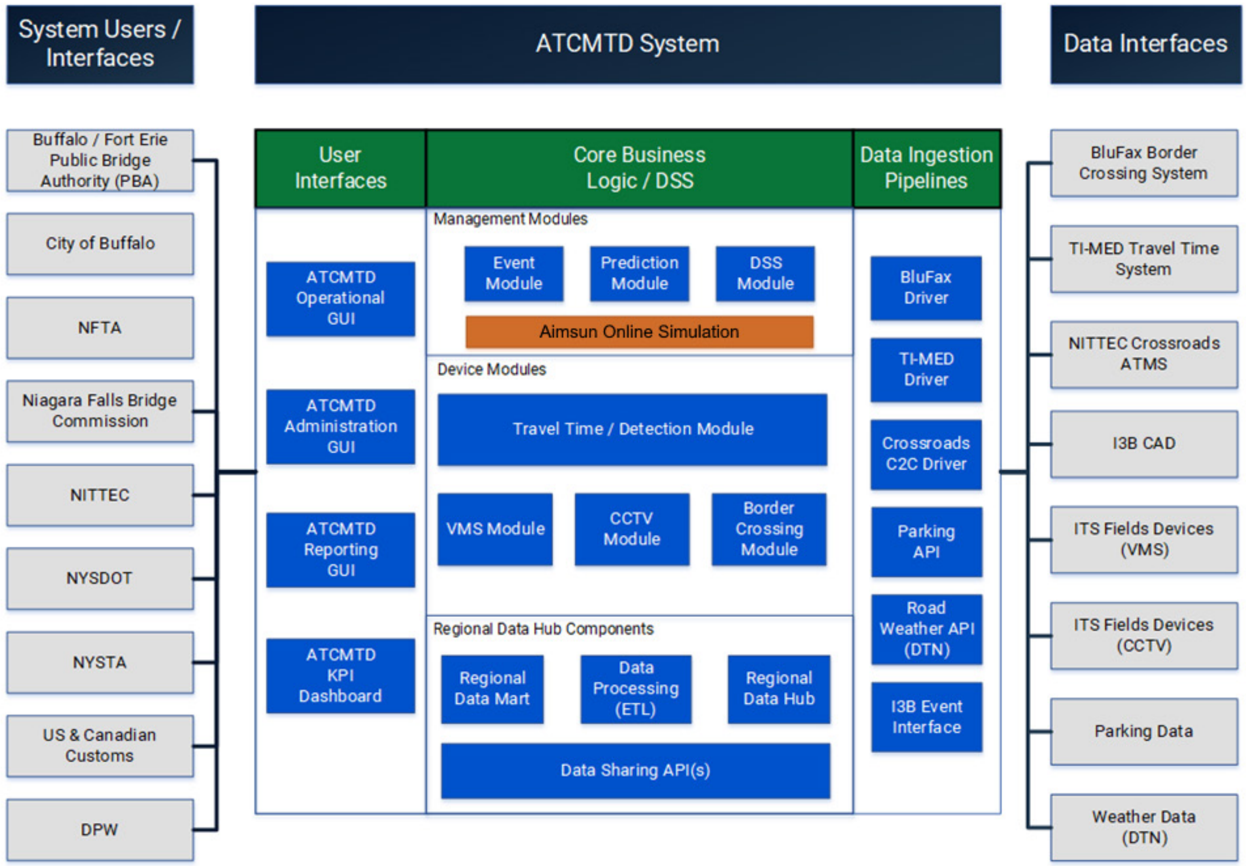
AllRoads was developed by Parsons based on their Intelligent NETworks® Smart Mobility (iNET™) system, along with an accompanying data hub and data mart to store and disseminate the data to external agencies for information sharing with the traveling public. The data is used by Parsons' AI and micro-simulation based integrated DSS to generate predicative traffic management strategies. The core systems are supplemented by multiple pilot deployments of field equipment and new systems to fill gaps in the region's data. This includes truck parking data, transit park-and-ride occupancy, and arterial traffic information.

The key components/modules comprising the system include:

- Core DSS including the iNET® DSS Rules Engine, Event Management Module and integration with the Aimsun system.
- Aimsun Live Microsimulation Tool & Traffic Prediction Engine, which will run real-time simulations (micro & meso) providing analyzed response plan elements and predictive traffic flow metrics based on an underlying regional model.
- INET® Device Modules that include specific device modules for monitoring Closed Circuit Television (CCTV) cameras, Dynamic Message Signs (DMS), traffic signals, roadway weather information systems.
- Regional Smart Mobility Data Hub that collects data inputs, both raw and processed, for historical referencing, archiving, and advanced analytics
- Regional Smart Mobility Data Mart that serves up normalized ATCMTD data, in standard Traffic Management Data Dictionary (TMDD) and JavaScript Object Notation (JSON) formats, including Key Performance Metrics and data elements collected by the various subsystems.
- Center-to-Center (C2C) Module which will be the gateway to send and receive data to and from external systems. It will be used to manage interaction with legacy systems, partners, and agencies (wherever possible, third-party interfaces will occur via the C2C module using the latest TMDD standards)
- CAD allows for input of data from a 911 partner in a CAD system

The System Context Diagram shown in Figure 1 provides a logical representation of the conceptual architecture showing the systems, stakeholders and subcomponents of the ATCMTD solution.

Figure 1: System Context Diagram



2.2.2 *Other Technology Deployments*

In addition to the AllRoads system, a variety of other projects and technology pilots were funded through the ATCMTD grant to further the project's goals.

2.2.2.1 <u>Road Weather Modeling</u>

NITTEC has access to the data from several weather monitoring stations in the region, but there is a gap in availability for road weather condition information. Previously, this was limited to manual reporting from snow removal vehicle operators. As a part of this project, NITTEC piloted the ClearPath Weather platform from DTN, which incorporates real-time and forecasted weather conditions, along with known pavement information, to model surface conditions. This data, which is automatically fed into the core AllRoads system, includes:

- Real-time Radar for the US and Canada
- Surface Observations
- Contoured Current Conditions
- Fronts & Pressure Centers
- National Weather Service Watches/Warnings/Advisories
- Local Storm Reports
- Storm Prediction Center Outlooks
- NHC Tropical Storm Forecasts

- Infrared Satellite 6hr loop, 30 min update
- Time-enabled looping Radar for US and Canada
- Real-time lightning
- Storm Attributes/Corridors (speed/direction/hail size)
- Heavy Precipitation Alerts
- Quantitative Precipitation (Rainfall) Estimates
- Freezing Rain and Snowfall Forecasts
- Tropical Storm Forecast Models (Spaghetti) models

This data allows for better management of weather events and improves the quality of information shared with stakeholders and the travelling public.

2.2.2.2 Traffic Signal Communications

The majority of traffic signal controllers in Erie and Niagara counties lack communications capability. This makes it impossible to remotely change signal timing plans to reflect current traffic conditions, which is one of the main tools used by the AllRoads decision support system to optimize performance.

To address this, grant funds were used to equip a series of traffic signals along Niagara Street with the Miovision suite of technology. This arterial is a key transit corridor and serves as the main alternate route to a downtown expressway when traffic conditions deteriorate. Implementing improved or alternative signal timing plans alleviates congestion and improves traffic flow. This made Niagara Street an ideal candidate to test signal optimization and alternative timing plans in response to traffic events, with the intent to expand the deployment if it is successful.

This corridor was also used to support a pilot of Transit Signal Priority (TSP) for transit vehicles in the region, allowing extra green time for through movements of buses when necessary.

To implement these functionalities, the grant funding was used to integrate the central signal software, which operates the traffic signal controllers, with AllRoads.

2.2.2.3 Enhanced Border Delay Monitoring

The Niagara region includes four international border crossings between the U.S. and Canada and the delay at each crossing is a vital piece of traveler information to provide to the public. Delay is continuously monitored and reported using a combination of License Plate reader, Bluetooth, and Wi-Fi technologies. However, not all crossings had the full range of detectors deployed and the accuracy at some crossings did not meet the standards of NITTEC's stakeholders. To address this issue, the grant was used to expand the technologies to the other crossing, resulting in a more accurate set of border delay data, which is provided to travelers and incorporated into the AllRoads system.

2.2.2.4 Lane Designation Integration

The region included four two-lane bridges as part of an expressway on which there is no shoulder to provide space for vehicles to pull over in the event of an incident or construction/maintenance activities. The curvature of the bridge also reduces the line of sight for approaching vehicles to see stopped traffic ahead. To address this, lane designation signs were installed on the bridges in the past, which were controlled by the bridge toll collection staff. However, the expressway has since transitioned to cashless tolling, and there are no longer staff on site to operate the lane designation signs. ATCMTD grant funds were used to integrate these signs into the NITTEC Operations Center so they can be changed in response to an event, improving safety and reducing congestion on the bridges. Future integration into AllRoads is planned.

2.2.2.5 Video Detection Pilot

Grant funding was used to pilot a TrafficVision, a video detection software which uses the pre-existing camera feeds to alert the NITTEC Traffic Operations Center (TOC) to congestion or stopped vehicles. The vast network of CCTV in the region makes it impossible for operations staff to view every camera at once. This software allows for reduced incident detection time and improved safety. The pilot deployment includes a subset of the CCTV network and can be expanded further upon review of its success.

2.2.2.6 Regional Model Expansion

As part of the region's previous ICM efforts, a hybrid micro- and macroscopic traffic model was developed to predict future traffic conditions based on current conditions. This model was previously limited to the network adjacent to the ICM corridor. To improve the quality of the decision support system within AllRoads and provide better recommendations to travelers, the team partnered with Aimsun to expand the model to encompass the entire regional network. This model also allows the region's planning agencies to model the impacts of future changes and improvements to the transportation network.

2.2.2.7 Additional Tasks

To support the project's goals, grant money was also used on some secondary efforts. These included development and integration of an independent data monitoring dashboard, integration with NITTEC's existing ATMS, and a staffing study which examined the increased workload on NITTEC's systems and operations teams created by the introduction of these new systems and data feeds.

2.2.3 Project Management

While not a technological deployment, a key aspect of this project which contributed to its success and lessons learned was its focus on project management practices. The systems engineering process was closely followed to clearly define the project parameters and requirements. In addition, the agile development process was used to develop, test, and implement the project in small section, or sprint, which allowed NITTEC and its stakeholders to begin using the system and providing feedback very early in the process.

2.3 Performance Metrics

Table 2-1: Performance Metrics Summary Table

Goal Area	Performance Measures	Data Method	Data Source(s)	Collection Time Period (Baseline)	Collection Time Period (Evaluation)	Limitations / Constraints
Safety	Change in incident response time	Before-and-After Method	Operations Center Event Logs	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Many complicating factors outside of the system’s control
Safety	Change in incident clearance time	Before-and-After Method	Operations Center Event Logs	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Many complicating factors outside of the system’s control
Reduced congestion and improved mobility	Change in travel time index on expressways and arterials during peak periods.	Before-and-After Method	Road Side Units	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Non-recurrent congestion may affect measurement
Reduced congestion and improved mobility	Change in planning time index on expressways and arterials during peak periods.	Before-and-After Method	Road Side Units	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Non-recurrent congestion may affect measurement
Reduced congestion and improved mobility	Difference in Simultaneous Delay at two or more crossings	Before-and-After Method	Road Side Units	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Weather, seasonality and secondary incidents may affect measurement
Reduced congestion and improved mobility	Average delay normalized by volume for each crossing / vehicle type	Before-and-After Method	Road Side Units	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Weather, seasonality and secondary incidents may affect measurement
Improved system performance or optimized multimodal system performance	Change in travel time index on expressways and arterials during peak periods.	Duplicate measure, see above	-	-	-	-
Improved system performance or optimized multimodal system performance	Change in planning time index on expressways and arterials during peak periods.	Duplicate measure, see above	-	-	-	-
Improved system performance or optimized multimodal system performance	Change in average on-time performance for transit vehicles	Before-and-After Method	Transit Data Feed	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Many complicating factors outside of the system’s control

Effectiveness of providing integrated real-time transportation information to the public to make informed travel decisions	Percent of events which impact CVO being pushed to each communications path/system	Before-and-After Method	System data	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Collaboration and connecting with trucking agencies
Improved inter-agency coordination	Change in number of agencies populating each type of data to the system	Before-and-After Method	System data	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Collaborating and receiving data from different agencies
Improved inter-agency coordination	Change in number of agencies receiving each type of data from the system	Before-and-After Method	System data	Jan 1, 2018 – May 31, 2024	May 31, 2024 – Dec 31, 2024	Collaborating and receiving data from different agencies
Improved inter-agency coordination	Lessons learned did project managers identify to facilitate future successful deployment(s)	Qualitative Summary	Discussion	N/A	N/A	N/A

2.3.1 Change in incident response time

Incident response time is the difference between the incident detection time and the scene arrival time. The average quarterly incident response time was calculated for all incidents, crashes, and non-incident crash types during the baseline evaluation period. Incidents with a response time of zero (where the detection time was equal to the scene arrival time) were excluded from the analysis.

2.3.2 Change in incident clearance time

Crash clearance time is the difference between the incident detection time and the incident clearance time for all incidents classified as crashes. The clearance time performance measure focuses on crashes only because crashes are the incident type for which clearance time is most relevant and important for system performance.

2.3.3 Change in travel time index on expressways and arterials during peak periods

The Travel Time Index (TTI) is the measure of average conditions that indicates how much longer, on average, travel times are during congestion compared to during the free-flow travel time. The objective benchmark for peak TTI is below 1.50. For all highways, Free Flow Travel Time is calculated using 55 miles per hour (mph). Peak periods are defined as 6:00 am to 10:00 pm, Monday through Friday.

2.3.4 Change in planning time index on expressways and arterials during peak periods

The Planning Time Index (PTI) (95th Percentile) is the amount of time a traveler should allow ensuring on-time arrival 95% of the time. This measure indicates the travel time reliability of a route. The objective benchmark for peak PTI is below 2.50. Peak periods are defined as 6:00 am to 10:00 pm, Monday through Friday.

2.3.5 Difference in Simultaneous Delay at two or more crossings

Simultaneous delay is defined as a five-minute interval where the current delay for vehicles is 30 minutes or greater at two or more border crossings.

2.3.6 Average delay normalized by volume for each crossing / vehicle type

Average delays in minutes at each border crossing are calculated for passenger vehicles and trucks and determined separately for U.S.-bound and Canada-bound traffic.

2.3.7 Change in average on-time performance for transit vehicles

On-Time Performance is the calculated difference between the actual time a vehicle encounters a specific stop compared to the time that vehicle was scheduled to be there. The window for Metro Bus on time is six minutes. An arrival is considered on time if it is less than two minutes early and less than four minutes late.

2.3.8 Percent of events which impact CVO being pushed to each communications path/system

Commercial vehicle operations (CVO) are adversely impact by non-recurrent congestion; the percentage of events which can be shared with these operators is used to measure the outreach potential of mitigation measures. Since the system was not operating in the baseline case, the comparison will be made with previous messaging strategies.

2.3.9 Change in number of agencies populating each type of data to the system

The number of agencies sharing data with the system. Since the system was not operating in the baseline case, the comparison will be made with previous data sharing strategies.

2.3.10 Change in number of agencies receiving each type of data from the system

The number of agencies obtaining data with the system. This will reflect the number of agencies and users who have been trained in using the system. Since the system was not operating in the baseline case, the comparison will be made with previous data sharing strategies.

2.3.11 Lessons learned did project managers identify to facilitate future successful deployment(s)

A qualitative discussion of the lessons learned by the project team during its various phases. Additionally, this will include an overview of feedback received from the stakeholder agencies.

2.4 Data Limitation/Challenges

2.4.1 External Factors

Many of the mobility and safety measures identified are subject to a wide variety of factors outside the team's control, as transportation patterns change over time. In particular, the impacts of

COVID on travel behavior are varied and significant. While the year 2020 was removed from analysis, the effects on transportation have extended beyond this, even to present day. For example, it should be noted that the Canadian government did not fully lift border crossing restrictions until September 2022. While these factors cannot be completely accounted for, they can be kept in mind when viewing the results.

2.4.2 Institutional Barriers

Over the course of the project, full implementation of the system's capabilities were often limited not by technological issues but by difficulties in soliciting cooperation from necessary stakeholders.

2.4.3 Non-Quantifiable Benefits

Many of the accomplishments of this system are centered on the benefits it provides NITTEC and its member agencies in terms of access to real-time data and improved situational awareness. These are vital to improved traffic operations and planning in the region, but do not necessarily translate into immediate, numerical benefits to safety and mobility performance metrics.

2.5 Evaluation Design and Methods

2.5.1 Data Collection

Data is critical for the achievement of goals for the ATCMTD System. The breadth of the data use cases includes data collection, fusion, distribution and archiving for all manner of performance measures, performance management, real-time operations and real-time information.

These data operations were conducted between the Data Mart and the Data Hub subsystems, as well as the Performance Measures subsystem which calculated the performance metrics and the Decision Support subsystem that used the data to calculate and recommended management actions. Data that was managed included static and dynamic data such as dynamic link data and link inventory data; dynamic event data and static roadway network data; DMS static and dynamic data; CCTV static and dynamic data; real-time vehicle location data; travel time, weather alerts, decision support subsystem recommendations, timing plan recommendations, and border crossing wait time data.

Data collection was done continuously (24/7/365) as was processing and archiving.

2.5.2 Before-and-After Method

The non-experimental-design, before-and-after method is often used in assessing the efficacy of a technological deployment. In this study design, baseline data was collected before the deployment of the ATCMTD on June 1, 2024, to serve as a baseline measure. After the intervention was introduced, data collection continued. Being mindful of confounding factors, the outcomes are attributed to the intervention.

2.5.3 Evaluation Data Structure

Available data for each performance measure were aggregated into quarterly averages to capture seasonal variation within each year. Baseline years included 2018, 2019, 2021, 2022, 2023, and in 2024, Q1 and April-May. The year 2020 was excluded from the baseline evaluation due to irregularities caused by the start of the COVID-19 pandemic.

For the post-deployment evaluation, data was grouped from June 1 to August 31, 2024 and from September 1 to November 30, 2024 to emulate the quarterly variation shown in the baseline evaluation. This post-deployment data was compared to corresponding periods in 2023 (June to August and September to November) to assess changes from the baseline period.

Quarterly averages were calculated as regional totals and broken down by corridor, vehicle type, and/or U.S- or Canada-bound traffic as applicable to each measure and where data was available.

3 Evaluation Results

3.1 Improved Safety – Incident Response Time

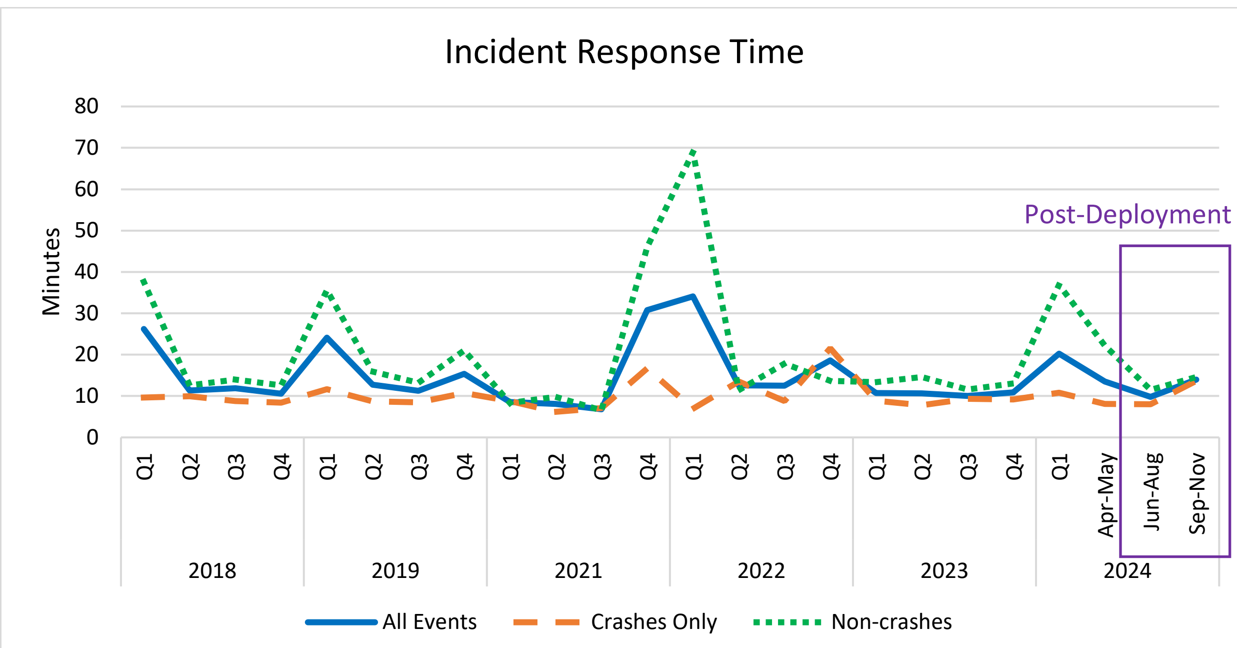
3.1.1 Measure

The average quarterly incident response time was calculated for all incidents, crashes, and non-incident crash types during the baseline evaluation period. Incidents with a response time of zero (where the detection time was equal to the scene arrival time) were excluded from the analysis.

3.1.2 Baseline Results

Figure 2 below shows the average incident response time during the baseline evaluation and post-deployment periods. The response time ranged from approximately 7 to 34 minutes among all incidents. There was less variability among crashes only, which ranged between 6 and 22 minutes. There was a significant increase in average incident response time for non-crash incidents in Q1 2022 (34 minutes) from an average of eight minutes in the previous year.

Figure 2: Incident Response Time



3.1.3 Post-Deployment Results

During the evaluation period, Figure 2 shows incident response times in all three categories that are similar to the baseline. The response time for all events was approximately 3 minutes faster on average during the evaluation period than during the baseline, with crash response times being about 1 minute slower and other events being about 8 minutes faster. However, these changes are likely due to normal year-to-year fluctuations in these values. AllRoads includes tools to improve situational awareness and, in turn, these measures, but it will take a significant amount of time before NITTEC's member agencies are using the system to its full capacity at that level.

3.2 Improved Safety – Incident Clearance Time

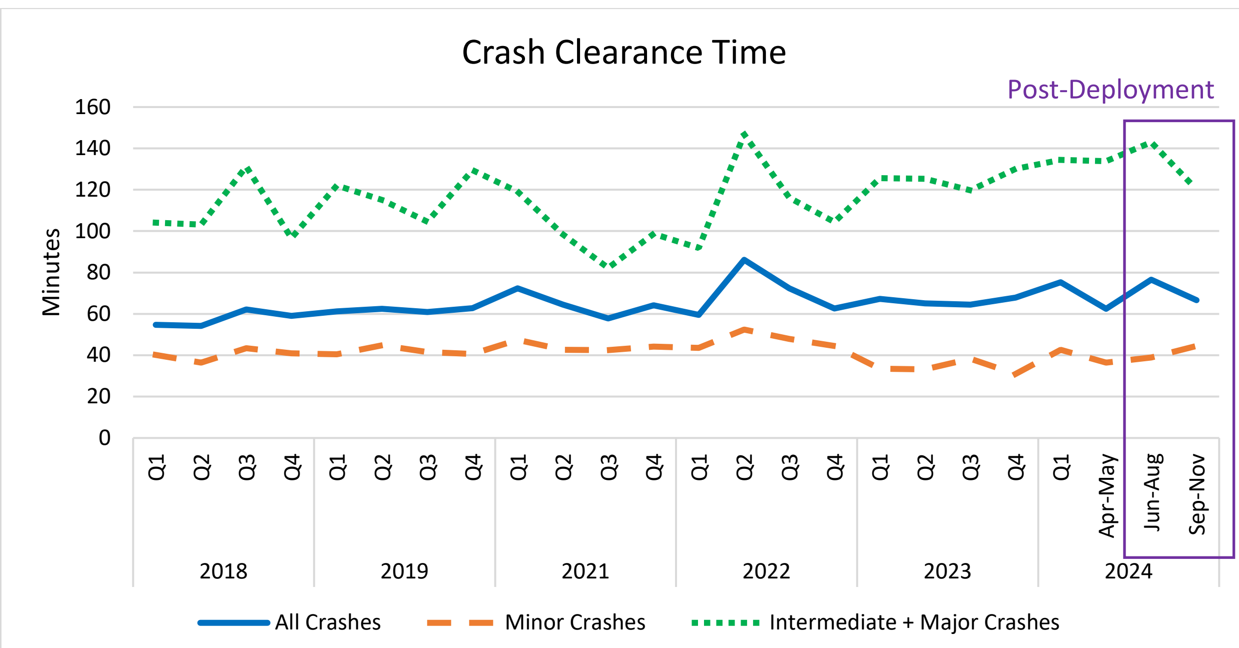
3.2.1 Measure

The average quarterly incident clearance time was calculated for all crashes during the baseline evaluation period and for incidents by severity (minor severity, intermediate and major severity combined, and all severities combined.) Crashes with a response time of zero (where the detection time was equal to the clearance time) were excluded from the analysis. The clearance time performance measure focuses on crashes only because crashes are the incident type for which clearance time is most relevant and important for system performance.

3.2.2 Baseline Results

Figure 3 below shows the average incident clearance time for crashes by severity during the baseline evaluation and post-deployment periods. Among all crashes, the clearance time ranged from approximately 54 to 86 minutes, with minor crashes ranging from 31 to 52 minutes and the combination of intermediate and major crashes ranging from 82 to 147 minutes.

Figure 3: Crash Clearance Time



3.2.3 Post-Deployment Results

During the evaluation period, Figure 3 shows that crash clearance times in all three categories that are similar to the baseline. The response time for all crashes was approximately 7 minutes longer on average during the evaluation period than during the baseline, with intermediate/major crash response times being about 17 minutes slower and minor crashes being nearly identical. However, these changes are likely due to normal year-to-year fluctuations in these values. AllRoads includes tools to improve situational awareness and, in turn, these measures, but it will take a significant amount of time before NITTEC's member agencies are using the system to its full capacity at that level.

3.3 Reduced Congestion and Improved Mobility – Travel Time Index & Planning Time Index

3.3.1 Measure

The Travel Time Index (TTI) and Planning Time Index (PTI) during peak periods were calculated quarterly for twelve links across four expressways: Interstate 90, Interstate 190, Interstate 290, and New York State Route 33.

3.3.2 Baseline Results

Quarterly TTI and PTI values are presented in Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, and Figure 9. The TTI during the baseline ranged from 1.00 to 1.56, with the average TTI for individual segments ranging from 1.07 (for I-190 Southbound from Exit 22 to Exit 16) to 1.31 (for I-90 Westbound from Exit 50 to Exit 55). The PTI during the baseline ranged from 1.00 to 3.36, with the average PTI for individual segments ranging from 1.20 (for I-190 Southbound from Exit 22 to Exit 16) to 2.03 (for I-90 Westbound from Exit 50 to Exit 55).

Figure 4: Travel and Planning Time Indices – I-90

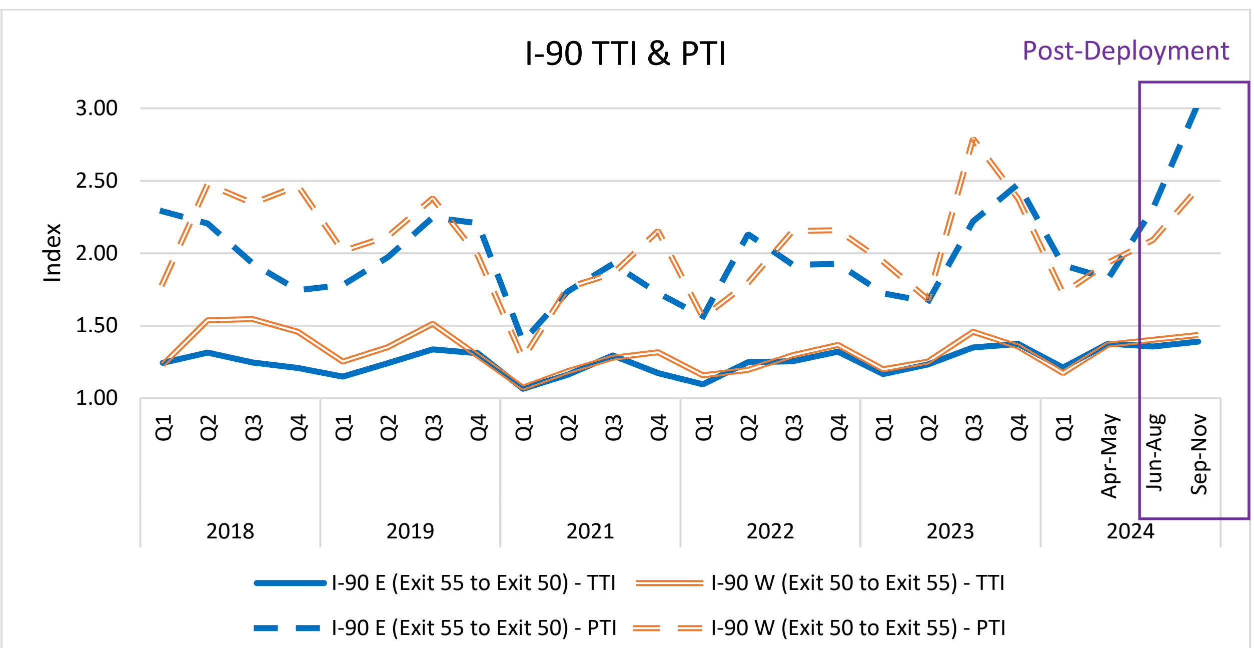


Figure 5: Travel and Planning Time Indices – I-190 (I-90 to Exit 7)

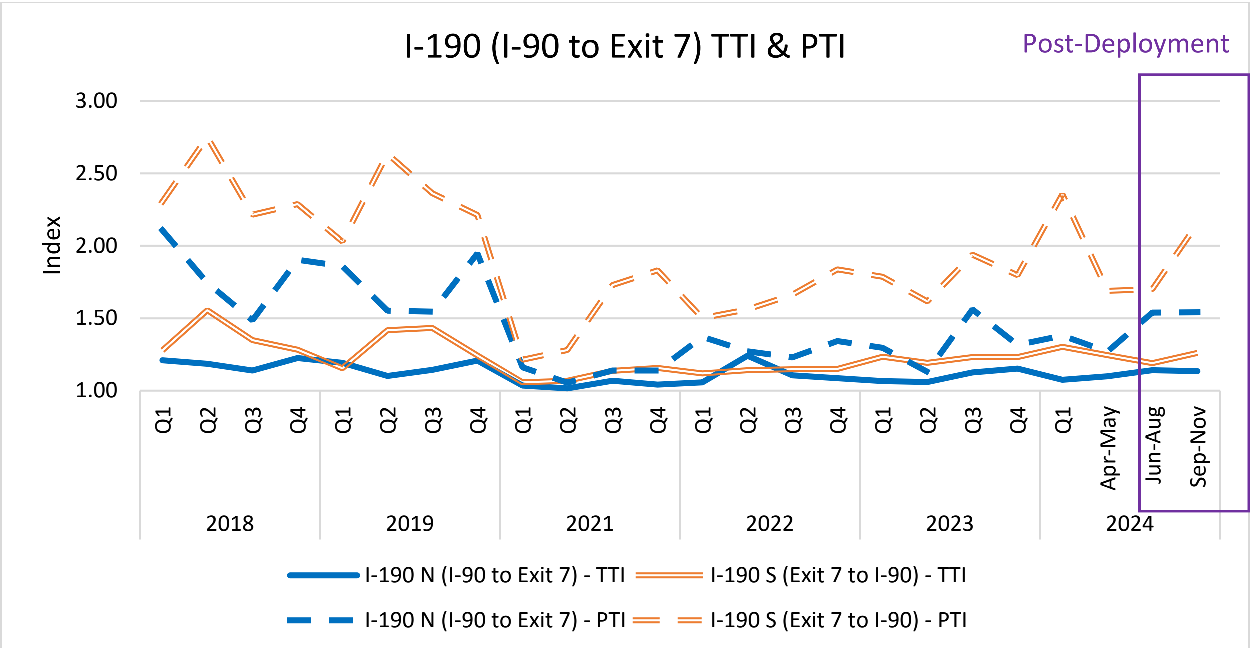


Figure 6: Travel and Planning Time Indices – I-190 (Exit 7 to Exit 16)

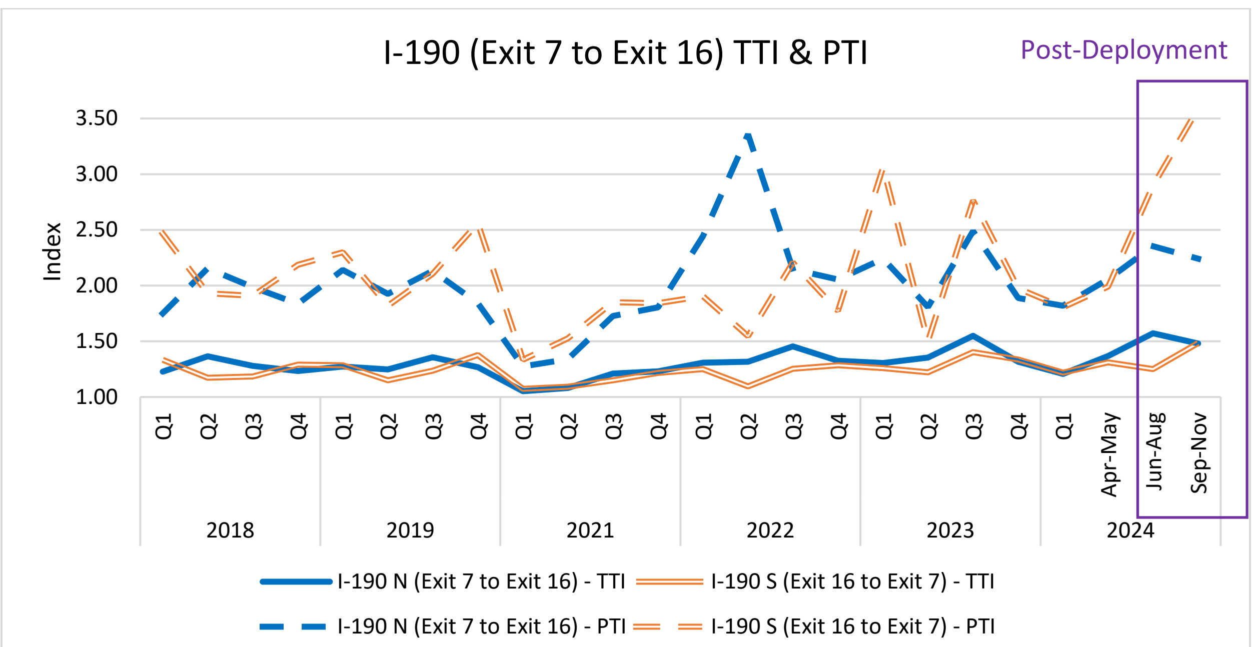


Figure 7: Travel and Planning Time Indices – I-190 (Exit 16 to Exit 22)

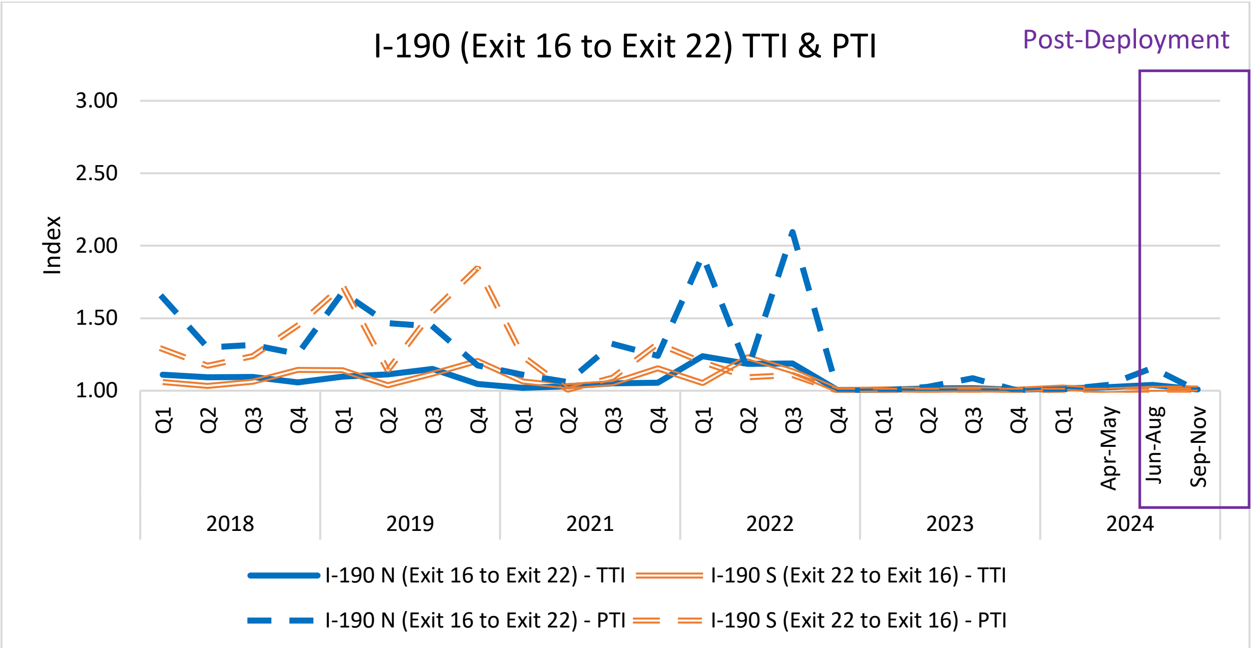


Figure 8: Travel and Planning Time Indices – I-290

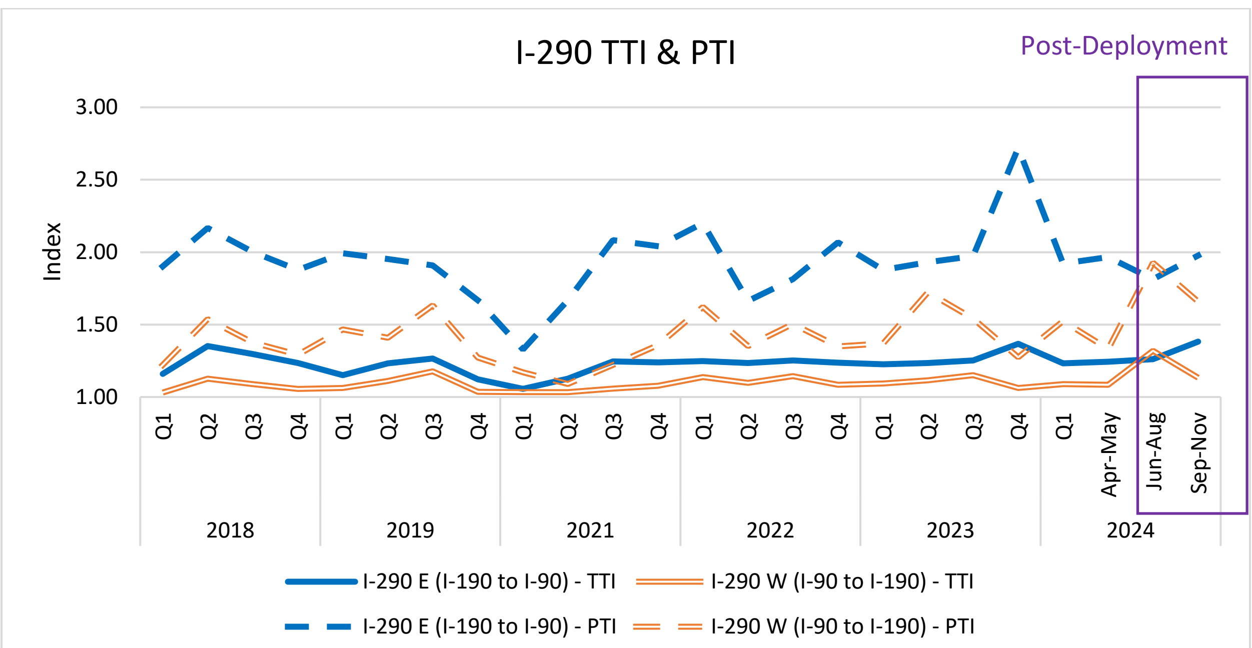
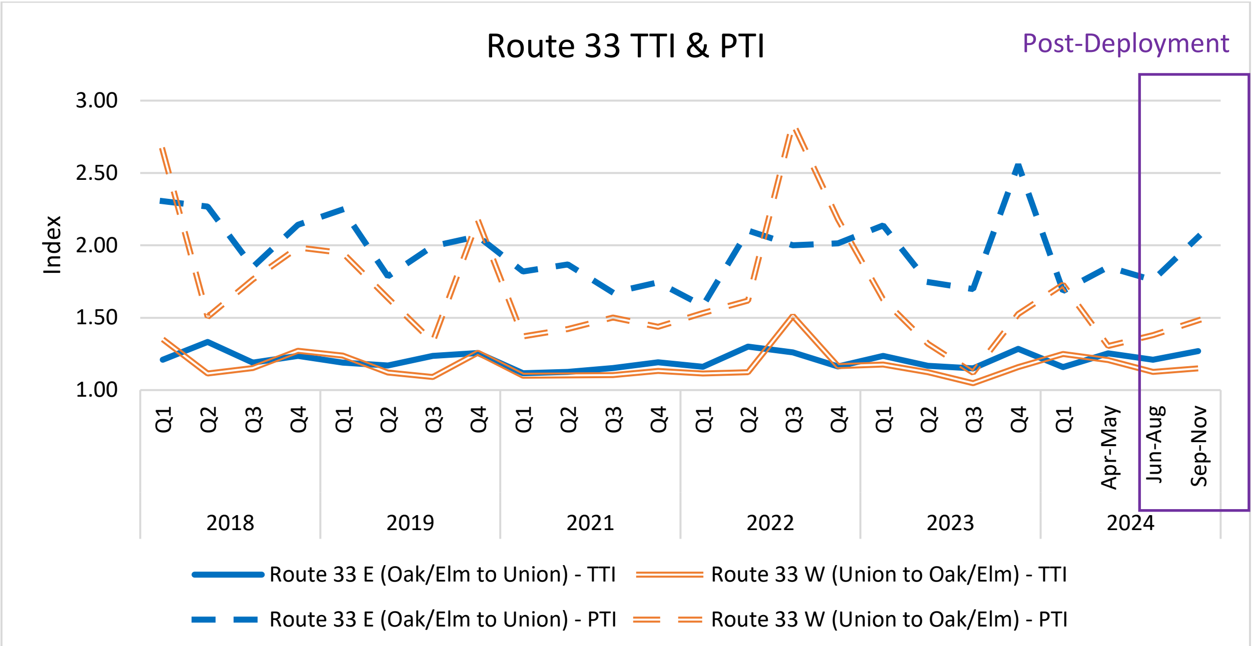


Figure 9: Travel and Planning Time Indices – Route 33



3.3.3 *Post-Deployment Results*

During the evaluation period, the TTI remained similar to the baseline period, with an average change of 0.02. The largest shifts were an increase of 0.24 (on I-190 Northbound from I-190 to Exit 7) and a decrease of 0.06 (on I-190 Southbound from Exit 22 to Exit 16). PTI also remained similar, with an average change of 0.18. The largest shifts were an increase of 1.23 (on I-190 Southbound from Exit 16 to Exit 7) and a decrease of 0.28 (on Route 33 Westbound from Union Road to Oak Street/Elm Street). However, these changes are likely due to normal year-to-year fluctuations in these values. AllRoads includes tools improve travel time reliability by helping to reduce the factors that cause non-recurrent congestion (such as crashes and unplanned incidents), but it will take a significant amount of time before NITTEC's member agencies are using the system to its full capacity at that level.

3.4 Reduced Congestion and Improved Mobility – Simultaneous Border Delay

3.4.1 *Measure*

The percentage of five-minute intervals where simultaneous delay occurred at two or more border crossings between the Peace Bridge, Lewiston-Queenston Bridge, and Rainbow Bridge was calculated for each quarter.

3.4.2 *Baseline Results*

As shown in Figure 10, U.S.-bound simultaneous delays for cars ranged from 0% to 42%, while Canada-bound simultaneous delays for cars ranged from 0% to 30%. Figure 11 shows that for trucks, U.S.-bound simultaneous delays occurred between 1% and 17% of the time and the range for Canada-bound simultaneous delays was 0% to 4%.

Figure 10: Simultaneous Car Delay

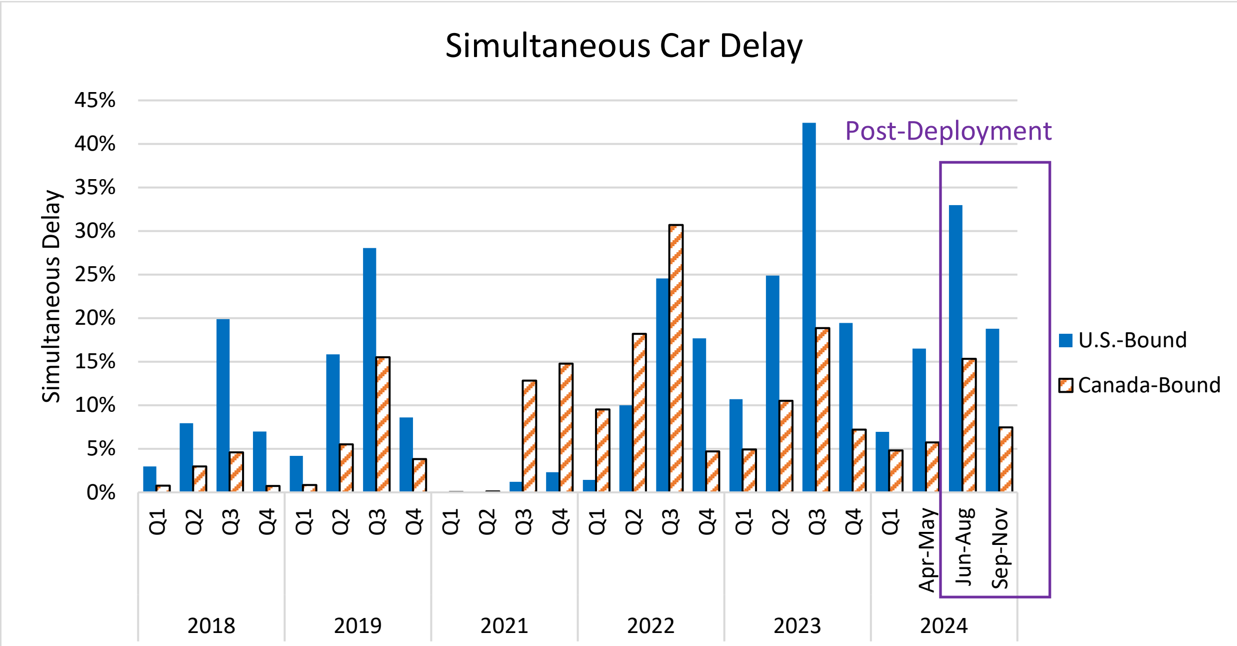
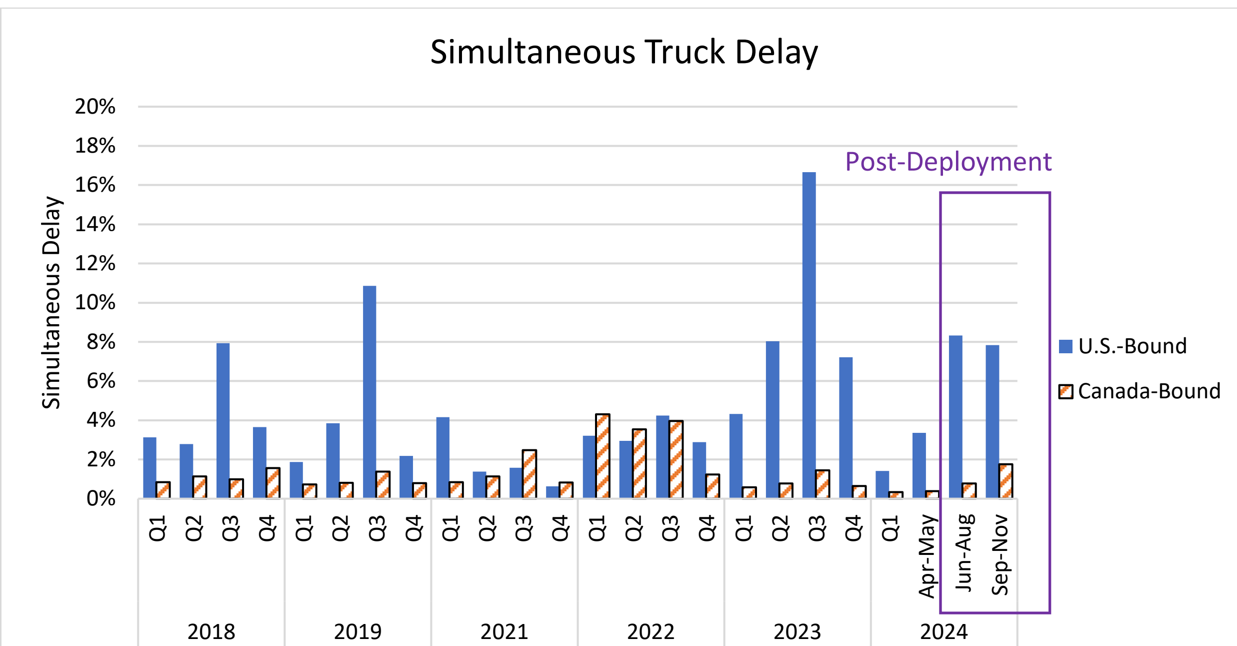


Figure 11: Simultaneous Truck Delay



3.4.3 Post-Deployment Results

Post-deployment simultaneous delay for cars decreased for U.S.-bound traffic by 19% from June-August 2024 and by 30% from September-November 2024 from the corresponding periods in 2023. Post-deployment simultaneous delay for Canada-bound traffic decreased by 15% in both June-August and September-November 2024 compared to the corresponding periods in 2023.

Post-deployment simultaenous delay for trucks decreased in June-August 2024 for U.S.-bound traffic by 46% and Canada-bound traffic by 37%, and in September-November for U.S.-bound traffic by 20% compared to the corresponding periods in 2023. Post-deployment simultaneous delay increased for Canada-bound truck traffic from September-November 2024 by 75% compared to the corresponding period in 2023. This increase likely results from the already very low rate of simultaneous delay for Canada-bound trucks, as the actual numerical increase was still low.

3.5 Reduced Congestion and Improved Mobility – Normalized Border Delay

3.5.1 Measure

Average delays in minutes at each border crossing were calculated quarterly for cars and trucks. Truck data on border wait times was not available for 2018.

3.5.2 Baseline Results

Average delays are summarized for passenger vehicles in Figure 12 (U.S.-bound traffic) and Figure 13 (Canada-bound traffic). Average quarterly delays at border crossings are summarized for trucks in Figure 14 (U.S.-bound) and Figure 15 (Canada-bound).

Figure 12: Passenger Vehicle Delays to U.S. (Average Minutes)

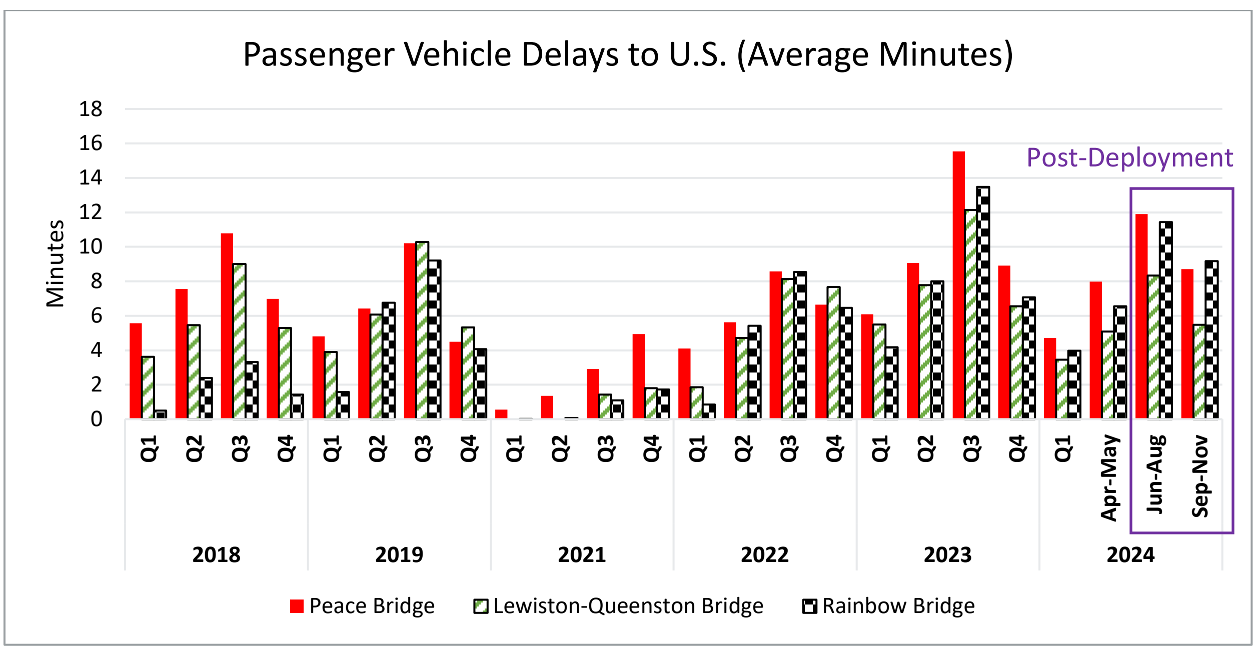


Figure 13: Passenger Vehicle Delays to Canada (Average Minutes)

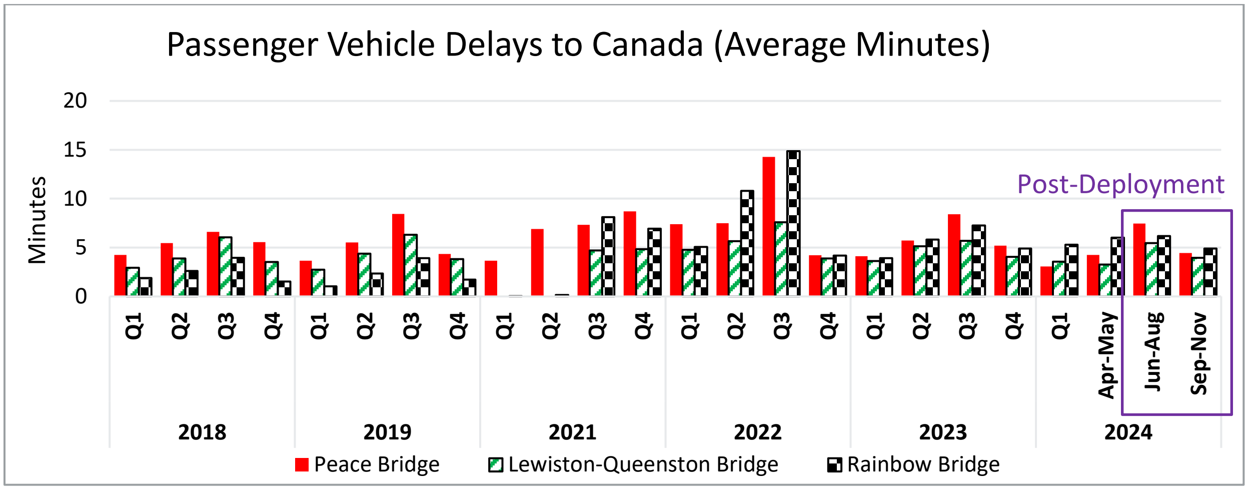


Figure 14: Truck Delays to U.S. (Average Minutes)

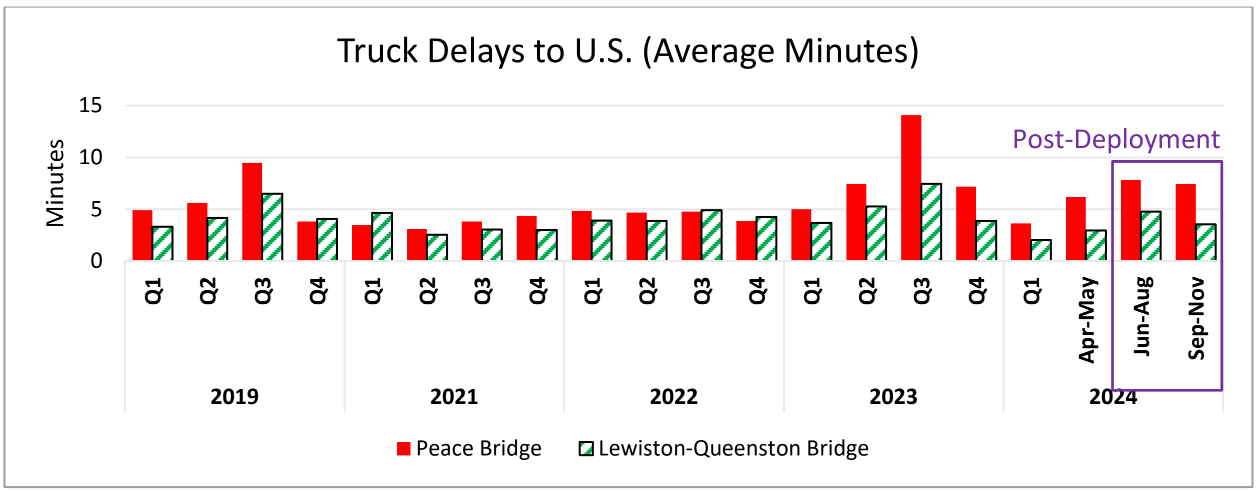
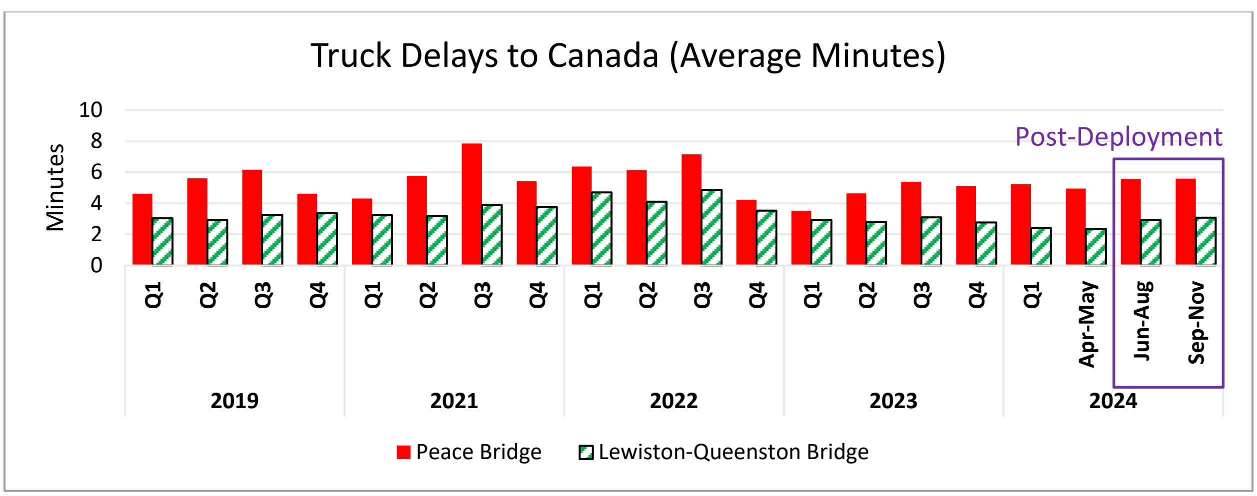


Figure 15: Truck Delays to Canada (Average Minutes)



As shown in Figure 12 for passenger vehicle delays to the U.S., the average length of delay ranged from 1 to 16 minutes at the Peace Bridge, from 0 to 12 minutes at the Lewiston-Queenston Bridge, and from 0 to 13 minutes at the Rainbow Bridge. As shown in Figure 13 for passenger vehicle delays to Canada, the average length of delay ranged from 3 to 14 minutes at the Peace Bridge, from 0 to 8 minutes at the Lewiston Queenston Bridge, and from 0 to 15 minutes at the Rainbow Bridge. For both U.S.- and Canada-bound cars, average delays were highest in 2023 Q3 at 8-16 minutes across the three bridges.

As shown in Figure 14 for truck delays to the U.S., the average length of delay ranged from 3 to 14 minutes at the Peace Bridge and from 2 to 7 minutes at the Lewiston-Queenston Bridge. As shown in Figure 15 for truck delays to Canada, the average length of delay ranged from 4 to 8 minutes at the Peace Bridge and from 3 to 5 minutes at the Lewiston-Queenston Bridge.

3.5.3 Post-Deployment Results

For passenger vehicle delays to the U.S., the post-deployment average length of delay was 8 minutes in June-August and 12 minutes in September-November for the Peace Bridge, 8 minutes in June-August and 5 minutes in September-November for the Lewiston-Queenston Bridge, and 11 minutes in June-August and 9 minutes in September-November for the Rainbow Bridge. These average delays were shorter during the post-deployment period as compared to the corresponding time periods in 2023 for the Peace Bridge and Lewiston-Queenston Bridge. The Rainbow Bridge, which had slightly longer delay in September-November 2024.

For passenger vehicle delays to Canada, average post-deployment delays were 7 minutes in June-August and 4 minutes in September-November for the Peace Bridge, 5 minutes in June-August and 4 minutes in September-November for the Lewiston-Queenston Bridge, and 6 minutes in June-August and 5 minutes in September-November for the Rainbow Bridge. These average delays were shorter in the post-deployment period as compared to the corresponding time periods in 2023 for the Peace Bridge and the Lewiston-Queenston Bridge. The Rainbow Bridge had slightly longer average delay for Canada-bound passenger vehicles in June-August 2024.

For truck delays to the U.S., average post-deployment delays were 8 minutes in June-August and 7 minutes in September-November for the Peace Bridge, and 5 minutes in June-August and 4 minutes in September-November for the Lewiston-Queenston Bridge. These average delays were shorter in the post-deployment period as compared to the corresponding time periods in 2023 for both bridges.

For truck delays to Canada, average post-deployment delays were 6 minutes in both June-August and in September-November for the Peace Bridge and were 3 minutes in both June-August and in September-November for the Lewiston-Queenston Bridge. These average delays were about equivalent to the corresponding time periods in 2023 for both bridges.

3.6 Improved System Performance or Optimized Multimodal System Performance – On-time Transit Performance

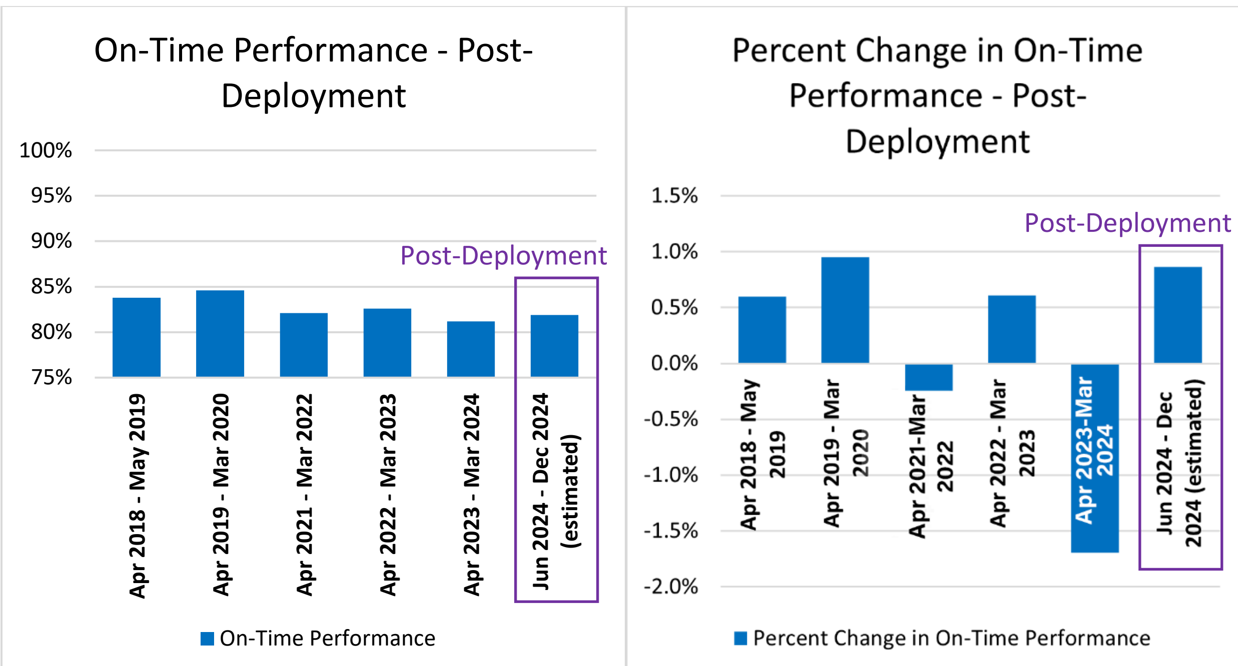
3.6.1 Measure

An average of on-time performance, as a percentage, was determined for the entire network annually. The calculation is performed for each NFTA fiscal year, which begins on April 1 and ends on March 31.

3.6.2 Baseline Results

As shown in Figure 16, the on-time performance during the baseline period ranged from 81.2% to 84.6% and the percent change ranged from -1.7% to 1.0%.

Figure 16: On-Time Performance & Percent Change in On-Time Performance



3.6.3 Post-Deployment Results

The on-time performance during the evaluation period was 81.9%, and improvement of 0.9% from the previous period.

3.7 Effectiveness of Providing Integrated Real-time Transportation Information to the Public to Make Informed Travel Decisions – CVO Event Sharing

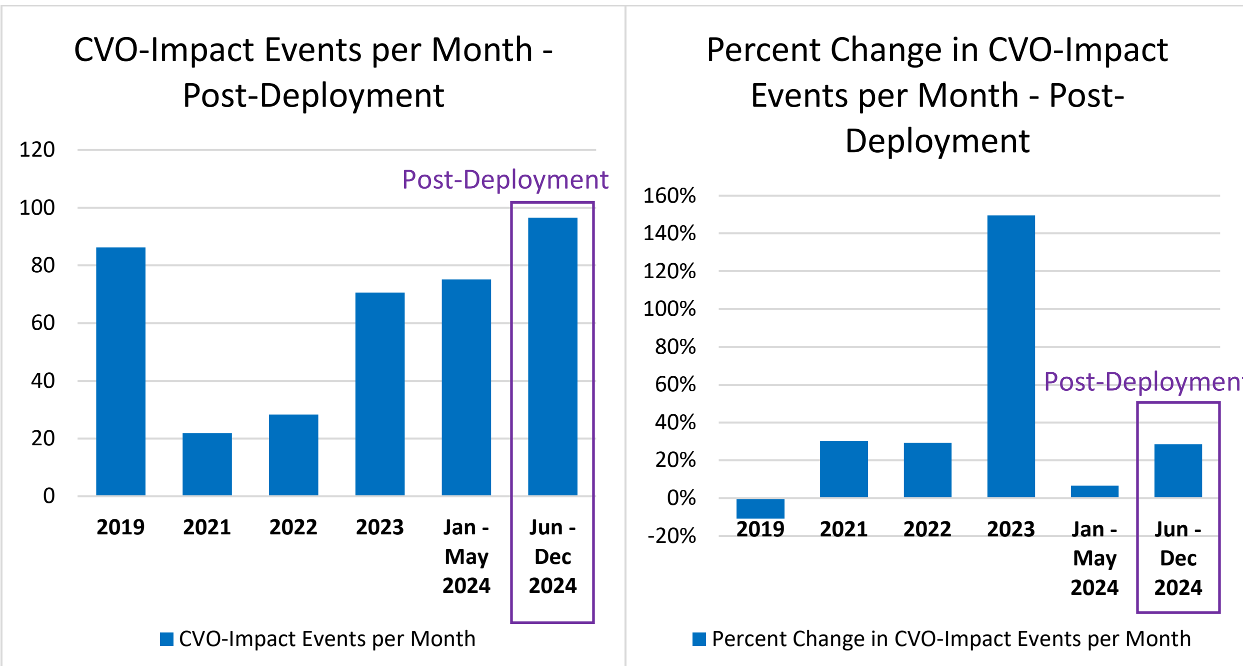
3.7.1 Measure

The average number of events which impact commercial vehicle operations was determined for each month.

3.7.2 Baseline Results

As shown in Figure 17, the number of average monthly events during the baseline period ranges from 21.9 to 86.3 and the percent change in events ranges from -11% to 149%.

Figure 17: CVO-Impact Events per Month and Percent Change in CVO-Impact Events per Month



3.7.3 Post-Deployment Results

The average number of events during the evaluation period was 96.6 events, 28% more than the previous period.

3.8 Improved Inter-agency Coordination – Agencies Populating and Receiving Data

3.8.1 Measure

In 2022, NITTEC underwent a capability maturity assessment with FHWA for data business planning. As a part of this effort, which agencies collect and use different transportation datasets was documented. Following the deployment of AllRoads, this exercise was repeated to identify improvements in data access in sharing.

3.8.2 Baseline Results

As shown in Table 3-1 and **C – Data Collected and Used**

U – Data Used

Figure 18, in 2022 a total of 27 datasets were collected and used in 43 instances across nine agencies. A total of 43 datasets were used across nine agencies.

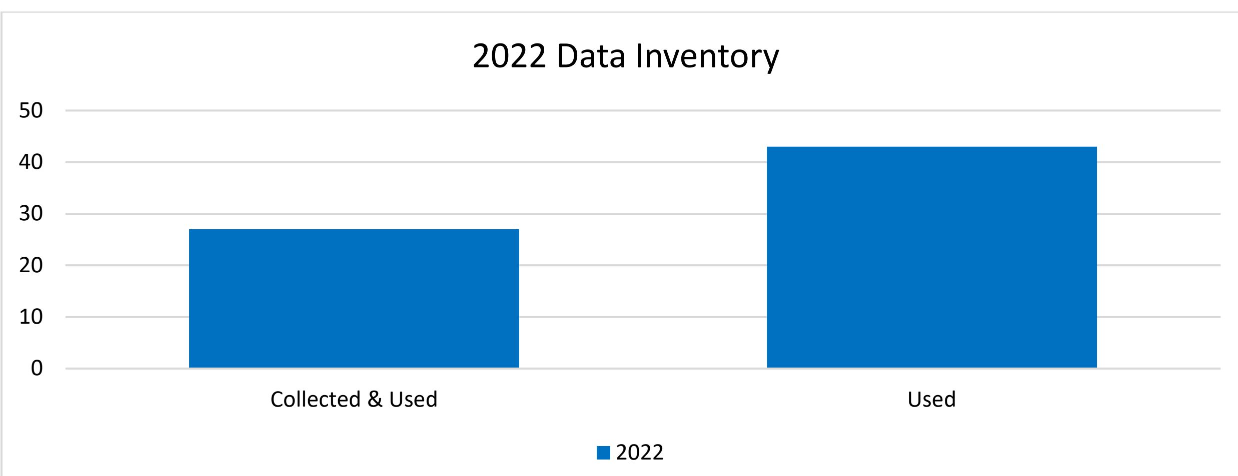
Table 3-1: 2022 Data Inventory

Agency	Volume (Real-Time)	Volume (Historic)	Freeway Speeds	Incident Response	Construction	Weather	Tolls	Pavement	Vehicle Location	Demographic	Border Delays	Origin-Destination
NYSDOT	-	C	C	C	C	C	-	C	-	-	-	-
NYSTA	C	C	C	-	-	C	C	-	-	-	-	-
City of Buffalo	-	U	U	U	-	-	-	C	U	-	-	-
NFTA	-	U	U	U	U	U	-	-	C	U	-	U
UB	-	-	U	U	-	-	-	-	-	-	-	-
MTO	-	-	C	C	C	C	-	C	-	-	-	-
NFBC	-	-	-	C	-	C	-	-	-	-	C	-
NITTEC	-	-	C	C	C	C	-	-	-	-	U	-
GBNRTC	-	-	U	U	-	-	-	-	-	C	-	C

C – Data Collected and Used

U – Data Used

Figure 18: 2022 Data Inventory



3.8.3 Post-Deployment Results

As shown in Table 3-2 and ***Pre-existing data integrated into AllRoads**

****Data expanded and integrated into AllRoads**

*****New data integrated into AllRoads**

Figure 19, the number of datasets collected by the end of 2024 was 39, an increase of 44%. By the end of 2024, a total of 84 users across 17 agencies had been trained in the AllRoads system. The number of instances of datasets being used by the end of 2024 was 55 across the former – and several additional – agencies, an increase of 28%. In Table 3-2, weather data was expanded to include simulated road weather conditions, vehicle location was incorporated real-time location and status of agency vehicles, and border crossing data was enhanced by the deployment of additional equipment.

Table 3-2: 2024 Data Inventory

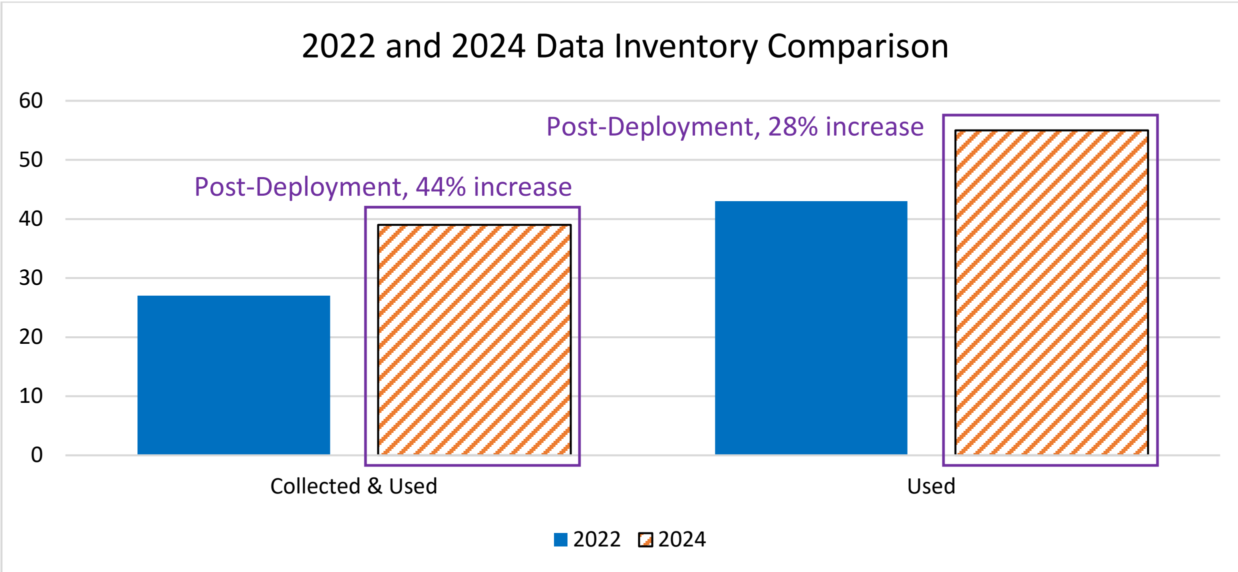
Agency	Volume (Real-Time)	Volume (Historic)	Freeway Speeds*	Incident Response*	Construction*	Weather**	Tolls	Pavement Condition	Vehicle Location**	Demographic	Border Delays**	Origin-Destination	Arterial Speeds***	Intersection Counts***	Traffic Signal PMs***	Parking***
NYSDOT	-	C	C	C	C	C	-	C	C	-	-	-	-	C	C	-
NYSTA	C	C	C	-	-	C	C	-	C	-	-	-	-	-	-	C
City of Buffalo	-	U	U	U	-	-	-	C	U	-	-	-	U	C	C	-
NFTA	-	U	U	U	U	U	-	-	C	U	-	U	-	-	-	C
UB	-	-	U	U	-	-	-	-	-	-	-	-	-	-	-	-
MTO	-	-	C	C	C	C	-	C	-	-	-	-	-	-	-	-
NFBC	-	-	-	C	-	C	-	-	-	-	C	-	-	-	-	-
NITTEC	-	-	C	C	C	C	-	-	U	-	U	-	C	U	U	U
GBNRTC	-	-	U	U	-	-	-	-	-	C	-	C	-	U	U	-
Erie County	-	-	-	U	-	U	-	-	C	-	-	-	-	-	-	-
PBA	-	-	-	U	-	U	-	-	-	-	C	-	-	-	-	-
CBSA / USCBP / DHS	-	-	-	-	-	U	-	-	-	-	U	-	-	-	-	-
Police (Local, State / Provincial, Sheriff)	-	-	-	C	-	U	-	-	-	-	-	-	-	-	-	-
Local Fire	-	-	-	U	-	U	-	-	-	-	-	-	-	-	-	-

***Pre-existing data integrated into AllRoads**

****Data expanded and integrated into AllRoads**

*****New data integrated into AllRoads**

Figure 19: 2022 and 2024 Data Inventory Comparison



3.9 Improved Inter-agency Coordination – Lessons Learned

A qualitative discussion of key takeaways, lessons learned, and recommendations for future deployers is included in Section 4.

4 Lessons Learned, Recommendations, and Conclusions

4.1 Key Takeaways

- This project produced a variety of quantitative and qualitative benefits to the region, stemming from increased availability and sharing of transportation data. Ensuring that all agencies have access to consistent and reliable information in real-time allows for better situational awareness and coordination. This allows NITTEC and its members to respond efficiently and effectively to ongoing events, as well as plan for future scenarios.
- AllRoads, the principal deployment of this project, provides NITTEC and its member agencies with a powerful tool for situational awareness, inter-agency coordination, and decision support, all in a cloud-based, centralized location.
- The ongoing collection of data, and transformation of that data into real-time and historical performance measures, allows NITTEC to continuously monitor how the transportation network is performing. It will also indicate how implementation of this system is impacting those metrics over time into the future.
- Specific project outcomes which have already proven successful include:
    - Implementation of emergency signal timing along an arterial corridor
    - Access to enhanced weather information
    - Cross-agency management of planned construction events
    - Use of newly accessible arterial speed, intersection count, and traffic signal timing information
- The success of this project can be in part attributed to a robust set of systems requirements produced, which could then be met by following the systems engineering and agile development processes.
- The roadblocks in this project occurred early on, largely caused by the team's initial underestimation of the project management tasks required to take on a task of this size.
- These challenges were ultimately addressed and overcome by breaking the project into two phases – a planning phase and an implementation phase – and using a portion of the grant funds to pay for consultant services to assist in project management tasks.
- A number of the performance measures evaluated in Section 3 did not show significant difference between the pre- and post-deployment periods. This may be a result the time needed by NITTEC's members to adopt the tools in the system which allow improvements to be made in these areas. Some metrics did show significant improvement, including: simultaneous border crossing delay, CVO events shared, and data being collected and used by NITTEC's member agencies.
- It is difficult to perform a strict cost-benefit analysis on this project as many of the outcomes are not associated with a concrete dollar amount. However, it should be noted that the number of data feeds and systems integrations which were conducted as part of the development of AllRoads could have each been a project in their own right. By combining these into a single deployment, significant cost-savings have been achieved when

compared to integrating each of these components individually. Furthermore, AllRoads will continue to serve this role moving forward, preventing the need for costly individual deployments for new data sources or systems in the future.

4.2 Project Lessons Learned

Over the course of the project, the team learned that more in-depth up front planning than originally thought was required regarding future deployment strategies. The process of bringing on consultants, identifying the user needs and systems requirements, and producing the project planning documentation ultimately took about 6 years before actual development of the system could begin.

There is also a need to consider ongoing maintenance costs before entering into deployment, especially software and procurement of external data sources. While grants like ATCMTD are a one time sum, the systems being funded often follow a subscription or annual support model, so continuing to pay for them in the future requires significant foresight. In this case, while NITTEC and its agencies expect to continue to benefit greatly from the system, the annual cost represents a significant percentage of NITTEC's annual budget.

Finally, the deployment demonstrated to the project team, and NITTEC stakeholders, the importance of developing well thought out system requirements and implementing systems engineering management strategies. There were many times during development when the developer and the stakeholders had different notions of what a system requirement meant or what need was being fulfilled which ultimately led to significant back and forth. However, the agile development process allows for instances like these to occur, and ultimately be resolved, without having significant negative impacts on the project timeline.

4.3 Recommendations for Future Deployers

- Need for project managers to carefully consider the amount of up front planning needed before entering into deployment. If an agency is not equipped to handle these tasks internally, additional consulting services should be utilized.
- Need to identify ongoing maintenance costs should be considered before entering into deployment. Identify these upfront and prepare budgets accordingly.
- Need to develop clear and actionable system requirements which address user needs. Agile development allows for flexibility as the project development is underway.