Integrated Corridor Management Concept of Operations (ConOps) for the I-495 Corridor (ICM-495) in the New York Metropolitan Region

Version 1.0

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1. INTRODUCTION

The Interstate 495 (I-495) Corridor, centrally located in the New York/New Jersey metropolitan area with a population of 19.8 million people, is the most densely populated area in the United States. In response to the need to enhance mobility, safety and travel reliability across the region, partnering agencies and authorities, led by the New York City Department of Transportation (NYC DOT) and New York State Department of Transportation (NYSDOT) submitted and received a United States Department of Transportation (USDOT) grant to support the development of a Concept of Operations (ConOps) for Integrated Corridor Management (ICM) on the I-495 corridor.

The purpose of the ICM initiative in this corridor (henceforth referred to as the ICM-495 corridor) is to align relevant congestion management processes across the metropolitan region in order to build integrated, balanced and responsive transportation programs and systems throughout the corridor. These programs and systems will actively reduce congestion; address traveler demand; monitor and control traffic; and improve the mobility, reliability, and safety of all users including: mass transit, expressways, arterials, freight and passenger travel, and public and private transportation modes.

1.1. DOCUMENT OVERVIEW

This document presents the ConOps for the ICM-495 Corridor and is developed based on input from regional operations, maintenance, and systems management stakeholders.

The ConOps is focused on achieving the following ICM-495 Corridor goals (for additional information on goals and associated objectives, see the *ICM-495 Concept of Operations Study Systems Engineering Management Plan*):

Goal 1. Strengthen corridor level operational collaboration to enable coordinated responses to events in the corridor;

Goal 2. Improve ability to dynamically operate corridor systems and facilities with an emphasis on travel reliability;

Goal 3. Enhance management of short-term and long-term demand-supply imbalances in the corridor;

Goal 4. Improve availability and use of travel choices in the corridor through targeted and actionable information.

Guided by these goals, the ConOps defines the institutional and operational frameworks and agreements, protocols, and approaches and strategies that will be in place after the implementation of the I-495 Corridor's ICM Concept. The ConOps also includes the roles and responsibilities between key stakeholders that own, manage, operate, and maintain the systems that are part of the operational framework. Additionally, this document:

- Supports New York Metropolitan Transportation Council's (NYMTC) Program, Finance, and Administration Committee (PFAC) Resolution # 403 adopted on April 22, 2015.
- Supports NYSDOT's strategic vision for Active Transportation Demand Management (ATDM) for reliable, seamless door to door travel.
- Aligns with the relevant congestion management processes for the New York/North Jersey metropolitan region.

- Incorporates components of existing Transportation System Management and Operations (TSMO) deployments where feasible with modified and new concept solutions as needed.

This ConOps was developed using partner and stakeholder feedback obtained during the outreach activities described in Table 1-1. (For additional information see the *ICM-495 Concept of Operations Study, Technical Memorandum #3: Results of Partnering Agency, Authority, and Stakeholder Outreach, Appendix A*).

Table 1-1. Overview of ICM-495 Partner and Stakeholder Outreach Activities

Activity	Stakeholders	Outcome
ICM-495 Corridor ConOps Study Planning Workshop (September 9, 2015)		
A one-day workshop to identify operational issues and potential corridor management strategies and opportunities to support the ConOps planning process.	The workshop included 49 stakeholders from the following agencies: NYSDOT, NYC DOT, NJDOT, NYMTC, NJTPA, NJT, MTA, Hudson TMA, PANYNJ, TRANSCOM, and USDOT.	A common understanding of the ICM concept as it applies to the travel contexts and constraints along the ICM-495 Corridor. The information gathered was used to: • Focus the stakeholder outreach and initial scenario development efforts • Supplement the current conditions and challenges of the corridor inventory • Support development of the performance metrics
Capability Maturity Model Workshop (March 8, 2016)		
A one-day workshop to introduce FHWA's TM CMF to regional stakeholders and to walk through the framework within the context of the ICM-495 Corridor.	Participation included stakeholders from the following agencies: NYSDOT, NYC DOT, PANYNJ, MTA, NYCT, LIRR, NYMTC, NJDOT, NJTPA, NJTA, TRANSCOM, NJIT, and FHWA.	A consensus-driven determination of the institutional capability for ICM across the corridor along with a set of 17 actions grouped by topic area and responsible agency – for use as a roadmap for regional stakeholders to advance TSMO capabilities in support of the ICM-495 Corridor ConOps.
One-on-One Interviews (April – September 2016)		
One-on-one meetings with partner agencies to identify agency-specific challenges, opportunities, and needs with regard to mobility across the corridor.	Interviews included: • MTA-NYCT and MTA Bus Company (April 5, 2016) • MTA B&T (April 19, 2016) • PANYNJ's PATH and TB&T (April 21, 2016) • LIRR (May 9, 2016) • JTMC (May 17, 2016) • NYCEM (September 21, 2016) • NJDOT (throughout the process in coordination with the New Jersey Northeast Corridor (NJNE) ICM ConOps development process) • NJT (July 21, 2016 and August 5, 2016 – as part of the NJNE ICM ConOps) • NJTA (July 12, 2016 – as part of the NJNE ICM ConOps)	Agency-specific feedback was gathered on the following topics and aggregated, summarized, and included in the *ICM-495 COIN Technical Memorandum.* • Planning and operational issues and considerations • Event and incident management • Information feeds, data sources, and data-driven decision-making • ATMS and traveler information systems • Freight and truck issues • Public-facing information • Capital projects • Legal and regulatory issues • Inter-agency coordination and Memoranda of Understanding • Technology installation and upgrades • ICM interface

Activity	Stakeholders	Outcome
Scenario Planning Workshop (August 2, 2016)		
A one-day workshop, set up as a series of roundtable discussions to identify potential TSMO solutions within the corridor. Scenarios highlighting events that would significantly impact corridor mobility were discussed along with possible strategies.	53 stakeholders participated from the following agencies: NYSDOT, NYC DOT, NYCEM, MTA NYCT, MTA LIRR, MTA Bus Company, MTA B&T, PANYNJ, NJDOT, NJTA, NJTPA, TRANSCOM, and FHWA.	Identification of existing operational gaps and proposed ICM strategies to address the 12 user needs identified through previous outreach efforts and presented during the workshop. User needs were refined post-workshop based on feedback received.

ATMS - Advanced Traffic Management System
B&T - Bridges and Tunnels
COIN - Corridor Operating Conditions, Inventory and Needs
FHWA - Federal Highway Administration
JTMC - Joint Transportation Management Center
LIRR - Long Island Rail Road
MTA - Metropolitan Transportation Authority
NJDOT - New Jersey Department of Transportation
NJIT - New Jersey Institute of Technology
NJT - New Jersey Transit
NJTA - NJ Turnpike Authority
NJTPA - North Jersey Transportation Planning Authority
NYCEM - NYC Emergency Management
NYCT - New York City Transit
PANYNJ - Port Authority of New York and New Jersey
PATH - Port Authority Trans-Hudson
TM CMF - Traffic Management Capability Maturity Framework
TB&T - tunnels, bridges, and terminals
TMA - Transportation Management Association
TRANSCOM - Transportation Operations Coordinating Committee

The remainder of this document consists of the following sections and content:

- Chapter 2 - lists references used in developing the ConOps.
- Chapter 3 - provides an overview of existing corridor operating conditions, inventory, systems, and management approaches.
- Chapter 4 - explains the justification and need for the ICM-495 Concept.
- Chapter 5 - describes the ICM-495 concept.
- Chapter 6 - presents the operational scenarios expected from the ICM-495 concept.
- Chapter 7 - summarizes the expected impacts of the ICM-495 concept.
- Chapter 8 - analyzes the expected improvements of the ICM-495 concept.

Note, additional information on desired changes and performance measures are included in *Appendix A: Description Tables of Desired Changes* and *Appendix B: Performance Measures*, respectively.

1.2. Intended Audience

The primary intended audience of this ConOps document includes regional stakeholder and organizational entities who operate and manage key components of the corridor transportation network. This includes New York and New Jersey state transportation agencies (NYSDOT and NJDOT), New York City's transportation agency (NYC DOT), and New York and New Jersey MPOs (NYMTC and NJTPA) along with public and private entities responsible for management and operation of highways, arterial streets, commuter rail, transit rail, buses, bridges and tunnels, and parking facilities.

1.3. CONOPS DEVELOPMENT PROCESS

A robust system engineering process (SEP) was followed to ensure consideration of all ICM-495 system lifecycle operations and maintenance factors. By following the SEP process, the region was able to reap the following benefits:[1]

- *Comprehensive planning activities*. The SEP prioritizes identification of stakeholder needs and expectations as well as system operations and requirements. The result of these activities is a technology-agnostic ICM-495 concept providing the greatest value to system users.
- *Numerous stakeholder involvement.* The SEP focuses on stakeholder involvement early and often. As a result, NYSDOT will be able to draw on a large, diverse set of resources throughout the ICM-495 system lifecycle.
- *Maintenance, operation, and system enhancements*. The comprehensive documentation resulting from the SEP will support NYSDOT's team in operating, maintaining, and upgrading the system as needed, with minimal impact.
- *Consistency with regional ITS architecture*. NYSDOT is able to review, verify, and maintain consistency with relevant regional documentation.
- *Keep up-to-date with technology*. Documentation of interfaces and systems components will enable NYSDOT to replace and enhance technology as needed with minimal impact.

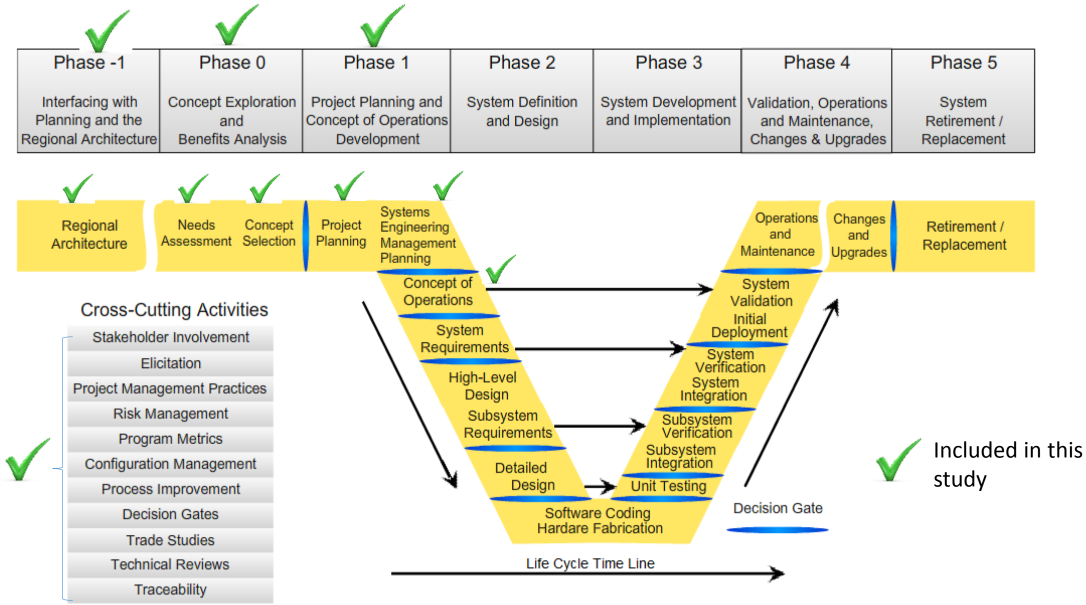
Additionally, following the SEP ensured that the ConOps is consistent with the agreed-upon ICM-495 Corridor vision (see the *ICM-495 Concept of Operations Study Technical Memorandum #6*).

The team reviewed the *New York City Sub-Regional Intelligent Transportation System (ITS) Architecture* and the *Connected Corridor Regional ITS Architecture* for use in developing this ConOps document. The regional architectures, based on *Version 7.0 of the US National ITS Architecture* provide region-specific strategies for ITS implementation within the existing regional transportation infrastructure. Because of the nature of the ICM Initiative, which is multimodal and integrates a variety of traffic management and transit functions to provide improved monitoring, response, and control capabilities, a significant portion of both regional ITS architectures will be impacted by the project.

The SEP system lifecycle consists of a series of phases regulated by management decisions which confirm that the system is mature enough to leave one phase and enter another. Figure 1-1 illustrates the "Vee" Process model used for this project and identifies the portion of the diagram and the phases addressed by this ConOps (Phase -1, Phase 0, and Phase 1).

[1] Adapted from FHWA-CA Division ITS guide

Figure 1-1. "Vee" Process Model (Source: Adapted from FHWA-CA Division ITS guide)



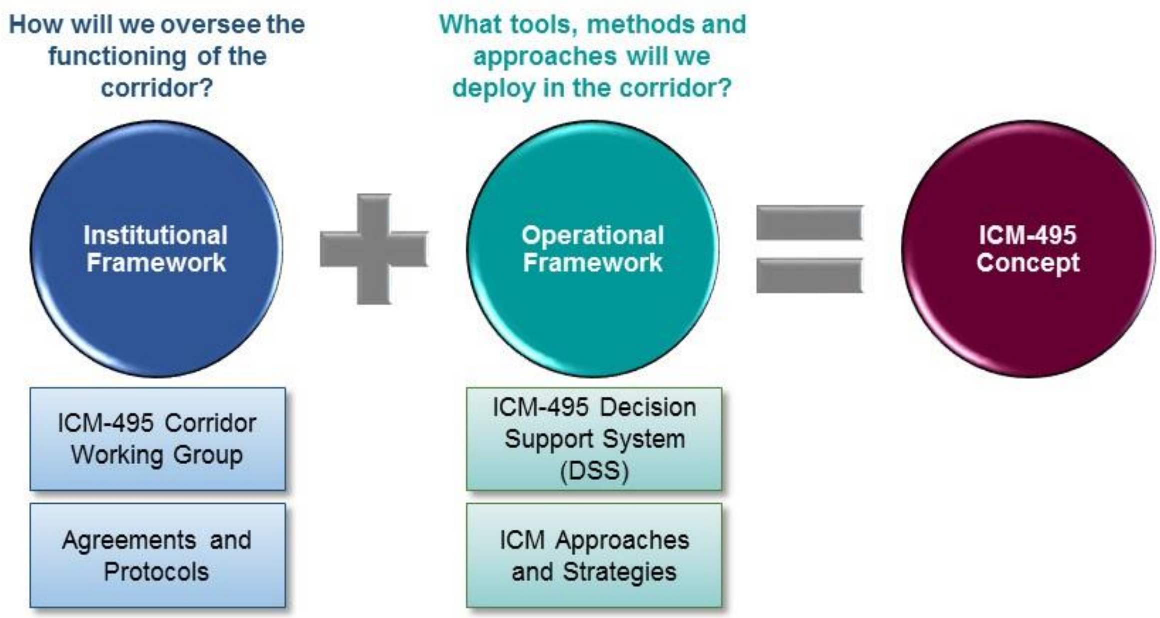
Discussed in further detail in subsequent chapters, the project team conducted the following activities in support of ConOps development.

- **Vision, Goals, and Objectives Development.** The team formulated concise vision, goals, and objectives through collaboration and the development of a shared understanding of the roles, responsibilities, and needs of all corridor stakeholders. This included partnering agencies, authorities, network owners and operators, and users of the ICM-495 Corridor.
- **Corridor Inventory.** Existing resources were gathered, traffic conditions were assessed, and gaps were identified. Transportation systems, assets, and conditions were then evaluated, including the type and range of impacts associated with previous and current TSMO deployments.
- **User Need Identification.** Working with stakeholders, challenges along the corridor were identified resulting in a list of user needs.
- **Operational Concept and Framework Development.** Feasible TSMO strategies and the use of performance criteria were explored. These strategies were described as part of a broader ICM framework for the corridor.
- **Scenario Development.** Operational scenarios were developed to describe how concept deployments should perform under various conditions that are commonly encountered in the corridor.
- **Performance Metrics Development.** Standardized performance metrics and evaluation criteria were developed to show the direct impacts of concept deployments. Metrics were based on a comprehensive understanding of how performance of current TSMO deployments are measured and evaluated.
- **Benefit/Cost Analysis.** Proposed ICM strategies were systematically assessed to compare benefits and costs. The assessment was based on identified challenges and needs; the Corridor vision; and success factors and related metrics.
- **Framework Development.** Institutional and operational frameworks were established to define how the ICM concept will be implemented and operated in the corridor.

1.4. ICM-495 Concept

The ICM concept coordinates transportation management techniques among agencies and their network through two layers: institutional and operational, as shown in Figure 1-2.

Figure 1-2. Graphical Overview of the ICM-495 Concept (Source: ICF)



Institutional Framework – described in Section 5.2.1 – is the establishment of a working arrangement that enables effective oversight and support for corridor-level initiatives. The framework includes the working group and the necessary agreements, protocols and policies. Simply put, the institutional element addresses the question – *"How do we oversee the functioning of the Corridor?"*

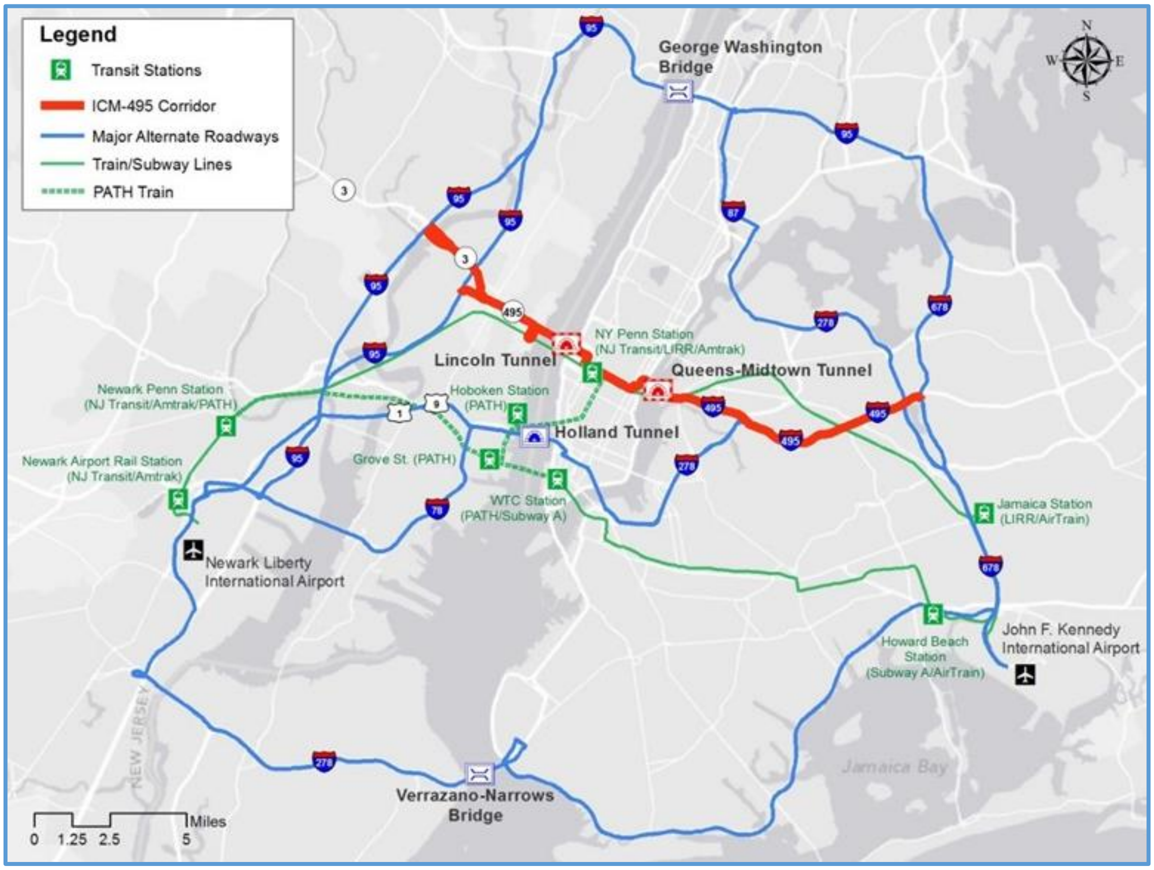
Operational Framework – described in Section 5.2.2 – involves sharing information and management responsibilities and employing the technological means and Active Transportation and Demand Management (ATDM) strategies to achieve active management of Corridor assets. The framework addresses the question – *"What tools, methods and approaches will we deploy in the Corridor?"*

1.5. Corridor Overview

Corridor Boundaries. The ICM-495 Corridor includes sections of Route 495 (NJ 495) and Route 3 (NJ 3) in New Jersey and I-495 (the Long Island Expressway (LIE) and Queens Midtown Expressway) in New York. The Corridor connects the NJ Turnpike (a section of I-95) to the Van Wyck Expressway (I-678) and traverses Midtown Manhattan and two key regional facilities – the Lincoln Tunnel, which connects New Jersey and Manhattan under the Hudson River, and the Queens Midtown Tunnel (QMT), which connects Manhattan and Queens under the East River. Local street grids with diverse residential, commercial, and industrial uses interact with the Corridor along its entire length, including Union City and Secaucus in New Jersey, Midtown Manhattan, and dense neighborhoods in Queens. The location of the Corridor in the context of the regional transportation network is shown in Figure 1-3.

The Corridor contains a dense network of roadway and railway assets managed by a number of jurisdictions with varying levels of cooperation and coordination. This fragmented administration hampers efforts to create a region wide congestion management strategy and makes day-to-day operational control difficult as agencies collect different data, use different protocols, and measure performance in different ways.

Figure 1-3. ICM-495 Corridor Overview (Source: NYC DOT)



ICM-495 Partnership. The ICM-495 partnering agencies (Table 1-2), hereinafter referred to as the ICM-495 Partnership, were involved in the development of this ConOps. Each partnering agency has an economic and political interest in the efficient management, maintenance and operations of the Corridor's transportation networks.

Table 1-2. ICM-495 Partnership Agencies

Jurisdiction	Operating Agency	Planning Agency
New York State	NYC DOT	NYMTC
	NYSDOT	
	MTA B&T	
	MTA NYCT	
	MTA Bus Company	
	LIRR	
New York & New Jersey States	PANYNJ	FHWA
	PATH	
	TB&T	
	TRANSCOM	
New Jersey State	NJDOT	NJTPA
	NJT	
	NJTA	

1.6. Relationship to Other Initiatives

The ICM-495 Concept of Operations was developed in collaboration and with consideration of the following key initiatives in the region:

- New Jersey Northeast Corridor (NJNE) ICM ConOps development – A parallel effort for ICM development is underway in northern New Jersey on facilities that are adjoining the ICM-495 corridor. Common stakeholders in both the corridors were engaged throughout the project and information from both the ICM development efforts were shared and used to guide the concept development.
- I-495 Managed Lanes Initiative – Ongoing initiative on developing active traffic management strategies in the corridor were considered and factored into the ConOps.
- Several other initiatives identified in Section 3.6 guided the identification of strategies and concepts listed in this document.

2. REFERENCED DOCUMENTS

The following list includes the references used by the project team to develop the concepts in this document.

External References:

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- NYC DOT and NYSDOT. ICM-495 Concept of Operations Study. May 9, 2016. Task 5. *Technical Memorandum #2: Outreach Participation Plan and Scenario Planning Process for Collaborative Outreach and Participation.* USDOT.
- NYC DOT and NYSDOT. ICM-495 Concept of Operations Study. October 4, 2016. Task 5. *Technical Memorandum #3: Results of Partnering Agency, Authority, and Stakeholder Outreach.* USDOT.
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3. OVERVIEW OF EXISTING CORRIDOR OPERATING CONDITIONS, INVENTORY, SYSTEMS, AND MANAGEMENT APPROACHES

Section 3 provides an overview of the existing ICM-495 Corridor including descriptions of:

- Corridor boundaries, stakeholders, and operating and supporting agencies;
- Critical challenges facing the Corridor;
- Transportation management centers (TMCs) within the Corridor;
- ITS, roadway assets, and transit assets within the Corridor;
- Corridor data collection and dissemination sources;
- Ongoing initiatives and programs impacting the Corridor;
- Planned improvements to the Corridor;
- Corridor modes of operation; and
- Operational and policy constraints.

3.1. Corridor Overview

The ICM-495 Corridor is centrally located in the New York/New Jersey metropolitan area. It has a population of 19.8 million people and is the most densely populated area in the United States. The following sub-sections describe the Corridor boundaries, stakeholders, operating agencies, and supporting agencies. For a full inventory of corridor operations see *Technical Memorandum #1: Corridor Operating Conditions, Inventory, and Needs (COIN).*

3.1.1. Corridor Boundaries

The Corridor includes the facilities listed in Table 3-1.

Table 3-1. Corridor Facilities

Type	Facility
Primary Facilities	NJ 3 from the western spur of NJ Turnpike (I-95) to NJ 495
	NJ 495 from the NJ Turnpike and NJ 3 to the Lincoln Tunnel
	34th Street and adjoining Manhattan local street grid connecting the QMT and the Lincoln Tunnel
	I-495 from the QMT to I-678
Parallel & Connecting Facilities/Routes	***New York***
	Van Wyck Expressway (I-678) between JFK Airport and Grand Central Parkway
	Brooklyn-Queens Expressway (I-278)
	Cross-Bronx-Expressway
	Grand Central Parkway
	Belt Parkway
	Clearview Expressway and Cross Island Parkway
	Queens major arterials and local street grid, including Woodhaven Boulevard
	East River Bridges
	Verrazano Narrows Bridge (VNB)
	New Jersey

Type	Facility
	I-95/George Washington Bridge
	US 1&9
	I-78/Holland Tunnel
	NJ Turnpike – I-278 to/from VNB
	Bayonne Bridge/Route 440
	Union City, Jersey City, Hoboken, and Secaucus major arterials and local street grid
Alternate Modes	***New York***
	LIRR, MTA NYCT Subway, MTA buses, bus rapid transit (BRT) services (e.g., M34 Select Bus Service [SBS]), East River ferries, Amtrak at NY Penn Station, AirTrain JFK, NYC Bike Share
	New Jersey
	PATH, NJT trains and buses, Lincoln Tunnel express bus lane (XBL), Amtrak at Newark Penn Station, AirTrain Newark, Hudson River Ferries
Airports/Ports	JFK Airport, Newark Liberty Airport, LaGuardia Airport, and Teterboro Airport
	Newark/Elizabeth Port

3.1.2. Corridor Stakeholders

As described in Section 1.5 and listed in Table 1-2, the ICM-495 Corridor contains a dense network of roadway and railway assets managed by different jurisdictions with varying levels of cooperation and coordination. In addition to the ICM-495 Partnership agencies, other stakeholder groups were involved, or had their interests represented, in the development of the ConOps. Some of these stakeholders participated in the early outreach efforts for the ICM but a majority of these corridor stakeholders will be engaged as part of the next phases of system development.

- Amtrak
- City of New York
- Commercial business and industry
- Commercial vehicle companies and freight industry
- Federal Emergency Management Agency (FEMA)
- Fire Department of New York (FDNY)
- Hudson TMA
- New Jersey State Police
  New York City emergency medical services agencies
- NYCEM
- New York City Police Department (NYPD)
- New York State Office of Emergency Management
- New York State Police
- Private parking facilities
- Private sector information service providers
- Public and private bus companies
- US Department of Homeland Security
- Towing industry

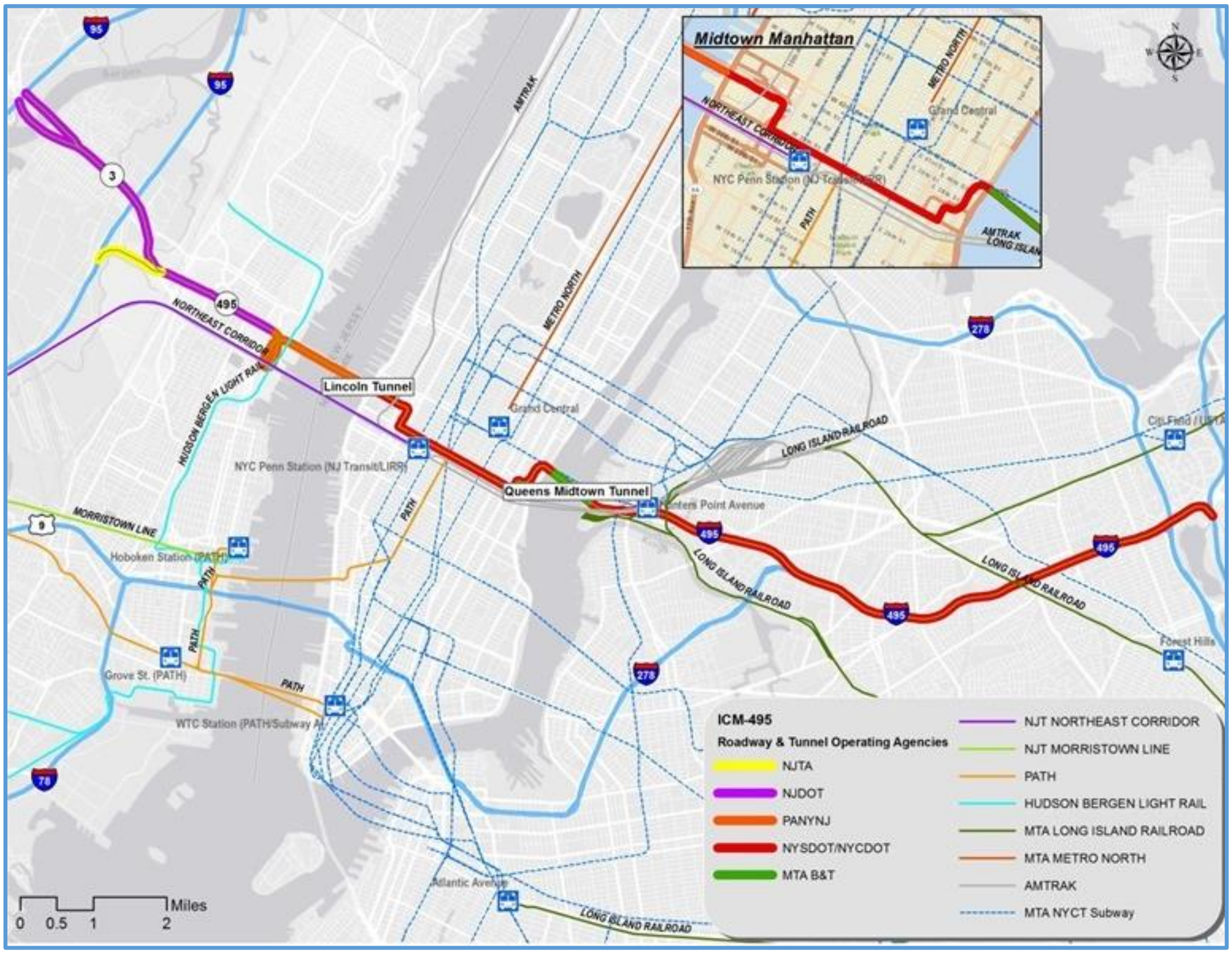
3.1.3. Operating Agencies

Corridor operations occur under the fragmented administration of multiple operating agencies. This fragmented jurisdiction results in varied performance measures, protocols and priorities. Ultimately, agencies' different responsibility structures create difficulty in providing seamless regional mobility and economic development along the corridor. A summary of the authoritative breakdown by operating agency within the Corridor is presented in Table 3-2 and in Figure 3-1. Comprehensive descriptions of each operating agency and associated facility(ies) can be found in *Technical Memorandum #1: Corridor Operating Conditions, Inventory, and Needs (COIN).*

Table 3-2. Operating Agency Authority within the Corridor

Jurisdiction	Operating Agency	Operating Authority
New York	NYC DOT	• 34th Street and the adjacent crosstown streets connecting the Lincoln Tunnel and QMT • Traffic signals within city • Managed lanes movable barrier system (58th street to QMT)
	NYSDOT (Region 11)	I-495/Long Island Expressway
	MTA	New York City subway system
	MTA B&T	QMT
	MTA NYCT	Subway and most local bus routes in NYC
	MTA Bus Company	Most express bus routes in Queens, the Bronx and Brooklyn; and local bus routes in Queens
	LIRR	Commuter rail from Long Island to points in NYC
New York and New Jersey	PANYNJ	River crossings between New York and New Jersey and some interstate transportation facilities
	PATH	PATH rail system connects New Jersey (Newark, Jersey City, and Hoboken) with New York (Lower and Midtown Manhattan)
	TB&T	Roadway river crossings: Lincoln Tunnel, Holland Tunnel, George Washington Bridge, and three Staten Island crossings. PANYNJ Bus Terminal (PABT). Operation of XBL in Lincoln Tunnel and approach.
New Jersey	NJDOT	NJ 3 and NJ 495
	NJT	NJ rail, bus, and light rail networks, includes commuter rail between NJ and NY Penn Station
	NJTA	• Western Spur Interchange 16W with NJ 3, located at the far western end of the corridor • Eastern Spur Interchange 16E with Route 495 • Tear Drop roadway in Interchange 16E complex serving as entry point to Lincoln Tunnel XBL service

Figure 3-1: Jurisdictions of the ICM-495 Corridor roadways (Source: NYC DOT)



3.1.4. Supporting Agencies

Table 3-3 provides an overview of other Corridor agencies along with their potential for providing support to the ICM initiative.

Table 3-3. Other Agencies

Jurisdiction	Agency	Role
New York	NYPD	Safety, enforcement, and incident response in the five boroughs
	FDNY	Fire protection, hazardous materials cleanup, and incident response in the Five Boroughs. Most Emergency Medical Services are also operated by FDNY
	NYC Sanitation Department	Wintertime pre-treatment and snow removal on New York City roadways.
	MTA Police	Safety, enforcement, and incident response at MTA roadway facilities.
	NYCEM	New York City emergency response coordinating agency.
	Private ambulances	Responds to some emergency medical service calls (those routed to private ambulance companies) under the auspices of the FDNY.

Jurisdiction	Agency	Role
New York and New Jersey	PANYNJ Police	Operates interstate road crossings, the PATH train, and the region's airports.
	NY Waterway	Operates ferry service between NY and NJ; Operates East River Ferry service (until 2017; after 2017, operated by Hornblower)
New Jersey	New Jersey State Police	Safety, enforcement, and incident response on New Jersey state highways.
	Municipal Police Departments	Safety, enforcement, and incident response within their respective municipalities; May assist on highways upon request of NJ State Police or PANYNJ Policy.

3.2. Overview of Critical Corridor Challenges

The Corridor is a vital link in the region's freight and person travel network, and by many measures, the facilities comprising the corridor are heavily monitored and managed for day to day travel. However, it faces challenges that keep it from delivering a travel experience consistent with the vision of stakeholders. The Corridor's main challenges fall under three categories: traffic, freight, and public transportation. Challenges and associated factors under each of the three categories are highlighted in Table 3-4. Descriptions of these challenges can be found in the *Technical Memorandum #1: Corridor Operating Conditions, Inventory, and Needs (COIN).*

Table 3-4: Corridor Challenges

Challenge	Factors
Category: Traffic	
Severe congestion during peak commuting periods on I-495	Mainline has demand higher than capacity
	Frequent merges and weaves reduce throughput
	Heavy truck usage
Severe congestion during peak periods on Midtown Streets	High number of pedestrian conflicts
	Queue spillback from bridges and tunnels in afternoon/evening period
Severe congestion during peak commuting periods on NJ 495	Demand during morning and evening peaks
	Unacceptable levels of traffic impact during incidents
Low travel time reliability	Corridor traffic is disrupted by crashes on a daily basis
	Limited accessibility for the incident response and emergency crews at the Lincoln Tunnel and QMT
	Frequent traffic disruptions by work zones
Plan, coordination, monitoring and management of work zones along ICM-495	Lack of a formal and consistent work zone planning system
	Lack of tools, procedures, and processes for universal work zone planning
	Lack of monitoring capability to confirm compliance with agreed traffic management plan
	Lack of ability to revise impact assessments based on work zone status
Category: Freight	
Disproportional impact on freight	Limited options for truck re-routing
	Delivery time-windows induce peaks on demand
Category: Public Transportation	
Buses face low average speeds in Manhattan	Lack of separated exclusive lanes in Manhattan
	Short spacing between traffic signals
	Short distance between stops

3.3. Transportation Management Centers

The following section provides a high-level overview of each of the Corridor's major TMCs along with a listing of all other TMCs (Table 3-5). Information on the roles and operational responsibilities of each TMC is listed in Table 3-6. For additional information see the *Technical Memorandum #1: Corridor Operating Conditions, Inventory, and Needs (COIN).*

3.3.1. Major TMCs in New York

Joint Traffic Management Center. The Joint Traffic Management Center (JTMC), located at 28-11 Queens Plaza North, Long Island City, consists of representatives of the New York transportation and emergency response agencies, including NYSDOT, NYC DOT, and the NYPD. The JTMC is responsible for managing traffic in New York City and detecting and responding to roadway incidents. Through the use of cameras and speed detectors placed on roadways, staff from NYSDOT, NYC DOT, and NYPD can observe and share information on the exact nature of an unplanned occurrence and the appropriate coordinated response, and rapidly deploy resources in order to clear incidents as quickly as possible. The JTMC is operated seven days a week, 24 hours a day. The system covers 75 miles of the New York State highway system.

NYC DOT TMC. Co-located with the JTMC at 28-11 Queens Plaza North, Long Island City (Figure 3-2), the NYCDOT is responsible for managing traffic along NYC arterials and corresponding traffic signals across the five boroughs.

Figure 3-2. NYC DOT TMC, located across the hall from the JTMC in Queens (Source: TRANSCOM/JTMC)

NYC Office of Emergency Management (OEM). Also located at 28-11 Queens Plaza – the NYC OEM coordinates FDNY, Regional Emergency Medical Services Council of NYC (REMSCO), Metropolitan Transit Authority (MTA), and Taxi & Limousine Commission (TLC) activities during severe weather events such as hurricanes, flooding, and snowstorms.

MTA B&T Operations Center/TMCs. MTA B&T owns and operates seven bridges and two tunnels including: Verrazano-Narrows, Robert F. Kennedy (Triborough), Bronx-Whitestone, Throgs Neck, Henry Hudson, Marine Parkway, Cross Bay Bridges, Queens-Midtown, and Hugh L. Carey (Brooklyn-Battery) Tunnels. Each facility has a desk area, manned by uniformed officers 24 hours a day, seven days a week which serves as the facility operations center/TMC. The nerve center for MTA B&T Operations is the Operations Central Command Center (OCCC) located on Randall's Island. It operates 24/7 with dedicated senior officers and headed by a Director of Central Operations. MTA B&T's communication to any outside agency occurs through the command center, with incidents reported to TRANSCOM via OpenReach. While each facility has a local operations center on-site, the facilities can also be controlled from the OCCC in the event of a disaster, disruption, or other impact to the on-site management.

MTA NYCT Bus Command Center Operations. Located in Brooklyn (at 1 Jamaica Avenue at Bushwick Avenue) the multimodal transportation service provider, is the central bus operations center for the

MTA. Responsibilities at the command center working with Road Operations' distributed dispatch centers include vehicle tracking and dispatch systems along with emergency management and transit management.

3.3.2. Major TMCs in New York and New Jersey

Figure 3-3. Diagram of PA-AOC (Source: PANYNJ)

PANYNJ TMCs. After the reorganization of its TMCs is complete, the PANYNJ will have four operational centers: (1) the Primary Port Authority Agency Operations Center (PA-AOC), (2) a backup PA-AOC, (3) a disaster recovery site, and (4) a Traffic Engineering Center. Each of the centers will have a separate instance of the agency-wide Transportation Management Software (TMS), which PANYNJ is in the process of procuring, and each will have the ability to monitor and/or control one or more facilities. In addition to the four centers, there will be an instance of the TMS at each of the 10 PANYNJ facilities to monitor and/or control nearby ITS assets, and "lightweight" applications at the other seven locations (see Figure 3-3). The seven other locations do not deal with roadway assets and include the airports, the Port, and the Ferry Terminal. The Network Operations Center (NOC) will serve as PANYNJ's data repository and information hub.

3.3.3. Major TMCs in New Jersey

Statewide Traffic Management Center. The Statewide Traffic Management Center (STMC), established by NJDOT, is co-managed by the NJTA and NJDOT. The STMC is operational 24 hours a day, seven days a week, and 365 days a year. It is jointly staffed by personnel from each of the participating agencies. Each agency manages its own roadways from the STMC, but the co-location affords efficient and effective statewide coordination of response to traffic incidents and emergencies. The fiber network converge provides access to a wide range of roadway information including video feed from more than 400 traffic surveillance cameras, as well as roadway metrics, weather, and roadway surface condition data. The operators at STMC have direct access to DMS and can record information about traffic conditions and incidents into NJDOT's traffic incident management (TIM) system. Operators are also responsible for providing traveler information and coordinating congestion management and incident response in regard to public impact.

New Jersey TRANSIT Bus Operations Systems. New Jersey TRANSIT (NJT) Bus Operations (the bus division of NJT) is responsible for NJT bus service across the Corridor. Located in various locations, NJT

Bus Operations provides transit management services including bus dispatch and scheduling along with the handling of fare management systems.

NJT Rail Operations Systems. NJT Rail Operations (the rail division of NJT) is responsible for NJT commuter rail service across the Corridor. Located in various locations, NJT Rail Operations provides transit management services including commuter rail scheduling and handling of the fare management systems.

3.3.4. TRANSCOM TMC

Operations Information Center. TRANSCOM's Operations Information Center (OIC) collects and disseminates real-time incident and construction information, 24 hours-a-day, to over 100 member agency and affiliated agency facilities. The OIC coordinates and helps to marshal member agencies' traveler information resources such as, VMS, 511 traveler information systems, and highway advisory radio (HAR) for regional incident response. The TRANSCOM free data feed also provides information during incidents to travel information companies and transportation application providers.

OpenReach System. TRANSCOM's OpenReach system incorporates data from its 16 member agencies, as well as many other affiliated agencies, into a single platform, allowing for interagency coordination and enhanced situational and operational awareness (see Figure 3-4). In addition to the agencies listed in the figure, the NJ State Police, MTA Bridges & Tunnels, Port Authority of NY&NJ [PA-AOC], and NYS Bridge Authority also inputs data directly into OpenReach. The information provided by the system includes highway and transit incidents, highway and transit construction, highway and transit special events, real-time travel times and speeds, closed circuit television feeds, variable message sign (VMS) locations and messages, and highway advisory radio locations. OpenReach is also the source for traveler information on the New York State and New Jersey State 511 systems. It also provides this information to any public or private organization through its free data feed.

Figure 3-4. TRANSCOM Member Agency Inputs to OpenReach (Source: TRANSCOM Systems ConOps)

Highway Incident Data	Planned Highway Roadwork	Planned Highway Special Events
Conn DOT NJ DOT NJ Turnpike Authority NYSDOT Region 10 NYSDOT Region 11 NYSDOT Region 8 NY State Thruway Authority NYC DOT NYPD NYSP	NJ DOT NYSDOT Region 10 NYSDOT Region 11 NYSDOT Region 8 NYC DOT	NJ Turnpike Authority NYSDOT Region 8

Data Fusion Engine (DFE). TRANSCOM's DFE collects, aggregates, prioritizes and distributes real-time multimodal information (highway travel time and transit rail/bus data) for agency operated systems. The data is used to support regional travel information feed services for DMS systems, 511 systems in New York and New Jersey and data analysis systems.

3.3.5. EOC Clearinghouse

Statewide Transportation Information and Coordination Center. NYSDOT's Statewide Transportation information and Coordination Center (STICC), located in Albany, NY, monitors real-time transportation conditions and provides information and coordination for the important events by "MOICC" (Main

Office Information Coordination Center) which is responsible for reporting systems, backup communications, and overall agency coordination for large-scale events.

3.3.6. Other TMCs in the Corridor

Table 3-5. Other TMCs in the Corridor

Name	TMC Type	Description	Location
Long Island Municipal/County Local Traffic Operations Centers (TOCs)	Traffic	Local municipal and county TOCs	Various
MTA B&T OCCC	Traffic	Randall's Island Operations Center	Randall's Island
NYC DOT TMC	Traffic	Traffic management of NYC arterials and traffic signals across 5 boroughs.	28-11 Queens Plaza North, Long Island City
NYC DOT OEM	Traffic	Traffic incident response.	28-11 Queens Plaza North, Long Island City
NYPD TMC	Traffic	NYPD Traffic Unit ops. Highway Emergency Local Patrol (HELP) trucks are dispatched from here	28-11 Queens Plaza North, Long Island City
NYSDOT R11 NYC Area ATMS	Traffic	NYC freeway mgmt. system	28-11 Queens Plaza North, Long Island City
NYSDOT Statewide IEN	Traffic	Interconnect TMCs across NY state	Albany, NY
AMTRAK Operations Center	Transit	Includes scheduling systems	Penn Station, Manhattan vicinity (2 blocks away)
AMTRAK/LIRR/NJT Penn Station Control Center	Transit	Control center for Penn Station. Primary control of customer info systems	Penn Station, Manhattan, NY
Long Island Transit Operators Systems	Transit	Transit Mgmt. Multimodal Trans. Service Provider	Various
MTA LIRR Operations Center Systems	Transit	Train dispatch, vehicle tracking, and scheduling systems	Jamaica, Queens, NY
MTA Metro-North Operations Center Systems	Transit	Control of Grand Central Terminal. Train dispatch, vehicle tracking, and scheduling systems	Grand Central Terminal
MTA NYCT Paratransit Command Center	Transit	Paratransit ops center; Communicates with private ops centers, and private vehicles	Long Island City, Queens, NY
MTA NYCT Subway Rail Control Center	Transit	Central transit ops center including scheduling, vehicle tracking	333 West 53rd Street, New York, NY
NYC DOT Division of Ferry Operations Systems	Transit	NYC DOT Staten Island Ferry and Licensed Ferry Operators Systems	Whitehall Terminal, downtown Manhattan
PABT/Station Operations Control Centers	Traffic	Central ops coordination and communications systems; Also includes central systems such as facility-based ITS servers	Various
PANYNJ PATH Operations Center	Transit	Central ops coordination and communications systems	Jersey City, NJ

3.3.7. Summary of TMC Roles along the Corridor

Table 3-6. Roles of each TMC in the Corridor

Name	Role											
	Archived Data Mgmt.	Comm. Vehicle Admin	Emergency Mgmt.	Enforcement Agency	Maint. & Const. Mgmt.	Other Traffic Mgmt.	Other Transit Mgmt.	Other Emergency Mgmt.	Traffic Mgmt.	Transit Mgmt.	Multimodal Trans. Services	Rail Operations
Major TMCs												
JTMC			X		X	X	X	X	X	X		
NYC DOT TMC			X		X				X	X		
MTA B&T Operations Center		X	X		X				X			
MTA NYCT Bus Command Center with Road Ops			X							X	X	
PA-AOC	X	X	X			X	X	X	X	X	X	X
STMC	X		X		X	X			X			
NJT Bus Operations System							X			X	X	
NJT Rail Operations System							X			X	X	
TRANSCOM OIC	X		X		X		X		X	X	X	
Other TMCs												
LI Municipal/County Local TOCs									X			
MTA B&T OCCC	X	X	X		X	X			X			
NYCEM TMC			X		X				X	X		
NYPD TMC			X	X					X			
NYSDOT R11 NYC Area ATMS									X			
NYSDOT Statewide IEN						X			X			
AMTRAK Ops Center										X	X	X
AMTRAK/LIRR/NJT Penn Station Control Center										X	X	
Long Island Transit Ops Systems			X							X		
MTA LIRR Ops Center Systems			X							X	X	X
MTA Metro-North Ops Center Systems			X							X	X	X
MTA NYCT Paratransit Comm. Center										X		
MTA NYCT Subway Rail Control Center			X							X	X	
NYC DOT Div. of Ferry Ops Systems			X		X					X	X	
PABT/Station Ops Control Centers									X	X	X	
PANYNJ PATH Ops Center			X		X					X	X	

3.4. ITS Systems and Field Assets

From various TMCs in the region, agencies with operational responsibility over Corridor facilities support travel in different ways. From monitoring traffic volumes, to identifying incidents and reacting to them, these agencies rely on multiple active traffic management (ATM) systems, and networks of ITS devices to achieve their goals. The following sections summarize existing Corridor ATM systems and ITS assets along with their owners and maintainers. For further information see the *Technical Memorandum #1: Corridor Operating Conditions, Inventory, and Needs (COIN).*

3.4.1. Traffic Management System Functionality

High-level functionality used by agencies' ATMS and/or other software platforms for facility operations in the Corridor are summarized in Table 3-7.

Table 3-7: High-level ATMS functionality

Agency	Facility	Incident Management	Traveler Information	Rev. Lane System	Video	Traffic Signal System*	Bus Rail Vehicle Tracking	Transit Trip Planner
NJDOT	STMC	X	X		X			
NJT	Rail Operations Center	X	X				X	
	Bus						X	
NJTA	TMC	X	X	X	X			
PANYNJ	Lincoln Tunnel	X	X	X				
	PA-AOC	X	X		X			
	PATH	X			X		X	
NYC DOT	TMC	X	X	X	X	X		
MTA	QMT	X			X			
	OCCC	X			X			
	LIRR	X	X				X	
	NYC Bus	X					X	
	NYC Subway	X					X	
NYSDOT	JTMC	X	X	X	X			
TRANSCOM	(N/A)	X	X		X			

*Controlled by the facility, at the facility.

3.4.2. Roadway Field Assets

Existing roadway field assets used to operate and manage roadways in the Corridor are summarized in Table 3-8.

Table 3-8: Roadway field assets

Agency	Detection	CCTV	Traveler Info	Overhead Lane Use Control Signs	Traffic Signal System	HELP/SSP Vehicles
NJDOT	Video and toll tag readers	Partial coverage along NJ 3; Partial coverage along I-495 and NJ-495	511NJ	No	No	Yes
NJTA	Roadside Sensors	Full Coverage	511NJ	No	No	Yes

Agency	Detection	CCTV	Traveler Info	Overhead Lane Use Control Signs	Traffic Signal System	HELP/SSP Vehicles
PANYNJ	Video detection	Full coverage	511NJ	Yes	No	No
NYC DOT	Road Transport Mgmt. System at intersection approaches; Mid-block Toll tag readers	Partial coverage	511NY	No	Adaptive signal system east of 8th Ave Traffic signal system west of 8th Ave	No
MTA B&T	Video detection	Partial coverage	511NY	In tunnel, required by Manual on Uniform Traffic Control Devices (MUTCD)	No	No
NYSDOT Region 11	Toll tag readers	Partial coverage	511NY	No	No	Yes

3.4.3. Transit Field Assets

Existing transit field assets used to operate and manage transit in the Corridor are summarized in Table 3-9.

Table 3-9: Transit field assets

Agency	Automatic Vehicle Location (AVL)/ GPS	Traveler Information	Overhead Lane Use Control Signs	Transit Signal Priority (TSP)	APC
NJT Commuter Rail	Yes	511NJ; Customer Information Systems; Customer Information Display Systems	N/A	N/A	No
NJT Commuter Bus	Yes	511NJ	Yes	No	No
NJT Local Bus	Yes	Operator provided	No	No	No
PATH	CBTC upgrade in progress	511NJ; Customer Information Systems; PATHVISION; 511NY	N/A	N/A	No
LIRR	Yes	511NY; Customer Information Systems; Kiosks in Penn Station	N/A	N/A	No
NYCT Bus and MTA Bus	Yes	511NY	No	Central TSP (limited number of routes)	Planned
NYC Transit	Yes	511NY; Customer Information Systems	N/A	N/A	No

3.5. DATA SHARING AND COLLABORATION

The ICM-495 Decision Support System (DSS) requires robust data from both historical sources (to use as a baseline for performance measurement) and continuous incoming data (to assess network performance, identify problems, and define solutions). Currently, the ICM-495 partner agencies use historic and real-time transportation data for activities such as: analysis, modeling and simulation of scenarios; predictive traffic modeling; monitoring corridor mobility; providing multimodal travel times; providing en-route traveler advisories and alternate travel routes; and adaptive signal control and TSP. Each of these activities provides: (1) a piece of the overall corridor mobility picture, (2) a basis for interagency collaboration, and (3) traveler-friendly information to influence informed decision-making.

TRANSCOM Data Fusion Engine (DFE). The DFE was developed and is maintained by TRANSCOM to support agency needs for unified and harmonized real-time data (including both highway and transit). This information is used to support situational awareness and for agency-specific events (e.g., incidents, special events, etc.) Travel time data includes not only TRANSMIT data but also data from other technologies such as Bluetooth devices and roadway pucks, as well as from private vendors. Additionally, this data is archived to support both after action assessments by regional operations users and planning activities.

Probe Detection (TRANSMIT/TIMED). The most frequently used Corridor roadway data source is Probe Detection (TRANSMIT/TIMED), the network of passive E-ZPass readers. Operated by TRANSCOM, Probe Detection tracks travel speeds for roadway segments and displays these speeds according to pre-selected parameters. It also aggregates segment speeds to show the overall travel speed across a corridor. These feeds are made available to partner agencies as well as to third-party websites and apps who can display data on their platforms or use the data to automatically calculate faster routes. The speed information is also used by roadway operators for incident detection and to identify persistent hotspots for potential intervention.

CCTV. Certain agencies also make CCTV feeds available to the general public. These are not intended for on-the-go use, but rather to inform a mode choice before departure, or for media access, so they can report on conditions via their broadcast means.

Transit Vehicle Sensor Data. Real-time transit information is collected by position sensors located on the vehicles and by detection of the status of the signaling system. This data is collected by agencies to determine persistent trouble spots along the network, adjust service patterns, align schedules, and other operational improvements.

Incident Information Management System (IIMS) is another tool that is being piloted in the region to collect field condition information and share with transportation management stakeholders through a remote device used by incident and maintenance personnel.

For additional detailed information on Corridor data see the *Technical Memorandum #1: Corridor Operating Conditions, Inventory, and Needs (COIN).*

3.6. Relevant Ongoing Initiatives and Programs

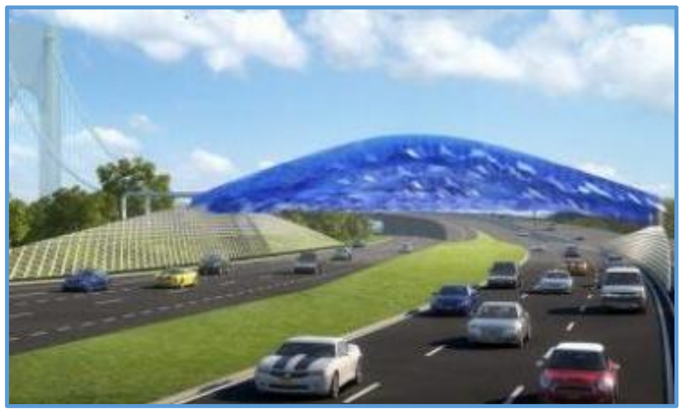
The following section describes several ongoing initiatives in the Corridor which are relevant to the ICM initiative, these include:

- Open Road Tolling;
- Managed Lanes;
- 511NY and 511NY Rideshare;
- SBS Program;
- Connected Vehicle (CV) Pilot;
- Adaptive Signal Control; and
- Connected Corridors in New Jersey.

Many of these programs are described in more detail in *Technical Memorandum #1: Corridor Operating Conditions, Inventory, and Needs (COIN).*

3.6.1. Open Road Tolling

Figure 3-5. Open Road Tolling Concept Drawing (Source: MTA)

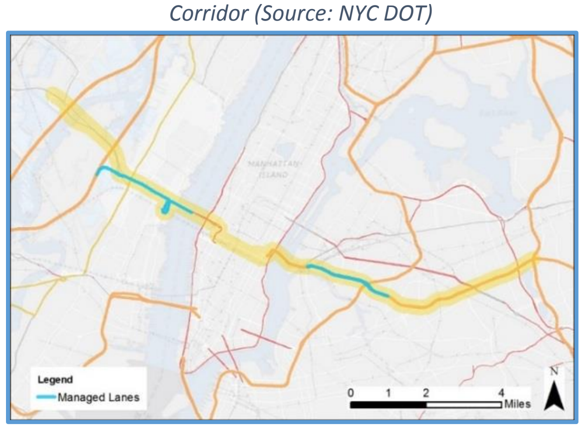


On January 2017, MTA B&T began its plan to remove toll gates on MTA bridges and tunnels and replace them with an electronic, automatic (i.e., open road) tolling system. These crossings include:

- Hugh L. Carey Tunnel (January 2017)
- QMT (January 2017)
- Rockaway Bridges (Spring 2017)
- Robert F. Kennedy Bridge (Summer 2017)
- Verrazano-Narrows Bridge (Summer 2017)
- Throgs Neck Bridge (Fall 2017)
- Bronx-Whitestone Bridge (Fall 2017)

Figure 3-5 presents a concept drawing of the electronic, automatic tolling system. The open road tolling system uses sensors and cameras to toll cars as they pass underneath facility gantries. The gantries read the vehicle's EZ-Pass tag for automatic charging. Any vehicle that does not have an E-ZPass will have its license plate photographed and a bill sent to their household within 30 days. The driver can then pay online, by mail, by phone, or at an in-person service center. Electronic signs will also be placed along the roadside to display various messages to drivers.

Figure 3-6. Location of Managed Lanes along the I-495 Corridor (Source: NYC DOT)



3.6.2. Managed Lanes

As shown in Figure 3-6, the Corridor includes two sections of managed lanes each operated by multiple agencies and described in the sections below:

- Contraflow, High Occupancy Vehicle (HOV) Lanes on I-495 in New York (from the LIE to the QMT) [green line on right side of figure].
- Contraflow, Bus Lanes on NJ 495 in New Jersey (from the NJ Turnpike Interchange 16E to the PABT in Midtown Manhattan) [green line on left side of figure].

Figure 3-7. Entrance to the Queens side of the QMT in standard configuration (Source: MTA)

I-495 in New York - LIE HOV Contraflow Lane into the QMT (Figure 3-7 and Figure 3-8)**.** The QMT is a main corridor connecting Manhattan to Queens and Long Island via the LIE. During normal operations, the roadway includes three lanes of traffic in each direction. During the morning peak (7 to 10 AM), a contraflow bus and HOV lane is in operation to optimize traffic flow through the QMT. The lane runs westbound (WB) from the vicinity of 58th Street to the QMT and requires coordination between MTA B&T (operating the QMT) and NYSDOT (operating the LIE). Vehicles allowed in the lane include buses, taxis, motorcycles, and any motorist with three or more people in their vehicle (HOV3+). The contraflow lane is facilitated by a movable barrier system that adjusts the roadway from three lanes in each direction to four lanes WB and two lanes eastbound (EB) during the morning commute. The movable barrier is operated by NYC DOT staff. Although the contraflow lane speeds trips through the most heavily congested section of the highway, throughput is still limited by surface streets in Manhattan, as well as a lack of HOV lanes earlier in the trip, meaning vehicles have likely encountered serious congestion before reaching the HOV lane.

There is currently a project underway to extend the contraflow lane further east to the intersection of the Van Wyck Expressway. This extension could be joined with enhanced lane management techniques, such as tracking via Probe Detection of speeds in the HOV lane versus the regular access lanes, such as currently practiced on the HOV lane section of the LIE in Nassau and Suffolk Counties.

NJ 495 (2.5 mile Contraflow Bus Lane from NJ Turnpike to the Lincoln Tunnel). NJ 495 is a (mostly) six-lane freeway that includes a reversible exclusive bus lane (XBL) used during the morning rush hour (6 to 10 AM). The XBL is operated by the PANYNJ and runs the entire 2.5 mile length of the freeway from the NJ Turnpike Interchange 16E to the PABT in Midtown Manhattan, including the Lincoln Tunnel's center tube. The roadway is owned and operated by multiple agencies that include: (1) NJTA between the NJ Turnpike and Route 3, (2) NJDOT between Route 3 and Park Avenue near the Union City/Weehawken border, and (3) PANYNJ east of Park Avenue, including the helix between the New Jersey Palisades and the entrance of the Lincoln Tunnel.

During the morning commute over 100 bus carriers, including NJT and other private carriers, use the XBL to directly access the PABT for more reliable travel times. There is no XBL-style operation during the afternoon commute as it is more spread out. During non-morning commute hours, the XBL is used for all vehicle traffic. Since the XBL lane is nearing capacity, the PANYNJ is evaluating the potential to convert a general purpose lane into a managed-use lane open to buses, carpools, and, potentially, paying single occupancy vehicles (SOVs).

Figure 3-8. Lincoln Tunnel XBL in operation in Long Island (Source: PANYNJ)

3.6.3. 511NY, 511NJ, 511NY Rideshare, and NJ Rideshare

511 Systems. New York and New Jersey each operate 511 systems[2], providing transportation information via phone and website. These systems provide real-time travel and delay information, information about ongoing construction and route impairments, and information about transportation solutions, such as carpooling and transit. Use data from both systems are entered into OpenReach.

511NY Rideshare. For over 20 years, NYSDOT has operated a 511NY Rideshare transportation demand management (TDM) program that provides services to support ridesharing and other alternative modes. This includes a ridematching system to help commuters and travelers find rideshares for work and special events. It also provides support services to employers to offer commuter benefits programs such as commute tax benefits, teleworking, and emergency preparedness planning. 511NY Rideshare also provides an answering service, responding to emails and phone calls, regarding travel questions. This service often sees an uptick in support calls during temporarily disruptive situations and is constantly looking for up-to-date information about transportation and travel situations from this Corridor's operating agencies. Within the ICM-495 corridor, 511NY Rideshare works to reduce SOV travel by helping travelers find alternative modes (e.g., transit, ferry, and carpooling) on regular travel days as well as days when travel may be compromised by temporarily disruptive situations.

NJ Rideshare. Launched July 2016, NJ Rideshare operates through a partnership between NJTPA and eight New Jersey-based non-profit TMAs. The program provides a forum (via website) for commuters interested in finding rideshare partners. By creating a profile with NJ Rideshare, commuters search for their own matches and look for available vanpools. The website also includes a commute calendar feature, which allows users to track cost-savings and positive impact on the environment as a result of the commute activities.

[2] https://511ny.org/ and http://511nj.org/

3.6.4. Select Bus Service Program

The SBS Program (Figure 3-9), co-developed and operated by NYC DOT and MTA NYC, is aimed at improving travel time reliability and bus service along high ridership corridors throughout New York City. The program includes a suite of improvements – dedicated bus lanes, off-board fare payment, station spacing, transit signal priority and enhanced bus stops – to local city bus lines which reduce trip time and passenger delay. Currently in operation across all five boroughs, including the M34 on 34th Street in the ICM-495 Corridor, SBS uses off-board fare payment with all-door boarding as its primary method of reducing dwell time. Additionally, routes in the outer boroughs and along Manhattan avenues have a limited stop frequency. Some SBS routes also have a designated bus-only lane and curb extensions to aid boarding.

Figure 3-9. New York City's SBS includes bus service improvements along high ridership corridors (Source: MTA)

3.6.5. Connected Vehicle Pilot

Overview. In September 2016, New York City was one of three sites awarded a USDOT ITS Joint Program Office (JPO)-funded cooperate agreement to design, build, and test a CV Pilot Deployment. Led by the NYC DOT, the goal of the pilot is to improve traveler and pedestrian safety using vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) CV technologies, aligning directly with the city's Vision Zero Initiative.[3] The Pilot (conducted in three phases is focused on applying CV in tightly-spaced intersections in a dense urban transportation system. The project site includes: (Area 1) a 4-mile segment of FDR Drive in the Upper East Side and East Harlem neighborhoods in Manhattan, (Area 2) 4 one-way corridors in Manhattan, and (Area 3) a 1.6 mile segment of Flatbush Avenue in Brooklyn.

[3] The Vision Zero Initiative is New York City's effort to end traffic deaths and injuries on the City's streets through better street designs and regulations, and enforcement and public outreach efforts.

Technology (Figure 3-10)**.** Over 15 safety applications will provide in-vehicle warnings to drivers. 5,800 cabs, 1,250 MTA buses, 400 commercial fleet delivery trucks, and 500 City vehicles will be fit with V2V, CV technology. Dedicated Short Range Communications (DSRCs) will be added to 310 signalized intersections for V2I technology while 8 roadside units (RSUs) will be deployed along FDR Drive and 36 RSUs at other strategic locations for V2I, CV technology. One hundred pedestrians will be equipped with personal devices to assist them in safely crossing the street while drivers will receive in-vehicle pedestrian warnings to support reductions in vehicle-pedestrian conflicts.

Figure 3-10. New York City is developing, deploying, and testing safety based CV applications. (Source: NYC DOT)

3.6.6. Adaptive Signal Control

The Corridor includes several adaptive signal control deployments as described in the sections below:

- New York – Midtown in Motion (MIM) and TSP
- New Jersey - Meadowlands Adaptive Signal System for Traffic Reduction

Midtown in Motion (Figure 3-11). Installed in 2011, MIM is a congestion management system that assesses conditions in real-time and remotely adjusts Midtown traffic signal patterns to unplug bottlenecks and smooth the flow of traffic. MIM detector systems are managed by the NYC DOT TMC and cover a large area of avenues and cross streets in the Midtown section of the Manhattan Central Business District, including 34th Street, which is part of the proposed ICM-495 Corridor. The approach roads to the QMT are not included in the active management area, but are part of the detection zone that feeds the decision support system for MIM. The real-time detector systems include: 40 Probe Detection tag readers for segment travel times; over 100 microwave sensors for block level flows, detector occupancies, and speeds; and over 50 pan-tilt-zoom CCTV cameras.

Figure 3-11. NYC DOT TMC operators tweak Midtown traffic in response to real-time conditions. (Source: DNAinfo/Jill Colvin)

Transit Signal Priority. Since 2008, NYC DOT and MTA NYCT have worked together to develop a system of TSP that uses existing citywide ITS infrastructure deployed by both agencies; using an on-board GPS, buses communicate priority requests via the MTA's Bus Command Center to the NYC DOT TMC, which evaluates requests. If approved, requests are sent out via the city's wireless network, NYCWiN.

Meadowlands Adaptive Signal System for Traffic Reduction (Figure 3-12). The Meadowlands Adaptive Signal System for Traffic Reduction (MASSTR) program includes the deployment of SCATS (Sydney Coordinated Adaptive Traffic System) adaptive traffic control system across nearly 144 intersections in the Hackensack Meadowlands District. The system is run through wireless and fiber-optic communications and vehicle detection devices. Traffic conditions and signal operations are monitored and controlled in real time with signal timing adjusted based on traffic flow. The system is operated by the New Jersey Sports and Exposition Authority (NJSEA) from the NJSEA TMC in Lyndhurst, NJ. MASSTR is not accessible to NJDOT or NJDOT's TOC.

Figure 3-12. NJSEA TMC Operations (Source: NJSEA)

3.6.7. Connected Corridors in New Jersey

The Connected Corridor ITS architecture is part of an initiative led by the NJTPA, who are working with 21 organizations—from New York City, through New Jersey and into the Philadelphia metro area in Pennsylvania to connect existing ITS infrastructure to support multimodal and seamless transportation operations. The Connected Corridor ITS architecture recommended several strategies with implications for ICM-495, covering topics such as implementing ATM strategies along segments of the Corridor, implementing or deploying ITS in the Corridor to support better traffic management but also facilitate better data collection, expanding coverage of safety service patrols (SSP), especially with consideration for freight traffic, and improving collaboration between agencies and integration among various modes.

3.7. Corridor Improvements

There are a number of initiatives underway to manage demand, provide for smoother operations, and increase the function and utility of the overall transportation network across the Corridor. These initiatives are listed in Table 3-10. For more information see *Technical Memorandum #1: Corridor Operating Conditions, Inventory, and Needs (COIN).*

Table 3-10: Summary of ongoing transportation management projects

Project Name	Agency	Summary
Automatic Traffic Management System	NJDOT	Design and deploy Automatic Traffic Management System. Provide funding for the complete delivery of the Final Design document for Automatic Traffic Management System for one of I-80, or I-78.
Bike Share	NYC DOT	Provide bicycles for short-term one-way or round-trip rentals to provide convenient and inexpensive mobility and leverage the City's mass transit system by extending the reach of local access to transit stations, and providing access to areas not well covered by the subway network.
Bridge Strike Task Force	NYC DOT, NYSDOT	Employ comprehensive ITS systems to monitor truck movements and share information with drivers and managers to assist in their route choices and avoid bridge strikes in and around New York City.

Project Name	Agency	Summary
Congestion Relief, ITS Improvements (Smart Move Program)	NJDOT	Deploy ITS elements through separate projects or during other preservation projects to minimize cost and disruption of ITS installation. Procure ITS elements in advance and install early in projects
"Drivers First" Initiative	NYSDOT	Minimize disruptions at highway and bridge projects across the state by reviewing and analyzing best practices used regionally and determine how to safely implement these across the state given regional budget, legal and traffic volume differences.
Drive Smart	NYC DOT	Use pricing signals and financial incentives to influence travel behavior and choices through usage-based insurance, mileage-based user fees (in lieu of a gas tax), driver feedback applications, and driver incentive programs.
East Side Access	MTA-LIRR	Connect LIRR network to a new terminal beneath Grand Central Terminal in Manhattan. Implement ITS including real time traveler information, transit vehicle tracking, transit maintenance, and transit security.
ITS Resource Center	NJDOT	Develop statewide ITS Strategic Plan, ITS Deployment Plan, and Work Zone Mobility Monitoring Program. Conduct research and testing, evaluate scenarios, and perform training and outreach to develop best practices for ITS implementation.
ITS Program	NYSDOT, FDNY, NYPD, NYC Dept. of Environmental Protection, NYC Dept. of Sanitation, MTA B&T, NYCEM, TRANSCOM, and PANYNJ	Implement ATMS on all highways within New York City to provide real time traffic information. Connect technologies to the JTMC in Queens to manage real time traffic conditions and incidents and perform Emergency Transportation Operation functions. Develop interfaces from the JTMC to other regional emergency management centers in New York City to share traffic incident information. Implement Highway Emergency Local Patrol (HELP) Program to patrol the roads and assist motorists when their vehicles become disabled on the highways.
Mobility and Systems Engineering Program	NJDOT	Plan, design, and procure ITS and Advanced Traveler Information System (ATIS) elements. Ensure compliance with Federal mandates. Review and develop new technology and the possible application, design, procurement, testing and deployment of such technologies. Develop contract documents and engineering plans for ITS contracts. Provide technical and engineering support for the Traffic Operations Centers. Support NJDOT's traffic signal optimization efforts and the Arterial Management Center.
New Jersey Rideshare	NJTPA	Provide a free carpooling matching service to support an alternative to driving alone.
New York Rideshare – Enhanced Commuter Services	NYSDOT	Provide cost effective and reliable alternatives to driving alone. Through integration with 511NY, assist travelers in more effectively accessing mass transit, and forming carpools and vanpools. In partnership with NYC DOT, help to implement the Go Smart program—an individualized marketing program that encourages sustainable transportation by providing personalized travel plans in focused neighborhoods.

Project Name	Agency	Summary
NYC DOT Improvements	NYC DOT	Improve citywide ITS signal coordination, traffic signal prioritization, GPS traffic data, and coordinate ITS deployment in New York City.
NYSDOT Incident Mgmt. System	NYSDOT	Integrate Incident Mgmt. System communications network to other agencies. Provide hardware and software to determine position of maintenance vehicles.
NYSDOT Traffic Surveillance	NYSDOT	Install various detector technologies, including loop detectors, microwave detectors, and CCTV cameras, and then provide the collected data to traveler information systems.
NYSDOT Weather Data	NYSDOT	Deploy fixed and mobile sensors to collect road and weather conditions to alert motorists and maintenance crews to icy road conditions, snow cover, high winds, dense fog, and other environmental hazards, and coordinate management response.
Off-Hour Deliveries	NYC DOT	Encourage businesses to accept off-hour shipments through financial incentives and innovative ideas to aid in deliveries and reduce peak period congestion on New York City streets.
PARK Smart	NYC DOT	Improve curb access and reduce congestion by implementing a program that can include progressive parking rates, extended meter time limits, delivery windows, and paid commercial parking.
Statewide Traffic Operations and Support Program	NJDOT, NJSP	Reduced non-recurring delays due to incidents, work zones, weather emergencies, poor signal timings, and special events through a STMC, roadside assistance, a NJDOT/NJSP TIM Unit, and a Central Dispatch Unit (CDU).
SBS	NYC DOT, MTA	Implement BRT improvements on routes throughout the city. To date, NYC DOT and NYCT have jointly implemented fourteen SBS routes across all five boroughs, with more routes currently in the planning phase.

3.8. Corridor Modes of Operations

3.8.1. Normal Operations

During normal operations, transit agencies operate according to schedules calibrated to passenger demand and infrastructure capability. These operations are monitored from independent agency command centers, with on-time information distributed by some agencies through their own online channels. Roadway conditions are also monitored by the individual roadway operators from command centers. Highways within New York City under NYSDOT jurisdiction are monitored from the JTMC, which has staff from both the City and State DOTs. Each of the river crossings is monitored and patrolled by its operator, while the NYPD patrols roadways within New York City. At key intersections in Midtown Manhattan, Traffic Enforcement Agents (TEAs) are deployed to guide traffic and improve safety. The deployment of these TEAs is set by schedule and location with little variation. Two sections of managed lanes are controlled by their respective agencies with configuration changes completed according to schedule with some slight room for adjustments around the designated times.

Roadway conditions in the corridor and across the region are monitored by TRANSCOM, who then redistributes the data to its partner agencies, as well as travel information companies and transportation application providers. From their Operations Information Center (OIC) in Jersey City, TRANSCOM collects and disseminates real-time incident and construction information, 24 hours-a-day, to over 100 facilities of its member agencies and affiliated agencies. The OIC coordinates and helps to marshal member agencies' traveler information resources such as VMS and 511 traveler information.

TRANSCOM also operates OpenReach, which incorporates data including highway and transit incidents, construction, special events, real-time travel times and speeds, CCTV feeds, and VMS locations and messages. Data in OpenReach feeds the traveler the New York State and New Jersey 511 systems. Additionally, TRANSCOM operates the TRANSCOM Data Fusion Engine, which collects, aggregates, and distributes real-time travel time information for highway and transit services. This data supports regional travel information feeds services for DMS systems, 511 systems in New York and New Jersey and data analysis systems.

3.8.2. Incidents

Incident response varies by agency along the Corridor. Each of the roadway operators has their own police force, who are the primary responders to any incidents. Transit operators have protocols in place to route around disruptions, if possible, or to cross-honor fares between agencies if similar service is available. Based on the severity of transit disruptions, transit agencies will communicate through their websites or directly to media contacts. Only during severe multi-day disruptions will transit agencies coordinate with roadway operators to communicate via roadway assets such as VMS.

Most incidents are coordinated locally, with local police response triggered. NYPD will communicate over their internal channels if additional assets are required for incidents on New York City roadways, and can respond to accidents on the river crossings upon request from the operator.

Through the JTMC, NYC DOT, NYSDOT, and NYPD coordinate directly during incidents on the New York side of the Hudson. On the New Jersey side of the river, operational control is less fragmented, and the NJ STMC provides situational awareness to other agencies, rather than response coordination. When incidents span jurisdictional boundaries, there is bilateral communication based on established relationships and protocols between the agencies. Responses are coordinated through TRANSCOM if incidents will have spillover effects from one agency's jurisdiction to another. Agencies use VMS signs, social media, their own websites, 511 services, and media announcements to communicate relevant information to the public.

3.8.3. Special Events

Figure 3-13. Transit workers protesting in the streets of NYC (Source: http://www.nydailynews.com/new-york/nyc-transit-workers-warn-strike-seek-better-pay-article-1.2874853)

Pre-planned special events are typically handled according to protocols decided in pre-event planning meetings, though the convening of these meetings is ad hoc with no activation threshold. Attendance is determined by the meeting organizer. Roadway and transit operators will have known responses and will use triggers for additional levels of response. During these events, TRANSCOM helps coordinate transportation management between member agencies, if events will have spillover effects that may impact facilities beyond the event location. These management efforts include maintaining a database of real-time locations, dates, times, sponsoring organizations and key agencies affected. It also includes integration with OIC activities, since planned projects may need to be cancelled or modified to minimize congestion on impacted routes before, during, and after the event.

Coordination calls with TRANSCOM are used by the Corridor's operating agencies to coordinate responses for one-time or recurring events that may impact multiple facilities. Most events like parades and street fairs are known and recurring yearly, but small variations from year-to-year demand specialized response. Larger events like United Nations Week, Papal visits, or an impending strike will typically be enough to convene the necessary stakeholders for a dedicated response planning meeting (Figure 3-13).

3.8.4. Emergencies

Emergencies or other large no-notice events are handled by agencies according to those agencies' standard operating procedures (SOPs). For large emergencies, emergency management functions may come into play, requiring coordination by NYCEM or the New Jersey Office of Emergency Management, which will coordinate between facility operators and responding entities.

During major emergencies, direction may come from political entities rather than field-level commanders. Emergency Management offices will communicate political directives to implementing agencies and facilitate situational awareness and communication back-and-forth between the elected officials and the response on the ground.

In addition, during emergencies TRANSCOM hosts regional conference calls and provides a one to two hour regional conditions report to support regional activity coordination.

3.8.5. Weather

Weather events are treated as a pre-planned special event, as many adverse weather events are forecast in advance. Roadway and transit operators will take the necessary precautions to prepare their infrastructure for adverse conditions. The operators will then monitor the progress of the weather event to ensure users' safety. Additional levels of response may be deployed or withdrawn based on the severity of weather.

Figure 3-14. Overturned tractor-trailer on the SB Van Wyck Expressway during a snowy AM weekday commute. (Source: http://www.nbcnewyork.com/news/local/NYC-Traffic-Delays-Lanes-Closed-After-Tractor-Trailer-

In New York City, the Department of Sanitation is responsible for treating and clearing roadways from snow and ice. Department of Sanitation responses will be activated by the Mayor in consultation with the Sanitation Commissioner and other City agencies. During weather events, NYPD will monitor road conditions and communicate via the JTMC with regard to closures or detours for safety.

In New Jersey, NJDOT currently receives weather reports and email alerts from Schneider Electric DTM. NJDOT also has around 15 Road Weather Information System (RWIS) locations throughout the state that provide weather reporting capabilities on dewpoint and temperature monitoring. To some internal and external stakeholders, NJDOT will conduct 2-hour storm reports, starting at the onset of a storm, which gives everyone a view of what is happening across the state.

During more severe weather threats, such as hurricanes, roadway responses will be coordinated at higher political levels with input from Emergency Managers. In addition, during weather events, TRANSCOM hosts regional conference calls and provides a one to two hour regional conditions report to support regional activity coordination.

4. JUSTIFICATION AND NEED FOR ICM

4.1. Justification for Changes

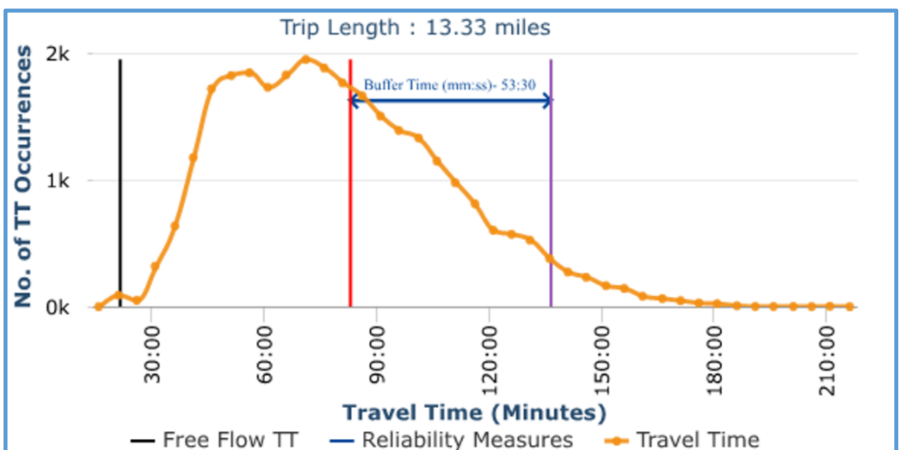
Through the stakeholder outreach process a preliminary set of concerns, operational deficiencies, and gaps in services were identified and vetted. Based on this information, the justification for an ICM concept was developed. ICM-495 is driven by the following Corridor challenges (described in further detail in the sub-sections below):

- Continued challenges with travel time reliability in the Corridor
- High prevalence of incidents and incident-related delay
- Pronounced supply-demand imbalance across modes and facility types
- High incidence of planned events that stress Corridor operating conditions
- Rapidly evolving landscape of traveler information technology, modes, and expectations
- New opportunities for operational collaboration through data sharing and IT

4.1.1. Continued Challenges with Travel Time Reliability in the Corridor

Increasing travel time reliability is of prime concern in the Corridor. Unreliable travel times caused by congestion, incidents, and work zones result in motorists needing to budget a large amount of added time over a baseline journey to compensate for potential delays. In Figure 4-1, which was an output of analysis from TRANSCOM data, drivers traversing the corridor EB during the PM peak must add an average of 53 minutes buffer onto an expected 83 minute journey in order to arrive on time 95% of the time. This buffer lowers productivity, increases congestion, and contributes to an overall lower quality of life in the metropolitan area.

Figure 4-1: Eastbound PM travel time reliability in the corridor (Source: TRANSCOM)



Free Flow	Average	Planning Time	Buffer Time
21:24	82:47	136:17	53:30

A lack of travel time reliability for freight deliveries cause trucking firms to assume worst-case scenarios for delivery time. In response, they acquire larger fleets, driving up acquisition, labor, and maintenance costs, all of which are eventually passed on to end users. These large fleets themselves cause congestion on roadways and the parking and depot space required for them contributes to inefficient and unproductive land uses.

For transit operators and users, this wide variability in travel time lowers the usefulness of transit as a reliable mobility option, removing revenue from the transit system and contributing to congestion as choice passengers opt to drive instead. Like freight operators, transit operators must pad schedules, and increase fleet and labor numbers. Additional schedule padding also results in congestion at the PABT as more buses are left idling in the facility.

4.1.2. High Prevalence of Incidents and Incident-related Delay

Incidents are a major cause of delay on the Corridor. However, unlike congestion, which tends to occur in similar locations and times from day-to-day, incident delays can occur at any place at any time. Incidents are also highly variable and must be assessed on a case-by-case basis to determine the appropriate response for on-scene attention and recovery (see Figure 4-2). Incidents can range from involvement of one-vehicle to involvement of multiple vehicles, can close down only one lane or multiple lanes, could happen on a stretch of roadway or at an intersection – all these variables can cause different impacts and require different responses. Because of the non-recurrent nature of incidents, they also provide challenges for communication to inform the relevant authorities and corridor users of potential impacts.

Figure 4-2. Congestion caused by an incident involving two buses during the AM rush hour in the Lincoln Tunnel
(Source: http://wtop.com/news/2015/06/the-latest-on-lincoln-tunnel-crash-more-than-30-hurt-on-bus/)

Incidents are a major contributor to a lack of travel time reliability, with the follow-on effects to drivers, freight operators, and transit riders as noted in the previous section. Multiple incidents in close proximity can create scenarios where diversions begin to overlap, hindering response and magnifying delays. Incident response delays on the Corridor also have the possibility of slowing response to other situations that may develop within the same patrol area. While incident detection is often not a problem, continued monitoring of incident response and associated traffic impacts remains a challenge.

4.1.3. Pronounced Supply-Demand Imbalance

Dynamically balancing supply and demand requires the tight integration of active traffic management with active demand management. While peak periods (i.e., recurring congestion) are of significant concern, the ability for demand management strategies to support event response (i.e., nonrecurring congestion) (both planned, such as work zones and special events, and unplanned, such as incidents and emergencies) is critical to this Corridor.

Unlike other ICM corridors around the country, where excess capacity is available on arterials and transit, the ICM-495 is unique in the levels of saturation of all modal options during peak hours. The two road tunnels, the train tunnels, and the bus terminal all have finite capacities with regard to how many passengers can be transported in a given period of time. Implementing strategies to maximize this existing infrastructure – the foundation of ATDM – is critical for the region. This includes consideration for how the effects of any implemented strategy will course through the network, looking at system-wide performance impacts. Strategies will focus on influencing decision-making throughout a traveler's trip chain including: destination, time-of-day, mode, route, and lane/facility choices.

The focus on short-term and long-term demand management is critical in this Corridor. ATDM measures will be installed as part of the I-495 Managed Use Lane Extension (see Section 3.6.2), which includes part of the corridor. In addition, there are the robust regional TDM programs that promotes higher occupancy use – 511NY Rideshare and NJ Rideshare (see section 3.6.3). By effectively managing demand, spreading peaks, and providing for reliable alternate modes of transit, total vehicle volumes can be reduced, alleviating congestion, and making trips more predictable.

4.1.4. High Incidence of Planned Events that Stress Corridor Operating Conditions

Construction is a major source of delay in the Corridor, as well a major source of frustration for Corridor users. As with any complex network, disruptions in one area can propagate to other non-obvious areas. To add to this challenge, the corridor will undergo dramatic changes over the next 10-15 years. Major construction is planned for the PABT and managed use lanes are expected to be operational soon. In addition, large scale construction and maintenance on other facilities may have spill-over effects on Corridor ICM initiatives.

4.1.5. Rapidly Evolving Landscape of Traveler Information Technology, Travel Modes, and Traveler Expectations

The last 10 years in New York City has seen a revolution in transportation choices and information. The revolution is not just about additional choices but also about more reliable information and the way information is presented to the traveler. The users of this corridor have a lot more awareness of travel disruptions and more options to travel than before. As these services evolve, the flexibility and customization available to travelers seeking information has greatly increased. Several key aspects that are increasingly seen in traveler information include:

Figure 4-3. Traveler information is becoming increasingly multimodal and customizable. (Sources: Apple iTunes Store, UDOT)

- Tailored information based on locations determined by a traveler's device. The 511NY multimodal trip planner continues to be a vital part of the traveler information systems but other compilation of data sources to create a multimodal, integrated picture of available choices are starting to emerge. For example, an app called "Transit" brings together Uber, Car2go, transit and bike share into one application.
- Reliance and growth of Transportation Network Companies (TNCs) in the corridor has created a complex challenge of understanding and managing the positives and negatives of these services.
- Growth of new apps targeting casual carpooling

These traveler information services will play a key role within the heavily congested ICM-495 corridor. For examples, providing dynamic, real-time, customized multi-modal information to travelers before and during their trip through mobile and online applications and en-route variable message signs, will help operate the corridor at optimal performance. These informational strategies support load balancing and help make the dynamic mild to moderate shifts required on heavily constrained modes.

4.1.6. New Opportunities for Operational Collaboration Possible Through Data Sharing and Information Technology

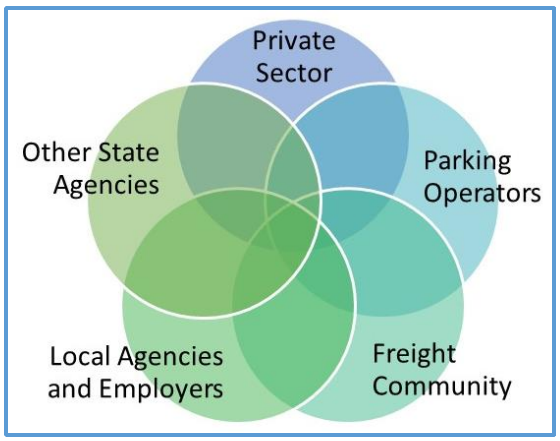
By actively collaborating together, ICM partners can build on each other's strengths and capabilities to better communicate with travelers and manage their facilities in a more dynamic manner, focusing not just on vehicles but on the person throughput that the system services. Multi-agency partnerships (e.g., NYC DOT/MTA's SBS implementation and regional partnerships such as TRANSCOM) in the New York/New Jersey region have proven to be effective at bringing together stakeholders to focus on system performance outcomes. In addition, partnerships with larger regional employers and institutions, created through the 511NY Rideshare programs can significantly extend the reach and value of ICM strategies.

Although agencies currently engage with each other and are aware of conditions, active collaboration requires a responsive real-time joint decision-making capability that builds from day-to-day operational engagement, especially at a TMC level. The JTMC and other management centers in the corridor are the nerve centers for coordinating systems management and operations. These centers provide situational awareness of regional transportation systems and play a vital role in the lives of travelers throughout the state by providing real-time traveler information, managing incidents and events on the network, and coordinating responses during emergencies. This integration may range from simple operator-to-operator exchanges all the way to data fusion and integration.

There is a strong history of working together in the region. However, different agencies and centers involved may have different ways of handling issues and making decisions. Having clear protocols that describe roles and responsibilities and communication procedures are important for effective active collaboration. Increasing standardization and integration of information between modal transportation management agencies, including sharing of real-time information, lends support to the ICM vision.

In parallel, involving new partners in systems management (Figure 4-4) is necessary to support the entire travel experience. Advancing new partnerships includes bringing in:

Figure 4-4. New partnerships to involve in ICM systems management (Source: ICF)



- **The private sector,** as developers of new mobility and traveler information business models, as well as employers who influence how their employees get to work through their own business practices and protocols (e.g., telecommuting policies, flexible work schedules, transit passes, and parking policies).
- **Parking operators,** including the private sector and local governments, to advance smart strategies in relation to parking pricing, preferential parking for carpools and vanpools, appropriate hours and rates for on-street versus

off-street parking, informal or formal park-and-ride arrangements to support transit and ridesharing, and other strategies such as real-time parking availability.

- **The freight community,** including shippers, carriers, and receivers, to advance strategies to better manage goods movement across all modes in ways that reduce congestion, improve reliability, and enhance regional economic competitiveness.
- **Local agencies and employment hubs** that play an important role in travel demand and operations.
- **Other state agencies and their partners** responsible for housing, economic development, and health services to support mobility needs for populations with unique travel needs and constraints, including low-income populations, veterans, the mobility challenged, and aging populations.

4.2. Identification of User Needs

Based on the team's assessment of current operational processes and challenges summarized in Section 4.1, the following key user needs were identified. These needs (Table 4-1) form the basis for the development of the ICM-495 Concept described in Chapter 5. Each need is described in further detail in the paragraphs below.

Table 4-1. User Need Statements

No.	User Need Description
1	Enhance corridor-wide agency situational awareness particularly during incident response
2	Enhance protocols to create unified agency definitions for corridor events
3	Improve corridor-level decision-making on agency incident response practices
4	Improve incident response and clearance times along the Corridor
5	Support and prioritize higher occupancy vehicle trip reliability (HOVs, bus transit) along the Corridor
6	Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor
7	Dynamically manage (through Active Traffic Management) for key bottleneck areas
8	Provide actionable traveler information at key decision points outside and along the corridor
9	Improve customizability of messages for management of freight demand and regulation of truck traffic
10	Enhance corridor manager engagement with key stakeholders such as employers, special event managers, parking operators, private sector partners on demand management

1. **Enhance Corridor-Wide Agency Situational Awareness Particularly During Incident Response.** Stakeholders identified awareness on ongoing corridor conditions and incident reporting and management as top priorities for ICM. Incident-related data is not captured consistently or reliably and reporting protocols are different across the various agencies that operate within the Corridor. This makes it more challenging for various agencies to become aware of an incident or know who is responding. While the initial incident may be widely known, the awareness of corridor agencies varies as the incident response progresses. Continued awareness of field conditions is vital as agencies plan their responses to events that may be taking place in other parts of the corridor.

2. **Enhance Protocols to Create Unified Agency Definitions for Corridor Events.** Because of the high volume of traffic on the Corridor, many incidents occur on a daily basis. It is important to provide a definition that identifies an incident that has corridor implications and requires an integrated approach to managing it. Furthermore, the NYCEM operates within a large portion of this region and

has its own triggers for events in which they must be involved. Therefore, it is important to define the differences between ICM Events and NYCEM events, or identify when ICM can support NYCEM's efforts. Event duration, response duration, and degree of severity are characterization parameters being considered.

3. **Improve Corridor-Level Decision Making On Agency Incident Response Practices.** In order for effective incident response, multiple agencies need to be on the same page and know what tools in the toolbox are available for a coordinated response. Travelers do not care about the specific agency, only that the response is coordinated and seamless from their perspective. Providing multi-jurisdictional interventions will require a level of management cooperation that goes beyond the monitoring and information sharing that currently exists at TRANSCOM, the JTMC, and other bilateral and multilateral efforts.

4. **Improve Incident Response and Clearance Times along the Corridor.** Field incident response too, is typically a multi-agency affair. Greater coordination between operating agencies and law enforcement can help improve on-site management of an incident, leading to reduction in incident delays. Through a focused TIM program, traffic management, towing, and law enforcement can work together to maintain mobility while ensuring responder safety. Because the various agencies respond to incidents in the Corridor in different ways, a multi-agency ICM Playbook could help with situational awareness by documenting scenario types, including response plans to fit the ICM framework and context, and defining each agencies' roles and actions according to each type of event.

5. **Support and Prioritize Higher Occupancy Vehicle Trip Reliability (HOVs, Bus Transit) Along the Corridor.** In this Corridor, transit is not a supporting mode; rather transit is equal and possibly dominant to driving during peak times. Even though Corridor roadways are at capacity, there is potential to reduce the number of SOVs by prioritizing HOVs and transit travel and making these modes more convenient and attractive to travelers. Methods include enabling these modes faster travel time through the Corridor in comparison to SOVs. However, transit options must work together to improve travel time reliability and reduce delay as MTA trains and LIRR are over capacity during peak hours and park and ride lots are often full, so there is no excess capacity to shift drivers to transit.

   The opportunity to reduce SOVs and prioritize transit lies in improvements to bus operations in the Corridor. Currently, buses have difficulties merging onto highways and into HOV lanes due to high volumes of traffic. Transit only ramps, HOV extensions, and TSP can help push buses through congestion and strengthen the reliability of bus transit trips in the Corridor. Transit drivers can also provide en-route information about roadway conditions to transit management centers or even other drivers, to help better respond to road conditions.

6. **Proactively Manage Short-Term Demand Surges and Ongoing Diversions on Facilities in the Corridor.** The Corridor plays host to hundreds of events each year, each of which creates a temporary surge of trips and requires a measure of traffic management. These events can be either pre-planned or impromptu. For pre-planned events, network operators can draw from prior experiences with similar parameters, with appropriate interventions chosen. Effective management of events benefits eventgoers themselves, as well as minimizes disruptions on the surrounding network. There are also opportunities to coordinate with private sector route guidance companies

to redirect travelers away from key bottleneck areas and onto alternatives that can accommodate the diversion and were designed to handle the amount of traffic being diverted.

7. **Dynamically Manage (Through ATM) Key Bottleneck Areas.** Various bottleneck locations exist within this Corridor that require careful management and provide for opportunities for improvement using ICM. These bottlenecks impact travel time reliability, as discussed in Section 4.1.1 and can affect multiple modes, including transit, freight, and private vehicle travel. Some of the key bottleneck locations include the Lincoln Tunnel and the QMT, particularly during AM and PM peak periods. Active traffic management strategies, such as high occupancy toll (HOT) lanes, speed warning, queue warning, dynamic junction control, and ramp balancing may have applicability in different parts of the Corridor.

8. **Provide Actionable Traveler Information at Key Decision Points Outside and Along the Corridor.** Traveler Information must be provided early enough in a traveler's trip, that their decision-making impacts Corridor performance, whether it is to shift modes or to take an alternate route. In this Corridor, the travel shed is geographically vast and decisions about travel can be made as far south as Pennsylvania or as far north as Connecticut. Decision points such as Newark Penn Station, Newark Airport, and JFK Airport allow a traveler to make decisions about modes, times, and routes for travel through the Corridor because these locations are where multiple transit mode types converge and where travelers can choose to change modes if desired. For example, Newark Penn Station is a hub for NJT, Newark Light Rail, PATH, Amtrak, and several local, regional, and national bus carriers.

9. **Improve Customizability of Messages for Management of Freight Demand and Regulation of Truck Traffic.** While freight plays an important role in the Corridor, freight trips are heavily influenced by the Corridor's older roadway infrastructure and associated freight restrictions. Managing the Corridor includes managing freight traffic and, when necessary, diverting freight traffic to other routes. There is a need for freight-specific traveler information to ensure freight drivers have alternative options but also travel on appropriate roads. With the rise of online shopping services offering same-day and short window deliveries, the number of truck trips along the Corridor is increasing. Because freight involves the physical movement of goods, it is nearly impossible to divert freight trips to other modes. At the same time, different roadways across the Corridor were built to different standards for widths and heights. As a result, it is key to have a unified and understandable communication system so truck drivers are aware of the maximum allowable dimensions on each segment of roadway.

10. **Enhance Corridor Manager Engagement with Key Stakeholders Such As Employers, Special Event Managers, Parking Operators, and Private Sector Partners on Demand Management.** With the importance of demand management along the Corridor, operating agencies need to establish partnerships with stakeholders who are influential in reducing or redistributing the demand levels on the Corridor. Enhanced employer-based TDM programs, active parking management and planned special event management strategies are needed to ensure that there is direct engagement with travelers. Through partnerships, operating agencies can communicate current and anticipated travel information in the Corridor not only through their traditional traveler information channels but through direct engagement with employers, special event managers, parking operators.

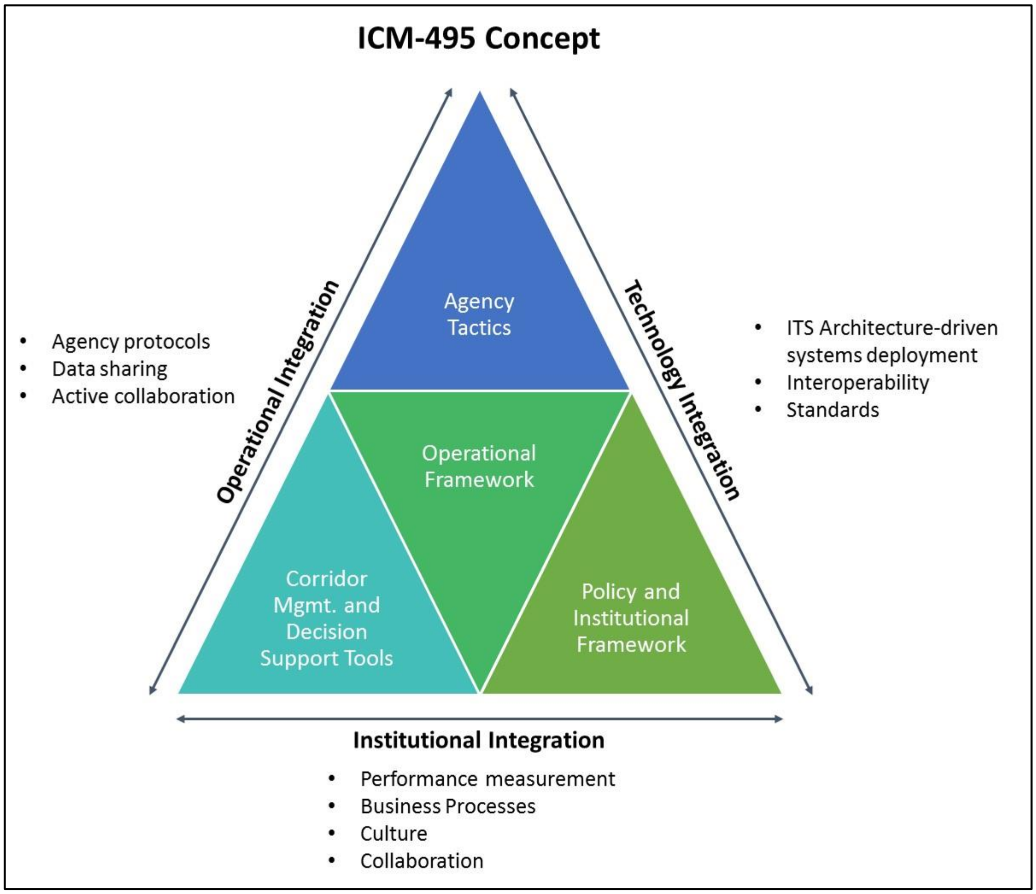
4.3. Description of Desired Changes

Supporting the above mentioned needs in a complex environment like the ICM-495 Corridor requires a framework that takes into account legacy systems, existing ITS architectures, and information sharing resources that are functioning at a high-degree of capability today. Desired changes proposed for this project are shown in the framework below (Figure 4-5) along four dimensions of change. These include:

- **Policy and Institutional Framework.** Changes to language, agreements, and performance standards and established structure to ensure ICM is embraced by all operating agencies in the Corridor.
- **Operational Framework.** Changes to the way operating agencies manage their systems and services to better support ICM.
- **Corridor Management and Decision Support Tools.** Identification of better data to support ICM.
- **Agency Tactics.** Changes to operating agencies response strategies to close any gaps that can hinder an effective ICM-495 Concept.

The following sub-sections describe each dimension of change in further detail.

Figure 4-5. Description of Desired Changes in the Corridor (Source: ICF)



4.3.1. Changes to Policy and Institutional Framework

Effective corridor management depends on harmonization of the various policies and institutional arrangements that exist among stakeholders. Table 4-2 lists the policy issues identified during ConOps development.

Table 4-2. ConOps-related Policy Issues

Topic	Description
Funding	Funding is a big challenge to support systems in the region. Maintaining the status of the infrastructure requires a substantial amount of available funds. Dedicating funds for ITS which are typically not part of ongoing expenses will be difficult.
Automation	When considering corridor integration, the region will need to look beyond reliance on operator-led activation and deactivation of strategy/decisions. High levels of automation will be required. Need to determine what increases in technology can be made to take the burden off of the operator. If everyone agrees on a protocol, there can be more automated systems.

Without a common understanding of policies and operational constraints it is difficult for the corridor to operate seamlessly. For an effective ICM Corridor, potential modifications from current operations to support ICM from a policy and institutional perspective are needed under the following key areas:

Technology Procurement. The *New York City Sub-Regional Intelligent Transportation System (ITS) Architecture* and the *Connected Corridor Regional ITS Architecture* define the current and future vision for interoperability and data exchanges in the region. With a multitude of operating agencies and systems, a clear understanding of and adherence to ITS standards is needed across Corridor agencies to enable effective procurement and systems development**.**

Operations Policy. An agreed upon ICM policy statement should be established. The signed ICM policy statement should identify roles and responsibilities, overall objectives, and core performance measures to provide the institutional buy-in from the different operating agencies. Policy-level support is also needed to address freight demand consistently in the corridor.

Planning and Performance Measurement is necessary for continual targeted improvements in the corridor. Common corridor-specific performance measures can help simplify this process.

Workforce Training supports improved coordination between Corridor agencies during incidents and emergencies. This engagement will support reductions in clearance times and enhance the safety and mobility of Corridor travelers.

Culture and Institutions. Establishing a communication method to showcase corridor operational improvements will build support for the program.

Data Management. ICM depends on data availability from various agencies. Ongoing data management is required. Agreements for identifying roles and responsibilities to ensure critical data dependencies are maintained during operations are necessary for ICM.

For detailed information on the above changes and their rationale, refer to Technical Memorandum #5, *Listing of Initial TMS Concepts and Operating Scenarios*

4.3.2. Changes to Operational Framework

The corridor consists of numerous agencies and stakeholders, each with varying operational strategies and objectives. These differences can create significant inefficiencies in response, especially in regard to bottlenecks and at key locations and jurisdictional boundaries. Although there is significant activity along the Corridor and with the NYC region, operational collaboration has been limited to roadway and law enforcement entities. Table 4-3 lists the operational gaps identified during the course of ConOps development.

Table 4-3. ConOps-related Operational Gaps

No.	Gap Description
1	No single point of contact between agency operations centers
2	No integration of weather data for corridor user information and operations
3	Limited strategies for freight mobility and multimodal opportunities
4	Fragmented incident management coordination and response across agencies
4a	No common incident classification guidelines
4b	No consistent set of protocols for consistent data formats
4c	Minimal diversion management capabilities
4d	No protocols for reporting information quickly from the field so that all agencies receive updates in time to understand, analyze, and react to a situation

Through ICM, it is important to shift towards a multimodal focus and integrate transit with highway operations. Potential modifications from current operational approaches that will support ICM, include the following:

Harmonization of Operational Protocols. There is a need to standardize operational protocols and regulations. Incident reporting procedures vary across agencies, creating a challenge in developing joint operational responses. Oversize/overweight restrictions are also reported differently across state jurisdictions. Travelers may not be able to easily distinguish these differences.

Transit-Highway Cooperation Improvements will enhance situational awareness. Bus operations can provide updates on field conditions. For example, information sharing between the JTMC and the Bus Operations center can be valuable in enabling a quicker response to events.

Identification of ICM Event Definition and Reporting. Not all events require coordination between agencies. Similarly, very large events are handled effectively through the emergency management process. However, defining a sub-set of events that are likely to have involvement with multiple agencies in the corridor helps focus the ICM on events where a coordinated response currently does not exist.

For detailed information on the above changes and their rationale, refer to Technical Memorandum #5, *Listing of Initial TMS Concepts and Operating Scenarios*

4.3.3. Changes in Corridor Management and Decision Support Tools

Various support tools can bring awareness to the current level of performance and can forecast the impacts of conditions on the corridor. This is important as understanding Corridor performance can improve decision-making reliability. The following list includes suggested changes in corridor management and decision support tools for ICM.

C2C Real-Time Operational Information Sharing. Greater information sharing will improve corridor-wide situational awareness, particularly during incident response. A C2C network will allow operators to exchange data feeds and alert information.

Field-to-Center Incident Reporting. Similarly, field-to-center communications will connect operators and first responders, and will help reduce clearance times.

Corridor Impact Assessment and Predictive Capabilities. There is also a need for corridor-wide impact assessments which will improve corridor-level decision-making, especially in regard to agency incident response practices.

Real-Time Performance Reporting. Performance reporting dashboards will improve decision-making by facilitating unified corridor-wide performance awareness.

For detailed information on the above changes and their rationale, refer to Technical Memorandum #5, *Listing of Initial TMS Concepts and Operating Scenarios*

4.3.4. Changes to Agency Tactics

Advancements in systems technology provide new tools in each operating agency's toolbox for corridor management. Through ICM-enabled tactics, agencies can improve dynamic management, specifically at bottlenecks in the corridor. The following includes suggested changes in agency tactics that will support ICM:

Enhance Situational Awareness. ICM aims to enhance situational awareness in the corridor. There are several traffic management strategies and roadway investments to consider such as volume detection capabilities, speed detection capabilities, RWIS sensors, truck height sensors, etc. These improvements will increase awareness of field conditions and corridor-level decision-making.

Improve Corridor-Level Joint Incident Response. ICM will also improve joint incident response and clearance times. Diversion management should be considered at the corridor level. Arterial DMS can support route choice and proactively manage short-term demand surges. There is also opportunity to improve towing contracts and capabilities for quick-response vehicles.

Short-Term and Long-Term Demand Management. ICM demand management tactics will improve the reliability of travelers' decision-making capabilities by providing real-time, multimodal information. They will also help balance demand across modes and time of day through tactics such as variable tolling and transit fare implementation and traffic responsive managed lane operations. Diversion outside of the study corridor must also be considered. The corridor does not stand alone but rather, is part of a much larger regional transportation network.

Bottleneck Mitigation and Active Traffic Management. Active traffic management strategies such as adaptive ramp metering, queue warning, dynamic reversible lanes, and transit signal priority add a higher level of traffic management capability on the corridor than what currently exists.

Traveler Information. Multi-modal, proactive, real-time information enhances the dissemination of information to travelers and improves inter-agency coordination during events. It also enables travelers to make informed choices regarding pre-trip and en-route mode changes, improving trip reliability and reducing travel time.

Event Management and **Construction Coordination.** Development of new tools, processes and playbooks that help with continued coordination of events and construction in the corridor are necessary to provide travelers with alternatives during times when corridor facilities are restricted.

For detailed information on the above changes and their rationale, refer to Technical Memorandum #5, *Listing of Initial TMS Concepts and Operating Scenarios*

4.4. Priorities among Desired Changes

All identified changes were recognized as a priority by stakeholders. However, their implementation and adoption will be driven by the system description in Chapter 5. It is likely that some of the changes may be adopted sooner than others. Changes around agency tactics may take longer to implement.

To help guide system development, a high-level benefit-cost analysis (BCA) was performed on selected identified operational strategies and tactics. The BCA provided quantitative insights into the potential performance of several proposed changes and strategies on the ICM-495 corridor. It also provided a sense of the value associated with various investments and strategy implementations. The BCA provides the ICM-495 stakeholders with the preliminary high-level analysis resources, data, and materials needed to present a compelling case to decision-makers and agency leadership for continued investment in ICM on this corridor. The detailed analysis approach and results are summarized in the *Technical Memorandum #8: TMS Concept B/C Assessment and Priority Analysis*. Analysis and summary of impacts of the changes implemented as part of the ICM system are provided in Chapter 7 and Chapter 8.

4.5. Alternatives Considered but not Included

A list of Corridor-based changes representing a holistic view of operational strategies and tactics are included in Section 4.3. However, based on stakeholder input, certain alternatives were not considered as part of the ICM concept. These include:

- Cordon-based, congestion-based pricing of corridor users. While dynamic tolling at the existing tunnel tollbooth locations is considered, broader pricing policy was not considered as part of the study.
- Increased capacity along Corridor mainlines and transit through infrastructure improvements.
- Changes to facility ownership or management of Corridor assets.
- Realignment of TMCs or functions. No changes to overall agency functions or organizational responsibilities are proposed.
- Actively promoting diversions to arterial streets is not considered due to the challenges of limited capacity and lack of situational awareness.
- Restructuring law enforcement or non-transportation agency processes was not considered within scope of the ICM. However, greater coordination with these groups is included.

5. ICM-495 OPERATIONAL CONCEPT

This chapter describes the proposed ICM-495 Concept. This concept was developed in response to the stakeholder concerns and desired changes identified in Chapter 4 to improve performance along the I-495 Corridor.

5.1. ICM Vision, Goals, and Scope

The following vision statement was developed for the ICM-495:

> *"To enhance the current transportation management systems of the ICM-495 Corridor by using state of the practice solutions to build integrated, balanced, responsive, efficient, effective, and equitable programs and systems that actively reduce traveler demand; monitor and control traffic; and improve the mobility, reliability, and safety of all users. Solutions and resources will create a balanced network that reflects integration of pre-existing programs and systems with modified and new deployments. Improving overall Corridor performance will be a priority by providing better knowledge about real-time conditions and alternative travel options within practical operational, institutional, and financial constraints."*

This vision statement reflects the desire of partnering agencies and authorities to optimize traffic flows within the Corridor and its transportation networks in balanced and integrated ways – between various transit alternatives, expressways, and arterials; freight and passenger travel; and public and private transportation modes in a manner that equitably accommodates all users of the ICM-495 Corridor.

Building from the stated vision, the identified user needs and the desired changes, four goals for the ICM project are identified.

Goal 1. Strengthen corridor level operational collaboration to enable coordinated responses to events in the corridor;

Goal 2. Improve ability to dynamically operate corridor systems, and facilities with an emphasis on travel reliability

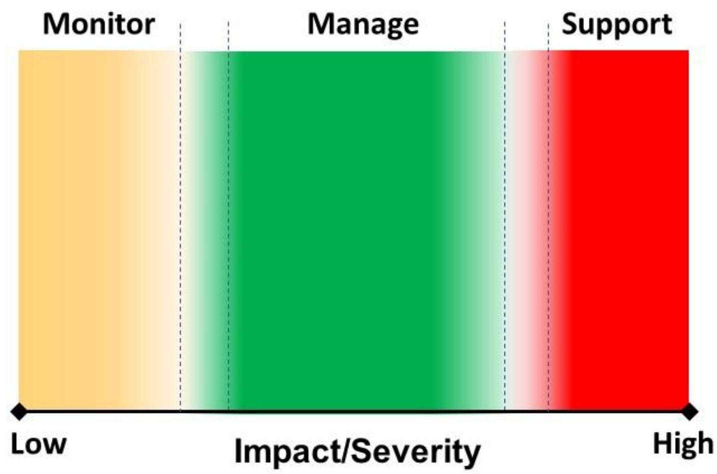
Goal 3. Enhance management of short-term and long-term demand-supply imbalances in the corridor

Goal 4. Improve availability and use of travel choices in the corridor through targeted and actionable information

The scope of ICM is directly dependent on the impact/severity of the event, (as shown in Figure 5-1). Generally, the proposed ICM system will:

- **Monitor** low-impact events – Proposed ICM system elements will help provide greater situational awareness of low-impact events to corridor stakeholders
- **Manage** actively medium-impact events (ICM events) – This is at the heart of the ICM scope. For events that impact corridor operations, proposed ICM system elements help improve collaboration between operating agencies in the corridor.
- **Support** high-impact events that might be managed by Emergency Operations Centers (EOC events) who have their own procedures and playbooks

Figure 5-1. Scope of the ICM System (Source: ICF)



It should be clarified that Figure 5-1 is not meant to indicate distribution of events by severity—that is, the number of low, medium and high impact events. Instead, this figure portrays the ICM's capability to manage a wide range of events, from Low-Medium to Medium-High impact. Impact levels are defined later in this chapter but they correspond to existing approaches used by corridor stakeholders to define severity.

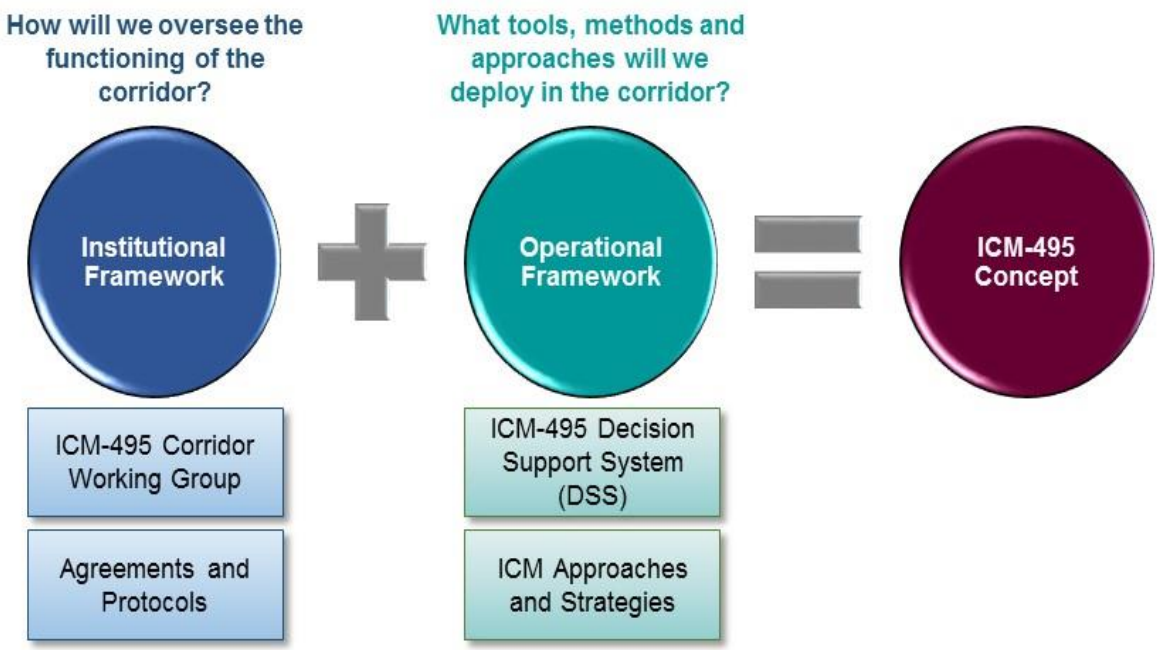
5.2. Description of ICM-495 Concept

The ICM approach coordinates transportation management techniques among agencies and their network through two layers: institutional and operational, as shown in Figure 5-2.

The Institutional Framework – described in Section 5.2.1 – is the establishment of a working arrangement that enables effective oversight and support for corridor-level initiatives. The framework includes the working group and the necessary agreements, protocols and policies. Simply put, the institutional element addresses the question – *"How do we oversee the functioning of the Corridor?"*

The Operational Framework – described in Section 5.2.2 – involves sharing information and management responsibilities and the technological means employed to achieve active management of Corridor assets. The framework addresses the question – *"What tools, methods and approaches will we deploy in the Corridor?"*

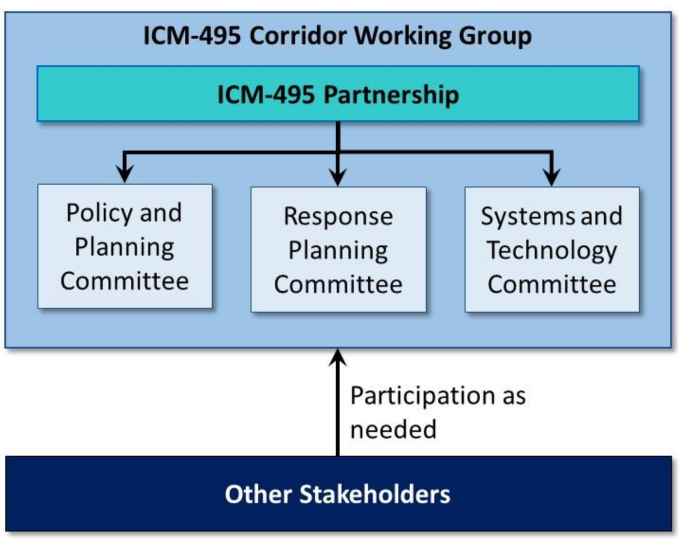
Figure 5-2. Graphical Overview of the ICM-495 Concept (Source: ICF)



5.2.1. Institutional Framework

The ICM-495 Concept Institutional Framework (Figure 5-3) defines how agencies cooperate and manage their individual assets in order to optimize the overall performance of the integrated Corridor and satisfy the cross-agency, cross-jurisdictional needs. The following subsections detail the different elements of the Institutional Framework and the type of agreements needed between agencies.

Figure 5-3. Institutional Framework for the ICM-495 Concept (Source: ICF)



5.2.1.1. ICM-495 Partnership

The Partnership consists of agencies directly responsible for transportation management in the Corridor. Each partnering agency has an economic and political interest in the efficient management, maintenance and operation of the Corridor's transportation networks. These agencies provide the technical resources needed for the implementation of the ICM-495 Concept. Partnership agencies include (listed by jurisdiction):

New York State	New York and New Jersey	New Jersey
• NYC DOT • NYSDOT • MTA B&T • MTA NYCT • MTA Bus Company • LIRR • NYMTC	• PANYNJ (PATH and TB&T) • TRANSCOM • FHWA	• NJDOT • NJT • NJTA • NJTPA

5.2.1.2. Other Stakeholders

Other stakeholder agencies with an interest in the Corridor that might be included for specific decision-making in the corridor include:

- Amtrak
- City of New York
- Commercial business and industry
- Commercial vehicle companies and freight industry
- FEMA
- FDNY
- Hudson TMA
- MTA Police
- Municipal Police, Fire, and Emergency Medical Departments
- New Jersey State Police
- NY Waterway
- NYC emergency medical services agencies
- NYC Sanitation Department
- NYCEM
- NYPD
- NYS Office of Emergency Management
- New York State Police
- PANYNJ Police
- Private ambulances
- Private parking facilities
- Private sector info service providers
- Public and private bus companies
- US Department of Homeland Security
- Towing industry

5.2.1.3. ICM-495 Corridor Working Group

The ICM-495 Corridor Working Group (described in Table 5-1) is comprised of representatives from all the ICM-495 Corridor partnering agencies. It is the entity responsible for the overall strategic direction of the ICM-495 Concept and is organized into three committees staffed by the partner agencies. The corridor working group can build on existing committees and forums that are already in place in the New York region. Examples highlighted in stakeholder discussion include TRANSCOM based committees, Metro Mobility Council, and ITS Architecture working groups which have been used in the region previously. As noted above, other stakeholders are included as needed.

Table 5-1. ICM Working Group Roles and Responsibilities

Name	Responsibilities	Meeting Occurrence
Policy and Planning Committee	• Supervising the implementation of new operational policies or enhancements to existing policies in the Corridor (e.g., VMS policies, Travel Times, Dynamic Tolling) • Coordinating planning and programming capital and maintenance projects that impact the Corridor • Developing a joint work program and project partnerships for Corridor-level initiatives including identification of funding sources and grant applications • Developing a capability to model strategies and identify benefits (i.e., developing an analysis model of the corridor) • Generating support for Corridor decisions across agency decision-makers	quarterly or up to six times annually
Response Planning Committee	• Continually improving response plans for Corridor events working with various TMC operators, planners and first responders • Coordinating response strategies across stakeholders including identifying agreed upon responses to conditions • Performing after-action reviews of ICM events to understand how the ICM-495 system is functioning • Supporting pre-planning of sustained disruptions of the Corridor such as major construction, weather events and special events • Engaging regularly with EOC and on-site law enforcement to improve TIM processes and responder safety	Monthly or after a major event
System and Technology Committee	• Supervising ICM-495 DSS compliance with required standards and the *New York City Sub-Regional Intelligent Transportation System (ITS) Architecture* and the *Connected Corridor Regional ITS Architecture* • Ensuring ICM-495 DSS interoperability across agency boundaries and with other corridors • If needed, supporting the revision and updates of existing standards, and the development of new standards • Overseeing support provided by the ICM-495 DSS for the design and implementation of pilot projects (e.g., Connected Vehicle-related).	Quarterly or every six months

5.2.1.4. Agreements, Operating Procedures, and Policies

Given the nature of integrated systems—corridors crossing multi-jurisdictional boundaries—interagency agreements and clear operating procedures are needed to efficiently manage the corridor and coordinate response efforts. For this project, new agreements and operating procedures, or updates to existing ones, will be needed to ensure the development and implementation of an effective system satisfying the need and goals of all stakeholders. Table 5-2 provides examples of interagency agreements, operating procedures, and policies that may need to be developed or amended as part of this system concept. It should be noted that other items may also be needed depending on the final architecture and design.

Table 5-2. Overview of ICM-495 Concept-Related Agreements and Operational Procedures

Name	Description
Agreements	
Project charter	Document stating the scope, objectives, and participants in an ICM-related actions (e.g., integrated corridor-wide VSL, traveler information, oversize warnings, and VMS). The document often serves as a reference of authority for the future of the project. Elements outlined typically include a preliminary delineation of roles and responsibilities, the project objectives, the main stakeholders, and the authority of the project manager.
Memo of Understanding (MOU)	Formal but non-binding agreement between two or more parties establishing an official partnership between them. These documents typically describe how the various parties would work together on a project or program.
Data sharing agreement	Agreement enabling participating agencies and/or entities to use data that has been collected and/or processed by other agencies.
Operating Procedures	
Standard operation and maintenance procedures	Agreements outlining the procedures that are to be followed by individual agencies in support of normal system operations. Such agreements may establish guidelines on how traffic signal coordination is to be promoted and implemented across jurisdictions, how freeway ramp metering rates are to be established, who would be responsible for the maintenance of ICM field devices, etc.
Incident and event management procedures	Agreements outlining the procedures that should be followed by individual agencies in response to detected incidents and unplanned events. Such agreements may define procedures for identifying response routes for incident responders, identifying detours for the general traffic and transit vehicles, updating and disseminating incident-related traveler information, deploying and operating variable message signs, initiating and terminating special traffic signal timing plans along arterials, and modifying freeway ramp metering operations.
Policies	
Development and reporting of common corridor-specific performance measures	A core set of performance measures for the corridor, agreed upon by operating agencies allow for continual improvements to be targeted in the corridor.
Prioritizing programming of ICM projects	Support for implementing the projects and ideas defined in the Concept of Operations is needed to bring ICM to fruition. This may include agency-level prioritization of the projects/initiatives that support ICM, and regional projects championed by all that are undertaken by agencies such as TRANSCOM.
Analysis, Modeling and Simulation framework for corridor management	Development of an AMS testbed framework allows for new tactics and strategies to be tested and verified before implementation in the field.

5.2.2. Operational Framework

The Operational Framework describes the day-to-day operation of the ICM-495 Corridor. The framework consists of two elements –

(1) the ICM-495 Decision Support System (DSS) and
(2) the enhanced tools and approaches that will be deployed in the Corridor.

5.2.2.1. ICM-495 Decision Support System

The ICM-495 DSS (Figure 5-4, page 54) is a computer-based information system that supports organizational decision-making activities by bringing together the Corridor's human and existing ITS resources. The DSS facilitates active collaboration and coordinated management and response processes amongst partner agencies—a much needed tool as events are constantly and rapidly evolving, regardless of whether they are recurring (e.g., rush hour) or not (e.g., traffic accidents).

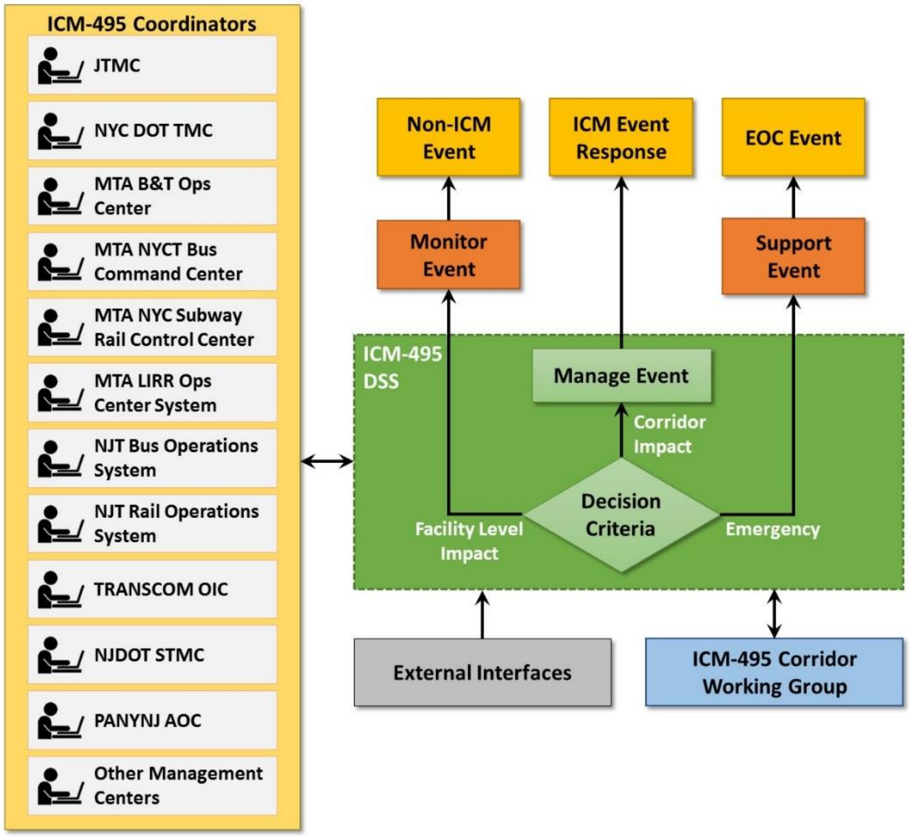
Given the complexity of the corridor, the ICM-495 DSS heavily relies on the human-element of the system to coordinate responses, building upon a robust data integration and fusion capability that exists in the region. The DSS, as envisioned currently, does not include an online simulation element, predictive capabilities, nor does it include command and control capabilities. However, it does allow for automatic updates for certain agency resources like traveler information through external interfaces. The DSS emphasizes flexibility and adaptability to accommodate changes in the environment and the decision making approach of the user.

The proposed DSS establishes a core capability for the Corridor to which additional capability can be added including on-line simulation and prediction systems in the future. The complexity of the corridor operations and agency responsibilities necessitate this evolutionary approach to decision-support.

At this state in the ConOps, the functions of the ICM-495 DSS are defined but the ICM-495 DSS itself is solution-agnostic. Meaning the ConOps is silent on whether implementation of an ICM-495 DSS should be conducted as a separate system or as an enhancement of an existing system used by agencies in the corridor.

Figure 5-4 presents a high-level context view of the ICM-495 DSS. The ICM-495 DSS continuously collects and analyzes information on current conditions to determine the role it will play in responding to events. Based on the decision – assessed using pre-determined criteria – the system either monitors the event (non-ICM event), manages the event (ICM Event), or provides support (EOC-event).

Figure 5-4. ICM-495 DSS Context Diagram (Source: ICF)



The following definitions (Table 5-3) are critical to the understanding of the proposed ICM-495 DSS shown graphically in Figure 5-4.

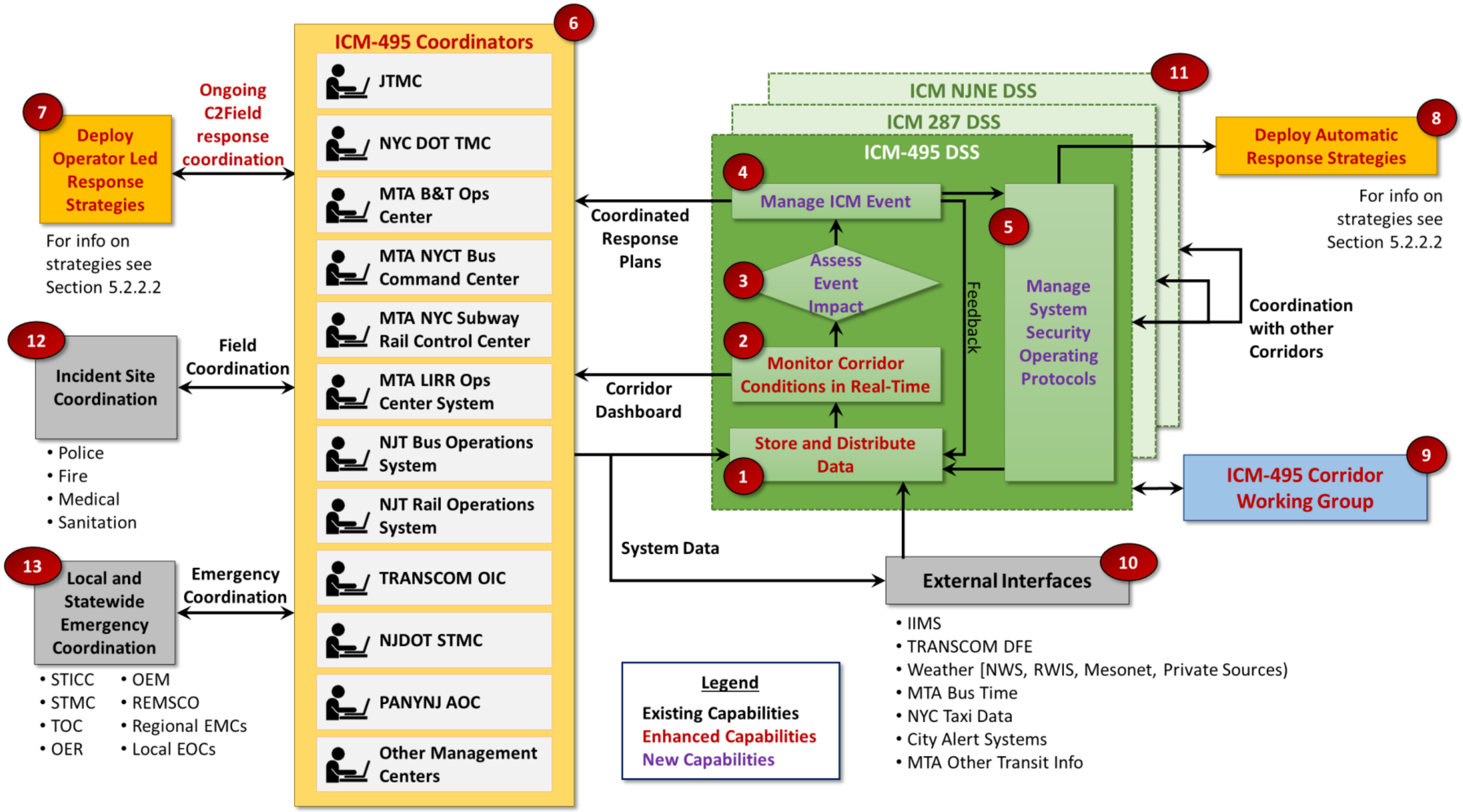
Table 5-3. ICM-495 DSS-Related Definitions

Term	Description
ICM Event	An event that meets one or more of the following criterion for corridor-level management. • Anticipated impact duration of the event – 2 hours or more • Has multimodal, multi-agency implications in terms of disruption – impacts at least one other mode or agency • Is occurring at defined corridor chokepoints • Does not result in Emergency Operations Center (EOC) activation
Non-ICM Event	An event that is managed individually by partner agencies but does not rise to the level requiring a corridor-level response. Most of these events are confined to the facility of interest. These could include minor incidents like stalled vehicles, debris on the roadway, bus breakdowns etc.
EOC Event	An event which requires the activation of an EOC. In these events, the primary role of coordination is deferred to the EOC that is managing the event.
ICM Coordinators	Each operating entity in the Corridor will identify a person designated as the ICM coordinator. This person's function is to support the human element of the coordinated response for ICM when an ICM Event is identified. For each ICM Event, one of the ICM-coordinators will become the ICM Event manager depending on where the event is located. When functioning as the ICM Event manager, the ICM coordinator will lead the coordination of the response and direct the responses required by other ICM coordinators.

ICM-495 Corridor Working Group	The ICM-495 Corridor Working Group, discussed in Section 5.2.1.3, is responsible for the continual improvement and strategic direction of the ICM-495 DSS.
External Interfaces	These represent the data interfaces necessary to support the operations of the ICM-495 DSS including obtaining corridor data on the state of the network.

Functionally, the ICM-495 DSS is further elaborated on graphically in Figure 5-5 and described in Table 5-4

Figure 5-5. ICM-495 Concept Functional View (Source: ICF)



The table below is organized by the numbering presented in the graphic.

Table 5-4. ICM-495 DSS-Related Functions

No.	Function	Description
1	**Store and Distribute Data**	The ICM-495 DSS stores and distributes all quality checked data (e.g., IIMS, TRANSCOM DFE, Weather [NWS, RWIS, Mesonet, Private Sources], MTA Bus Time, NYC Taxi Data, City Alert Systems, and MTA Other Transit Info). This includes timestamped and, when available, geotagged logs of all information generated and shared within the ICM-495 DSS for other functions. Data to the ICM-495 DSS is provided to various external interfaces from agency-operated systems and/or via existing data fusion engines available in the region.
2	**Monitor Corridor Conditions in Real-Time**	The ICM-495 DSS uses fused data to develop key performance indicators for the Corridor and visualization necessary for ICM Coordinators to have a dashboard view of corridor performance.
3	**Assess Event Impact**	Based on pre-existing rules established by the ICM-495 Corridor Working Group, the ICM-495 DSS assesses a confirmed event against a set of criteria to identify whether the situation will be managed individually (i.e., a facility level event which impacts a single agency), by the EOC, or if it is an ICM Event. Event impacts may be defined using MUTCD levels and those used in NYSDOT Emergency Transportation Operations Playbook.
4	**Manage ICM Event**	When an ICM Event is identified, all ICM Coordinators (#6) are notified. Depending on the location of the event, an ICM Event Manager is identified among the ICM Coordinators. The ICM Event Manager then helps coordinate the information exchanges necessary between the agencies through their respective ICM Coordinators who will continue to be responsible for their own agency operations. The ICM Event Manager may also activate agreed-upon automated responses (for example, posting to 511, informing other corridors and TMCs (#8)). As the event progresses, ICM Coordinators and the ICM Event Manager will update the ICM-495 DSS with ongoing conditions based on their coordination with the field through Incident Site Coordination (#12).
5	**Manage System Security Operating Protocols**	This function supports the user management and cyber security of the ICM-495 DSS.
6	**ICM-495 Coordinators**	ICM coordinators represent the human-element of the response. They are the identified points of contacts within each of the major Corridor TMCs and will be contacted as part of an ICM Event.
7	**Deploy Operator Led Response Strategies**	Utilizing coordination with the ICM Event Manager, ICM Coordinators will be responsible for deploying various operator-led strategies (identified in Section 0) including active traffic management, demand management, and traveler information.
8	**Automated Response Strategies**	The ICM Corridor Working Group (#9) may identify a set of automated responses to ICM Events including notification on 511, notification to other corridor ICMs or to other TMCs. These will be automatically generated by the ICM-495 DSS upon approval by the ICM Event Manager (#6).
9	**ICM-495 Corridor Working Group**	The ICM-495 Corridor Working Group provides strategic direction and continual improvement of the ICM-495 DSS performance by conducting after-action reviews, policy assessments, and response plan improvements.
10	**External Interfaces**	External interfaces provide the data necessary for ICM-495 DSS performance from existing sources of data integration and fusion available in the Corridor.

No.	Function	Description
11	Other ICMs	The ICM-495 DSS will interface with other DSS developed for ICM projects around the New York and New Jersey region, sharing information when an ICM Event is in effect as well as providing a corridor-level dashboard for situational awareness.
12	Incident Site Coordination	It is likely that the incident response is going to be led in the field by law enforcement, following an Incident Command Structure (ICS). The ICM Coordinator will be responsible for coordinating with the field-level response to the event. However, the use of automated tools like the Incident Information Management System (IIMS) are included in the coordination element.
13	Local and Statewide Emergency Coordination	When an EOC is activated, all ICM coordinators will be responsible for supporting the EOC function. Where possible, data from the ICM-495 DSS can be used to support EOC operations.

5.2.2.2. DSS Operation Modes

Three general modes of operation are described for the proposed DSS, although additional more detailed scenarios could be added throughout the system design and implementation process. It should be noted that these descriptions are not meant to provide detailed guidance on how ICM Partners shall operate under each condition, i.e., specific actions to be taken. Instead, these descriptions provide details on expected circumstances for which the ICM-495 Corridor Working Group would need to develop protocols and agreements to implement proper responses and strategies to successfully and efficiently manage ICM Events.

Manage Single Event. This is the simplest form of operation for the DSS, i.e., one ICM Event being managed by one ICM Event Manager. Under this scenario, the DSS is constantly acquiring data and monitoring the status of the corridor in order to determine its scope of work (i.e., monitor, manage, support). Once an event is tagged as an ICM Event, the DSS analyses the situation and provides a platform to manage the event for all corridor stakeholders, following the sequence of functions.

Manage Multiple Events. It is not realistic to expect that ICM Events will take place one at a time. Therefore, individual ICM Partners will need to engage in and/or manage multiple ICM Events within the corridor at any given period of time—that is, ICM Partners will have ICM Coordinators and ICM Event Manager for events occurring simultaneously. These simultaneous events may occur within or outside of the ICM-495 Corridor, leading to three specific operation sub-scenarios:

1. Multiple events occurring within the ICM-495 Corridor and managed by one ICM Event Manager. For instance, there are multiple incidents on the freeway and the corridor experiences several breakdowns in different locations and therefore cannot be classified and treated as a single event by the facility owner like NYSDOT.
2. Multiple events occurring within the ICM-495 Corridor and managed by multiple ICM Event Managers. For instance, there is a traffic accident on I-495 being managed by NYSDOT while LIRR has a breakdown of their commuter rail services going into Penn Station.
3. Multiple events occurring within the ICM-495 Corridor and other adjacent corridors like the NJNE. For instance, the PANYNJ is identified as the ICM Event Manager to address an incident

that is affecting freight traffic within NJNE Corridor, while simultaneously being an ICM Coordinator for an event affecting New York's I-495 Corridor (where PANYNJ is also an ICM Partner).

Under these sub-scenarios, the DSS uses pre-established internal protocols of action to identify best course of action to determine the management structure of each identified ICM Event.

Manage transitions to an ICM Event from non-ICM Event, and vice versa. As events go through their disruption cycle (i.e., emergence, peak impact, dilution of impact), the DSS will implement pre-established mechanisms (protocols) for transitioning to/from a non-ICM Event to/from an ICM Event. This includes managing the transition from facility-level events (that impact a single agency) to ICM Events and back, and from ICM Events to emergency events managed by the EOC.

5.2.2.3. ICM Operational Approaches and Strategies

To achieve the ICM-495 concept goals and objectives, the ICM-495 Partnership will follow an overarching plan of enhancing the "tools" available in the individual agency's "toolbox" to manage their facilities along with overall corridor-wide improvements. This plan unfolds along seven operational approaches tied to the identified user needs described in Section 4.2. Each approach is described in greater detail in the sections below, along with a list of proposed strategies, their rationale, and responsible Corridor agencies. Note that several of these strategies provide benefits beyond the Corridor, having regional and statewide implications. Table 5-5 provides a mapping of the operational approaches to the user needs.

Table 5-5. Matrix of Operational Approaches and User Needs

Approach	User Needs									
	1	2	3	4	5	6	7	8	9	10
A. Improved Corridor Monitoring	✓		✓	✓			✓			
B. Enhanced Traveler Info		✓			✓			✓	✓	
C. Corridor-Based Demand Mgmt.				✓	✓		✓	✓		✓
D. Coordinated Incident & Event Mgmt.		✓		✓	✓	✓				
E. Transit Bus Tech Improvements					✓	✓	✓			
F. Work Zone Coordination			✓					✓		
G. Active Traffic Management							✓			

Approach A. Improved Corridor Monitoring (User Need #1, 3, 4, and 7)

The ICM-495 concept will include systems that improve corridor monitoring, enabling faster and more precise incident detection and a better understanding of baseline conditions. Improved information across roadway and transit modes will facilitate data-driven decision-making for managers and users in the Corridor. An improved monitoring program will also bring agencies in the Corridor to a uniformly high level of information gathering and dissemination, and help to reduce information gaps between jurisdictions. Specific strategies for Approach A are listed in Table 5-6.

Table 5-6. Approach A. Improved Corridor Monitoring Strategies

ID	ICM Strategies	Rationale	Agency
a.1	**Enhance volume detection in corridor**	Cover gaps in detection necessary for situational awareness	NYC DOT, NYSDOT, NJDOT, NJTA, PANYNJ, TB&T
a.2	**Improve access to arterial speed detection in Corridor (especially to transit bus operations)**	Cover gaps in detection necessary for situational awareness. Share existing arterial data (HERE) data available at TRANSCOM with MTA.	NYC DOT, NJDOT, NYSDOT, MTA
a.3	**Improve incident/event reporting especially on arterials**	Address current lack of sufficient incident reporting on arterials	NYC DOT, NJDOT, NYSDOT
a.4	**Add RWIS sensors in the Corridor with grip sensors at key locations**	Cover gaps in detection necessary for situational awareness	NYC DOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T
a.5	**Install truck height sensors and over height warning systems at key locations upstream from tunnels**	Address bottlenecks caused by tunnel height restrictions	PANYNJ TB&T, MTA B&T, NYSDOT

Approach B. Enhanced Traveler Information (User Need #2, 5, 8, and 9)

As part of the goal of facilitating informed decision-making on mode choice and route choice, it is a responsibility of the ICM concept to provide robust, reliable, real-time data to those who need it. Allowing travelers to make informed decisions is a key goal of ICM, and allows journeys to be adjusted in real-time to avoid unnecessary delays by giving travelers a full suite of information and options as to how a journey can be completed in the desired amount of time. Specific strategies for Approach B are listed in Table 5-7.

Table 5-7. Approach B. Enhanced Traveler Information Strategies

ID	ICM Strategies	Rationale	Agency
b.1	**Create freight-specific portal of information/messaging on 511**	Enhance freight information in the corridor	NYC DOT, NYSDOT,MTA, PANYNJ, NJDOT, NJT, NJTA, TRANSCOM
b.2	**Use proactive messaging of weather conditions on DMS and 511**	Enhance traveler information dissemination for improved corridor management	NYC DOT, NYSDOT, PANYNJ, NJDOT, NJT, NJTA, TRANSCOM
b.3	**Comparative travel time between key crossings at decision points**	Support reliable decision-making abilities for travelers at key decision points	NYC DOT, NYSDOT,MTA, PANYNJ, NJDOT, NJT, NJTA, TRANSCOM
b.4	**Unified communications strategy on traveler information for incidents and events**	Enhance traveler information dissemination for improved corridor management	NYC DOT, NYSDOT,MTA, PANYNJ, NJDOT, NJT, NJTA, TRANSCOM

Approach C. Corridor-Based Demand Management (User Need #4, 5, 7, 8, and 10)

A well-considered demand management program can improve the performance of the Corridor by smoothing travel peaks and reducing trips, either by combining person-trips onto more efficient modes like transit and ridesharing, or by promoting programs that enable travelers to forego trips entirely. Success of the 495 ICM Concept is contingent on providing trip replacements that are comparable in terms of time, cost, and flexibility as the original trip. Adjusting short-term demand will help to balance flows on a day-to-day basis, while long-term demand measures will manage the existing capacity of the network and delay the need for expensive capacity enlargements. Specific strategies for Approach C are listed in Table 5-8.

Table 5-8. Approach C. Corridor-Based Demand Management Strategies

ID	ICM Strategies	Rationale	Agency
c.1	**Expand and enhance a corridor-focused employer-based telework program**	Support and prioritize higher occupancy vehicle trip reliability along the corridor	NYSDOT
c.2	**Implement emergency playbooks with TDM Operators to support operations during adverse weather**	Mitigation of adverse weather impacts resulting from Corridor-focused demand management.	NYSDOT

Approach D. Coordinated Incident and Event Management (User Need #2, 4, 5, and 6)

Incidents along the Corridor are a significant source of non-recurring delay. Because of their random nature, it is impossible to predict exactly where and when an incident will take place. Incidents also have varying levels of severity. A coordinated incident management approach will allow incidents to be cleared faster, returning the roadway to its baseline condition. A well-coordinated response may also have the effect of lowering response times, especially when specialized rescue or recovery equipment is needed. The Corridor plays host to hundreds of events each year, each of which creates a temporary surge of trips and requires a measure of traffic management. Specific strategies for Approach D are listed in Table 5-9.

Table 5-9. Approach D. Coordinated Incident and Event Management Strategies

ID	ICM Strategies	Rationale	Agency
d.1	**Arterial DMS to support route choice**	Address current insufficiency of equipment on arterials	NYC DOT, NJDOT, NYSDOT
d.2	**Improve towing contracts/capabilities for quick-response especially for heavy-vehicle wrecks**	Enable improvement in the coordination of response and incident response times in the corridor.	NYC DOT, NJDOT, NYSDOT, NJTA
d.3	**Expand HELP program functionality**	Enable improvement in the coordination of response and incident response times in the corridor.	NYSDOT

Approach E. Transit Bus Technology Improvements (User Need #5, 6, and 7)

As a major provider of mobility along the Corridor, especially through the Lincoln Tunnel, transit buses present a prime opportunity to receive technology upgrades that will improve their average speeds. MTA-operated Express Buses that travel from the further reaches of Queens into Manhattan have the opportunity for informed route diversions from the segment of I-495 they use for access between their stops in Queens and the QMT. The vehicle locators on transit buses can also be integrated with roadway information to provide more accurate journey times for the public-facing prediction data that MTA provides to its riders. These measures are designed for day-to-day operations to balance flows, make travel times more reliable, and create better operating conditions for transit. Specific strategies for Approach E are listed in Table 5-10. Transit Signal Priority (TSP) and other active traffic management elements that support bus operations are described in Approach G - Active Traffic Management.

Table 5-10. Approach E. Transit Bus Technology Improvement Strategies

ID	ICM Strategies	Rationale	Agency
e.1	**Improve Bus Time application to incorporate impact of diversions**	Enhance multimodal coordination during planned/unplanned events	MTA

ID	ICM Strategies	Rationale	Agency
e.2	**Explore unified fare media**	Proactively manage short-term demand surges and ongoing diversions on facilities in the corridor	NJT, PATH, MTA

Approach F. Work Zone Coordination (User Need #3 and 8)

Construction and associated work zones are a necessary part of maintaining roadway and utility infrastructure, but the temporary reallocations of right-of-way from travel space to construction space lowers network capacity and can be a major source of recurring and non-recurring delay. Work zones also tend to be of medium to long duration, allowing for a strategic response rather than a solely reactive one. By coordinating construction activities across jurisdictions, authorities can ensure that capacity is not impinged on alternate routes and that network flow is optimized around areas disrupted by work zones. Construction not only delays trips, but also creates a wide variability in travel times. Proper planning and mitigation measures can make trips faster and more reliable; the goals of this ICM Concept. Specific strategies for Approach F are listed in Table 5-11.

Table 5-11. Approach F. Work Zone Coordination Strategies

ID	ICM Strategies	Rationale	Agency
f.1	**Standardized Work Zone traffic management plan impact assessment and approval**	Cover existing lack of agency coordination for planned events	NYC DOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T
f.2	**Work Zone traffic management plan compliance monitoring**	Ensure pro-active real-time benefits through traffic responsive operations	NYC DOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T

Approach G. Active Traffic Management (User Need #7)

Several ATM-based strategies have been identified for implementation under the ICM-495 Concept with several of these extensions of existing initiatives. To optimally design and deploy these strategies, the Corridor has been divided into seven segments in the EB direction and nine segments in the WB direction. Segmentation was based on the following considerations (to the extent reasonably possible for each criterion):

- ✓ Segment break points should occur at easily recognizable landmarks or locations.
- ✓ Segment break points should avoid splitting queues, for simplified accounting of strategy impacts on bottleneck mitigation.
- ✓ Segment break points should be consistent across both directions and all times of the day.

Figure 5-6. ICM-495 Corridor Extents and Analysis Segments (Source: Arup/Cambridge Systematics)

Table 5-12 provides the ICM strategies considered for each Corridor segment, along with the rationale for each strategy's inclusion along the specific segment.

Table 5-12. Approach #7. Active Traffic Management Strategies (by Segment)

Segment	ICM Strategies	Rationale
	WESTBOUND	
1 Westbound	Adaptive ramp metering	Adaptive ramp meters offer flow control to manage entrance volume in advance of the potential bottleneck near the downstream end of Segment 1, which may allow for greater mainline throughput at the bottleneck as a result of added capacity in the auxiliary lanes that traverse this bottleneck.
	Contraflow lane between current end of contraflow lane and the Van Wyck Expressway.	Congestion on this segment and on Segment 7 East generally occurs at different times of day, such that during the AM Peak when traffic is relatively light on Segment 7 East and relatively heavy on Segment 1 West, an additional lane can be repurposed from the eastbound direction to the eastbound direction to address a potential bottleneck near the downstream end of Segment 1 West and also to more efficiently allocate lanes during incident/event situations.
2 Westbound	None	Segment does not have significant recurrent congestion or crash concentrations.
3 Westbound	Adaptive ramp metering	Adaptive ramp meters offer flow control to manage entrance volume in advance of the potential bottleneck at the toll plaza near the downstream end of Segment 3, and can also prevent mainline traffic from diverting to local arterials to perform partial queue jumping.

Segment	ICM Strategies	Rationale
	Dynamic toll pricing	An extension of current toll operations to help spread demand more uniformly throughout the day, thereby making more efficient use of roadway capacity.
	Open road tolling	An enhancement of current toll operations to help reduce delays at incidents at toll plazas.
4 Westbound	Speed harmonization	Shock waves can occur in the QMT due to the effects of periodic disruptions in flow caused by traffic signals at the tunnel exit. Speed harmonization can help mitigate the negative impacts of these shock waves on both roadway throughput and safety.
5 Westbound	Transit signal priority	All intersections are signalized, but are not yet equipped with TSP.
	Arterial parking restrictions	40th Street is a reasonable alternative route to 34th Street in the eastbound direction, given the configuration of access from the Lincoln Tunnel and to the QMT. 40th Street furthermore has parking lanes on both sides of the roadway at present, which may be repurposed as at least one additional dedicated travel lane to significantly improve eastbound throughput on the corridor.
6 Westbound	Dynamic merge control	Depending on current traffic loads on each westbound entrance to the Lincoln Tunnel at any given time, the various lane drops can be reallocated to different approaches to optimize throughput (for example, to ensure a bottleneck-inducing mainline lane drop does not occur in advance of a low-volume entrance that will be adding a new lane after the merge).
	Dynamic toll pricing	An extension of current toll operations to help spread demand more uniformly throughout the day, thereby making more efficient use of roadway capacity.
	Open road tolling	An enhancement of current toll operations to help reduce delays at incidents at toll plazas.
7 Westbound	Speed harmonization	Shock waves can occur in the Lincoln Tunnel due to the effects of high frequencies of forced lane changes at the tunnel exit. Speed harmonization can help mitigate the negative impacts of these shock waves on both roadway throughput and safety.
8 Westbound	Hard shoulder running	Available shoulder space (considering both inside and outside shoulder spaces) is generally sufficient to support an additional westbound lane on this segment for the capacity-constrained portion between Route 3 and the start of the reversible median lane. This could provide additional capacity through a recurrent bottleneck that occurs on this portion of roadway during the AM Peak, when the reversible median lane is generally opened to the opposite direction of traffic.
9 Westbound	None	Segment does not have significant crash concentrations, and recurrent congestion is caused by queue spillback from downstream sections beyond the scope of this analysis.
EASTBOUND		
1 Eastbound	None	All major congestion appears to be caused by a bottleneck on the downstream Segment 3.
2 Eastbound	Dynamic reversible lane	Dynamic use of the reversible lane leading up to the Lincoln Tunnel toll plaza in conjunction with thorough monitoring of delays in each direction can yield more efficient operations than time-of-day strategies, as it ensures that this lane's added capacity is provided to inbound traffic before the three conventional inbound lanes become saturated, and is not released back to the westbound direction until volumes on that side are

Segment	ICM Strategies	Rationale
		sufficiently high to warrant it in the PM peak. This can delay the onset of congestion at the beginning of the AM peak, and can also accelerate congestion dissipation at the end of the AM peak. Dynamic reversible lanes can also provide for more efficient handling of incident/event situations.
	Adaptive ramp metering	Adaptive ramp meters offer flow control to manage entrance volume in advance of the potential bottleneck at the toll plaza near the downstream end of Segment 2, and can also prevent mainline traffic from diverting to local arterials to perform partial queue jumping.
	Dynamic toll pricing	An extension of current toll operations to help spread demand more uniformly throughout the day, thereby making more efficient use of roadway capacity.
	Open road tolling	An enhancement of current toll operations to help reduce delays at incidents at toll plazas.
3 Eastbound	Speed harmonization	Shock waves can occur in the Lincoln Tunnel due to the effects of periodic disruptions in flow caused by traffic signals at the tunnel exit. Speed harmonization can help mitigate the negative impacts of these shock waves on both roadway throughput and safety.
	Dynamic reversible lane	Dynamic lane allocation through the Lincoln Tunnel in conjunction with thorough monitoring of delays in each direction can yield more efficient operations than time-of-day strategies, as it ensures that as much capacity remains available to inbound traffic on Segment 3 East during the PM peak until volumes and delays on the opposing Segment 7 West justify switching one or more lanes to service outbound traffic instead. Dynamic reversible lanes can also provide for more efficient handling of incident/event situations.
4 Eastbound	Transit signal priority	All intersections are signalized, but are not yet equipped with TSP.
	Arterial parking restrictions	40th Street is a reasonable alternative route to 34th Street in the eastbound direction, given the configuration of access from the Lincoln Tunnel and to the QMT. 40th Street furthermore has parking lanes on both sides of the roadway at present, which may be repurposed as at least one additional dedicated travel lane to significantly improve eastbound throughput on the corridor.
5 Eastbound	Open road tolling	An enhancement of current toll operations to help reduce delays at incidents at toll plazas.
	Dynamic toll pricing	An extension of current toll operations to help spread demand more uniformly throughout the day, thereby making more efficient use of roadway capacity.
	Dynamic reversible lane	There may be outbound capacity available during the AM Peak period when a disproportionate number of lanes are made available to inbound traffic, when the arterial network on the receiving side of the tunnel may lack the capacity to handle the throughput of so many inbound lanes. Dynamic reversible lanes can take advantage of these periods and those of incident/event situations to optimize lane allocations to the two directions for more efficient operations.
	Speed harmonization	Shock waves can occur in the QMT due to the effects of periodic disruptions in flow caused by the toll plaza at the tunnel exit. Speed harmonization can help mitigate the negative impacts of these shock waves on both roadway throughput and safety.

Segment	ICM Strategies	Rationale
6 Eastbound	None	Segment does not have significant recurrent congestion or crash concentrations.
7 Eastbound	Adaptive ramp metering	Adaptive ramp meters offer flow control to manage entrance volume in advance of the potential bottleneck near the downstream end of Segment 7, and can also prevent mainline traffic from using auxiliary lanes to perform partial queue jumping.
	Queue warning system	A high concentration of crashes occurs on this corridor, which may be partially a result of queues that are highly variable throughout the day (i.e., no congestion in the AM peak, significant congestion in the PM peak). A queue warning system could help address collisions that are happening at the back end of this queue.
	Contraflow lane from where the current one ends to beyond the Van Wyck Expressway	Congestion on this segment and on Segment 1 West generally occurs at different times of day, such that during the PM Peak when traffic is relatively light on Segment 1 West and relatively heavy on Segment 7 East, an additional lane can be repurposed from the westbound direction to the eastbound direction to address a potential bottleneck near the downstream end of Segment 7 East and also to more efficiently allocate lanes during incident/event situations.

5.3. Implementation Roadmap

Table 5-13 shows how the ICM-495 Partnership's resources will be utilized to deploy systems and strategies across the seven approaches described above. Some resources will be available at the unveiling of the ICM-495 concept, while others will be set in motion at some future point when funding and institutional conditions are aligned. This implementation timeframe is indicated as follows:

- **Immediate** - needs to be in place within the first three months of ICM operation
- **Short Term** – in place within nine months of ICM operation
- **Medium Term** – in place within 18 months of ICM operation
- **Long Term** – occurs after 18 months of ICM operation

Table 5-13. ICM-495 Implementation Roadmap

ID	ICM Implementation Elements	Immediate	Short Term	Medium	Long Term
ICM-495 DSS					
ICM-495 Decision Support System					
N/A	ICM-495 DSS	✓			
Comprehensive List of Approaches and Strategies					
Approach A. Improved Corridor Monitoring					
a.1	Enhance volume detection in corridor	✓			
a.2	Improve access to arterial speed detection in corridor	✓			
a.3	Improve incident/event reporting especially on arterials	✓			
a.4	Add RWIS sensors in the corridor with grip sensors		✓		
a.5	Install truck height sensors and over height warning systems at key locations upstream from tunnels		✓		
Approach B. Enhanced Traveler Information					
b.1	Create freight-specific portal of information/messaging on 511	✓			
b.2	Use proactive messaging of weather conditions on DMS	✓			
b.3	Comparative travel time between key crossings at decision points	✓			
Approach C. Corridor-Based Demand Management					
c.1	Expand and enhance a corridor-focused employer-based telework program		✓		
c.2	Develop an emergency-oriented playbook for TDM to support operations during adverse weather	✓			
Approach D. Coordinated Incident and Event Management					
d.1	Arterial DMS to support route choice		✓		
d.2	Improve towing contracts/capabilities for quick-response especially for heavy-vehicle wrecks	✓			
d.3	Expand HELP program functionality	✓			
Approach E. Transit Bus Technology Improvements					
e.1	Improve Bus Time application to incorporate impact of diversions	✓			
e.2	Explore unified fare payment strategy			✓	
Approach F. Work Zone Coordination					
f.1	Standardized Work Zone traffic management plan impact assessment and approval	✓			
f.2	Work zones traffic management plan compliance monitoring	✓			
Approach G. Active Traffic Management					
g.1	Adaptive ramp metering		✓		
g.2	Contraflow lanes	✓			
g.3	Dynamic toll pricing		✓		
g.4	Open road tolling	✓			
g.5	Speed harmonization		✓		
g.6	Transit signal priority (TSP)	✓			
g.7	Arterial parking restrictions		✓		
g.8	Dynamic merge control		✓		
g.9	Hard shoulder running		✓		
g.10	Dynamic reversible lane		✓		
g.11	Queue warning system		✓		

5.4. Alignment with Regional ITS Architecture

The ICM-495 Concept may impact portions of the existing regional ITS architectures in the region: the *New York City Sub-Regional Intelligent Transportation System (ITS) Architecture* and the *Connected Corridor Regional ITS Architecture*. Table 5-14 identifies the services packages directly pertinent to corridor-level traffic and transit operations through the ICM concept. These packages will be part of the various transportation management strategies (Table 5-13) being explored. With the implementation of the ICM concept, the architecture interfaces between various ITS elements may change requiring an update to both the identified regional architectures.

Table 5-14. Service Packages for ICM-495 Concept Corridor-Level Traffic and Transit Operations

Service Package			
AD3	ITS Virtual Data Warehouse	ATMS10	Electronic Toll Collection
APTS07	Multi-modal Coordination	ATMS16	Parking Facility Management
APTS09	Transit Signal Priority	ATMS17	Regional Parking Management
ATIS01	Broadcast Traveler Information	ATMS18	Reversible Lane Management
ATIS02	Interactive Traveler Information	ATMS21	Roadway Closure Management
ATIS05	ISP Based Trip Planning and Route Guidance	ATMS22	Variable Speed Limits
ATMS01	Network Surveillance	ATMS23	Dynamic Lane Mgmt. and Shoulder Use
ATMS02	Traffic Probe Surveillance	ATMS24	Dynamic Roadway Warning
ATMS03	Traffic Signal Control	ATMS26	Mixed Use Warning Systems
ATMS04	Traffic Metering	EM04	Roadway Service Patrols
ATMS05	HOV Lane Management	MC08	Work Zone Management
ATMS06	Traffic Information Dissemination	MC09	Work Zone Safety Monitoring
ATMS07	Regional Traffic Management	MC10	Maintenance and Construction Activity Coordination
ATMS08	TIM System		

5.5. Data and Performance Characteristics

Performance measures and evaluation targets were identified that assess operational and management processes through the project's timeframes and geographic characteristics, taking into account that regional agencies collect different types of data, use different protocols, and measure performance in different ways. Additional information about the performance measures and their evaluation targets are provided in *Technical Memorandum #8: TMS Concept B/C Assessment and Priority Analysis*. The performance measures are defined by the following three categories and summarized in Table 5-15.

5.5.1. Dynamic Management Performance Measures

Dynamic management performance measures evaluate the corridor's day-to-day operations, along with surrounding areas. These measures focus on understanding the state of mobility metrics on real-time or short-term timeframes. They provide an operational diagnosis of the corridor through dynamic monitoring via sensors; aggregating and storing data for short term evaluations. The nature of these measures may require extensive data collection and processing, but are focused at specific geographic areas along the corridor. Dynamic management measures include mobility, reliability, and incident management performance measures that address throughput efficiency, speed, travel times, and incident response and clearance times on the Corridor. Some of the performance measures assess data along a corridor segment, while others pull from Origin-Destination (O-D) trip data, bus stop data, and incident event reports. *Appendix B: Performance Measures* provides the complete list of dynamic management performance measures, possible data sources, and the geography or unit being measured.

5.5.2. Short-term Management Performance Measures

Short-term management performance measures evaluate the Corridor's governance and management scheme. This is important given the extent of the corridor, the number of stakeholders involved, and the complexity of management procedures to implement the ICM strategy proposed. These measures focus on actions that might take time to be implemented, and they will be updated on a monthly or bi-monthly timeframe. Contrary to the dynamic management performance measures, these measures focus on the ICM-495 region as a whole, as they evaluate the coordination between stakeholders and the strategies implemented network-wide. *Appendix B: Performance Measures* provides the complete list of short-term management performance measures, possible data sources, and the geography or unit being measured.

5.5.3. Strategic Management Performance Measures

Strategic management performance measures focus on evaluating actions and strategies over the long-term. These performance measures help agencies to assess the project's progress in order to reach the project's vision. These measures are less data intensive, and may be updated less frequently. The performance measures focus on different geographies along the Corridor, as some measures will evaluate progress network-wide, as well as impact on precise locations (like corridor segments or particular O-D trips). Table 5-15 provides a brief summary of the performance measures and their objectives. *Appendix B: Performance Measures* provides the complete list of Strategic Management performance measures, possible data sources, and the geography or unit being measured.

Table 5-15. Performance Measures, Evaluation Targets, and Objectives

Type	ID	Performance Measure	Evaluation Target	Objectives
CATEGORY: Dynamic Management Performance Measures				
Mobility	DM-1	Person miles traveled (PMT).	>95% average PMT during peak hours at selected segments, across comparable days.	• Increase the throughput efficiency. • Impact average speed. • Control for lane closures and operation strategies. • Effect HOV lanes performance.
	DM-2	Travel speed (mph).	>95% average speed, during peak hours at selected segments and across comparable days.	
	DM-3	Time of lane closures, reversible lanes, and operational strategies (%).	To be defined according to ICM strategies.	
	DM-4	HOV lane average vehicle occupancy (%).	>40% occupancy at HOV lanes during peak hours.	
Reliability	DM-5	Travel time (minutes) between selected origin and destinations for peak and non-peak hours.	+/- 15% increase/decrease in travel times during peak hours at selected segments and across comparable days.	• Travel time impacts. • Public transportation reliability impacts. • Travel delay impacts on recurrent bottlenecks
	DM-6	Travel time index (%) between selected origin and destinations for peak and non-peak hours.	<200% (less than two times the free-flow travel time) at selected origin and destinations, and across comparable days.	
	DM-7	On-time performance (%).	<50% of arrivals within +/- 5 minutes of schedule during peak hours, at selected bus stops, and comparable days.	
	DM-8	Public transportation wait assessment (%)	<10% of headways no more than 5 minutes longer than scheduled headway.	
	DM-9	Person hours of delay (hours) at peak and off-peak periods, on selected bottlenecks.	<110% of average delay at peak hours on selected bottlenecks.	
Incident Management	DM-10	Response time to incident reported (freeway and arterials) (minutes).	Respond to 95% of reported incidents after 30 minutes of incident reported.	• Measure of the response time and clearance time.
	DM-11	Incident clearance time (freeway and arterials) (minutes).	Clear 80% of incidents reported after 1.5 hours of incident report.	

Type	ID	Performance Measure	Evaluation Target	Objectives
CATEGORY: Short-term Management Performance Measures				
Institutional Governance[4]	ST-1	Rating of project performance across different agencies.	>50% approval rating of project performance across agencies.	• Measure ICM performance across agencies, at different project phases. • Improve decision- making roles and responsibilities. • Set degree of formalization.
	ST-2	Number of instances and/or agreements of inter-organizational coordination among stakeholders.	To be defined.	
	ST-3	Number of pre-defined and approved strategies for coordinated action.	To be defined.	
	ST-4	Number of resolved actions agreed upon by stakeholders during management meetings.	To be defined.	
ICM Operations	ST-5	Number of inter-agency regular events added to ICM playbook.	To be defined	• ICM capabilities for day-to-day event coordination, planned construction management. • Integrate transit services into ICM operations. • Evaluate incident resolution. • Evaluate Corridor's dashboard operation. • Evaluate ITS equipment investments and operations.
	ST-6	Number of Construction Works Management Plans integrated to ICM playbook.	To be defined.	
	ST-7	Number of transit operations strategies integrated to ICM playbook.	To be defined.	
	ST-8	After incident rating across agencies.	>50% approval rating of project performance across agencies.	
	ST-9	ICM-495 dashboard performance and data quality assessment.	Update dashboard daily 90% of time, with 75 percent of healthy detectors.	
	ST-10	ITS equipment deployment and performance.	To be defined.	
Transportation Demand Management	ST-11	Number of employees enrolled and using telework program.	Greater or equal to previous enrollment and usage.	• Measure Program effectiveness and participation. • Measure fluctuations in transit ridership during ICM events.
	ST-12	Number of employees using 511NY Rideshare and New Jersey's ridesharing services on the corridor.	Greater or equal to previous number of employers.	

[4] *Integrated Corridor Management Initiative: Demonstration Phase Evaluation,* http://ntl.bts.gov/lib/54000/54300/54350/ICM_National_Evaluation_Framework___FHWA-JPO-13-015_.pdf

Type	ID	Performance Measure	Evaluation Target	Objectives
	ST-13	Ridesharing ridership along the corridor.	Greater or equal to previous ridership, when possible compared to same month conditions.	
	ST-14	Percent of Citibike bikes going from LIC stations to Midtown Manhattan stations in the AM, and the reverse in the PM period.	Greater or equal to previous usage, when possible compared to same month conditions.	
	ST-15	Comparison of train ridership between normal conditions and special/temporary events.	To be defined.	
	ST-16	Comparison of bus ridership between normal conditions and special/temporary events.	To be defined.	
	ST-17	Number of 'Match Me in Emergency' participants in the corridor.	Greater or equal to previous number of participants.	
CATEGORY: Strategic Management Performance Measures				
Safety	SM-1	Yearly incident rate on corridor and arterials.	Decrease incident rate by 5%.	• Effect of the ICM on incident rate. • Impact of the ICM on traffic safety.
	SM-2	Yearly crash (injury/fatality/PDO) rate on freeway and arterials.	Decrease fatality crashes by 50%, injury crashes by 25% and PDO crashes by 10%.	
Mobility	SM-3	Number of severely congested corridor segments. (% of entire corridor and type of lane).	Decrease severely congested corridor segment by 10% during non-peak hours.	• Evaluate general effect on congestion. • Effect on Corridor's travel time reliability. • Evaluate effect of traveler information to users.
	SM-4	Buffer Time Index (% of extra time needed to complete a trip on time, 95 percent of the time) for different days and time periods.	Reduce Buffer Time Index by 5% during peak hours.	
	SM-5	Change in user travel patterns from traveler information system.	Over 5% trips shifted to route informed during peak hours.	
Transit	SM-6	Yearly ridership in transit services on corridor and relevant arterials.	Maintain or increase yearly transit ridership.	• Impact on transit demand. • Effect on reliability of transit services.
	SM-7	On-time Performance.	Increase average on-time performance by 5%.	
Environment	SM-8	Amount of $CO_{2\text{-equ}}$ emitted on corridor per year.	Decrease amount of CO2-equ emitted on corridor per year by 5%.	• Environmental impact on corridor.
Demand Management	SM-9	Mode split.	Decrease drive-alone modal split by 5%.	• Evaluate the effect on mode shift from to other modes

Type	ID	Performance Measure	Evaluation Target	Objectives
				(carpool and vanpools, transit, telecommute).
Project Acceptance	SM-10	Yearly user level of satisfaction.	50% approval of corridor operation by users.	• Evaluate user's perception of the ICM project. • Evaluate level of satisfaction among internal partners with ICM program. • Evaluate the project's institutional maturation and acceptance among region's stakeholders.
	SM-11	Yearly partnership level of satisfaction.	70% approval of corridor operation by partners.	
	SM-12	Yearly stakeholder project acceptance.	50% approval of corridor operation by stakeholders and 20% of stakeholders approached having incorporated ICM-495 strategies in plans and policies.	

6. OPERATIONAL SCENARIOS

Operational scenarios provide a description of how the proposed system and concepts in Chapter 5 will be used to address ongoing challenges in the Corridor. The following scenarios are presented in Table 6-1.

Table 6-1. Listing of Operational Scenarios

Scenario	Section	Title	Page
Normal Operations	6.1	Normal Operations	75
Planned Event	6.2	Planned Special Event	78
	6.3	Weather Scenario	81
Unplanned Event	6.4	Unplanned Traffic Event East of the QMT	84
	6.5	Traffic Incident West of Lincoln Tunnel	87
	6.6	Unplanned Commuter Rail Event with Corridor Implications	90
Long-Term Closures	6.7	Long-Term Closures of a Traffic Link	93
	6.8	Long-Term Closure to a Transit Line	97

It is important to note that the scenarios are not meant to include all details of the response conducted by the agencies for the event. The scenarios are meant to highlight the enhancements provided by the ICM Concept – namely the ICM-495 DSS and the new set of strategies and tactics that may be available in the Corridor. The overall response to a scenario is the combination of the existing approach with the new capabilities added by ICM. Each scenario is described as a table with the following elements:

<u>Scenario Overview</u>

- Location Impacted
- Event Start Time and Short Description

<u>Existing Approach (without ICM)</u>

- Key challenges
- Approach

<u>Enhanced Corridor-Specific Approach (With ICM)</u>

- Key Outcomes
- ICM-495 Decision Support
- ICM Tactics and Strategies

6.1. Normal Operations

Normal Operations Scenario (AM Peak)

Scenario Overview

Location Impacted: Entire Corridor	**Event Start Time:** 5:30 AM

Event Description:

6:00 AM – Traffic starts to build on either side of the corridor (EB into Manhattan from the Lincoln Tunnel, WB from the QMT).

8:00 AM – Both the QMT and Lincoln Tunnel are seeing usual back-ups along their approach. With the new Open Road Tolling on the QMT, the location of back-up has shifted to inside tunnel creating new challenges as vehicles enter Manhattan. Corridor includes significant bus usage during this time. Bus service along 34th Street is moving at an average of 4.5 mile per hour. XBL bus lanes are moving as planned. On the approaches to the QMT, buses use the extra lane dedicated to all HOV vehicles. M34 and M34A (SBS) are operating on the east and west sides of Manhattan via 34th Street. Rail transit is functioning normally with PATH, NJT, LIRR, Metro-North operating with minimal delays.

9:00 AM – Corridor is experiencing some minor incidents and stalled vehicles on the Queens side. Both EB and WB general traffic on 34th Street are operating at 7-8 mph, with some more congested sections at slower speeds. There was a brief delay due to a stopped vehicle on an approach to Lincoln Tunnel that is being cleared.

10:30 AM – Volumes continue to be high but are starting to come down from the peak hour.

Existing Approach: Without ICM

Key challenges without ICM:

(1) Agencies have growing but currently limited ability to implement dynamic strategies to adjust to changing demand or traffic issues
(2) Limited Center to Center (C2C) or Operator to Operator connections between transit and highway management.
(3) Incomplete awareness of corridor conditions beyond each agency's sphere of operations. While there is some awareness through TRANSCOM, keeping the situational awareness current is a challenge.
(4) Differences in agency protocols and processes lead to difficultly in developing a coordinated response around conditions.

- Transit agencies operate according to schedules calibrated to passenger demand and infrastructure capability. These operations are monitored from independent agency command centers. Roadway conditions are monitored by the individual roadway operators from command centers. Highways within New York City that are under NYSDOT jurisdiction are monitored from the JTMC, which has staff from both the City and State DOTs. Each of the river crossings is monitored and patrolled by its operator, while the NYPD patrols roadways within New York City. At key intersections in Midtown Manhattan, TEA are deployed to guide traffic and improve safety. Two sections of managed lanes are controlled by their respective agencies with configuration changes done according to schedule with some slight room for adjustments around the designated times.
- Roadway conditions in the corridor and across the region are monitored by TRANSCOM, who then redistributes the data to its partner agencies. Minor incidents are monitored and responded by the agency (with law enforcement playing the vital role on the field). Incidents are reported through the OpenReach system to other stakeholders. Overall delays in the system (speed below a historical threshold are also noted). Drivers may adjust their planned routes in response to radio traffic reports, VMS, and online traffic sources, such as the Google Maps traffic layer, Waze, 511NY, and the MTA's Drive Time app, which gives travel times for MTA facilities such as the Corridor's QMT. Transit users are using Bus Time and other apps that rely on MTA data for real time transit status information.

Enhanced Corridor-Specific Approach: With ICM			
Key outcomes of ICM in this scenario: (1) A real-time corridor dashboard that monitors conditions and shares it with all the ICM coordinators, especially as event conditions changes. (2) An improved set of approaches and strategies that are now available in the Corridor to deal with travel time reliability and person throughput.			
ICM-495 Corridor Decision Support ("DSS")			
Actions	**Detail**		**Benefit**
1. Store and Distribute Data	The DSS builds on existing data fusion capabilities that exist in the corridor through interfaces with TRANSCOM Data Fusion Engine and other ATMS operated by various management centers.		This is an enhancement to current capabilities and leverages existing investments in data by the ICM-495 partners.
2. Monitor Corridor Conditions	Through the DSS, a real-time corridor-dashboard is made available to all ICM coordinators who are able to see not only the corridor conditions but also the various key performance indicators for the corridor in unified multimodal, multi-agency manner.		This adds corridor-level performance monitoring to the agencies and improves overall situational awareness.
3. Assess Event Impact	The DSS conducts a continuous assessment of events that are recorded in the corridor against established criteria to see if they would rise up to corridor-level concern.		This capability enables greater awareness of event impacts as they occur especially if they become more difficult to manage.
ICM Tactics and Strategies			
ICM Approach	Agencies	Scenario-Specific Application	Benefit
Approach A: Improved Corridor Monitoring			
Enhance volume detection in corridor	NYC DOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T	Through fixed infrastructure detection of non-intrusive volume detectors (either video or radar), this strategy can cover gaps in detection of volumes necessary for situational awareness including managed lanes operations.	By combining existing sources of transit usage along with road volumes, person throughput can be calculated and monitored as a performance measure.
Improve incident/event reporting especially on arterials	NYC DOT, NJDOT, NYSDOT	Integration with city-wide New York City alerts and notification systems can improve awareness of arterial conditions.	By better understanding arterial conditions, transit and highway operators are able to understand constraints in the Corridor.
Approach B: Enhanced Traveler Information			
Comparative travel time between key crossings at decision points	NYC DOT, NYSDOT, MTA, PANYNJ, NJDOT, NJT, NJTA	Continued use and enhancements to comparative travel times between various bridge and tunnel crossings in the Corridor, combined with transit travel times can provide improved route choice to the Corridor.	Support reliable decision-making abilities for travelers at key decision points.

ICM Approach	Agencies	Scenario-Specific Application	Benefit
Approach C: Corridor-Based Demand Management			
Expand and enhance a corridor-focused employer-based telework program	NYC DOT, NYSDOT	As part of an active demand management initiative, 511NY Rideshare identifies a priority set of employers in the corridor for direct engagement on telework and transportation choices.	Enable short-term and long-term demand shifts from single occupancy vehicles to higher-occupancy modes.
Approach D: Coordinated Incident and Event Management			
Expand HELP program functionality	NYSDOT	The Corridor experiences several minor incidents, which, if managed proactively, can prevent them from becoming an ICM Event. Through an enhanced HELP system, minor incidents are managed more effectively from the JTMC.	Enable improvement in the coordination of response and incident response times in the corridor.
Approach G: Active Traffic Management			
All Strategies	Multiple Agencies	All these strategies help improve travel reliability in the Corridor through dynamic management of the core facilities in the corridor.	Enhanced focus on travel reliability.

6.2. Planned Special Event

Planned Special Event Scenario

Scenario Overview

Organizers successfully filed permits with the appropriate Community Affairs Office to conduct a large march on Saturday morning. The march is anticipated to impact the city for most of the day with over 250,000 anticipated attendees. March organizers have been working closely with NYPD and the NY Parks Department in preparation for the day's events. Given the number of registered participants, marchers have been provided specific groups and staggered start times to balance the number of marchers along the route. Each group will walk the agreed upon route:

- Rally at Hudson Yards Park (between 33rd and 36th Streets and 10th and 11th Avenues)
- March East on 34th Street to Broadway Street
- March North on Broadway to 42nd Street

Entry to the march will also be granted outside of Penn Station on 34th and 8th Streets as well as at the intersection of 38th and Broadway Streets. Additionally, major intersections along the route will be open to marchers as access/exit points. The designated bus drop off is located on 11th Avenue between 34th and 36th Street and the designated bus pick up is located on 42nd Street between 7th and 8th Avenue.

Event Progression:

Days leading up to march

One week prior to march: Announcements on anticipated march-related road closures and congestion are made through media outlets, social media, 511NY Rideshare, and partner agencies' websites (including 511) and mobile applications.

Friday evening before march: NYPD (along with other relevant city organizations) set up temporary traffic barriers and wayfinding signs along march route, designated access/entry points, rally location, end of march location and bus drop off and pick up locations.

Day of the march

8:00 AM: Transit and rail are experiencing projected high demand along open routes leading to the march. In anticipation of the increased demand, MTA, PATH, and LIRR are running these routes on a weekday schedule. Roadway congestion and delay are growing due to the increased demand and number of blocked off roadways. Freight vehicles are also impacted by delays.

10:45 AM: Marchers gather at the rally meeting site (Hudson Yards Park).

12:00 PM: Group 1 begins marching.

12:15 – 3:15 PM: Remaining groups begin marching in 15 minute intervals. Along the route marchers enter and exit along the access/exit points.

1:00 PM: Due to the number of people who have been arriving at Penn Station since the morning, there is a major bottleneck at the route entry point on 34th and 8th Streets.

4:15 PM: Most marchers have made it to the end of the march route (42nd and Broadway).

5:15 PM: March activities officially end and the crowd begins to disperse. Tens of thousands of people begin walking to buses (at the bus pick up location), nearby transit stops, nearby rail stops, or call for taxis/private vehicles to head home.

8:15 PM: The majority of the crowd has left the march location and crowds have largely dissipated.

10:15 PM: NYC DOT and other participating agencies begin removing temporary traffic barriers and wayfinding signs.

ICM Event Criteria	ICM-495 Partners Involved	
☑ Duration (2 hours or more) ☑ Multimodal Impacts ☑ Multiple ICM-495 partners impacted	**New York State (NYS)**	NYC DOT, MTA B&T, MTA NYCT, MTA Bus Company, LIRR, NYSDOT
	NYS and New Jersey	PANYNJ, PATH, TB&T, TRANSCOM
	New Jersey	N/A

Existing Approach: Without ICM
Key challenges without ICM: (1) Independent assessments of event impact. Collaboration exists but it is ad hoc and based on relationships. (2) Level of real-time traveler information varies across Corridor based on jurisdictional capabilities.
• Several weeks in advance of event, numerous city agencies are notified about the event. • Partner agencies work with agencies managing the event (i.e., Community Affairs Office, NYPD, and NY Parks Department) to assess street closures and determine optimal operating strategies. This coordination is primarily through relationships and there are no formal processes in place. • NYC DOT and NYPD set up street closures. Transit and NYSDOT monitor their own facilities at their respective TMC. This includes assessing congestion and delay conditions before and during the event. Messaging on VMS and 511 is also activated. • Coordination between agencies occurs via data entry into the OpenReach system and ad-hoc communications between operators at different agencies.
Enhanced Corridor-Specific Approach: With ICM
Key outcomes of ICM in this scenario: (1) Common understanding of anticipated event impacts. (2) Proactive messaging to travelers including freight. (3) Formal coordination among operating agencies within the Corridor. (4) Improved situational awareness of corridor conditions among operating agencies. (5) Active and dynamic management of facilities. (6) Real-time traveler information to enable travelers to make more informed choices.

ICM-495 Corridor Decision Support ("DSS")		
Actions	**Detail**	**Benefit**
1. Monitor traffic conditions	DSS receives planned special event information from partner agencies in advance of event.	Improved awareness of Corridor-wide impacts.
2. Assess impact and determine event type	DSS runs pre-determined impact assessment criteria on identified event to determine nature of event. Based on the location and duration of the event, this event is categorized as an ICM Event.	Agencies are able to identify events with corridor-level impacts.
3. Notify ICM Coordinators	• DSS notifies designated ICM coordinators at partner agencies via web/email or text. • DSS identifies event manager based on asset and location. In this case NYC DOT is responsible for operating and maintaining streets along the route.	Event is handled by a designated set of management personnel.
4. Manage ICM Event	ICM Coordinators utilize the DSS online communications forum to exchange information on operating and managing affected assets to support traveler information sharing, route detours, and improved transit operations along congested route for the event.	Improved coordination in response between agencies.
5. Implement Automated Strategies	DSS uses pre-determined ICM Corridor Working Group policies and protocols to implement select automated strategies. Strategies includes an automatic update to traveler information services (e.g., 511) and notifications to TDM managers across the region.	Improved timeliness of information due to automated strategies unhindered by operator approval.
6. Report Performance Data	DSS calculates performance measures while the special event is occurring and once the event. DSS provides performance reports for after action reviews.	Continual assessment and improvement of Corridor.

ICM Tactics and Strategies			
ICM Approach	**Agencies Involved**	**Scenario-Specific Application**	**Benefit**
Approach A: Improved Corridor Monitoring			
Improve access to arterial speed detection in corridor	NYC DOT	Detects conditions on parallel arterials that can be used to adjust detours shown on VMSs.	Enhanced corridor-wide situational awareness in advance of and during event.
Approach B: Enhanced Traveler Information			
Create freight-specific portal of information/messaging on 511	NYC DOT, NYSDOT, MTA, PANYNJ, TRANSCOM	• Prior to event: Focused, proactive messaging about the event and potential impacts on freight routes. • During event: Congestion warnings provided in real-time to freight 511.	Enhanced freight information results in better trip making decisions by freight drivers before, during, and after the event until conditions return to normal.
Comparative travel time between key crossings at decision points	NYC DOT, NYSDOT, MTA, PANYNJ,	Travel time feeds from TRANSCOM provide data to automated signs.	Provide actionable traveler information at key decision points outside and along the Corridor.
Unified communications strategy	NYC DOT, NYSDOT, MTA, LIRR, PANYNJ, TB&T, PATH	• Provide early info to media and third-party notification services to allow travelers to make decisions before leaving home. • DSS receives information from the field and messaging can be updated based on contemporaneous information.	Provide actionable traveler information at key decision points outside and along the Corridor.
Approach D: Coordinated Incident and Event Management			
Arterial DMS to support route choice	NYC DOT, MTA, PANYNJ, TB&T	Provides actionable information to travelers, including transit information.	Enhance protocols to create unified agency definitions for Corridor events.
Approach E: Transit Bus Technology Improvements			
Explore unified fare media	MTA, PATH, Private bus carriers	A unified payment system that allows access across systems with same media. Allows for post-event reconciliation and avoids the need for transit employees to manually admit passengers.	Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Approach G: Active Traffic Management			
Transit Signal Priority	NYC DOT, MTA	To be installed on parallel arterials to speed transit bus movement.	Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Arterial Parking Restrictions	NYC DOT, MTA	To provide extra capacity on parallel arterials, potentially with dedicated bus lanes.	Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Queue Warning and Speed Harmonization	NYC DOT	Inform motorists of upcoming queues due to the incident and manage speeds of upstream traffic	Dynamically manage (through ATM) for key bottleneck areas.

6.3. Weather Scenario

Weather Event Scenario

Scenario Overview

Location Impacted: Entire ICM-495 Corridor and larger New York City area (Manhattan, Queens, Brooklyn, Staten Island, Bronx)
Event Start Time: Early Fall, weekday PM rush hour – thunderstorm hits down at 4 PM

Event Progression:
8:00 AM: Weather sources forecast heavy rains/thunderstorm (with 80% probability) hitting the area around the PM rush hour. Given the previous dry spell, moderate seasonal temperatures (currently 45 degrees with an anticipated high of 60 degrees), the thunderstorm is expected to produce heavy rain resulting in low visibility and slippery road conditions.
2:30 PM: Weather conditions remain normal while demand on the Corridor grows in advance of the PM rush hour. Traffic speeds are consistent and transit services are operating normally.
4:00 PM: Thunderstorms hit the region, bringing heavy rain mixed with thunder and lightning.
4:30 PM: Due to conditions, travel speeds around the Corridor and surrounding areas have slowed down and several rear-end collisions have occurred along major freeways (Route 3 in New Jersey and I-495 through New Jersey and New York), impacting passenger vehicle and bus travel. Train travel is not affected.
6:00 PM: Light rain continues along the Corridor while the PM rush continues at a reduced speed due to road weather and incident conditions.
8:00 PM: Weather conditions return to normal and Corridor conditions begin to improve.

ICM Event Criteria	ICM-495 Partners Involved	
☑ Duration (2 hours or more) ☑ Multimodal Impacts ☑ Multiple ICM-495 partners impacted	**New York State (NYS)**	NYC DOT, NYSDOT, MTA B&T, MTA NYCT, MTA Bus Company, LIRR, NYMTC
	NYS and New Jersey	PANYNJ, PATH, TB&T, TRANSCOM
	New Jersey	NJDOT, NJT, NJTA, NJTPA

Existing Approach: Without ICM

Key challenges without ICM:
(1) Independent assessment of scenario impact
(2) Collaboration exists but is ad-hoc based on relationships
(3) Minimal proactive messaging and lack of situational awareness beyond agency jurisdiction

- Partner agencies are monitoring their own facilities from their management centers (JTMC, AOCs, MTA Bus Operations, NJT, STMC). There are differing levels of capability, awareness, and use of forecast weather information.
- Typically, there is no messaging on DMS or 511 about forecasted conditions.
- Travelers get limited advance notification about PM conditions during the AM peak or in the afternoon from partner agencies. They may get information from external sources (e.g., television reports, radio or websites).
- Once the event hits, agencies manage operations on their facility according to their incident management protocols. Local incident management is often led by law enforcement (responsible for controlling incident response).
- Coordination between agencies occurs via data entry into the OpenReach system and ad-hoc communications between operators at different agencies.
- Limited transit traffic integration creates limited opportunity to manage disruptions to transit for person throughput.

<table>
<tr><th colspan="3">Enhanced Corridor-Specific Approach: With ICM</th></tr>
<tr><td colspan="3">Key outcomes of ICM in this scenario:
(1) Common understanding of the forecasted conditions.
(2) Proactive messaging to travelers including freight.
(3) Active and dynamic management of facilities.
(4) Improved situational awareness of corridor conditions among operating agencies.</td></tr>
<tr><th colspan="3">ICM-495 Corridor Decision Support (“DSS”)</th></tr>
<tr><th>Actions</th><th>Detail</th><th>Benefit</th></tr>
<tr><td>1. Monitor weather and traffic conditions</td><td>• DSS periodically receives current observations and forecasts up to 24 hours from weather and road weather data sources, including national products, used by partner agencies.
• DSS generates an event ID for impact assessment when a forecast condition is met.
○ Forecast probability x severity is greater than or equal to threshold criteria</td><td>Uniform event threat perception across agencies based on common assessment of weather conditions.</td></tr>
<tr><td>2. Assess impact and determine event type</td><td>DSS runs pre-determined impact assessment criteria on identified event to determine whether it is a non-ICM Event, an ICM Event, or an EOC Event. Since this weather condition meets the criteria, it is flagged as an ICM Event</td><td>Agencies are able to think beyond their own facilities and assets through identification of corridor-level impacts.</td></tr>
<tr><td>3. Notify ICM Coordinators</td><td>Notifications sent to designated ICM coordinators at partner agencies via web/email or text. Event is not location-specific so no event manager is identified.</td><td>Event is handled by a designated set of management personnel.</td></tr>
<tr><td>4. Manage ICM Event</td><td>• <u>Before thunderstorm:</u> After ICM Coordinators are notified, peer-to-peer information is exchanged regarding agency reaction to weather forecast via a simple, online communications forum. Discussions include proactive message content and timing.
• <u>During thunderstorm</u>: The DSS online communications forum is used to exchange information on operating and managing affected agencies assets.
○ Minor Incidents – Each ICM Coordinator is responsible for their agency assets. They communicate information via DSS forum, including requests for other agency support.
○ Major Incidents – Refer to unplanned Transit or Traffic Event Scenario.</td><td>Individual agency goals and response complexity are recognized as part of response, due to a human-centric approach to management.</td></tr>
<tr><td>5. Implement Automated Strategies</td><td>DSS uses pre-determined ICM Corridor Working Group policies and protocols to implement select automated strategies.
○ Strategies includes an automatic update to traveler information services (e.g., 511) and notifications to TDM managers across the region.</td><td>Improved timeliness of information due to automated strategies unhindered by operator approval.</td></tr>
<tr><td>6. Report Performance Data</td><td>DSS calculates performance measures throughout duration of thunderstorm and provides reports for after action reviews.</td><td>Continual assessment and improvement of Corridor performance due to readily available data.</td></tr>
</table>

ICM Tactics and Strategies			
ICM Approach	**Agencies Involved**	**Scenario-Specific Application**	**Benefit**
Approach A: Improved Corridor Monitoring			
Add RWIS sensors in the corridor with grip sensors at key locations	NYC DOT, NYSDOT, NJDOT, NJTA, PANYNJ, TB&T	*<u>During thunderstorm</u>:* RWIS sensors provide real-time grip readings along key Corridor locations. When these readings fall below a specified threshold, the ICM-495 Corridor Dashboard automatically alerts ICM coordinators.	Coverage of gaps in roadside detection necessary for road weather-related situational awareness.
Approach B: Enhanced Traveler Information			

Use proactive messaging of weather conditions on DMS and 511	NYC DOT, NYSDOT, PANYNJ, NJDOT, NJT, NJTA	• *<u>Before thunderstorm</u>*: Pre-existing policies and procedures among partner agencies result in proactive messaging about forecasted event.
		  ○ *Includes posting messages on DMS during AM peak and on 511. Posting may be automated from the DSS.*
		• *<u>During thunderstorm</u>*: Policies and procedures also include DMS warnings when grip factor thresholds are met.
		  ○ *May be automated or operator-led.*
			More informed decision-making by travelers in before, during, and after the storm until conditions return to normal.

Create freight-specific portal of info/messaging on 511	NYC DOT, NYSDOT,MTA, PANYNJ, NJDOT, NJT, NJTA, TRANSCOM	• *<u>Before thunderstorm</u>*: Focused, proactive messaging about forecasted event and potential impacts on freight routes • *<u>During thunderstorm</u>*: When grip factor thresholds are met on freight routes, real-time warnings are uploaded to freight 511.	Enhanced freight information results in better trip making decisions by freight drivers before, during, and after the storm until conditions return to normal.
Approach C: Corridor-Based Demand Management			
Implement emergency playbooks with TDM Operators to support operations during adverse weather	NYSDOT	• *<u>Before thunderstorm</u>*. Based on forecast, TDM managers engage constituent employers and broadcast travel advisories via email, website, and social media. • *<u>During thunderstorm</u>*. TDM managers are able to provide one-stop services for travel disruption in the Corridor.	Mitigation of adverse weather impacts resulting from Corridor-focused demand management.
Approach G: Active Traffic Management			
Deploy speed harmonization at key locations during adverse weather.	NYSDOT, NJDOT, NJTA, PANYNJ, TB&T	Before the Corridor becomes congested, at a certain threshold RWIS data and precipitation information trigger weather-responsive algorithms resulting in lower speeds on the Corridor.	Reductions in rear-end crashes due to weather-based speed reduction/optimization.

6.4. Unplanned Traffic Event East of the QMT

LIE Traffic Event

Scenario Overview

Location Impacted: Entire ICM-495 Corridor in New York, Penn Station, and other East River crossings	**Event Start Time:** Weekday morning, 7:30am

Event Progression:
7:30 AM: A three-car crash on the EB (inbound) LIE just before the entrance to the QMT blocks all lanes heading into Manhattan.
7:35 AM: NYPD response determines that the roadway will need to be closed for the duration of the rescue, recovery, and clean-up.
8:15 AM: Traffic builds on the inbound LIE, backing up to the Brooklyn-Queens Expressway interchange.
9:00 AM: One lane is reopened to traffic.
9:45 AM: The incident is cleared and all lanes are returned to service.

ICM Event Criteria	ICM-495 Partners Involved	
☑ Duration (2 hours or more) ☑ Multimodal Impacts ☑ Multiple ICM-495 partners impacted	**New York State (NYS)**	NYC DOT, NYSDOT, NYPD, MTA
	NYS and New Jersey	TRANSCOM
	New Jersey	**N/A**

Existing Approach: Without ICM

Key challenges without ICM:

(1) Independent assessment of scenario impact
(2) Collaboration exists but is ad-hoc based on relationships.
(3) Minimal proactive messaging and lack of situational awareness beyond agency jurisdiction.

- Partner agencies monitor their own facilities from their own management centers (JTMC, AOCs, LIRR). Based on existing relationships, there is ongoing communication between JTMC and MTA B&Ts about the ongoing incident.
- There are differing levels of capability and awareness of changes in volume or the accessibility of major portions of the transportation network.
- Once the event occurs, agencies manage operations on their facility according to institutional memory and authority-specific protocols.
- Coordination between the agencies occurs via direct bilateral contacts, rather than via specific response protocols.
- First responders take on-scene control and are responsible for decisions on field regarding the nature of site management including lane closures.
- Travelers primarily get information from external media sources. En-route travelers on LIE approaching the incident depending on their location may be informed by appropriate VMS messages. Detour or rerouting options are not given. Information about the initial incident is posted on 511 but as event progresses, updates to incidents are harder to obtain via existing traveler information sources.
- Limited transit-traffic integration creates limited opportunity to redirect travelers to transit nor help transit buses make decisions on routing especially as they approach the tunnel.

Enhanced Corridor-Specific Approach: With ICM

Key outcomes of ICM in this scenario:

(1) Common understanding of the incident conditions.
(2) Proactive messaging to travelers including dynamic management of facilities.
(3) Improved situational awareness of corridor conditions among operating agencies.

ICM-495 Corridor Decision Support ("DSS")		
Actions	**Detail**	**Benefit**
1. Monitor Traffic and Transit Conditions	• DSS includes baseline travel times for the corridor. DSS detects slowdown in speeds and reduced volumes entering the QMT. • DSS detects increased volume on exit ramps and parallel arterials.	Ability to detect delays and disruptions.
2. Assess Impact and Determine ICM Event	• For each event, DSS assesses whether it meets the criteria for an ICM Event, non-ICM event, or an EOC event. • Previous comparable events are recalled to provide an estimate of resolution time and strategies employed and this event meets the impact criteria identified.	Identification of corridor-level impacts allows agencies to think beyond their facilities/assets.
3. Notify ICM Coordinators	• For an ICM Event, notifications are sent out to all designated ICM coordinators in the partner agencies, and an ICM Event Manager is designated from the primary affected agency. • In this case, the event manager is NYSDOT.	A designated set of management personnel are tapped to address the event.
4. Manage ICM Event	• As the event begins, DSS offers an online communications forum to exchange information. Wide-scale coordination begins between various roadway and transit operators. • Each ICM coordinator is responsible for the management and supervision of their own assets using their available strategies but will communicate information back to the group via the forum including requests for other agencies. • NYSDOT ICM Event Manager updates the group with ongoing field conditions. Because MTA bus operations is included as an ICM coordinator, they are able to track this response in real-time as well.	A human-centric approach to management that recognizes the individual agency goals and the complexity of response.
5. Implement Automated Strategies	• Based on the ICM Corridor Working Group policies and protocols, DSS will be able to implement select automated strategies. • For this scenario, this includes providing an automatic update to traveler information services like 511 and notifying the TDM managers in the region.	Certain strategies can be initiated without operator approval improving timeliness of information
6. Report Performance Data	• DSS will calculate performance measures during the scenario and provide reports for after action reviews. • Readily available data for performance management and continual improvement.	Performance metrics provide tangible goals, measure progress, and provide areas for improvement

ICM Tactics and Strategies			
ICM Approach	**Agencies Involved**	**Scenario-Specific Application**	**Benefit**
Approach A: Improved Corridor Monitoring			
Enhance volume detection in corridor	NYSDOT, NYC DOT	Will be used to inform VMS messaging. Will be used to detect incident location	Enhance corridor-wide agency situational awareness particularly during incident response.
Improve access to arterial speed detection in corridor	NYSDOT, NYC DOT	Detects conditions on parallel arterials that can be used to adjust detours shown on VMSs.	Enhance corridor-wide agency situational awareness particularly during incident response.

ICM Approach	Agencies Involved	Scenario-Specific Application	Benefit
Approach B: Enhanced Traveler Information			
Comparative travel time between key crossings	NYSDOT, NYC DOT, MTA B&T	Enhanced travel time feeds provide data to automated signs at key decision points to provide traveler route choice.	Provide actionable traveler information at key decision points outside and along the Corridor.
Unified communications strategy	NYSDOT, NYC DOT, LIRR, MTA B&T, NYPD	Provide early information to media and third-party notification services to allow travelers to make trip decisions before leaving home.	Provide actionable traveler information at key decision points outside and along the Corridor.
Approach C: Corridor-Based Demand Management			
Expand and enhance a corridor-focused employer-based telework program	NYSDOT	Lowers the total number of trips required. Gives telework options in case of transportation network disruption.	Support and prioritize higher occupancy vehicle trip reliability (HOVs, bus transit) along the Corridor.
Approach D: Coordinated Incident and Event Management			
Arterial DMS to support route choice	NJDOT, NJTA, PANYNJ, TB&T	Provides actionable information to travelers, including transit information.	• Enhance protocols to create unified agency definitions for corridor events. • Improve incident response and clearance times along the Corridor.
Approach E: Transit Bus Technology Improvements			
Improve Bus Time application to incorporate impact of diversions	MTA	• Provides updated arrival times for Express buses that may be diverted off of I-495. • Improve predicted arrival times for local buses on parallel arterials that will not be diverted, but will be delayed due to additional volume.	Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Approach G: Active Traffic Management			
Dynamic reversible lane	MTA B&T, NYC DOT, NYSDOT, NYPD	Extend hours of QMT reversible lane. Requires coordination with highway operations crews and TEAs on the Manhattan side of the QMT.	Dynamically manage (through ATM) for key bottleneck areas.
Queue Warning and Speed Harmonization	NYSDOT	Inform motorists of upcoming queues due to the incident and manage speeds of upstream traffic.	Dynamically manage (through ATM) for key bottleneck areas.

6.5. Traffic Incident West of Lincoln Tunnel

Lincoln Tunnel Traffic Event

Scenario Overview

Location Impacted: Entire ICM-495 Corridor in New Jersey, PABT, Hudson River Crossings, Penn Station, PATH, and ICM-495 Corridor in Manhattan
Event Start Time: Weekday morning, 7:00am

Event Progression:
7:00 AM: A truck fire on the Helix leading to the Lincoln Tunnel blocks all lanes heading into Manhattan.
7:05 AM: PANYNJ Police Department response determines that inbound Helix will need to be closed for the duration of the rescue, recovery, and clean-up. One lane of the outbound Helix is also closed.
7:45 AM: Traffic builds on NJ-495, backing up to the NJ Turnpike 16E interchange.
8:30 AM: The one to New Jersey is reopened to traffic.
9:30 AM: One lane to Manhattan is reopened to traffic.
10:00 AM: The incident is cleared and all lanes are returned to service.

ICM Event Criteria	ICM-495 Partners Involved	
☑ Duration (2 hours or more)	**New York State (NYS)**	NYC DOT, NYSDOT, NYPD
☑ Multimodal Impacts	**NYS and New Jersey**	TRANSCOM, PANYNJ TB&T, PATH
☑ Multiple ICM-495 partners impacted	**New Jersey**	NJDOT, NJTA, NJT

Existing Approach: Without ICM

Key challenges without ICM:
(1) Independent assessment of scenario impact.
(2) Minimal proactive messaging and lack of situational awareness beyond agency jurisdiction.
(3) Collaboration exists but is ad-hoc based on relationship.
(4) Private bus companies have access to same information as the general public.

- Partner agencies monitor their own facilities from their own management centers (STMC, AOCs, NJT).
- There are differing levels of capability and awareness of changes in volume or the accessibility of major portions of the transportation network.
- Once the event occurs, agencies manage operations on their facility according to institutional memory and authority-specific protocols.
- Coordination between the agencies occurs via direct bilateral contacts, rather than via specific response protocols.
- First responders take on-scene control.
- Travelers primarily get information from external media sources. Detour or rerouting options are not given.
- Limited transit-traffic integration creates limited opportunity to redirect travelers to transit. With the significant transit use in the corridor, transit agencies have limited awareness of ongoing field conditions to make appropriate routing decisions. Many of these decisions may have to be made outside the corridor boundaries.

Enhanced Corridor-Specific Approach: With ICM

Key outcomes of ICM in this scenario:
(1) Common understanding of the incident conditions.
(2) Proactive messaging to travelers including dynamic management of facilities.
(3) Improved situational awareness of corridor conditions among operating agencies.

ICM-495 Corridor Decision Support ("DSS")		
Actions	**Detail**	**Benefit**
1. Monitor Traffic and Transit Conditions	DSS includes baseline travel times for the corridor. DSS detects slowdown in speeds and reduced volumes entering the Lincoln Tunnel. DSS detects increased volume on exit ramps and parallel crossings.	Ability to detect delays and disruptions.
2. Assess Impact and Determine ICM Event	• For each event, DSS assesses whether it meets the criteria for an ICM Event, non-ICM event, or an EOC event • Based on the location and the duration, this event is tagged as an ICM Event.	Identification of corridor-level impacts allows agencies to think beyond their facilities/assets.
3. Notify ICM Coordinators	• For an ICM Event, notifications are sent out to all designated ICM coordinators in the partner agencies, and an ICM Event Manager is designated from the primary affected agency. In this case, PA-AOC is the ICM Event Manager. • Notifications are sent out via web/email, texts, or internal networks to other ICM coordinators.	• A designated set of management personnel are tapped to address the event. • Corridor situational awareness is increased.
4. Manage ICM Event	• As the event begins, the DSS offers an online communications forum to exchange information. Wide-scale coordination begins between various roadway and transit operators. • Each ICM coordinator is responsible for the management and supervision of their own assets but will communicate information back to the group via the forum including requests for other agencies. For facilities that are managed manually or according to time-based patterns, adjust and extend those interventions until the incident is cleared. • Operators of parallel crossings are alerted to expect extra volume. Transit assets such as NJT, PATH, and private bus companies are notified to potentially expect increased demand from travelers who may change mode from driving to transit. • Some buses will be diverted to other crossings or to rail interface points like Newark Penn Station or Secaucus Junction.	A human-centric approach to management that recognizes the individual agency goals and the complexity of response
5. Implement Automated Strategies	• Based on the ICM Corridor Working Group policies and protocols, DSS will be able to implement select automated strategies. • For this scenario, this includes providing an automatic update to traveler information services like 511 and notifying the TDM managers in the region.	Certain strategies can be initiated without operator approval improving timeliness of information.
6. Report Performance Data	• The DSS will calculate performance measures during the scenario and provide reports for after action reviews. • Readily available data for performance management and continual improvement.	Performance metrics provide tangible goals, measure progress, and provide areas for improvement.

ICM Tactics and Strategies			
ICM Approach	**Agencies Involved**	**Scenario-Specific Application**	**Benefit**
Approach A: Improved Corridor Monitoring			
Enhance volume detection in corridor	NJDOT, NJTA, PANYNJ TB&T	Fixed non-intrusive volume detection will be used to inform VMS messaging, detect incident location and support decision of XBL activation/deactivation outside of regularly scheduled times.	Enhance corridor-wide agency situational awareness particularly during incident response.
Improve access to arterial speed detection in corridor	NJDOT, Local agencies	Detects conditions on parallel arterials that can be used to adjust detours shown on VMSs.	Enhance corridor-wide agency situational awareness particularly during incident response.
Approach B: Enhanced Traveler Information			
Comparative travel time between key crossings at decision points	NJDOT, NJTA, PANYNJ TB&T	Travel time feeds from TRANSCOM provide data to automated signs.	Provide actionable traveler information at key decision points outside and along the Corridor.
Unified communications strategy	NJDOT, NJTA, NJT, PANYNJ TB&T, PATH	• Provide early information to media and third-party notification services to allow travelers to make trip decisions before leaving home. • DSS receives information from the field and messaging can be updated based on contemporaneous information.	Provide actionable traveler information at key decision points outside and along the Corridor.
Approach G: Active Traffic Management			
Dynamic reversible lane	NJTA, PANYNJ TB&T	XBL operation before or after usual opening/closing times. Requires coordination with ramps to PABT.	Dynamically manage (through ATM) for key bottleneck areas.
Adaptive Ramp Metering	NJTA, NJDOT	Prevent traffic from entering incident zone.	• Dynamically manage (through ATM) for key bottleneck areas. • Improve incident response and clearance times along the Corridor.
Queue Warning System	NJTA, NJDOT	Prevent follow-on incidents.	• Dynamically manage (through ATM) for key bottleneck areas. • Improve incident response and clearance times along the Corridor.

6.6. Unplanned Commuter Rail Event with Corridor Implications

Commuter Rail Disruption

Scenario Overview

Location Impacted: Entire ICM-495 Corridor in New Jersey, Penn Station, and 33rd Street PATH Station
Event Start Time: Weekday morning, 6:30 AM

Event Progression:
6:30 AM: After a scheduled opening of Portal Bridge to allow a ship to pass through, the bridge does not close properly. NJT is not able to provide service between Newark and Secaucus.
6:40 AM: NJT puts a notice on their website and notifies media outlets of the service suspension. Travelers choose alternate modes or forgo trips entirely.
6:45 AM: NJT begins cross-honoring fares with private bus carriers and PATH.
10:00 AM: The Portal Bridge closes and regular NJT and Amtrak service is resumed.

ICM Event Criteria	ICM-495 Partners Involved	
☑ Duration (2 hours or more)	**New York State (NYS)**	N/A
☑ Multimodal Impacts	**NYS and New Jersey**	PANYNJ, PATH, TB&T, TRANSCOM
☑ Multiple ICM-495 partners impacted	**New Jersey**	NJDOT, NJT, NJTA

Existing Approach: Without ICM

Key challenges without ICM:
(1) Independent assessment of scenario impact.
(2) Collaboration exists but is ad-hoc based on relationships.
(3) Minimal proactive messaging and lack of situational awareness beyond agency jurisdiction.

- Partner agencies monitor their own facilities from their own management centers (JTMC, AOCs, NJT ROC, NJDOT STMC). There are differing levels of capability and awareness of changes in volume or the accessibility of major portions of the transportation network.
- Once the event occurs, agencies manage operations on their facility according to institutional memory and authority-specific protocols.
- Coordination between the agencies occurs via direct bilateral contacts, rather than via specific response protocols.
- Travelers primarily get information from external media sources. Detour or rerouting options are not given.
- Limited transit-traffic integration creates limited opportunity to manage disruptions to transit for person throughput.

Enhanced Corridor-Specific Approach: With ICM

Key outcomes of ICM in this scenario:
(1) Common understanding of the incident conditions.
(2) Proactive messaging to travelers including dynamic management of facilities.
(3) Improved situational awareness of corridor conditions among operating agencies.

ICM-495 Corridor Decision Support ("DSS")

Actions	Detail	Benefit
1. Monitor Traffic and Transit Conditions	DSS includes schedule information for trains using the Hudson River tunnels and the Northeast Corridor mainline.	• Knowledge of overall cross-Hudson rail capacity. • Ability to detect delays and disruptions.
2. Assess Impact and Determine ICM Event	• For each event, the DSS assesses whether it meets the criterion for an ICM Event, non-ICM event or an EOC event.	Identification of corridor-level impacts allows agencies to think beyond their facilities/assets.

Actions	Detail	Benefit
	• Due to the duration and multimodal nature, this event is tagged as an ICM Event.	
3. Notify ICM Coordinators	• For an ICM Event, notifications are sent out to all designated ICM coordinators in the partner agencies, and an ICM Event Manager is designated from the primary affected agency. NJT is the Event Manager for the event. • Non-NJT transit assets such as NY Waterway ferry and private bus operators are notified to potentially expect increased demand from displaced train commuters and/or to expect additional roadway congestion.	• A designated set of management personnel are tapped to address the event. • Corridor situational awareness is increased.
4. Manage ICM Event	As the event begins, DSS offers an online communications forum to exchange information. Wide-scale coordination begins between various transit providers, both public and private. Transit providers communicate with roadway operators to strategize for the expected increase in roadways demand. Each ICM coordinator is responsible for the management and supervision of their own assets but will communicate information back to the group via the forum including requests for other agencies.	A human-centric approach to management that recognizes the individual agency goals and the complexity of response.
5. Implement Automated Strategies	Based on the ICM Corridor Working Group policies and protocols, DSS will be able to implement select automated strategies. For this scenario, this includes providing an automatic update to traveler information services like 511 and notifying the TDM managers in the region.	Certain strategies can be initiated without operator approval improving timeliness of information.
6. Report Performance Data	• DSS will calculate performance measures during the scenario and provide reports for after action reviews. • Readily available data for performance management and continual improvement.	Performance metrics provide tangible goals, measure progress, and provide areas for improvement.

ICM Tactics and Strategies

ICM Approach	Agencies Involved	Scenario-Specific Application	Benefit
Approach B: Enhanced Traveler Information			
Comparative travel time between key crossings at decision points	NJDOT, NJTA, PANYNJ TB&T	Travel time feeds from TRANSCOM provide data to automated signs	Provide actionable traveler information at key decision points outside and along the corridor
Unified communications strategy	NJDOT, NJT, PATH	• Provide early information to media and third-party notification services to allow travelers to make trip decisions before leaving home. • DSS receives information from the field and messaging can be updated based on contemporaneous information.	Provide actionable traveler information at key decision points outside and along the corridor
Approach C: Corridor-Based Demand Management			

ICM Approach	Agencies Involved	Scenario-Specific Application	Benefit
Expand and enhance a corridor-focused employer-based telework program	NJTPA	Lowers the total number of trips required. Gives telework options in case of transportation network disruption.	• Improve incident response and clearance times along the corridor. • Support and prioritize higher occupancy vehicle trip reliability (HOVs, bus transit) along the Corridor. • Enhance corridor manager engagement with key stakeholders such as employers, special event managers, parking operators, private sector partners on demand management.
Approach E: Transit Bus Technology Improvements			
Explore unified fare media	NJT, PATH, Private bus carriers	A unified fare payment system that allows access across systems with the same media. Allows for post-event reconciliation and avoids the need for transit employees to manually admit passengers.	Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Approach G: Active Traffic Management			
Dynamic reversible lane	NJTA, PANYNJ TB&T	XBL operation before or after usual opening/closing times. Requires coordination with ramps to PABT.	Dynamically manage (through ATM) for key bottleneck areas.
Dynamic toll pricing	PANYNJ TB&T, NJTA	Demand-responsive tolling.	Dynamically manage (through ATM) for key bottleneck areas.

6.7. Long-Term Closures of a Traffic Link

Long-Term Traffic Closure

Scenario Overview

Location Impacted: Entire ICM-495 Corridor in New York, Manhattan, Penn Station
Event Start Time: Spring

Event Progression:
April: A routine inspection of the LIE Bridge over Newtown Creek reveals a dangerously corroded beam, forcing the closure of the westbound span. For the duration of the 3-month repairs, one WB lane will be shifted onto the EB lane between the Brooklyn-Queens Expressway and QMT. As a result, the EB roadway will carry two lanes instead of three. An HOV-3 restriction is put into place for WB traffic and trucks are banned.
May: Repairs continue, but heavy delays are daily occurrences on I-495 and on parallel crossings.
July: Repairs are complete and the bridge is returned to full service.

ICM Event Criteria	ICM-495 Partners Involved	
☑ Duration (2 hours or more)	**New York State (NYS)**	MTA, NYC DOT, NYSDOT
☑ Multimodal Impacts	**NYS and New Jersey**	TRANSCOM
☑ Multiple ICM-495 partners impacted	**New Jersey**	N/A

Existing Approach: Without ICM

Key challenges without ICM:
(1) Independent assessment of scenario impact.
(2) Minimal proactive messaging and lack of situational awareness beyond agency jurisdiction.
(3) Collaboration exists but is ad-hoc based on relationships.
(4) No coordinated effort for overall traveler mobility, no awareness of duration of work.

- Partner agencies monitor their own facilities from their own management centers (JTMC, AOCs, MTA Rail Control Center). There are differing levels of capability and awareness of changes in volume or the accessibility of major portions of the transportation network.
- After the initial inspection and a few days of chaotic operations, different agencies have worked out operating protocols to adjust to new traffic matters. Agencies manage operations on their facility according to institutional memory and authority-specific protocols. Coordination between the agencies occurs via direct bilateral contacts, rather than via specific response protocols.
- Travelers primarily get information from 511, VMS, and external media sources. Explicit detour or rerouting options not provided since some lanes are still open. However, traveler information sources suggest the use of alternate routes.
- Limited transit-traffic integration creates limited opportunity to manage disruptions to transit for person throughput. Transit bus operations make their own adjustments to schedule and routes based on analysis of conditions but have limited awareness of conditions on the roadway beyond what is being reported by the drivers.
- Local wayfinding and work zone impacts are managed by the contractors for NYSDOT. Additional TEAs and support personnel are also available on on-site.
- Local telework and TDM programs actively provide information on the long-term closure, including reaching out to the 511NY Rideshare and NJ Rideshare ridematching database participants, employers and putting together information packages on 511NY Rideshare websites and social media.

Enhanced Corridor-Specific Approach: With ICM		
Key outcomes of ICM in this scenario: (1) Common understanding of the incident conditions (2) Proactive messaging to travelers including dynamic management of facilities (3) Improved situational awareness of corridor conditions among operating agencies		
ICM-495 Corridor Decision Support ("DSS")		
Actions	**Detail**	**Benefit**
1. Monitor Traffic and Transit Conditions	DSS includes schedule information for transit services and baseline conditions for Queens roadways.	Knowledge of overall cross-East River capacity.
2. Assess Impact and Determine ICM Event	For each event, DSS assesses whether it meets the criterion for an ICM Event, non-ICM event or an EOC event. With the long-term nature of the event, this long-term closure is managed as an ICM Event.	Identification of corridor-level impacts allows agencies to think beyond their facilities/assets
3. Notify ICM Coordinators	• For an ICM Event, notifications are sent out to all designated ICM coordinators in the partner agencies, and an ICM Event Manager is designated from the primary affected agency. NYSDOT is the Event-Manager for this event. • Notifications are sent out via web/email, texts, or internal networks.	• A designated set of management personnel are tapped to address the event. • Corridor situational awareness is increased.
4. Manage ICM Event	• As the event begins, DSS offers an online communications forum to exchange information. Wide-scale coordination begins between various transit providers and traffic operators. • Each ICM coordinator is responsible for the management and supervision of their own assets but will communicate information back to the group via the forum including requests for other agencies. • Transit assets and parallel crossings are notified to potentially expect increased demand from displaced commuters and/or to expect additional roadway congestion. • Detours around work zones are coordinated with estimated times of completion made known.	A human-centric approach to management that recognizes the individual agency goals and the complexity of response.
5. Implement Automated Strategies	• Based on the ICM Corridor Working Group policies and protocols, DSS will be able to implement select automated strategies. • For this scenario, this includes providing an automatic update to traveler information services like 511 and notifying the TDM managers in the region.	Certain strategies can be initiated without operator approval improving timeliness of information.
6. Report Performance Data	• DSS will calculate performance measures during the scenario and provide reports for after action reviews. • Readily available data for performance management and continual improvement.	Performance metrics provide tangible goals, measure progress, and provide areas for improvement

ICM Tactics and Strategies			
ICM Approach	**Agencies Involved**	**Scenario-Specific Application**	**Benefit**
Approach A: Improved Corridor Monitoring			
Enhance volume detection in corridor	NYSDOT, NYC DOT, MTA B&T	Will be used to support decision of various vehicle restrictions into Manhattan. Overall person throughput will be the performance metric rather than vehicle throughput. DSS receives information from the field and messaging can be updated based on contemporaneous information.	Enhance corridor-wide agency situational awareness particularly during incident response
Improve access to arterial speed detection in corridor	NYSDOT, NYC DOT, MTA B&T	Detects conditions on parallel arterials that can be used to adjust detours shown on VMSs.	Enhance corridor-wide agency situational awareness particularly during incident response.
Improve accident/incident reporting especially on arterials	NYSDOT, NYC DOT, MTA B&T	• CCTV network used to identify severity of incident and dispatch appropriate response. Rapid incident response will need to be a priority as parallel arterials operate at or over capacity. • DSS receives information from the field and messaging can be updated based on contemporaneous information.	Enhance corridor-wide agency situational awareness particularly during incident response.
Approach B: Enhanced Traveler Information			
Comparative travel time between key crossings at decision points	NYSDOT, NYC DOT, MTA B&T	Travel time feeds from TRANSCOM provide data to automated signs.	Provide actionable traveler information at key decision points outside and along the Corridor.
Unified communications strategy	NYSDOT, NYC DOT, MTA B&T, LIRR, NYCT	• Provide early information to media and third-party notification services to allow travelers to make trip decisions before leaving home. • DSS receives information from the field and messaging can be updated based on contemporaneous information. • Provides information on work duration and expected completion.	Provide actionable traveler information at key decision points outside and along the Corridor.
Approach C: Corridor-Based Demand Management			
Expand and enhance a corridor-focused employer-based telework program	NYSDOT	Lowers the total number of trips required. Gives telework options in case of transportation network disruption.	• Support and prioritize higher occupancy vehicle trip reliability (HOVs, bus transit) along the Corridor. • Enhance corridor manager engagement with key stakeholders such as employers, special event managers, parking operators,

ICM Approach	Agencies Involved	Scenario-Specific Application	Benefit
			private sector partners on demand management.
Approach E: Transit Bus Technology Improvements			
Improve Bus Time application to incorporate impact of diversions	MTA	Some local bus routes may be diverted off parallel arterials. Bus movements on remaining I-495 lane will be prioritized.	Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Approach F: Work Zone Coordination			
Standardized work zone traffic management plan impact assessment and approval	NYSDOT, NYC DOT, NYPD, MTA	• A working group is convened to plan for anticipated impacts, adjust interventions based on data and observation, and alert agencies that may be indirectly affected. • Publishes and refines messaging to public.	• Enhance protocols to create unified agency definitions for corridor events. • Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Construction works traffic management plan compliance monitoring	NYSDOT, NYC DOT	• Ensures mitigation strategies are being followed and collects performance measure data to inform future comparable disruptions.	• Enhance protocols to create unified agency definitions for corridor events • Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Approach G: Active Traffic Management			
Adaptive Ramp Metering	NYSDOT	To prevent single WB lane from being overwhelmed.	Dynamically manage (through ATM) for key bottleneck areas.
Transit Signal Priority	NYC DOT, MTA	To be installed on parallel arterials to speed transit bus movement	• Proactively manage short-term demand surges and ongoing diversions on facilities in the corridor • Support and prioritize higher occupancy vehicle trip reliability (HOVs, bus transit) along the corridor
Arterial Parking Restrictions	NYC DOT, MTA	To provide extra capacity on parallel arterials, potentially with dedicated bus lanes.	Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Dynamic Merge Control	NYSDOT	Improve conditions at lane drop where WB roadway will merge to one lane. EB roadway can be maintained through channelization from 2-lane tunnel to 2-lane highway.	Dynamically manage (through ATM) for key bottleneck areas.

6.8. Long-Term Closure to a Transit Line

Long Term Transit Closure

Scenario Overview

Location Impacted: Entire ICM-495 Corridor in New Jersey, Manhattan, Penn Station
Event Start Time: Winter

Event Progression:

- **January:** An electrical fire at the 9th Street PATH station causes severe damage to the platform and track bed. Service from Hoboken and Journal Square to 33rd Street is suspended while repairs take place. The work is estimated to take 4 months.
- **February:** Travelers have adjusted to new patterns, using a combination of buses to PABT, ferries, or PATH service to World Trade Center and then changing to subways.
- **March:** Repairs on one track are completed, and a very limited single-track service is resumed
- **April:** The system is restored to normal service.

ICM Event Criteria	ICM-495 Partners Involved	
☑ Duration (2 hours or more)	**New York State (NYS)**	MTA, NYC DOT
☑ Multimodal Impacts	**NYS and New Jersey**	PANYNJ, PATH, TB&T, TRANSCOM
☑ Multiple ICM-495 partners impacted	**New Jersey**	NJDOT, NJT, NJTA

Existing Approach: Without ICM

Key challenges without ICM:

(1) Independent assessment of scenario impact.
(2) Minimal proactive messaging and lack of situational awareness beyond agency jurisdiction.
(3) Collaboration exists but is ad-hoc based on relationships.
(4) No coordinated effort for overall traveler mobility.
(5) No awareness of duration of work.

- Partner agencies monitor their own facilities from their own management centers (JTMC, AOCs, NJT ROC, NJDOT STMC). There are differing levels of capability and awareness of changes in volume or the accessibility of major portions of the transportation network.
- Once the event occurs, agencies manage operations on their facility according to institutional memory and authority-specific protocols. Coordination between the agencies occurs via direct bilateral contacts, rather than via specific response protocols.
- Travelers primarily get information from agency traveler information and external media sources. Detour or rerouting options are not given explicitly but PATH and other agencies do recommend alternate routes and transit services. Given the nature of the event, cross-honoring of fares is only applied for the initial few days of the event.
- Local TMAs and the TDM program are providing updates of transit service disruptions, shuttles (if active), Ridematching services to minimize the use of single occupancy vehicles. Given the nature of the event, most users are switching to other modes of transit but need help in familiarizing themselves with new alternatives.
- Transit agencies (especially bus operations) have limited ability to absorb new demand or add capacity in the short-term.

Enhanced Corridor-Specific Approach: With ICM

Key outcomes of ICM in this scenario:

(1) Common understanding of the incident conditions.
(2) Proactive messaging to travelers including dynamic management of facilities.
(3) Improved situational awareness of corridor conditions among operating agencies.

ICM-495 Corridor Decision Support ("DSS")		
Actions	**Detail**	**Benefit**
1. Monitor Traffic and Transit Conditions	DSS includes schedule information for PATH, ferries, buses, and average cross-Hudson travel times.	• Knowledge of overall cross-Hudson rail capacity. • Ability to detect delays and disruptions.
2. Assess Impact and Determine ICM Event	For each event, DSS assesses whether it meets the criterion for an ICM Event, non-ICM event or an EOC event. This event meets the criteria for an ICM Event based on previous comparable events are recalled to provide an estimate of resolution time and strategies employed.	Identification of corridor-level impacts allows agencies to think beyond their facilities/assets.
3. Notify ICM Coordinators	For an ICM Event, notifications are sent out to all designated ICM coordinators in the partner agencies, and an ICM Event Manager is designated from the primary affected agency. In this case, PATH is the designated event-manager.	• A designated set of management personnel are tapped to address the event. • Corridor situational awareness is increased.
4. Manage ICM Event	• As the event begins, DSS offers an online communications forum to exchange information. Wide-scale coordination begins between various transit providers, both public and private. Transit providers communicate with roadway operators to strategize for the expected increase in roadways demand. • Non-NJ TRANSIIT transit assets such as NY Waterway ferry and private bus operators are notified to potentially expect increased demand from displaced train commuters and/or to expect additional roadway congestion. • Each ICM coordinator is responsible for the management and supervision of their own assets but will communicate information back to the group via the forum including requests for other agencies.	A human-centric approach to management that recognizes the individual agency goals and the complexity of response.
5. Implement Automated Strategies	• Based on the ICM Corridor Working Group policies and protocols, DSS will be able to implement select automated strategies. • For this scenario, this includes providing an automatic update to traveler information services like 511 and notifying the TDM managers in the region.	Certain strategies can be initiated without operator approval improving timeliness of information.
6. Report Performance Data	• DSS will calculate performance measures during the scenario and provide reports for after action reviews. • Readily available data for performance management and continual improvement.	Performance metrics provide tangible goals, measure progress, and provide areas for improvement.

ICM Tactics and Strategies			
ICM Approach	**Agencies Involved**	**Scenario-Specific Application**	**Benefit**
Approach A: Improved Corridor Monitoring			

ICM Approach	Agencies Involved	Scenario-Specific Application	Benefit
Enhance volume detection in corridor	NJDOT, NJTA, PANYNJ TB&T	• Will be used to support decision of XBL activation/deactivation outside of regularly scheduled times in order to provide for extra capacity into Midtown. • DSS receives information from the field and messaging can be updated based on contemporaneous information.	Enhance corridor-wide agency situational awareness particularly during incident response.
Approach B: Enhanced Traveler Information			
Comparative travel time between key crossings at decision points	NJDOT, NJTA, PANYNJ TB&T	Travel time feeds from TRANSCOM provide data to automated signs.	Provide actionable traveler information at key decision points outside and along the Corridor.
Unified communications strategy	NJDOT, NJT, PATH	• Provide early information to media and third-party notification services to allow travelers to make trip decisions before leaving home. • DSS receives information from the field and messaging can be updated based on contemporaneous information. • Provides information on work duration and expected completion.	Provide actionable traveler information at key decision points outside and along the Corridor.
Approach C: Corridor-Based Demand Management			
Expand and enhance a corridor-focused employer-based telework program	NJTPA	Lowers the total number of trips required. Gives telework options in case of transportation network disruption.	• Support and prioritize higher occupancy vehicle trip reliability (HOVs, bus transit) along the Corridor. • Enhance corridor manager engagement with key stakeholders such as employers, special event managers, parking operators, private sector partners on demand management.
Approach E: Transit Bus Technology Improvements			
Improve Bus Time application to incorporate impact of diversions	NJT	• Requires additional functionality from NJT to support additional buses from key nodes to PABT. • Private carriers do not currently provide location information.	• Support and prioritize higher occupancy vehicle trip reliability (HOVs, bus transit) along the Corridor. • Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.

ICM Approach	Agencies Involved	Scenario-Specific Application	Benefit
Explore unified fare media	NJT , PATH, Private bus carriers	A unified fare payment system that allows access across systems with the same media. Allows for post-event reconciliation and avoids the need for transit employees to manually admit passengers.	Proactively manage short-term demand surges and ongoing diversions on facilities in the Corridor.
Approach G: Active Traffic Management			
Dynamic reversible lane	NJTA, PANYNJ TB&T	XBL operation before or after usual opening/closing times. Requires coordination with ramps to PABT.	Dynamically manage (through ATM) for key bottleneck areas.
Dynamic toll pricing	PANYNJ TB&T, NJTA	Demand-responsive tolling to prevent roadway crossings from being overwhelmed by travelers displaced from PATH.	Dynamically manage (through ATM) for key bottleneck areas.

7. SUMMARY OF IMPACTS

The proposed ICM-495 Operational Concept in Chapter 5 and its application under various scenarios in Chapter 6 imply a wide variety of impacts for the ICM-495 partner agencies as well as other stakeholders. This chapter provides a summary of institutional, operational, financial, and maintenance impacts. More detailed impact assessments are likely necessary as part of system development and design.

7.1. Institutional Impacts

The proposed ICM-495 Operational Concept acknowledges and takes advantage of the unique capabilities and functions of the Corridor stakeholders. In general, the ICM-495 DSS allows for agencies to actively collaborate while maintaining control and independence of their core functions. However, there are several areas of impacts that need to be considered and accounted for in systems development. These include:

A new focus corridor-focused operational investments and culture – Each ICM-495 partner agency needs to build internal decision-maker support for an increased focus on operations in the corridor. These include building support for programming projects to implement the proposed systems in the corridor and ensuring that built projects consider concepts in the ICM-495 ConOps and use supportive and interoperable technologies. Due to the substantial amount required, funding of system support and of infrastructure status maintenance are big challenges in the region. Looking to dedicate funds for ITS, which are typically not part of ongoing expenses, is difficult. With ongoing staff for support and for maintenance, being able to identify the performance benefit for the staff and having to compete for resources with other areas is an issue. Tracking performance improvement supports the case that operations are as important as capital improvements.

Perhaps the most important initiative will be aligning the cultures of the disparate agencies and jurisdictions in order to most effectively provide a complete mobility solution for the Corridor’s travelers. The first step towards this goal and a key driver going forward will be the formation of a traffic management steering committee and a multi-agency executive council, each of which will meet regularly to set the Corridor’s traffic management agenda. This alignment of cultures will also be facilitated by regular peer-to-peer exchanges and engagements for key personnel to meet and become familiar with other agencies’ operations

Support for a defined ICM Coordinator role within their agency – An important resource/investment by a participating agency is the definition of an ICM coordinator role among the management center personnel. This can be an expansion of an existing operator’s responsibility or a new resource to support corridor-level operations.

Improvements and changes in protocols and policies – Agencies need to look at opportunities to synchronize processes and protocols around incident and events management in the corridor to enable common understanding of corridor-level responses. Many of the joint operations centers in the region focus on the personnel that work there. However, human beings are not capable of being as productive and immediate as an automated system can be. Systems need to be integrated, data is automatic, but the incident management piece needs to be more automated. The question remains regarding how much more technology can be used to take the burden off the operator. If everyone agrees on a protocol, there can be more automated systems. The agencies will need work together on a number of business processes. These include planning and scoping to conduct regional traffic management exercises, developing multi-year maintenance plans to procure and maintain specialized equipment, and creating a regional incident management tracking database.

Commitment to a corridor-based decision support system – The notion of decision support as described in Chapter 5 is not a big leap for the agencies. There are excellent data repositories and fusion engines that are available in the corridor. However, ICM requires the capability to go from data aggregator to decision support. Partner agencies need to commit to the use of the ICM-495 DSS as a common platform for management and support the interfaces necessary for the ICM-495 DSS to provide timely and real-time monitoring of the corridor.

7.2. Operational Impacts

Operationally, individual actions of an agency can have corridor impacts. Hence a greater degree of understanding of how agency practices affect other partners is necessary. The following impacts are identified in this section.

New Agreements. Agencies must agree on a project charter that clearly defines the scope, objectives, and participants of the ICM-495 program. These agreements will codify roles and responsibilities, objectives, stakeholders, and chains of command. These agreements must also define the level and procedures for information standardization and sharing. The ICM-495 DSS will function based on the framework developed in these agreements, including the Corridor Working Group, which will be the core administrative function and main coordinator of ICM responses.

Harmonized Maintenance Procedures. As agencies will be operating equipment and technologies on their facilities that will directly impact other facilities, a set of standard procedures must be adopted, including thresholds for various levels of intervention. The agencies must also agree on standards of uptime, and contingency procedures in case certain equipment is not available for corridor management.

Harmonized Incident Management Procedures. Incidents will have impacts across facilities and across jurisdictions, requiring agencies to agree on a standard set of responses. These procedures and "playbooks" must be wide-ranging, taking into account the impacts on traffic, transit, and other forms of alternate mobility.

Common Project and Policy Framework. Equipment procurement will be a major factor in the initial implementation, requiring agencies to develop standard policies to acquire, install, and maintain equipment. The agencies must also agree on the priorities, phasing, and timeline of standing up the various interventions. The agencies must also develop a common suite of performance measures to monitor the effectiveness of the equipment deployment and operational changes along the corridor.

Common Testing Procedures. The agencies will develop an Analysis, Modeling, and Simulation (AMS) plan to allow testing and verification of new measures before they are deployed into the corridor. Further information about the AMS plan can be found in Section 8.

7.3. Technology Impacts

From a technology standpoint, the ICM-495 Operational Concept adds a new capability for decision support that builds on existing data services and interfaces in the region. Through the ICM-495 DSS, the agencies will together develop the capability to automate data analysis and system operations in order to be able to deliver interventions without manual operator input. The agencies will also extend the umbrella of systems engineering beyond design and integration to the testing, validation, operation, and full equipment life-cycle.

From a facility standpoint, several ATM strategies are proposed as part of ICM. These will necessarily involve new equipment, procedures, and requirements. The alignment of technologies among the agencies will necessarily be difficult at first as new equipment, procedures, and requirements are introduced. As staff becomes more familiar and confidence in the ICM-495 DSS grows, effective use of the new capabilities will become more apparent and less disruptive to the agencies' operations.

7.4. Financial Impacts

Financially, ICM projects include the following benefits and costs:

Benefit from Improved Travel Time. Based on standard monetization factors for occupants of buses and private autos and for freight operators, per segment travel time improvements of between 7 and 18 percent result in benefits accrued to users.

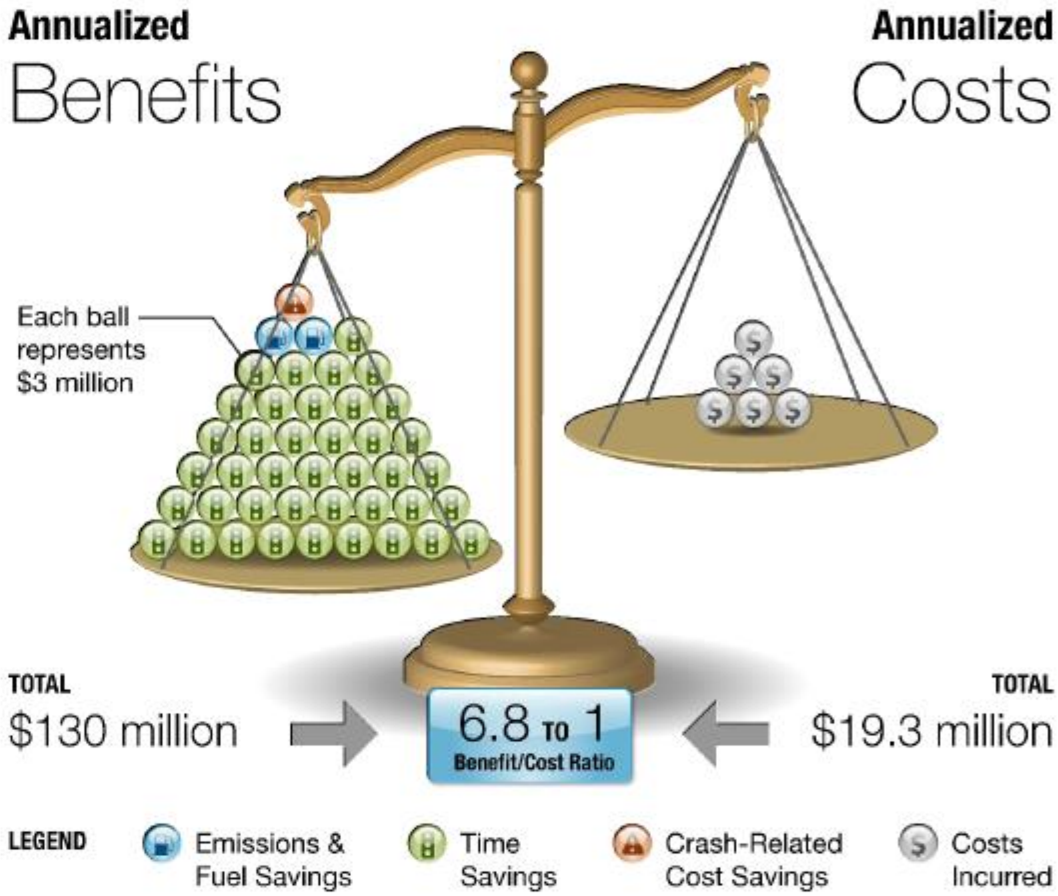
Benefit from Reduction in Crashes. Through interventions designed to improve safety, the total number of crashes on the corridor are reduced. This results in benefits found from injuries avoided, repair costs avoided, clean-up costs avoided, reduction in delays, reduction in the payout of insurance claims, and reduction in the loss of workplace productivity.

Benefit from Reduction in Emissions and Fuel Consumption. The reduced delays, more even speeds, and reduced idle times create fuel savings realized directly to users, as well as reduced emissions, whose benefits are seen across society. Reductions in CO, CO2, NOx, SOx, VOC, and Particulate Matter are monetized using standard value factors.

Additional Costs of ICM interventions. Many of the technologies to be implemented have costs associated with installation, training, and maintenance. Some of the ICM strategies chosen, such as hard shoulder running, speed harmonization, queue warnings, adaptive ramp metering, an incident management suite, enhanced traveler information systems, dynamic merge control, variable tolling equipment, a contraflow freeway lane, and transit signal priority fall under this rubric. Other strategies, such as dynamic reversible lanes, arterial parking prohibitions, and open road tolling have already been installed under programs unrelated to the ICM-495 initiative and will be optimized for this effort through policy changes that do not require any additional capital expenditure.

A high-level benefit-cost analysis was conducted to provide quantitative insights into the potential performance of several ICM strategies on the ICM-495 corridor, to provide a sense of the value associated with various investments and strategy implementations. Merging the benefit and cost analysis results provides greater insight into the economic performance and value of the ICM-495 investments. Specifically, given an annual benefit of approximately $130.6 million to the traveling public across all segments and jurisdictions, combined with a corresponding annual cost of $19.3 million specifically for the strategies analyzed, this indicates an overall benefit-cost ratio of 6.8 to 1 (See Figure 7-1). Put another way, every $1.00 invested in ICM on this corridor generates $6.77 in benefits for users of those facilities. Alternatively, a decision not to fund these strategies could be expected to result in a net loss to the public of $111 million annually.

Figure 7-1. Benefit-Cost Analysis of ICM-495 Operational Concept



When interpreting these results, it is important to recognize that benefits are only fully achieved when all parts of the system are effectively engaged together, rather than operated in isolation. The results of the benefit/cost analysis show that the benefits obtained from the system are generally concentrated on the more congested segments and those with higher volumes, which is expected given that delay reductions and other benefits cannot occur on a segment that has no performance issues to begin with.

More details on the benefit-cost analysis are available at *Technical Memorandum #8: TMS Concept B/C Assessment and Priority Analysis.*

7.5. Maintenance and Support Strategies

Overall maintenance of specific equipment will remain the responsibility of the owning agency. As the uptime and availability of equipment will have an impact on the entire corridor, the ICM-495 agreements will contain minimum service standards. The initial deployment of ICM-495 policies will be predicated on the legacy equipment currently installed, but it is expected that as capabilities increase and equipment replacement cycles come due, a joint equipment procurement, installation, maintenance, and support agreement will be formed through the Corridor Working Group. This will allow agencies to bring the equipment required for management and monitoring into compatibility and begin to create the framework for fully-shared ICM services.

Each agency is expected to be capable of supporting their currently installed equipment, as well as any new equipment purchased. This support may be accomplished with the help of any supplier or original equipment manufacturer, potentially through standard warranties. This will include any routine maintenance and any hardware failures on a remove/replace basis. Software failures may require supplemental agreements with vendors or integrators, or potentially third-party support.

Agencies will be encouraged to perform cross-training to the other ICM-495 stakeholders through the Corridor Working Group so that all Corridor operators are aware of the capabilities and limitations of the installed equipment.

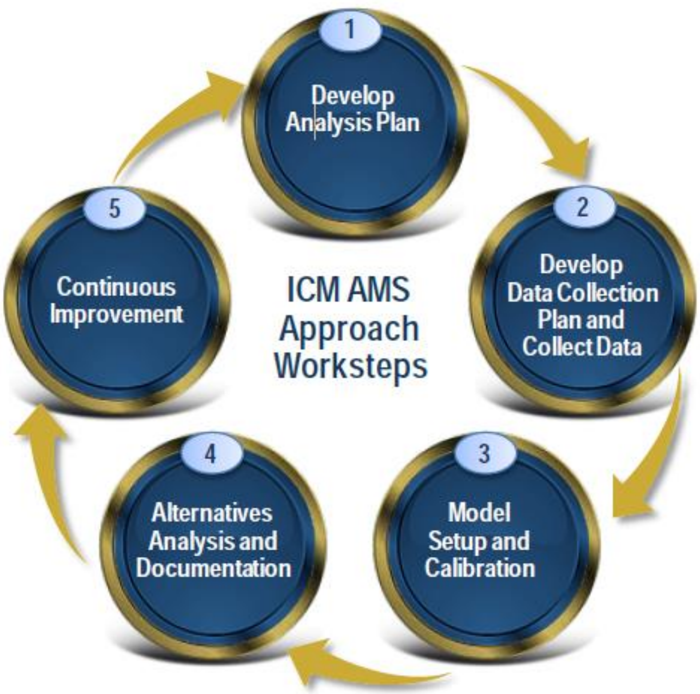
8. ANALYSIS OF IMPROVEMENTS

A detailed plan is proposed to verify concepts provided in the ConOps as part of the next phase in the concept development. The following section provides a summary of the AMS Plan that is developed for this project.

8.1. Analysis, Modeling, and Simulation Plan

There are five major worksteps that need to be considered regarding any AMS tools as part of an ICM system (see Figure 8-1). The figure also highlights the iterative nature of the AMS tool usage in the overall ICM system.

Figure 8-1: ICM AMS Approach Worksteps



Step 1: Analysis Plan: A key element of the ICM AMS work flow is the development of an AMS Analysis Plan. The development of a robust AMS Analysis Plan can bring a variety of benefits to the development of an ICM system and may include the following:

- Identify flaws or technical issues in the ConOps
- Communicate the scope of the project
- Identify project challenges and plan mitigations
- Identify and prioritize resources to meet project objectives
- Better understand existing corridor conditions and deficiencies beyond field observable conditions
- Set expectations of project participants and define roles and responsibilities
- Utilize AMS in an iterative manner, utilizing the design process to refine alternatives
- Document the analysis planning process

An AMS Analysis Plan not only documents decisions on core details required for the development of any AMS tool or process, it also documents the potential ICM events that will need to be analyzed, the resulting strategies that will need to be evaluated for each of those ICM events, any AMS analysis methods or assumptions needed for the evaluation to be completed, and the resulting performance metrics that will be presented from the AMS analysis to illustrate the potential benefits of the envisioned ICM system deployment under that particular ICM event and ICM strategy deployment scenario. An AMS analysis plan should also be considered a living document that evolves through the life of the ICM system from planning, development, deployment, operation, and maintenance.

Step 2: Data Collection: This steps builds on the details in the *Technical Memorandum #1: Corridor Operating Conditions, Inventory, and Needs (COIN)* and further dives into the data needs for operation of the ICM-495 system, including additional data sources that would need to be obtained or sourced to support the level of analysis required. This step define the data elements needed for the AMS tool to be successful and the collection of that data.

Additional data collection may need to be conducted, or additional ITS infrastructure may need to be installed to support ongoing data needs. This would build off of the recommendations of the ConOps and move forward into a more detailed assessment of exactly what data is needed to support the AMS analysis.

Step 3: Model Development: The third step in the AMS work flow is to develop the actual AMS model according to the developed AMS plan and the established validation criteria. As additional issues and changes to the AMS tool are discovered through this process, the AMS plan will need to be updated and further detailed to include additional assumptions or inputs in order to use the AMS model. This step is critical to ensure that the modeling results can be considered reasonable. Models that are not based on observed conditions and that cannot replicate observed field conditions cannot reasonably be expected to deliver accurate predictions under different potential future deployment of ICM strategies.

Step 4: Alternative Analysis: In the fourth step, the analysis is executed with the AMS tools for the prescribed combinations of ICM events and potential ICM strategy deployments (the alternatives). All analyses for the ICM strategy deployment conditions (the 'With ICM' scenarios) are compared against the same ICM event analyzed under a 'Do-Nothing' (or 'Without ICM') analysis for the exact same ICM event. This comparison shows where benefits of the ICM system can be realized, and reveal the potential for any unintended dis-benefits from the deployed strategies.

A further extension of this effort is to monetize and combine the individual benefits seen under each analyzed ICM events / ICM strategy deployment combination by weighting the benefits seen under that scenario by the probability of that scenario occurring on any given day out of an entire calendar year. Those combined net ICM benefits can then be compared against an annualized lifecycle cost of the ICM system deployment and operations and maintenance costs to produce a benefit-cost ratio to assess the effectiveness of the ICM System.

Step 5: Continuous Improvement: The fifth step is the continued maintenance of the AMS model based on the lessons learned from the previous steps and recurring implementation of updates to accommodate any further expansion or modification to the ICM system. The AMS model must be considered for planned maintenance through updating and refreshing the model to better reflect observed field conditions under general conditions (roadway improvements, land use changes, traffic demand changes) and under specific ICM events (driver responses to the event or deployment strategies and the resulting transportation system performance).

8.1.1. AMS Model

The ICM-495 Concept will be analyzed using an offline AMS model. The offline model uses an expert rules-based DSS, where the ICM response strategies are developed or selected using heuristics or business rules and the AMS model is run to support real-time operations management during ICM events. The AMS model runs multiple scenarios for historical or hypothetical ICM events to help plan which improve the response plans and to help improve the rules-based DSS this decides on ICM actions during an actual ICM event. Using an offline model removes a primary concern that the Corridor's complexity and geographic scale would prevent a full corridor model from being run in a sufficient timeframe to be used as a near real-time support evaluation model. With the model run time constraint removed, the model can be developed to include as much of the corridor and alternative routes as is desired to support the evaluation of the proposed ICM Concept.

An offline model also alleviates the potential for reduction in the amount of real-time sensor installations that would be needed to monitor the system performance of the corridor. While real-time sensors are still needed to assess the ongoing operations of the corridor in a rules-based DSS ICM, the real time data can concentrate more on speed or travel time performance data that is readily available through TRANSCOM and NYC DOT's JTMC. However, in order to support near real-time modeling of current traffic conditions in an AMS model, the dynamic adjustment of travel demands to represent the current field observed conditions requires sufficient real-time volume monitoring capabilities. These volume monitoring capabilities, while present to some degree in the corridor, are currently much less available than operations level data (speed and travel time) and, in general, are much more difficult and expensive to deploy.

The offline model will be used to evaluate a wide variety of different operational conditions, including varying demand conditions, under special event demand conditions, under crash scenarios, under lane closure scenarios, and many others. The variety of different ICM responses will be modeled in a non-real time manner, and the resulting evaluations of the tested ICM strategies will be used to help refine and improve the library of rules that are used to select the different ICM strategies to deploy under different ICM events. Additionally, recorded system performance of the ICM-495 Corridor during actual ICM events that occurred and were responded to will be simulated after the fact. This will allow the ICM operators to review and potentially improve on the ICM strategies deployed for that particular type of ICM event.

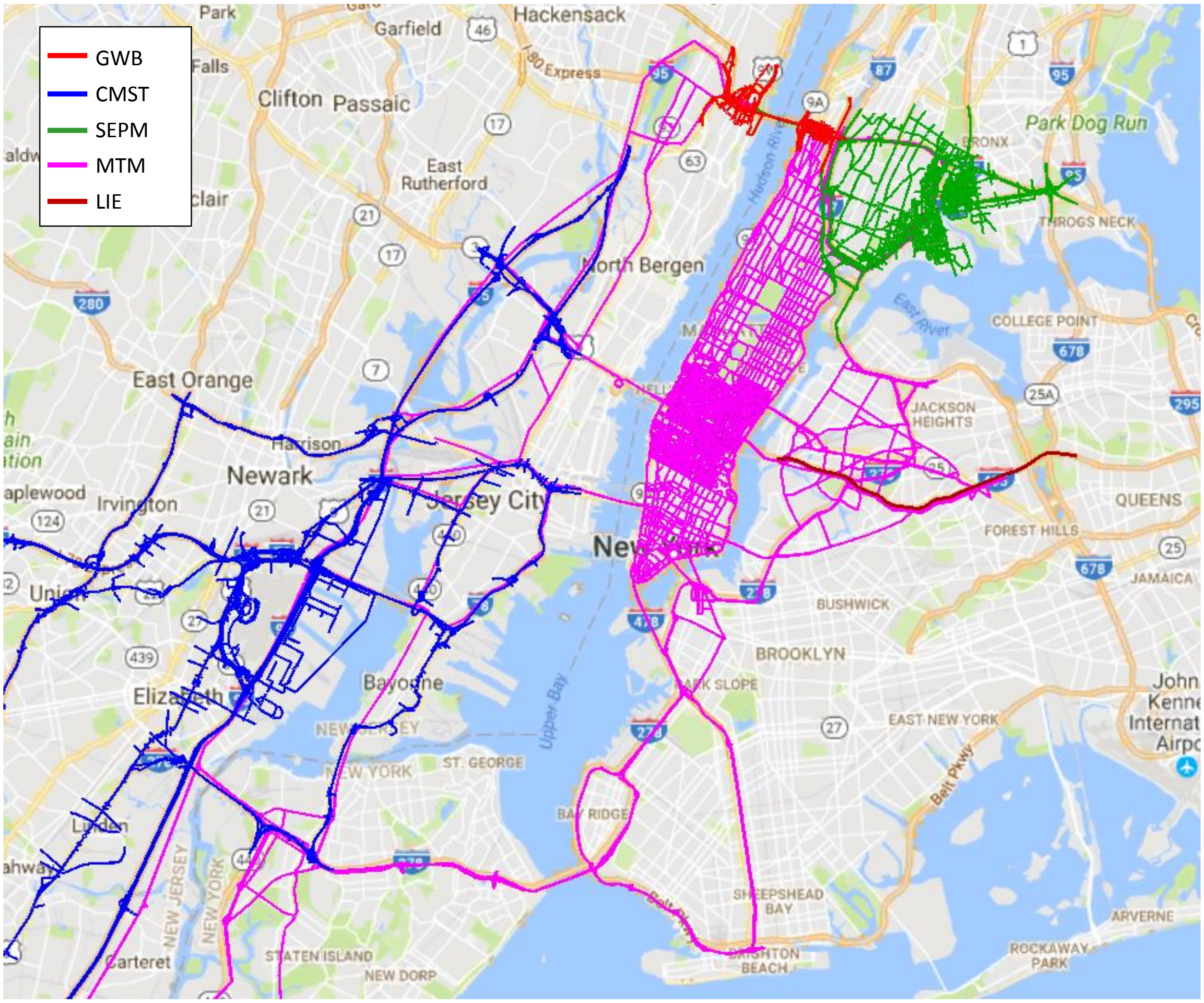
8.1.2. AMS Modeling Platform

The ICM-495 Concept will create a Dynamic Traffic Assignment (DTA) based modeling tool with hybrid (meso/micro) fidelity simulation in the Aimsun modeling platform. Aimsun has a strong track record of being used for DTA modeling in the NYC region. Figure 8-2 highlights the existing geographic coverages of various Aimsun models completed in recent years in the ICM-495 Study Corridor, including the following models produced by different agencies:

- PANYNJ's George Washington Bridge Model Combined NY-NJ Model (GWB)
- NYC DOT's Manhattan Traffic Model (MTM)

- NYC DOT's Sheridan Expressway Planning Model (SEPM)
- PANYNJ's Customized Modeling and Simulation Tool for Evacuation and Recovery (CMST)
- NYSDOT's LIE HOV Contra-flow Lane Model

Figure 8-2: Existing Aimsun Simulation Models in the ICM-495 Corridor



Source of Background Image: Google Maps

In addition to the above models, three other new DTA model development efforts are ongoing or will be started soon.

- PANYNJ's Diversion Model: A new Aimsun model to analyze potential impacts of traffic diversions across the Hudson River from lane or road closure during construction periods is currently under development. In that effort, much of the above models will be merged and updated into a single model, as well as the development of off-hours (overnight) travel patterns.
- NYC DOT's CV Pilot Deployment Study: As part of this ongoing Study, the Aimsun-based MTM is planned to be updated to help support various mobility impact analysis of the CV Pilot Study, including evaluating the impacts of crash events on the study's roadways.
- NYC DOT's Brooklyn-Queens Expressway: A new Aimsun model will be developed to support study of the various lane closure and construction impacts related to the rehabilitation of structures on portions of the Brooklyn-Queens Expressway.

Depending on the various schedules for development of the various projects, all or some of these efforts can be leveraged and combined into a single ICM-495 offline evaluation model. While this will provide much of the network components of the required AMS tool, these elements will need to be reviewed, likely updated to current geometric conditions, and possibly expanded to ensure full coverage of the entire ICM-495 corridor and the identified key alternative roadways.

Additionally, the O-D travel demand patterns will need to be redeveloped, considering the changing geography of the models, and likely expanded beyond the morning and evening peak periods into the midday and overnight periods to support the full complement of the hours of operation of the ICM-495 system. The ICM-495 AMS model will include a linkage to the overall regional travel demand patterns as modeled by NYMTC's Best Practices Model (NYBPM).

Mode split or mode shift estimates and the larger regional impacts will be analyzed through use of NYBPM. While the NYBPM can be limited in assessing the non-recurring short term nature of many of the ICM events, it can still be leveraged to assess the potential of the overall changes during long term events on the regional travel patterns and help assess which trips would either remain in the ICM-495 corridor and which trips may divert outside of the corridor completely. Finally, while the current highway assignment component in the NYBPM consist of static-assignment of the vehicle trips, the activity based model (ABM) trip modeling can still be utilized to provide useful insights into the nature of the trips using the ICM-495 Corridor.

8.2. Limitations

The DTA AMS model would be capable of evaluating many of the ICM strategies, either directly or indirectly. Table 8-1 presents the proposed ICM strategies for the ICM-495 corridor with an initial assessment of the capabilities of the proposed AMS model's ability to model the ICM action. Each assessment is rated as being well suited (green ball), conditionally suited (yellow ball), or poorly suited (red ball) for evaluation in the AMS model.

Some elements, such as those related to bottleneck mitigation and active traffic management are very well suited and can be modeled directly within the proposed simulation framework. For example, the modeling of hard shoulder running could be directly simulated within the AMS model. Such actions are common place in DTA evaluation models, and can either be modeled through built-in functions in the modeling platform, or through the development of advanced programming interfaces (APIs) to expand the capabilities of the modeling platform.

Table 8-1. AMS Evaluation Capabilities for Potential ICM Actions

ID	ICM Strategy	AMS Evaluation Capabilities
Approach A. Improved Corridor Monitoring		
a.1	Enhance volume detection in corridor	● (red)
a.2	Improve access to arterial speed detection in corridor	● (red)
a.3	Improve incident/event reporting especially on arterials	● (red)
a.4	Add RWIS sensors in the corridor with grip sensors	● (red)

ID	ICM Strategy	AMS Evaluation Capabilities
a.5	Install truck height sensors and over height warning systems at key locations upstream from tunnels	🔴
Approach B. Enhanced Traveler Information		
b.1	Create freight-specific portal of information/messaging on 511	🟡
b.2	Use proactive messaging of weather conditions on DMS	🟡
b.3	Comparative travel time between key crossings at decision points	🟢
Approach C. Corridor-Based Demand Management		
c.1	Expand and enhance a corridor-focused employer-based telework program	🟡
c.2	Develop an emergency-oriented playbook for TDM to support operations during adverse weather	🟡
Approach D. Coordinated Incident and Event Management		
d.1	Arterial DMS to support route choice	🟢
d.2	Improve towing contracts/capabilities for quick-response especially for heavy-vehicle wrecks	🔴
d.3	Expand HELP program functionality	🔴
Approach E. Transit Bus Technology Improvements		
e.1	Improve Bus Time application to incorporate impact of diversions	🟡
e.2	Explore unified fare payment strategy	🟡
Approach F. Work Zone Coordination		
f.1	Standardized Work Zone traffic management plan impact assessment and approval	🟢
f.2	Work zones traffic management plan compliance monitoring	🔴
Approach G. Active Traffic Management		
g.1	Adaptive ramp metering	🟢
g.2	Contraflow lanes	🟢
g.3	Dynamic toll pricing	🟢
g.4	Open road tolling	🟢
g.5	Speed harmonization	🟢
g.6	Transit signal priority (TSP)	🟢
g.7	Arterial parking restrictions	🟢
g.8	Dynamic merge control	🟢
g.9	Hard shoulder running	🟢
g.10	Dynamic reversible lane	🟢
g.11	Queue warning system	🟢

AMS Evaluation Capabilities Legend:

🔴 = Not Capable / Poorly Suited 🟡 = Conditionally Suited 🟢 = Well Suited

On the other hand, some strategies that are poorly suited for evaluation include those that cannot be directly simulated, but their impacts may still be able to be included indirectly in the model framework through assumptions of their impacts. An example of this could include the installation of over height truck sensors at low clearance locations. The actual sensors and response of a truck to take another route is likely not going to be meaningfully simulated in the model. However, the model could still be used to simulate a low clearance bridge strike crash and the overall impacts of that crash could be assessed by comparing the operations of the crash scenario to another simulation of a no-crash scenario. The resulting annual benefits of the warning system could then be assessed by multiplying the impacts of a single typical event's impact by the estimated number of bridge strike events that would be prevented each year.

In between the well suited and poorly suited strategies are strategies that can be considered conditionally suited for evaluation in the AMS model. These are strategies or actions that may be able to be partially simulated in the AMS model, but significant assumptions are still needed in order to estimate the impacts. For example, in considering improving the Bus Time application to incorporate impact of diversions, the improvement to Bus Time themselves cannot be simulated, however the resulting changes in bus routing and diversion impact analysis can be directly simulated and an evaluation of the impacts on bus passenger travel delays or the adherence to schedule of the bus routes could be directly evaluated with the AMS model.

At the onset of the next stage of development of the AMS model in order to support the future development of the proposed ICM-495 Operational Concept, these details and capabilities will need to be reviewed in more detail, and more assumptions will need to be established and agreed upon by the appropriate agencies and stakeholders. It is important to consider such details carefully and include them in the AMS Analysis Plan to ensure that they are fully thought through, documented, and agreed to by all stakeholders before the analysis is actually undertaken.

APPENDIX A: DESCRIPTION TABLES OF DESIRED CHANGES

Implementing ICM along the I-495 Corridor requires a framework that takes into account legacy systems, existing ITS architectures, and information sharing resources that are functioning at a high-degree of capability today. Proposed changes fall along the following four dimensions of change (which are described in further detail in the sections that follow).

Page	Dimension	Description
113	Policy and Institutional Changes to Support ICM	Changes to language, agreements, and performance standards and established structure to ensure ICM is embraced by all operating agencies in the Corridor.
114	Operational Framework Changes to Support ICM	Changes to the way operating agencies manage their systems and services to better support ICM.
115	Changes to Corridor Management and Decision Support Tools for ICM	Identification of better data to support ICM.
116	Agency Tactics to Support ICM	Changes to operating agencies response strategies to close any gaps that can hinder an effective ICM-495 Concept.

CHANGES TO POLICY AND INSTITUTIONAL FRAMEWORK

The following section provides additional details for the ICM-495 ConOps Document, *Section 4.3.1 - Changes to Policy and Institutional Framework.*

Table A-2. Policy and Institutional Changes to Support ICM

ICM Actions	Rationale
Technology Procurement	
Maintenance and Update of Regional ITS Architecture	ITS Architecture defines the current and future vision for interoperability and data exchanges in the region.
Clarify regional implementation of ITS standards	With the multitude of operating agencies and systems, it is important that a clear understanding of ITS standards is present across the corridor agencies to enable effective procurement and systems development
Shared technical procurement language between operating agencies on interfaces	Related to the previous item, harmonization of procurement language especially around critical interfaces, standards and systems allows agencies to procure systems for ICM and other operations effectively.
Establishment of ICM Performance Based Procurement Framework to support federal funding for projects that can be linked to ICM	Using the performance standards set up for the corridor, procurement should be tied and prioritized to the measures identified.
Operations Policy	
Establishment of agreed upon ICM policy statement between operating entities	A signed ICM policy statement identifying roles and responsibilities, overall objectives and core performance measures (and targets) provides the institutional buy-in from the different operating agencies in the corridor
Continued development to freight policy that either enables management of freight traffic on the system, supports the increased efficiency of freight traffic, or shifts freight traffic to off-peak times.	Managing freight demand depends on regional policy. With limitations in truck routes, challenges with delivery locations times, policy-level support is needed to adequately support freight demand in the corridor
Include ICM programs in RTPs	Including ICM in planning documents provides official acknowledgement of the integration of ICM into the planning process
Planning and Performance Measurement	

Table A-2. Policy and Institutional Changes to Support ICM

ICM Actions	Rationale
Development and reporting of common corridor-specific performance measures	A core set of performance measures for the corridor, agreed upon by operating agencies allow for continual improvements to be targeted in the corridor.
Prioritizing programming of ICM projects	Support for implementing the projects and ideas defined in the Concept of Operations is needed to bring ICM to fruition. This may include agency-level prioritization of the projects/initiatives that support ICM, and regional projects championed by all that are undertaken by agencies such as TRANSCOM
Analysis, Modeling and Simulation framework for corridor management	Development of an AMS framework allows for new tactics and strategies to be tested and verified before implementation in the field
Workforce Training	
Peer to peer transportation operator forum that supports greater engagement of day to day operators of the various management centers	Improved relationships between operators fostered through operators forums will allow for improved coordination between agencies during times of high-stress (like incidents and emergencies)
Conduct SHRP2 Train the Trainer Engagement with First Responders	Improving incident clearance times while maintaining traveler and responder safety is critical. Included in this action are continued emphasis on TIM performance measurement.
Culture and Institutions	
Communication of corridor performance with external stakeholders	Establishing a communication method to showcase operational improvements in the corridor will build support for the program
Establishment of ICM operating governance structure (ICM Operational Rep at each agency) and regular (quarterly) meetings to review ICM events post action), review ICM reports against performance measures and develop ICM Playbook	An established structure for governance will create a forum for corridor-focused discussions including system improvements and after action reviews
Data Management	
Identification of data sources responsibility	ICM depends on data availability from different agencies. Agreement on maintaining and supporting data sources is essential as a policy statement to ensure that critical data dependencies are maintained during operations. This includes understanding of enhanced service level agreements and prioritization of repairs on critical sensors, data systems, cameras when outages occur

Changes to Operational Framework

The following section provides additional details for the ICM-495 ConOps Document, *Section 4.3.2 - Changes to Operational Framework.*

Table A-3. Operational Framework Changes to Support ICM

ICM Actions	Rationale
Harmonization of Operational Protocols ***(Maps to User Need #2)***	
Development of common incident reporting protocols (location reporting, status reporting, severity, impact reporting)	Differences in how and when incidents are reported create challenges in developing joint operational responses. While the tools used are largely the same, processes and procedures around incident reporting need to be harmonized across the different agencies
Development of common oversize/overweight restriction information	With OS/OW issues prominent in the corridor, slight differences in how agencies report restriction information can have big impacts.
Make consistent the use/method of OpenReach (or OpenReach-like) functionality including	Differences in how and when incidents are reported create challenges in developing joint operational responses. While the tools used are

Table A-3. Operational Framework Changes to Support ICM

ICM Actions	Rationale
possible integration of all ATIS/ATMS used by Agencies to record and manage incidents.	largely the same, processes and procedures around incident reporting need to be harmonized across the different agencies
Transit-Highway Cooperation Improvements ***(Maps to User Need #1)***	
Create direct operational linkage between bus operations center and JTMC	Bus operations are significantly impacted by corridor conditions but they also represent a vital set of "eyes" on the road who can provide updates on field conditions. Sharing the information between the JTMC and the Bus Operations center can be critical in enabling a quicker response to events
Share real-time operational data map from TRANSCOM to Bus Operations	Bus operations are significantly impacted by corridor conditions but they also represent a vital set of "eyes" on the road who can provide updates on field conditions. Sharing the information between the JTMC and the Bus Operations center can be critical in enabling a quicker response to events
Identification of ICM Event Definition and Reporting ***(Maps to User Need #2, 3, 4)***	
Create a definition and criteria of an ICM-Event	Not all events require coordination between agencies. Similarly, very large events are handled effectively through the emergency management process. However, defining a sub-set of events that are likely to have involvement with multiple agencies in the corridor helps focus the ICM on events where a coordinated response currently does not exist
Develop ICM Playbook framework and response plan process for an ICM-Event. The playbook would not be a one-size-fits-all set of steps; instead it should define ICM-level events and provide tiered responses, depending on event type/scale. Responses would identify recommended actions and their actors and where responses align with protocols already in place	For such events, a joint response process that allow for agreed upon corridor responses is critical
Develop after action review process for ICM-Event	For ICM events, an after action review process is essential especially in the early years are processed and responses start to mature.
Develop ICM Reports	To support after action reviews, there needs to be a capability to quickly summarize the impacts, the response effectiveness in terms of agreed upon performance measures

CHANGES IN CORRIDOR MANAGEMENT AND DECISION SUPPORT TOOLS

The following section provides additional details for the ICM-495 ConOps Document, *Section 4.3.3 – Changes in Corridor Management and Decision Support Tools.*

Table A-4. Changes to Corridor Management and Decision Support Tools for ICM

ICM Actions	Rationale
C2C Real-Time Operational Information Sharing ***(Maps to User Need #1)***	
Share TRANSCOM Real-Time Operational data with NYC Bus Operations	Improve corridor wide information through co-ordination with modes
Incorporation of transportation-specific NYPD Alerts with JTMC Operations	Leverage ongoing event notification services that are used by first responders to improve situational awareness of the corridor
Field-to-Center Incident Reporting ***(Maps to User Need #4)***	

Table A-4. Changes to Corridor Management and Decision Support Tools for ICM

ICM Actions	Rationale
Improve field to center information exchange using tools like IIMS in the corridor	Facilitate improvement in incident response through the mechanism of improved information exchange
Corridor Impact Assessment and Predictive Capabilities ***(Maps to User Need #3)***	
Create an impact predictor tool for ICM-Events to predict likely duration based on historical data	Facilitate agency requests for greater understanding of incident clearance times
Real-Time Performance Reporting ***(Maps to User Need #1, 4)***	
Provide real-time dashboard of corridor performance	Facilitate unified corridor-wide performance awareness
Provide real-time dashboard of key alternatives	Facilitate unified corridor demand management visualization

CHANGES TO AGENCY TACTICS

The following section provides additional details for the ICM-495 ConOps Document, *Section 4.3.4 – Changes to Agency Tactics.*

Table A-5. Agency Tactics to Support ICM

ICM Actions	Agencies	Rationale
Enhance Situational Awareness ***(Maps to User Need # 1, 3, 4, 7)***		
Enhance volume detection capabilities or deploy new capabilities in corridor, including speed and travel times and differentiating between HOV and general use lanes	NYCDOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T, MTA B&T	Cover gaps in detection necessary for situational awareness
Enhance access to arterial speed detection or deploy new detection capabilities in corridor	NYCDOT, NJDOT, NYSDOT	Cover gaps in detection necessary for situational awareness
Improve incident/event reporting especially on arterials	NYCDOT, NJDOT, NYSDOT, TRANSCOM	Address current lack of sufficient incident reporting on arterials
Add RWIS sensors in the corridor with grip sensors	NYCDOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T, MTA B&T	Cover gaps in detection necessary for situational awareness
Work zone coordination improvements	NYCDOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T, MTA B&T	Address current lack of sufficient coordination between agencies with respect to planned events
Install truck height sensors and over height warning systems at key locations upstream from tunnels	PANYNJ TB&T; MTA B&T/NYSDOT	Address bottlenecks caused by tunnel height restrictions
Improve Corridor-Level Joint Incident Response ***(Maps to User Need #4, 5, 6)***		
Communication with bus operations about route adjustments	MTA,PANYNJ, NJ Transit, with NYCDOT, NYSDOT, NJDOT, TRANSCOM acting as info source to inform transit agencies	Integrate bus operations into Corridor Management
Improve incident site management	NYCDOT, NYSDOT,MTA, PANYNJ, NJDOT, NJ Transit, NJTA	Address lack of protocols for effective on-site management of incidents
Arterial DMS to support route choice	NYCDOT, NJDOT, NYSDOT, TRANSCOM	Address current insufficiency of equipment on arterials

Table A-5. Agency Tactics to Support ICM

ICM Actions	Agencies	Rationale
Improve towing contracts/capabilities for quick-response especially for heavy-vehicle wrecks	NYCDOT, NJDOT, NYSDOT, NJTA	To enable improvement in the co-ordination of response and incident response times in the corridor.
Expand HELP program	NYSDOT	To enable improvement in the co-ordination of response and incident response times in the corridor.
Conduct after-action "hot washes" to review incidents, responses, and outcomes on the corridor	All	TO provide feedback to refine incident response strategies
Short-Term and Long-Term Demand Management ***(Maps to User Need #4, 5, 7, 8, 10)***		
Expand and enhance a corridor-focused employer-based telework program	NYCDOT, NYSDOT,MTA, PANYNJ, NJDOT, NJ Transit, NJTA	As part of active pursuit of demand management strategies in the corridor.
Engage Waze about partnering on event/incident notification on corridors (?) by providing Waze access to a data feed from TRANSCOM	NYCDOT, NYSDOT, NJDOT, NJTA, TRANSCOM	Engagement with third party providers for enhanced situational awareness
Traffic-responsive (as opposed to TOD) Managed lanes operations	NYSDOT, NYCDOT, MTA B&T, NJDOT, PANYNJ, TRANSCOM	Ensure pro-active real-time benefits through traffic responsive operations
Variable tolls and transit fares according to demand or expected peaks	NJDOT, MTA B&T, PANYNJ, NJT, MTA	Balance demand across modes and times of day
Comparative travel time between key crossings at decision points	NYCDOT, NYSDOT,MTA, PANYNJ, NJDOT, NJ Transit, NJTA, TRANSCOM	Provision of reliable decision making ability to travelers at key decision points
Bottleneck Mitigation and Active Traffic Management ***(Maps to User Need #5, 6, 7)***		
Temporary hard shoulder running for transit vehicles	NJTA, NYCDOT, NYSDOT, NJDOT	Used to provide additional capacity during short term demand surges
Dynamic junction control at key interchanges	NYCDOT	
Expand Transit signal priority along key arterials on the corridor (which?)	NYCDOT, NJDOT, NYSDOT	Enable and prioritize transit oriented strategies along the corridor
Improve arterial operations Manhattan side of QMT (westbound) to account for ORT implementation	NYCDOT	Strategy to enable key bottleneck management
Real-time arterial route-guidance in mid-town for access to LT	NYCDOT, MTA B&T, PANYNJ	Strategy to enable key bottleneck management
Speed harmonization leading to QMT in light of ORT	NYCDOT, NYSDOT, TRANSCOM	Strategy to enable key bottleneck management
Traveler Information ***(Maps to User Need #2, 5, 8, 9)***		
Create freight-specific portal of information/messaging on 511	NYCDOT, NYSDOT,MTA, PANYNJ, NJDOT, NJ Transit, NJTA, TRANSCOM	Enhance freight information in the corridor
Use proactive messaging of weather conditions on DMS	NYCDOT, NYSDOT, PANYNJ, NJDOT, NJ Transit, NJTA, TRANSCOM	Enhance traveler information dissemination for improved corridor management
Improve Bus Time to incorporate impact of diversions	MTA	Enhance multi-modal co-ordination during planned/unplanned events

Table A-5. Agency Tactics to Support ICM

ICM Actions	Agencies	Rationale
Enhance public transit information including routing information that crosses agency boundaries	MTA,PANYNJ, NJ Transit, TRANSCOM	Enhance multi-modal co-ordination during planned/unplanned events
Greater integration between payment systems for transit modes and roadways	MTA, NJT, PANYNJ, NYTA, NJTA	Enhance traveler ability to change between modes and improve travel time and reliability
Leverage the 511NY Rideshare TDM program to provide tailor information on modal options, emergency/event transportation updates, etc. directly to employers, major destinations, and neighborhoods	NYSDOT	Enhance traveler ability to change between modes and improve travel time and reliability
Event Management and Construction Coordination ***(Maps to User Need #2, 3, 8)***		
Add regular events (e.g., UN Week) into ICM playbook	NYCDOT, NYSDOT,MTA, PANYNJ, NJDOT, NJ Transit, NJTA, TRANSCOM	Enhance corridor wide decision making for incidents
Create in-agency task forces to plan, operate, and assess responses to planned events	NYCDOT, NYSDOT,MTA, PANYNJ, NJDOT, NJ Transit, NJTA, TRANSCOM	Enhance multi-modal co-ordination during planned/unplanned events
Standardized Construction Works traffic management plan impact assessment and approval	NYCDOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T	Cover existing lack of agency coordination for planned events
Construction Works traffic management plan compliance monitoring	NYCDOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T	Ensure pro-active real-time benefits through traffic responsive operations
Improve communications to motorists during roadway construction	NYCDOT, NYSDOT, NJDOT, NJTA, PANYNJ TB&T, MTA B&T, TRANSCOM	Provision of reliable decision making ability to travelers at key decision points

APPENDIX B: PERFORMANCE MEASURES

ICM-495 ConOps *Section 5.5: Data and Performance Characteristics* discusses the performance measures and evaluation targets identified that assess operational and management processes through the project's timeframes and geographic characteristics. They take into account that regional agencies collect different types of data, use different protocols, and measure performance in different ways. The performance measures are defined by the following three categories:

- Dynamic Management Performance Measures
- Short-term Management Performance Measures
- Strategic Management Performance Measures

Dynamic Management Performance Measures

Table B-6. Dynamic Management Performance Measures

Objective	Performance Measure	Data Required	Possible Data Source	Geography/Unit
Mobility				
Increase the throughput efficiency along the corridor.	Person miles traveled (PMT).	Vehicle volume by segment, mode, time of day, and lane (if possible); average vehicle occupancy; and segment length.	Installed sensors or video cameras, and regional model's occupancies.	Corridor segments, accounting for entrances, exits, and installed instrumentation.
Impact on average speed on corridor and arterials.	Travel speed (mph).	Speed and traffic volumes for freeways and arterials, by segment, mode, time of day and lane (if possible).	Speed sensors, probe vehicles, private data vendors.	Corridor segments, accounting for entrances, exits, and installed instrumentation.
Control for lane closures and operation strategies.	Time of lane closures, reversible lanes, and operational strategies (%).	Timeframes for lane closures, reversible lanes, and other strategies implemented.	Regional transportation agencies.	Corridor lane segments, accounting for lane closures, reversible lanes, and other strategies implemented.
Effect of HOV lanes performance.	HOV lane average vehicle occupancy (%).	Vehicular volume at HOV lanes and general purpose lanes.	Installed sensors or video cameras.	Corridor segments with HOV lanes.
Reliability				
Travel times on selected origins and destinations.	Travel time (minutes) between selected origin and destinations for peak and non-peak hours.	Travel times for peak and non-peak periods, accounting for different mode choices.	Speed sensors, probe vehicles, private data vendors.	Selected O-3 trips along corridor.
Effect on travel times on user during peak hours.	Travel time index (%) between selected origin and destinations for peak and non-peak hours.	Ratio of peak period travel time compared with 95^{th} percentile of fastest travel times from previous data.	Speed sensors, probe vehicles, private data vendors.	Selected O-D trips along corridor.
Effect on public transportation reliability on corridor.	On-time performance (%).	Ratio of on-time arrivals versus scheduled arrivals at selected stops.	AVL, on-board equipment, transit agencies.	Selected bus stops and services.

Objective	Performance Measure	Data Required	Possible Data Source	Geography/Unit
Effect on public transportation scheduled performance.	Public transportation wait assessment (%)	The percentage of headways no more than a specified amount longer than scheduled.	AVL, on-board equipment, transit agencies.	Selected bus stops and services.
Effect on travel delay on recurrent bottlenecks.	Person hours of delay (hours) at peak and off-peak periods, on selected bottlenecks.	Traffic volume, average speed, and average vehicle occupancy.	Installed sensors or video cameras, speed sensors, probe vehicles, private data vendors, regional model's occupancies.	Recurrent bottlenecks along the corridor.
Incident Management				
Measure the response time to incidents reported on corridor.	Response time to incident reported (freeway and arterials) (minutes).	Time taken to arrive at incident event.	From incident response operational procedures.	Individual incident events, classifying events by type (fatal, injury, property damage only [PDO]), location, time, and mode.
Measure the clearance time to incidents reported on corridor.	Incident clearance time (freeway and arterials) (minutes).	Time taken to clear incident.	From incident response operational procedures.	Individual incident events, classifying events by type (fatal, injury, PDO), location, time, and mode.

Short-term Performance Measures

Table B-7. Short-Term Performance Measures

Objective	Performance Measure	Data Required	Possible Data Source	Geography/ Unit
Institutional Governance[5]				
Measure ICM performance across agencies, at different project phases.	Rating of project performance across different agencies.	Interviews and surveys.	ICM project management.	Network-wide.
Improve decision-making roles and responsibilities.	Percentage of instances and/or agreements of inter-organizational coordination among stakeholders, compared to the target number of agreements set as goals for different project phases.	Signed agreements (MOU, plans, and other documents).	ICM project management.	Network-wide.
Degree of formalization of pre-defined and approved	Percentage of pre-defined and approved strategies for coordinated action, compared to the target number of strategies set as	Strategy list pre-defined and approved.	ICM project management.	Network-wide.

[5] *Integrated Corridor Management Initiative: Demonstration Phase Evaluation,* *http://ntl.bts.gov/lib/54000/54300/54350/ICM_National_Evaluation_Framework___FHWA-JPO-13-015_.pdf*

Objective	Performance Measure	Data Required	Possible Data Source	Geography/ Unit
coordinated response plans.	goals, at different project phases.			
Improvements in decision- making roles and responsibilities.	Percentage of resolved actions agreed upon by stakeholders during management meetings, compared to total number of actions discussed.	Meeting notes/agenda.	ICM project management.	Network-wide.
ICM Operations				
ICM capabilities for day-to-day event coordination.	Number of inter-agency regular events added to ICM playbook, compared to the goals set by stakeholders at specific project phases.	Strategies added to ICM playbook.	ICM project management.	Network-wide.
ICM capabilities to deal with planned construction.	Number of Construction Works Management Plans integrated to ICM playbook, compared to the goals set by stakeholders at specific project phases.	Strategies added to ICM playbook.	ICM project management.	Network-wide.
Integration of transit services to ICM operations.	Number of transit operations strategies integrated to ICM playbook compared to the goals set by stakeholders at specific project phases.	Strategies added to ICM playbook.	ICM project management.	Network-wide.
Evaluate how incidents are being resolved internally.	After-incident rating across agencies.	Interviews and surveys.	ICM project management.	Network-wide.
Evaluate corridor's dashboard operation.	ICM-495 dashboard performance and data quality assessment.	Dashboard update frequency and quality of data used.	ICM project management.	Network-wide.
Evaluate ITS equipment investments and operation	ITS equipment deployment and performance.	Field data.	ICM project management.	Network-wide.
Transportation Demand Management				
Measure effectiveness of tele-work program.	Number of employees enrolled and using telework program.	Number of employees of employers located in the corridor who are enrolled in and using the employer's telework program.	Telework program management.	Metropolitan area.
Measure employees using Rideshare services.	Number of employees using 511NY Rideshare[6] and New Jersey's ridesharing services[7,8] on the corridor.	Number of employees added/removed from 511NY Rideshare, NJ TMA programs, and NJTPA Rideshare services.	511NY Rideshare program, NJ TMA programs, NJTPA.	Network-wide.

[6] http://511nyrideshare.org/

[7] http://www.state.nj.us/transportation/commuter/rideshare/tma.shtm

[8] http://www.njtpa.org/home.aspx

Objective	Performance Measure	Data Required	Possible Data Source	Geography/ Unit
Measure ridesharing usage in the corridor.	Ridesharing ridership along the corridor.	Ridesharing services (e.g. vanpools, UberPool/ LyftLine/Via/etc, shared taxis) monthly ridership on corridor.	511NY Rideshare, NJ TMA, NJTPA TDM program; TNCs; taxi-sharing services.	Network-wide.
Measure bikeshare usage at bikeshare stations along corridor (particularly in Long Island City).	Percent of Citibike bikes going from LIC stations to Midtown Manhattan stations in the AM, and the reverse in the PM period.	Origin-destination data from selected bike stations.	Citibike data.	Selected bikeshare stations.
Fluctuations in train ridership during ICM events.	Comparison of train ridership between normal conditions and ICM events.	Train ridership – during ICM events and normal conditions.	Region's train service operators.	Network-wide.
Fluctuations in bus ridership during ICM events.	Comparison of bus ridership between normal conditions and ICM events.	Bus ridership – during ICM and normal conditions.	Region's bus service operators.	Network-wide.
Match Me in Emergency Participants.	Number of 'Match Me in Emergency' participants in the corridor.	Number of 'Match Me in Emergency' Participants from 511NY Rideshare database.	511NY Rideshare database.	Network-wide.

Strategic Management Performance Measures

Table B-8. Strategic Management Performance Measures

Objective	Performance Measure	Data Required	Possible Data Source	Geography/ Unit
Safety				
Effect of the ICM on incident management.	Yearly rate of incidents cleared within incident clearance target goal.	Percentage of incidents cleared within target, compared with total number of incidents responded.	Incident response management.	Network-wide.
Impact of the ICM on traffic safety.	Yearly crash (injury/fatality/PDO) rate on freeway and arterials.	Number of crashes (fatalities, injuries, and property damage only) on corridor freeway and arterials.	Incident response, crash databases.	Network-wide.
Mobility				
Evaluate general effect on congestion.	Number of severely congested corridor segments. (% of entire corridor and type of lane).	Travel speed by segment.	Speed sensors, video cameras, probe vehicles, private data vendors, and aerial imagery.	Corridor segments with data available.
Effect on the corridor's travel time reliability, and the impact on users.	Buffer Time Index[9] (% of extra time needed to complete a trip on	Travel time across selected origins and destinations,	Speed sensors, probe vehicles,	Selected origin and

[9] *FHWA Travel Time Reliability Guidelines,* http://ops.fhwa.dot.gov/publications/tt_reliability/brochure/ttr_brochure.pdf

Objective	Performance Measure	Data Required	Possible Data Source	Geography/ Unit
	time, 95 percent of the time) for different days and time periods.	across different days of the year.	private data vendors.	destination pairs.
Evaluate effect of traveler information to users.	Change in user travel patterns from traveler information system.	Trip route selection for selected origins and destinations with and without information across comparable days and scenarios.	Video cameras, probe vehicles, private data vendors.	Selected origin and destination with traveler information enabled.
Transit				
Impact on transit demand.	Yearly ridership in transit services on corridor and relevant arterials.	Number of transit service riders.	Transit agencies.	Network-wide.
Effect on reliability of transit services.	On-time Performance.	Percentage of on-time arrivals versus scheduled arrivals at selected stops.	AVL, on-board equipment, transit agencies.	Network-wide.
Environment				
Environmental impact on corridor.	Amount of $CO_{2\text{-equ}}$ emitted on corridor per year.	Vehicle miles traveled, speeds and accelerations by segment, and vehicle emission factors.	Volume sensors, speed sensors, EPA tail-pipe emission tests.	Network-wide.
Demand Management				
Evaluate the effect on mode shift from to other modes (carpool and vanpools, transit, telecommute).	Mode split.	Modal use across the corridor.	Yearly mode use survey, US census.	Network-wide.
Project Acceptance				
Evaluate user's perception of the ICM project.	Yearly user level of satisfaction.	Performance ranking across users' perspective of quality of service, traveler experience, strategies' impact, communication strategies.	Survey and interviews. Possible use of social media.	Network-wide.
Evaluate level of satisfaction among internal partners with ICM program.	Yearly partnership level of satisfaction.	Performance ranking across partner's perspective of strategies' overall impact and impact on day-to-day activities.	Survey and interviews.	Network-wide.
Evaluate the project's institutional maturation and acceptance among region's stakeholders.	Yearly stakeholder project acceptance.	Performance ranking among other stakeholder's (MPO, States, private sector) perspective of strategies' overall impact and number of plans and documents integrating ICM-495 strategies. Analysis of incorporation of emergent technology (connected/autonomous vehicles, shared mobility, etc.).	Survey and interviews, relation to local and regional plans.	Network-wide.