Integrated Corridor Management Concept Exploration:

Suffolk County Department of Public Works and New York State Department of Transportation, Region 10

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Final Report

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Abstract

The focus of this project was to explore the possibility of ICM in Suffolk County, NY. ICM is considered one of the key strategies of Transportation Systems Management and Operation (TSMO), which involves multimodal and multijurisdictional efforts in managing congestion caused by incidents along major commute corridors. As part of this research effort, a data driven approach was adopted using available data sources to analyze, quantify, and identify incidents and their traffic impacts. The study area encompassed eight major roadways throughout the county. The trip pattern information from the New York Metropolitan Transportation Council Best Practice Model was supplemented by StreetLight Traffic Data to ensure the use of up-to-date traffic data in order to have an accurate understanding of traffic patterns. In addition, the extensive data available in TRANSCOM Data Fusion Engine (DFE) was used to identify incident scenarios and their travel time impacts, to be analyzed in the simulation model to assess benefits of ICM response plans. To evaluate the potential impacts of ICM response plans, different microsimulation scenarios (in TransModeler) were developed. They evaluated the benefits of ICM response plans that have been triggered to handle incidents along I-495 (Long Island Expressway). The scenarios analyzed incidents at different locations (Eastbound versus Westbound) as well as different time durations. The analysis results indicated potential travel time savings of 30-40% on average.

Keywords

Integrated Corridor Management (ICM), Transportation Systems Management and Operation (TSMO), microsimulation

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Acronyms and Abbreviations

AMS	Analysis Modeling and Simulation
ATDM	Active Transportation Demand Management
ATM	Active Traffic Management
ATSC	Adaptive Traffic Signal Control
AVL	Automatic Vehicle Logging
DSS	Decision Support System
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GPS	Global Positioning Systems
HOV	High Occupancy Vehicle
ICM	Integrated Corridor Management
IMA	Inter-Municipal Agreements
INFORM	Information for Motorists
LHTL	Lower Hudson Transit Link
NITTEC	Niagara International Transportation Technology Coalition
NPMRDS	National Performance Management Research Data Set
NYBPM	New York Best Practices Model
NYCDOT	New York City Department of Transportation
NYMTC	New York Metropolitan Transportation Council
NYSDOT	New York State Department of Transportation
NYSERDA	New York State Energy and Research Development Authority
ODME	Origin Destination Matrix Estimation
RITA	Research and Innovative Technology Administration
RITIS	Regional Integrated Transportation Information System
SANDAG	San Diego Association of Governments
SCDPW	Suffolk County Department of Public Works
TMC	Traffic Management Center
TRANSCOM	Transportation Operations Coordination Committee
TSMO	Transportation Systems Management and Operations
TMS	Traffic Management System
USDOT	United States Department of Transportation
VMS	Variable Message Signs

Summary

This research project is sponsored by New York State Energy Research and Development Authority (NYSERDA). The authority has been actively encouraging research in areas to reduce emissions and energy consumption. Transportation is one of the largest contributors to emissions; efficient management of traffic/transportation will help reduce emissions. NYSERDA supports research in such areas by jointly funding projects with the New York State Department of Transportation (NYSDOT). This project is supported by a grant focused on the use of tools such as Integrated Corridor Management (ICM).

The research effort was conducted to explore the possibility of applying ICM in Suffolk County, NY. ICM is considered one of the key strategies of Transportation Systems Management and Operation (TSMO) which involves multimodal and multijurisdictional efforts in managing congestion caused by incidents along major commute corridors. NYSDOT R10/INformation FOR Motorists (INFORM) and Suffolk County Department of Public Works (SCDPW) are the two main stakeholders for managing traffic in Suffolk County. They have established excellent working relationships, and staff in their operations and planning group are well known to each other. They routinely coordinate actions during planned events such as 4th of July fireworks, U.S. Open Golf Tournaments, and unplanned events such as inclement weather and incidents. Thus, an excellent foundation exists on which to build additional coordinated traffic management strategies, such as ICM.

The two stakeholders are very different in the size and footprints of their ITS deployments. NYSDOT R10's INFORM system is one of the most mature ITS systems in the country. It includes large scale deployments of travel time sensors, point flow measurements, variable message signs, and centralized traffic management from the INFORM TMC. New York State owns and provides routine maintenance of their ITS equipment. In comparison, SCDPW has a smaller footprint, and under their unique Intermunicipal Agreements (IMA), the municipalities own and maintain the signals while SCDPW retains all operational control. However, both agencies have a centralized traffic control system and similar traffic signal controllers and software. This provides the opportunity to have coordinated action in applying response-plans developed expressly to support traffic management.

The effect of COVID-19 on public agencies that rely on federal/state/local funding to build, operate, and maintain their ITS infrastructure has been severe. New York State (NYS) and Suffolk County have diverted resources towards managing the pandemic. This has impacted their capital programs and deferred future investments, accentuating the need for coordination and the efficient use of existing ITS resources in the management of traffic. Additionally, there has been a shift away from public transit and into private auto use, which, if sustained, has the potential to increase the importance of traffic management in the Long Island region.

There are existing tools available in the region—INFORM, Transportation Operations Coordination Committee (TRANSCOM), Waze—that can be used to develop new strategies on top of the existing ITS infrastructure of both NYSDOT R10 and SCDPW, to manage traffic in a coordinated effort.

For this research effort, a data driven approach was adopted using the available data sources to analyze, quantify, and identify types of incidents and their traffic impacts. The study area encompasses eight major roadways—three County Roads (CR 93, CR 97, and CR 83) and five State Routes (SR 454, SR 347, SR 25, SR 27) and the Long Island Expressway (I-495). Using the New York Best Practice Model (NYBPM) as a starting point, a detailed microsimulation model of this area was developed and supplemented with Origin-Destination patterns from Streetlight Traffic Data. The extensive data available in TRANSCOM was used to identify incident scenarios, to be analyzed in the simulation model, to assess the benefits of coordinated actions (ICM response plans). Typical incidents were created in the model and cases were run with and without response plans. The plans included using Variable Message Signs (VMS) to notify the road users, use of apps such as Google Maps, Apple Maps and Waze to inform the driving/decision-making, and modified traffic signal timing plans (and/or use of enforcement) to handle the detoured traffic. The analysis results indicated an average travel time savings of 30–40% in and around the Long Island Expressway and Service Roads.

One of the recurring themes in the coming years in the development and application of traffic models will be the use of the newer types of data such as vehicle probe data from Automatic Vehicle Logging (AVL) and Global Positioning Systems (GPS), travel time, vehicle trajectories, detailed information from the Connected Vehicle systems etc., as part of model development. The possibility of developing "living, breathing models" that can be updated using real-time information and be embedded in traffic management centers (operations) is very real, and a far cry from the traditional view of models viewed as part of planning applications based on historical data. Traffic analysis tools (i.e., multiresolution traffic simulation models) are utilized in real-time ATM/ATDM applications, such as Integrated Corridor Management (ICM), Active Traffic Management (ATM), Active Transportation Demand Management (ATDM), and Adaptive Traffic Signal Control (ATSC). This will enable a faster response to evolving traffic conditions in the field.

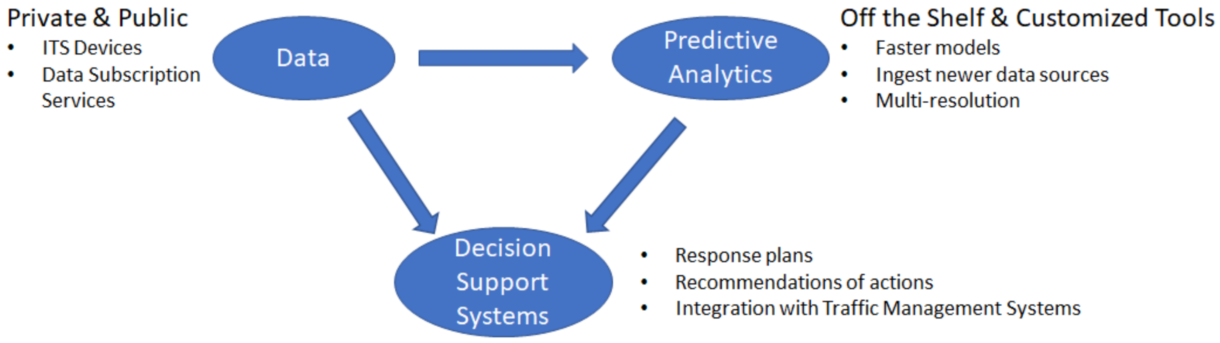
These data-intensive approaches are becoming more practical as the private sector has started offering paid/free subscriptions to these newer data sources, for example, INRIX, Streetlight, HERE, Wejo, Waze, RITIS, NPMRDS, etc. Agencies are considering expanding their data sharing agreements and exploring these data subscription services.

Initiatives that are currently in progress within the region include: NYS is in discussions with Waze to integrate their data feeds with Transcom; SCDPW is in discussions with Waze to become a partner in their Waze for Cities program; and NYS is a partner in the RITIS program. The Transcom data feed includes the HERE travel time information. As the availability of funds to maintain a large ITS footprint becomes constrained, agencies are considering developing hybrid approaches—using their ITS devices in conjunction with private data service providers to have a robust data set to support their operations and planning efforts.

Having quantified the potential benefits of coordinated action (response plans) the logical next step in this exploration is to leverage such data sources to build tools that will be available in the TMC, for the operations staff to run evaluations in real-time (or near real-time) as part of Integrated Decision Support Systems.

Looking ahead there are three themes that need to be considered to further the ICM exploration for this region. They are (a) Data, (b) Predictive Analytics, and (c) Integrated Decision Support in Traffic Management Systems. These three themes and their relationships are presented graphically in Figure ES-1.

Figure S-1 Recommended Next Steps



The region is well underway with the data-related items and has been laying the foundations for incident response plans. Building on these advancements, along with the solid working relationship of NYSDOT and Suffolk County, the next step would be to develop a framework for a Decision Support System, integrate it into the Traffic Control System, and provide access in the TMC.

1 Introduction

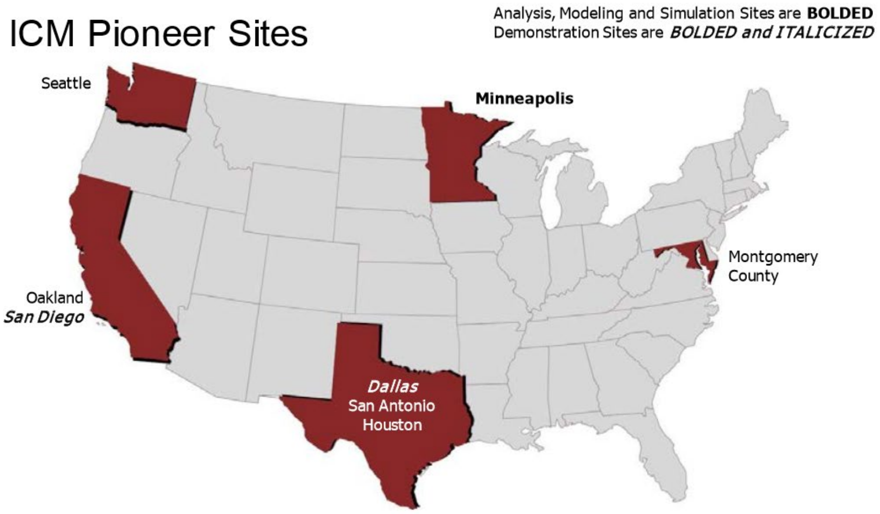
This research project is sponsored by New York State Energy Research and Development Authority (NYSERDA). The authority has been actively encouraging research into technology that can lead to a reduction in energy consumption and/or emissions. Transportation is one of the largest contributors to emissions and efficient transportation systems management will help reduce emissions. NYSERDA supports research in such areas by jointly funding projects with the New York State Department of Transportation (NYSDOT). This project is supported by a grant focused on the use of tools such as Integrated Corridor Management (ICM).

The USDOT Publication (FHWA-JPO-12-075) defines Integrated Corridor Management (ICM) as the concept and practice of managing a corridor in an integrated fashion, and the Integrated Corridor Management System (ICMS) as the underlying infrastructure that enables agencies to perform that management process in an efficient manner. Further it states another way to view an ICMS is as a group of independent systems joined (integrated) by a Decision Support System (DSS). The ICMS would use the DSS component to analyze corridor data and provide recommended congestion mitigation strategies to corridor managers and operators.

USDOT has been funding research into this area going back to 2008 when early work led to the identification of the eight pioneer sites. Subsequently in 2010, five sites were short listed for evaluation using AMS. Two of the three sites (Dallas and San Diego) were selected for demonstration in 2013–2014. Figure 1 presents these locations.

Figure 1. ICM Pioneer Sites

Source: FHWA- JPO-12-074 ICM AMS Guide



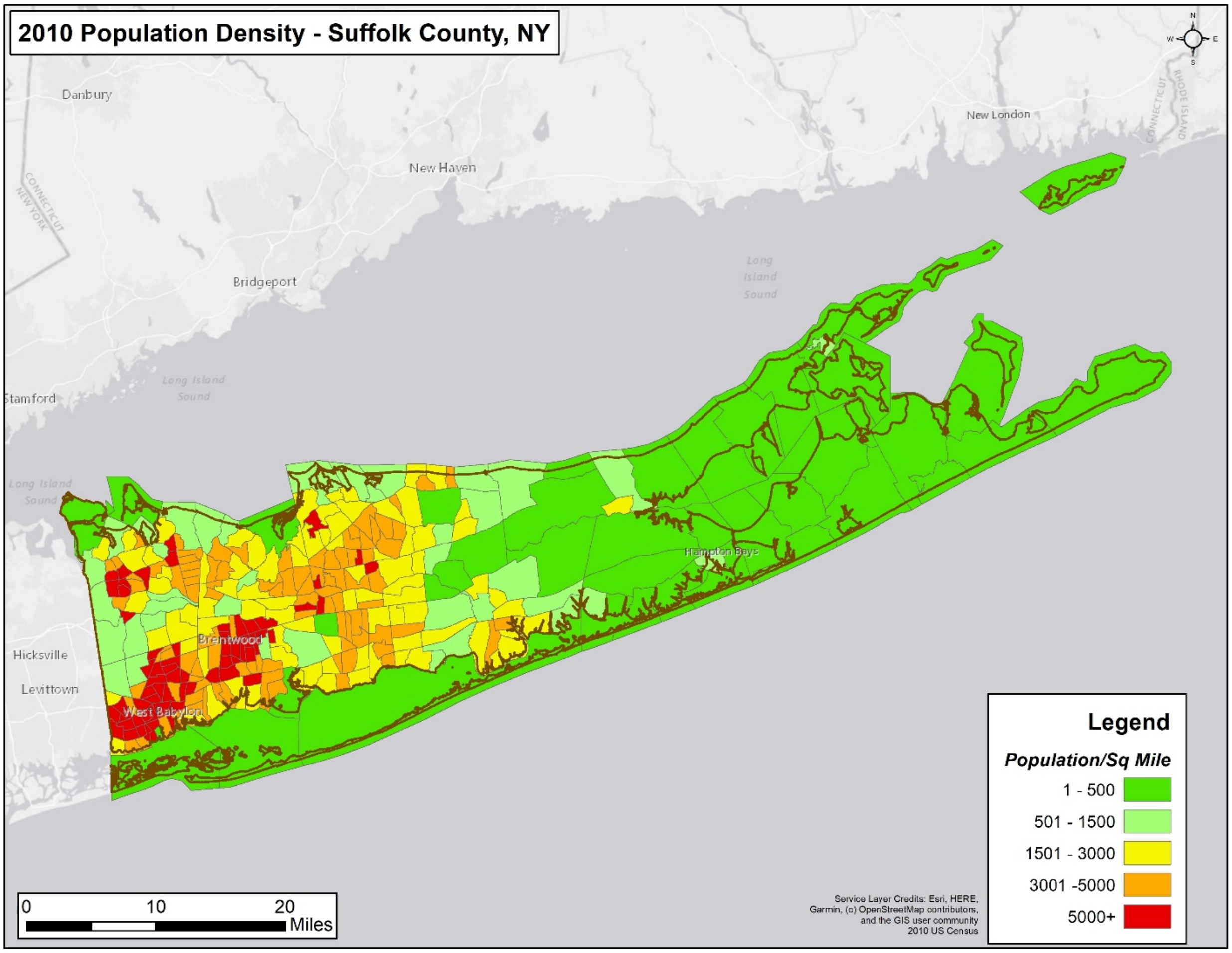
Following the two demonstrations, USDOT published the ICM implementation guide, and the lessons learnt. In the last few years USDOT supported the development and implementation of ICM at the San Diego site (SANDAG). This live demonstration has resulted in USDOT funding additional sites throughout the country to support exploration and implementation of ICM. The NY Metro Area was a recipient of one such grant, which is funding a project titled: ICM 495 Concept of Operations Study that is being led by NYCDOT/NYSDOT jointly. In addition to these locations, in Upstate New York the Niagara International Transportation Technology Coalition (NITTEC) is exploring the application of ICM to that region. Also, NYSDOT is currently in the process of developing and implementing the Lower Hudson Transit Link (LHTL) Integrator Corridor Management System (ICMS). This research effort is an exploration of ICMS in NYS Region 10, especially for a suburban traffic network that is typical on Long Island.

1.1 New York State Region 10

Long Island NYS Region 10, is home to the INFORM system. This is one of the first corridor-level ITS systems that were deployed in the country. This system provides a very good ITS framework and foundation on which to build an ICMS.

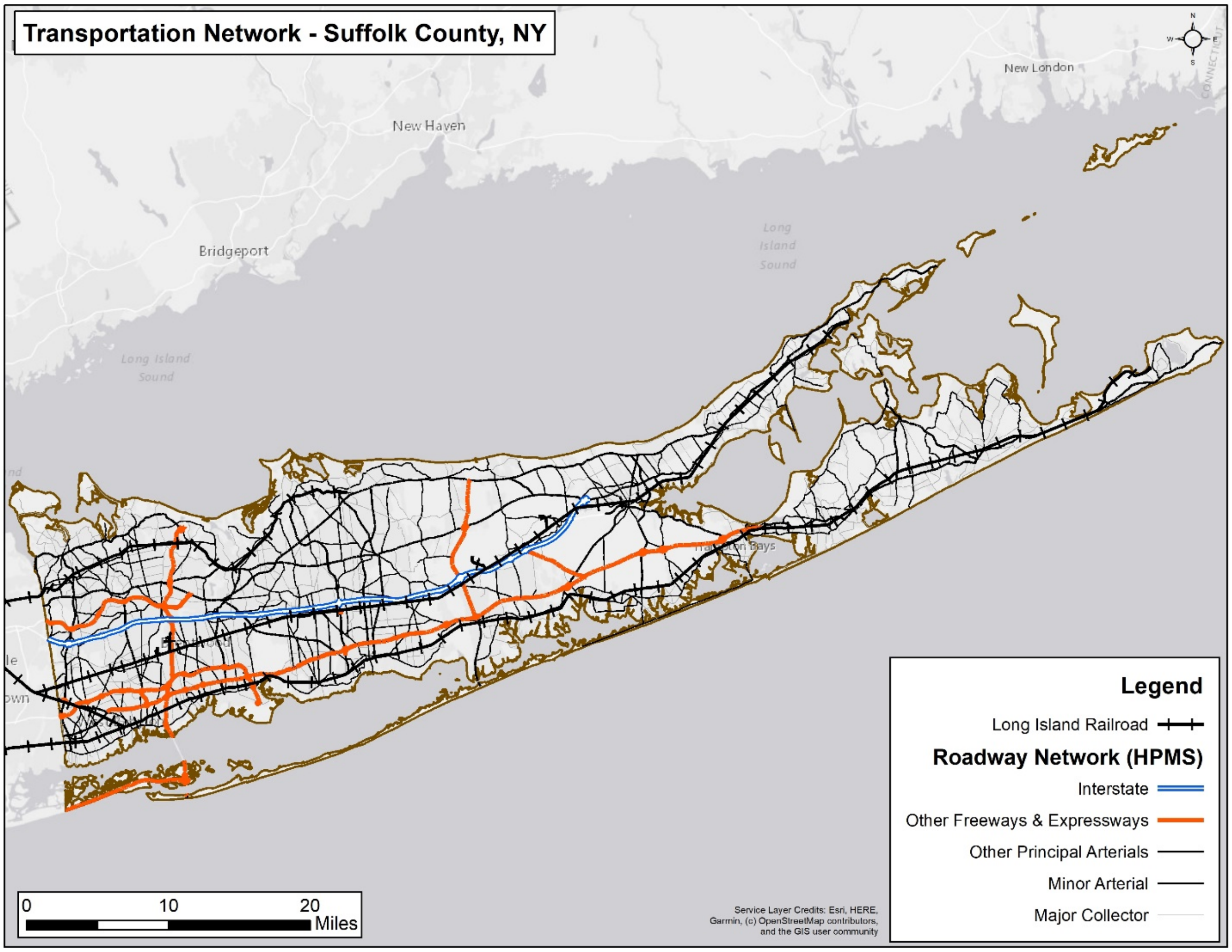
Long Island is located just east of New York City (NYC) and is composed of Nassau and Suffolk Counties. These counties are both considered within the NYC Metropolitan area. Suffolk County is predominantly suburban and hosts approximately 1.48 million residents throughout its 2,373 square miles.[1] Of the total area, only 912 sq miles (38%) is land, resulting in approximately 1,623 people per square mile. The western portion of the county is more densely populated than the East. As presented in Figure 2, the highest population density is in the southwestern portion of the county.

Figure 2. Population Density, 2010—Suffolk County, NY



The overall shape of the county is unique, more than three times the distance east to west as it is north to south. Due to this shape and the peninsular geography, the transportation network is constrained in its geographic extent, with most major roadways running longitudinally. In this region of Long Island, Public Transportation is sparse. There are three major LIRR Lines which run East/West and no rail lines which run North/South. Figure 3 presents an overview of the Transportation Network for Suffolk County showing the Long Island Railroad and roadway network according to the Federal Highway Performance Monitoring System dataset (HPMS).

Figure 3. Suffolk County, NY Transportation Network



Suffolk County has roadways of five functional classifications; Table 1 presents the total lane miles for each functional classification.

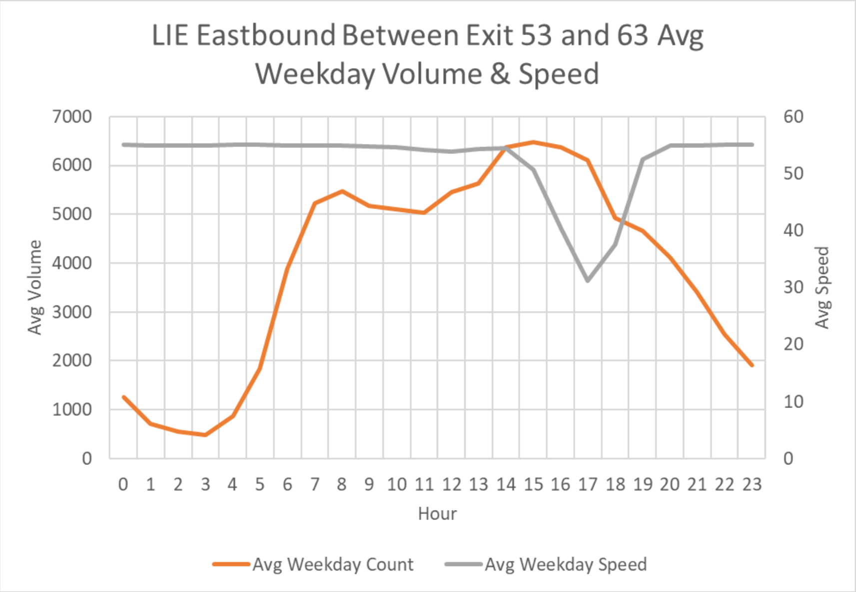
Table 1. Summary of Lane Miles in Suffolk County

Roadway Network	Functional Class	Roadway Type	Lane Miles
FHWA Highway Performance Monitoring System (HPMS)	1	Interstate	333
	2	Other Freeways & Expressway	665
	3	Other Principal Arterial	1,076
	4	Minor Arterial	1,808
	5	Major Collector	1,307

According to the 2019 American Community Survey, 87% of workers in Suffolk County commute to work using a car, truck, or van. Furthermore, 68% of households have access to two or more vehicles where only 6% of household have no access to vehicles. This dependency on private vehicles for transportation, coupled with a constrained roadway network, leads to periods of heavy congestion. The major roadways in Suffolk County, often experience flow compression, which results in reduced speeds. An example of this situation is presented in Figure 4 and Figure 5 for a section of the LIE.

Figure 4. Volume and Speed Data for LIE WB

Figure 5. Volume and Speed Data for LIE EB



1.2 Project Approach and Report Organization

The main elements of an ICMS are real-time data, libraries of response plans, Decision Support Systems (DSS), and Traffic Management Systems (TMS) to implement the recommended actions. Over the last few years there has been an explosion in traffic data made available via private data providers who are leveraging the GPS and location-based data from mobile devices. There has also been an advancement in the application of predictive analytics, in the field of traffic engineering. This has led to the use of traffic simulation tools that were traditionally used in the off-line mode but are now used as embedded components of a DSS and integrated with a TMS, to facilitate response in real-time. These emerging trends have occurred at a rapid pace in the last few years and have enhanced the ICM Systems. These are now part of the Transportation Systems Management and Operations (TSM&O) toolbox.

As a first task, a comprehensive literature review was completed to understand these trends and identify approaches that could be applied in NYS Region 10. This was followed by a task to identify the available data sets and traffic management strategies of Suffolk County and NYSDOT (the two main agencies that manage traffic in the region). Using these data sets and a combination of their strategies, an Analysis, Modeling and Simulation (AMS) task was undertaken to evaluate the potential benefits from ICM strategies. Following the AMS task, a framework for the DSS was identified using the findings from the previous tasks, setting the stage for the next steps in the research effort.

The report has five sections: (a) literature review; (b) an overview of the study area; (c) AMS activities; (d) DSS framework; and (e) summary and next steps.

2 Literature Review

Modern city dwellers are mostly overwhelmed with traffic congestion that degrades environmental quality and raises travelers' frustration through excessive travel delay. Usually, a city suffers from both recurring and non-recurring congestion. "Recurring congestion" refers to a known congestion pattern that is caused by routine traffic volumes operating in typical environment, whereas, "non-recurring" congestion refers to an unexpected or unusual congestion caused by an event that was unexpected and transient relative to other similar days (Neudorff et al., 2006). Due to the limited expandability of the existing traffic network in urban areas, there is a constant need for efficient traffic management to meet the growing travel demand. Such need has initiated several advanced and efficient traffic management schemas including Integrated Corridor Management (ICM).

ICM is a traffic management tool that manages traffic networks affected by scheduled events, traffic incidents, and weather conditions etc. It helps transportation managers to manage known and unknown fluctuations in travel demand of a corridor under different agencies' jurisdiction. A transportation corridor refers to "a combination of discrete, adjacent surface transportation networks (e.g., freeway, arterial, rail networks) that link the same major origins and destinations" (Reiss et al., 2006). In addition, the corridor is defined operationally rather than geographically or organizationally. According to Reiss et al. (2006), ICM is defined as "the coordination of individual network operations between adjacent facilities that creates an interconnected system capable of cross-network travel management." In other words, ICM is a multiagency collaborative approach to optimize use of available infrastructure by directing travelers to underutilized capacity in a transportation corridor (Cronin et al., 2010). To direct the travelers, various strategies are adopted such as influencing motorists to shift departure times, routes, or modal choices, or adjusting roadway capacity dynamically. ICM strategies, applied in a congested or busy corridor, provide a benefit by alleviating recurrent or non-recurrent congestion.

The Research and Innovative Technology Administration (RITA), Federal Highway Administration (FHWA), and Federal Transit Administration (FTA)—partnering with eight of the Nation's busiest corridors located in Oakland and San Diego, CA; Dallas, Houston, and San Antonio, TX; Montgomery County, MD; Seattle, WA; and Minneapolis, MN—completed the ICM Initiative's initial phase in 2007 and developed concepts of operations (ConOps) and system requirements. Experiences on ICM concept, concept of operations, and system requirements specifications development from San Antonio (TX), San Diego (CA) and I-75 corridor (GLITS I-75) are summarized in (Johnson and Fariello, 2008), (Estrella et al., 2008) and (Yang and Wei, 2008) respectively. Moreover, analysis, modeling, and simulation of corridors related to federal ICM initiatives are documented in (Alexiadis et al., 2008, Cronin et al., 2010) as well as the knowledgebase[2] in the USDOT ITS joint program office website.

A ConOps includes discussions on the existing network boundaries, operational and institutional conditions, needs and potentials for ICM, ICM vision, goals and objectives, operational approaches and strategies, alignment with regional intelligent transportation system architecture, implementation issues, performance measures and targets, and different operational scenarios etc. (Neudorff et al., 2006). According to Neudorff et al. (2006), the primary goals and objectives of a generic corridor's ICM initiative include establishing corridor perspective, ensuring corridor mobility and reliability, delivering timely, accurate and reliable traveler information, and managing corridor events and incidents. In addition, authors discuss the ICM operational approaches and strategies to achieve the generic goals and objectives. These strategies include sharing information, improving the operational efficiency of network junctions, accommodating cross-network routes, and promoting modal shifts, managing capacity in the short term (real time) and long term. As such, the San Francisco ICM initiative (on I-80) comprised full scale active traffic management strategies such as freeway management system, corridor-wide adaptive ramp metering including High Occupancy Vehicle (HOV) bypass lanes for transit access, speed harmonization through advisory variable speed signs, an arterial management system, a transit management system, a traveler information system, commercial vehicle operations, traffic surveillance and control system, and an incident management system (Minoofar et al., 2008).

Besides the USDOT initiatives, extensive research efforts have been conducted in various ICM related areas:

- ICM supportive strategies (Zhang et al., 2012, Liu et al., 2013a, Liu et al., 2013b, Hong et al., 2017).
- Methodology (Alm et al., 2007).
- Tools (Wirtz et al., 2005, Sisiopiku et al., 2007, Zhou and Mahmassani, 2007, Zhou et al 2008.
- Regional ICM planning framework (Veneziano, 2014).

(Alm et al., 2007) present an ICM planning methodology that evaluates short- and long-term improvement strategies to mitigate corridor-wide mobility problem. Examples of different tools and methods that have been developed to support ICM initiatives include Dynamic Traffic Assignment (DTA) models (Wirtz et al., 2005, Sisiopiku et al., 2007), and Origin-Destination (O-D) demand estimation (Zhou and Mahmassani, 2006, Etemadnia and Abdelghany, 2009) and prediction methods (Zhou and Mahmassani, 2007).

The DTA model is a valuable tool to model congestion dynamics and test different pre-planning strategies in an urban transportation network. In addition, dynamic O-D demand estimation and prediction model is an integral part of a real-time DTA model system (Zhou et al., 2008). On the other hand, input data accuracy directly influences O-D demand estimation and prediction, thus it affects the testing results (of pre-planning strategies) as well as ICM decisions. Therefore, researchers are keen to receive accurate and consistent data, which leads to frequent use of advanced data fusion techniques (Alnawaiseh et al., 2014) and/or advanced prediction methods (e.g. Kalman filter, extended Kalman filter) (Zhou and Mahmassani, 2007).

Data fusion is a collection of techniques by which information from different sources are combined to provide better insights (El Faouzi et al., 2011). Researchers adopt different approaches such as statistical, probabilistic, and artificial intelligence in data fusion, depending on the nature of the problem and the underlying data sets. As such, (Zeng et al., 2008) researchers view incident detection as an evidence fusion problem and solve it by combining evidence theory with probabilistic support vector machines (SVM). Moreover, data fusion is extremely common in handling detector data anomaly caused by detector failure, noise etc. (Treiber et al., 2011, Bachmann et al., 2013). Other than detector data, GPS data (Moreira-Matias et al., 2016), GPS based travel time (Barceló et al., 2010), cellular/mobile devices data (Calabrese et al., 2011, Iqbal et al., 2014), and probe vehicle data (Yang et al., 2017) are also utilized to estimate O-D demand. The estimated O-D demand is then dynamically assigned to a network utilizing Dynamic Traffic Assignment (DTA).

DTA, is widely applied in different traffic management systems including advanced traveler information systems (Sundaram et al., 2011), incident management systems (Kamga et al., 2011), emergency management systems (Ji et al., 2016), and network reliability related modeling efforts, etc. Intrinsically, travel patterns are influenced by individual choices of travel mode, departure time, and route in multimodal urban transportation networks. Zhou et al. (2008) incorporate these factors in a dynamic trip micro-assignment and (meso) simulation system. Since a traveler's prime concern is travel time, experienced travel time plays a pivotal role on route choice decision. Hence, experienced travel time or forecasted travel time (Barceló et al., 2010) are typically applied in the context of dynamic assignment (Chiu et al., 2011).

While an existing network's traffic conditions as well as travel times are known, the next effort is made to formulate a predefined set of ICM strategies from which the optimal strategy can be chosen. Some of the documented strategies include:

- Zhang et al. (2012) represented an integrated corridor traffic optimization model to minimize total traffic delay while diverting traffic from a mainline freeway to an arterial road in real time.
- Chen et al. (2015) developed a framework that picks a signal timing plan from a set of predefined plans and evaluates the effectiveness with coordination for adverse weather conditions.
- Etemadnia et al. (2012) present a distributed autonomic architecture for real-time traffic network management. The system monitors traffic patterns and develops integrated traffic management schemes by investigating the most efficient team-formation strategies among controllers to mitigate a non-recurrent traffic congestion situation.
- Dynamic toll pricing (Dong et al., 2011) as well as network optimization (Gupta et al., 2016) and revenue maximization (Hassan et al., 2013) are the effective traffic management tools that utilize predicted traffic conditions.

Typically, an ICM project includes an online decision support system (DSS) that utilizes real-time traffic state knowledge as input. The traffic state knowledge includes predicted network state, inventory list (e.g., variable message board and signal timing plan etc.), and different ICM strategies to offer the optimal strategy (Hashemi and Abdelghany, 2016).

In more recent studies, efforts have been made to study travel demand (Sana et al., 2017), traffic management strategies (Hong et al., 2017, Kuhn et al., 2017), and ATIS usage (Luna et al., 2017) in ICM-related projects. Sana et al. (2017) employ statistical models to obtain facility-specific, time-dependent O-D matrices from the relative flow provided by Google's aggregated and anonymized trip (AAT) data. However, the limited spatial accuracy made the data unsuitable for facility-specific O-D matrices estimation. To identify proper actions for improving traffic management and system operations, Kuhn et al. (2017) presented a framework focusing on different improvement areas, such as business process, system and technology, performance measurement, organization and workforce, culture, and collaboration. Hong et al. (2017) presented a weather-related Active Transportation and Demand Management (ATDM) framework where an online prediction model sends predicted traffic conditions to an offline model to generate and adjust traffic management strategies. Utilizing some selected ATDM strategies (applicable to their testbed), authors show that the appropriate settings of operational features and logic combination of strategies can ensure maximum operational effectiveness to improve traffic performance. Luna et al. (2017) assessed the use of ATIS in Dallas US-75 and San Diego I-15 corridors. A comparative analysis among the responses collected before and after ICM implementation in both sites reveals that the smartphone is more popular among young people compared to older (55 or more). It also concludes that the people facing more frequent severe congestion or having longer trips are more likely to check real-time information frequently than their counterparts.

In the literature, it is obvious that the researchers have made significant efforts to study ICM and its components. Their overwhelming efforts on data fusion, O-D estimation, and prediction, and DTA maximize accuracy but nevertheless raise the complexity in ICM implementation. Such complexity is a challenge when one of the participating stakeholders has resource limitations. Leveraging existing tools and building on work done is one way to address these challenges. In the NYC Metro Region, the real-time data fusion engine TRANSCOM SPATEL data fusion and analysis tool[3] is one such tool. This tool is made available to all partner agencies, which includes NYSDOT. Studies have shown that the incident detection and travel time estimation algorithms employed by TRANSCOM's system for managing incidents and traffic (TRANSMIT) perform reasonably well compared to other relevant algorithms (Niver et al., 2000).

Based on the review of the state of the practice (acknowledging that it is moving at a fast pace and newer techniques are being applied continuously), the use of such a robust data source with incident detection capability has not been observed in any ICM related published literature. Unlike Chen et al. (2015), we could use the TRANSMIT[4] data (that is part of the TRANSCOM DFE) directly instead of using data transmitted from roadway and signal installation. Also, the use of real-time data (and historical data) can be a supplement to the traditional approach of using simulation-based dynamic traffic assignment (DTA) for real-time traffic estimation and prediction as part of an ICM evaluation (Mahmassani, 1998/ Mahmassani and Zhou, 2005).

Since incidents (e.g., inclement weather events, and traffic incidents) bring significant changes in traffic flow patterns and thus, reduce the effectiveness of traffic signal timing plans designed for normal conditions. Responsive signal timing plans are preferable when such incidents occur. Signal coordination that typically slashes traffic congestion results in an uncoordinated and sub-optimal timing plan under adverse weather conditions (Perrin et al., 2001). Authors in that publication argue that the saturation flows and speeds decrease by 20% and 30% respectively, and start-up lost times increase by 23% in a severe snow and slush accumulated road condition. They propose four general criteria—storm severity, projected duration, area of influence, and immediately projected running speeds—to determine an inclement weather signal timing plan.

In a simulation based study, Lieu and Lin (2004) assess the benefits of signal retiming under inclement weather conditions and find the retiming beneficial when traffic flows are moderately high. Agbolosu-Amison et al. (2005) reveal the signal retiming benefits (e.g., up to 20% reduction in control delay) during inclement weather with a near saturated traffic flow condition. Al-Kaisy and Freedman (2006) review the impacts of adverse weather on signal operation and the potential benefits of implementing weather-responsive signal control in isolated and coordinated signalized intersections in urban and suburban areas under various traffic conditions. Previous efforts to devise weather-related traffic management systems are limited to a few countries and locales; however, there is an increased recognition for such actions during inclement weather conditions (Chen et al., 2015).

Although incident (crash) induced traffic management studies are not limited, few papers (Ahmed and Hawas, 2015, Covell et al., 2015, Smith, 2015) focus on signal retiming plans. Smith (2015) introduces a DTA complex model with less computational efficiency relative to traditional DTA models. Ahmed and Hawas (2015) present a simulation-based signal control system design, which has yet to be proved efficient in a real network. Covell et al. (2015) optimized the timing for an isolated signalized intersection, utilizing local traffic flow; however, since the study focuses on isolated intersections only, it is not applicable for a corridor.

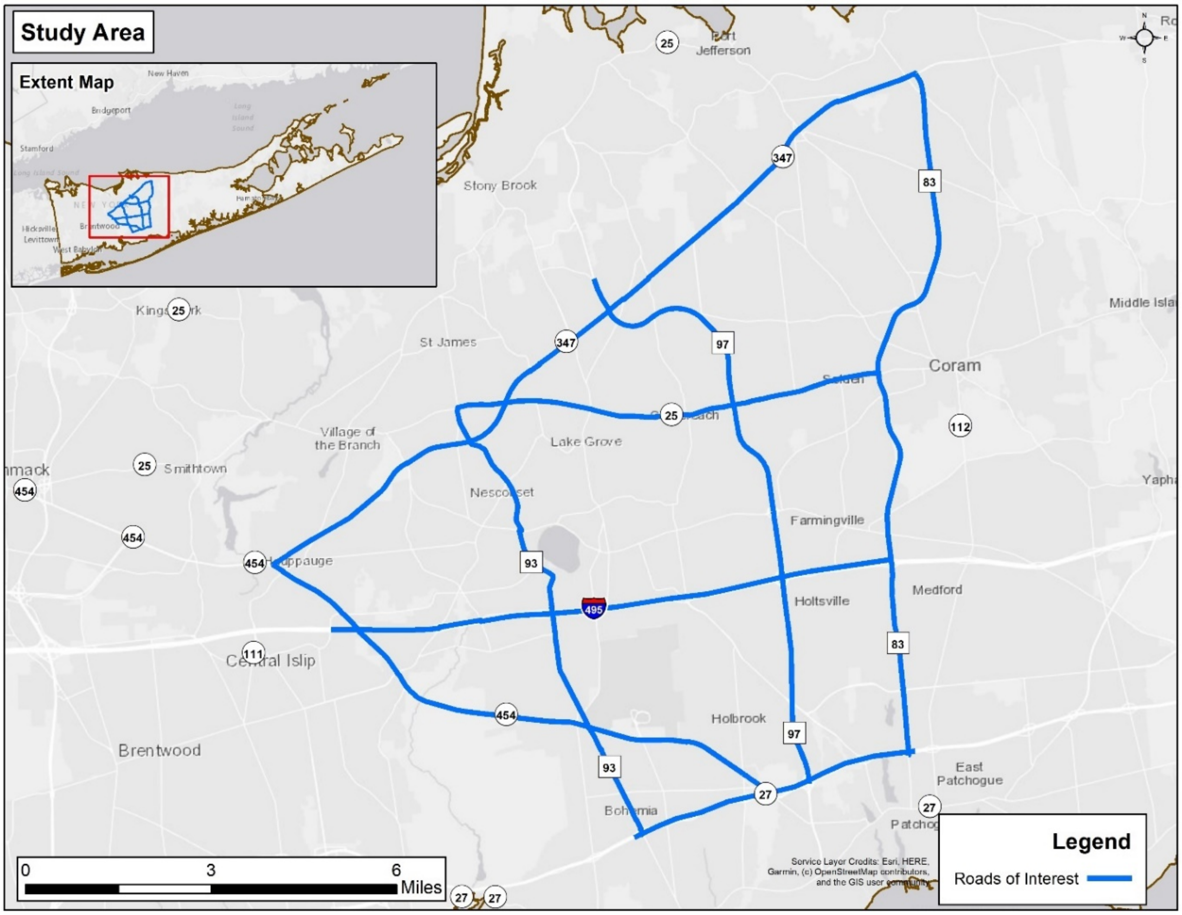
In summary, the literature research identified recent advances in ICM and the trend toward the integration of new and emerging data sources. In Suffolk County, the availability of TRANSMIT presents an opportunity to develop a real-time (TRANSMIT), data-driven, signal timing plan selection process, which would be responsive to traffic and weather incidents, in corridors managed by agencies with differing ITS capabilities and infrastructure.

We are proposing an innovative way to trigger specific control strategy/actions based on a corridor's traffic flow pattern, in real time, with the goal of improving traffic management. This technology would provide a mechanism to improve responsiveness to unanticipated congestion, such as caused by inclement weather or a traffic incident. Essentially, this research would serve as a connector between the real-time traffic data received from an advanced data source (such as TRANSCOM) and the control decisions/actions.

3 Study Area

The project study area encompasses eight major roadways—three County Roads and five State Routes. As displayed in Figure 6, the three County Roads—CR 93, CR 97, and CR 83—run latitudinally. The five State Routes—SR 454, SR 347, SR 25, SR 27, and I-495—mostly run longitudinally. As described in the introduction section, the roadway network in Suffolk County is constrained by the north and south shores of Long Island with a limited number of east/west major roadways. The dominant commuting pattern is westbound in the a.m. and eastbound in the p.m. Therefore, the roadways which run in these directions are heavily used at those times of the day. These roadways were selected for analysis as they are heavily used by commuting traffic and can be used as alternatives to each other if needed. For example, if a driver is located south of the Long Island Expressway (LIE) and east of CR 83, they may choose to use the LIE or SR-27 to travel westward. In addition, if an individual lives in the northeastern extent of the study area, they may choose to travel west using SR-347 or use CR-83 to travel south, then take the LIE west. There are several alternative routes to navigate between a trip's origin and destination using this roadway network.

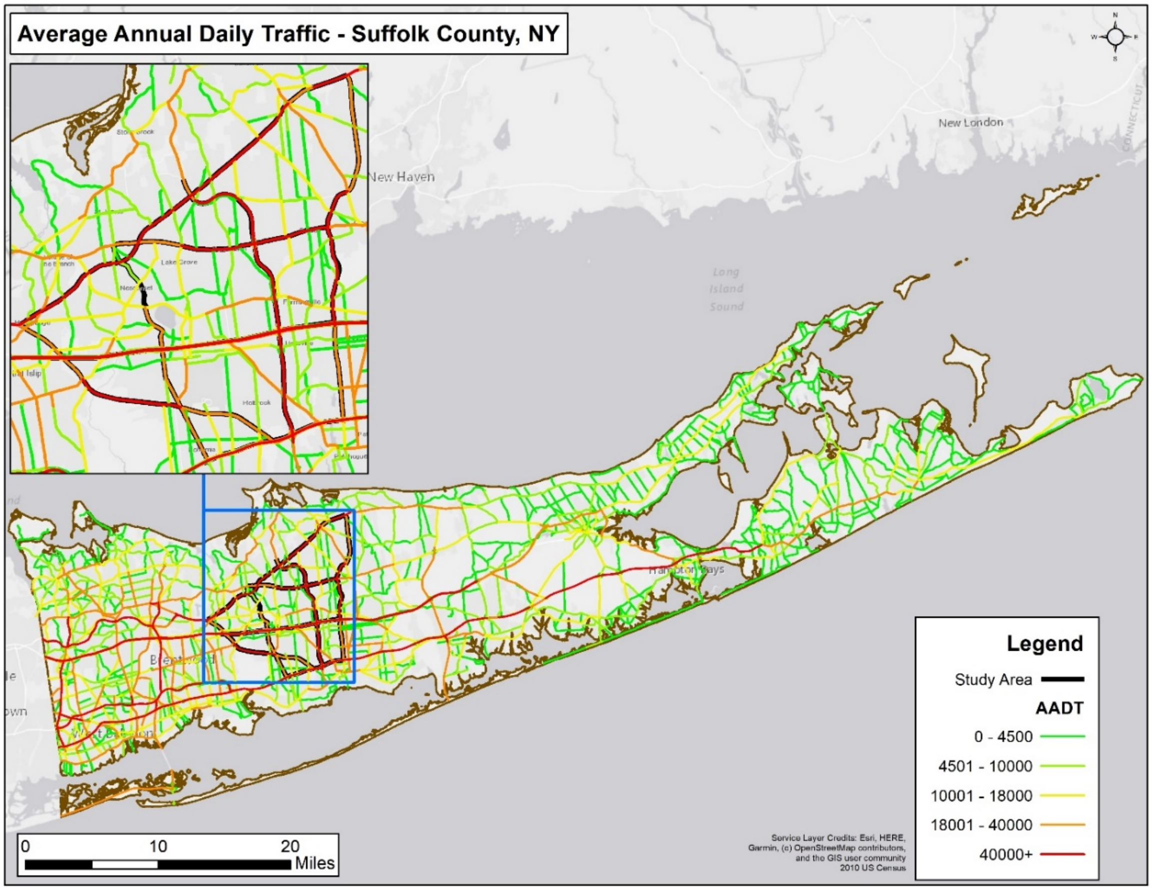
Figure 6. Study Area Roads of Interest



3.1 Traffic Patterns

Due to the connectivity and versatility of these roadways, they naturally attract drivers. Figure 7 presents the average annual daily traffic (AADT) for Suffolk County. As shown in the figure, the study area roadways selected are among the busiest in the county.

Figure 7. Average Annual Daily Traffic Suffolk County in 2017



Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
2010 US Census

The traffic pattern within the study area has two peak periods, one in the a.m. and the other in the p.m. Figure 8 presents average speeds at key locations through the study area network. At most locations, the lowest speeds are experienced during the a.m. (6 a.m.–10 a.m.) and p.m. (3 p.m.–7 p.m.) periods.

Figure 9 and 10 present the a.m. and p.m. peak hour volume, respectively, by direction for locations where data was made available by NYSDOT and SCDPW between 2015 and 2019. These graphics emphasize the directional peaking characteristics between the a.m. and p.m. periods. For example, the LIE in the a.m. carries approximately 2,000 more vehicles in the WB direction then the eastbound. In the p.m., the opposite pattern occurs where it carries approximately 1,200 more vehicles in the EB direction than the WB.

Figure 8. Study Area–April 2019 Average Weekday Network Speeds

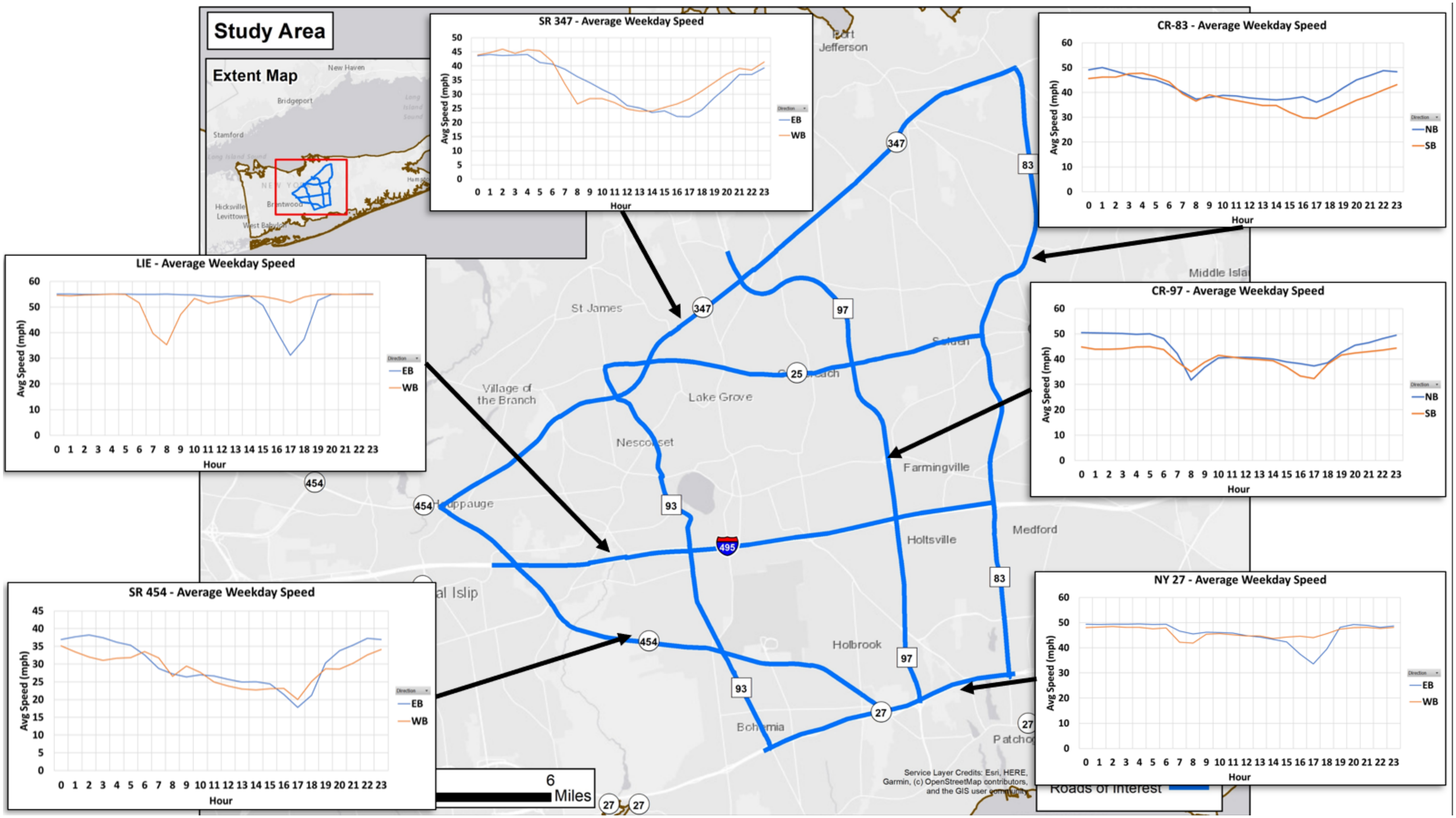
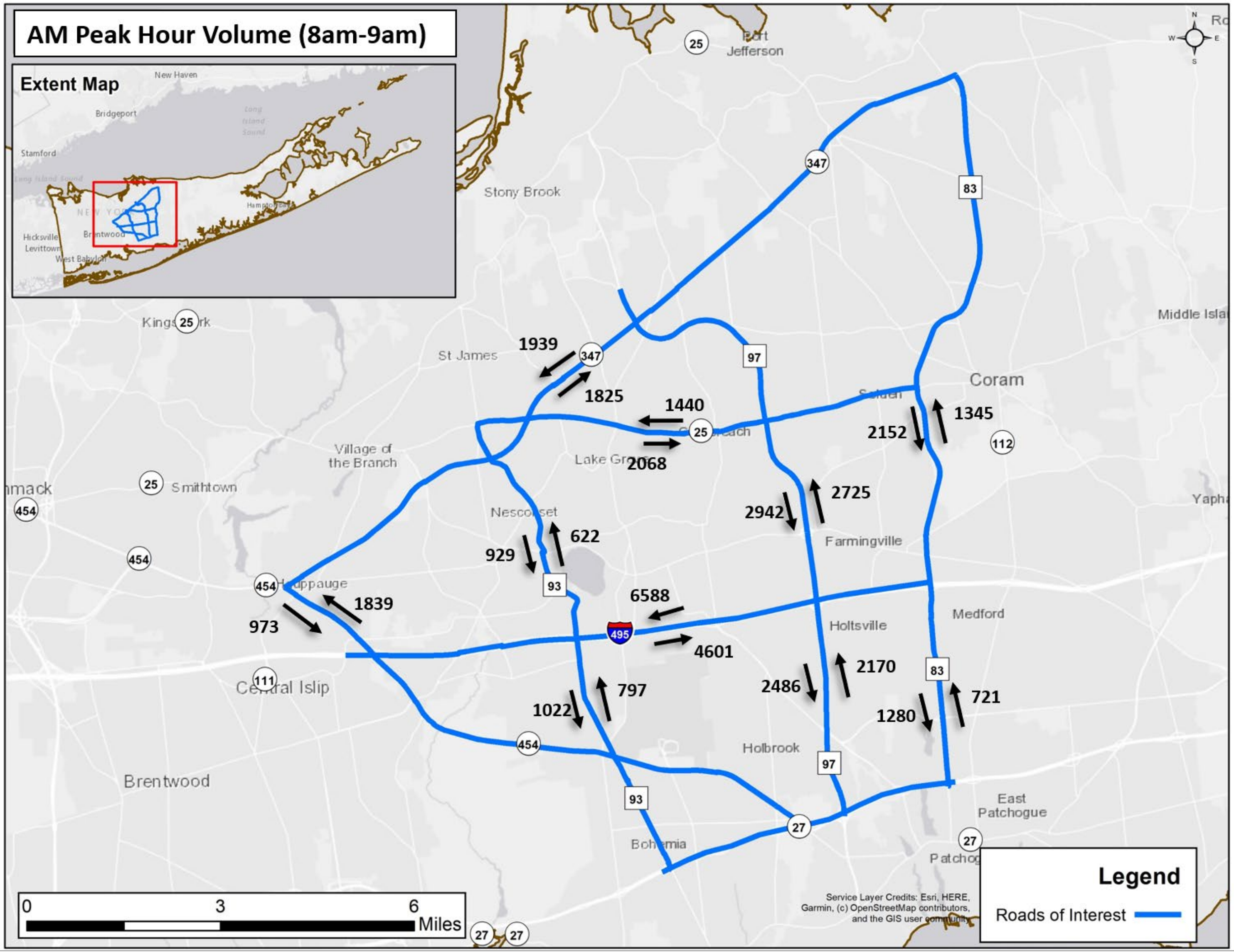
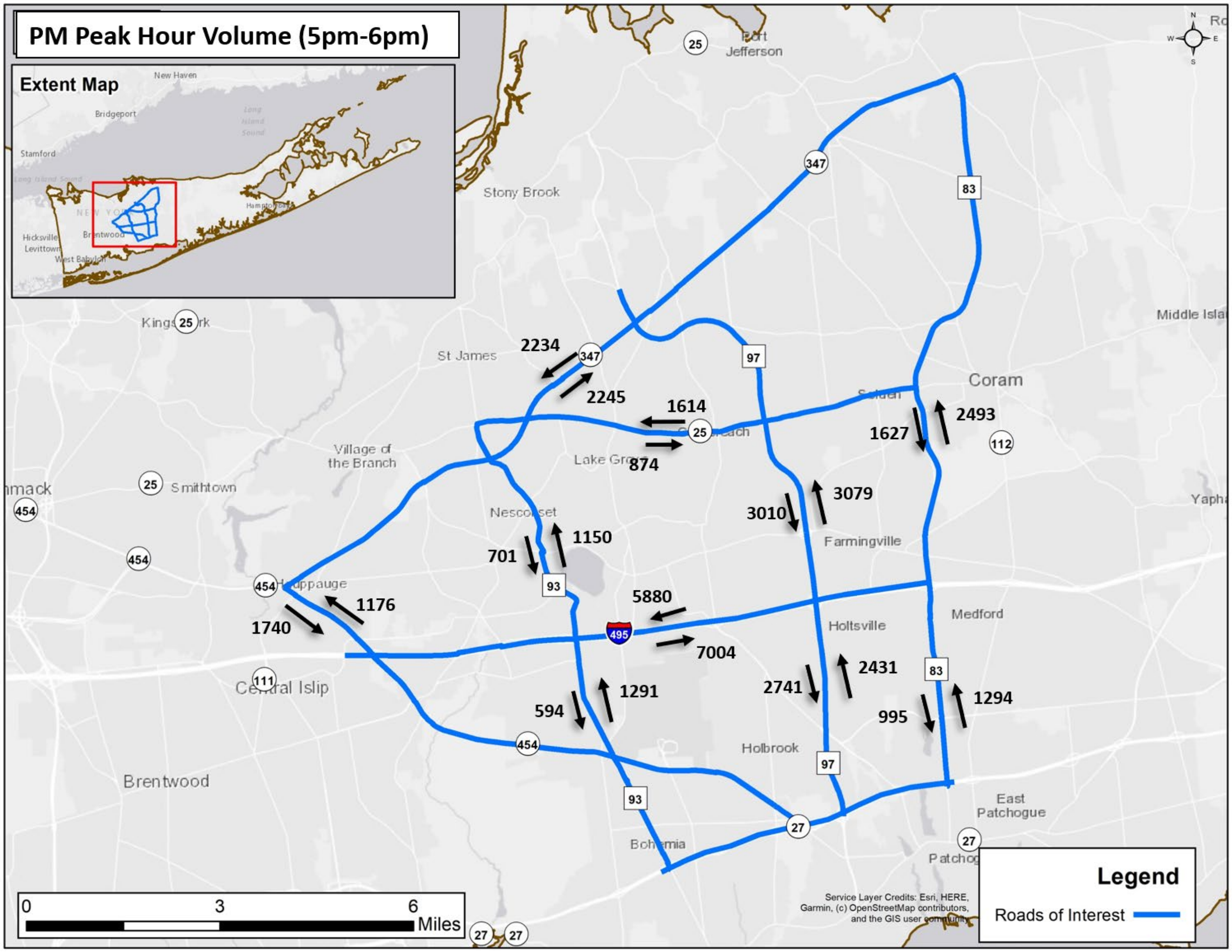


Figure 9. AM Peak Hour Volume (8:00 a.m.–9 a.m.)



Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Figure 10. PM Peak Hour Volume (5:00 a.m.–6 a.m.)



3.2 SCDPW and Region 10 Traffic Management

New York State Region 10 includes all of Suffolk County and Nassau County. NYS Region 10 manages all the NYS routes and interstates (Long Island Expressway), and owns, manages, and operates the signals on State roadways.

Suffolk County, on the other hand, possesses operational control of traffic signals while the local jurisdictions (municipalities, towns, villages) own and maintain the signals. This is part of their Inter-Municipal Agreements (IMA).

However, SCDPW coordinates with NYSDOT routinely, and the two agencies generally try to have signal timing plans that are compatible at the locations where the State and county routes intersect. Both agencies use the Naztec Signal Controllers with the Naztec firmware and use the ATMS.now central control system software to monitor the signalized intersections.

In terms of their ITS footprints, NYSDOT is much larger. The INFORM system includes not only signalized intersections, but also ramp meters, VMS, overhead height detection systems, cameras, microwave sensors, Bluetooth readers, and travel-time (toll tag reader based) segments. These devices are managed from the TMC in Hauppauge by staff 24 hours a day, seven days a week. They have fiber connections with the TMC, providing the ability to support real-time updates, monitoring, and reporting. INFORM uses the NYS incident logging system (OpenReach) and provides route travel time using the Transmit readers. The data sets are included in the Data Fusion Engine (DFE) developed by TRANSCOM. The Transcom data feeds include the hazards layer, which includes incidents logged by Waze users. This provides another layer of information for the operators in the TMC to support their monitoring functions. INFORM is one of the most mature ITS traffic management systems in the country.

In contrast, SCDPW has far fewer signalized intersections, limited number of cameras, no VMS, and does not have a fully operational TMC. There is no around-the-clock staff, and they have very limited detectors (wireless pucks) or travel time. They do have access to the data available from Transcom (travel time) and are in the process of exploring how to become a partner in the Waze for Cities program.

4 Analysis, Modeling, and Simulation Activities

As a result of a series of discussions conducted with New York State Department of Transportation (NYSDOT), Region 10, and Suffolk County Department of Public Works (DPW) a group of corridors were selected for analysis as part of the study.

A summary of the key takeaways from those discussions follows:

- ***Real-Time Signal Control**:* NYSDOT and SCDPW have very different operating protocols for their ITS systems, however they both share the same field hardware (Naztec) for the traffic controllers and the central traffic control system (ATMS.now). A primary difference is in the communication to the field. NYSDOT has real-time communication via fiber and can change the signal timings plans in real time from their INFORM Traffic Management Center. SCDPW does not have that capability as it does not have a fiber connection (using wireless instead), and does not have a continuously staffed TMC.
- ***NYSDOT Diversion Routes:*** Each region in the State has defined diversion routes as part of large a statewide project. These diversion routes are part of the incident response plans for the major State roadways. In the study area for this project, the routes of interest are I-495 (Long Island Expressway LIE), NY-25, NY-25A, and NY-27 (Sunrise Highway). The diversion routes include the use of Suffolk County roadways, including the three roadways that are part of the study area—CR 83 (N Ocean Avenue), CR-97 (Nicolls Road) and CR-93 (Lakeland Avenue).
- ***CR97 Nicolls Road***: SCDPW is in the process of implementing a Bus Rapid Transit (BRT) corridor along this arterial and as a result the roadway will not be included in the traffic analysis at the present stage of the current effort. Instead, the primary focus will be on CR-83 (N Ocean Avenue) and CR-93 (Lakeland Avenue).

Taking into consideration the above items, it was decided that the AMS activities would be focused on the analysis of these diversion plans, and their potential benefits. As discussed in the Task 2 literature report, a critical element of any ICM system is the set of response plans, which consist of these diversion plans. It is anticipated that the AMS activities will develop refinements (companion signal timing plans for these diversion routes) and trigger conditions for the use of the diversion plans during recurring and non-recurring events on the roadway network.

4.1 AMS Tool Selection

As discussed in Section 2, one of the standard tools used to evaluate response plans are microscopic traffic models. Such models have the ability to represent changes in signal timing plans (a main component of the response plan), changes in traffic demand (diversions), and produce a variety of metrics that can be used to quantify the effects. For the analysis of diversions, an estimate of travel demand is critical at both a regional and local level. The study area is part of the larger regional MPO model—the NYBPM[5]—and this was used as the basis of developing a model of the study area. The NYBPM is a tool that was developed and maintained by New York Metropolitan Transportation Council (NYMTC) and is in TransCAD,[6] a comprehensive transportation planning software developed by Caliper Corporation. The suite also includes TransModeler, which is a fully integrated microscopic traffic simulation model that can be used to analyze subareas within TransCAD. This tool was selected to support the AMS tasks.

4.2 Data Sources

There were four main data sources that were used to support the analysis. These include traffic counts, traffic signal timing plans, Transcom DFE, and StreetLight Traffic Data. The following section presents a summary of these data sources.

4.3 Traffic Counts

Traffic counts are generally available in two types: (a) continuous 24-hour traffic flow measurements from devices such as ATRs (Automatic Traffic Recorders) and (b) intersection turning movement counts in 15-minute intervals for the peak periods that are measured using video (e.g., MioVision) or manually.

NYSDOT has a repository of such data sets—on the Traffic Data Viewer[7] (TDV). The TDV was accessed and the data within the study area (81 locations) were summarized and used for analysis. Similarly, SCDPW has an online portal where the data along county routes can be accessed. The portal was accessed and the data for approximately 47 locations were compiled. An example of this data is presented in Figure 11. Figure 12 presents the collection locations graphically.

Figure 11. August 2018 Average Weekday Traffic Flow Profile Example

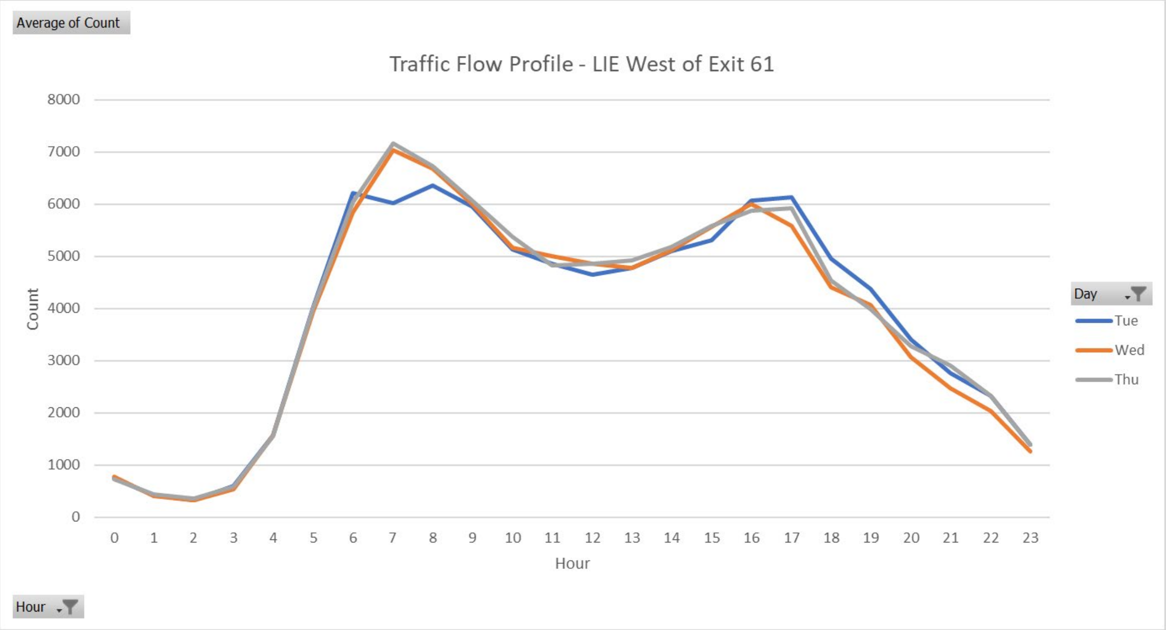
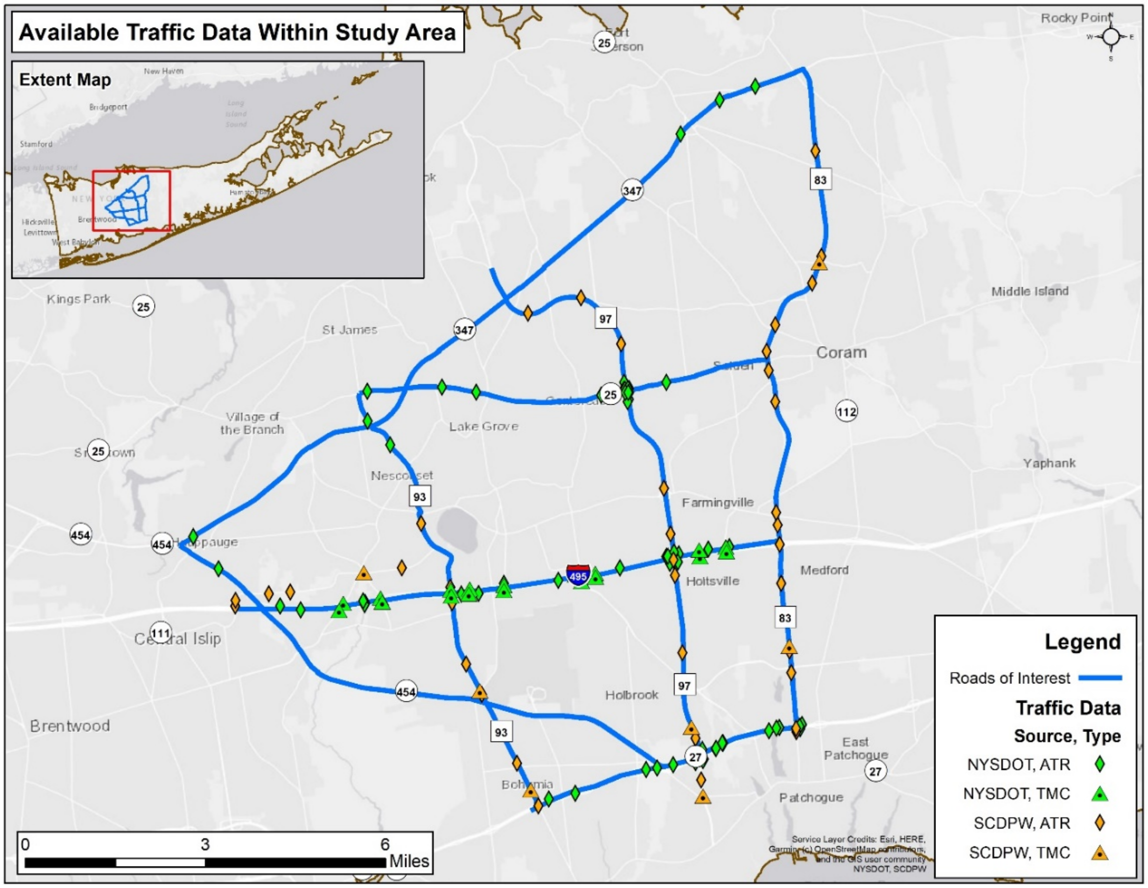


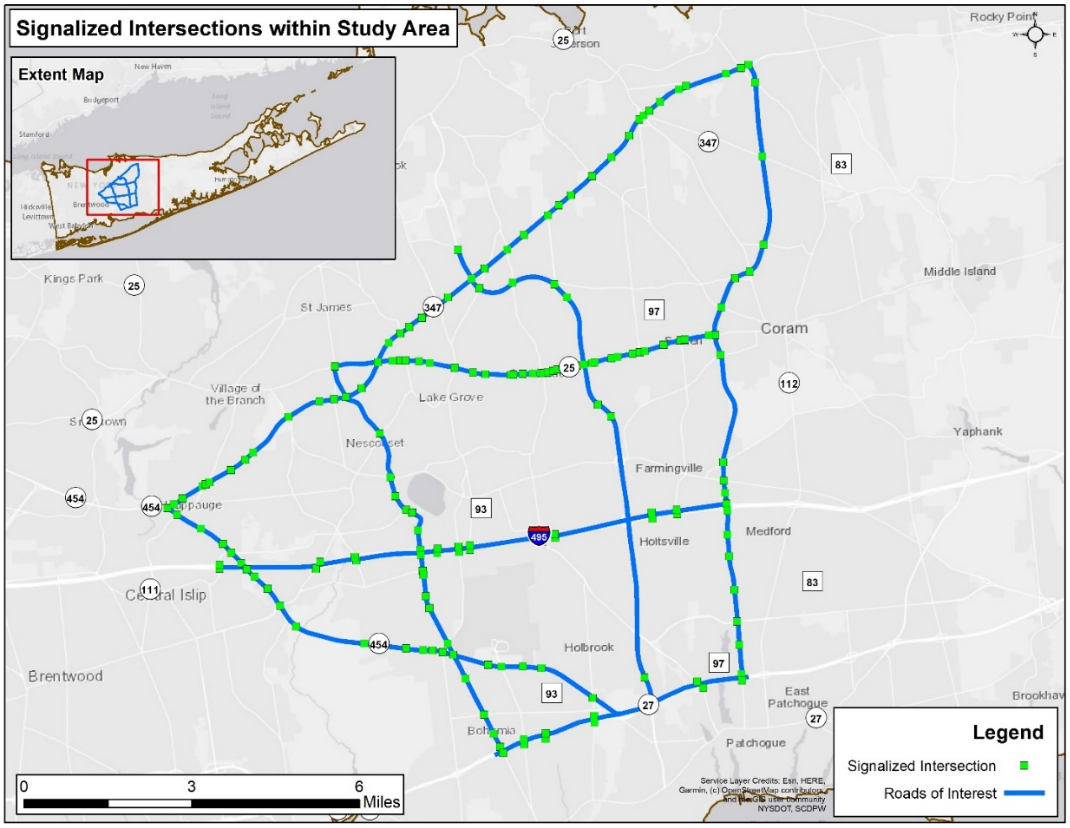
Figure 12. Traffic Data Available within Study Area



4.3.1 Traffic Signal Timing Plans

Both SCDPW and NYSDOT have provided signal timing plans for the signalized intersections throughout the study area. At certain locations where the timing plans were not readily available, the timing from adjacent intersections were replicated in the simulation models. In summary, there were 168 signalized intersections throughout the study corridors, all of which run as Actuated Signal Control. The locations of the signalized intersections are presented in Figure 13.

Figure 13. Signalized Intersections



4.3.2 Transcom DFE

TRANSCOM is a coalition of 16 transportation and public safety agencies in the New York-New Jersey-Connecticut metropolitan region. It was created in 1986 to provide a cooperative, coordinated approach to regional transportation management.[8] This coalition has developed a Data Fusion Engine (DFE) that provides both current and historical travel time and incident information within the NY Metro region. Figure 14 presents an illustration of the travel time and incident logs. This information was analyzed on select routes in the study area that have data coverage to assess the effects of incidents on travel time.

Figure 14. Travel Time Analysis—Transcom DFE Illustration

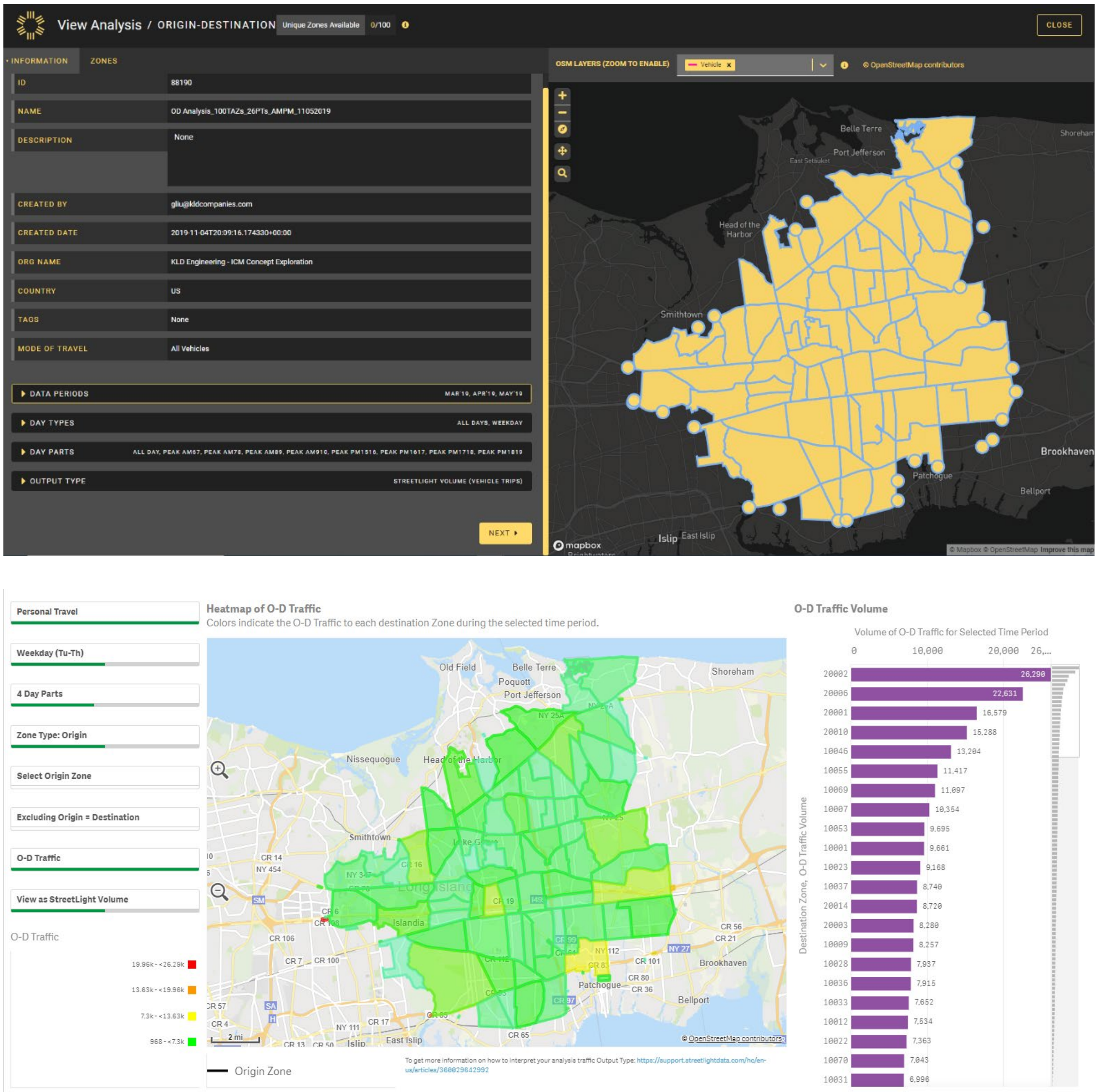
Event Ended at 03:02:00 PM
ORI193829710 – Construction
Start Date Time – 10:00:00 AM
End Date Time – 03:02:00 PM
Description
NYSDOT – Region 10: Construction, construction on I–495 eastbound between Exit 61 – Patchogue Holbrook Road; CR 19 (Brookhaven) and Exit 63 – North Ocean Avenue; CR 83 (Brookhaven) 1 to 2 lanes closed until 3:00 P.M.

	01/08/2019
Free Flow mm:ss / mph	03:25 / 55.0
Average mm:ss / mph	03:27 / 54.4
Planning mm:ss / mph	03:47 / 49.6
Buffer mm:ss	00:20
Total Events	2

4.3.3 Streetlight Traffic Data

Travel patterns can be defined using Origin Destination matrices (O-D Tables). These are traditionally part of travel demand models (like the NYBPM) and used in microscopic traffic analyses. These can be adjusted/estimated based on field counts using standard procedures that are part of traffic analysis tools and known as Origin Destination Matrix Estimation (ODME) processes. These methods use observed traffic counts, to adjust the O-D Tables. Traditionally, collecting O-D tables is an expensive effort that required the use of LPR (license plate recognition) type methods; however, in the recent years this data is more prevalent and is available from multiple data service providers. One such vendor is StreetLight.[9] They provide a service known as StreetLight InSight®—a web application that can be used to convert anonymous location data from millions of mobile devices into customized, actionable analytics. As part of this effort, this data source will be used to develop O-D tables for the study area. See Figure 15 below for a snapshot of the platform.

Figure 15. StreetLight Data Platform



ID	88190
NAME	OD Analysis_100TAZs_26PTs_AMPM_11052019
DESCRIPTION	None
CREATED BY	gliu@kldcompanies.com
CREATED DATE	2019-11-04T20:09:16.174330+00:00
ORG NAME	KLD Engineering - ICM Concept Exploration
COUNTRY	US
TAGS	None
MODE OF TRAVEL	All Vehicles
DATA PERIODS	MAR'19, APR'19, MAY'19
DAY TYPES	ALL DAYS, WEEKDAY
DAY PARTS	ALL DAY, PEAK AM67, PEAK AM78, PEAK AM89, PEAK AM910, PEAK PM1516, PEAK PM1617, PEAK PM1718, PEAK PM1819
OUTPUT TYPE	STREETLIGHT VOLUME (VEHICLE TRIPS)

Personal Travel

Weekday (Tu-Th)

4 Day Parts

Zone Type: Origin

Select Origin Zone

Excluding Origin = Destination

O-D Traffic

View as StreetLight Volume

Heatmap of O-D Traffic

Colors indicate the O-D Traffic to each destination Zone during the selected time period.

To get more information on how to interpret your analysis traffic Output Type: https://support.streetlightdata.com/hc/en-us/articles/360029642992

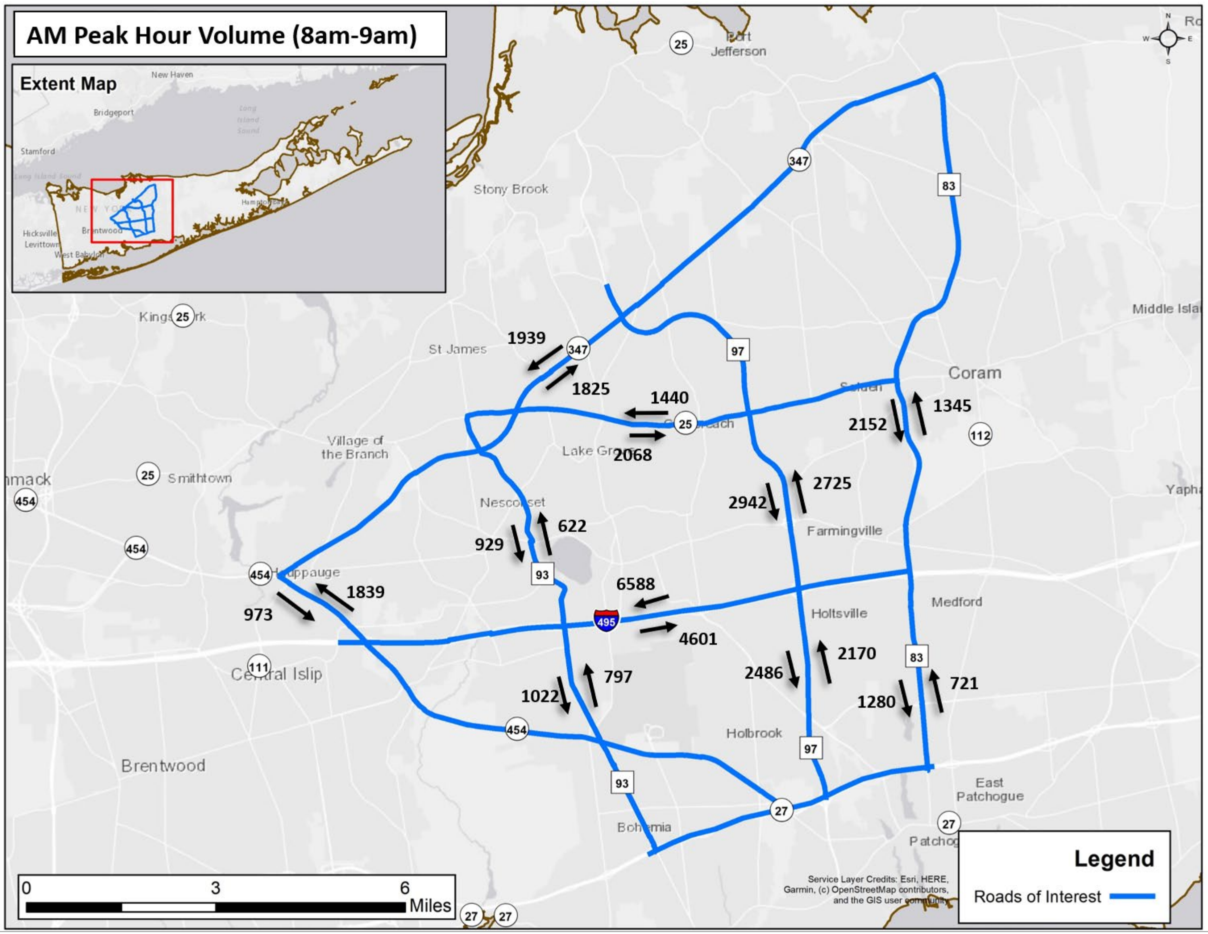
4.4 Data Summaries

As stated previously several data sources were leveraged throughout this task. The data from these sources were summarized and used for analysis. A brief summary of how each source was summarized and used for analysis can be found below.

4.4.1 Traffic Counts Summaries

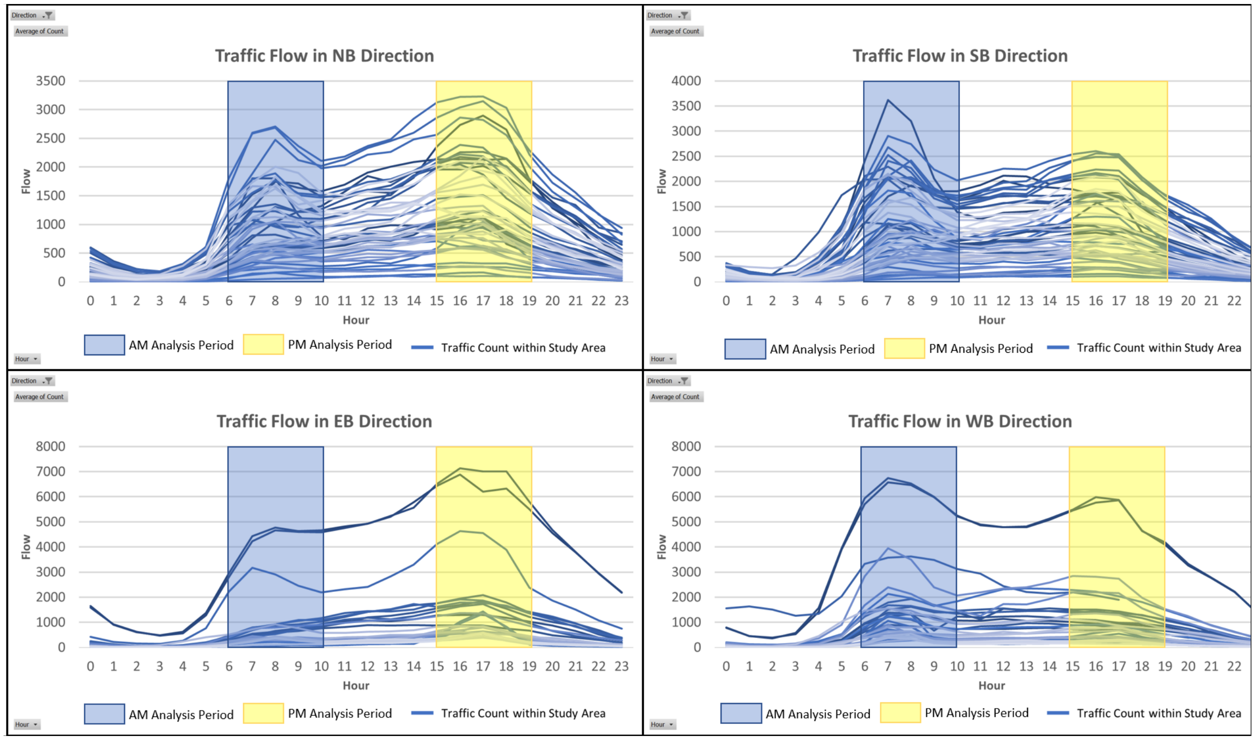
The traffic data from 2015 to 2019 provided by NYSDOT and SCDPW presented in Figure 12 was processed and summarized into hourly flow maps. This was done to help understand the overall traffic pattern and peaking characteristics within the study area. For illustrative purposes, an example of the flow map can be seen below in Figure 16 presenting peak hour volume at key locations. This graphic includes a subset of count locations, which were a total of 128 locations throughout the study area.

Figure 16. AM Peak Hour (VPH) (8 a.m.–9 a.m.) Traffic Flow Map at Key Locations



To help understand the traffic pattern, the traffic count data was looked at over a 24-hour period by direction. Figure 17 presents four charts which show the traffic flow data by direction. According to the data, there are clear peaks in both the a.m. and p.m. periods. Using this data, the a.m. and p.m. periods of analysis were selected as 6 a.m.–10 a.m. for the a.m. period and 3 p.m.–7 p.m. for the p.m. period. It is also evident that the NB and EB direction experience heavier volume in the p.m. period, whereas the SB and WB direction experience heavier volume in the a.m. period.

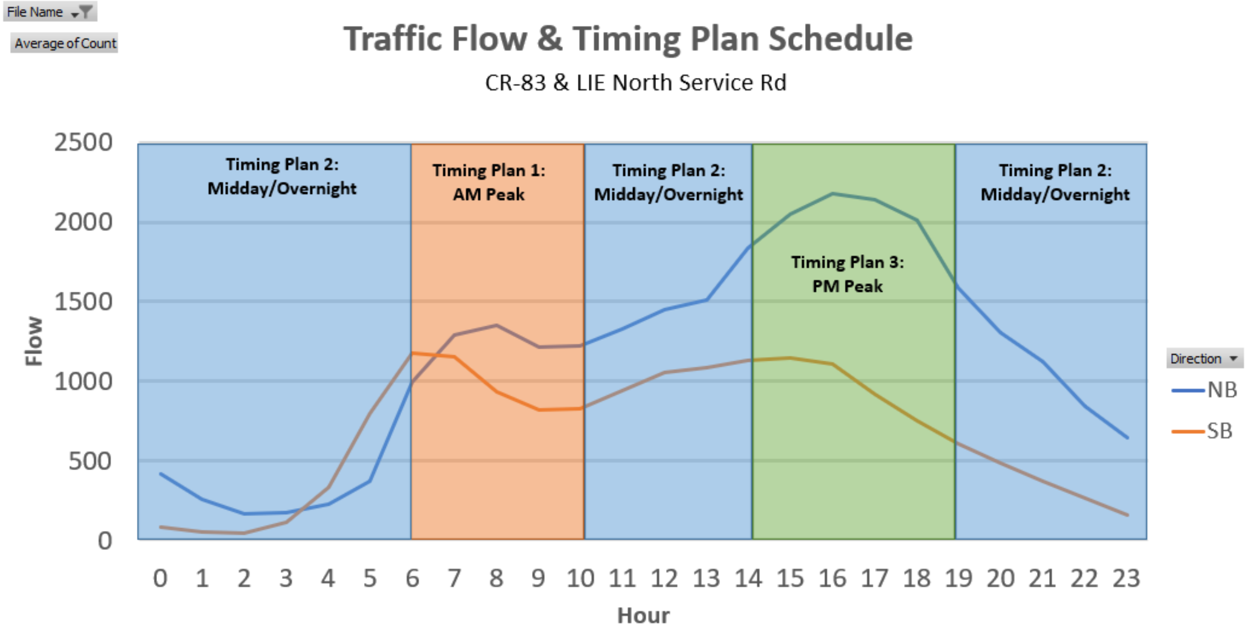
Figure 17. Traffic Flow Data within Study Area by Direction



4.4.2 Traffic Signal Timing Plans

The signal timing plans provided by NYSDOT and SCDPW were reviewed and coded into the simulation model to accurately represent real-world conditions. The split, offset, and actuation parameters were all coded into the model as per the data provided. This includes the signal timing schedule information, if provided. Figure 18 presents a sample signal timing plan scheduled overlaid on traffic count data for the intersection of CR-83 and LIE North Service Road. As delineated by the different color rectangles, the timing plan changes correlate to changes in traffic levels, as expected. The available signal timing data indicates that signals along a given corridor typically followed a similar schedule. Therefore, when schedule or timing information was not provided, the nearest adjacent intersection with available timing data was used to supplement. If there was no nearby available data, then "dummy" signal timings were created to allow the simulation to run.

Figure 18. Signal Timing Plan Schedule Example



4.4.3 Transcom DFE Data Summaries

The Transcom DFE was leveraged to obtain travel time/speed and incident data for select corridors within the study area. The speed data was compiled and summarized for an average weekday condition. Figure 19 presents the average weekday speed profile for six key locations within the study area. The incident data was also investigated to understand the impact of incidents on travel time. Figure 20 presents total number of unplanned incidents for 2019 within our study area. The most incidents occurred during the a.m. period on Fridays between 7 a.m. and 10 a.m. As expected, the a.m. and p.m. periods, when traffic is the highest, were also times with the most incidents.

To investigate the impact an individual incident has on the roadway network, the team isolated one event which occurred on July 22, 2019, at 5:30 p.m. Figure 21 presents travel time information related to an accident which occurred on the LIE near Exit 59 that caused the center lane to be closed. As presented in the figure, the observed travel time for July 22, 2019, has additional delays of 15 minutes compared to the historical average.

Figure 19. Transcom Speed Data

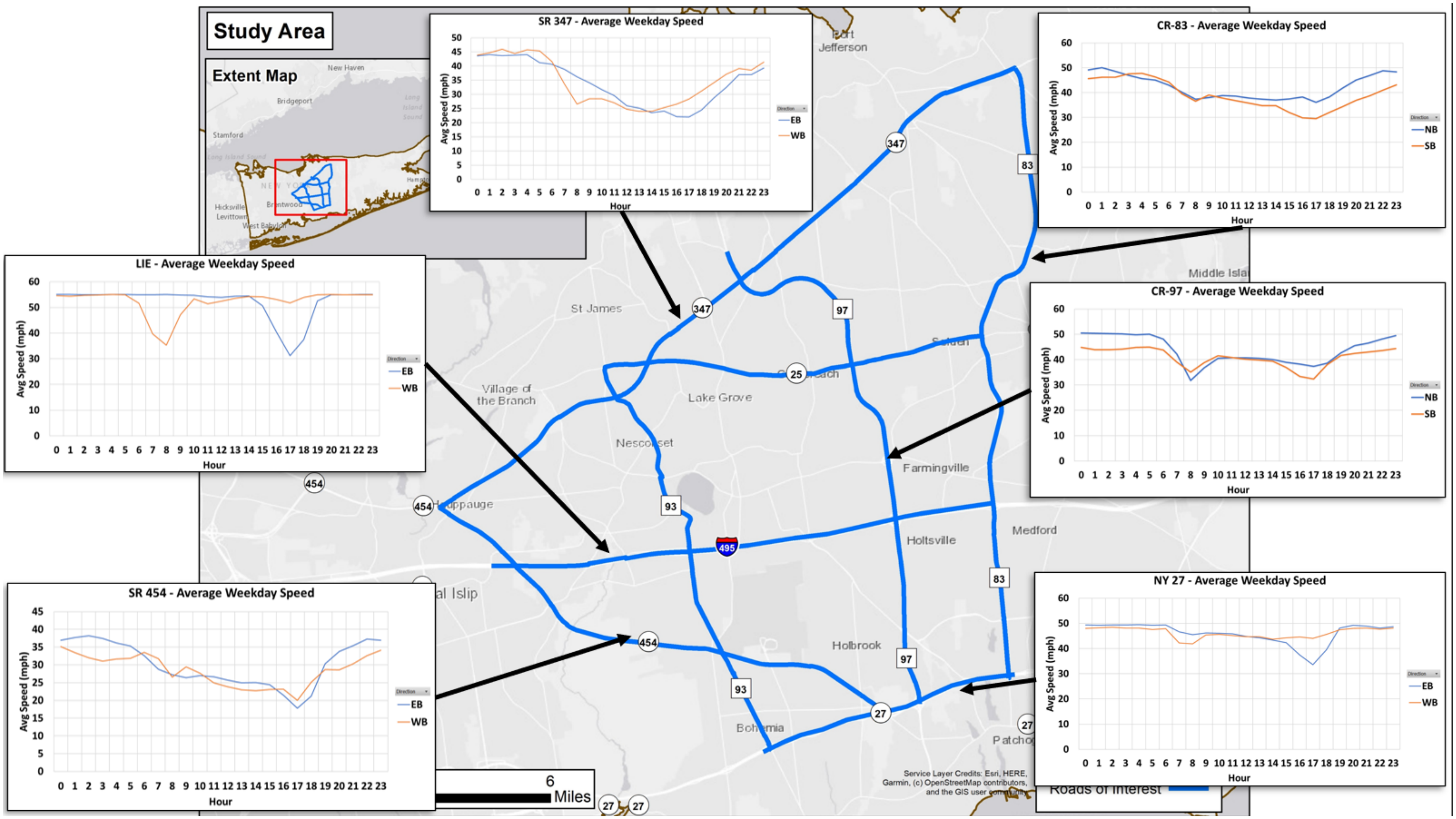
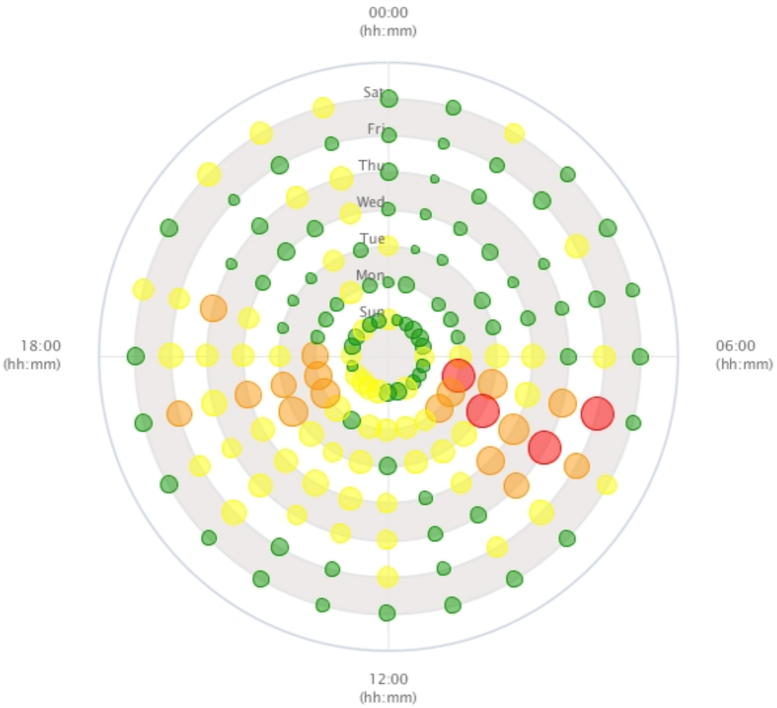


Figure 20. Transcom Incident Log—Suffolk County 2019

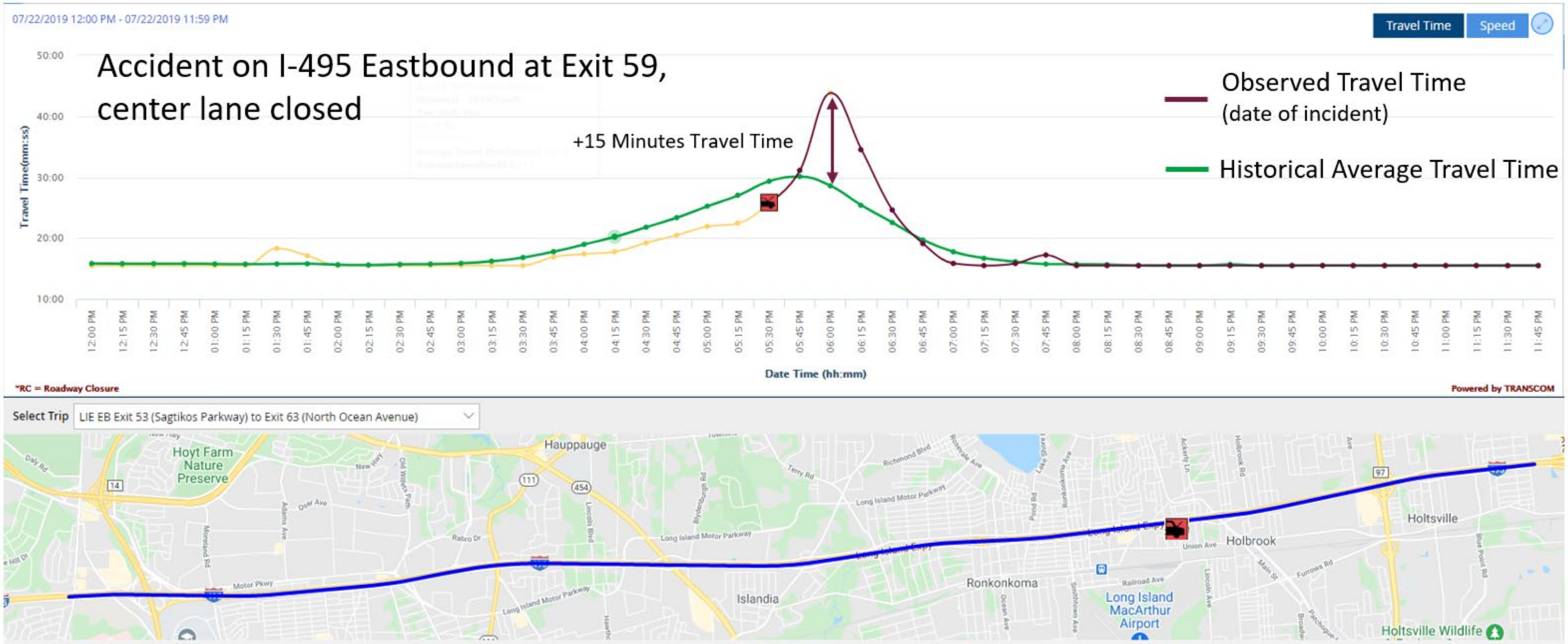
TRANSCOM℠
TRANSPORTATION OPERATIONS COORDINATING COMMITTEE



Most Incidents			Event Count			
Hour	Day	Hour/Day	🟩	🟨	🟧	🟥
8-9	Monday	7-8/Friday	0-6	7-13	14-20	21-25

Hours/Day	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	11 - 12	12 - 13	13 - 14	14 - 15	15 - 16	16 - 17	17 - 18	18 - 19	19 - 20	20 - 21	21 - 22	22 - 23	23 - 0
Sunday	8	2	3	6	6	5	7	3	3	4	9	6	6	11	9	11	9	2	7	5	5	8	4	4
Monday	2	5	0	3	4	3	9	23	17	16	8	9	9	10	6	13	18	16	15	3	4	3	9	4
Tuesday	7	1	2	0	5	4	10	19	24	12	10	11	6	11	7	12	18	14	8	2	2	2	8	4
Wednesday	3	2	3	5	2	4	10	12	20	17	8	3	7	11	13	10	11	15	9	8	4	6	5	8
Thursday	6	1	4	0	2	3	5	17	24	14	5	4	7	7	7	11	7	13	9	15	2	5	9	10
Friday	4	2	4	6	10	5	9	25	14	12	8	3	8	4	6	12	8	14	12	8	0	2	6	3
Saturday	6	4	7	4	6	3	5	4	7	5	5	5	5	3	5	4	6	6	6	8	6	10	9	8

Figure 21. Transcom DFE Incident Example



Select Trip: LIE EB Exit 53 (Sagtikos Parkway) to Exit 63 (North Ocean Avenue)

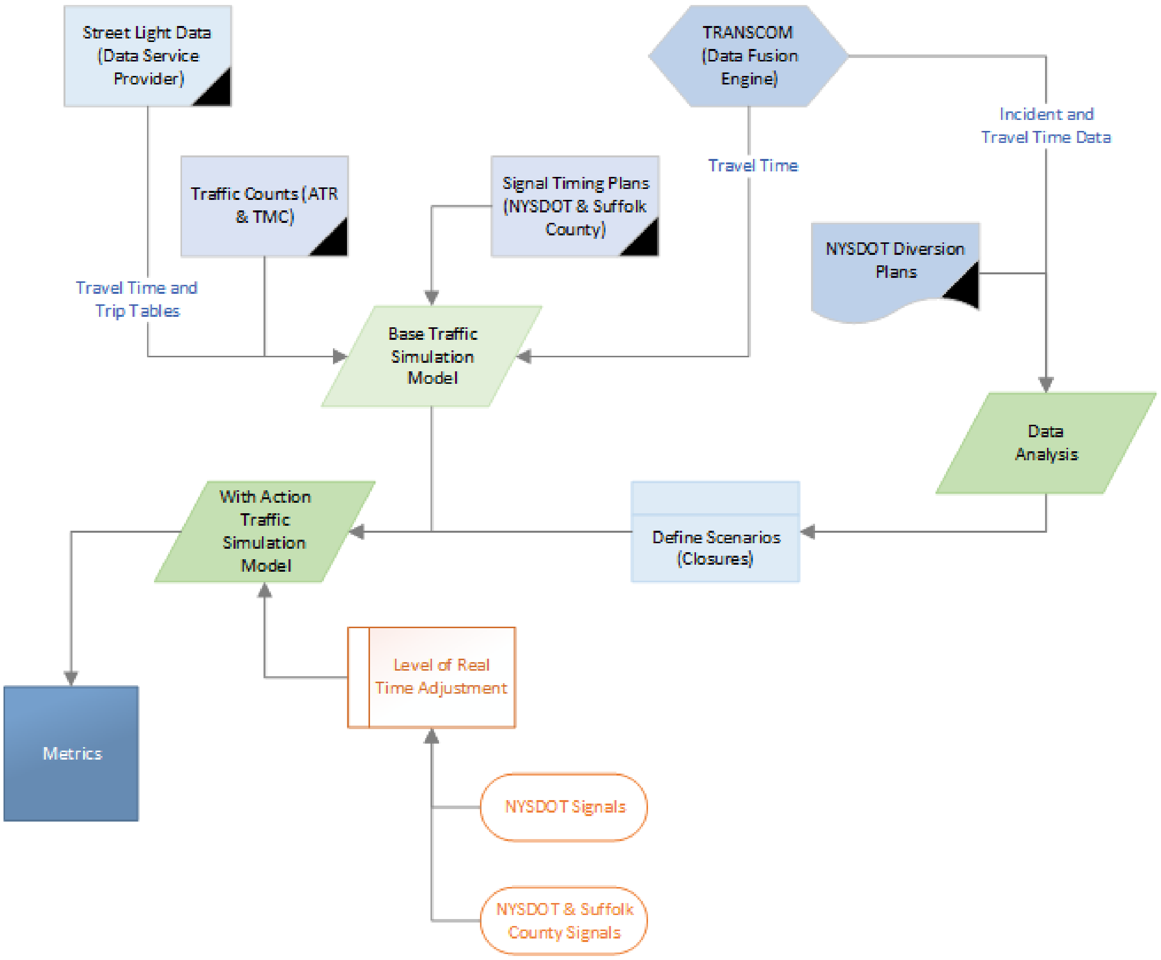
4.5 Analysis Periods

The analysis periods are focused on the weekday peak periods—a.m. and p.m. As seen in Figure 17, there are distinct peaks during these two periods, which are the focus of the analysis.

4.6 Approach

Figure 22 presents the methodology graphically. As shown in the figure, the process will bring together the data sets, the models, the response plans as scenarios, and the model outputs will be used to compare the scenarios and quantify the benefits of the actions/response plans.

Figure 22. AMS Methodology



4.7 Base Model Development and Scenario Analysis

Using the available data sets a base model was developed and calibrated. The NYBPM subarea model was used as a starting point. The trip tables using Streetlight Traffic Data were used as a seed matrix in the model and using the ODME procedures in TransCAD the trip table was adjusted to match the field counts. This O-D base model was used for the scenario evaluations. The calibration/validation of the model is presented in appendix A of this report.

There were three distinct scenarios that were identified for simulation evaluation, based on a review of the types of incidents recorded in Transcom and the State's diversion routes. The scenarios are summarized in Table 2 and shown in Figure 23, Figure 24, and Figure 25.

Table 2. Incident Scenarios

Scenario	Roadway	Direction	Description	Type	Time Period
Scenario 1	Long Island Expressway and Service Rd	Eastbound	Between Exit 61 and Exit 62	Full closure of LIE and Service Rd Eastbound	3:30 p.m. to 4:30 p.m.
Scenario 2	Long Island Expressway Eastbound	Eastbound	Between Exit 61 and Exit 62	Full closure of LIE Eastbound	3:30 p.m. to 4:30 p.m.
Scenario 3	Long Island Expressway	Westbound	Between Exit 57 and Exit 56	Full closure of LIE Westbound	6:30 a.m. to 7:30 a.m.

Figure 23. Incident Scenario 1

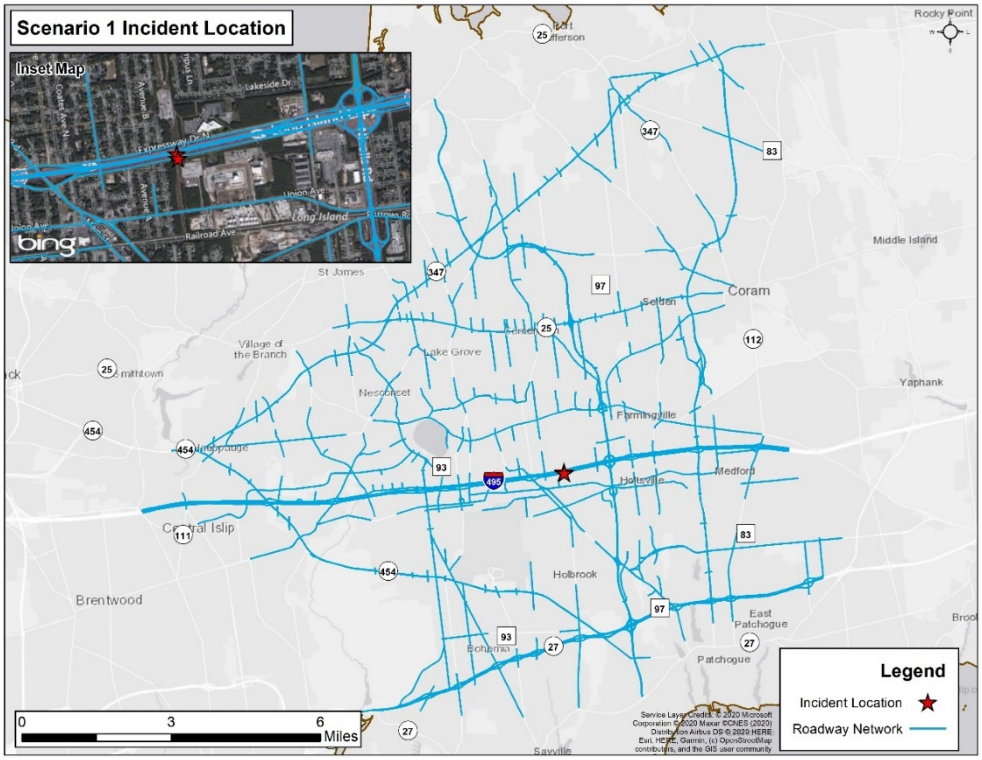


Figure 24. Incident Scenario 2

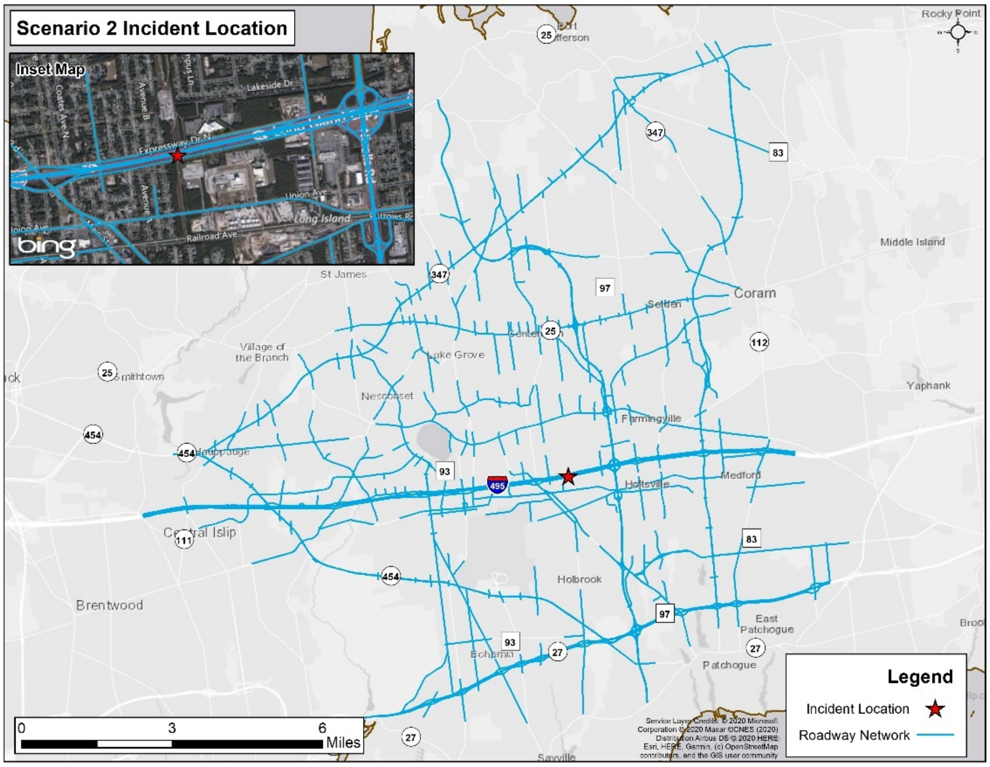
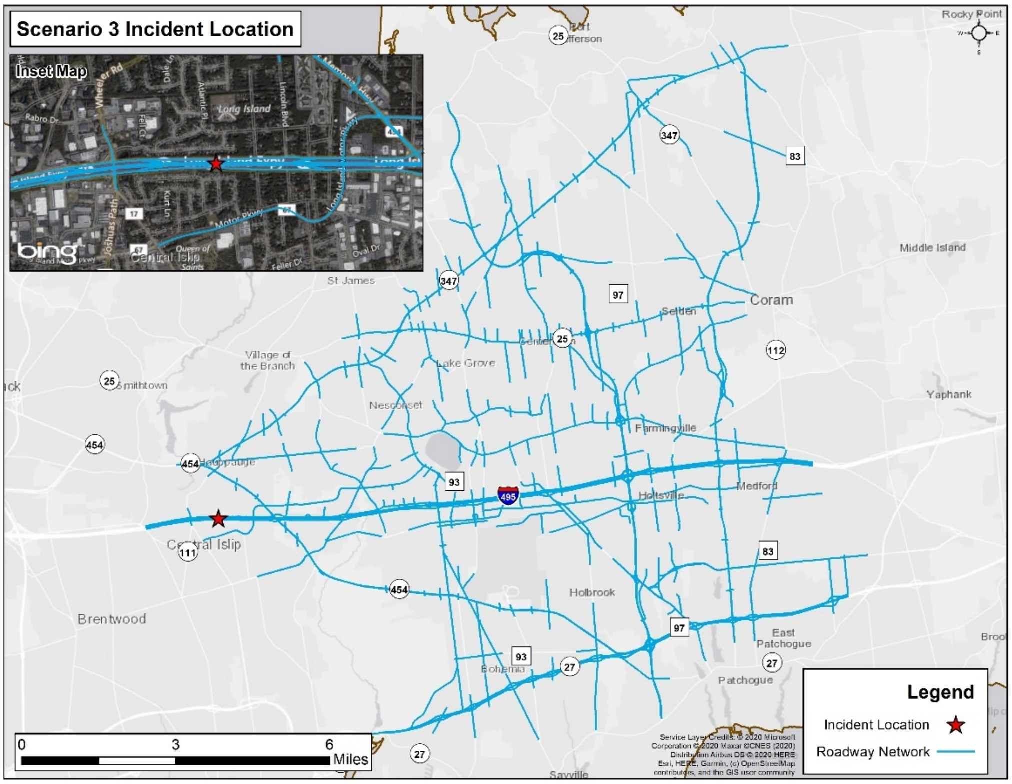


Figure 25. Incident Scenario 3



The incidents were created in the model, and two cases were run (with and without action). The "With Action" scenario represents the condition when a coordinated response plan is activated. The plans included using VMS to notify the road users, use of apps such as Google Maps, Apple Maps, and Waze to inform the driving/decision making, and modified traffic signal timing plans (and/or use of enforcement) to handle the detoured traffic.

Figure 26 present a comparison of the average travel time between exits on the mainline and the service road, for the three scenarios. Figure 27 present a comparison of the O-D pair-based travel time during the p.m. peak period from the west end of the model to the east end of the model.

Figure 26. Scenario Analysis Summary

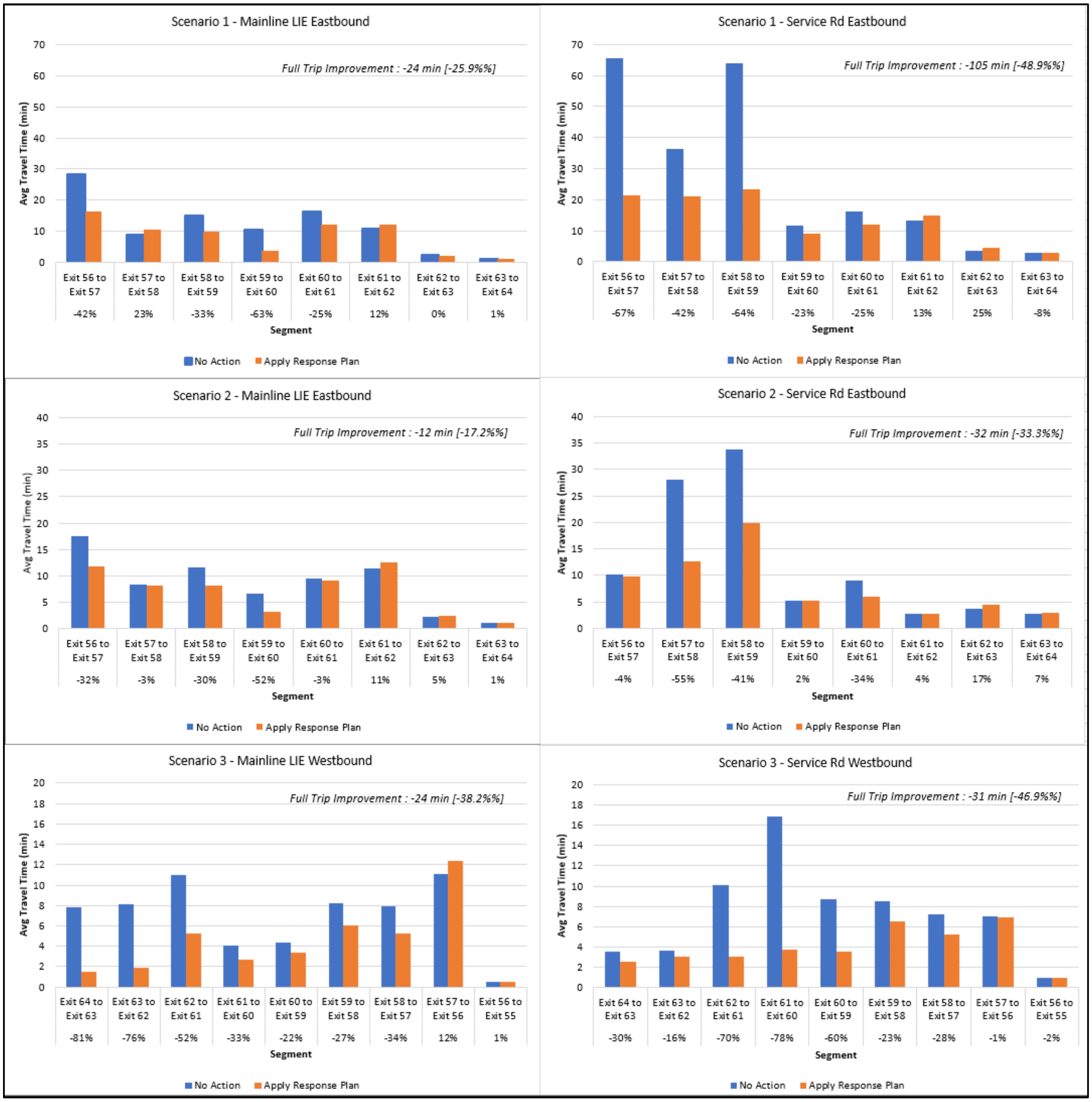
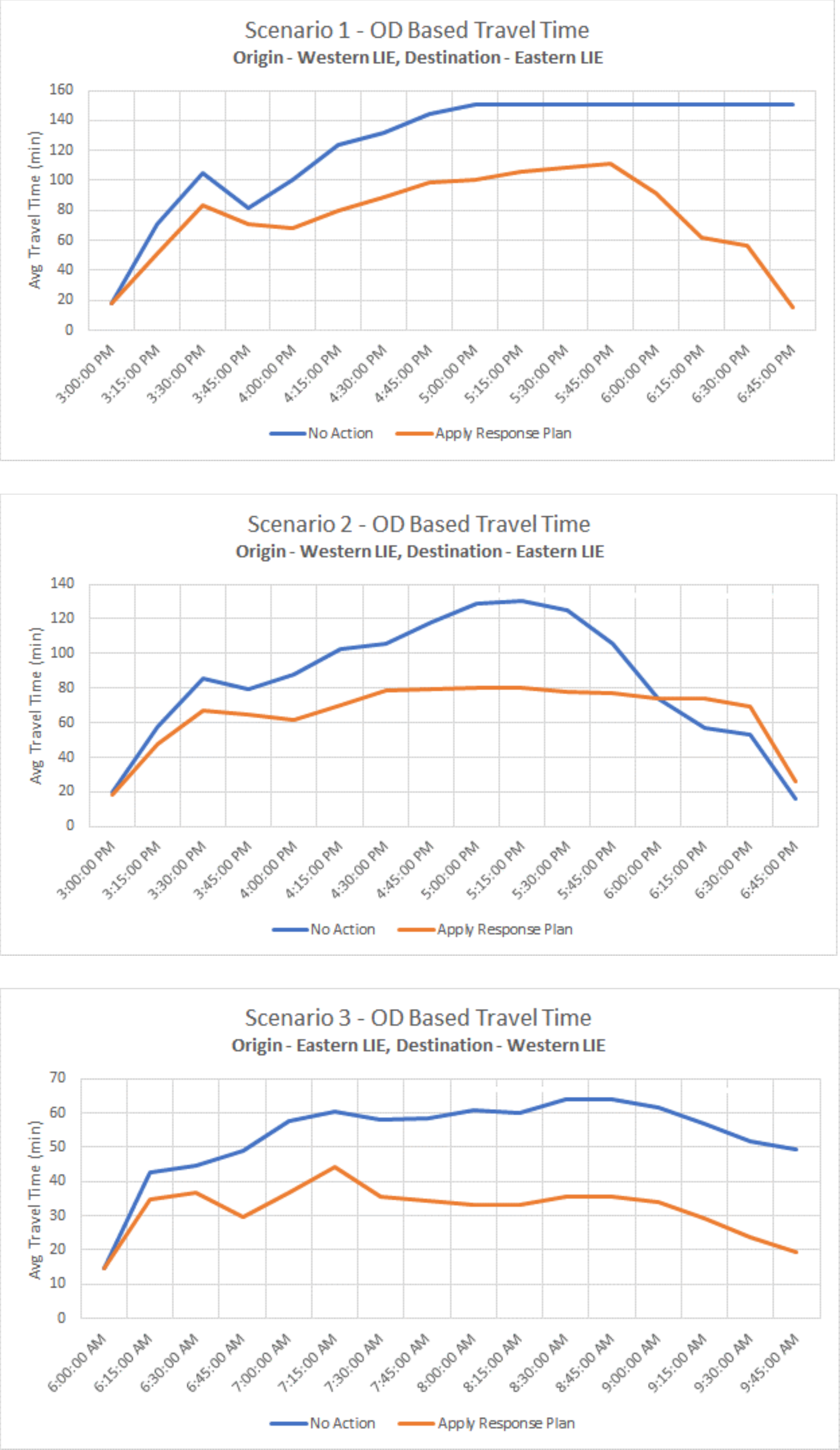


Figure 27. Scenario Analysis Summary



Based on the data presented, the response plans provide a travel time improvement that is in the range of 30–40% on average, and as much as 100 mins/trip. This is consistent with the expectations and reinforces the need to explore such coordinated actions.

5 Decision Support System Framework and ICM Playbook

5.1 Incidents in Long Island

Section 4 presented a summary of the various data sets that were used to represent the typical traffic conditions in the study area. Figure 19 is an example of the speed profiles and Figure 17 presents traffic flow during a typical weekday. A few key characteristics were the following:

- Distinct weekday a.m. and p.m. peak periods.
- The directionality in the peaking is not consistent:
    - LIE, NY 27, NY 347, and CR-97 have distinct directional peaks.
    - NY 454 and CR 83 are generally equally busy in both directions.
- The traffic volumes in peak periods are elevated in both directions.

Figure 28 and Figure 29 present a snapshot of the number of incidents recorded by Transcom in Suffolk County in 2019 and within the study area, respectively. As seen in these figures, the incidents are frequent and occur all along the study area/roadways. Figure 20 provides a summary by hour by day of week. The data suggests that there are as many as 25 such incidents occurring in a single hour across these roadways.

Under these conditions, the effect of traffic incidents can be detrimental, because as volume to capacity (v/c) ratios exceed 0.85 and approach 1.0, traffic flow becomes unstable and any reduction in capacity as a result of incidents has a nonlinear increase in delays. Figure 21 presents one example where the closure of a single lane resulted in doubling the travel time and the effects lasted as much as 2 hours.

Figure 28. Incident Data from Transcom (Suffolk County) in 2019

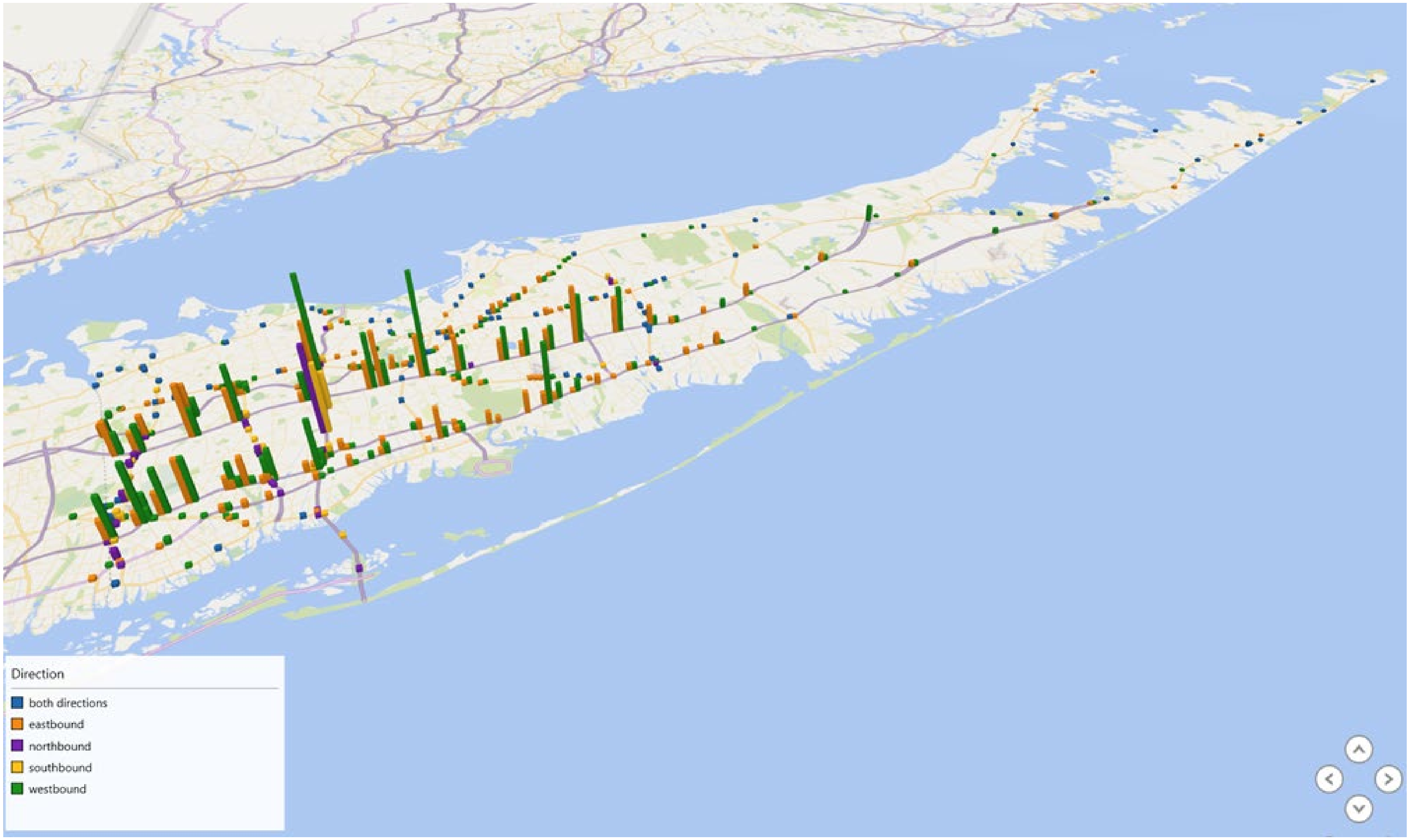
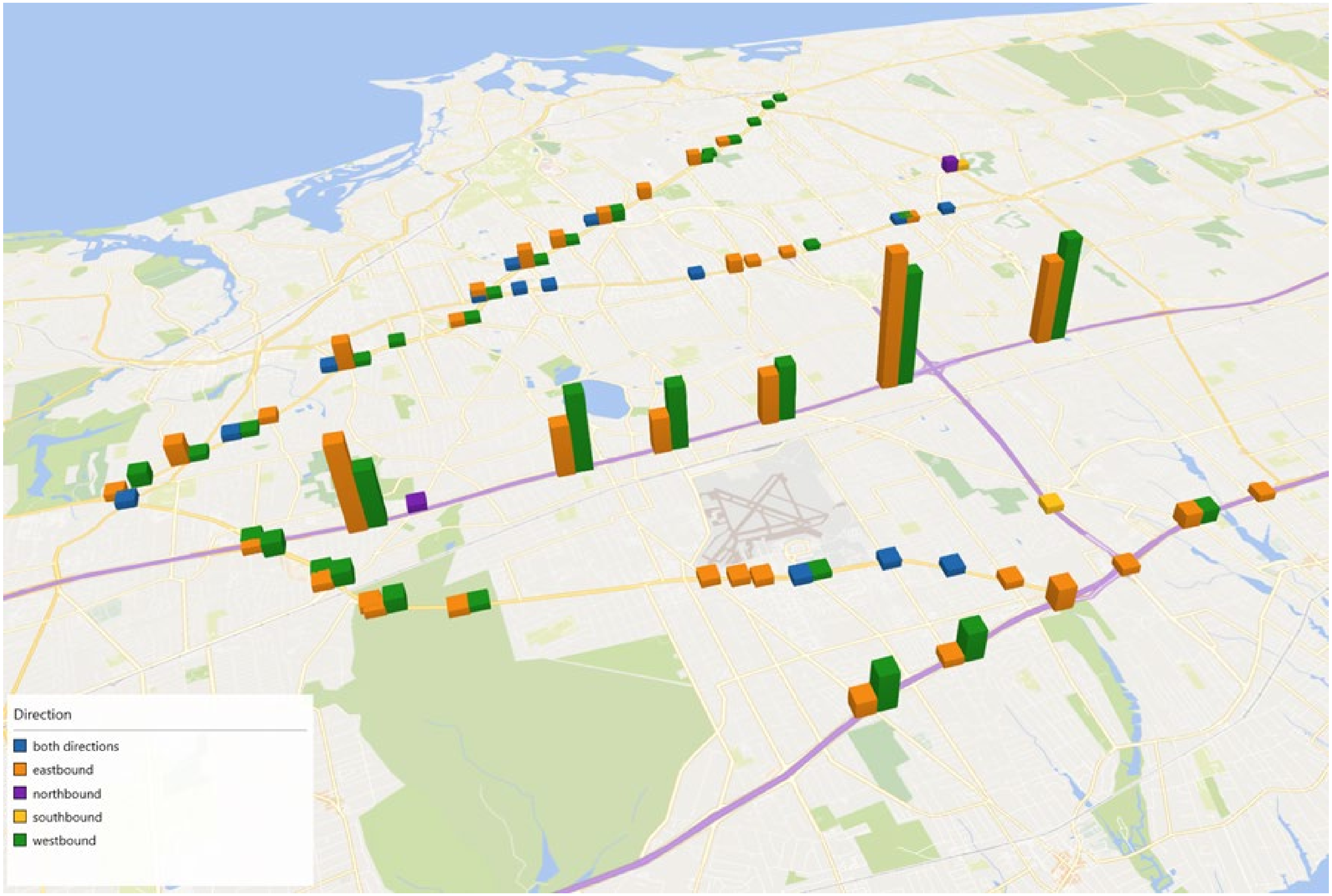


Figure 29. Incident Data from Transcom (Study Area) in 2019



5.2 Incident Response

Suffolk county is within NYS Region 10 and, as mentioned earlier, these two agencies coordinate and work well together. They routinely collaborate in developing traffic management plans for planned events on long Island such as the July 4 Fireworks, U.S. Open Golf, etc. During emergency events (weather related) the State and county each activate their ICS (incident command stations) and have staff coordinating to share resources during winter storms and other weather events. An example of this collaboration is seen in the excerpt from the Regional ITS Architecture. Figures 30 and 31 show the service packages for Early Warning Systems and Incident Management.

Figure 30. NYSDOT Region 10 ITS Architecture—Service Package PS 11

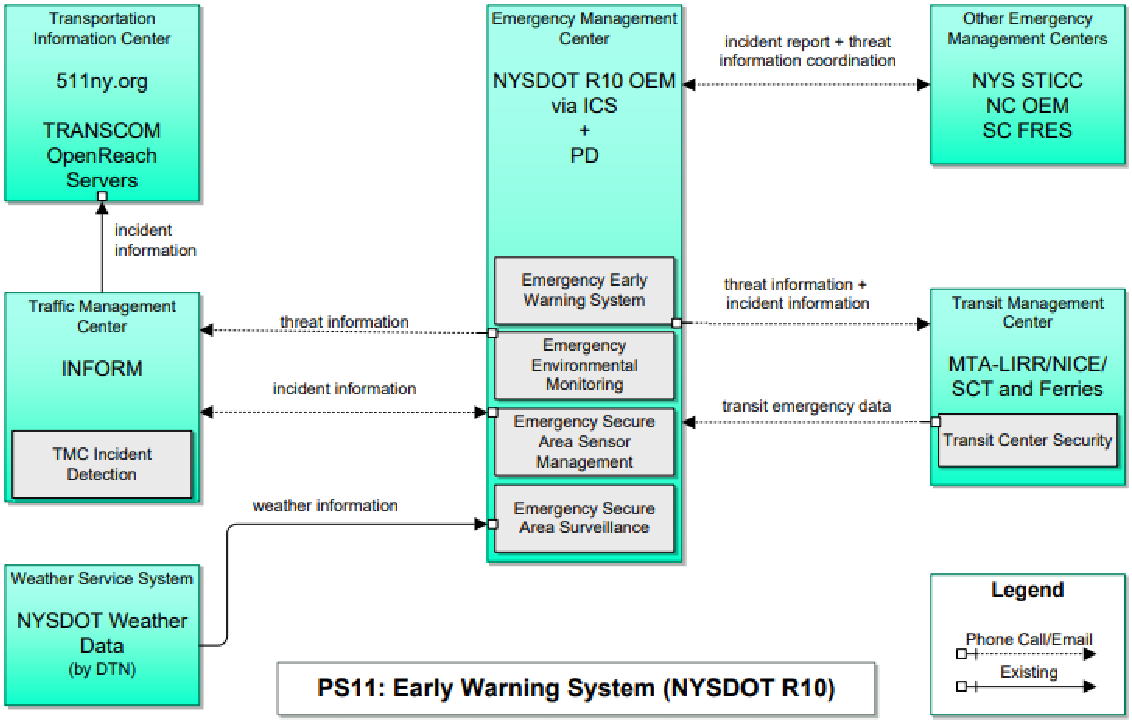
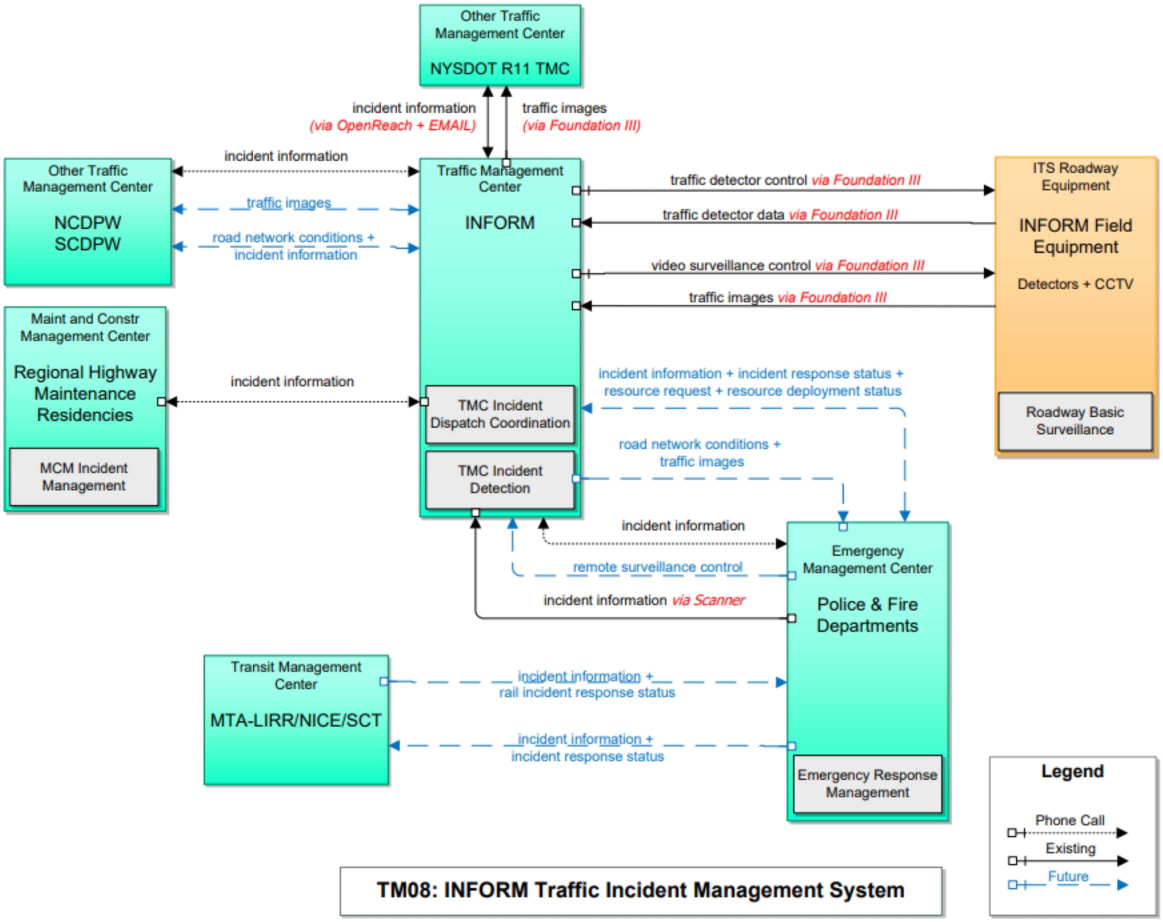


Figure 31. NYSDOT Region 10 ITS Architecture—Service Package TM08



5.3 NYS Diversion Routes

NYSDOT has been working on a separate initiative to develop regional diversion routes as part of their playbook for Traffic Management Centers (TMCs) across all 11 regions in NYS. This was spearheaded by the main office in Albany, and other regions followed the same protocols. These playbooks are readily available in the TMC, and the operations staff are well versed and trained in the use of the response plans, which are developed for incidents on roadways that are managed by NYS and have identified primary and secondary diversion routes for incidents that range from partial to full closures. The response plans are enhanced with a supporting messaging (VMS), enforcement, and signal timing plans as well as put in place with the support of police departments (PD). Figure 32 presents one page from one such diversion plan. INFORM/Region 10 shared copies of these diversion routes as a reference for this study.

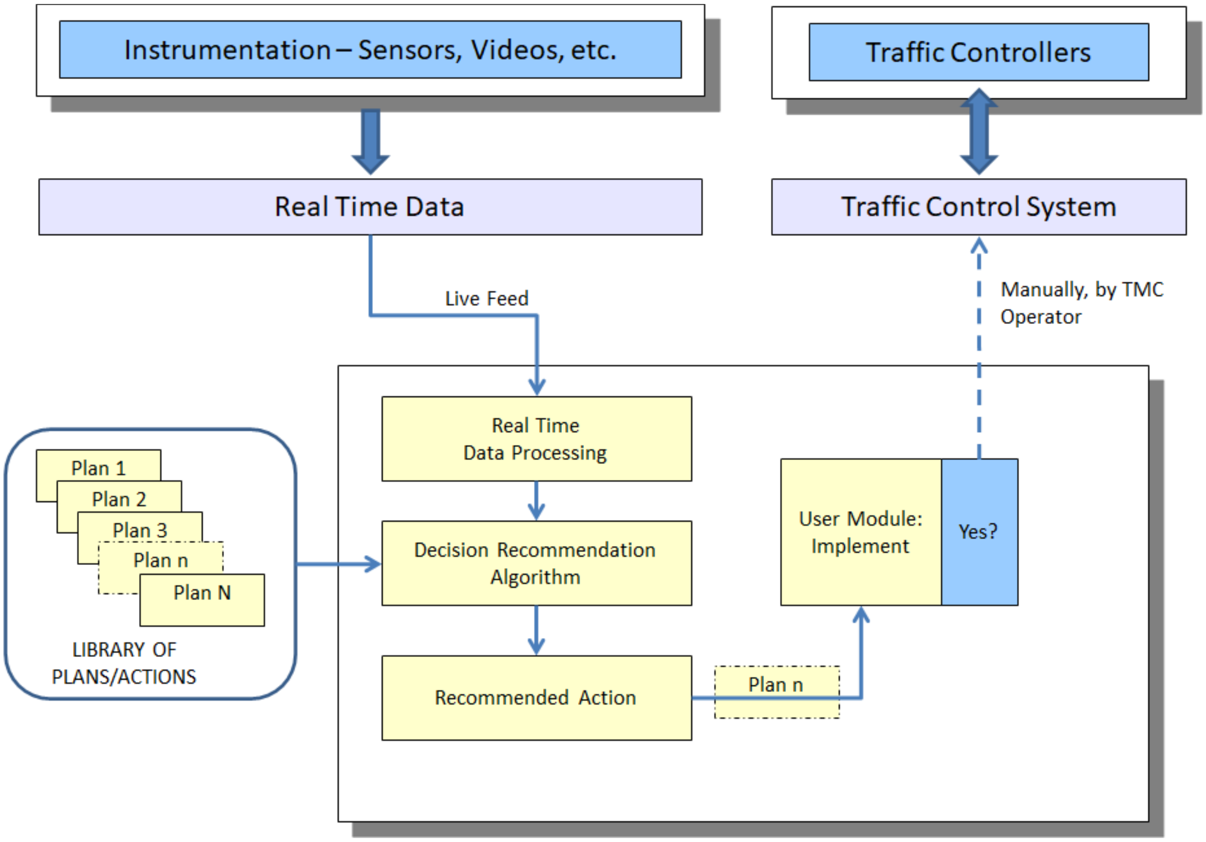
Figure 32. NYSDOT Regional Diversion Plans—Sample Extract

These diversion plans form the foundation to develop ICM response plans. An ICM response plan typically includes actions such as activating Variable Message Signs to notify road users, changes to traffic control (ramp metering, signal timing) and supplemented with enforcement (PD). These diversion plans have these elements and can be adapted for traffic management strategies that can be part of the ICM playbook. These plans need to be reviewed, and pre-approved for use. The triggers for these plans would be based on real-time traffic conditions that are monitored from the INFORM TMC and can be integrated into a decision support system (DSS) to will alert the TMC operators based on real-time traffic conditions. This DSS will be the heart of the ICMS that can be deployed to assist the region for their traffic management.

5.4 Decision Support Systems

Figure 33 presents a framework for a Decision Support Systems (DSS) that can be part of an ICMS. As seen in the figure, there is a library of pre-approved actions (response plans) that are activated based on field conditions in real time and presented to the TMC operators for their consideration. The operations can then in turn choose to act based on the recommendations.

Figure 33. Conceptual Framework for a Decision Support System



As indicated earlier, NYS has a playbook that they have developed for the diversion routes, and it can be adapted to support ICM actions and response plans. As seen in section 3, the AMS activities included simulation-based evaluation of three response plans that had incidents, designated diversion routes with enforcement and VMS, as well as a set of associated signal timing plans, which resulted in the travel times improved by as much as 30–40% with coordinated action. As part of the next steps in this research exploration effort, the framework for the DSS needs to be expanded, and the initial set of response plans (playbooks) need to be defined.

6 Summary and Next Steps

This research effort was conducted to explore the possibility of applying ICM in Suffolk County, NY. ICM is considered one of the key strategies of Transportation Systems Management and Operation (TSMO) which involves multimodal and multijurisdictional efforts in managing congestion caused by incidents along major commuter corridors. As discussed in this report, NYSDOT R10/INFORM and SCDPW are the two main stakeholders for managing traffic in Suffolk County. They have established excellent working relationships, and staff in their operations and planning group are well known to each other. They routinely coordinate actions during planned events such as 4th of July fireworks, U.S. Open Golf Tournaments, and unplanned events such as weather (snowstorms), and incidents. Thus, an excellent foundation exists on which to build additional coordinated traffic management strategies, such as ICM.

The two stakeholders are very different in the size and footprints of their ITS deployments. NYSDOT R10/INFORM happens to be one of the most mature ITS systems in the country and includes large-scale deployments of travel time sensors, point flow measurements, variable message signs, with centralized traffic management from the INFORM TMC. NYS owns and provides routine maintenance of their ITS equipment. SCDPW on the other hand has a smaller footprint and, with their rather unique Intermunicipal Agreements (IMA), do not maintain the equipment in the field as it is the responsibility of the local jurisdiction (municipalities, towns, or villages), but does retain operational control.

Both agencies are, however, on the same level in terms of traffic signal controllers and central traffic control system software. This provides the opportunity to take coordinated action in terms of applying specific signal timing plans as part of any response plans developed expressly to support traffic management.

The effect of COVID-19 on public agencies, that rely on federal/state/local funding to build, operate, and maintain their ITS infrastructure, has been very severe. New York State and Suffolk County have diverted large parts of their resources toward managing the pandemic, given that NYS was the epicenter of the initial breakout in the country (HR&A Advisors, 2020). This has also impacted their capital programs and deferred future investments. This highlights an increased need for coordination and efficient use of existing resource (ITS Infrastructure) to manage traffic. Additionally, there has been a shift away from public transit and into private automobile use, which, if sustained, has the potential to increase the importance of traffic management in the Long Island region.

There are existing tools available in the region—INFORM, Transcom, Waze—that can be used to develop strategies on top of the existing ITS footprints of both NYSDOT R10 and SCDPW to manage traffic in a coordinated effort. For this research effort, a data driven approach was adopted using the available data sources to analyze, quantify, and identify the types of incidents and their traffic impacts. Traffic simulation was then used to evaluate the benefits of coordinated action. The outline for response plans were developed as part of these analyses.

One of the recurring themes in the coming years in the development and application of traffic models will be the use of the newer types of data such as vehicle probe data from AVL/GPS, travel time, vehicle trajectories, detailed information from the Connected Vehicle systems, etc. as part of model development. The possibility of developing "living, breathing models" that can be updated using real-time information and be embedded in traffic management centers (operations) is very real, and a far cry from the traditional view of models viewed as part of planning applications based on historical data. Traffic analysis tools (i.e., multiresolution traffic simulation models) are being utilized in real-time ATM/ATDM applications, such as Integrated Corridor Management (ICM), Active Transportation Demand Management (ATDM), and Adaptive Traffic Signal Control.

Figure 34. Blended Use of Models for Planning and Operations

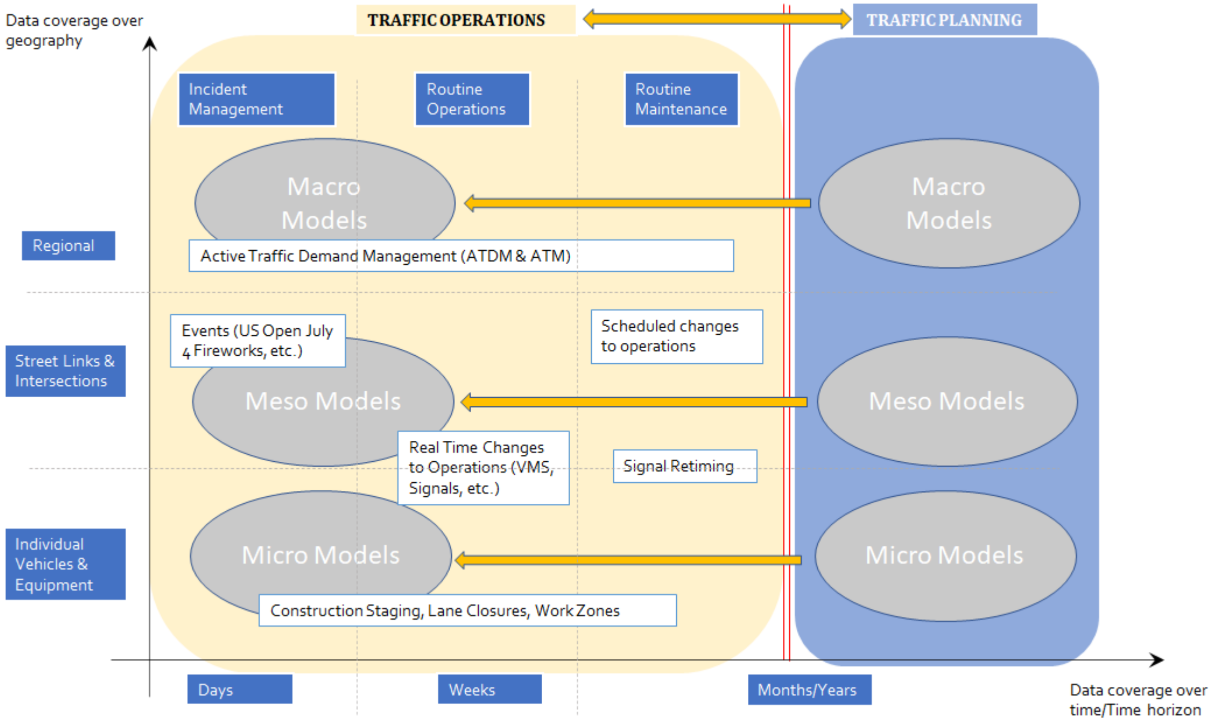


Figure 34 presents a gradual merging of planning and operations using data sets and tools that support analysis in real time. This trend will allow a faster response to evolving traffic conditions in the field. The analysis tools have been expanding and now provide support to run large-scale models in real time in TMCs and have been integrated into real-time decision support systems that are a key element of the ICM toolbox (Aimsun, 2020), (PTV Group, 2020), (Immense.AI, 2020). These data intensive approaches are becoming more practical as the private sector has started offering paid/free subscriptions to these newer data sources. A few such offerings include the following:

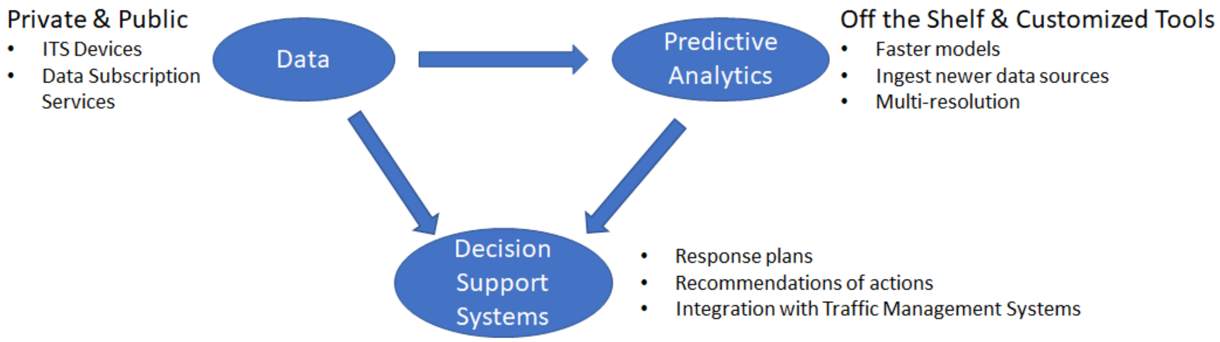
- INRIX (INRIX, 2020), Streetlight (StreetlightData, 2020), and HERE (HERE, 2020) have created mature platforms that provide users the ability to focus on their areas of interest and analyze traffic patterns (travel time, speeds, and Origin-Destination patterns) over specific time periods/intervals.
- There are newer players in this space such as Wejo (Wejo, 2020), who are building partnerships with automobile manufacturers to leverage data from their connected vehicles and provide similar platforms.
- Waze is one of the most popular navigation apps, that has a companion Waze for Cities (Waze, 2020) program that allows governmental agencies to interact with their end users directly via the App and provides the opportunity to analyze travel patterns (travel times) within their jurisdiction.
- FHWA has provided the NPMRDS data sets, which is free to all governmental agencies. This data set includes speed/travel time information on a lot of roadways (New York Metropolitan Transportation Council, n.d.).
- The University of Maryland (CAITT Lab) and their partnership with FHWA have developed a data fusion and analysis platform (RITIS) that leverages the INRIX data and made it available to governmental agencies that were part of their FHWA TMC Pooled Fund Study (Univ of Maryland, 2020).

Agencies are considering expanding their data sharing agreements and exploring data subscription services. These are items that are currently in progress within the region: NYS is in discussions with Waze to integrate their data feeds with Transcom, SCDPW is in discussions with Waze to become a partner in their Waze for Cities program, and NYS is a partner in the RITIS program.

As availability of funds to maintain large ITS footprints become constrained, the agencies can consider developing hybrid approaches of using their ITS devices in conjunction with private data service providers to have a robust data set to support their operations and planning efforts. By leveraging such data sources (a few of which were explored in this research effort), building tools that will be available in the TMC for the operations staff to run evaluation in real time (or near real time) as part of Integrated Decision Support Systems, would be the logical next step in progressing this ICM exploration.

Looking ahead there are three themes that need to be considered to further the ICM exploration for this region. They are (a) Data, (b) Predictive Analytics, and (c) Integrated Decision Support in Traffic Management Systems. These three themes and their relations are presented graphically in Figure 35.

Figure 35. Recommended Next Steps



The region is well underway with the data-related items and has been laying the foundations for incident response plans. Building on these advancements, and the solid working relationship of NYSDOT and Suffolk County, the next step would be to develop a framework for a Decision Support System, integrate it into the Traffic Control System, and provide access in the TMC.

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Appendix—Model Development and Calibration

As described in the executive summary of the report, a detailed microsimulation model was developed and used as a platform to analyze the different ICM scenarios. This appendix goes into detail how the model was developed, calibrated, and validated.

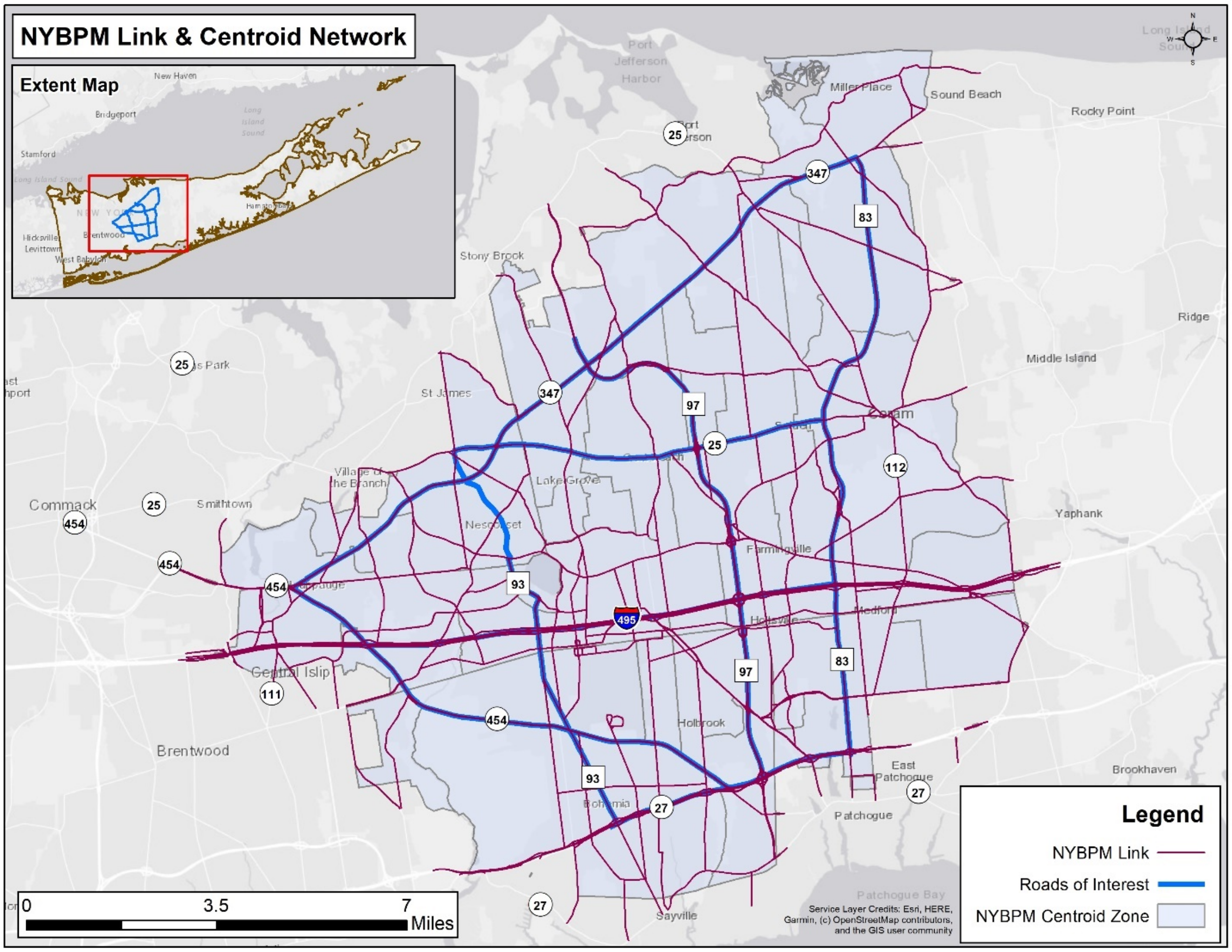
A.1 Time Period of Analysis

As most incidents occurred during the busiest times of day, namely the Weekday a.m. and p.m. and p.m. peaks, those were the time periods analyzed. A weekday a.m. and weekday p.m. peak period simulation model was developed which cover 6:00 a.m. to 10 a.m. and 3:00 p.m. to 7:00 p.m., respectively.

A.2 Base Model Development

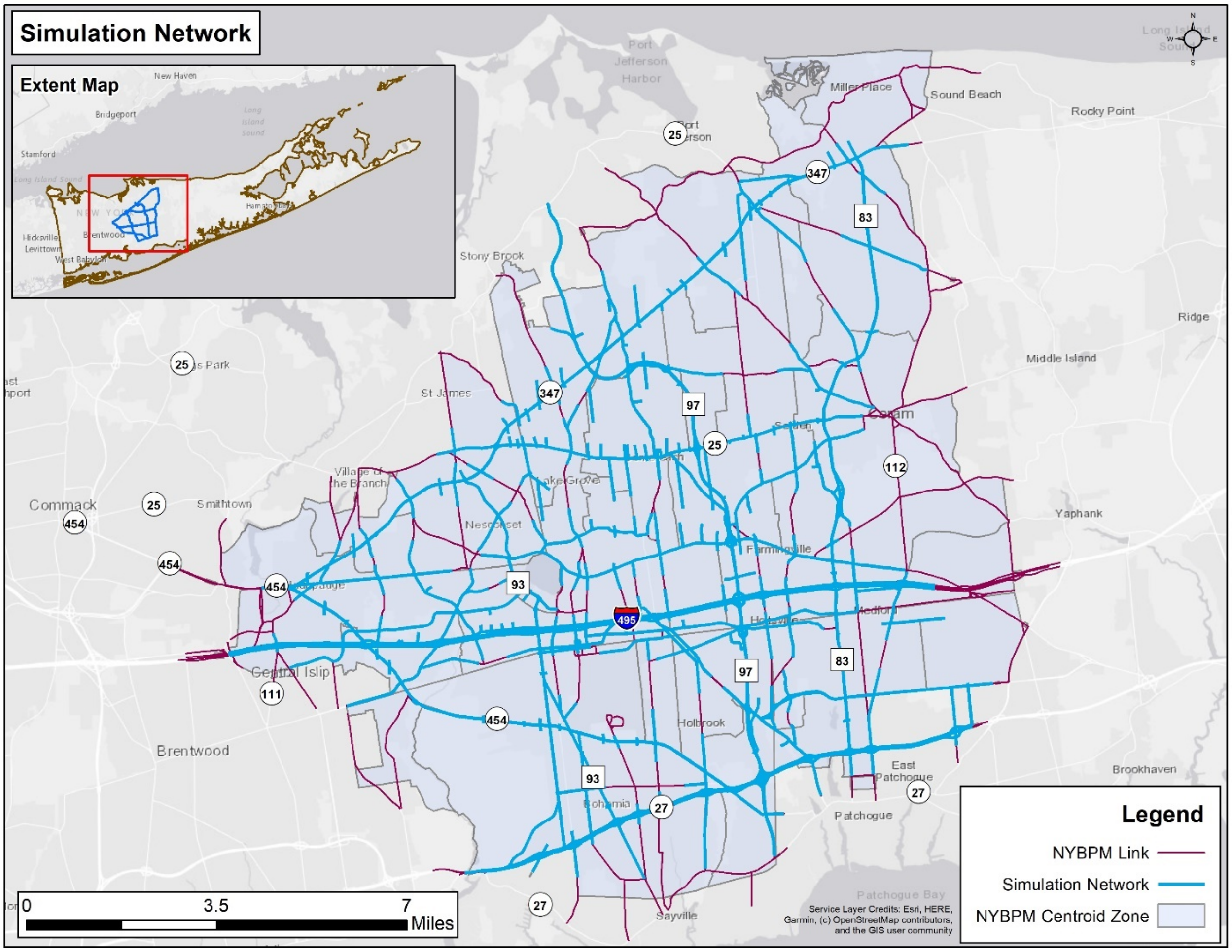
The New York Best Practice Model (NYBPM) was used as a starting point for model development. A subarea of the NYBPM roadway network was extracted using TransCAD. The subarea contains the relevant roadway links and centroid zone configuration which can be shown graphically in Figure A-1**.** The NYBPM provides information on the roadway network including functional class, number of lanes, posted speed limit, etc. This served as a starting point for the network development. The network coverage was reviewed and modified accordingly to provide an accurate representation of the study corridors.

Figure A-1. NYBPM Link and Origin-Destination Zone Network Overview



The final simulation network is presented below in Figure A-2 and contains approximately 945 lane miles of roadway. The roadway link parameters were reviewed and updated according to the latest Google Street view imagery, including verification of speed limits, number of lanes, and intersection control. All signal timing information provided by NYSDOT and SCDPW was coded into the network. For intersections where signal timing information was not available, simple signal timings were created based on data at adjacent intersections.

Figure A-2. Simulation Network



The NYBPM Centroid Zone structure served as the basis for the origin/destination zone structure and is shown graphically in Figure A-1 and Figure A-2. The NYBPM Centroid Zone structure follows the US Census Tract boundaries. These zones represent areas which bound the start and end points of a trip, known as origin and destinations. StreetLight data was the basis for estimating total number of trips for each origin/destination pair. The StreetLight trip tables provide the average total # of vehicle trips between OD pair by hour for a typical weekday. These trip tables were adjusted based on field data to more accurately represent the trip patterns using up-to-date traffic count data provided by NYSDOT and SCDPW, this process is called Origin-Destination Matrix Estimation (ODME) and was performed within TransModeler. After that, the trip tables were disaggregated into different vehicle classes. Vehicle classification data was used to apply factors to the total # of trips to disaggregate into the different vehicle classes of Autos and Buses/Trucks. Approximately 93% of vehicles are Autos and 7% Buses/Trucks for both the a.m. and p.m. trip tables.

The trip tables for the a.m. and p.m. periods are shown graphically in Figure A-3 and Figure A-4, respectively, and represent total number of trips by origin and destination zone. The a.m. period presents a concentrated number of trips for a select number of zones, primarily on the eastern and western borders of the study area. Conversely, the p.m. period shows much more dispersed trip pattern with greater number of total trips. In addition to the eastern and western borders attracting and generating high number of trips so are the northern and southern boundaries. This indicates a less focused directional pattern of traffic for the p.m. period.

Figure A-3. StreetLight OD Trips for Weekday AM (6 a.m.–10 p.m.)

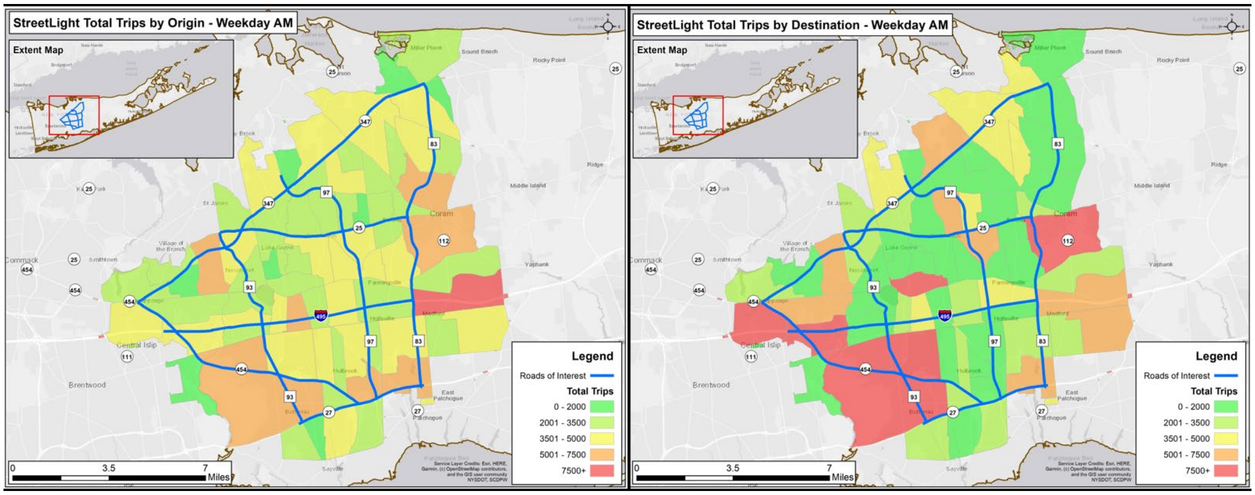
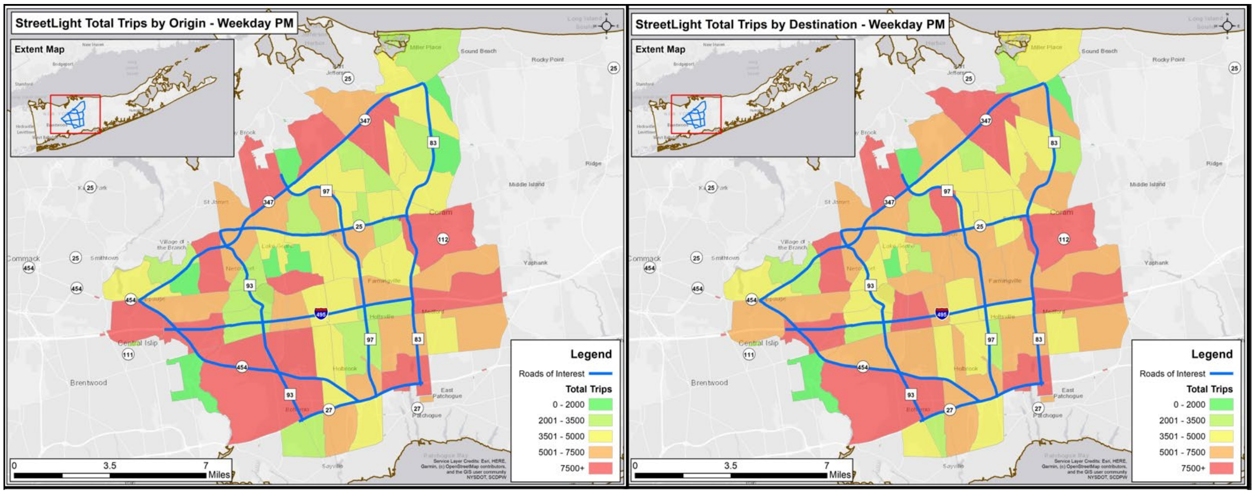
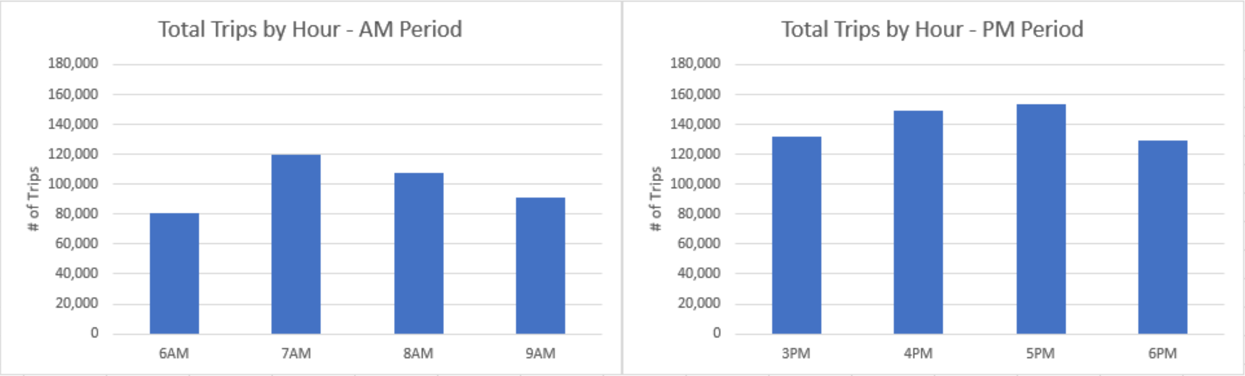


Figure A-4 StreetLight OD Trips for Weekday PM (3 a.m.–7 p.m.)



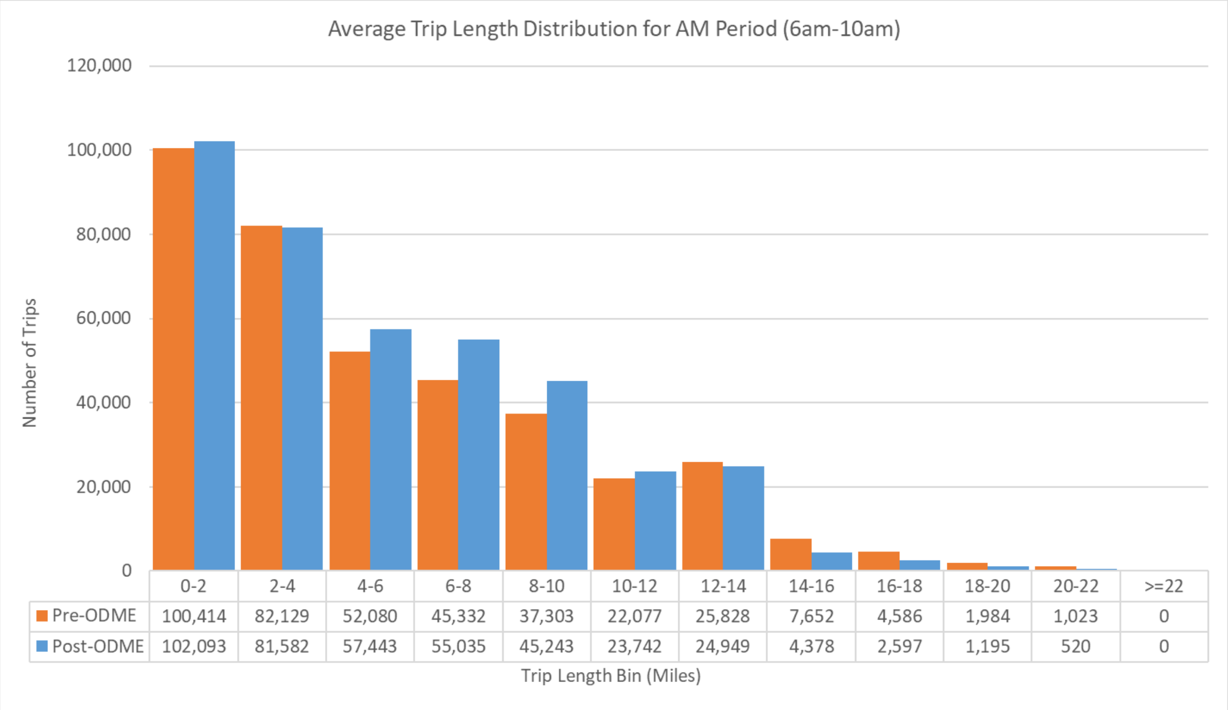
The total number of trips by hour and period shown in Figure A-5, present the variation in the trips generated by hour. The a.m. period shows a steep increase in trips from 6 a.m.–7 a.m. to 7 a.m.–8 a.m. and gradually decreases until the end of the period. The p.m. period experienced the highest number of trips between 5 a.m.–6 a.m. The p.m. period, on average, contains approximately 40,000 more trips compared to the a.m. period.

Figure A-5—Total Trips by Hour by Period



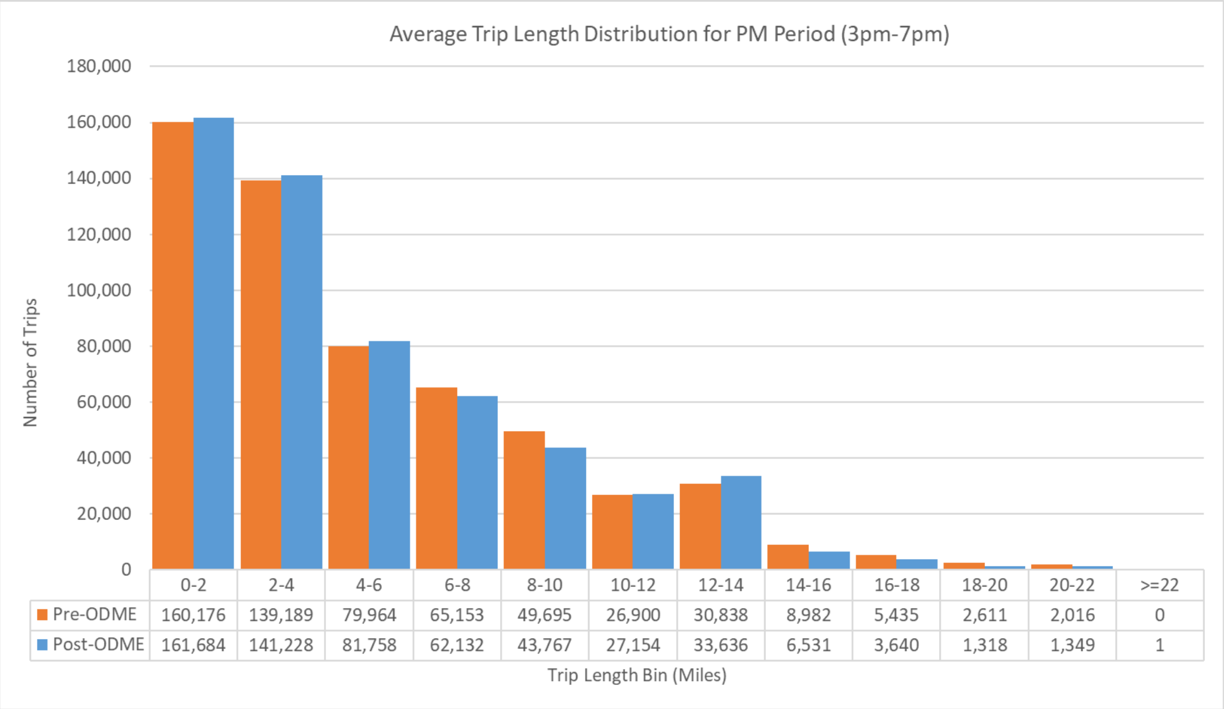
During the ODME process, it is possible for simulated trip lengths between OD pairs to change in order to best match the field traffic count data. Figure A-6 and Figure A-7 below present the Pre-ODME and Post-ODME Trip Length Distributions for the AM and PM Periods, respectively. For the AM Period, the ODME process resulted in an increase in number of trips which fell between 0–2 miles, 4–6 miles, 6–8 miles, 8–10 miles, and 10–12 miles. The p.m. period showed a more comparable results between the Pre and Post ODME trip length distributions. There was an increase in shorter trips from 0–6 miles while an increase in trips 12–14 miles was observed. In summary, the average trip changed from 5.5 miles/trip to 5.41 miles trip (2% change), and from 5.08 miles/trip to 4.91 miles/trip (3% change) in the a.m.–7 a.m periods, respectively.

Figure A-6. Average Trip Length Distribution for Morning Period



	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	>=22
🟧 Pre-ODME	100,414	82,129	52,080	45,332	37,303	22,077	25,828	7,652	4,586	1,984	1,023	0
🟦 Post-ODME	102,093	81,582	57,443	55,035	45,243	23,742	24,949	4,378	2,597	1,195	520	0

Figure A-7. Average Trip Length Distribution for Evening Period

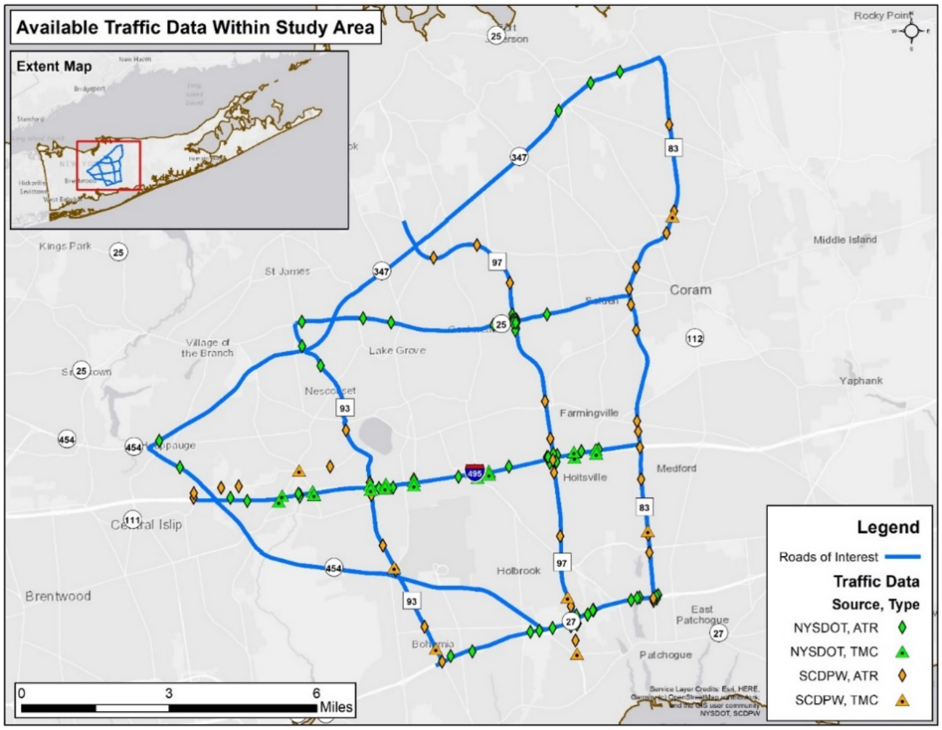


	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	>=22
🟧 Pre-ODME	160,176	139,189	79,964	65,153	49,695	26,900	30,838	8,982	5,435	2,611	2,016	0
🟦 Post-ODME	161,684	141,228	81,758	62,132	43,767	27,154	33,636	6,531	3,640	1,318	1,349	1

A.3 Existing Conditions

To develop an existing conditions model to serve as a baseline for analysis, a comprehensive dataset was developed from traffic data made available from NYSDOT and SCDPW. The locations of available data are presented in Figure A-8 and contain data from 2015 to 2019. As shown in the figure, there is at least one ATR or TMC on each of the study corridors. This data was reviewed and checked for consistency and a validation dataset composed of 33 locations was created to validate the mode.

Figure A-8. Available Traffic Data within the Study Area



A.3 Calibration and Validation

Typically, model calibration requires modifying link characteristics and driving behavior at either the local (i.e., section, vehicle class) or global level (i.e., all objects). This may include adjusting parameters such as reaction time or a vehicle type's acceleration factor. The car following model used if the General Motors Car-Following model. Several simulation input characteristics can be found below in Table A-1 through Table A-3, most of which are the default settings.

Table A-1. Vehicle Class Parameters

Vehicle Class	Sub-Class	Mean Length (ft)	Std dev (ft)	Min Length (ft)	Max Length (ft)	Width (ft)
Autos	N/A	15.3	1.7	13.6	18.8	6.0
Trucks	Light	31.2	4.4	17.0	34.0	8.0
	Heavy	69.1	7.5	40.7	75.0	8.5
Bus	N/A	34.0	2.0	31.7	36.6	7.0

Table A-2. Look-Ahead Parameters

Parameters	Input
Time Headway (sec)	90
Minimum # of Links	2
Maximum # of Links	5

Table A-3. Car Following Acceleration Factors

% Of Drivers	Emergency (ft/s^2)	Car Following (ft/s^2)	Free Flow (ft/s^2)
5	-0.50	-0.20	-0.10
25	-0.30	-0.10	-0.05
30	0.00	0.00	0.00
25	0.05	0.10	0.30
15	0.10	0.20	0.50

The simulation used Stochastic Shortest Path Assignment model which utilized Travel Time as the user cost for both a.m. and p.m. models. The maximum number of iterations was set at 200 with a relative gap of 0.01 while using 100% demand for the p.m. model. The p.m. model converged at the 166th Iteration. The maximum number of iterations was set at 260 for the AM Model with a relative gap of 0.01 while using 100% demand. The a.m. model converged at the 221st iteration.

To determine if the simulation was sufficiently calibrated, a validation target was defined. This validation target was to match at least 75% (25 locations) of the counts with GEH of 5 or less for each hour of the simulation. As presented in Table A-4 below, the model outputs met the validation targets for all hours in both the a.m. and p.m. periods.

Table A-4. Simulation Validation

AM Simulation Count Validation (% of locations)				
Hour	**6AM - 7AM**	**7AM - 8AM**	**8AM - 9AM**	**9AM - 10AM**
GEH < 5	88%	79%	82%	85%
GEH < 10	91%	91%	100%	97%

PM Simulation Count Validation (% of locations)				
Hour	**3PM - 4PM**	**4PM - 5PM**	**5PM-6PM**	**7PM-8PM**
GEH < 5	76%	76%	79%	76%
GEH < 10	94%	100%	94%	88%

Figure A-9 and Figure A-10 present the goodness of fit for the a.m. and p.m. Model Counts versus Observed Counts. The coefficient of determination presented as R^2 represents the "goodness of fit" between model output and the observed traffic counts. The closer to the value of 1, the better the fit. As presented below, the R^2 for the a.m. and p.m. models are .9856 and .9691, respectively.

Figure A-9. AM Model Count Validation—Goodness of Fit

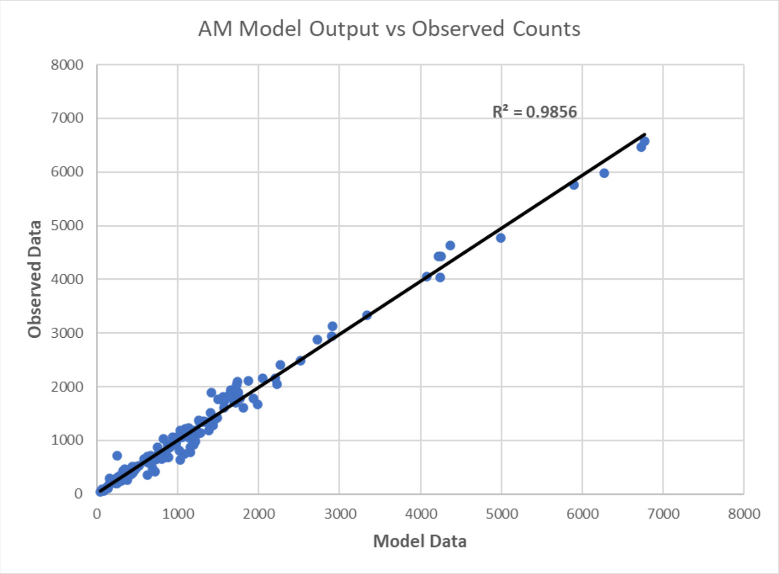
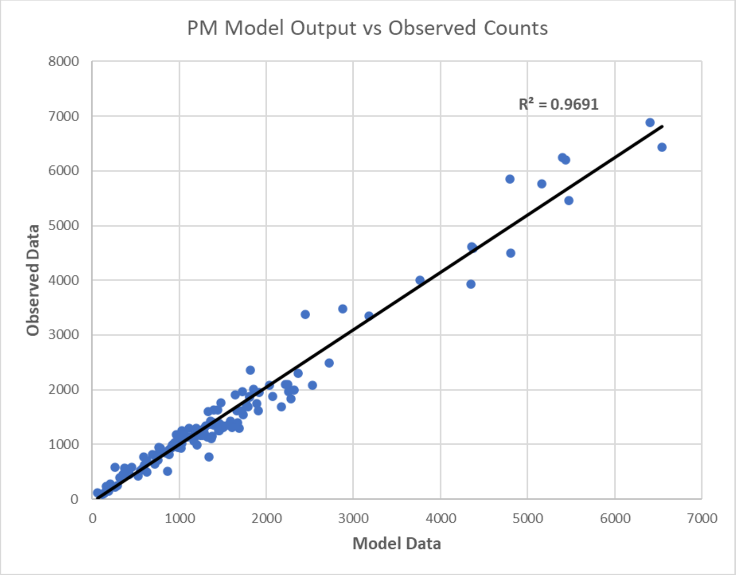


Figure A-10. PM Model Count Validation—Goodness of Fit

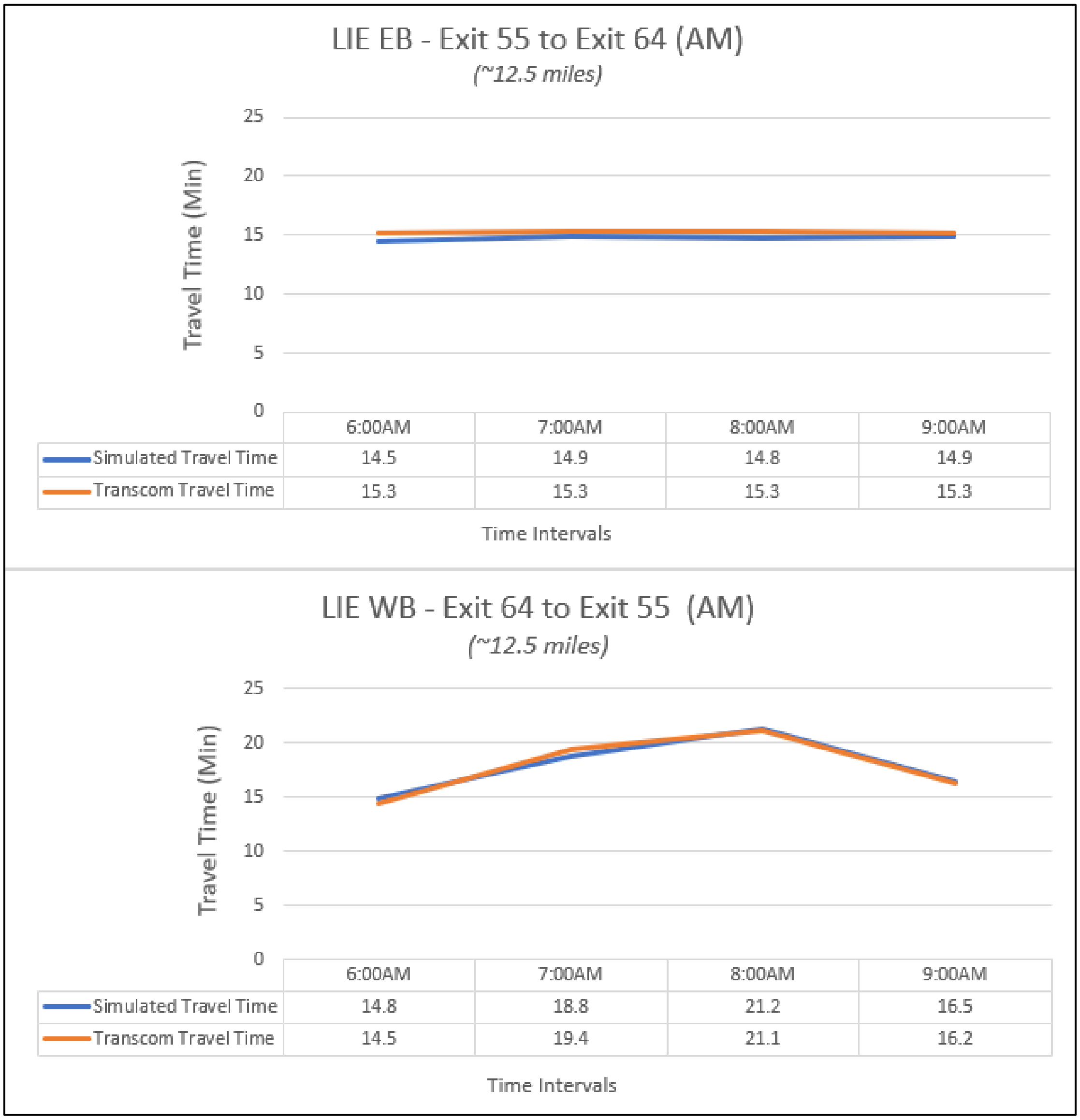


In addition to traffic count validation, simulated model travel times were also reviewed and compared against observed travel time information. Using the TRANSCOM DFE, travel time data was downloaded for the following roadways segments: Long Island Expressway between Exit 55 and Exit 64, SR454 between New Highway and Sunrise Hwy (SR27), and SR347 between SR25A and SR454. The model travel time output was compared against the data and is presented in Figure A-11 through Figure A-13 for the a.m. period and Figure A-12 through Figure A-14 for the p.m. period.

AM Period

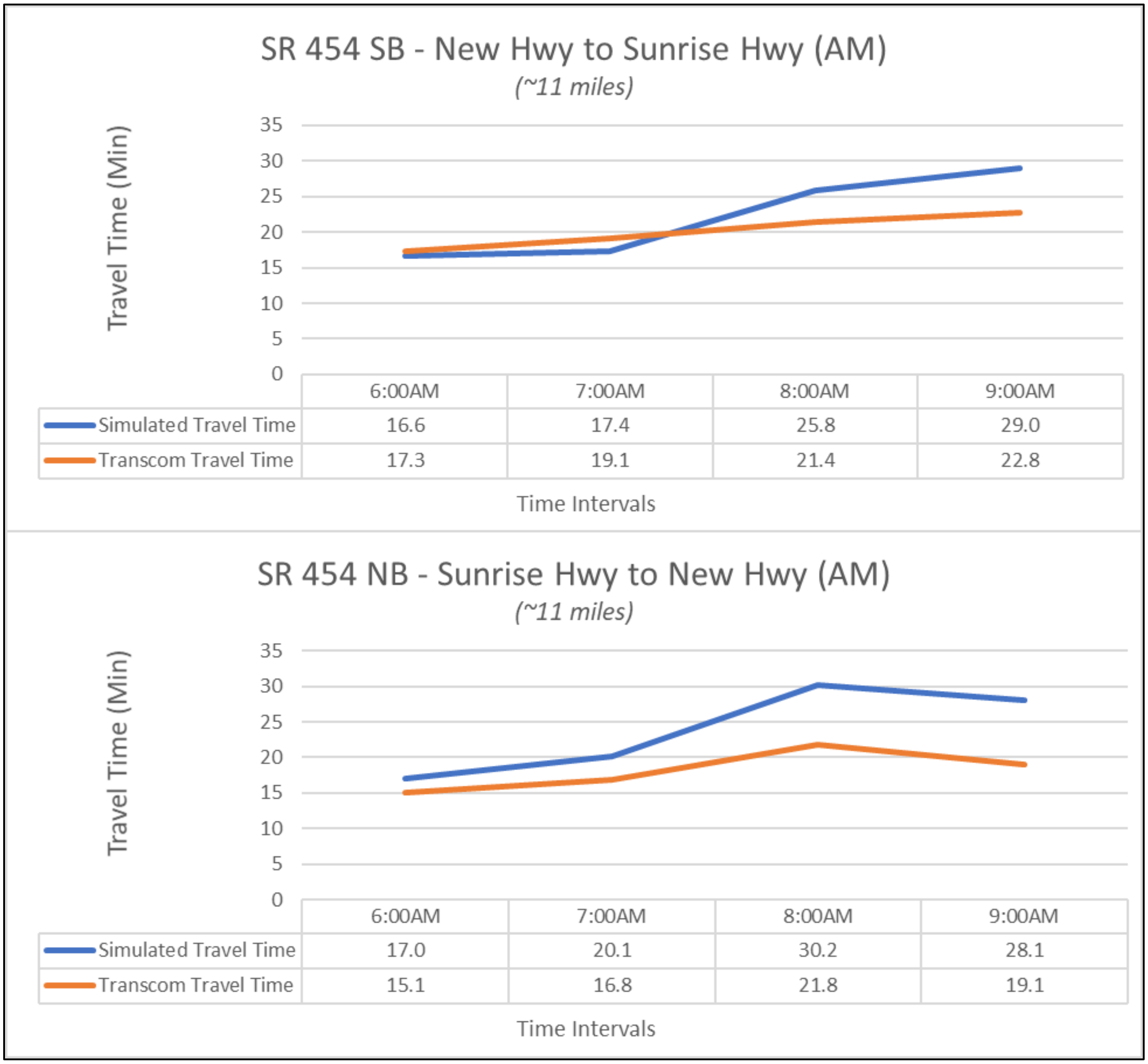
The Eastbound travel time on the LIE was within 10% of the observed travel time as shown below in Figure A-11. The simulated travel time in the Westbound direction is within 5% or 1 minute of the observed travel time for all time intervals.

Figure A-11. AM Travel Time Validation—LIE from Exit 55 to Exit 64



The travel time comparison for SR 454 between New Highway and Sunrise Hwy (SR27) during the p.m. period can be found below in Figure A-12. For SR 454, the simulated travel time closely matches the observed travel time between 6 a.m. and 8 a.m. for both the Southbound and Northbound directions. After 8am, the simulated travel time begins to deviate with as much as a 10-minute difference for the Northbound direction and a 6-minute difference for the Southbound direction. This difference may be attributed to the lack of most recent signal timings in the field along this route. Overall, the travel time trend is consistent between the simulated travel time and observed travel time. For the Southbound direction, travel time gradually increases from 6 a.m.–10 a.m. For the Northbound direction, travel time increases until 9 a.m. and decreased afterwards.

Figure A-12. AM Travel Time Validation—SR 454 from New Hwy to Sunrise Hwy

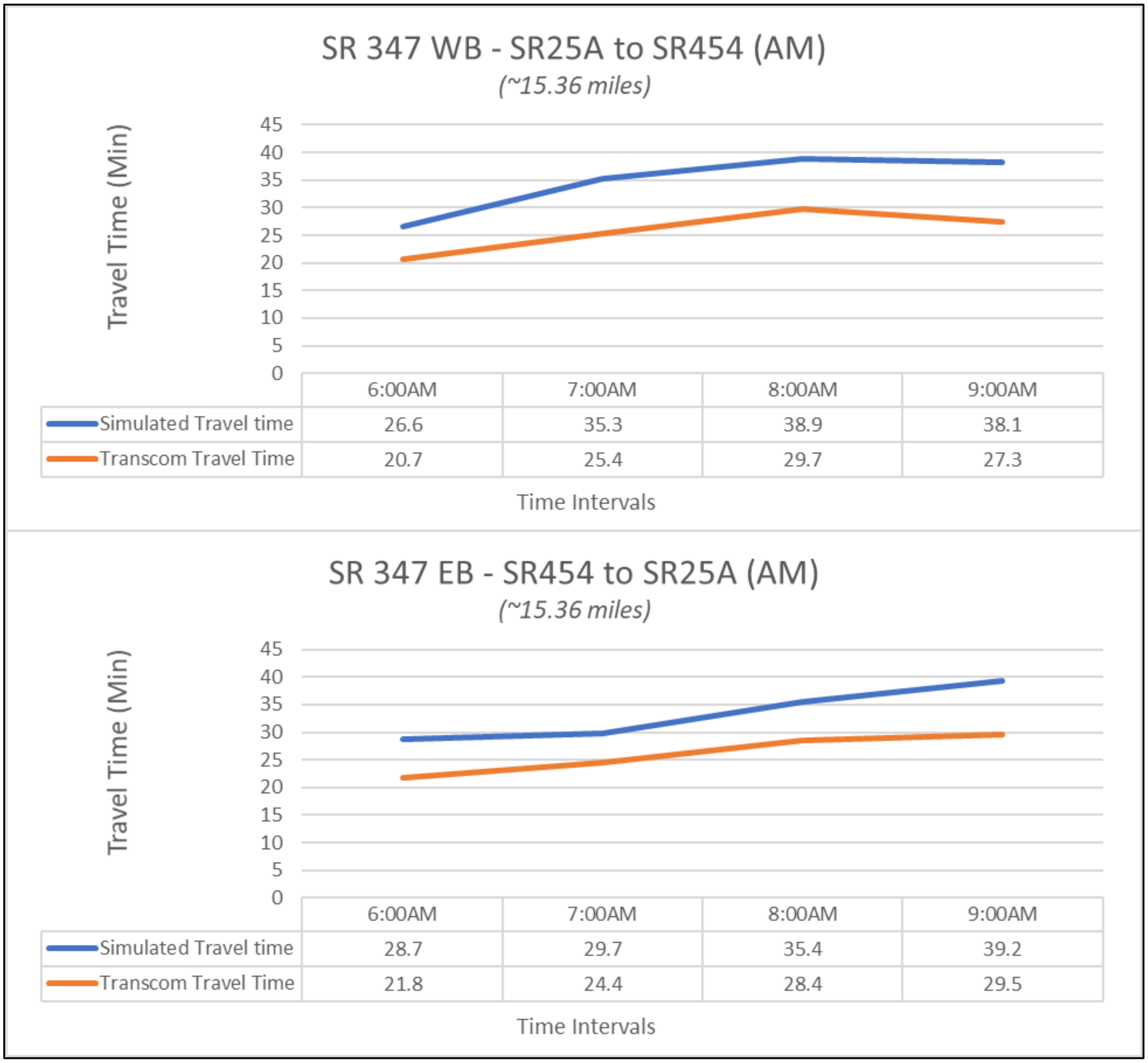


	6:00AM	7:00AM	8:00AM	9:00AM
Simulated Travel Time	16.6	17.4	25.8	29.0
Transcom Travel Time	17.3	19.1	21.4	22.8

	6:00AM	7:00AM	8:00AM	9:00AM
Simulated Travel Time	17.0	20.1	30.2	28.1
Transcom Travel Time	15.1	16.8	21.8	19.1

The travel time comparison for SR 347 between SR25A and SR454 can be found below in Figure A-13. Overall, the simulated travel time is slower than the observed travel time data from Transcom. On average, SR 347 in the Westbound direction is approximately 9 minutes slower than the observed travel time and 7 minutes slower in the Eastbound direction. However, the trend for both the Eastbound and Westbound direction are consistent between simulated and observed travel times.

Figure A-13. AM Travel Time Validation—SR 347 from SR25A to SR454



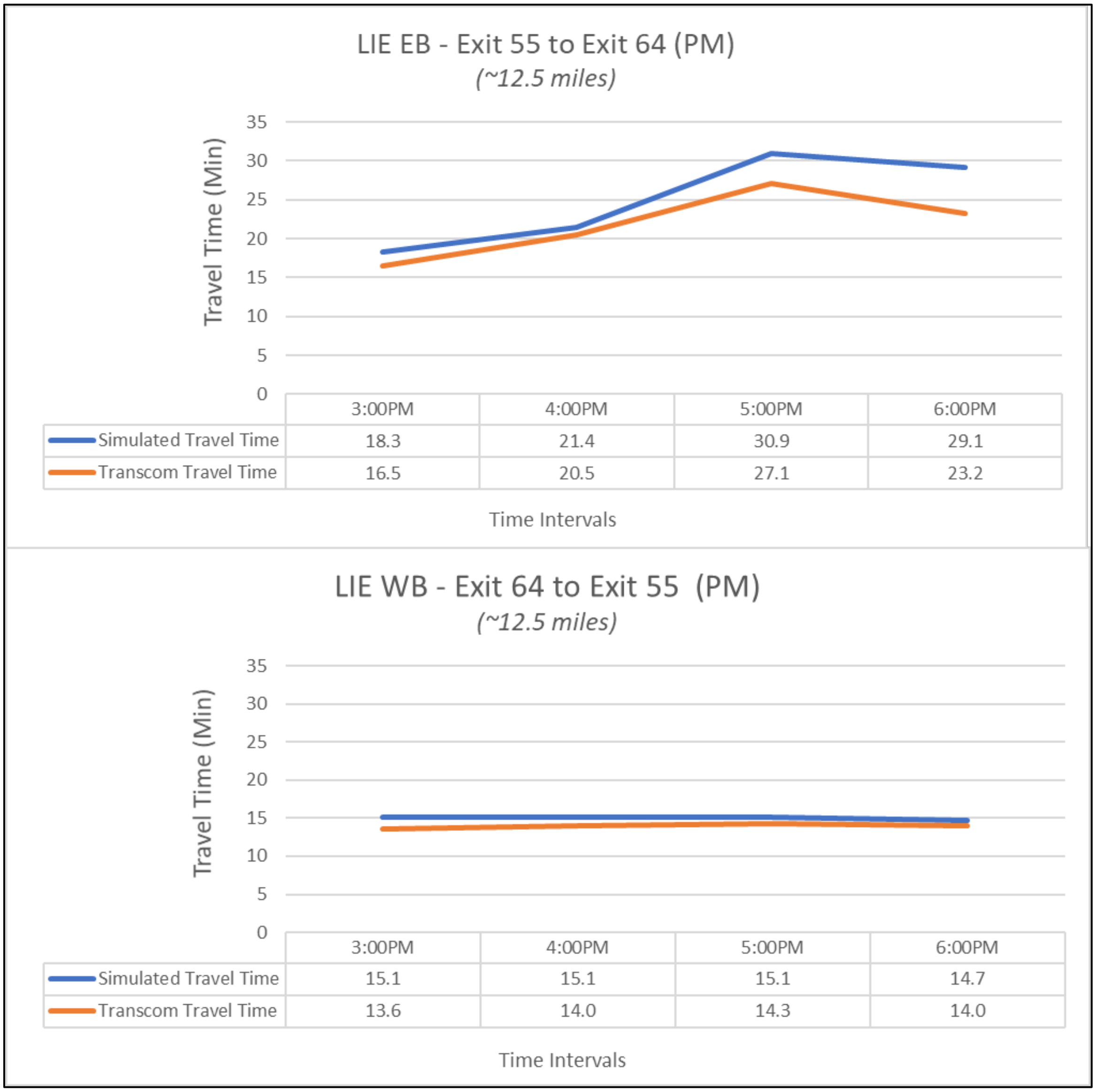
	6:00AM	7:00AM	8:00AM	9:00AM
Simulated Travel time	26.6	35.3	38.9	38.1
Transcom Travel Time	20.7	25.4	29.7	27.3

	6:00AM	7:00AM	8:00AM	9:00AM
Simulated Travel time	28.7	29.7	35.4	39.2
Transcom Travel Time	21.8	24.4	28.4	29.5

PM Period

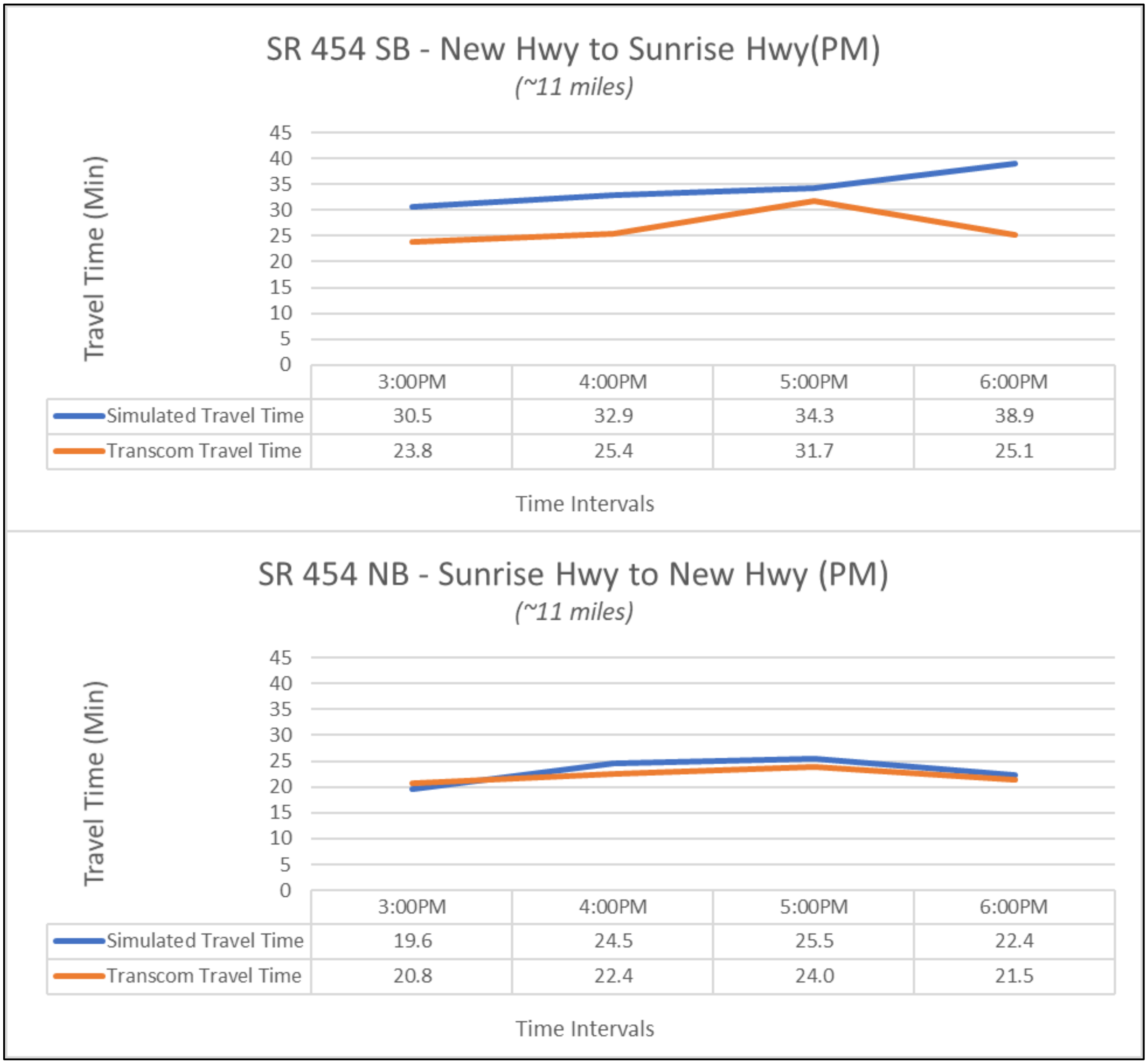
The travel time comparison for the LIE during the p.m. period can be found below in Figure A-14. The Eastbound travel time on the LIE was within 11% for 3 of the 4 hours of simulation, while the last hour the simulated travel time was approximately 6 minutes slower than the observed data. The Westbound travel time for the p.m. simulation closely matched the observed data being within 8% of the observed travel time, on average. The trend for both the Eastbound and Westbound directions are in close agreement. For the Eastbound direction, the slowest time interval is 5 p.m.–6 p.m. for both the simulated and observed travel time. The trend for the Westbound direction is relatively flat for both the observed and simulated travel times.

Figure A-14. PM Travel Time Validation—LIE from Exit 55 to Exit 64



The travel time comparison for SR 454 between New Highway and Sunrise Highway during the p.m. period can be found below in Figure A-15. The Northbound travel times are within 2 minutes for all time intervals. In the Southbound direction, the simulation is approximately 8 minutes slower, on average, compared to the observed travel time. This difference may be attributed to the lack of most recent signal timings in the field along this route.

Figure A-15. PM Travel Time Validation—SR 454 from New Hwy to Sunrise Hwy



	3:00PM	4:00PM	5:00PM	6:00PM
Simulated Travel Time	30.5	32.9	34.3	38.9
Transcom Travel Time	23.8	25.4	31.7	25.1

	3:00PM	4:00PM	5:00PM	6:00PM
Simulated Travel Time	19.6	24.5	25.5	22.4
Transcom Travel Time	20.8	22.4	24.0	21.5

The travel time comparison for SR 347 during the p.m. period can be found below in Figure A-16. For the Westbound direction, the simulated travel time is in close agreement during the first 2 hours of simulation then begins to deviate by up to 10 minutes in the final hour. Whereas the observed travel is relatively flat and remains at approximately 31 minutes. In the Eastbound direction, the travel time matches very well until the last hour where the simulated travel time exceed observed travel time by approximately 10 minutes.

Figure A-16. PM Travel Time Validation—SR 347 from SR25A to SR454

Endnotes

[1] https://en.wikipedia.org/wiki/Suffolk_County,_New_York

[2] Intelligent Transportation Systems—Integrated Corridor Management https://www.its.dot.gov/research_archives/icms/knowledgebase.htm

[3] TRANSCOM Data Fusion and Analysis Tools: https://xcmdfe.xcmdata.org

[4] Travel Time Information Systems: https://www.dot.ny.gov/divisions/operating/oom/transportation-systems/systems-optimization-section/ny-moves/travel-time-information-systems

[5] New York Best Practices Model (NYBPM): https://www.nymtc.org/Data-and-Modeling/New-York-Best-Practice-Model-NYBPM

[6] TransCAD Transportation Planning Software: https://www.caliper.com/tcovu.htm

[7] Traffic Data Viewer: https://www.dot.ny.gov/tdv

[8] TRANSCOM: https://www.xcm.org/XCMWebSite/Index.aspx

[9] Transportation Analytics On-demand| StreetLight Data: https://www.streetlightdata.com/

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