Version 1.0

TheConnectedCorridor

A road map for developing and deploying innovative technology across all modes of transportation for the next 20 years.

Final Report

New Jersey's TSM&O Strategic Plan and ITS Architecture

Prepared for

North Jersey Transportation Planning Authority

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Document Control Record

Version	Main Changes	Contributions From	Date
V1.0	Final, incorporating comments on previous draft from multiple stakeholders	S. Dilts, L. Neudorff (CH2M) and S. Caviness (NJTPA)	December 2014

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ATM	active traffic management
CAD	computer-aided dispatch
CMM	capability maturity model
D-RIDE	dynamic ridesharing
DVRPC	Delaware Valley Regional Planning Commission
FHWA	Federal Highway Administration
G-MAP	*Comprehensive Regional Goods Movement Action Program for the New York-New Jersey Metropolitan Region* (as issued by the Port Authority of New York / New Jersey)
HSIP	Highway Safety Improvement Program
I-78	Interstate 78
I-95	Interstate 95
IAC	ITS Architecture Committee
ICM	integrated corridor management
ITS	Intelligent Transportation System
ITSRC	ITS Resource Center
MAP-21	*Moving Ahead for Progress in the 21st Century*
NJDOT	New Jersey Department of Transportation
NJIT	New Jersey Institute of Technology
NJTPA	North Jersey Transportation Planning Authority
NPRM	Notices of Proposed Rulemaking
Plan 2040	*Plan 2040: NJTPA Regional Transportation Plan for Northern New Jersey*
RIMIS	Regional Integrated Multimodal Information Sharing
SJTPO	South Jersey Transportation Planning Organization
SSP	safety service patrol
STIP	state transportation improvement program
Strategic Plan	*The Connected Corridor plan*
TIM	traffic incident management
TIP	transportation improvement program
TOPS-BC	Tools for Operations – Benefits and Costs (from the FHWA document: *Operations Benefit/Cost Analysis desk Reference—Providing Guidance to Practitioners in the Analysis of Benefits and Costs of Management and Operations Projects)*
TRANSCOM	Transportation Operations Coordinating Committee
TSM&O	transportation systems management and operations
TSP	transit signal priority
USDOT	U.S. Department of Transportation
V2I	vehicle-to-infrastructure
V2V	vehicle-to-vehicle

Executive Summary

New Jersey is a densely populated and heavily traveled state. Its transportation system is largely built-out, with little room for physical expansion to gain capacity. Yet a growing population needs better access to jobs, services, and recreational opportunities, and economic development requires efficient transportation. New and innovative technology, commonly known as Intelligent Transportation Systems or ITS, can help meet these needs in a cost-effective manner while improving the way our system operates and enhancing travel for people and goods.

The Federal Highway Administration (FHWA), the New Jersey Department of Transportation (NJDOT), New Jersey's three Metropolitan Planning Organizations (MPOs) and other regional, state, county, and local transportation agencies have made ITS implementation a high priority. They are developing new operational strategies to leverage these smart technologies and bring innovation to our transportation system. They are working together to establish *"The Connected Corridor"* through New Jersey, from New York City to Philadelphia. The goal is to connect our system not only physically, but also virtually with technology for the benefit of millions of daily travelers.

The project has its roots in the Transportation Efficiency Act for the 21st Century (TEA-21), enacted by Congress in 1998. To provide for future interoperability of key transportation services at a national level, the act included provisions mandating that all federally supported investments in technology be coordinated through a National ITS Architecture — a guide for planning and integrating intelligent transportation systems — by April 2005. To address this mandate, the NJTPA, NJDOT and South Jersey Transportation Planning Organization (SJTPO) agreed to combine their efforts in a joint consultant-supported project. They recognized that interagency cooperation would provide economiesof scale and facilitate consistency in final guidelines and standards, known as architectures, serving the state. The project developed two Regional ITS Architectures (one for each MPO area) and a Statewide ITS Architecture. All were under the management of the NJTPA. They were approved by the NJTPA Board in February 2005.

The purpose of this project is to update the 2005 effort and create a document that will support the State of New Jersey's broad strategic vision, consistent with the requirements of federal law. Objectives of The Connected Corridor are to update the 2005 NJ Statewide and Regional Intelligent Transportation Systems (ITS) Architecture and Deployment Plan and serve as a shared vision by transportation agencies of how the various information technology systems work together to provide a safer, more efficient and more effective transportation system for travelers.

Beyond a focus on ITS architecture, The Connected Corridor seeks to realize a broader programmatic approach for planning, developing, and implementing transportation systems management and operations (TSM&O) throughout the state of New Jersey, including connections to and coordination with adjoining states. ITS will be a key element of this TSM&O effort.

In short, The Connected Corridor has established a strategic framework and is a powerful tool to guide and support the development and acceleration of a pipeline of innovative projects that are linked to the region's transportation goals. It also supports planning for operations and enhances the movement of people and freight.

State of the Practice

TSM&O — also often referred to simply as "operations"— is defined in recent federal legislation (Moving Ahead for Progress in the 21st Century [MAP-21]; Federal Highway Administration [FHWA], 2012a) as "integrated strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system." These operational strategies and technologies provide effective and relatively low-cost alternatives to large, capital-intensive improvements, and are generally implemented more quickly.

TSM&O and ITS are not new to New Jersey and the various transportation agencies within the state. For the most part, however, these operational strategies and systems have been developed and deployed as individual, mode-specific projects, often targeting a specific problem or opportunity, with funding decisions made on a case-by-case basis. These individual projects have yielded many benefits, including reduced congestion and improved real-time information to support traveler decisions. Moreover, the transportation and enforcement entities within the state and beyond regularly share information and coordinate their respective operations, particularly for major special events (e.g., the 2014 Super Bowl) and construction activities (e.g., Pulaski Skyway), and during significant incidents and other emergencies (e.g., Superstorm Sandy).

One way to evaluate the state's transportation system is by considering a good/better/best analysis of its level of performance. Based on its ability to meet current needs much of the time, all in all, New Jersey's transportation system is at a "good" (and often "better") level in terms of managing overall performance.

Critically, even with these efforts to coordinate and improve operations, New Jersey has been missing an effective mechanism to help agencies develop, deploy, and manage TSM&O strategies and technologies in an integrated manner while addressing broader needs such as sustainability and community development — that is, "connecting" operations with the transportation planning process as well as with the end users. *The Connected Corridor* seeks to address this need by developing a "road map" to take the "good" level transportation operations New Jersey has today, make it "better," and ultimately the "best" system possible. Making these connections—across all modes of transportation and across all transportation agencies (including local, state, and regional)—is of vital importance to New Jersey's economic future and the quality of life for its citizens and other users of the state's transportation network. **The Connected Corridor** concept— supported by the updated NJ ITS Architecture — serves as New Jersey's TSM&O strategic plan.

The Connected Corridor Goals

- **Mobility—**Enhancing the movement of people and goods by reducing congestion and delays.
- **Reliability—**Improving the efficiency of the surface transportation system through increased consistency of travel times from day to day.
- **Economic Competitiveness—**Improving operations of those transportation network segments that serve freight movements, key economic sectors, and trade markets.
- **Environment and Resiliency—**Reducing emissions and noise from the surface transportation network. A related consideration is to keep the transportation network operational during and immediately following severe weather events and related disruptions.
- **Safety and Incident Management—** Reducing crashes, serious injuries, and fatalities on the surface transportation network. A related consideration is minimizing the impact of crashes on the operation of the transportation network when crashes do occur.
- **Accessibility—**Increasing the integration and connectivity of the transportation system, across and between modes, thereby enhancing the ability of people to reach opportunities and activities, and generally making their trips better.

Vision, Goals and Objectives

To achieve the vision of "a connected transportation system supported by technology," The Connected Corridor must be firmly rooted in the priorities of all regions of the state. As such, The Connected Corridor goals (see above box) were derived from statewide goals, regional goals (as documented in MPO long-range plans) and from priority areas identified in current federal transportation authorization.

The Connected Corridor goals establish a framework for identifying operations objectives. These objectives are described in terms of system performance outcomes (e.g., congestion levels, crash rates, travel times and delays, reliability, and mode choices) that are important to transportation network users. These objectives, and the associated performance measures, provide the basis for establishing a comprehensive and integrated TSM&O program and a pipeline of project-specific innovations, technologies, and operational strategies.

Intelligent Transportation System Architecture Committee

The development of The Connected Corridor concept was guided by the New Jersey **ITS Architecture Committee (IAC),** comprising several key stakeholders as listed in Table ES-1 below. It is envisioned that the IAC will assume ownership of The Connected Corridor, overseeing future updates to the associated documents and collectively guiding the implementation of the concept to ensure optimal collaboration, coordination, and results.

TABLE ES-1
Intelligent Transportation System Architecture Committee Membership

New Jersey Department of Transportation	Delaware Valley Regional Planning Commission
New Jersey Transit	New Jersey State League of Municipalities
New Jersey Turnpike Authority	New Jersey Association of Counties
Federal Highway Administration	New York Metropolitan Transportation Council
Federal Transit Administration	Transportation Management Association Council of New Jersey
Port Authority of New York and New Jersey	Delaware River Joint Toll Bridge Commission
Transportation Operations Coordinating Committee	Rutgers University, New Jersey Institute of Technology, Monmouth University, and Princeton University
North Jersey Transportation Planning Authority	Intelligent Transportation Society of New Jersey
South Jersey Transportation Planning Organization	

FIGURE ES-1
The Connected Corridor Vision and Goals

Strategic Recommendations for The Connected Corridor

A key attribute of The Connected Corridor concept is that of "integration" — defined as "combining or coordinating separate elements so as to provide a harmonious, interrelated whole." In the context of The Connected Corridor, integration of operations and ITS involves three facets — institutional, operational, and technical — as shown in Figure ES-2 below. While these key aspects of integration are addressed separately in terms of recommendations for The Connected Corridor, as summarized below, they are closely related and interdependent.

Institutional Recommendations

Institutional integration is perhaps the most critical attribute for the long term success of The Connected Corridor. This integration involves coordination and collaboration between various departments within a transportation agency and among numerous transportation agencies and jurisdictions within regions, the state, and beyond to support and achieve seamless interoperability of the transportation network.

Achieving institutional integration requires that operations becomes a formal core program with the same emphasis as construction and maintenance activities. In other words, operations must be "mainstreamed" into the planning, scoping, budgeting, and programming processes at the individual agency and regional MPO levels. In addition to these business processes, institutional integration also involves ongoing collaboration — relationships and partnering among levels of state government and with public safety agencies, local governments, MPOs, regional entities, and the private sector.

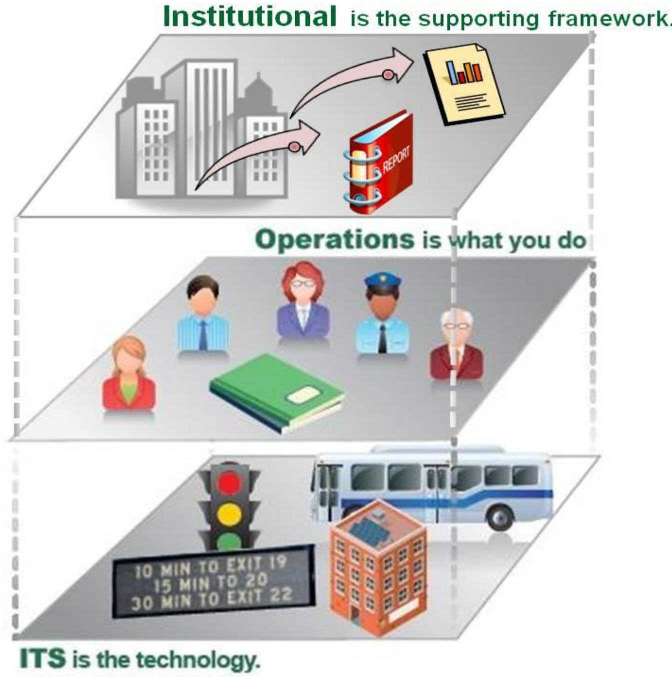

FIGURE ES-2
Integration considerations
(Adopted from the FHWA Planning for Operations Guidance)

Key institutional recommendations for The Connected Corridor are summarized below:

- Formalize the IAC and its ongoing mission to update and maintain The Connected Corridor on a continuing basis, defining the IAC's membership and its responsibilities for moving the concept forward to reality, including updating this Connected Corridor plan and the NJ ITS Architecture on a recurring basis. Other responsibilities of the IAC may include finalizing operations objectives and performance measures as noted below.
- Expand on the current mechanisms for regular coordination and cooperation between transportation agencies, enforcement, MPOs, and other entities (e.g., construction coordination, incident management, and special event management support as provided by TRANSCOM and Delaware Valley Regional Planning Commission). This includes developing and executing formal interagency agreements in support of multimodal operations strategies, and defining the respective agency roles and responsibilities for a variety of operational scenarios.
- Continue ongoing activities to formally adopt the "objectives-driven, performance-based approach to metropolitan planning" as recommended by FHWA (and shown in Figure ES-3) as a means to meet federal transportation planning requirements for the inclusion of "operational and management strategies to improve the performance of existing transportation facilities."
- Finalize outcome-based operations objectives (as part of the objectives-driven, performance-based planning approach shown in Figure ES-3), which should focus on the most important transportation

issues in the state and each MPO region, with each objective consisting of specific, measurable, and time-bound statements of performance that will lead to accomplishing The Connected Corridor goals. (Note: sample operations objectives are included in the strategic plan).

- Develop a manageable set of performance measures and metrics for each objective. These performance measures should then be used in the planning process to analyze, select, and prioritize operations strategies and other transportation improvements. The performance measures will also subsequently be used to monitor and evaluate deployed strategies and systems. This effort should be coordinated with the measures being identified by FHWA in accordance with MAP-21.
- Create standard performance reports, including dashboards, for internal use (e.g., identify trends in performance so that specific problems can be targeted), for decision-makers, and for the traveling public.
- Develop a consistent approach, including identifying standard tools, for analyzing and prioritizing TSM&O projects — one that considers estimated life-cycle costs and associated benefits. This approach should also include providing training to transportation operations and planning staff throughout the state on the selected tools.

Note that these institutional recommendations are not new endeavors, per se, but rather a continuation, expansion, and/or formalization of activities already underway, with an increased emphasis on TSM&O as appropriate.

FIGURE ES-3
An Objectives-Driven, Performance-Based Approach to Metropolitan Planning
(Adapted from the FHWA)

Operational Recommendations

TSM&O strategies, coupled with the supporting ITS technology, are an important aspect of delivering transportation services to customers. Experience has shown that aggressive applications of operations strategies can, in effect, recover much of the capacity lost due to congestion and disruptions. Operations strategies also enhance safety, promote reduced emissions, and increase system reliability. Perhaps most importantly, actively managing the transportation network can improve travelers' experiences, providing them with real-time information and choices throughout the trip chain — from origin to destination — leading to network performance optimization and increased efficiency.

The strategies are relatively low cost (compared to adding capacity), much quicker to implement (two to three years), and offer substantial benefits (with very positive benefit-cost ratios). Here are some examples:

- Active traffic management strategies have resulted in 10 to 30 percent reductions in crashes (dynamic speed limits and queue warning) and up to 30 percent reduction in congestion (dynamic shoulder lanes).
- Transit signal priority has improved bus running times by 2 to 15 percent, with minimal impact on side street operations.
- Adaptive traffic signal control has reduced arterial delays by 4 to 40 percent.
- Analyses of integrated corridor management has shown benefit-cost ratios of 5:1 to 10:1.

TSM&O strategies and their application may be viewed as part of an operations continuum as shown in Figure ES-4. As a general rule, the transportation agencies within New Jersey are solidly in the "good" area of this continuum, approaching "better" in several instances. As such, most of the operations recommendations focus on moving TSM&O into the "better" area and further towards a future "best."

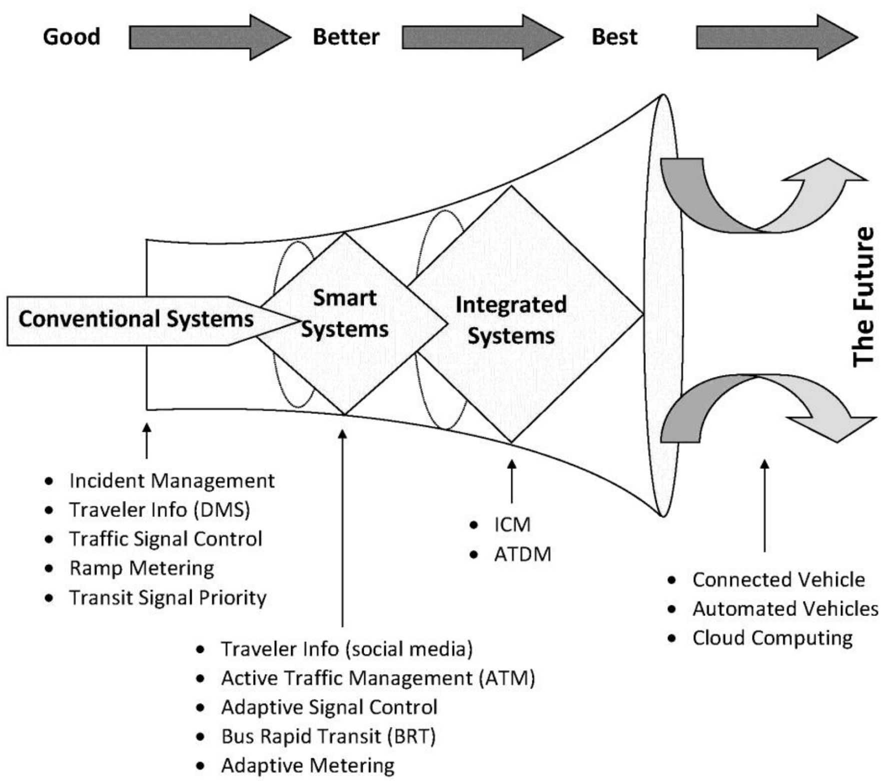

FIGURE ES-4
Continuum of Operations Strategies
(Source: *The Connected Corridor*)

Technology Recommendations

The rapid advancements in technologies have significantly affected operations and travel demand over the past few years. It is hard to imagine a transportation network within the state without E-ZPass® and transit fare cards. Virtual technologies such as smartphone and tablet applications, providing real-time traveler information and allow users to purchase and display train tickets, directly helping to improve the transportation experience. Data are becoming more plentiful through vehicle probes — information that is often collected and provided by the private sector. In a broader sense, the connectivity offered by such technological enhancements is changing the way we think about transportation. For example, the Internet and cloud computing enable would-be commuters to work from home, thereby eliminating trips that would otherwise add to congestion, increase pollutant emissions, and potentially decrease safety. Emerging technologies, such as the "Connected Vehicles" initiative (providing wireless communications between vehicles and between a vehicle and transportation infrastructure as shown in the diagram below) and autonomous vehicles will likely have an even greater impact on transportation compared to everything that has come before. All of these technologies can help support the strategic vision, goals, and objectives of The Connected Corridor.

The Connected Corridor project does not recommend any specific technologies in support of the TSM&O strategies; such decisions should be made during project design and reflect the current state of the practice. The project has updated the NJ ITS Architecture, which should be used as a tool to help support these technology decisions, to promote consistency between individual ITS-based projects, to ensure these projects are consistent with The Connected Corridor goals and objectives, and to verify and validate that each project conforms to the National ITS Architecture (in accordance with FHWA and Federal Transit Administration [FTA] rules). The architecture will also support identifying communication links between agencies, system interfaces, and the associated standards by which information and system control functions can be effectively shared and distributed among agencies and their respective transportation management systems. The architecture update was based on guidelines developed by FHWA using the Turbo Architecture™ software product.

The Connected Corridor concept and approach can encourage, support, guide, and shape technology innovations and integration within and between each of New Jersey's transportation agencies, as well as with transportation entities in surrounding states. Examples in this regard include the "Connected Vehicles" initiative and the associated wireless communications (between vehicles and with the transportation infrastructure) in support of safety, mobility, and environmental applications, and autonomous (i.e., self-driving) vehicles. The Connected Corridor activities and processes flow in both directions — innovation, collaboration, and new thinking can come from the bottom up *and* from the top down.

Connected Vehicle Applications
(Adapted from the FHWA)

Implementing, Maintaining, and Updating

As New Jersey's TSM&Ostrategic plan, The Connected Corridor is ready for implementation and will be guided towards this next step by New Jersey's federally supported Capability Maturity Model (CMM) process. The Connected Corridor will continue to be guided and led by a collaborative IAC, now composed of 22 different regional transportation agencies and organizations. The IAC will ensure that the recommendations identified become reality, and it will regularly review and update The Connected Corridor *plan* and NJ ITS Architecture as appropriate.

The effort will continue to be managed and maintained by the NJTPA with support provided by the New Jersey Institute of Technology (NJIT), serving as NJDOT's ITS resource center. This Connected Corridor plan and updated NJ ITS Architecture are intended to be living documents that should be regularly reviewed and updated over time.

Recommendations

TSM&O recommendations for The Connected Corridor are divided among 10 program areas shown in Table ES-2. The table also indicates the extent to which these operations program areas help to achieve The Connected Corridor goals, and identify some of the specific strategies recommended for further analysis and/or implementation. Not all of the TSM&O strategies identified will be appropriate for every facility and/or location within the state. Accordingly, each proposed strategy — particularly the newer ones — will need to be analyzed as part of the aforementioned objectives-driven, performance-based planning process. This analysis includes a comparison of the estimated benefits and costs to identify specific projects and to ensure that these operations strategies and projects will help solve an existing or future need and problem, and can do so in a cost-effective manner throughout the system's life cycle.

Overlaps exist between many of the program areas; for example, traveler information, which is identified as a separate program area, is also an integral part of freeway management, transit management, arterial management, commercial vehicle operations, and regional integration. Moreover, multimodal and regional integration can impact the operations and supporting technologies for nearly all of the other program areas. It is therefore important to remember that the paradigm of program areas used in The Connected Corridor plan is merely a model for structuring and organizing the discussion and should not be viewed as a rigid form of classification.

Below are two tables summarizing the recommendations (Additional information related to the listed TSM&O strategies is provided in Appendix A):

- Table ES-2 – **"TSM&O Recommendations for The Connected Corridor"** – indicates the extent to which these TSM&O program areas help to achieve The Connected Corridor goals,
- **"Summary of Recommendations for TSM&O Strategy Implementation"** summarizes the operations recommendations for The Connected Corridor, providing the following information:
    - Program area
    - Where New Jersey currently stands in the program area in terms of good, better, and best
    - Associated strategies for moving the state towards "best"
    - Potential locations for the deployment of these operations strategies
    - Additional explanatory information

TABLE ES-2
TSM&O Recommendations for The Connected Corridor

TSM&O Program Areas	The Connected Corridor Goals						Sample Operations Strategies
	Mobility	Reliability	Economic Competitiveness	Environment and Resiliency	Safety and Incident Management	Accessibility	
Freeway Management	●	●	●	●	●	◐	Active traffic management (e.g., dynamic speed limits, dynamic shoulder lanes)
Incident Management	◐	●	●	●	●	◐	Expanded service patrols, inlcuding arterial streets
Transit Management	●	●	◐	●	●	●	Transit Signal Priority
Arterial Management	●	●	◐	●	◐	◐	Signal retiming program including adaptive signal control
Traveler Information	●	●	●	●	●	●	Additonal information, provided on more of a multimodal basis
Multimodal and Regional Integration	●	●	●	●	●	●	Integrated Corridor Management
Electronic Payment	●	●	●	●	◐	●	Greater integration across modes; potential for more variable pricing
Commercial Vehicle Operations	◐	●	●	◐	●	◐	Expand ITS along major freight routes; establish "virtual" freight corridor
Climate Change Adaptation	◐	●	◐	●	●	●	"Harden" critical ITS infrastructure and transportaiton management centers
Data Management	●	●	●	●	●	●	Single multimodal data warehouse – statewide and with other states

Table key:
● = major contribution | ◐ = some contribution | ○ = minimal contribution

Summary of Recommendations for TSM&O Strategy Implementation

Program Area	Strategy	Application (Project Location)	Current Performance Outcome: Good	Better	Best	Recommendations
Freeway Management	Fill in geographic gaps with respect to ITS deployment Implement Active Traffic Management (ATM)	Potential ATM segments: • I-280 • I-78 (I-287 & NY) • I-80 (Rt 15 & GWB) • I-295 (Rtes. 42 & 38) • I-76 / Rt 42 / I-676 • I-195 (NJTP and I-295)				Expanding coverage of current systems and ITS devices such as surveillance/ detectors to measure traffic flows, CCTV, DMS, and communications cable. ATM strategies include dynamic speed limits, dynamic lane control, queue warning, dynamic shoulder lane, and junction control. ATM study currently underway for NJDOT to identify specific segments and associated ATM strategies. Potential segments subject to change as a result.
Electronic Payment	Provide greater integration between modes for electronic payment, such as using the same payment mechanism for either, or a common back office and invoicing process.	Statewide				The concept of a single regional electronic tag and a single monthly invoice incorporating all toll facilities in the northeast was very cutting edge when E-ZPass was first introduced. The concept has subsequently expanded to include most of the east coast (to North Carolina). Other enhancements have included high speed toll lanes and using E-ZPass for other payments (e.g., parking at the New York area airports). Similarly, New Jersey Transit has introduced advanced fare payment technologies, including "MyTix" that provides customers the convenience of buying rail tickets and passes securely from a mobile device. The agency also provides a contactless payment system using certain credit/debit cards and specially equipped mobile phones on selected bus routes and at the Newark AirTrain Station.
Incident Management	Implement automated linkages and data exchange protocols between Transportation Management Centers (TMC) and Police Computer Aided Dispatch (CAD)	Statewide, focusing first on the John A. Cifelli Statewide Traffic Management Center (STMC) in Woodbridge, NJ and State Police				Linkages and protocols must ensure that personally identifiable information from the police CAD is never transmitted to the TMC.
	Investigate expanding the SSP program	Segments without coverage.				NJDOT already has a robust program of Safety Service Patrols (SSP) and inter-agency coordination activities such as Incident Management Teams.

Program Area	Strategy	Application (Project Location)	Current Performance Outcome			Recommendations
			Good	Better	Best	
	Update and standardize ITS-based technologies and systems throughout NJ Transit.	NJ Transit operations centers, systems, and rolling stock.				Some of the existing ITS-based technologies are relatively old – for example, NJ Transit is still using track circuits in many locations, and there are varying degrees of accuracy. Additionally, as is the case with old technology and systems that have been implemented over several years, there are multiple operations centers in geographically separated locations, with multiple legacy systems with multiple configurations.
Transit Management	Real-time monitoring of park & ride lots (i.e., # of available spaces) and available transit seating	Locations to be determined. Initial priorities would be the parking lots and transit vehicles serving the ICM corridors.				Information to be used in support of integrated traveler information and ICM
	Implement Transit Signal Priority (TSP)	Bus routes within ICM corridors, and any arterials where congestion impacts bus operations and maintaining schedule adherence is difficult.				TSP detects when a bus is nearing a signalized intersection and manages signal operation, turning the traffic signals to green sooner or extending the green phase, thereby allowing the bus to pass through more quickly.
Arterial Management	Update signal timing parameters on state and local arterials on a more frequent basis as needed	Statewide, including local systems				The ITE 2012 *National Traffic Signal Report Card* gave an overall D+ for the U.S. as a whole.
	Expand adaptive signal control operations throughout the state as appropriate	Locations to be determined. Initial priorities would be the ICM corridors that are not identified for TSP.				Adaptive Traffic Signal Control continuously monitoring arterial traffic conditions and the queuing at intersections to dynamically adjust the signal timing parameters to smooth the flow of traffic along coordinated routes and to minimize overall stops and delays.

Program Area	Strategy	Application (Project Location)	Current Performance Outcome			Recommendations
			Good	Better	Best	
Traveler Information						
	Integrate traveler information; provide on a multi-modal basis	Statewide: such as including transit info on NJ511 in an integrated fashion along with roadway info; DMS along ICM roadways prior to exits for transit stations, showing comparative travel times for NJ Transit rail and freeway to common destinations				All the NJ transportation agencies have robust programs for traveler information – DMS (travel times, next transit vehicle arrival), web, use of social media (particularly NJ Transit). Information can be better integrated sothat travelers don't need to switch between mode-specific websites and applications.
Multi-Modal/ Regional Integration						
	Deploy Integrated Corridor Management (ICM) systems throughout state.	Potential corridors include. • The I-495 corridor between the NJ Meadowlands and the Van Wyck Expressway in NYC • The NJ Northeast Corridor along US Route 1 & 9 including the NJ Turnpike & Garden State Parkway, and NJ Transit & Amtrak's Northeast Corridor rail line between Woodbridge & Jersey City • Garden State Parkway / NJ Transit North Jersey Coast Line • I-80 / NJ Transit Gladstone,				Inter-agency and regional coordination has long been a mainstay of transportation entities in New Jersey – as well as New York and eastern Pennsylvania – particularly during major incidents and construction activities, special events, and extreme weather conditions. This regional coordination has been greatly supported and promoted by TRANSCOM, including automated information and video sharing between numerous public agencies via their OpenReach System. DVRPC also promotes and proactively supports inter-agency coordination in the Philadelphia region, such as incident management coordination activities and information and video sharing viaits Regional Integrated Multi-Modal Information Sharing (RIMIS) project, using the same platform as TRANSCOM's Open Reach.

Program Area	Strategy	Application (Project Location)	Current Performance Outcome			Recommendations
			Good	Better	Best	
		Morristown, Montclair–Boonton Lines / Rt 46 / Other Parallel Routes • Garden State Parkway / NJ Transit Main and Bergen County Lines / Rt 17 • Parallel Routes (County Road 551) • Atlantic City Expressway / Rt 42 / NJ Transit Atlantic City Line / US 30				
Commercial Vehicle Operations						
	Enhance the traveler information sources previously noted to include truck–specific information	Along routes with significant truck traffic (e.g., I-80, I-78)				
	Pursue and implement the recommendations being developed as part of the “Comprehensive Regional Goods Movement Action Program for the New York-New Jersey Metropolitan Region (G-MAP),” which is a joint initiative of the Port Authority, NJDOT, and NYSDOT.	Statewide and beyond. Recommended G-MAP early actions that may impact operations and ITS include: • Streamlining permitting for oversize/overweight vehicles across jurisdictional boundaries, including the design and interface of a single customer application and response. • Designating an “I-95 Virtual Freight Corridor” integrating				The purpose behind G-MAP is to develop a comprehensive long-term regional goods movement plan for the New York/New Jersey region that establishes a framework and action plan for the identification and prioritization of freight strategies and projects within a 30-year planning horizon.

Program Area	Strategy	Application (Project Location)	Current Performance Outcome			Recommendations
			Good	Better	Best	
		ITS components and shared enforcement information				
		• A NY-NJ freight open data portal to provide a coordinated, system-wide approach to make it easily accessible to the public and industry.				
Climate Change Adaptation						
	Using the enhanced traveler information, ATM, ICM and other TSM&O strategies previously noted to support the management of evacuations and returning traffic following an extreme weather event	Statewide				The impacts of and responses to Hurricane Irene and Superstorm Sandy highlight how important adaptation can be, including the utilization of TSM&O strategies and supporting ITS.
Data Management						
	Develop and implement a "Data Warehouse"	Statewide				This involves integrating existing databases (e.g., NJDOT Management System Integration [MSI], NJ Transit, TRANSCOM Open Reach, DVRPC RIMIS) providing a single access portal, consistent geo-referencing and formats, data mining, etc. in support of integrated traveler information, performance management, planning, and other Connected Corridor activities

Note: This is not a grade relative to other states and regions across the country but a general assessment against the Capability Maturity Model (CMM) framework for traffic management as noted

SECTION 1
Introduction and Overview

This document is The Connected Corridor plan (Strategic Plan) for New Jersey. It provides a broad concept and programmatic approach for planning, developing, and implementing transportation systems management and operations (TSM&O) strategies and the supporting Intelligent Transportation System (ITS) technologies throughout the state of New Jersey, including connections to and coordination with adjoining states. This Strategic Plan and the accompanying NJ ITS Architecture (consisting of a Turbo Architecture™ file and supporting documentation) provide a snapshot of TSM&O within New Jersey. Moreover, the Strategic Plan provides several program recommendations — addressing institutional, operational, and technical attributes — for making The Connected Corridor concept a reality.

Developing The Connected Corridor concept was guided by the New Jersey **ITS Architecture Committee (IAC),** comprising several key stakeholders as listed in Table 1. The IAC reflects members' combined input, perspectives, passion for operations, New Jersey experiences, and local knowledge. The North Jersey Transportation Planning Authority (NJTPA) managed and oversaw the project.

TABLE 1
IAC Membership

New Jersey Department of Transportation	Delaware Valley Regional Planning Commission
New Jersey Transit	New Jersey State League of Municipalities
New Jersey Turnpike Authority	New Jersey Association of Counties
Federal Highway Administration	New York Metropolitan Transportation Council
Federal Transit Administration	Transportation Management Association Council of New Jersey
Port Authority of New York and New Jersey	Delaware River Joint Toll Bridge Commission
Transportation Operations Coordinating Committee	Rutgers University, New Jersey Institute of Technology, Monmouth University, and Princeton University
North Jersey Transportation Planning Authority	Intelligent Transportation Society of New Jersey
South Jersey Transportation Planning Organization	

1.1 Background

As part of Transportation Efficiency Act for the 21st Century (TEA-21) legislation, in order to provide for future interoperability of key transportation services at a national level, Congress mandated that all federally supported investments in technology be coordinated through a National ITS Architecture by April 2005. To meet this mandate and to develop collaborative and consistent architectures in the most cost-effective manner, the NJTPA, NJDOT and South Jersey Transportation Planning Organization (SJTPO) agreed to combine resources to commission a consultant. The consultant, approved by the NJTPA Board in February 2005, was tasked with developing two regional ITS Architectures and a Statewide ITS Architecture under the management of the NJTPA.

Section 1201.c of the SAFETEA-LU legislation requires state and local governments to address information needs and data exchange associated with highway and transit information and monitoring systems when developing or updating their regional ITS architectures. The purpose of this project is to update the 2005 effort and create a document that will support the State of New Jersey's broad strategic vision, consistent with the requirements of legislation. This project aims to identify how a systems approach to the process can improve regional outcomes and enhance the state's and NJTPA's missions, and by informing short and long range planning.

TSM&O — also often referred to simply as "operations" — is defined in recent federal legislation (*Moving Ahead for Progress in the 21st Century* [MAP-21]; Federal Highway Administration [FHWA], 2012a) as follows:

> *"Integrated strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system."*

These operational strategies and the supporting ITS technologies provide effective and relatively low-cost alternatives to large, capital-intensive improvements.

TSM&O and ITS are not new to New Jersey and the various transportation agencies within the state. For the most part, however, these operational strategies and ITS-based systems have been developed and deployed as individual, mode-specific projects, often targeting a specific problem or opportunity, with funding decisions made on a case-by-case basis. These individual projects have yielded many benefits, including reduced congestion and improved real-time information to support traveler decisions. Moreover, the transportation and enforcement entities within the state and beyond regularly share information and coordinate their respective operations, particularly for major special events (e.g., the 2014 Super Bowl) and construction activities (e.g., Pulaski Skyway) and during significant incidents and other emergencies (e.g., Superstorm Sandy). All in all, New Jersey's transportation system is at a "good" (and often "better") level in terms of managing overall performance.

Critically, even with these operational improvements, New Jersey has been missing a performance-based, programmatic approach that encourages a collaborative and sustainably funded effort to develop, deploy, and manage TSM&O strategies and technologies in an integrated manner — that is, connecting operations with the transportation planning process, as well as with the end users. What is needed is a clear, understandable road map to take the "good" level transportation operations New Jersey has today, make it "better," and ultimately the "best" system possible. Making these connections across all modes of transportation and transportation agencies (including local, state, and regional) is of vital importance to New Jersey's economic future and the quality of life for its citizens and other users of the state's transportation network. The Connected Corridor concept — as described in this Connected Corridor plan and supported by the updated NJ ITS Architecture — is dedicated to this very purpose.

1.2 The Connected Corridor

The Connected Corridor concept — shown in Figure 1 — establishes a clear vision, supported by regionally endorsed goals and specific objectives, for moving the New Jersey transportation network towards a "better" rating and ultimately the "best" state. Establishing this kind of integrated and optimized approach through The Connected Corridor concept will create, for the first time in New Jersey and regionally, a place to plan, program, deploy, and manage new and enhanced operational strategies and technologies across all modes of our transportation system for the benefit of all of its users, planners, and operators.

1.2.1 Vision

The Connected Corridor concept is based on the following clear, strategic vision that can support all modes and all operators within the State of New Jersey and the region:

A <u>Connected</u> Transportation System Supported by Technology

1.2.2 Goals

To achieve this vision and establish an environment where innovative operational strategies and accelerated technology deployment are routinely achieved, The Connected Corridor must be firmly rooted in the priorities of all regions of the state. Accordingly, the strategic vision is supported by the goals shown in the cylinders in Figure 1. These goals were derived from statewide goals, regional goals (as documented in the Metropolitan Planning Organization’s long-range plans), and from priority areas identified in current federal transportation authorization (MAP-21). Following are definitions of The Connected Corridor goals:

- **Mobility—**Enhance the movement of people and goods by reducing congestion and delays.
- **Reliability—**Improve the efficiency of the surface transportation system through increased consistency of travel times from day to day.
- **Economic competitiveness—**Improve operations of those transportation network segments that serve freight movements, key economic sectors, and trade markets, thereby helping to expand and strengthen connections to the national and global economies.
- **Environment and resiliency—**Reduce emissions and noise from the surface transportation network, thereby helping to protect and enhance the natural environment. A related consideration is keeping the transportation network operational during and immediately following severe weather events and related disruptions.
- **Safety and incident management—**Reduce crashes, serious injuries, and fatalities on the surface transportation network. A related consideration is minimizing the impact of crashes on the operation of the transportation network when crashes do occur.
- **Accessibility—**Increase the integration and connectivity of the transportation system across and between modes, thereby enhancing the ability of people to reach opportunities and activities and generally making their trips better.

FIGURE 1
The Connected Corridor Vision and Goals

1.3 The New Jersey Transportation Systems Management and Operations Plan

As noted in the introductory paragraph, this Connected Corridor plan concept focuses on TSM&O, which consists of numerous operational strategies and are discussed in subsequent sections herein. ITS technologies — be they devices for monitoring traffic flow on the roadways, devices for monitoring transit vehicle location and status, hardware and software at transportation management centers, and/or

"Connected Vehicles" applications—are crucial to the success of these operations strategies. In essence, ITS represent the enabling technology for operations, including collecting and integrating the data necessary to optimize operations in real time and to measure performance.

TSM&O strategies — coupled with the supporting ITS technology — are an important aspect of delivering transportation services to customers. Experience has shown that aggressive applications of these operations strategies can recover much of the capacity lost due to congestion and disruptions. Operations strategies also enhance safety, promote reduced emissions, and increase system reliability. Perhaps most importantly, actively managing the transportation network can improve travelers' experiences, providing them with real-time information and choices throughout the trip chain — from origin to destination — leading to network performance optimization and increased efficiency. TSM&O strategies are relatively low cost (compared with adding capacity), much quicker to implement (two to three years), and offer substantial benefits (with very positive benefit-cost ratios) as shown in Table 2.

TABLE 2
Summary of Selected Operations and Benefits

Operations Strategy	Benefits and Benefit-Cost Ratios
Incident Management • Safety service patrols • Other detection, response, and management	• Overall, incident management reduced incident duration 30 to 50 percent • Safety service patrols have resulted in benefit/cost ratios of 2:1 to 42:1 • Average total incident duration in New Jersey has declined from 2.75 hours in 1995 to 1.44 hours in 2008
Integrated Corridor Management (ICM)	• ICM along I-15 in San Diego yielded estimated benefit/cost ratio of 9.7:1 • Simulation of ICM at several pioneer sites in the United States indicate benefit/cost ratios for combined strategies of 7.1:1 to 25.1:1
Ramp Management	• Freeway throughput increased 13 to 26 percent • Crashes decreased 15 to 40 percent • Travel times increased 10 percent
Road Weather Information Systems	• Crash rates reduced from 7 to 80 percent • Benefit/cost ratio of 2:1 to 10:1
Transit Management • Automated vehicle location/ computer-aided dispatch • Transit signal priority	• Automated vehicle location/computer-aided dispatch systems improved schedule adherence 9 to 23 percent • Transit signal priority improved bus travel times of 2 to 15 percent and improved schedule reliability with minimal impact on side street operations
Arterial Management (Adaptive Signal Control)	• Stops reduced 10 to 41 percent • Delays reduced 5 to 42 percent • Emissions reduced 3 to 22 percent

TABLE 2
Summary of Selected Operations and Benefits

Operations Strategy	Benefits and Benefit-Cost Ratios
Active Traffic Management • Dynamic Speed Limits • Dynamic Lane Assignment • Queue Warning • Dynamic Junction Control • Dynamic Shoulder Lanes	• Throughput increased by 3 to 7 percent • Crashes reduced 3 to 30 percent • Emissions decreased 2 to 8 percent • Exclusive bus use of shoulder (also called "bus on shoulder") in Illinois during peak periods increased bus on-time performance 68 to 92 percent and increased ridership
Managed Lanes (high-occupancy vehicle converted to high-occupancy toll with dynamic pricing)	In Minneapolis, peak-period throughput increased 9 to 33 percent; mainline crashes reduced 5.3 percent
Traveler Information • Route-specific travel time information • Personalized travel planning system for environmentally friendly routes and modes • 511 systems	• Improvement in on-time performance of 5 to 13 percent • Carbon dioxide emissions reduced by 20 percent • 511 systems achieved customer satisfaction of 68 to 92 percent

Note:
Primary source: Research and Innovative Technology Administration (2014), with additional information from the Federal Highway Administration and American Association for State Highway and Transportation Officials operations' presentations for departments of transportation and metropolitan planning organizations senior management.

1.4 Context of The Connected Corridor

The term "**connected**" has several connotations. From a geographic perspective, the New Jersey transportation network represents a critical link in the northeast, providing connections between the New York City metropolitan area (and points north and east) and the Philadelphia area (and points south and west). The network also serves a major port complex along with several recreational areas. As such, the reliable and safe operation of the surface transportation network within the state is crucial not only for New Jersey residents and businesses, but also for all sorts of travelers and users beyond the state's boundaries.

FIGURE 2
Integration Considerations (Adopted from the FHWA Planning for Operations Guidance)

The concept of "**integration**" is another important way of looking at The Connected Corridor. The goal of integration — and The Connected Corridor — is to bring the management and operation of the surface transportation network into a unified whole, thereby making the various transportation modes and facilities perform better and work together. In the context of The Connected Corridor, the integration involves several facets — institutional, operational, and technical — as shown in the Figure 2. While these key integration considerations are addressed separately in terms of the Strategic Plan recommendations for The Connected Corridor, they are nevertheless closely related and interdependent. For example, operational integration, including the deployment of advanced and multimodal TSM&O strategies,will be more cost-effective when technical integration (e.g., adoption of statewide standards and protocols in accordance with the NJ ITS Architecture) has been achieved. Perhaps most critical is that successful institutional integration (and the associated business processes, interagency agreements, managerial support, and funding) is essential to fully achieving operational and technical integration.

Addressing these integration considerations and interdependencies is a key consideration throughout the entire life-cycle of The Connected Corridor concept (Figure 3) as summarized below:

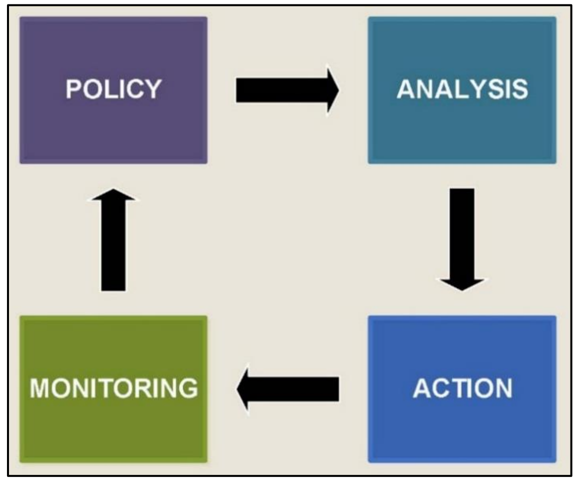

FIGURE 3
Continuous Life-Cycle and Phases of The Connected Corridor

- **Policy—**These policy activities — such as developing and then committing to program goals and operations-oriented objectives, establishing business and planning practices in support of TSM&O, and providing the required funding and staff support — are primarily related to institutional integration. In essence, “mainstreaming” TSM&O into the institutional frameworks at the agency and regional levels sets the stage for successfully accomplishing the other Connected Corridor phases and activities. Policy is set primarily at the agency executive level in coordination with the MPO’s (and the regional and statewide) long-range transportation plans.
- **Analysis—**These analysis activities focus on evaluating and then prioritizing the most appropriate TSM&O strategies and ITS technologies for deployment, including the specific agency network segments and corridors where they should be deployed. This process requires both operational and technical integration (e.g., identifying multimodal and multiagency operational scenarios, defining linkages and protocols for data sharing in support of these scenarios, using appropriate tools to estimate operational benefits and costs, and documenting the results [e.g., a concept of operations]). Institutional integration is also critical in terms of incorporating the selected operations projects into the congestion management program, transportation improvement program (TIP), and other planning documents for funding. Planning, programming and operations staff within operating agencies would primarily conduct analsysis, with assistance from regional partners such as MPOs.
- **Action—**These action activities focus on deploying the selected TSM&O projects, including making sure the project conforms to the statewide and National ITS Architectures, developing system requirements, designing the system, implementing ITS hardware and software, and conducting acceptance testing — primarily technical considerations in accordance with the principles of systems engineering. Institutional considerations, such as contracting mechanisms and ensuring adequate staff have been identified and trained for operating and maintaining the system following acceptance, are also important. Operations and the ITS technical staff at the agency level would primarily implement action.
- **Monitoring—**Once the selected TSM&O strategies, supporting ITS technologies, and systems have been deployed, they should be continuously monitored and evaluated against a number of performance measures and metrics to ensure the strategies are having the desired effect on the transportation system, and providing feedback to the policy and analyses phases as to which strategies are best for future deployment. These activities involve both institutional considerations (e.g., defining performance

measures and metrics that link to the operations objectives as part of the policy activities) and technical issues (e.g., collecting, integrating, and storing traffic and other data from multiple sources —both public and private — into a data warehouse). It is also important to develop tools to query the data warehouse and use the information to create a variety of performance-based reports and dashboards for translating performance measures into easily understandable information. Monitoring the results will also inform updates to the policy efforts, including updating the regional and statewide priorities, operations objectives, and performance metrics. Planning and operations staff at the transportation agencies and MPOs would primarily conduct the monitoring.

1.5 Document Layout

This Connected Corridor plan builds upon the already robust operations programs and agency coordination within the state, providing a “road map” for deploying and integrating operations strategies across all modes for the next 10 to 20 years, including how the recommended operations and ITS program can “connect” with the regional and statewide planning processes. This Strategic Plan is focused on the program level. Specific TSM&O projects are generally not identified, although the Strategic Plan does establish the framework for identifying and programming future projects in support of The Connected Corridor.

The next three sections address the institutional, operational, and technical attributes of The Connected Corridor, respectively, including an overview of what constitutes “best,” and recommendations for minimizing the current gaps and moving the concept forward to this “best” condition. Emphasis is placed on the institutional and operations attributes. Individual technologies are not defined — such decisions are made during the scoping and design processes for individual projects. Moreover, the updated NJ ITS Architecture is only briefly summarized, with additional details available in other documents prepared for this project. The final section addresses the next steps and future considerations, including a plan for maintaining and updating The Connected Corridor concepts and recommendations contained herein.

SECTION 2
The Connected Corridor from an Institutional Perspective

Institutional integration involves the coordination and collaboration of various departments within a transportation agency and among numerous transportation agencies and jurisdictions within the state — and across state lines — to support and achieve seamless interoperability of the transportation network. To achieve effective institutional integration, the senior management of these transportation agencies (and other stakeholders, such as the MPO and enforcement) must be aware of the benefits from operations and the value of being part of an integrated regional system, and then develop and implement policies and procedures to support The Connected Corridor.

Achieving institutional integration requires that operations become a formal core program with the same emphasis as construction and maintenance activities.[1] Recent research performed under the Second Strategic Highway Research Program (SHRP2) has found that for state and local transportation agencies to reach the full potential of their operations program, specific supportive processes and institutional arrangements must be instituted and managed, similar to what has been done for other formal core programs (such as construction and maintenance). One of the keys to having a successful operations environment is to integrate operations strategies and the supporting ITS technologies into the agency's institutional framework and corresponding business processes. In other words, operations must be "mainstreamed" into the planning, budgeting, and programming processes. Such mainstreaming must occur at both the individual agency and the regional (i.e., MPO) and statewide levels as described below.

2.1 Mainstreaming Operations at the Agency Level

The SHRP2 L06 Project "Institutional Architectures to Advance Operational Strategies" developed a formal process whereby transportation agencies can self-assess their institutional capabilities and identify actions to continually improve their operations-related activities, focusing on integrating and mainstreaming operations into the agency's program while also addressing the regional planning process. The process uses a Capability Maturity Model (CMM) framework that focuses on improving business processes and the institutional architecture in support of more effective operations. The CMM framework identifies the following six dimensions of organizational capability:

- **Business processes—**formal scoping, planning and programming, and budgeting (resources)
- **Systems and technology—**use of systems engineering, system architectures, standards (and standardization), and interoperability
- **Performance—**defining measures, data acquisition and analytics, and utilization
- **Culture—**technical understanding, leadership, outreach, and program legal authority

[1] As an analogy, providing a safe and reliable transportation network may be likened to a three-legged stool, with each leg representing the functions of building the necessary infrastructure, preserving that infrastructure through maintenance and reconstruction, and operating and managing it on a daily basis so the available capacity can be utilized to its fullest extent. The transportation network cannot effectively serve customer needs if any of these three legs is missing or is underemphasized (i.e., too short) relative to the others.

- **Organization and staffing—**programmatic status, organizational structure, staff development, recruitment and retention
- **Collaboration—**relationships and partnering among levels of government and with public safety agencies, local governments, MPOs, and the private sector

For each of these six dimensions, four levels of maturity have been defined as shown in Table 3, where the term “maturity” is related to the degree of formality and optimization of these processes in support of effective operations.

TABLE 3
Levels of Capability Maturity Model Organizational and Institutional Maturity

Level	Description	The Connected Corridor Equivalent
1—Performed	Activities and relationships are largely ad hoc, informal, and champion-driven — substantially outside the mainstream of other activities within the transportation agency.	**Good**
2—Managed	Basic strategy applications understood, key processes and support requirements identified, and key technology and core capacities under development; however, there islimited internal accountability and uneven alignment with external partners.	↓
3—Integrated	Standardized strategy applications are implemented in priority contexts and managed for performance; operations-related technical and business processes are developed, documented, and integrated into the agency and the regional transportation planning process; and partnerships are aligned.	**Better** ↓
4—Optimized	Operations are addressed as a full, sustainable core agency program, established on the basis of continuous improvement with top level management status — part of the region-wide program and planning process with formal partnerships with all involved agencies.	**Best**

In 2013, FHWA in association with the American Association of State Highway and Transportation Officials (AASHTO) initiated a program with the stated goal “to help agencies assess their improvement needs and progress, and initiate some of the action steps required to measurably transform their organizations to being more operations- and reliability-focused.” This implementation assistance program is a two- to three-year endeavor involving a workshop to assess the current levels of maturity for each CMM dimension, developing an implementation plan identifying several action items for moving from the current level to the next level for several of these dimensions, and then implementing these approved action items. Twenty of the lead adopters selected — including New Jersey Department of Transportation (NJDOT) in association with Delaware Valley Regional Planning Commission (DVRPC), NJTPA, and other transportation agencies in New Jersey — are receiving financial and technical assistance as part of the implementation assistance program.

A facilitated one-day CMM workshop was conducted with the various New Jersey operations stakeholders (e.g., representatives from NJDOT, New Jersey Turnpike Authority, New Jersey Transit, NJTPA, DVRPC, South Jersey Transportation Planning Organization [SJTPO] and TRANSCOM) on August 8, 2013, at the NJDOT headquarters building in Trenton. The purpose of the workshop was to develop a consensus evaluation of the current levels of capability for the six dimensions and to identify potential next steps for advancing the effectiveness of operations activities in New Jersey — in essence, to move from the current level to the next level. The results of the CMM workshop and the associated gaps are summarized in Table 4.

TABLE 4
Summary of Results from the New Jersey Capability Maturity Model Workshop

Dimension	Level	Examples of Current Agency Institutional Gaps
Business processes	Good	• Lack of overall statewide strategic plan • Need better integration into overall statewide comprehensive strategy, evaluating trade-offs between operations and other strategies and needs • Need to educate non-operations partners and policy makers regarding operations
Systems and technology	Good to Better	• Challenge of keeping up to date with latest operational strategies and technologies (e.g., providing information to customers using latest available platforms) • Complexity and delays related to operations of state-level information technology • Regional architectures out of date (but currently being updated)
Performance measurement	Good	• Common set of definitions needed across all stakeholders • Need more emphasis on outcome measures on a statewide basis (as opposed to individual events) • Travel time report card published only once • After-action debriefing process not formalized
Culture	Better	• General public perception of NJDOT as “building highways”— major operations initiatives not always visible • Need to do more to “sell” operations strategies and benefits to public and decision-makers, including more use of social media • Need more of a regional corridor approachand a one market/universal travel time vision
Organization and staffing	Good to Better	• Recruitment, retention, and training inadequate for personnel movement and turnover • Need more structured and tailored program for operations-related training • Need position descriptions that match operations core capabilities (e.g., positions that do not fully align with state titles) • Difficult to outsource
Collaboration	Better	• Interagency relationships not all formalized or institutionalized • Lack of guidance from departments of transportation with respect to local lead projects • All opportunities for collaboration not always capitalized (in part due to staff limitations)

The next step in the process is for NJDOT and the other stakeholders to develop an implementation plan that identifies and prioritizes short- to mid-term action items (i.e., doable within a two-year time frame) that will address several of these institutional gaps and help advance the operations program to the next levels of capability (i.e., going from “good” to “better” and possibly to “best”). Table 5 summarizes potential recommendations for improving institutional integration at the agency level.

TABLE 5
Institutional Recommendations for Moving Towards "Better/Best"— Agency Level

Lead Agency: NJDOT, in collaboration with the MPOs and other transportation agency stakeholders

Complete the implementation plan as part of the FHWA/AASHTO CMM framework, and upon approval of FHWA and receipt of support funding, carry out the various action items therein.

As part of the Lead Adopter program, FHWA has developed a toolkit to help guide development of the implementation plan. Potential action items may include (and are not limited to):

- Conducting peer exchanges with other transportation agencies around the country that are already at a high level of capability maturity
- Conducting staff training on various operations strategies and evaluation tools
- Developing a statewide and/or regional TSM&O concept of operations
- Developing a process for regularly engaging and collaborating with information technology staff
- Developing internal visions or stories of TSM&O benefits (including benefit/cost ratios) leveraging past successes (e.g., major events such as the 2014 Super Bowl) and using this material to develop an outreach program to familiarize key stakeholder constituencies (e.g., freight, safety, and legislative) of the importance and relevance of TSM&O, and to the transportation uses via press releases, agency websites, and social media
- Identifying key staff and providing funding for participation in national forums (e.g., AASHTO, ITS America, Transportation Research Board, Institute of Transportation Engineers, Institute of Electrical and Electronics Engineers) and encouraging senior agency executives to participate as well
- Establishing a formal debriefing process for major incident and emergencies to review and update responsibilities and procedures as documented in formal agreements
- At the completion of the two-year implementation period, conducting another CMM workshop to measure progress in terms of mainstreaming operations, followed by developing another long-term implementation plan for reaching "best" in all six CMM dimensions

2.2 Mainstreaming Operations at the Regional and State Levels

The CMM framework also addresses institutional integration and mainstreaming at the regional and statewide levels. Overall, institutional integration (i.e., mainstreaming) of operations at the regional level — encompassing the three MPOs that cover the state as shown in Figure 4 — can be rated as "good" with several aspects falling into the "better" category. Some examples are noted as follows:

- The *Plan 2040: NJTPA Regional Transportation Plan for Northern New Jersey* (Plan 2040; NJTPA, 2013) includes many references to operations strategies and the supporting ITS technologies, including such statements that ITS is "one of the most cost-effective ways to address congestion" and "Plan 2040 supports continued investment in ITS infrastructure and the development of ITS policy for the region." Moreover, NJTPA is actively pursuing a Planning for Operations Program,[2] identifying opportunities for expanding the role of the NJTPA in regional operations planning, developing a framework for addressing operational issues, and incorporating them into ongoing and future work plans and the project development process.

[2] Additional information on Planning for Operations is provided in section 2.3.

- Operations have been an ongoing emphasis within DVRPC for many years. A *Transportation Operations Master Plan* (DVRPC, 2009) was developed in 2009 to present a comprehensive long-term vision of transportation operations in the region, bridging individual agency programs to create a cohesive vision. The plan, which is to be updated in the near future, is integrated into the regional long-range plan. DVRPC also plays an active role in operations, supporting information and video sharing in the Philadelphia area via their Regional Integrated Multimodal Information Sharing (RIMIS) Project, managing and supporting several traffic incident management task forces, and providing software programs to improve incident management responses and foster interagency coordination.
- While it may be the smallest MPO in the state with generally less congestion and safety issues, the SJTPO region has recognized the traffic flow impacts caused by the summer recreational season. Operations and supporting ITS technologies can be applied to such tourism corridors, and the regional planning process needs to address this approach. SJTPO is also funding ITS projects through federal programs, such as the effort to improve signal timing and maintenance in Vineland, NJ.

FIGURE 4
MPO Regions

- NJDOT and the MPOs have recently started The Complete Team initiative, an ongoing effort to increase collaboration between planners and operators within the state. In addition to the aforementioned FHWA/AASHTO CMM framework, NJDOT and the MPOs are also regularly performing self-assessments (i.e., good level, some level, lack of coordination) with respect to the transportation planning process, data sharing, performance measurement, congestion management system, funding and resource sharing, institutional arrangements, regional ITS architecture, and regional MPO projects.

Additionally, the congestion management processes with each of the MPOs include ways to consider applicable TSM&O strategies.

Institutional integration on a statewide basis and with other states can also be rated as “good,” with several aspects falling into the “better” category. Such coordination and information sharing has long been a mainstay of transportation entities in New Jersey — as well as in New York and eastern Pennsylvania — particularly during major incidents and construction activities, special events, and extreme weather conditions. This statewide and multi-state coordination has been greatly supported and promoted by TRANSCOM, a coalition of transportation and public safety agencies (including NJDOT, New Jersey Turnpike Authority, New Jersey Transit, New Jersey State Police, and the Port Authority of New York and New Jersey). According to its mission statement, “TRANSCOM improves the mobility and safety of the traveling public by supporting its member agencies through interagency communication and the enhanced utilization of their existing traffic and transportation management systems. Further, as additional systems become available, TRANSCOM is a forum for ensuring that they are implemented in a coordinated manner.” TRANSCOM manages an effective regional construction coordination program and supports automated information and video sharing between numerous public agencies via their OpenReach System. As previously noted, DVRPC also promotes and proactively supports interagency coordination in the Philadelphia region, such as their various incident management coordination activities, and information and video sharing via their RIMIS project, which using the same platform as TRANSCOM’s Open Reach.

NJDOT, New Jersey Turnpike Authority, New Jersey Transit, and the Port Authority of New York and New Jersey are also voting members of the I-95 Corridor Coalition, with NJTPA, DVRPC, SJTPO, and TRANSCOM participating as affiliate members. The coalition is an alliance of transportation agencies, toll authorities, and related organizations from the states of Maine to Florida, with affiliate members in Canada. The coalition provides a forum for key decision- and policy-makers to address transportation management and operations issues of common interest. Coalition projects have included coordinated incident management activities, commercial vehicles operations, electronic payment services, a Vehicle Probe Project (VPP) providing comprehensive and continuous travel time information on freeways and arterials using probe technology, the development of a congestion monitoring program using the coalition's vehicle probe data, and ongoing training of managers and operations staff.

But a gap still exists because TSM&O is not fully mainstreamed into the continuing regional transportation planning process. ITS deployment projects and the ongoing operations and maintenance activities associated with these strategies have not yet become an integral part of the capital programming and budgeting processes (and the resulting TIP and State Transportation Improvement Program [STIP]). The aforementioned New Jersey CMM workshop touched on institutional integration and mainstreaming at the regional level, identifying the following gaps and issues:

- Need stronger connection between locally identified projects and long-range transportation planning needs (TIP/STIP)
- Need support for getting projects into TIPs
- Need for evaluating trade-offs between operations and other strategies and needs at the MPO level

Moreover, some of the gaps identified in Table 4 (e.g., need for more emphasis on outcome measures on a statewide basis) also have a regional and statewide perspective.

Mainstreaming TSM&O into the regional and statewide institutional processes — including planning — is not just a matter of achieving “best” practices; it is also a requirement in the current federal transportation authorization (MAP-21), which states:

> *“The metropolitan planning process shall provide for consideration of projects and strategies that will promote efficient system management and operation.”*

The same section of the legislation also includes other considerations for projects, including supporting the economic vitality of the metropolitan area, increasing the safety of the transportation system, increasing the accessibility and mobility of people, protecting and enhancing the environment, promoting energy conservation, improving the quality of life, and enhancing the integration and connectivity of the transportation system, across and between modes — all potential benefits resulting from implementing operations strategies and the supporting technologies.[3]

2.3 Performance-Based Approach to Metropolitan Transportation Planning

An objectives-driven, performance-based approach is recommended by FHWA as a means to meet federal transportation planning requirements for including “operational and management strategies to improve the performance of existing transportation facilities” in the planning process and promoting "efficient system management and operation." This objectives-driven, performance-based approach to planning for operations within a metropolitan area — conducted in collaboration among planners, transportation providers, operators, and other stakeholders — is shown in Figure 5, with some of the key activities summarized below.

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[3] And, as previously discussed, these same considerations were brought to bear in developing the Connected Corridor goals.

FIGURE 5
An Objectives-Driven, Performance-Based Approach
(Adapted from the FHWA)

2.3.1 Regional Goals

One or more regional goals should be established that focus on efficiently managing and operating the transportation system. The goals broadly describe what the region and/or state want to accomplish, focus on outcomes, and provide the basis for developing operations objectives. The goals established for The Connected Corridor have previously been discussed.

2.3.2 Operations Objectives

Objectives are specific, measurable statements of performance that will lead to accomplishing the regional goals. The operations objectives should focus on the most important issues in the region/state (e.g., delay, safety) — matters that the decision-makers and the public care deeply about. This will aid in getting buy-in and commitment to the objectives. FHWA's *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations—A Desk Reference* (Desk Reference; FHWA, 2010a) and the associated *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach – A Guidebook* (*Guidebook*; FHWA, 2010b) emphasize the importance of each operations objective having SMART — specific, measurable, agreed, realistic and time-bound — characteristics.

Operations objectives are preferably described in terms of those system performance outcomes from the perspective of users. Aspects of system performance that are important to users include levels of congestion, crashes, travel times and delays, travel time reliability, mode choices, and access to traveler information.

Developing activity-based objectives that relate directly to any operations and technology gaps and the extent to which these gaps are being addressed in support of the performance outcomes is important. All such activity-oriented operations objectives should support one or more outcome-oriented operations objectives, providing a simple check to make sure that operations activities are performed in pursuit of a system performance outcome.

Table 6 summarizes some potential outcome and activity-based operations objectives for The Connected Corridor. These objectives will need to be reviewed by the stakeholders and then refined and expanded to become SMART objectives. For example, the objective "reduce average delay per traveler" as identified in Table 6 (as part of the "mobility" goal) would need to be expanded to read "reduce average delay per traveler by X percent by year Y," thereby creating an operations objective that is specific, measurable, and time-bound.

TABLE 6
Sample Operations-Oriented Objectives for The Connected Corridor [a]

Goal	Outcome-Oriented Objectives	Activity-Oriented Objectives
Mobility	• Reduce the percentage of facility miles (e.g., highway, arterial, rail) and/or interchanges experiencing recurring congestion during the peak periods. • Reduce the daily hours of recurring congestion on major facilities. • Reduce average delay per traveler (this can be regional and/or statewide and mode-neutral and/or mode and link specific). • Reduce the regional average travel time index.	• Increase the percent of major roadway facilities (miles) that are equipped with ITS hardware and actively managed (this could be further refined by strategy and roadway type). • Increase the percent of park-and-ride facilities with real-time monitoring of available spaces.
Reliability	• Reduce total person hours of delay by time period (e.g., peak, off-peak) caused by all transient (i.e., nonrecurrent) events (e.g., traffic incidents, special events, and work zones). • Decrease the average buffer index (for multiple routes, corridors, or trips), and reduce the average planning time index (for specific routes or corridors). • Improve average on-time performance for specified transit routes and/or facilities.	• Reduce the standard deviation (peak and off peak) of speeds along freeway and arterial segments. • Increase the percent of major freeway facilities provided with active traffic management strategies and associated hardware.
Economic competitiveness	• Decrease the annual average travel time index for freight-significant routes. • Decrease point-to-point travel times on selected freight-significant highways. • Reduce buffer index on regional freight routes during peak and off-peak periods.	• Increase percent of major roadway facilities serving ports and other intermodal and/or freight facilities that are equipped with ITS hardware and actively managed.
Environment and resiliency	• Reduce emissions (e.g., carbon dioxide, nitrogen oxide, carbon monoxide, particulate matter) from vehicles and other transportation-related sources (on a corridor, region, or statewide basis). • Reduce the per capita time (transport-related) to evacuate individuals in a region/specific area.	• Increase the extent to which ITS and operations-related communication networks are deployed and/or configured in a redundant fashion to ensure information is available to system operators and users in an emergency or system failure.

TABLE 6
Sample Operations-Oriented Objectives for The Connected Corridor [a]

Goal	Outcome-Oriented Objectives	Activity-Oriented Objectives
Safety and incident management	• Reduce mean time of incident duration on transit services and arterial and expressway facilities. • Reduce the crash rate (per person hours, vehicle miles of travel) by severity (e.g., fatal, serious injury) and corridor/facility type (including work zones). • Reduce the number of serious injuries and/or fatalities (statewide and regionally by corridor and/or facility). • Reduce the number of congestion-inducing incidents occurring at freeway interchanges and ramps.	• Increase the number of miles covered by safety service patrols. • Increase number of staff in region or state with incident management responsibilities who have completed the National Incident Management System training
Accessibility	• Increase transit mode share (e.g., net person-miles travel by mode, net person-trips by mode, net change in transit ridership). • Increase alternative (non-single-occupancy vehicle) mode share for all trips in selected corridors. • Improve average transit travel time compared with auto in major corridors. • Reduce average travel time into and out of selected special events.	• Transit traveler information is integrated into the statewide 511 web and phone service. • Increase the corridor-miles included in actively managed integrated corridor management systems. • Increase park-and-ride lot capacity. • Increase number of users of notifications for traveler information (e.g., e-mail, text message). • Increase number of social media followers (e.g., Twitter, Facebook).
Other and/or applicable to all	• Increase customer satisfaction ratings as measured by surveys (this can be segregated by service, such as traveler information, incident management, corridor management, transit operations, work zone management).	• Increase the percent of the regional/statewide transportation system monitored by transportation management centers for real-time performance, including data collection and storage in support of performance measures and other analytics.

[a] Most of these — particularly the outcome objectives — were derived from FHWA (2010a), which identifies more than 200 possible SMART objectives that may be considered as part of the objectives-driven, performance-based approach for planning.

2.3.3 Performance Measures

Analyzing, selecting, and prioritizing operations strategies — and the subsequent monitoring and evaluation activities — should be based on performance measures. The importance of identifying and then using performance measures throughout the process cannot be over-emphasized: If you do not measure results, then you cannot tell success from failure; if you cannot see success, then you cannot reward it; if you cannot see failure, then you cannot correct it. In other words, you cannot manage it unless you measure it!

By definition, a SMART objective readily lends itself to developing the associated performance measures. Moreover, the aforementioned FHWA *Desk Reference* (2010a) also identifies potential performance measures for the various objectives identified therein.

While there are numerous potential performance measures that can be identified for The Connected Corridor (e.g., average travel times, average delays per person, travel time index,[4] buffer index,[5] planning time index,[6] on-time performance of transit, crash rate [number of crashes per some measure of vehicle miles traveled], number of crashes resulting in serious injuries or fatalities, mean time of incident duration, emissions per vehicle, percent of trips made by transit, and overall cost and cost-effectiveness), when developing and using performance measures, it is important to remember the following attributes of good and useful performance measures:

- **Goals and objectives—**Performance measures should reflect the goals and objectives for The Connected Corridor.
- **Limited number of measures—**All other things being equal, fewer, rather than more, measures are better. Too much information, too many kinds of information, or information presented at too fine a level can overwhelm decision-makers and the public.
- **Ease of collection—**The data required for performance measures should be easy to collect and analyze, preferably directly and automatically from the various transportation management systems that comprise or complement The Connected Corridor.
- **Data needs—**At the same time, performance measures should not be solely defined by what data are readily available. Data needs and the methods for analyzing the data should be determined by what it will take to create or populate the desired measures. Data collection specific to performance measurements should be identified and collected.
- **Sensitivity—**Performance measurement must be designed in such a way that change is measured at the same order of magnitude as will likely result from the implemented actions.
- **Simple and understandable—**Within the constraints of required precision, accuracy, and facilitating improvement, performance measures should prove simple in application with consistent definitions and interpretations. Data collected for performance measures must be presented in a way that can be easily understood by the public and can improve decision-making.
- **Facilitate improvement—**The ultimate purpose of performance measures must clearly be to improve the operation of the transportation network. Performance measures must, therefore, provide the ability to diagnose problems and to assess outcomes that reveal actual operational results, including estimates and predictions using simulation models and other analytical tools. In other words, meaningful performance measures should support wise investments.

[4] The travel time index — a measure of mobility — is the average travel time during the peak period, using congested speeds, divided by the off-peak period travel time, using posted or free-flow speeds.

[5] The buffer index — a measure of reliability — uses the 95th percentile travel time to represent a near-worst case travel time. It is computed as the difference between the 95th percentile travel time and average travel time, divided by the average travel time. It represents the extra buffer time a traveler should allow to arrive on-time for 95 percent of all trips (i.e., late arrival only one weekday per month). An advantage of expressing the reliability, or lack thereof, in this way is that a percent value is distance and time neutral.

[6] The planning time index—another measure of reliability and related to the buffer index—is computed as the 95th percentile travel time divided by the free-flow travel time, this measure represents the total travel time that should be planned when an adequate buffer time is included. For example, a planning time index of 1.60 means that, for a 15-minute trip in light traffic, the total time that should be planned for the trip is 24 minutes (15 minutes × 1.60 = 24 minutes).

Another consideration in defining performance measures for The Connected Corridor is consistency with the U.S. Department of Transportation (USDOT) rules and standards regarding performance measures. This activity — as required under MAP-21—is still in process. In March 2014, two interrelated Notices of Proposed Rulemaking (NPRM) were published in the *Federal Register*:

- A Safety Performance Measures NPRM that proposes safety performance measures and state DOT and MPO requirements for establishing and reporting specific annual targets for fatalities and serious injuries.
- A Highway Safety Improvement Program NPRM that updates the existing highway safety improvement program requirements and proposes a subset of the model inventory of roadway elements for all public roads, the Strategic Highway Safety Plan update cycle, and other revisions.

A second set of performance-related Notices of Proposed Rulemaking still remain to be developed and published. These will focus on pavement, bridges, and asset management. A third set will focus on congestion, emissions, system performance, freight, and public transportation.

MAP-21 requires states and MPOs to set performance measures and targets. States must report back on a biennial basis on their progress towards meeting those targets, and MPOs must include system performance reports in their long-range plans. NJDOT and NJTPA have been supporting this effort by testing delay and reliability performance measures (as proposed by AASHTO) along the Interstate 78 (I-78) and New Jersey Route 18 corridors.

Finally, in addition to developing and using performance measures as part of the regional transportation planning process and for the subsequent monitoring and evaluation activities, performance measures are also necessary for other purposes, including:

- **Decision-makers** (including elected officials) need to know the overall benefits and costs of the system — both estimated (prior to approval and deployment) and actual following implementation. These executives have to approve TSM&O programs and projects and the associated funding and are ultimately held accountable for their decisions.
- The **public** (i.e., the system's customers) are concerned with how well the transportation network is working, what is being done to fix any problems, how the transportation management strategies work and affect their travel, what are the alternatives, and when and where is the system most reliable.

While there is little difference in the types of data that must be collected for all of these uses, the level of detail of the information and how the information is presented and displayed will differ between audiences and uses. As an example, Washington State DOT publishes a quarterly performance report, *The Grey Notebook* (available at http://www.wsdot.wa.gov/accountability/). NJDOT also prepared a summary report in August 2010 on the performance of the transportation network, *Centerline* in August 2010 (available at http://www.state.nj.us/transportation/about/asset/centerline.shtm).

2.3.4 Identify, Evaluate, and Select Operations Strategies

Section 3 of The Connected Corridor plan identifies several potential operations strategies (See Appendix A for more information). These operational recommendations are provided at the programmatic level. More in-depth analyses will be required to evaluate and prioritize these strategies and then to define individual projects, including the specific locations where the strategies should be deployed.

As a result of an increasing competitive fiscal environment, state, regional, and local transportation planning organizations around the country are increasingly being asked to justify their programs and expenditures. TSM&O programs have not escaped this scrutiny, and operations and planning staff are routinely asked to rank their projects against traditional infrastructure projects, as well as conduct other value-related exercises. Because these projects are often competing for the same funds, a benefit/cost analysis provides a framework for prioritizing and ranking widely varying improvement types. This requirement can put TSM&O projects at a disadvantage because many specialists in this arena have limited experience in performing benefit/cost analysis for operations. And often, many of the established tools and data available for conducting benefit/cost analysis for traditional infrastructure projects are poorly suited to analyzing the specific performance measures, project timelines, benefits, and life cycle costs associated with operational improvements.

In response to this need, FHWA has developed the *Operations Benefit/Cost Analysis desk Reference: Providing Guidance to Practitioners in the Analysis of Benefits and Costs of Management and Operations Projects*, which includes Tools for Operations – Benefits and Costs[7] (TOPS-BC),a spreadsheet-based tool designed to assist practitioners in conducting benefit/cost analysis by providing four key capabilities:

- The ability for users to investigate the expected range of impacts associated with previous deployments and analyses of many TSM&O strategies
- A screening mechanism to help users identify appropriate tools and methodologies for conducting a benefit/cost analysis based on their analysis needs
- A framework and default cost data to estimate the life cycle costs of various TSM&O strategies, including capital, replacement, and continuing operations and maintenance costs
- A framework and suggested impact values for conducting simple benefit/cost analysis for selected TSM&O strategies

Regardless of which tool or approach is used to estimate benefits and costs for operations strategies, basing the analysis on life cycle costs and benefits is crucial. Estimating the life-cycle costs of operations TSM&O strategies is often complex. Compared with more traditional infrastructure improvements, TSM&O improvements typically incur a greater proportion of their costs as continuing operations and maintenance costs, as opposed to upfront capital costs. Much of the equipment associated with operations strategies also typically has a much shorter anticipated useful life than many traditional improvements and must be replaced as it reaches obsolescence. Planners and operations practitioners must fully consider and account for all the costs of operations strategies when evaluating and developing deployment and operations and maintenance plans. Failure to recognize and accurately forecast these costs may result in future funding or resource shortfalls, or worse, the inability to properly operate and maintain deployed TSM&O improvements.

The aforementioned TOPS-BC recommends the following structure for organizing cost data:

- **Capital costs—**These are upfront costs necessary to procure and install equipment related to the operations strategy. These costs will be shown as a total (one-time) expenditure and will include the capital equipment costs, as well as the soft costs required for design and installation.
- **Operations and maintenance costs—**These are continuing costs necessary to operate and maintain the deployed strategy, including labor costs. Without proper ongoing operations and maintenance, the full potential of TSM&O benefits cannot accrue. These operations and maintenance costs are typically presented as annual estimates.
- **Replacement costs—**These are the periodic costs of replacing and/or redeploying system equipment as it becomes obsolete and reaches the end of its expected useful life to ensure the continued system operation.
- **Annualized costs—**These are the average annual expenditure that would be expected to deploy, operate, and maintain the operations strategy and replace (or redeploy) any equipment as it reaches the end of its useful life. Within this cost figure, the capital costs will be amortized over the anticipated life

[7] It is noteworthy that several project stakeholders were members of the TOPS-BC Expert Panel during the development of the tool, including John Allen (NJDOT), Dennis Motiani (NJDOT), Laurie Matkowski (DVRPC), and Jim Hogan (formerly with NJDOT).

of each individual piece of equipment. This annualized figure is added with the reoccurring annual operations and maintenance cost to produce the annualized cost figure. This figure is particularly useful in estimating the long-term budgetary impacts of TSM&O deployments.

2.4 Summary of Recommendations for Institutional integration

Institutional recommendations for moving The Connected Corridor towards "best" from a regional and statewide perspective are summarized in Table 7. This list is not prioritized, although activities do serve as precedents for others, such as finalizing the operations objective before establishing performance measures. Additionally, some of these recommendations can be included in the CMM implementation plan previously discussed in terms of increasing the maturity level.

TABLE 7
Institutional Recommendations for Moving Towards "Better/Best" – Regional and Statewide

Lead Agency: All three MPOs (NJTPA, DVRPC, and SJTPO), in collaboration with NJDOT, New Jersey Transit, and other transportation agencies in the state.

- Formalize the IAC and its ongoing mission to update and maintain The Connected Corridor on a continuing basis, defining the IAC's membership and its responsibilities for moving the concept forward to reality, including updating the Strategic Plan and NJ ITS Architecture on a recurring basis. Other responsibilities of the IAC may include finalizing operations objectives and performance measures as noted below. Additional discussion of the potential IAC role in this regard is provided in Section 5.
- Continue and expand on the current mechanisms for regular coordination and cooperation between transportation agencies, enforcement, MPOs, and other entities, including operators and planners (e.g., Complete Team activities, construction coordination and incident management and special event management provided by TRANSCOM and DVRPC). This includes developing and executing formal interagency agreements in support of multimodal operations strategies, and defining the respective agency roles and responsibilities for a variety of operational scenarios.
- Continue ongoing activities to formally adopt the objectives-driven, performance-based approach to metropolitan planning as recommended by FHWA as a means to meet federal transportation planning requirements for the inclusion of "operational and management strategies to improve the performance of existing transportation facilities."
- Refine and finalize the outcome-based operations objectives (as listed in Table 6), with each objective consisting of specific, measurable and time-bound statements of performance that will lead to accomplishing The Connected Corridor goals (note: sample operations objectives are included in this Strategic Plan).
- Develop a manageable set of performance measures and metrics based on the selected objectives. These performance measures should then be used in the planning process to analyze, select, and prioritize operations strategies and other transportation improvements. The performance measures will also subsequently be used to monitor and evaluate deployed strategies and systems. This effort should be coordinated with the measures being identified by FHWA in accordance with MAP-21.
- Create standard performance reports, including dashboards, for internal use (e.g., identify trends in performance to target specific problems), for decision-makers and for the traveling public.
- Establish and document common performance terminology, definitions, and analytics across all agencies within the state, coordinating with New York and Pennsylvania.
- Develop a consistent approach, including identifying standard tools (e.g., TOPS-BC), for analyzing and prioritizing TSM&O projects—one that considers estimated life cycle costs and associated benefits. This should also include providing training on the selected tools to transportation operations and planning staff throughout the state.

Note that these institutional recommendations for The Connected Corridor are not new endeavors, per se, but rather a continuation, expansion, and/or formalization of activities already underway, with an increased emphasis on TSM&O as appropriate. For example, the three MPOs already use a form of performance-based planning — in accordance with the federally required congestion management process — to select appropriate investments that best respond to the regions' critical transportation needs. A number of the long-range plans address TSM&O and include high-level operations objectives (although they are not SMART as previously discussed). And collaboration between New Jersey's planners and operators is the focus of the Complete Team activities — modeled on the FHWA's Planning for Operations initiative — which focuses on a number of linked goals, including a more integrated transportation planning process, comprehensive data sharing, cooperative performance measure development and use, and cohesive use of the NJDOT congestion management system and the MPO's congestion management program.

SECTION 3
The Connected Corridor from an Operations Perspective

TSM&O strategies and their application may also be viewed as part of a "good-better-best" operations continuum. In addition to the CMM for evaluating and improving the institutional processes (as discussed in the previous section), FHWA is also developing capability maturity frameworks for several operations strategies including traffic management, incident management, emergency management, road weather management, and special event management. These operations frameworks consist of the same six dimensions and four levels as previously described for institutional integration.

Based on the preliminary capability maturity framework for traffic management, this operations continuum can be described as follows, with a graphical view of the continuum provided in Figure 6:

- **Good—**Agencies implement traffic management to address immediate concerns. Traffic management approaches are operator-driven and either static or based on time-of-day.
- **Better—**Traffic management is applied on more of a system-wide basis, using advanced strategies and technologies, and with a degree of automation.
- **Best—**Traffic management is integrated at the corridor and regional level, and includes all modes and facility types. Automation of traffic management processes is based on historical, current, and predicted data. New and emerging technologies are deployed on a continuous basis to improve system efficiency and operational benefits.

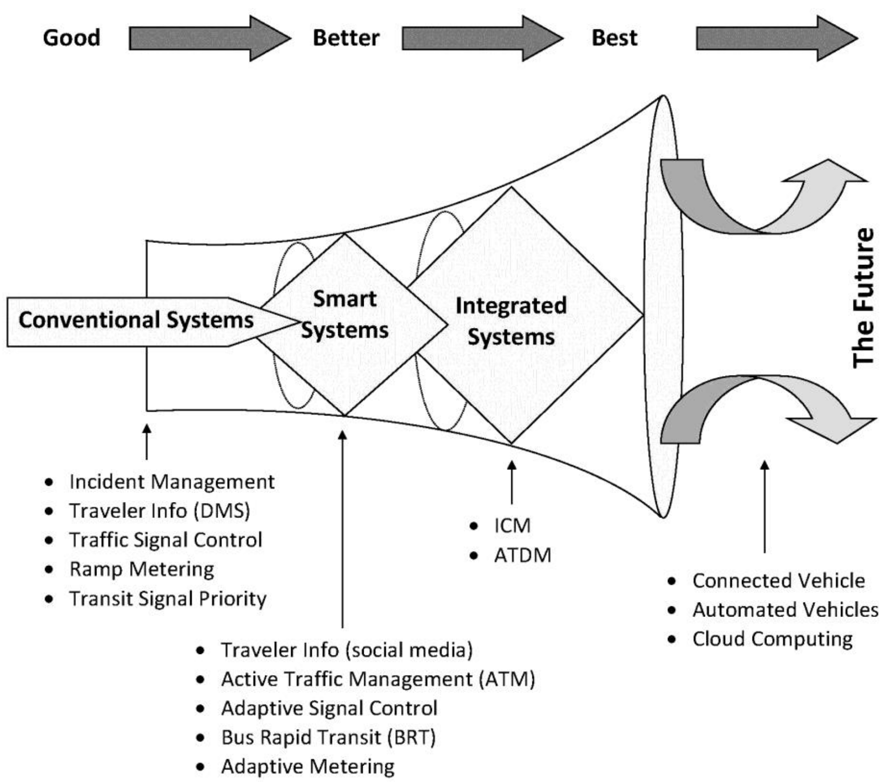


FIGURE 6
Continuum of Operations Strategies

The rest of this section identifies where New Jersey transportation agencies are in terms of "good-better-best" and includes potential recommendations for moving along this operations continuum towards "best." The term "potential" is used to describe these operational recommendations for a reason; some of the smarter and integrated (i.e., better and best) approaches may not be appropriate for every facility and/or location within the state. Each strategy and/or approach will need to be analyzed as part of the aforementioned objectives-driven, performance-based planning process, including a comparison of the estimated benefits and costs, to identify specific TSM&O projects and to ensure that these strategies and projects will help solve an existing or future need and problem, and do so in a cost-effective manner throughout the system's life cycle. In some cases — particularly for strategies and operational concepts that are new to the state — it might be worthwhile to first implement a pilot project to test the strategy's overall effectiveness. Once the strategies are prioritized and programmed (including the time frames for their deployment), additional analyses will be required (e.g., during concept development) to finalize the specific locations and network segments where the strategies will be deployed. When it comes to operations and ITS, Voltaire's statement that "best is the enemy of good" may sometimes be applicable, depending on the strategy and the proposed locations for deployment.

Once selected and funded, each strategy and the associated technologies need to be designed and implemented in accordance with the principles of system engineering. Moreover, once deployed, dedicated funding is necessary for the ongoing operations and maintenance of the strategies and supporting technologies to ensure the TSM&O benefits continue to accrue long into the future.[8]

The operational recommendations are divided among 10 program areas shown in Tables 8 and 9. Table 8 indicates the extent to which these TSM&O program areas help to achieve The Connected Corridor goals, while Table 9 identifies the agencies that will be involved in each program area. Overlaps exist between many of the program areas; for example, traveler information (identified as a separate program area) is also an integral part of freeway management, transit management, arterial management, commercial vehicle operations, and regional integration. Moreover, multimodal and regional integration can impact the operations and supporting technologies for nearly all of the other program areas. It is therefore important to remember that the paradigm of program areas used in The Connected Corridor plan is merely a model for structuring and organizing the discussion and should not be viewed as a rigid form of classification.

Table 10 summarizes the operations recommendations for The Connected Corridor, providing the following information:

- Program area
- Where New Jersey stands in the program area in terms of "good- better-best." This is not a grade relative to other states and regions across the country but a general assessment against the capability maturity framework for traffic management as noted in the beginning of this section.
- Associated strategies for moving the state towards "best"
- Potential locations for the deployment of these operations strategies
- Additional explanatory information

For several of the TSM&O strategies identified in Table 10, additional details are provided in Appendix A.

[8] Management support and funding commitments for TSM&O are part of the institutional framework as discussed in Section 2.

TABLE 8
TSM&O Program Areas and Contribution to Achieving Goals

TSM&O Program Areas	The Connected Corridor Goals						Sample Operations Strategies
	Mobility	Reliability	Economic Competitiveness	Environment and Resiliency	Safety and Incident Management	Accessibility	
Freeway Management	●	●	●	●	●	◐	Active traffic management (dynamic speed limits, dynamic shoulder lanes)
Incident Management	◐	●	●	●	●	◐	Expanded service patrols, inlcuding arterial streets
Transit Management	●	●	◐	●	●	●	Transit signal priority
Arterial Management	●	●	◐	●	◐	◐	Signal retiming program inlcuding adaptive signal control
Traveler Information	●	●	●	●	●	●	Additonal information, provided on more of a multimodal basis
Multimodal and Regional Integration	●	●	●	●	●	●	Integrated corridor management
Electronic Payment	●	●	●	●	◐	●	Greater integration across modes; potential for more variable pricing
Commercial Vehicle Operations	◐	●	●	◐	●	◐	Exapnd ITS along major freight routes; establish "virtual" freight corridor
Climate Change Adaptation	◐	●	◐	●	●	●	"Harden" critical ITS infrastructure and transportaiton management centers
Data Management	●	●	●	●	●	●	Single multimodal data warehouse – statewide and with other states

Table key:
● = major contribution ◐ = some contribution ○ = minimal contribution

TABLE 9
TSMO Program Areas and Involved Agencies

	Agencies					
TSM&O Program Areas	**NJDOT**	**New Jersey Turnpike Authority**	**New Jersey Transit**	**MPOs**	**Local Agencies and Counties**	**Other States**
Freeway Management	●	●		●		●
Incident Management	●	●	●	●	●	●
Transit Management	●	●	●	●	●	●
Arterial Management	●		●	●	●	
Traveler Information	●	●	●	●	●	●
Multimodal and Regional Integration	●	●	●	●	●	●
Electronic Payment		●	●	●		●
Commercial Vehicle Operations	●	●		●	●	●
Climate Change Adaptation	●	●	●	●	●	●
Data Management	●	●	●	●	●	●

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

Program Area			**Freeway Management**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Filling in geographic gaps with respect to ITS deployment	Potential segments include: • Western sections of I-80 and I-78 (i.e., west of I-287) • I-195 east of New Jersey Turnpike Interchange • Garden State Parkway south of I-195 • I-287 north of I-80 • I-295 from Delaware state line to Camden The Atlantic City Expressway	This involves expanding coverage of current systems and ITS devices, such as surveillance and detectors to measure traffic flows, closed-circuit television, dynamic message signs, and communications.
			Implementing active traffic management (ATM) strategies along selected segments throughout the state	Potential segments include: • I-287 (between I-95 and I-80) • I-78 (between I-287 and NY) • I-80 (between Route 15 and the George Washington Bridge) • I-280 • I-295 (between Routes 42 and 38) • I-76, Route 42, and I-676 • I-195 (between New Jersey Turnpike and I-295)	ATM strategies include dynamic speed limits, dynamic lane control, queue warning, dynamic shoulder lane, and junction control. An ATM study is underway for NJDOT to identify and prioritize specific segments and associated ATM strategies for deployment.
			Investigating the feasibility of ramp metering throughout the state	Statewide — need to conduct a feasibility study to determine optimum segments and associated ramp locations	Feasibility effort needs to consider ramp storage, acceleration lanes, metering rates, and adaptive metering that addresses mainline, ramp, and parallel arterial volumes in real time over an entire segment to determine metering rates.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

Program Area			**Incident Management**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Expanding coverage area of safety service patrols (SSP) as appropriate	Freeway segments where regular SSP coverage is not provided include the following: • Far west segments of I-80 and I-78 • Southern-most segment of I-295 • Northern segments of I-287 SSP coverage should be included along any and all segments where ATM and/or integrated corridor management (ICM) are deployed Implementing SSP along major arterial routes should also be considered and analyzed	NJDOT already has a robust program of SSP. The patrols cover 225 linear miles of interstate and state highways, where they assist motorists whose vehicles have become disabled as a result of a crash, a mechanical failure, or other cause and provide safety for emergency responders.
			Expanding traffic incident management (TIM) teams	Statewide, as appropriate	Such TIM teams to support interagency collaboration and coordination have been successfully used for major special events. NJDOT and the New Jersey State Police have formed incident management response teams whose members have been trained to respond to incidents that have a major impact on traffic flow. DVRPC manages several traffic incident management task forces and develops/maintains diversion route plans. This recommendation involves examining the expansion of such an approach throughout the state.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

			Implementing automated linkages and data exchange protocols between transportation management centers (TMC) and police computer-aided dispatch (CAD) systems	Statewide, focusing first on the John A. Cifelli Statewide Traffic Management Center in Woodbridge, N.J. and State Police; linkages with local police and fire should also be considered	Linkages and protocols must ensure that personally identifiable information from the police CAD is never transmitted to the TMC.
			Utilizing ATM and ICM to enhance incident management activities	Refer to ATM and ICM summaries for potential locations	ATM (i.e., dynamic speed limits and dynamic lane assignment) can be used to reduce speeds and provide advance lane closures in the area of an incident and queue warning can reduce secondary incidents and crashes.
Program Area			**Transit Management**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Seeking opportunities to update and standardize ITS-based technologies and systems throughout New Jersey Transit.	New Jersey Transit operations centers, systems, and rolling stock	Some of the existing ITS-based technologies are relatively old; for example, New Jersey Transit is still using track circuits in many locations resulting in varying degrees of accuracy. Additionally, as is the case with systems that have been implemented over several years, there are multiple operations centers in geographically-separated locations, with multiple legacy systems with multiple configurations.
			Implementing real-time monitoring of park-and-ride lots (i.e., number of available spaces) and available transit seating	Locations to be determined; initial priorities would be the major parking lots that are frequently filled, as well as lots and transit vehicles serving the ICM corridors	Information to be used in support of integrated traveler information and ICM. While not a TSM&O activity, per se, the feasibility of expanding or increasing the capacity of selected lots should also be investigated.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

			Implementing transit signal priority (TSP) and bus rapid transit-like improvements	Arterials for TSP to be determined; initial priorities could be the arterials and bus routes within ICM corridors and any arterials with frequent bus headways where congestion impacts bus operations and maintaining schedule adherence is difficult; TSP also applicable to light rail operations	TSP detects when a bus or light rail vehicle is nearing a signalized intersection and manages signal operation, turning the traffic signals to green sooner or extending the green phase, thereby allowing the bus or light rail vehicle to pass through more quickly. New Jersey Transit is in the process of examining TSP for several routes.
			Investigate application of bus on shoulder operations	Freeway segments with relatively frequent bus service and adequate shoulders in terms of width and structural capability to accommodate buses	A related arterial application would be to designate the curb lane only for buses; TSP would likely also be implemented. It would be necessary to determine the impact on traffic flow as a result of dedicating one lane to buses.
Program Area			**Arterial Management**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Updating signal timing parameters on state and local arterials on a more frequent basis as needed	Statewide, including local systems	The ITE 2012 National Traffic Signal Report Card gave an overall D+ for the United States as a whole. NJDOT is developing a signalization master plan ("T1-T6" effort, with each of the six tiers equating to an increased level of traffic management, from T6 [isolated intersections] to T1 [adaptive signal control]).
			Expanding adaptive signal control operations throughout the state as appropriate	Locations to be determined; initial priorities could be the ICM corridors that are not identified for TSP; other corridors will likely be identified as part of the signalization master plan (Level T1)	Adaptive traffic signal control continuously monitors arterial traffic conditions and the queuing at intersections to dynamically adjust the signal timing parameters to smooth the flow of traffic along coordinated routes and to minimize overall stops and delays.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

			Increasing the livability of local communities	Statewide	While not a specific TSM&O strategy, per se, many of the other operations recommendations (e.g., TSP, transit parking lot information, increased information on choices for travel, incident management) can be applied to enhance safety, reliability, environment, and accessibility at the local level, thereby enhancing overall livability.
Program Area			**Traveler Information**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Collecting and displaying additional information as previously noted (e.g., monitoring of park-and-ride lots, additional instrumentation of roadway segments, queue warning and other information provided by ATM)	Refer to ITS gaps under "Freeway Management," potential ATM locations, and potential ICM locations	In addition to being used for traveler information, increased real-time data are required for many of the advanced TSM&O strategies identified herein, including ATM, TSP, adaptive signal control, ICM, and climate change adaptation. The increased data also require increased management.
			Integrating traveler information and providing it on a multimodal basis	Statewide: such as, including transit information on NJ 511 in an integrated fashion along with roadway information; dynamic message signs along ICM roadways — prior to exits for transit stations — showing comparative travel times for New Jersey Transit rail and freeway to common destinations	All the New Jersey transportation agencies have robust programs for traveler information — dynamic message signs (travel times, next transit vehicle arrival), web, use of social media (particularly New Jersey Transit). Information can be better integrated such that travelers do not need to switch between mode-specific websites and applications.

TABLE 10

Program Areas and Operations Recommendations for The Connected Corridor

Program Area			**Multimodal and Regional Integration**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Continuing coordination with other states in terms of information sharing, incident management during major events, construction activities, and an overall commonality of operational approaches	Adjacent states such as New York, Pennsylvania, and Delaware, as well as Connecticut and Maryland, and beyond depending on the scenario	This strategy is already provided to a great extent via TRANSCOM, the I-95 Corridor Coalition, and DVRPC (a multistate MPO) as noted below and discussed in Section 2.
			Deploy Integrated Corridor Management (ICM) systems throughout State.	Potential corridors include: • The I-495 corridor between the NJ Meadowlands and the Van Wyck Expressway in NYC • The NJ Northeast Corridor along route US 1 & 9 including the NJ Turnpike & Garden State Parkway / NJ Transit & Amtrak's Northeast Corridor Rail Line between Woodbridge & Jersey City • Garden State Parkway / NJ Transit North Jersey Coast Line • I-80 / NJ Transit Gladstone, Morristown, Montclair – Boonton Lines / Rt 46 / Other Parallel Routes • Garden State Parkway / NJ Transit Main and Bergen County Lines / Rt 17 • Parallel Routes (County Road 551) • Atlantic City Expressway / Rt 42 / NJ Transit Atlantic City Line / US 30	Inter-agency and regional coordination has long been a mainstay of transportation entities in New Jersey – as well as New York and eastern Pennsylvania – particularly during major incidents and construction activities, special events, and extreme weather conditions. This regional coordination has been greatly supported and promoted by TRANSCOM, including automated information and video sharing between numerous public agencies via their OpenReach System. DVRPC also promotes and proactively supports inter-agency coordination in the Philadelphia region, such as their various incident management coordination activities and information and video sharing via their Regional Integrated Multi-Modal Information Sharing (RIMIS) project, using the same platform as TRANSCOM's Open Reach.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

			Deploying ICM systems throughout state. While The Connected Corridor is a strategic concept and programmatic framework, ICM consists of the operational coordination of multiple transportation networks and cross-network connections comprising a corridor on an ongoing and regular (i.e., daily) basis.	Potential corridors include: • The I-495 corridor between the New Jersey Turnpike and the Hudson River crossings (and into New York to the Long Island Expressway), including I-95, US 1 and 9, and Northeast Corridor Rail between Woodbridge and the Holland Tunnel (this potential ICM corridor was recently included in an application to FHWA) • Garden State Parkway and New Jersey Transit North Jersey Coast Line • I-80 and New Jersey Transit Gladstone, Morristown, Montclair-Boonton Lines, Route 46, and other parallel routes • I-78, New Jersey Transit Raritan Valley Line, and other parallel routes • Garden State Parkway, New Jersey Transit Main and Bergen County Lines, and Route 17 • I-295 and New Jersey Turnpike Corridor, plus other parallel routes (County Road 551) • Atlantic City Expressway, Route 42, New Jersey Transit Atlantic City Line, and US 30 • Garden State Parkway and Route 9	Interagency and regional coordination has long been a mainstay of transportation entities in New Jersey — as well as New York and eastern Pennsylvania — particularly during major incidents and construction activities, special events, and extreme weather conditions. This regional coordination has been greatly supported and promoted by TRANSCOM, including automated information and video sharing between numerous public agencies via their OpenReach System. DVRPC also promotes and proactively supports interagency coordination in the Philadelphia region, such as their various incident management coordination activities and information and video sharing via their Regional Integrated Multimodal Information Sharing (RIMIS) project, using the same platform as TRANSCOM's Open Reach. The I-95 Corridor Coalition supports traveler information, incident management, and commercial vehicle operations along the eastern seaboard and provides a forum for key decision- and policy-makers to address transportation management and operations issues of common interest.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

Program Area			**Electronic Payment**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Providing greater integration between modes (e.g., roadway, transit, and parking payment mechanisms) for electronic payment; examples include using the fare card for and between different transit agencies (New Jersey Transit, Port Authority Trans-Hudson Corporation, Southeastern Pennsylvania Transportation Authority) and a common back office and invoicing process for tolls and transit fares.	Statewide and coordinating with New York and Pennsylvania	The concept of a single regional electronic tag and a single monthly invoice incorporating all toll facilities in the northeast was very cutting edge when E-Zpass® was first introduced. The concept has subsequently expanded to include most of the east coast (Maine to North Carolina). Other enhancements have included high-speed toll lanes and using E-Zpass® for other payments (e.g., parking at the New York area airports). Similarly, New Jersey Transit has introduced advanced fare payment technologies, including MyTix that provides customers the convenience of buying rail tickets and passes securely from a mobile device. The agency also provides a contactless payment system using certain credit and debit cards and specially equipped mobile phones on selected bus routes and at the Newark Liberty Airport AirTrain Station.
			Introducing more variable tolls and transit fares that are adjusted by time of day and/or congestion levels	Statewide	This is a form of congestion pricing.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

			Investigating the feasibility of ultimately replacing the fuel tax with a mileage-based road usage charge	Statewide, coordinating with adjacent states and the I-95 Corridor Coalition	Total fuel tax receipts have not kept up with the transportation funding needs. This overall funding gap can only be expected to grow as the average fuel economy of the American vehicle fleet improves in accordance with Corporate Average Fuel Economy standards, and as the emerging fleet of electric vehicles and plug-in hybrid electric vehicles become more ubiquitous along the roadways. Many policy-makers and industry analysts across the nation agree that the fuel tax can no longer be relied upon to provide sustainable revenues for improving, operating, and maintaining the nation's roadway infrastructure. This widening gap between the most and least fuel-efficient vehicles has led to an issue of fairness. The user pays principle, requiring that all users of the roadway should pay their fair share based on their use of the transportation network, is accepted by consumers in other market places such as utilities. Several states have conducted road usage charge pilots, looking at issues of available technology, cost, privacy, and the involvement of the private sector.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

Program Area			**Commercial Vehicle Operations**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Enhancing the traveler information sources previously noted to include truck-specific information; this can include tailoring traveler information specifically for the freight community (via a website and apps)	Per the *New Jersey Statewide Freight Plan Phase II: Priority Highway Corridors* (NJDOT, 2007), the major freight corridors in the state are: • East-west freight corridor (I-78 and I-80) • North-south freight corridor (I-95, New Jersey Turnpike, and I-295) • Bergen County Connector freight corridor (New Jersey Route 17) • Northeastern New Jersey Beltway freight corridor (I-287)	An example of truck-specific information website (although not providing real time traffic conditions) is DVRPC's PhillyFreightFinder — a dynamic, web-based mapping application that pinpoints freight facilities and freight activity in the Philadelphia-Camden-Trenton region and contains 20 individual layers and over 350 features of infrastructure and facilities, all customizable by the user. Such an approach could be developed for all of New Jersey, including a layer showing real-time traffic and roadway conditions.
			Investigating and incorporating truck considerations and issues in the operations of the TSM&O strategies recommended herein; for example, adding SSP vehicles specially designed and equipped to deal with incidents involving large trucks and varying speed limits along major freight routes (via ATM) to better accommodate truck operations and movements	Major freight corridors as noted above	Application of dynamic shoulder lanes may reduce congestion thereby improving reliability for freight operations. When considering junction control or ramp metering at interchanges frequently used by trucks, acceleration and deceleration lanes need to be examined and incorporated into the operational concepts.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

			Pursuing and implementing the recommendations being developed as part of the Comprehensive Regional Goods Movement Action Program for the New York-New Jersey Metropolitan Region (G-MAP), which is a joint initiative of the Port Authority, NJDOT, and NYSDOT.	Statewide and beyond; recommended G-MAP early actions that may impact operations and ITS include: • Streamlining permitting for oversize and/or overweight vehicles across jurisdictional boundaries, including the design and interface of a single customer application and response • Designating an I-95 virtual freight corridor integrating ITS components and shared enforcement information • A New York-New Jersey freight open data portal to provide a coordinated, system-wide approach to make it easily accessible to the public and industry	The purpose behind G-MAP is to develop a comprehensive long-term regional goods movement plan for the New York/New Jersey region that establishes a framework and action plan for identifying and prioritizing freight strategies and projects within a 30-year planning horizon.
Program Area			**Climate Change Adaptation**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Using the enhanced traveler information, ATM, ICM, and other TSM&O strategies previously noted to support traffic operations prior to, during, and following an extreme weather event, including supporting the management of evacuations (and the returning movements)	Statewide	The impacts of and responses to Hurricane Irene and Superstorm Sandy highlight how important adaptation can be, including utilizing TSM&O strategies and supporting ITS. It should be noted that FHWA recently issued a Climate Change and Extreme Weather Resilience Order (5520) stating that it is FHWA policy to integrate consideration of climate and extreme weather risks into its planning, operations, policies and programs.

TABLE 10
Program Areas and Operations Recommendations for The Connected Corridor

			Investigating the need and prioritizing locations in terms of hardening critical ITS infrastructure and TMCs, followed by the associated improvements to the infrastructure (this is one of the lessons learned from Superstorm Sandy)	Statewide	Hardening may include back-up generators for TMCs, remote back-up servers, battery back-up for key signage along the roadway, and back-up communications to such signage, so that the technologies can continue to function during and immediately after severe weather events.
			Investigating the deployment of additional ITS infrastructure to collect weather-related data and integrating the data into the operations and decision-making processes	Statewide, focusing on vulnerable facilities, evacuation routes, and alternative routes.	Examples include environmental sensor stations for monitoring condition of roadway (e.g., fog, wind, and pavement condition), bridge scour monitors, and internal sensors in bridges, pavement, and rails to monitor structural fatigue during excessive heat.

TABLE 10

Program Areas and Operations Recommendations for The Connected Corridor

Program Area			**Data Management**		
Current Performance Outcome					
Good	**Better**	**Best**	**Recommended Strategy**	**Application (Strategy Locations)**	**Additional Information**
			Developing and implementing a data warehouse, which would be a central repository —real or virtual —of integrated data from multiple (and disparate) agencies and sources, across all modes and also include data management features and online access for use by all Connected Corridor stakeholders	Statewide and possibly adjacent states; a key issue to be resolved is to identify the entity within the state that will be responsible for developing and managing the data warehouse; another issue is the extent to which data from the private sector can be integrated and/or accessed	Most of the recommended operations strategies require an increased level of data and "Connected Vehicles" (as discussed in the last section) could significantly increase the amounts of available data. This strategy involves integrating existing and future databases (e.g., TRANSCOM Open Reach and the recently added data fusion engine, DVRPC RIMIS, NJDOT, New Jersey Transit, I-95 Corridor Coalition vehicle probe project [VPP] suite), providing a single access portal, consistent geo-referencing and formats, and data mining, in support of integrated traveler information, transportation planning and capital programming, performance management, and other Connected Corridor activities requiring data.

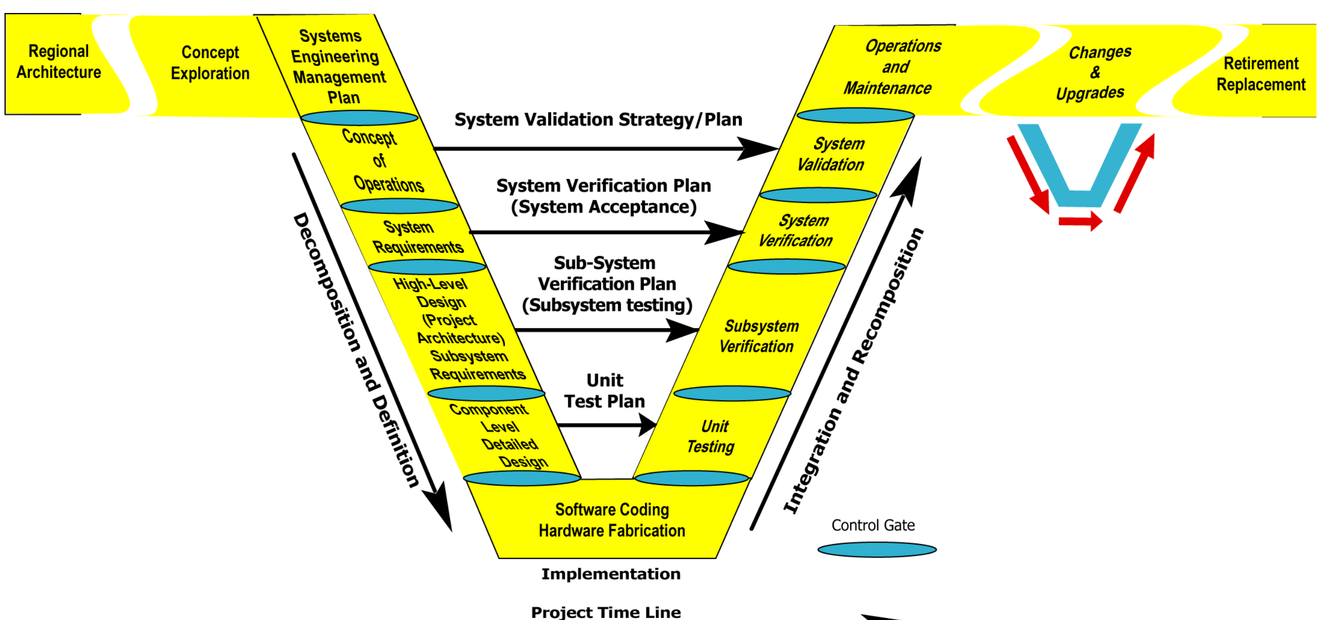
SECTION 4
The Connected Corridor from a Technical Perspective

As discussed in Section 1, ITS-based technologies are the enablers of TSM&O. In fact, advanced technologies have had a significant impact on travel demand and operations over the past few years. Virtual technologies, such as smartphone applications providing real-time traveler information, directly help to improve the transportation experience. In a broader sense, the “connectivity” offered by such technological enhancements is changing the way we think about transportation. For example, the Internet and cloud computing enable would-be commuters to work from home, thereby eliminating trips that would otherwise add to congestion, increase pollutant emissions, and potentially decrease safety. Moreover, as is discussed in the next section, emerging technologies such as the “Connected Vehicles” and autonomous vehicles will likely have an even greater impact on transportation compared to everything that has come before.

Technical integration in support of The Connected Corridor involves developing and subsequently implementing the means (e.g., communication links between agencies, system interfaces, and the associated standards) by which information and system control functions can be effectively shared and distributed among agencies and their respective transportation management systems. Most of this technical activity occurs during the action step as discussed in the introductory section and shown in previous Figure 3, with these technical considerations being performed in accordance with the principles of systems engineering — a process that is often shown as a “Vee” diagram (Figure 7).

This Connected Corridor plan does not include any specific recommendations regarding technologies or standards. Such decisions are typically made during the requirements and high-level design phases of the systems engineering process.

FIGURE 7
Systems Engineering “Vee” Diagram



One aspect of the systems engineering process addressed during The Connected Corridor project, shown in the upper left hand corner of Figure 7, is Regional Architecture. FHWA Rule 940 (23 CFR 940) requires ITS projects that are funded, in whole or in part, with the Highway Trust Fund to conform to the National ITS Architecture and standards. The rule states that "conformance with the National ITS Architecture is interpreted to mean the use of the National ITS Architecture to develop a regional ITS architecture, and the subsequent adherence of all ITS projects to that regional ITS architecture."

The TSM&O strategic planning effort included an update to the northern and southern New Jersey regional ITS architectures and the NJ ITS Architecture, which were last updated in 2005. More detailed discussions of the updated architectures are provided in other technical memoranda and deliverables, including a Turbo Architecture™ file. The overall approach and some of the key changes to the architecture are summarized below:

- A statewide / regional architecture offers a "30,000-foot view" of what a region or state looks like in terms of agency interconnections, data sharing links, and traffic monitoring and control capabilities at a given moment of time, and planned expansion of those capabilities.
- The NJ ITS Architecture update was based on guidelines developed by FHWA, focusing the evaluation and subsequent changes to the physical boundaries; changes in stakeholders (i.e., both new ones to be added and others to be removed); revisions to system inventories and services; and operational concepts and system functions that may have taken a new form, been dissolved, or newly created.
- Changes and updates were applied using the FHWA Turbo Architecture™ software product for representing the regional ITS architecture's current status, as well as accommodating The Connected Corridor vision and the institutional and operational recommendations.
- The existing south, central, and north ITS architectures (as defined in the 2005 update) were consolidated into a single NJ ITS Architecture representing all of New Jersey, while also ensuring compatibility with the neighboring regional architectures of the New York City metropolitan area and the Philadelphia area (DVRPC).

The National ITS Architecture identifies a series of transportation services for which transportation systems apply. These transportation services are addressed through 95 unique "service packages," where a service package[9] of different subsystems and communication flows needed to deliver a desired transportation service. Several new service packages were added and existing ones updated as part of Version 7 of the National ITS Architecture that was released in 2012. Table 11 partially lists these new and updated service packages included in the updated NJ ITS Architecture.

TABLE 11
New/Updated Service Packages Included in the Updated NJ ITS Architecture

Service Package	Change Since 2005	Corresponding TSM&O Strategy
AD02 – ITS Data Warehouse	Modified	Data Management
ATMS04 – Traffic Metering	Modified (was "Freeway Control")	Ramp metering
ATMS09 – Transportation Decision Support and Demand Management	Modified	ICM and ATM
ATMS22 – Variable Speed Limits	New	ATM
ATMS23 – Dynamic Lane Management and Shoulder Use	New	ATM
ATMS24 – Dynamic Roadway Warning	New	ATM

9 These were known as "market packages" in the 2005 update.

TABLE 11
New/Updated Service Packages Included in the Updated NJ ITS Architecture

Service Package	Change Since 2005	Corresponding TSM&O Strategy
ATMS25 – VMT Road User Payment	New	Mileage-based road usage charging
APTS09 – Transit Signal Priority	New	Transit Management/ICM
APTS11 – Multimodal Connection Protection	New	ICM
ATIS06 – Transportation Operations Data Sharing	Modified	ICM
EM09 – Evacuation and Re-Entry Management	Modified	Climate Change Adaptation
EM10 – Disaster Traveler information	Modified	Climate Change Adaptation
MC11 - Environmental Probe Surveillance	New	“Connected Vehicles” and environmental data
MC12 - Infrastructure Monitoring	New	Climate Change Adaptation

Another enhancement to the National ITS Architecture provided in Version 7 is the planning module in the Turbo Architecture™ tool that can be used to support the objective-oriented, performance-based planning process. Specifically, a broad set of goals were created with one-to-one correspondence to the planning factors identified in MAP-21. Each goal was then mapped to service packages in the National ITS Architecture. The user can select from a list of goals and/or objectives and use a key word search, and the tool will identify the relevant service packages for achieving the goal/objective. The planning module also allows the user to input performance measures associated with each objective. The relationship between these Turbo Architecture goals and The Connected Corridor goals is shown in Table 12.

TABLE 12
Relationship between National ITS Architecture Goals and The Connected Corridor Goals

Goals from Turbo Architecture™	Associated Connected Corridor Goals
Enhance mobility, convenience and comfort for transportation system users	Mobility/Accessibility
Enhance the integration and connectivity of the transportation system	Part of the vision statement
Improve the safety of the transportation system	Safety/Incident Management
Increase operations efficiency and reliability of the transportation system	Reliability
Preserve the transportation system	Inherent in all the goals
Reduce environmental impacts	Environmental Resiliency
Support regional economic productivity and development	Economic Competitiveness

It is noted that the objectives included in the architecture tool (as a pull-down menu) are not very useful as a planning tool. They are not SMART, tending to be very general in their description. In many cases, they are not even objectives. Several of them are really TSM&O strategies, program areas, or components (e.g., traffic signal management, traveler information, managed lanes, ramp management, transit signal priority, data collection, transportation management centers). Others are more like performance measures (e.g., travel time delay, incident duration, travel time reliability, mode shift, duration of congestion, planning time index, transit on-time performance). Moreover, the pull-down list of objectives is identical for each Turbo Architecture™ goal, with no recognition that different goals will have different types of objectives. Regardless, the Turbo Architecture™ objectives do not correspond to the list of potential outcome objectives as defined in the FHWA document *Advancing Metropolitan Planning for Operations*[10] on which the preliminary objectives for The Connected Corridor were based. Accordingly, the sample outcome-oriented objectives (listed in Table 6) were manually input into the final version of the Turbo Architecture™ tool for the NJ ITS Architecture.

[10]During the project, the CH2M HILL and AEA team discussed this issue with the FHWA ITS Architecture Team. FHWA plans to correct this in a subsequent update to the National ITS Architecture.

SECTION 5
The Future and Next Steps

5.1 Future Technologies and Applications

TSM&O and the enabling ITS technologies are always evolving. As such, the operations continuum — as shown in Figure 6 — is constantly in a state of flux. What was yesterday's "best" practices may now be merely "better" or just "good." Similar type changes can be anticipated in the future.

One particular area in this regard is "Connected Vehicles." The USDOT's Research and Innovative Technology Administration is the lead agency in "Connected Vehicles." There are several parallel initiatives:

Connected Vehicles Applications

- "Connected Vehicles" **safety** applications are designed to increase situational awareness and reduce or eliminate crashes through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) data transmission that supports: driver advisories, driver warnings, and vehicle and/or infrastructure controls. These technologies may potentially address up to 82 percent of crash scenarios with unimpaired drivers, preventing tens of thousands of automobile crashes every year.
- "Connected Vehicles" **mobility** applications provide a connected, data-rich travel environment. The network captures real-time data from equipment located on-board vehicles (e.g., automobiles, trucks, and buses) and within the infrastructure. The data are transmitted wirelessly and used by transportation managers in a wide range of dynamic, multimodal applications to manage the transportation system for optimum performance. This may have a significant impact on how data are collected and how the transportation network is managed. The traffic management and traveler information systems previously described have typically used sensor technologies embedded in, around, and/or above the road to determine real-time traffic flows, speeds, and travel times. Traveler information systems in New Jersey have benefited from E-ZPass® readers to use a relatively small, but increasing, sample of vehicles with toll tags to estimate segment travel times via the Transmit system. "Connected Vehicles" represent a major technical advancement that could lead to wholesale replacement of existing fixed detection subsystems by simply transmitting a basic message including identity, location, speed, and trajectory to roadside readers, other vehicles, and signal controllers. Eventual conversion of the fleet, where essentially 100 percent of vehicles communicate basic safety messages, would provide a whole new approach to a more refined and highly automated traffic management capability. Moreover, the "Connected Vehicles" capability will also include driver displays, perhaps eliminating the need for signs and supporting gantries along the roadway.

- “Connected Vehicles” **environmental** applications both generate and capture environmentally relevant real-time transportation data and use these data to create actionable information to support and facilitate “green” transportation choices. As an example, with real-time information on emissions, ATM and ICM strategies and operating parameters could be modified to minimize emissions. These data can also assist system users and operators with “green” transportation alternatives or options, thus reducing the environmental impacts of each trip. For instance, informed travelers may decide to avoid congested routes, take alternate routes, public transit, or reschedule their trip—all of which can make their trip more fuel-efficient and eco-friendly.

“Connected Vehicles” applications are also being focused on transit and commercial vehicle operations.

- The goal of the **transit** “Connected Vehicles” for mobility program is to improve public transportation by increasing transit productivity, efficiency, and accessibility; mitigating congestion in an integrated transportation environment; and providing travelers with better transportation information and transit services. The following three mobility applications have been selected as high-priority applications and are collectively identified as the Integrated Dynamic Transit Operations bundle:
  - **Connection Protection (T-CONNECT)—**Enables public transportation providers and travelers to communicate to improve the probability of successful transit transfers.
  - **Dynamic Transit Operations (T-DISP)—**Advances the concept of demand-responsive transportation services utilizing the global positioning system and mapping capabilities of personal mobile devices to enable a traveler to input a desired destination and time of departure tagged with their current location when requesting transit service.
  - **Dynamic Ridesharing (D-RIDE)—**Makes use of in-vehicle and hand-held devices to allow dynamic ride-matching, thereby reducing congestion, pollution, and travel costs to the individual with a low initial investment.
- Effective V2V and V2I deployments promise to reduce the number and severity of truck crashes. For example, the V2V truck safety program is addressing forward collision warning, blind spot/lane change warning, intersection movement assists, and electronic emergency brake lights. The V2I program is addressing curve speed warning and in-cab low bridge clearance warning.

The “Connected Vehicles” initiative promises to provide significant data to operators and information to drivers. Perhaps in the future, however, drivers will not even be needed. For example, Google™ has been testing self-driving cars on the California highway system. The vehicles are equipped with video cameras, radar sensors, and laser range finders that help them see the roadway and other vehicles. These autonomous vehicles are projected to be commercially available within the next 10 years (although many technological, legal, and institutional hurdles need to be overcome before these vehicles significantly penetrate the automotive market). But a possible future of connected vehicles, could allowfor significant increases in highway capacity (as provided by shorter headways) and near zero crashes, the definition of TSM&O and ITS — and what constitutes good, better, and best — could be something completely different from what the view is today.

5.2 Maintaining and Updating The Connected Corridor Concepts

This Connected Corridor plan, including the updated ITS architecture, is intended to be a “living” document. As the various recommendations are realized, the associated TSM&O programs and strategies are implemented, new operations priorities and strategies will emerge through the transportation planning process, and as the scope of ITS expands and evolves to incorporate new ideas and technologies, The Connected Corridor documentation will need to be regularly reviewed and updated to reflect these changes and new realities.

As with any worthwhile endeavor, The Connected Corridor concepts and framework need to be maintained and managed to ensure the goals and objectives are being met and that momentum and progress continues. This process is one of continual improvement and evolving with the region as its stakeholders make use of the architecture and the region's needs grow and change.

Updating these documents on a regular basis is an important part of the program planning and project implementation processes. By keeping current with the latest operational and technological developments (as incorporated in the architecture), stakeholder ideas for growth and progress can be synchronized, operations-oriented strategies and supporting ITS projects programmed, and systems built that will maximize the benefits for the traveling public.

The Connected Corridor vision and concepts should continue to be guided and led by a collaborative IAC, helping to ensure that the recommendations identified herein become reality, and regularly reviewing and updating this Strategic Plan and architecture as appropriate. As noted in Section 2, this will require formalizing the IAC and this ongoing mission and defining the IAC's membership and its responsibilities.

It is envisioned that the process would continue to be led by the NJTPA, which will be responsible for hosting the latest version of the Strategic Plan and Turbo Architecture™ on its website. NJTPA will also make the necessary updates to these Connected Corridor documents. The update process will require support and participation from stakeholders including DVRPC, SJTPO, NJDOT, New Jersey TRANSIT, New Jersey Turnpike Authority, TRANSCOM, Port Authority of New York and New Jersey, and various local MPOs including transportation management associations on the regional level.

Support will also be provided by the New Jersey Institute of Technology (NJIT). NJIT serves as NJDOT's ITS Resource Center (ITSRC) utilizing their vast knowledge of ITS as well as their exposure to the latest research in the field of ITS. NJDOT established the ITSRC at NJIT in 2008 as the primary research and technology resource for NJDOT's Transportation Systems Management Bureau. The main purpose of the ITSRC is to assist NJDOT in evaluating ITS technologies and optimizing strategies for deployment of TSM&O to meet the transportation needs of the state. The ITSRC enhances NJDOT's ITS resources through technology assessment, technology transfer and training, evaluation of ITS strategies and deployment scenarios, application of advanced transportation and traffic modeling tools for statewide transportation planning, management, and operation. ITSRC also is a valuable resource for data, such as ITS data warehouse, traffic counts, and geographic information system, as well as transportation models, such as corridor simulation models, regional travel demand forecasting, and activity-based models.

Some of the ongoing activities for maintaining and updating The Connected Corridor will include the following:

- **Goals—**The Connected Corridor goals were based on the transportation goals for the three MPOs within the state and current federal legislation (MAP-21). Should any of those goals be updated or modified, the goals for The Connected Corridor should also be reviewed and possibly updated.
- **Objectives—**A number of sample outcome- and activity-based objectives have been identified for each goal. These objectives need to be further vetted by the stakeholders and subsequently completed as SMART objectives, identifying measurable improvements (e.g., reduce recurring congestion by X percent) and a time period for achieving these stated improvements.
- **Performance measures—**Once the SMART objectives have been finalized, the associated performance measures will need to be defined and adopted by the New Jersey stakeholders. Ensuring that the selected performance measure are consistent with the measures identified by USDOT in accordance with the requirements of MAP-21 will also be necessary.
- **Mainstreaming operations into the institutional framework—**Following a two-year implementation period, another CMM workshop will be conducted to determine the levels of improvement in institutional mainstreaming. The results of this future workshop should be included in an updated

Strategic Plan, along with additional recommendations to further improve the levels of maturity (i.e., reaching "best").

- **Gap analysis—**As part of the strategic planning process, a gap analysis was conducted identifying where New Jersey transportation currently is with respect to the ultimate vision for several TSM&O programs. As new programs, strategies, and projects are implemented — as recommended in the Strategic Plan — New Jersey transportation will continue to reduce or eliminate these gaps as the stakeholders move from their current state of "good to better" towards "best." Such changes need to be identified and included in updated versions of the Strategic Plan. The definition of "best" could also change for some areas.
- **NJ ITS Architecture and the Turbo Architecture™ Tool—**Assuming the vision, goals, objectives, performance measures, and level of TSM&O deployment change, these changes should be reflected in the architecture. Such an effort may also include changing the list of stakeholders, the list of ITS elements (e.g., updating from "planned" to "existing"), interfaces between elements, applicable standards, and service packages. These and other changes may also be necessary when a new version of the National ITS Architecture is released.

It is envisioned that the IAC will meet quarterly to review any and all changes to the TSM&O environment within New Jersey (and beyond) in terms of institutional, operational, and technical attributes, and identifying any required changes to The Connected Corridor documentation. The responsibilities for project development, design, implementation, operation, and maintenance should continue to rest with the individual transportation agencies. Similarly, the MPOs will continue to be responsible for the transportation planning process in their respective regions (presumably following the objectives-driven, performance-based process as discussed herein).

Regularly maintaining and updating The Connected Corridor will help keep the concept and strategic framework as a useful and powerful tool that can guide the development of operations programs, support the development and acceleration of a pipeline of innovative projects that are linked to the state's and region's transportation goals, support an objectives-driven, performance-based approach to planning for operations, and enhance the movement of people and freight.

SECTION 6
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Appendix A
Additional Information on Program Areas and Selected Transportation System Management and Operations Strategies

APPENDIX A

Additional Information on Program Areas and Selected Transportation System Management and Operations Strategies

This appendix provides additional details on the program areas and some of the recommended strategies included in Table 10 (Chapter 3) for The Connected Corridor *Strategic Plan* (Strategic Plan). Each program area is identified, followed by a definition of the program area, related program areas, an assessment of the current operations and ITS technologies in New Jersey (i.e., "good," "better," and "best") and a summary of some of these existing transportation system management and operations (TSM&O) strategies and technologies; considerations for moving towards "best," followed by a list of some of the strategies that can be applied in moving towards "best."

After each program area description, additional details are provided on the several of these specific strategies. Some strategies would be new to New Jersey. Others currently exist, but can be expanded and/or enhanced as part of The Connected Corridor concept and framework.

In reviewing this information, it is important to remember the following:

- The assessment of good-better-best is based on the criteria contained in the Federal Highway Administration (FHWA) capability maturity framework (currently still in draft form) for traffic management as follows:
  - **Good—**Agencies implement traffic management to address immediate concerns. Traffic management approaches are operator-driven and either static or based on time-of-day.
  - **Better—**Traffic management is applied on more of a systemwide basis, using advanced strategies and technologies, and with a degree of automation.
  - **Best—**Traffic management is integrated at the corridor and regional level and includes all modes and facility types. Automation of traffic management processes is based on historical, current, and predicted data. New and emerging technologies are deployed on a continuous basis to improve system efficiency and operational benefits.
- Numerous recommended TSM&O strategies are included in Table 10 of the Strategic Plan. This appendix, however, includes only a subset of these strategies—the general focus being those strategies that would be relatively new if and when implemented in New Jersey, as well as strategies that have not been deployed on a widespread basis in the state. The reader should not infer that the strategies discussed herein are more important or have a higher priority as compared to those Table 10 strategies that are not addressed. The purpose of this appendix is to provide The Connected Corridor stakeholders with information on these newer strategies, assuming that these stakeholders are already knowledgeable about the more established and widely-deployed strategies (e.g., using closed circuit television [CCTV] to monitor flow and incidents, dynamic message signs [DMS] and the web for traveler information, safety service patrols). These established strategies and associated intelligent Traffic System (ITS) technologies are just as important to the overall success of The Connected Corridor.
- The state-of-the-practice for many of the newer strategies is continually (and often rapidly) evolving. As such, a potential responsibility of the ITS Architecture Committee (IAC) is keep abreast of any changes—including new information on benefits from deployments that occur in the future—and incorporate this information when updating The Connected Corridor documents.

Program Area: Freeway Management

Overall, freeway management and operations involves managing travel and controlling traffic through the application of policies, strategies, and actions to mitigate any potential impacts resulting from the intensity, timing, and location of travel and to enhance mobility on highway and freeway facilities.

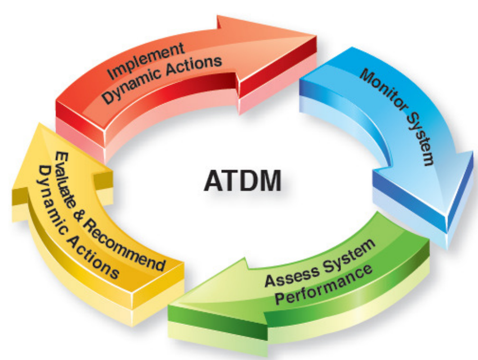
Related Areas: Incident Management, Traveler Information, Multimodal and Regional Integration, Electronic Payment, Commercial Vehicle Operations, Climate Change Adaptation, Data Management

Current Operations and Technologies in New Jersey: "Good" to "Better":

- New Jersey Department of Transportation (NJDOT) and the New Jersey Turnpike were early implementers of freeway management systems, with the New Jersey Turnpike being one of the first transportation agencies in the US to use variable speed limits over a significant stretch of roadway. New Jersey Turnpike recently updated their sign structures and DMS displays.
- Most of the major expressways in the state include detection for measuring traffic flows (e.g., average speeds, congestion levels) in real time, CCTV for monitoring operations and confirming reported incidents, and DMS for traveler information. Road weather information systems (RWIS) are also deployed.
- Most of the state's roadway network is managed from the John A. Cifelli Statewide Traffic Management Center (STMC) in Woodbridge, New Jersey (picture to the right), which houses the traffic management systems and staff for New Jersey Turnpike (including the Garden State Parkway), NJDOT, and the New Jersey State Police

- The Port Authority of New York and New Jersey's (Port Authority's) bridges and tunnels are also equipped with ITS technologies in support of real-time operations along these crucial facilities.
- Hard shoulder running is used along Route 29 for a short distance—a form of junction control. Hard shoulder running (currently called dynamic shoulder lanes by FHWA) also is used on the Newark Bay Hudson County Extension (as part of the Pulaski Bridge Project).
- The exclusive contra-flow bus lanes operating during the AM peak period from the New Jersey Turnpike through the Lincoln Tunnel to the Port Authority Bus Terminal are a prime example of the managed lanes concept with a transit focus.

Moving to "Best": The current freeway management systems tend to be "reactive"— not only in New Jersey, but throughout most of the United States. Freeway management in New Jersey should be enhanced to provide a more proactive approach based on prevailing and anticipated conditions to prevent delay and/or minimize breakdown conditions thereby optimizing the effectiveness, efficiency and safety of the freeway network. This dynamic management, control, and influence of traffic demand and traffic flow is known as "active transportation and demand management" (ATDM), which provides a proactive management approach over a traveler's entire trip chain. The focus of freeway management in this regard is during the trip.



Potential New/Enhanced TSM&O Strategies: Active traffic management (ATM) and ramp metering

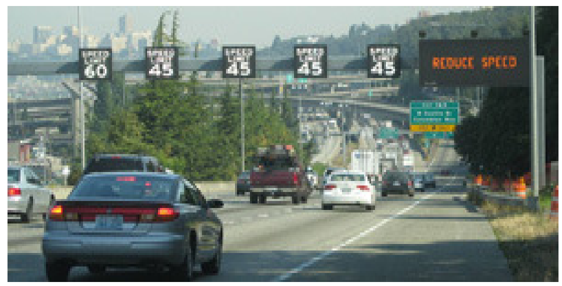
Strategy: Active Traffic Management Strategies

Description: The FHWA website (http://ops.fhwa.dot.gov/atdm/approaches/atm.htm) defines ATM as follows:

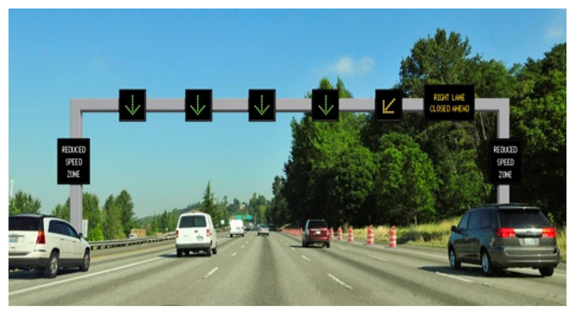
> *"Active traffic management (ATM) is the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions. Focusing on trip reliability, it maximizes the effectiveness and efficiency of the facility. It increases throughput and safety through the use of integrated systems with new technology, including the automation of dynamic deployment to optimize performance quickly and without delay that occurs when operators must deploy operational strategies manually. ATM approaches focus on influencing travel behavior with respect to lane/facility choices and operations."*

As part of an ATDM approach, ATM utilizes technology to make changes before conditions warrant—based on real time and anticipated congestion conditions—rather than in response to degraded operating conditions. Freeway-oriented ATM strategies are briefly described below.

Dynamic speed limits: This strategy, which has also been called variable speed limit, adjusts speed limit displays based on real-time traffic, roadway, and/or weather conditions. Dynamic speed limits can either be enforceable (regulatory) speed limits or recommended speed advisories, and they can be applied to an entire roadway segment or individual lanes. This "smoothing" process helps minimize the differences between the lowest and highest vehicle speeds.



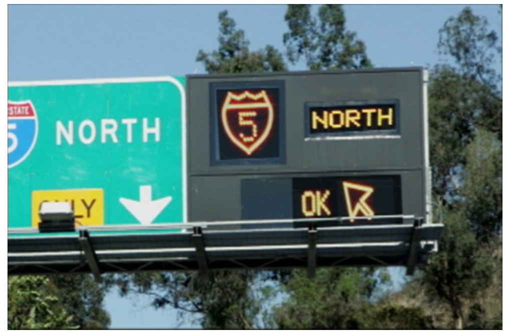
Dynamic lane assignment: This strategy, also known as dynamic lane use control, involves dynamically closing or opening of individual traffic lanes as warranted and providing advance warning of the closure(s), typically through dynamic lane control signs, to safely merge traffic into adjoining lanes. Dynamic lane assignment is often installed in conjunction with dynamic speed limits and also supports the ATM strategies of dynamic shoulder lanes and junction control.



Queue warning: This strategy involves real-time displays of warning messages (typically on DMS and possibly coupled with flashing lights) along a roadway to alert motorists that queues or significant slowdowns are ahead, thus reducing rear-end crashes and improving safety. The queue warnings may be included as part of speed displays and dynamic lane control.

Dynamic shoulder lanes: This strategy—also known as hard shoulder running or temporary shoulder use—allows drivers to use the shoulder as a travel lane based on congestion levels during peak periods and in response to incidents or other conditions as warranted during non-peak periods. This strategy is frequently implemented in conjunction with dynamic speed limits and dynamic lane assignment. It may also be used as a managed lane (e.g., opening the shoulder as temporary bus-only lane).

Dynamic junction control: This strategy consists of dynamically allocating lane access on mainline and ramp lanes in interchange areas where high traffic volumes are present and the relative demand on the mainline and ramps change throughout the day. For off-ramp locations, this may consist of assigning lanes dynamically (using signs) either for through movements, shared through-exit movements, or exit-only. For on-ramp locations, this may involve a closing a mainline lane upstream of a high-volume entrance ramp.



Lead Agency: NJDOT. NJDOT is currently analyzing the potential of ATM strategies along the limited access roadways the agency manages and operates. This effort will result in a prioritized list of roadway segments and the recommended ATM strategies, plus a concept of operations and requirements for an initial ATM implementation. The New Jersey Turnpike already has variable speed limits, albeit with very long distances between signs (relative to typical ATM installations). The Port Authority should also consider looking at this and other ATM strategies along the Turnpike and the Garden State Parkway. The same holds true for the Atlantic City Expressway.

Additional Information: ATM has been widely used in Europe. The FHWA 2006 international scan of ATM systems in Europe identified multiple benefits. Depending on the location and the combination of strategies deployed, specific ATM benefits measured in Europe included the following:

- An increase in average throughput for congested periods of 3 to 7 percent
- An increase in overall capacity of 3 to 22 percent
- A decrease in primary incidents of 3 to 30 percent
- A decrease in secondary incidents of 40 to 50 percent
- An overall smoothing of speeds during congested periods
- An increase in trip reliability
- The ability to delay the onset of freeway breakdown

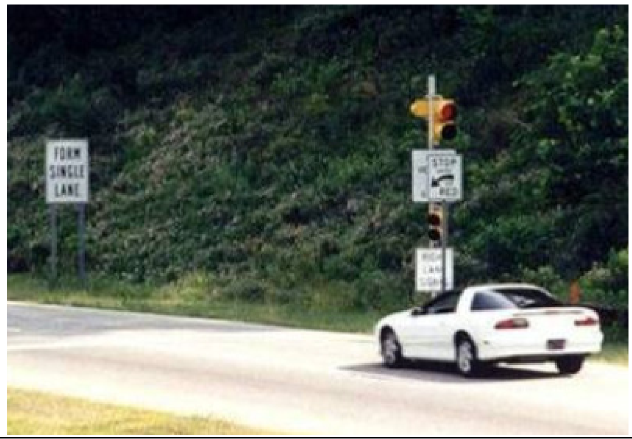
The deployment of ATM strategies is relatively new in the United States. Following are examples of benefits in this country:

- Dynamic speed limits (regulatory) and dynamic lane assignment were deployed along a 7-mile stretch of northbound Interstate 5 (I-5) just south of downtown Seattle, a corridor that was already actively managed via ramp metering, a robust incident management program, and traveler information. Measured benefits included the following:
  - A before and after study (3 years for each period) showed a 4.1 percent reduction in total crashes along the ATM segment.
  - The southbound segment of I-5 (without ATM) experienced a 4.4 percent increase in the number of crashes during the same period.
- Junction control was installed in Los Angeles at the northbound State Route (SR) 110 connector to northbound I-5. The system consists of blank out signs allowing the lane adjacent to the exit only lane to also be used as an exit lane during peak periods. This application of ATM resulted in the following benefits:
  - Traffic operations normalized in 2 to 3 weeks
  - Average ramp delay reduced from greater than 20 minutes to under 5 minutes
  - 30 percent reduction in crashes from previous year
- Dynamic speed advisories (i.e., not legal limits) and dynamic lane assignment strategies—along with converting high-occupancy vehicle lanes to high-occupancy toll lanes and using dynamic shoulder lanes for high-occupancy toll operations—were deployed in Minneapolis on Interstate 35W (I-35W), a corridor that was already actively managed via ramp metering, a robust incident management program, and traveler information. A formal evaluation indicated the following:
  - The dynamic speed advisories positively impacted the most severe congestion (speeds below 10 to 15 miles per hour [mph]).

- The instances and spread of extreme congestion waves has been reduced.
- On average, the morning peak experienced over 17 percent less congestion with the dynamic speed advisories in place.
- Crash reductions in the 6-month post-deployment period were realized on the order of 9 percent for fatal plus injury crashes and greater than 20 percent for property damage only and total crashes when the change in vehicle miles traveled was accounted for on I-35W.

Strategy: Ramp Metering

Description: Ramp metering involves installing traffic signal(s) on ramps to control the rate vehicles enter a freeway facility. Ramp metering smooths the flow of traffic onto the mainline, allowing more efficient use of existing freeway capacity. It also has shown to reduce crashes in the vicinity of ramps. The ATM-related strategy known as "adaptive ramp metering" should also be considered. Adaptive ramp metering utilizes traffic responsive or adaptive algorithms (as opposed to pretimed or fixed time rates) that can optimize either local or systemwide conditions. This in essence smooths the flow of traffic onto the mainline, allowing efficient use of existing freeway capacity.



Lead Agency: NJDOT. Ramp metering does not exist in New Jersey. As such, before deploying any metering, a statewide feasibility study should be initiated to analyze ramp metering and identify the optimum locations, if any, for metering. This will involve several considerations, including the following:

- Traffic flow problems and needs that ramp metering can help address (e.g., safety, recurrent congestion, supporting incident management activities)
- Ramp capacity and potential queues. Ramps must have adequate capacity and queue storage such that traffic does not back onto and disrupt traffic flow on the arterial street that feeds the ramp. It may be necessary to include ramp terminal treatments (e.g., queue detection, channelization, ramp widening, constructing turning/storage lanes on the feeding arterial, etc.) to offset impacts that result from metering operations.
- Potential for diversion along the arterial street network to avoid metered ramps. In general, ramp metering should be installed on all on-ramps along a stretch of freeway.
- Ramp metering algorithm and detection needs on the ramp and along the freeway, and possibly along the arterials.

Additional Information: Ramp metering benefits include safety and mobility. For example, consider the following:

- Portland, Oregon: 43 percent reduction in peak period collisions; 173 percent increase in average travel speed
- Seattle, Washington: 39 percent reduction in collision rate; 52 percent reduction in average travel time
- Minneapolis, Minnesota: 24 percent reduction in peak-period collisions; 16 percent increase in peak-hour travel speed
- Long Island, New York: 15 percent reduction in collision rate; 9 percent increase in average travel speed

Public outreach and information is essential. Ramp metering represents a form of positive control (i.e., regulating the rate that vehicles enter the freeway). But implementing metering and installing a traffic control device where none existed before can lead to the perception of a reduction in driving freedom by users. Accordingly, the institutional environment and stakeholder coordination may be the most important considerations when considering ramp metering. This should a public information program (including the media) and coordination with local jurisdictions and enforcement entities.

Program Area: Incident Management

Incident management (also known as "traffic incident management" is defined as the systematic, planned, and coordinated use of human, institutional, and technical resources to reduce the duration and impact of incidents—such as crashes, debris on the roadway, and work zone activities—and improve the safety of motorists, crash victims, and incident responders. These resources are also used to increase the operating efficiency, safety, and mobility of the surface transportation network by systematically reducing the time to detect and verify an incident occurrence; implementing the appropriate response; and safely clearing the incident, while managing the affected flow until full capacity is restored.

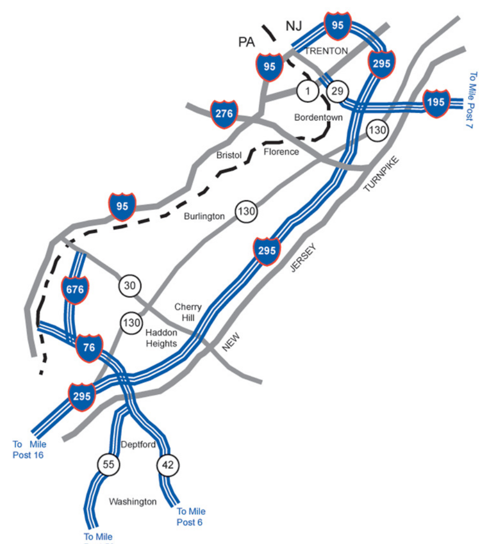
Related Areas: Freeway Management, Traveler Information, Arterial Management, Multimodal and Regional Integration, Commercial Vehicle Operations, Climate Change Adaptation, Data Management

Current Operations and Technologies in New Jersey: "Better": NJDOT has long had a robust incident management program; with average incident duration having been reduced by nearly 50 percent since 1995. The cornerstone of that program—as is the case with many incident management programs in the nations—is it safety service patrols (SSPs). They patrol 225 linear miles of interstate and state highways, assisting motorists whose vehicles have become disabled as a result of a crash, a mechanical failure, or other cause and provide safety for emergency responders. Assistance includes changing a flat tire, pushing a disabled vehicle off to the shoulder, pulling a vehicle trapped in mud or snow back onto the road, providing a small amount of gasoline and making minor repairs. SSP drivers also assist the New Jersey State Police and other secondary responders by promoting safety and diverting traffic during incidents and creating a safe work zone for emergency responders.

Locations: Routes currently covered by SSPs are shown below (i.e., the blue routes):

North (New Jersey Transportation Planning Authority [NJTPA])

South (Delaware Valley Regional Planning Commission [DVRPC])



Other incident management activities include the following:

- Incident detection via 911 and roadway detection and verification (and determining the appropriate response) via CCTV.

- NJDOT and the New Jersey State Police have formed Incident Management Response Teams (IMRT) whose members have been trained to respond to incidents that have a major impact on traffic flow.
- DVRPC manages several traffic incident management task forces (IMTF's) and develops/maintains diversion route plans.

Moving to "Best": Looking at expanding SSP operations to more routes, including major arterials. Integrating incident management activities with other operations recommendations herein, including using ATM strategies (e.g., reduced speed limits, dynamic lane control to close impacted lane[s] well in advance of the incident site), and queue warning) to support incident management activities and integrated corridor management (ICM) to support diversions around incidents as may be appropriates.

Program Area: Transit Management

Transit management involves implementing technologies and strategies to improve the operational efficiency, customer service and convenience, safety and security, and overall management of public transportation. Improving ridership is often a related objective for transit management.

Related Areas: Incident Management, Traveler Information, Multimodal and Regional Integration, Electronic Payment, Commercial Vehicle Operations, Climate Change Adaptation, Data Management

Current Operations and Technologies in New Jersey: "Good" to "Better": New Jersey Transit is New Jersey's public transportation corporation. Covering a service area of 5,325 square miles, New Jersey Transit is the nation's third-largest provider of bus rail and light rail transit, linking major points in New Jersey, New York, and Philadelphia. The agency operates a fleet of 2,027 buses, 711 trains, and 45 light-rail vehicles. On 236 bus routes and 12 rail lines statewide, New Jersey Transit provides nearly 223 million passenger trips each year.

New Jersey Transit applies ITS technologies to support operations and the related business areas of customer experience, safety and security, and financial performance. The role of ITS within New Jersey Transit is that of keeping clients informed and enhancing operational capabilities for their bus and rail services. Automated vehicle location is used to support real-time rail and bus operations and schedule adherence.

New Jersey Transit has a very robust traveler information system utilizing several different forms and technologies for information dissemination (as is described later under the "Traveler Information" program area). New Jersey Transit has also implemented transit signal priority (TSP) along Bloomfield Avenue in Essex County to reduce transit travel times and improve transit reliability.

Moving to "Best": Some of the existing ITS-based technologies are relatively old—for example, the rail is not as accurate as it could be and New Jersey Transit is still using track circuits in many locations—and there are varying degrees of accuracy. Additionally, as is the case with old technology and systems that have been implemented over several years, there are multiple operations centers in geographically separated locations, and multiple legacy systems with multiple configurations. Updating and standardizing ITS-based technologies and systems throughout New Jersey Transit would be helpful.

Transit operations should be better integrated with roadway operations (and vice-versa) via the application of ICM as is subsequently discussed under the "Multimodal Integration" program area. To the end, technology and systems should be deployed for obtaining real-time information on the number of available spaces in transit parking lots (and then providing that information, along with parking prices via traveler information strategies and technologies), and for additional TSP and bus rapid transit-like operational improvements.

Potential New/Enhanced TSM&O Strategies: Systems to monitor parking availability (in real time) at major New Jersey Transit parking facilities and additional TSP

Strategy: Real-Time Monitoring of Park-and-Ride Facilities and Seat Capacity

Description: One potential ICM strategy is to inform travelers of their options as to the best mode and/or route to take. Should the roadway options become severely congested—perhaps due to a major incident or construction activities—travel-time information can be provided in real time (such as on a roadway-mounted DMS as shown for the Integrated Traveler Information recommendation) to promote a modal shift to transit. However, if parking is available at or near a transit station or no seating is available on the train, then such an ICM approach probably does more harm than good.

This strategy would involve designing and implementing monitoring hardware and software—such as wireless sensors to detect parking space occupancy, or entrance and exit gate tracking, or some combination—at major transit park-and-ride facilities that are readily accessible from the roadways in the corridor. Automatic passenger counters technologies (e.g., treadle mats and infrared technology) and software may also be installed on transit vehicles within the corridor to count the number of passengers boarding and alighting a transit vehicle. Software monitors the passenger activity and uses an algorithm to determine the number of available spaces on the vehicle.

This real-time information on parking space and transit vehicle space can be used to determine if such comparative travel times should be displayed and modal shifts encouraged. The parking availability information, along with parking pricing, can also be distributed as part of other traveler information mechanisms such as New Jersey Transit apps and the state's 511 system. The data may also be stored and analyzed as part of the ongoing schedule assessments and updates. It may also be used in the future as part of demand-responsive parking pricing.

Lead Agency: New Jersey Transit

Locations: Unknown until a feasibility study is conducted coupled with a benefit/cost analysis in accordance with the objectives-driven, performance-based approach for metropolitan planning as discussed in the previous section. Another consideration with respect to locations is which corridors are selected for ICM strategies. (An initial list is subsequently provided herein as part of the ICM discussion.)

Additional Information: It is not uncommon for several park-and-ride facilities to fill up early during the AM peak period. For these locations, the feasibility analysis should also address adding parking capacity before implementing automated parking space monitoring.

Strategy: Transit Signal Priority

Description: Transit signal priority (TSP) manages the operation of traffic signals by using sensors, on-vehicle technology, and wireless communications to detect when a bus or light rail vehicle nears a signal controlled intersection, turning the traffic signals to green sooner or extending the green phase, thereby allowing the bus or light rail vehicle to pass through more quickly. Priority is typically "conditional," depending on such considerations as the amount of time (e.g., signal cycles) since the last priority was given, whether the bus or light rail vehicle is on schedule or not (i.e., generally there is no need for priority is the bus is currently operating on schedule), and the vehicle loading (i.e., number of passengers).

Lead Agency: New Jersey Transit, in concert with the owner/operator of the arterial used by the buses and the associated traffic signals

Locations: Unknown until a feasibility study is conducted coupled with a benefit/cost analysis in accordance with the objectives-driven, performance-based approach for metropolitan planning as discussed in the previous section. Such a feasibility study will need to address the following in identifying likely arterials for TSP:

- Buses and light rail vehicles experience significant delays at traffic signals, contributing to schedule reliability problems.
- Frequent bus and light rail vehicle headways exist along the route (e.g., 30 minutes or less), with sufficient bus and light rail loading (i.e., number of passengers).
- Automatic vehicle location system is in place for the buses and light rail vehicles along the route.

- Existing traffic signal controller hardware is compatible with TSP.
- Most, if not all, of the bus or light rail vehicle stops along route are far side (or can be relocated to far side).

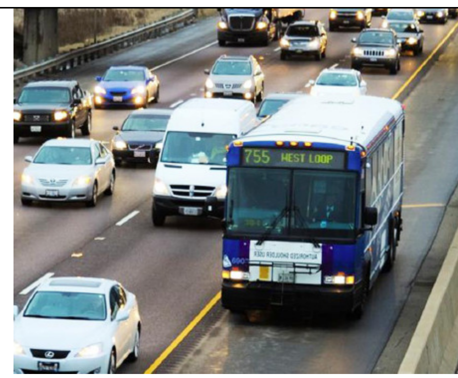
The most likely candidates for TSP likely will exist along major arterials within the larger metropolitan areas. Accordingly, NJTPA and DVRPC would be the metropolitan planning organizations (MPOs) most likely to be involved with TSP.

Additional Information: TSP has shown to improve average bus travel times. Following are examples:

- In Tacoma, Washington, the combination of TSP and signal optimization reduced transit signal delay approximately 40 percent in two corridors.
- TriMet (Portland, Oregon) was able to avoid adding one more bus by using TSP and experienced a 10 percent improvement in travel time and as much as a 19 percent reduction in travel time variability.
- In Chicago, PACE buses realized an average 15 percent reduction (3 minutes) in running time. Actual running time reductions varied from 7 to 20 percent, depending on the time of day.
- Los Angeles experienced as much as a 25 percent reduction in bus travel times with TSP.

Strategy: Bus on Shoulder Operations

Description: Bus on shoulder (BOS) operation is a form of dynamic shoulder lanes as described for ATM. Instead of opening the shoulder to all traffic, however, only buses are allowed to use the shoulder lane. Examples of this freeway-based strategy can be found in Minneapolis and northern Illinois (refer to picture to the left of the Illinois system). This strategy is also a form of bus rapid transit. An arterial version of this strategy is to assign the curb lane for buses (ether during peak hours, or an exclusive lane at all times). TSP is also typically used in conjunction with arterial bus lanes. An example of this strategy can be seen across the Hudson River in New York City along several major streets and avenues. These lanes are marked “Bus Only” or painted red as shown in the picture below.



Lead Agency: For BOS (freeway), NJDOT would be the lead agency, working with New Jersey Transit. For arterial lanes, New Jersey Transit would work in concert with the owner/operator of the arterial used by the buses and the associated traffic signals.

Locations: Unknown until a feasibility study is conducted coupled with a benefit/cost analysis in accordance with the objectives-driven, performance-based approach for metropolitan planning as discussed in the previous section. Such a feasibility study will need to address the following in identifying likely locations for BOS:

- Predictable congestion delays during the peak period (e.g., Minnesota DOT standards for BOS operations indicate that the speed must drop below 35 mph during the peak period)
- Number of buses using the freeway during peak periods, the delay they experience in the regular travel lanes, and the average passenger loading (information that is necessary for performing a benefit/cost analysis)
- The number of express buses (i.e., do not enter or exit frequently); the latter consideration may impact whether the inside or outside lane should be used for BOS

- The ability of the shoulder to accommodate buses—for example, are the existing shoulders "hardened" to accommodate the additional weight of buses relative to passenger cars—and shoulder width (general guidelines in this regard for BOS are minimum 11.5 feet)
- For an arterial location, the impact on nonbus traffic if an existing lane be dedicated to buses

Additional Information: A 2-year BOS pilot program was implemented in Illinois on the Interstate 55 corridor in Du Page and Cook Counties. Results were as follows:

- Bus on-time performance increased from 68 to 92 percent.
- Ridership increased threefold.
- The number of bus trips was increased to accommodate increased demand.
- There were no impacts on safety.
- BOS program was made permanent.

Program Area: Arterial Management

Arterial roadways are a crucial link in New Jersey's transportation system, providing local and regional mobility and access to land use that is vital to the state's economy and quality of life. The focus of arterial management is traffic signal control and timing such that drivers can travel along the arterial at the speed limit with minimum delays and stops.

Related Areas: Transit Management, Multimodal and Regional Integration, Climate Change Adaptation, Data Management

Current Operations and Technologies in New Jersey: "Good" to "Better": A nationwide problem with traffic signal systems is that once the technology is installed along a roadway, it still needs to be managed, operated, and maintained on a recurring basis, including keeping the timing plans and parameters up to date. As a general rule, this is not happening per the Institute of Transportation Engineers 2012 "National Traffic Signal Report Card" shown to the right. That said, a growing percentage of the traffic signals along state arterial roads are controlled and coordinated via ITS technologies. NJDOT and several local transportation agencies are making a concerted effort to include more signals and regularly manage them. An example of this is NJDOT's Signalization Master Plan ("T1-T6" effort), in which signalized intersections and corridors are rated in terms of needs as follows:

- T6—Isolated intersections
- T5—Time of day plans
- T4—Signal system upgrades
- T3—Communications link
- T2—Responsive signal timings
- T1—Adaptive signal systems

Adaptive traffic signal systems have recently been implemented in New Jersey, including 128 signals along several arterials surrounding the Meadowlands Sports Complex, sections of U.S. Routes 1, 130, and 168, and most recently 16 intersections along Routes 1 and 9 and Route 440 as part of the Pulaski Skyway effort.

Moving to "Best": Traffic signal management is a continuing effort, requiring annual funding to keep the signal timings up to date. This should be included as part of the planning processes and transportation improvement plan of all three MPOs. Expanding adaptive signal control may also be appropriate. Including arterials and the associated traffic signal control as part of the ICM concept is also part of a "Best" approach and may be facilitated with the expansion of adaptive signal control

Potential New/Enhanced TSM&O Strategies Expansion of adaptive signal control operations throughout the state as appropriate

Strategy: Adaptive Traffic Signal Control

Description: Adaptive traffic signal control is a strategy that continuously monitors arterial traffic conditions and the queuing at intersections and dynamically adjusts the signal timing to optimize one or more operational objectives (such as minimize overall delays). Adaptive traffic signal control approaches typically monitor traffic flows upstream of signalized locations or segments with traffic signals, anticipating volumes and flow rates in advance of reaching the first signal, then continuously adjusting timing parameters to optimize operations.

Lead Agency: NJDOT and traffic departments of larger metropolitan areas within the state

Locations: Unknown until a feasibility study is conducted coupled with a benefit/cost analysis in accordance with the objectives-driven, performance-based approach for metropolitan planning as discussed in the Strategic Plan. Traffic adaptive control can require significant detectorization, and such costs—both installation and ongoing maintenance—need to be considered. Additionally, older traffic signal hardware may not be compatible with traffic adaptive signal systems and software currently on the market. Arterials where traffic adaptive signal control will likely work the best typically have several of the following characteristics:

- Existing, old traffic signal hardware (i.e., controllers) needing replacement
- Traffic diversions from the freeway or other arterials (e.g., via ICM)
- Regular fluctuations in traffic volumes and patterns due to special events and tourist traffic
- High levels of nonrecurring congestion due to incidents and work zone activities
- Large volumes of traffic exiting on side streets that do not happen according to a regular schedule (e.g., stadium or outdoor park emptying as the result of a thunderstorm)
- Infrequent oversaturated conditions (the benefits of adaptive traffic signal control are not easily observable in oversaturated traffic conditions; although users have found that their systems may delay the start of oversaturation and reduce its duration)

All three MPOs are envisioned to be involved in the planning and funding of adaptive traffic signal control systems.

Additional Information: The benefits of adaptive traffic signal control systems have included the following:

- Reductions in stops of 10 to 41 percent
- Reductions in delays of 5 to 42 percent

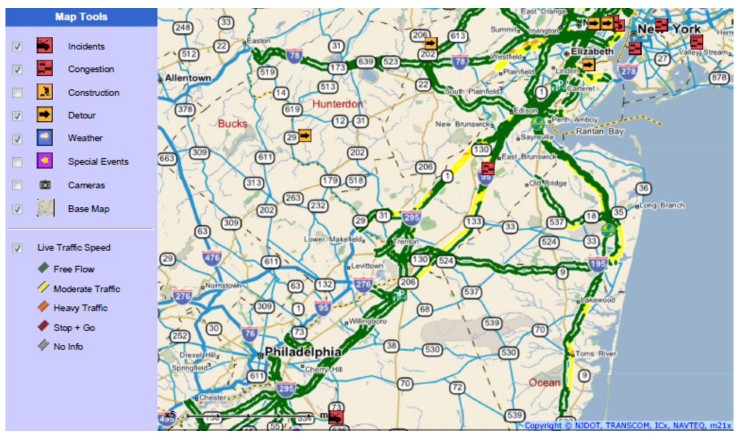
Program Area: Traveler Information

The goal of traveler information, as the program name implies, is for travelers to have information at their disposal to help them make more informed travel decisions throughout the trip chain about mode, route, departure time, activity choices, and parking. Traveler information can be provided pretrip (e.g., web, smartphone applications, email, television traffic reports), thereby enabling travelers to change their travel mode, change the trip departure time, or change the route of the trip to avoid an incident or normal congestion (and thereby reducing traffic demand in the affected area). Traveler information is also provided during a trip (e.g., via DMS, radio traffic reports, 511 phone services, and GPS-based navigation maps) allowing travelers to change their route, travel mode (via ICM), or to turn around and abandon the trip altogether to avoid a major incident, closure, or other significant congestion. Traveler information can also be provided at the end of the trip (e.g., real-time parking availability information). Even if the traveler does not change any trip plans, just knowing the nature of congestion—perhaps with some indication of travel time or incident location—can reduce drivers' frustration and anxiety, making them safer drivers that are less prone to take unnecessary chances, such as excessive lane changing. Traveler information is also a key component of TSM&O during special events and extreme weather events.

Related Areas: Freeway Management, Incident Management, Transit Management, Arterial Management, Multimodal and Regional Integration, Commercial Vehicle Operations, Climate Change Adaptation

Current Operations and Technologies in New Jersey: "Better": All New Jersey transportation agencies have robust programs for traveler information. Following are examples:

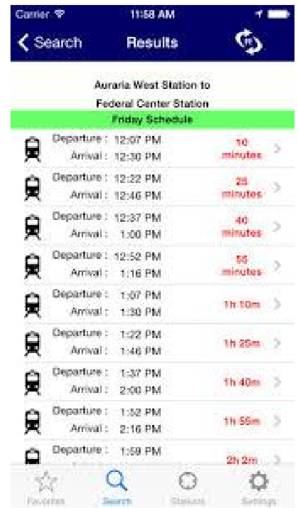
- Roadway DMS (NJDOT and New Jersey Turnpike) display travel times from the sign to major interchanges, using the real-time data from the Transmit system (i.e., using E-ZPass®-equipped vehicles to obtain the travel times). DMS is also used for other messages and alerts.
- New Jersey 511 system including a website (www.511nj.org) that allows users to click on a map showing real-time traffic conditions for many major routes in the state, incident and construction locations; weather alerts; camera tours and associated video; information regarding ongoing megaprojects; and links to other traveler information websites (e.g., New Jersey Transit, Southeastern Pennsylvania Transportation Authority [SEPTA], Newark Liberty International Airport, NY511, PA511). The 511 service also includes phone and text alerts capabilities.



- New Jersey Transit provides traveler information on DMS on rail station platforms and in-vehicle announcements. The New Jersey Transit website (www.njtransit.com) provides real-time information on the status of the rail and bus services, as well as alerts for rail and bus services. "My Bus Now" shows up to five user-selected routes and the current location of buses on that route. Clicking on a bus provides information on the time before the next series of stops. The website also includes a transit itinerary planning system. Other traveler information technologies and strategies employed by New Jersey Transit include the following:
  - The free email alert system ("My Transit") allows customers to receive alerts and advisories that can be delivered to a cell phone, mobile device, or email inbox for selected services that comprise an individual's trips. The alerts/advisories include delays of 15 minutes or more, schedule changes and other service adjustments, and station advisories.
  - "My Light Rail" includes a telephone number/text for a user to identify a light rail station and receive information on the next scheduled train to arrive at the station.
  - "My Bus" provides information on the next scheduled bus arrival for any route at any stop.

- DepartureVision, a free service, displays train departure screens on a user's desktop computer or web-enabled mobile device and features a countdown to train arrival/departure under "Status" starting at 30 minutes, so customers can see at a glance exactly how much time they have to catch their train.
- New Jersey Transit also takes advantage of social media technologies, allowing customers to access the agency through Twitter, Facebook, and a YouTube channel.

- Traveler information is available via private entities (e.g., INRIX, Google) via websites and smartphone apps.

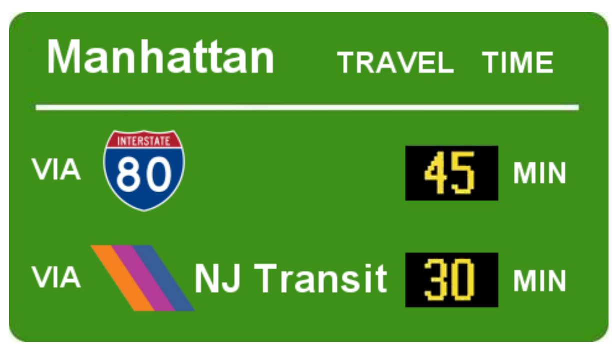


Moving to Best: Providing additional information as discussed for the "Freeway Management" and "Transit Management" program areas (e.g., information on available parking spaces at transit park-and-ride facilities) and integrating the information on a multimodal basis.

Potential New/Enhanced TSM&O Strategies: Real-time queue warnings and lane control guidance already provided; integrating traveler information and providing it on a multimodal basis is critical

Strategy: Integrated Traveler Information

Description: While a significant amount of real-time information is available to the users of the transportation network via the web, apps, trip planners, and the phone—in addition to on-network devices (e.g., DMS on roadways and transit stations)—the information is not integrated from a multimodal perspective. For example, 511NJ provides information on the expressways and major highways. If users wants to find out about transit options, then they have to go to the respective websites (e.g., New Jersey Transit, Port Authority Trans-Hudson [PATH], SEPTA), or to the regional transit trip planner on 511NY. 511NJ provides links to all of these transit websites and well as to 511 websites in neighboring states; however, it is still a multistep process and no direct comparisons of roadway and transit alternatives are provided.



A potential solution is developing a one-stop integrated database of traveler information where a user can view—via web and apps, and possibly future in-vehicle telematics—and compare all of the possible modal options, their current status, and estimated travel times for a particular trip using numerous single and multimodal options without having to switch between separate and individual websites. (Note that the integrated database of information is discussed in a separate program area for "Data Management." Such an integrated database could also be used to provide travel time signage on roadway DMS showing both the travel time on the roadway and on a parallel transit route. If roadway options become severely congested—perhaps due to a major incident or construction activities—then this travel time information (presented in real time) might promote a degree of modal shift. (As previously discussed in the "Transit Management" program area, this strategy requires that the status of parking availability at the transit station and seating on the train be known).

Lead Agency: Integrating traveler information will require involvement and collaboration among multiple agencies, including NJDOT, New Jersey Transit, New Jersey Turnpike, TRANSCOM, Port Authority, and the three MPOs in the state. One of these will need to be designated the lead to oversee and manage such a complex project, working

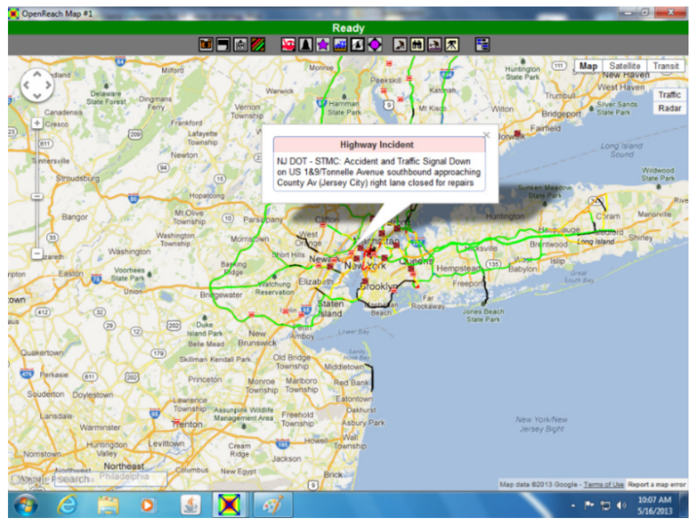
closely with the other involved entities. Potential candidates in this regard would include NJDOT, NJTPA, or TRANSCOM.
Locations: This is a statewide initiative, with no specific location other than the various traveler information website servers. Locations for the multimodal travel time DMS would likely be located along ICM corridors.

Program Area: Multimodal and Regional Integration

Integrated operations on a multimodal and regional (i.e., multiagency) basis are the key component of The Connected Corridor concept. This involves operating the transportation network as an integrated "whole" on a daily basis, bringing all the parts (i.e., individual agency systems and operational strategies) together.

Related Areas: Freeway Management, Incident Management, Transit Management, Arterial Management, Traveler Information, Electronic Payment, Commercial Vehicle Operations, Climate Change Adaptation, Data Management

Current Operations and Technologies in New Jersey: "Better": Interagency and regional coordination has long been a mainstay of transportation entities in New Jersey, as well as New York and eastern Pennsylvania, particularly during major incidents and construction activities (e.g., Pulaski Bridge), special events (e.g., the Super Bowl), and extreme weather conditions (e.g., Superstorm Sandy). TRANSCOM—a coalition of 16 major traffic, transit and public safety agencies in the New Jersey (including NJDOT, New Jersey Transit, New Jersey Turnpike, New Jersey State Police, the Port Authority, and PATH), New York, and Connecticut region—has provided a provide a cooperative, coordinated approach to regional transportation management for nearly three decades. Automated information and video sharing between numerous public agencies in the New York City metropolitan area is provided (in real time) via TRANSCOM's "Open Reach" system (see sample screen shot to the right). TRANSCOM uses real-time data on travel flow, video sharing, written advisories, utilization of member agency ITS-based systems, and other methods—collaborating with the member agencies and other entities—to help reduce the impact of incidents, construction activities, and other events that threaten to disrupt transportation operations. A data-fusion engine has recently been added as well. TRANSCOM also serves as the forum for interagency communications and operational decision-making during such major events.

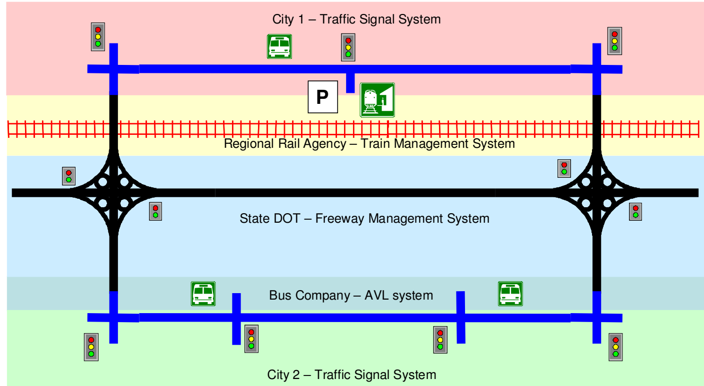


DVRPC promotes and proactively supports interagency coordination in the Philadelphia region, such as the various incident management activities previously noted in that program area. DVRPC also supports information and video sharing in the Philadelphia area via their Regional Integrated Multimodal Information Sharing (RIMIS) project, using the same platform as TRANSCOM's "Open Reach." Using the same platform means that information can be readily exchanged between public agencies throughout New Jersey and beyond as circumstances may dictate.

Moving to "Best": Given that major construction activities, incidents, and other events occur on an almost daily basis, it cannot be said that operational integration is not an ongoing activity in and around New Jersey. Nevertheless, integrated operations could be further enhanced to a regional and multimodal approach that addresses recurring congestion and relatively minor events by incorporating additional information (e.g., data of interest to commercial vehicle operators, parking information, information on variable tolls and pricing). Moreover, the full operations "toolbox"—including several of the newer TSM&O strategies already described (e.g., ATM, adaptive signal control, TSP, ramp metering)—can be integrated together via ICM as further discussed below.

Potential New/Enhanced TSM&O Strategies: ICM

Strategy: Integrated Corridor Management (ICM)



Description: While The Connected Corridor is a strategic concept, ICM consists of the operational coordination of multiple transportation networks and cross-network connections comprising a corridor on an ongoing and regular basis. Efforts to date to improve the operations and management of the surface transportation network have tended to focus on individual modes and agency networks—not only in New Jersey, but throughout the United States. In 2006, the U.S. Department of Transportation (USDOT), a joint effort of FHWA and the Federal Transit Administration initiated the ICM initiative with the expectation that "corridors offer an opportunity to operate and optimize the entire system as opposed to the individual networks." The ICM initiative started with foundational research, followed by the selection of several pioneer sites to develop ICM concept of operations, and subsequently the deployment of ICM systems in San Diego and Dallas. The application of ICM strategies throughout multiple corridors in the state will help achieve the broader vision of The Connected Corridor.

ICM involves numerous approaches and strategies as summarized below (from the FHWA ICM guidance document: (http://ntl.bts.gov/lib/jpodocs/repts_te/14284.htm), many of which—particularly in the area of information sharing –are already in place. Moreover, many of the strategies and approaches noted below for ICM are also identified as recommended strategies for The Connected Corridor under other program areas.

Provide Information Sharing and Distribution

- Provide automated information sharing (real-time data and video).
- Establish information clearinghouse/information exchange network between corridor networks/agencies (e.g., information is displayed on a single graphical representation of the corridor, showing real-time status of all the corridor networks and connections).
- Develop a corridor (or regional- or statewide-)-based advanced traveler information system database that provides information to travelers pretrip for all modes and facilities within the corridor (e.g., NJ511 with integrated transit information as previously discussed).
- Provide en-route traveler information devices owned and operated by network agencies (e.g., DMS, 511, transit public announcement systems) being used to describe current operational conditions on another network(s) within the corridor-, region-, and statewide.

Improve Operational Efficiency of Network Junctions and Physical Interfaces

- Improve TSP (e.g., extended green times to buses that are operating behind schedule).
- Protect transit hub connection (holding one service while waiting for another service to arrive).
- Coordinate operation between ramp meters and arterial traffic signals.

Accommodate / Promote Cross-Network Route and Modal Shifts

- Modify arterial signal timing to accommodate traffic shifting from freeway.
- Modify transit priority parameters to accommodate more timely bus/light rail service on arterial.
- Promote route shifts between roadways via en-route traveler information devices (e.g., DMS, HAR, 511) advising motorists of congestion ahead, directing them to adjacent freeways/arterials.
- Promote modal shifts from roadways to transit via en-route traveler information devices (e.g., DMS, HAR, 511) advising motorists of congestion ahead, directing them to high-capacity transit networks and providing real-time information on the number of parking spaces available in the park-and-ride facility.
- Promote shifts between transit facilities via en-route traveler information devices (e.g., station message signs and public announcements) advising riders of outages and directing them to adjacent rail or bus services.

- Re-route buses around major incidents.

Manage Capacity-Demand Relationship Within Corridor (Real-Time/Short-Term)

- Provide dynamic lane use control (reversible lanes/contra-flow) via ATM.
- Establish variable speed limits (based on congestion, construction, weather conditions) via ATM.
- Increase roadway capacity by opening shoulders to traffic.
- Convert regular lanes or shoulders to “transit-only” or “emergency-only.”
- Add transit capacity by adjusting headways and number of vehicles.
- Add transit capacity by adding temporary new service (e.g., express bus service, “bus bridge” around rail outage/incident).
- Restrict ramp access (metering rates, closures).
- Convert regular lanes to “truck-only.”
- Modify toll and parking rates.

Supporting Technologies

In addition to the strategies and technologies already described, day-to-day ICM operations may be enhanced through the application of decision support systems (DSS) to provide operators across the corridor with predictive “views” of all transportation networks within the corridor and suggest optimal combinations of TSM&O strategies to prevent or lessen the effects of congestion—both predictable (e.g., due to rush hour) and unpredictable (e.g., due to an incident). The ICM DSS gathers information on current network conditions by taking in data from the various freeway, transit, and arterial management systems (including information on predicted operating conditions) and then presents operators with several alternative response plans to mitigate the congestion caused by the event. These plans contain combinations of ICM strategies to address the specific scenario or combinations of scenarios. All of this happens within the span of minutes. The response plans are based on detailed business rules defined and agreed upon in advance by all operating agency stakeholders within the corridor. DSS is a key component in the ICM systems deployed in Dallas and San Diego and will be a key focus of the FHWA evaluation.

Lead Agency: Deploying ICM would require involvement and collaboration between multiple agencies, including NJDOT, New Jersey Transit, New Jersey Turnpike, TRANSCOM, the Port Authority, and the three MPOs in the state. The lead agency for planning, designing, and deploying ICM would depend on the characteristics of the corridor—this would most likely be NJDOT, New Jersey Turnpike, or New Jersey Transit, with support from the MPO. The IAC could also provide collaboration support as well.

The aforementioned FHWA ICM guidance (http://ntl.bts.gov/lib/jpodocs/repts_te/14284.htm) presents a process—based on the principles of systems engineering—for developing and implementing an ICM system. The next step is to finalize the potential corridors (as identified in Table 10 of the Strategic Plan) and then prioritize them in accordance with the objectives-oriented, performance-based planning process. This would be followed by establishing the appropriate institutional architecture for the selected ICM systems and putting in place all the necessary interagency agreements. The next step would then be developing a concept of operations for the ICM system, including an inventory of exiting TSM&O and ITS assets in the corridor; defining the ICM approaches and strategies; developing performance measures and metrics; identifying the institutional, operational, and technical issues (along with how these issues will be resolved); and finalizing the system concept (including numerous operational scenarios). Based on the concept of operations, the process would move into system requirements, design, implementation, testing, and evaluation.

Additional Information: In response to a recent USDOT Request for Proposal for deploying additional ICM corridors, New Jersey and New York jointly submitted a proposal to deploy ICM along the I-495 corridor between the New Jersey Turnpike and the Long Island Expressway. Other potential ICM corridors within the state are identified in the Strategic Plan.

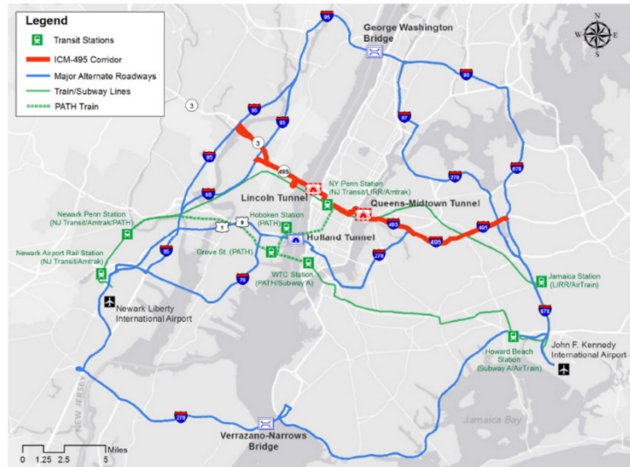


Figure 1. The ICM-495 Corridor

Program Area: Electronic Payment

Electronic payment involves payment systems and applications that do not involve cash at the point of sale and are used to pay for transportation services such as use of the roadway (tolls and congestion pricing), transit, and parking.

Related Areas: Freeway Management, Transit Management, Multimodal and Regional Integration, Commercial Vehicle Operations

Current Operations and Technologies in New Jersey: "Better" to "Best": The concept of a single regional electronic tag and a single monthly invoice incorporating all toll facilities in the northeast was very cutting edge when E-ZPass® was first introduced. The concept has subsequently expanded to include most of the east coast (to North Carolina) and much of the Midwest. Other enhancements have included high speed toll lanes, variable toll rates by time of day, and using E-Zpass® for other payments (e.g., parking at the New York area airports).

New Jersey Transit has introduced advanced fare payment technologies, including "MyTix" that provides customers the convenience of buying rail tickets and passes securely from a mobile device. The agency also provides a contactless payment system using certain credit/debit cards and specially equipped mobile phones on selected bus routes and at the Newark Liberty international Airport AirTrain Station.

Moving to "Best": New Jersey is already very close to "Best." Potential enhancements in this area include the following:

- Providing greater integration between modes (e.g., roadway, transit, and parking payment mechanisms) for electronic payment, Examples include using the fare card for and between different transit agencies (New Jersey Transit, PATH, SEPTA); and a common back office and invoicing process for tolls and transit fares (**Lead**—New Jersey Turnpike, New Jersey Transit, and Port Authority, working through the E-Zpass Interagency Group and the MPOs).
- Introducing more variable tolls and transit fares that are adjusted by time of day and/or congestion levels—a form of congestion pricing (**Lead**—The individual toll and transit agencies, working with local jurisdictions for variable parking pricing).
- Investigating the feasibility of ultimately replacing the fuel tax with a mileage-based road usage charge **(Lead—** NJDOT).

Program Area: Commercial Vehicle Operations

ITS applications for freight and commercial vehicle operations (CVO) involve a combination of commercial interests, economic productivity, public safety, and security, covering cover goods movement by all surface modes. CVO applications and technologies include the following:

Asset Tracking

- Tractor, truck, trailer, and container tracking
- Route adherence and monitoring

On-Board Status Monitoring

- Vehicle operating parameters
- Intrusion and tamper detection
- Automated hazardous materials placarding

Network Status Information

- Congestion alerts and avoidance
- First responder support and incident management

Gateway Facilitation

- Driver identification and verification
- Nonintrusive inspections
- Compliance facilitation
- Weigh-in-motion (WIM)
- Electronic toll payment

Freight Status Information

- Web-based freight portals
- Standard electronic freight information transfer
- Intermodal data exchange

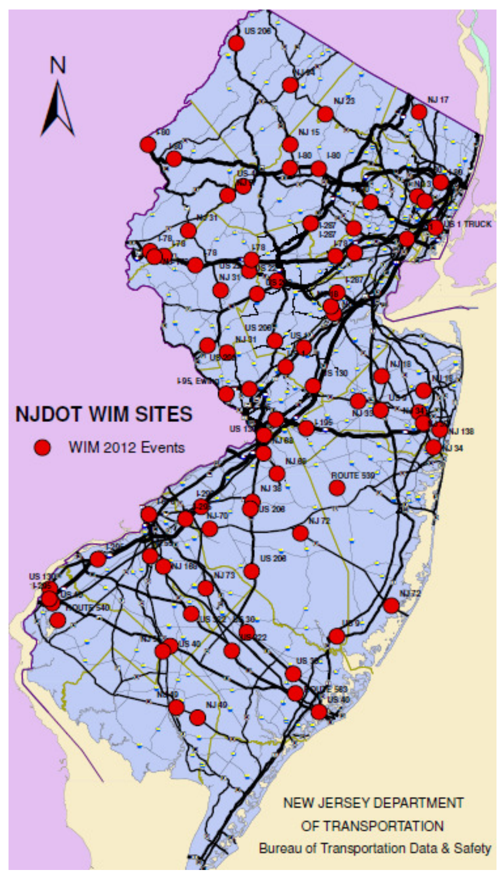
Related Areas: Freeway Management, Incident Management, Traveler Information, Multimodal and Regional Integration, Electronic Payment, Data Management

Current Operations and Technologies in New Jersey: "Good" to "Better": The Connected Corridor concept includes "connecting" the various freight and intermodal facilities in the New York/Newark area, south Philadelphia, in between, and beyond, all of which are served by New Jersey's transportation network. Per the *New Jersey Statewide Freight Plan Phase II: Priority Highway Corridors*, the major freight corridors in the state are as follows:

- East-west freight corridor (Interstates 78 and 80)
- North-south freight corridor (Interstate 95/New Jersey Turnpike/Interstate 295)
- Bergen County Connector freight corridor (New Jersey Route 17)
- Northeastern New Jersey Beltway freight corridor (Interstate 287)

Operating these corridors impacts the supply chain and the broader goal of economic competitiveness.

NJDOT operates several WIM sites around the state (refer to map to the right) to capture and record axle weights and gross vehicle weights as vehicles drive over the roadway sensors at normal traffic speed. WIM also records axle spacing, speed, and vehicle class according to the number of axles and axle weights. These locations also serve as permanent count stations. In addition to screening overweight trucks and enforcing gross vehicle weight and axle weight requirements, the data are also used for infrastructure design and management and freight/trade planning.



DVRPC provides a truck-specific information website known as "PhillyFreightFinder"—a dynamic, web-based mapping application that pinpoints freight facilities and freight activity in the Philadelphia-Camden-Trenton region. It contains 20 individual layers and over 350 features of infrastructure and facilities, all customizable by the user.

It should be emphasized that many of the operational and technology applications for commercial vehicle operations—including several of the associated CVO service packages in the National ITS Architecture—are typically provided by the freight operators themselves, such as asset tracking, on-board equipment and cargo status monitoring, communications between dispatch and driver, equipment safety and control, and performance reporting. The extent to which the private sector incorporates technology is generally in line with the size of the business, with the largest shippers, carriers, and warehouse operators having the most sophisticated systems and equipment. However, even the smallest businesses, down to individual owner operators, are likely to use some technology including personal computers, web applications, GPS devices, and cellular communication. As such, many of the CVO-related strategies and technologies are not specifically addressed in The Connected Corridor concept, which focuses more on activities and operations of the transportation network providers.

Moving to "Best": Improving operations along the aforementioned freight routes—as described for the previous program areas—will help to reduce congestion and improve reliability (an important consideration in today's just-in-time manufacturing environment), and thereby help commercial vehicle operations. Many of the TSM&O strategies identified herein can be adapted and enhanced to better address commercial vehicles, including the following:

- Enhancing the traveler information sources to provide truck-specific information, such as locations with available truck parking (and when they are open), segments with weight and/or height restrictions, along with real-time traveler information tailored specifically for the freight community (via a web site and apps) and expanding the "PhillyFreightFinder" concept throughout the state, including the addition of real-time roadway and travel conditions, is one possible approach in this regard
- Expanding ICM and ATM strategies to incorporate truck operations such as truck-specific diversions, truck lanes during off peak periods, and/or making hard shoulder running a truck lane (assuming the shoulder is wide enough and the shoulder pavement can handle the additional loading)
- Adding SSP vehicles that are specially designed and equipped to deal with incidents involving large trucks

Additionally, as noted in Table 10 of the Strategic Plan, the Port Authority, NJDOT, and NYSDOT are jointly developing a "Comprehensive Regional Goods Movement Action Program for the New York-New Jersey Metropolitan Region (G-MAP)."

Program Area: Climate Change Adaptation

The various TSM&O strategies help the environment through the reduction in transportation-related emissions, including criteria pollutants (e.g., carbon monoxide, ozone, and particulate matter) and Greenhouse gases, such as carbon dioxide, that contribute to climate change. However, the vast majority of climate scientists have concluded that climate change is real and will likely get worse. The following is per the U.S. Global Change Research Program's *Third National Climate Assessment* (2014):

> *"Weather events influence the daily and seasonal operation of transport systems. Transportation systems are already experiencing costly climate change related impacts. Over the coming decades, all regions and modes of transportation will be affected by increasing temperatures, more extreme weather events, and changes in precipitation. Disruptions to transportation system capacity and reliability can be partially offset by adaptation. Transportation systems as networks may use alternative routes around damaged elements or shift traffic to undamaged modes. Other adaptation actions include asset management programs, at-risk asset protection, and operational changes. As new and rehabilitated transportation systems are developed, climate change impacts should be routinely incorporated into the planning for these systems."*

USDOT has addressed adaptation in its 2011 policy statement on climate change adaptation: "*Through climate change adaptation efforts, the transportation sector can adjust to future changes, minimize negative effects and take advantage of new opportunities."*

Related Areas: Freeway Management, Incident Management, Transit Management, Arterial Management, Multimodal and Regional Integration, Data Management

Current Operations and Technologies in New Jersey: "Good" to "Better": The impacts of and responses to Hurricane Irene and Superstorm Sandy highlight how important adaptation can be. Moreover, the coordination and responses by New Jersey transportation agencies and TRANSCOM before, during, and after Sandy demonstrated why New Jersey gets a strong "Good, approaching "Better" in this program area.

Moving to "Best": The various TSM&O strategies previously discussed can be applied to adaptation for several climate change effects and the potential impacts on the surface transportation network as summarized below. It is important to note that extreme weather events stress the transportation network at precisely the time when smooth operation is most critical. Effective evacuation planning, including early warning systems, coordination across jurisdictional boundaries, and creating multiple evacuation routes, builds preparedness. But the operations and traveler information considerations do not stop here. During the extreme weather event, road condition information is important for emergency service providers who may need to reach individuals and neighborhoods at risk. Moreover, these operational considerations and the availability of accurate traveler information may be most important and critical following such an extreme weather event, when the affected population and commercial entities desire to get back to "normal" (e.g., return to homes, work, and their standard routine) as quickly as possible.

An underlying element in all of the climate change events and operational considerations shown below is that of **traveler information;** providing real-time information to travelers about the ongoing transportation impacts, how they may affect their travels, and warning them as to any changes to the norm (e.g., reduced speed limits, closed lanes, closed roadways, alternative routes), thus allowing travelers make better decisions about how they travel (mode), when they travel (time), where and whether they travel (location), and which route they travel (path).

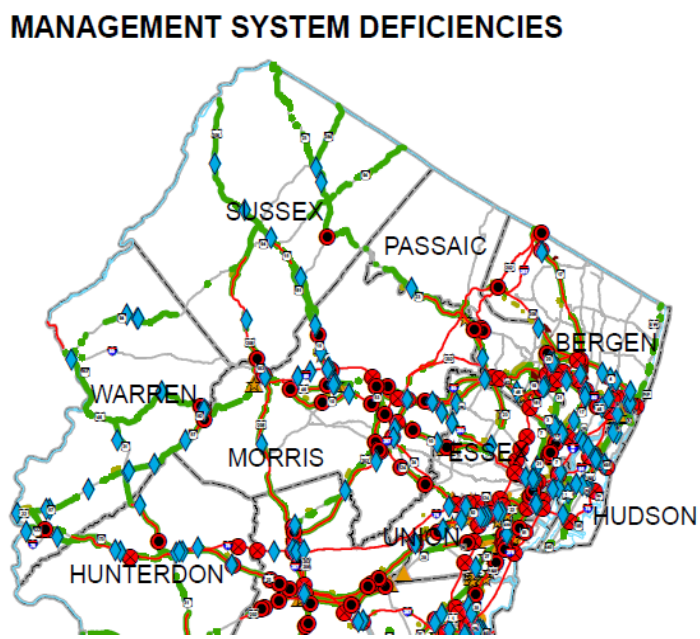
Climate Change Effects	Impacts on Transportation	Operations Considerations
Increases in very hot days	• Pavement softening and buckling • Thermal expansion of bridge expansion joints • Rail-track deformities and catenary issues • Limitations on periods of construction activity due to health and safety concerns • Vehicle overheating (resulting in roadway incidents) • Electrical system malfunctions	• Reduced speed limits (via ATM) • Truck weight restrictions • Road and transit diversions • Work zone management (altered schedules and lane closures) • Increase in incident management activities • Changes in modal splits (including walking)
Rising sea levels	• Flooding of coastal roads, tunnels, and rail lines • Erosion of road base and bridge supports (scouring) • Rail bed erosion	• Lane and road closures (and use of ATM) • Road and transit diversions (ICM)
Increases in intense precipitation events	• Increases in weather-related delays and traffic disruptions • Increased incidents • Erosion of road base and bridge supports (scouring) • Erosion of rail bed and power, signal and communications infrastructure.	• Reduced speed limits (via ATM) • Road and lane closures (via ATM) • Diversions via ICM • Increase in incident management activities
Increases in hurricane intensity	• More frequent and potentially more extensive emergency evacuations	• Contra-flow lane/hard shoulder running operations • Ramp management and closures • ICM along evacuation routes

Program Area: Data Management

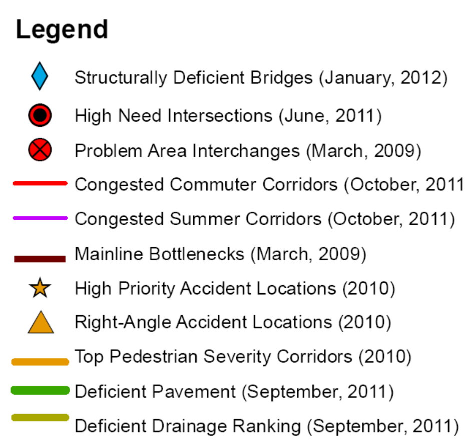
TSM&O strategies occur in real time and require real-time data on which to base the operations and control decisions. Newer TSM&O strategies and technologies—such as ATM, integrated traveler information and ICM as discussed for the previous program areas—require and subsequently provide even more data. Moreover, the "Connected Vehicle" initiative promises to significantly increase the amount of data available to operating entities. These data, plus information from other sources, are critical for estimating project benefits and costs as part of the objectives-driven, performance-based approach for metropolitan planning. The information is also crucial for determining system performance (using the established performance measures and metrics), and evaluating the extent to which the outcome-based operations objectives are being met. This requires a data management system for storing the data (i.e., archiving) and for providing ready access to those (e.g., planners and operators) who need the data.

Related Areas: Freeway Management, Incident Management, Transit Management, Arterial Management, Multimodal and Regional Integration, Electronic Payment, Commercial Vehicle Operations, Climate Change Adaptation

Current Operations and Technologies in New Jersey: "Better": There is a significant amount of information available regarding the operation of the transportation network in New Jersey, including the following:



- NJDOT has a wealth of geo-coded (i.e., GIS-based) information on a wide variety of transportation network attributes, including crash rates (by severity and type), bottleneck locations including a severity index for each, congested corridor locations, ITS equipment and communication conduits, growth areas, just to name a few related to operations. (Refer to graphic as an example).
- NJDOT and other transportation entities also use the VPP Suite (VPP stands for the I-95 Corridor Coalition's "Vehicle Probe Project"), which provides archived data on average vehicle speeds (along with various percentiles) and an estimate of user delay costs and can be used to identify and prioritize problem locations and bottlenecks and estimate benefit.
- New Jersey Transit regularly conducts online customer surveys as part of its *Scorecard* initiative, seeking feedback from customers on how the agency is performing and where it can improve to boost customer satisfaction. This is in addition to other performance data such as on-time performance.
- TRANSCOM and DVRPC provide data feeds (through "Open Reach" and RIMIS, respectively) that allows various user groups to access real-time event and link (travel time) data for use in their applications. Additionally, TRANSCOM has recently added a data fusion engine.



Moving to "Best": Two significant problems exist with these data in terms of accessing and using the information—they are split up among multiple systems, and the geo-referencing is not consistent (e.g., some use highway milepost referencing, while others use the "Traffic Management Channel" referencing standard). What is required is a "data warehouse" (potentially a virtual one) that accommodates collecting data from multiple agencies and data sources spanning across modal and jurisdictional boundaries. The data warehouse would perform additional transformations (e.g., common geo-referencing system) and provide additional meta-data management features that are necessary such that all data can be managed in a single repository with consistent formats and to allow on-line analysis and provide data mining features.

It is also noted that the New Jersey state legislature is considering an open data: bill—the New Jersey Open Data Initiative. As the bill (No. 2071) currently stands, its intent is to “increase public awareness and access to data and information created by and available from state departments and agencies, enhance government transparency and accountability, encourage public engagement, and stimulate innovation with the development of new analyses or applications based on the unique data provided by the state…” In essence, it will require certain information to be made available on the Internet by state departments and agencies. Such a data warehouse would help meet this requirement.

Lead: Identify the specific entity within the state that will be responsible for developing and subsequently managing the data warehouse represents a key issue. A regional entity, such as one of the MPOs or TRANSCOM would be a logical choice. Another issue is the extent to which data from the private sector can be integrated into the data warehouse and/or accessed by public sector entities.